SIPROTEC

Distance Protection 7SA6

V4.0

Manual

C53000-G1176-C133-1

Preface

Aim of this Manual

This manual describes the functions, operation, mounting, and commissioning of the device. In particularly, you will find:

- Information regarding configuration of the device → Chapter 5,
- Description of the device functions and setting facilities → Chapter 6,
- Instruction of operation while in service → Chapter 7,
- Instruction for mounting and commissioning → Chapter 8,
- List of the technical data → Chapter 10,
- Summery of the most significant data for the experienced user in the Appendix.

Target Audience

Protection engineers, commissioners, persons who are involved in setting, testing and maintenance of protection, automation, and control devices, as well as operation personnel in electrical plants and power stations.

Applicability of this Manual

This manual is valid for SIPROTEC® 7SA6; Distance Protection; firmware version 4.0

Indication of Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Council Directive 89/336/EEC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 73/23 EEC).

Conformity is proved by tests conducted by Siemens AG in accordance with Article 10 of the Council Directive in agreement with the generic standards EN 50081 and EN 50082 (for EMC directive) and the standards EN 60255-6 (for low-voltage directive).

The device is designed in accordance with the international standards of IEC 255 and the German standards DIN 57 435 part 303 (corresponding to VDE 0435 part 303).

Additional support

Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the local Siemens representative.

Courses

Individual course offerings may be found in our Training Catalog, or questions can be directed to our training center. Please contact your Siemens representative.

Instructions and Warnings

The warnings and notes contained in this manual serve for your own safety and for an appropriate lifetime of the device. Please observe them!

The following terms are used:

DANGER

indicates that death, severe personal injury or substantial property damage will result if proper precautions are not taken.

Warning

indicates that death, severe personal injury or substantial property damage can result if proper precautions are not taken.

Caution

indicates that minor personal injury or property damage can result if proper precautions are not taken. This is especially valid for damage on or in the device itself and consequential damage thereof.

Note
indicates information about the device or respective part of the instruction manual which is essential to highlight.

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

The successful and safe operation of this device is dependent on proper handling, installation, operation, and maintenance by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed. Non–observance can result in death, personal injury or substantial property damage.

QUALIFIED PERSONNEL

For the purpose of this instruction manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he has the following qualifications:

- Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Typographic and Symbol Conventions

The following text formats are used when literal information from the device or to the device appear in the text flow:

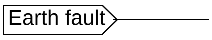
`Parameter names`, i.e. designators of configuration or function parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI® 4), are marked in bold letters of a monospace type style.

`Parameter options`, i.e. possible settings of text parameters, which may appear word-for-word in the display of the device or on the screen of a personal computer (with operation software DIGSI® 4), are written in italic style, additionally.

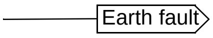
“`Annunciations`”, i.e. designators for information, which may be output by the relay or required from other devices or from the switch gear, are marked in a monospace type style in quotes.

Deviations may be permitted in drawings when the type of designator can be obviously derived from the illustration.

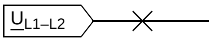
The following symbols are used in drawings:



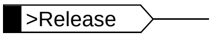
device-internal logical input signal



device-internal logical output signal

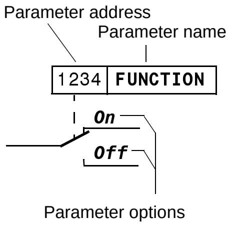


internal input signal of an analog value



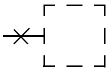
external binary input signal

external binary output signal

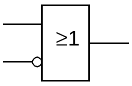


example of a parameter switch **`FUNCTION`** with the address 1234 and the possible settings ***`On`*** and ***`Off`***

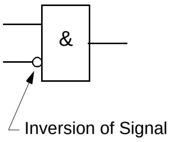
Furthermore, the graphic symbols according IEC 617–12 IEC 617–13 or similar are used in most cases.



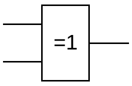
Analog input value



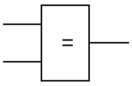
OR–Logic of input value



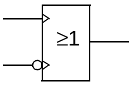
AND–Logic of input value



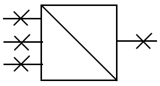
Exclusive *OR* (Non-equivalence): output active, if only *one* of the inputs is active



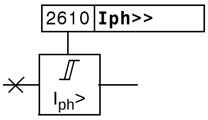
Coincidence: output active, if *both* inputs are active in the same direction



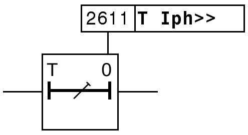
Dynamic input signals



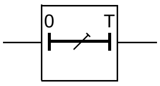
Creation of an analog output signal out of several analog input signals



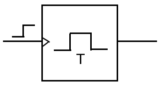
Monitoring stage with parameter address and parameter name



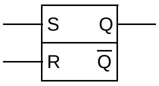
Timing element (pickup delay) with parameter address and parameter name



Timing element (resetting time delay)



Transition-operated timing element with action time T



Static memory (RS–flipflop) with Set Input (S), Reset Input (R), Output (Q) and Negated Output ($\overline{Q}$)

Table of Contents

Introduction

1

The SIPROTEC$^{®}$ 4 devices 7SA6 are introduced in this chapter. An overview of the devices is presented in their application, characteristics, and scope of functions.

1.1 Overall Operation

The numerical Distance Protection SIPROTEC® 7SA6 is equipped with a powerful 32 Bit microprocessor. This provides fully numerical processing of all functions in the device, from the acquisition of the measured values up to the output of commands to the circuit breakers. Figure 1-1 shows the basic configuration of the device.

Analog Inputs

The measuring inputs MI transform the currents and voltages derived from the instrument transformers and match them to the internal signal levels for processing in the device. The device has 4 current and 4 voltage inputs. Three current inputs are provided for measurement of the phase currents, a further measuring input (I_4) may be configured to measure the earth current (residual current from the current transformer star-point), the earth current of a parallel line (for parallel line compensation) or the star-point current of a power transformer (for earth fault direction determination).

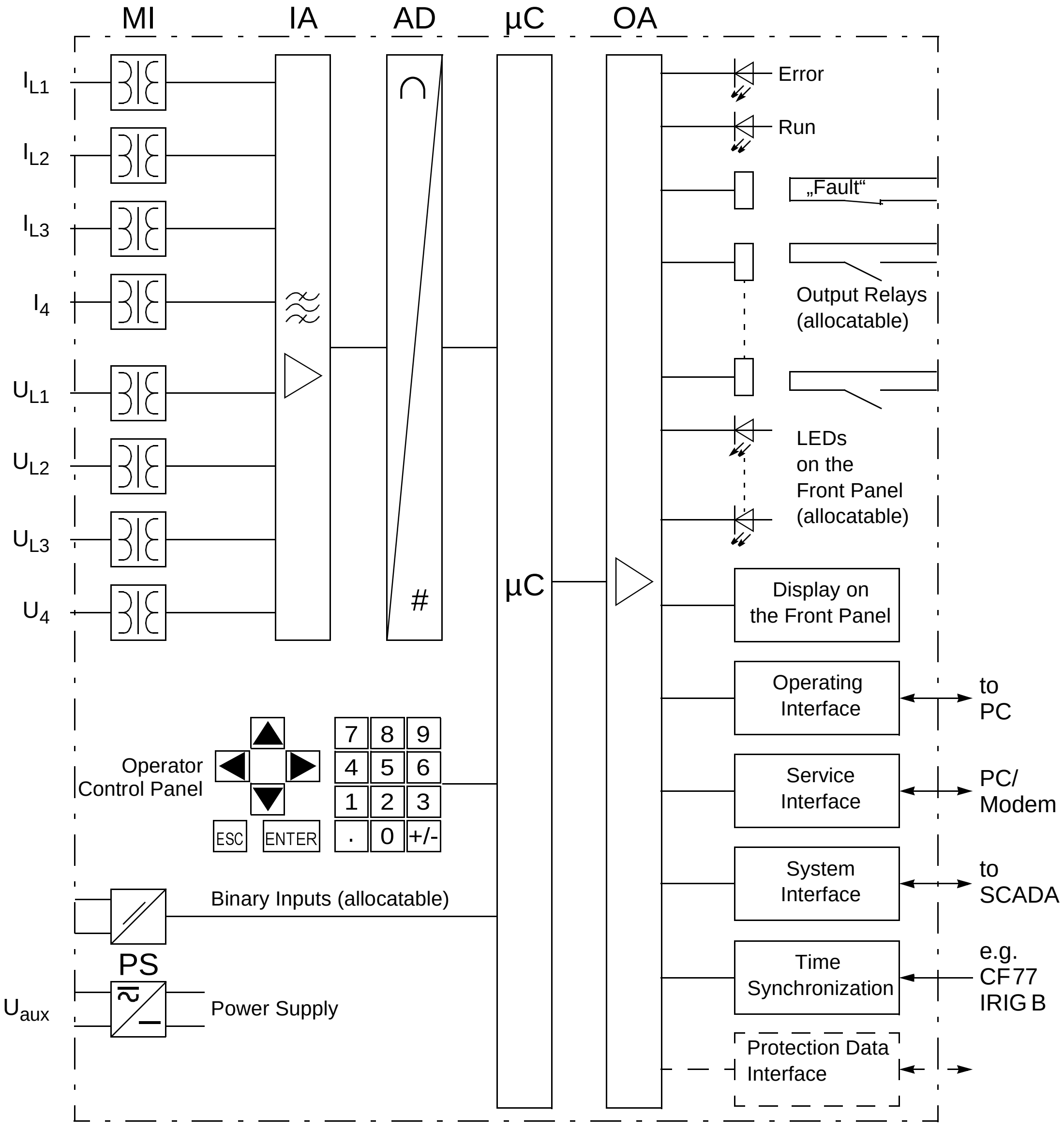


Figure 1-1 Hardware structure of the numerical device 7SA6 (maximum configuration)

A voltage measuring input is provided for each phase–earth voltage. A further voltage input (U_4) may optionally be used to measure either the displacement voltage (e–n–voltage) or any other voltage U_X (for overvoltage protection). The analogue signals are then routed to the input amplifier group IA.

The input amplifier group IA ensures that there is high impedance termination for the measured signals and contains filters which are optimized in terms of band-width and speed with regard to the signal processing.

The analogue/digital converter group AD has an analogue/digital converter and memory modules for the data transfer to the microcomputer.

Microcomputer System

Apart from processing the measured values, the microcomputer system also executes the actual protection and control functions. In particular, the following are included:

- Filtering and conditioning of the measured signals,
- Continuous supervision of the measured signals,
- Monitoring of the individual protection function pick-up conditions,
- Interrogation of threshold values and time sequences,
- Processing of signals for the logic functions,
- Reaching trip and close command decisions,
- Storage of fault annunciations, fault annunciations as well as fault recording data, for system fault analysis,
- Operating system and related function management such as e.g. data storage, real time clock, communication, interfaces etc.

Informations are provided via output amplifier group OA.

Binary Inputs and Outputs

The microcomputer system obtains external information through the binary inputs such as remote resetting or blocking commands for protective elements. The µC issues information to external equipment via the output contacts. These outputs include, in particular, trip commands to the circuit breakers and signals for remote annunciation of important event and conditions.

Front Elements

Light-emitting diodes (LEDs) and a display screen (LCD) on the front panel provide information on measured values, events, states and finally the functional status of the device.

Integrated control and numeric keys in conjunction with the LCD facilitate local interaction with the 7SA6. All information of the device can be accessed using the integrated control and numeric keys. The information includes protective and control settings, operating and fault messages, and measured values (see also Chapter 7). The settings can be modified as are discussed in Chapter 6.

If the device is provided with the main functions of system control, the required operation can also be carried out via the front cover.

Serial Interfaces

A serial **operating** interface on the front panel is provided for local communications with the 7SA6 through a personal computer. Convenient operation of all functions of the device is possible using the SIPROTEC® 4 operating program DIGSI® 4.

A separate serial **service** interface is provided for remote communications via a modem, or local communications via a substation master computer that is permanently connected to the 7SA6. DIGSI® 4 is required.

All 7SA6 data can be transferred to a central master or main control system through the serial **system** interface. Various protocols and physical arrangements are available for this interface to suit the particular application.

A battery backed clock is always provided and can be synchronized via a synchronization signal with IRIG-B (GPS via satellite receiver) or DCF 77.

Additional interface modules provide the option to carry out further communication protocols.

Power Supply

The 7SA6 can be supplied with any of the common power supply voltages. Transient dips of the supply voltage which may occur during short-circuit in the power supply system, are bridged by a capacitor (see Technical Data, Sub-section 10.1.2).

1.2 Applications

The numerical Distance Protection SIPROTEC® 7SA6 is a fast and selective protection device for overhead lines and cables with single- and multi-ended infeeds in radial, ring or any type of meshed systems with insulation ratings. The system starpoint can be earthed, resonant-earthed or isolated.

The device incorporates the functions which are normally required for the protection of an overhead line feeder and is therefore capable of universal application. It may also be applied as time graded back-up protection to all types of comparison protection schemes used on lines, transformers, generators, motors and busbars of all voltage levels.

Protection Functions

Recognition of the distance to fault with distance protection measurement, is the basic function of the device. In particular for complex multiphase faults, the distance protection has a non-switched 6-impedance-loops design (fullscheme). Different pickup schemes enable a good adaption to system conditions and the user philosophy. The influence of wrong distance measurement due to parallel lines can be compensated by feeding the earth current of the parallel line to the relay. Parallel line compensation can be used for distance protection as well as for the fault locator. It may be supplemented by teleprotection using various signal transmission schemes (for fast tripping on 100 % of the line length). In addition, an earth fault protection (for high resistance earth faults, ordering option) is available, which may be directional, non-directional and may also be incorporated in signal transmission. On lines with weak or no infeed at one line end, it is possible to achieve fast tripping at both line ends by means of the signal transmission scheme. Subsequent to energizing the line onto a fault which may be located along the entire line length, it is possible to achieve a non-delayed trip signal.

In the event of a failure of the measured voltages due to a fault in the secondary circuits (e.g. trip of the voltage transformer mcb or a fuse) the device can automatically revert to an emergency operation with an integrated time delayed overcurrent protection, until the measured voltage again becomes available. The overcurrent protection consists of three definite time overcurrent stages and an inverse time (IDMT) stage. For the IDMT stage, a number of characteristics based on various standards are available. The stages can be combined according to the user's requirements. Alternatively, the time delayed overcurrent protection may be used as back-up time delayed overcurrent protection, i.e. it functions independent and in parallel to the distance protection.

Depending on the version ordered, most short-circuit protection functions may also trip single-pole. It may work in co-operation with an integrated automatic reclosure (available as an option) with which single-pole, three-pole or single and three-pole automatic reclosure as well as several interrupt cycles are possible on overhead lines. Before reclosure after three-pole tripping, the permissibility of the reclosure can be checked by voltage and/or synchronization check by the device. It is possible to connect an external automatic reclosure and/or synchronization device as well as double protection with one or two automatic reclosure functions.

Apart from the short-circuit protection functions mentioned, further protection functions are possible such as earth fault detection (for isolated or resonant-earthed systems), multi-stage overvoltage and undervoltage protection, circuit breaker failure protection and protection against the effects of power swings (for impedance starting, simultaneously active as power swing blocking for the distance protection), as well as thermal overload protection for protecting the operational equipment (especially cables) against too much heating due to overloading.

For the rapid location of the damage to the line after a short-circuit, a fault locator is integrated which also may compensate for the influence of a parallel line and load.

Messages and Measured Values; Storage of Data for Fault Recordings

A series of operating messages provides information about conditions in the power system and the 7SA6 itself. Measurement quantities and values that are calculated can be displayed locally and communicated via the serial interfaces.

Messages of the 7SA6 can be indicated by a number of programmable LEDs on the front panel, externally processed through programmable output contacts, and communicated via the serial interfaces (see “Communication” below). With the help of the CFC graphic tool (Continous Function Chart) user-defined annunciations and logical combinations of internal or external signals can also be generated.

Important events and changes in conditions are saved under Annunciation in the Event Log or the Trip Log, the latter being used for faults. The instantaneous measured values during the fault are also stored in the device and are subsequently available for fault analysis.

Communication

Serial interfaces are available for communications with PCs, RTUs and SCADA systems.

A 9-pin D-subminiature female connector on the front cover is used for local communication with a personal computer. DIGSI®4 software is required to communicate via this port. Using the SIPROTEC® DIGSI®4 operator software, all operating and evalution procedures may be implemented via this operating interface, such as setting and modification of configuration and parameter settings, configuration of user-specific logic functions, reading out and display of operating and fault event messages as well as measured values, reading out and display of fault records, queries of device states as well as queries of measured values, and issuing of control commands.

Depending on the version ordered, further interfaces are on the rear side of the device. Thus a comprehensive communication can be built up with other digital operating control and storage systems:

The service interface can be operated via data or fibre optic cables. Communication via modems is also possible. This enables remote operation from a PC using the DIGSI®4 operating software, e.g. if several devices are to be operated from a central PC.

The system interface is used for central communication between the device and the control centre. It can also be operated via data and fibre optic cables. Standardized protocols for data transfer in accordance with IEC 60870-5-103 are available. This profile also enables the integration of devices into the SINAUT®LSA and SICAM® automation systems.

As an alternative SIPROTEC® 4 also provides a field bus interface with PROFIBUS FMS. The PROFIBUS FMS according to DIN 19245 with a very high capacity is a widespread communication standard in the control and automation technology. The profile of the PROFIBUS communication covers all types of information transmission needed for substation control and protection systems. Via this profile the devices are connected to the energy automation system SICAM®.

1.3 Features

- Powerful 32-bit microprocessor system.
- Complete digital processing of measured values and control, from the sampling and digitilization of measured values to close and trip decisions for the circuit breaker.
- Complete galvanic and reliable separation between the internal processing circuits of the 7SA6 and the external measurement, control, and DC supply circuits because of the design of the analog input transducers, binary inputs and outputs, and the DC converters.
- Complete scope of functions which are normally required for the protection of a line feeder.
- Different pickup modes can be selected enabling the user to adapt the distance protection system to different network conditions and his requirements.
- Polygonal tripping characteristics with separate setting along the X–axis (reach) and R–axis (arc resistance reserve) and separate R–setting for earth faults.
- Direction determination is done with unfaulted loop (quadrature) voltages and voltage memory, thereby achieving unlimited directional sensitivity.
- Compensation of the influence of a parallel line during earth faults is possible.
- Abundance of additional protective and control functions available, some as options.
- Continuous calculation and display of measured quantities on the front of the device.
- Simple device operation using the integrated operator panel or by means of a connected personal computer running DIGSI® 4.
- Storage of operational data, fault data, and oscillographic fault records with SER information to be used for analysis and troubleshooting.
- Communication with central control and data storage equipment via serial interfaces through the choice of data cable, modem, or optical fibers, as an option.
- Constant monitoring of the measurement quantities, as well as continuous self-diagnostics covering the hardware and software.

1.4 Scope of Functions

The numerical Distance Protection SIPROTEC® 7SA6 has the following functions (sometimes dependent on the order variant):

Distance Protection

- Protection for all types of short-circuit in systems with earthed, resonant-earthed or isolated star point;
- Different pickup schemes enable the user to adapt the distance protection system to different network conditions and user's requirements:
  overcurrent pickup, voltage and angular-controlled pickup or impedance starting (with polygonal angle-dependent characteristeric) can be selected;
- Reliable distinction between load and short-circuit conditions, also on long, heavily loaded lines;
- High sensitivity in the case of a weakly loaded system, extreme stability against load jumps and power swings;
- Optimum adaption to line conditions by means of a polygonal tripping characteristic with separate setting along the X–axis (reach) and R–axis (arc resistance reserve), separate R–setting for earth faults.
- Six measuring systems for each distance zone (full scheme design);
- Six distance zones, selectable as forward, reverse or non-directional reaching, one may be graded as an overreaching zone;
- Nine time stages for the distance zones;
- Direction determination is done with unfaulted loop (quadrature) voltages and voltage memory, thereby achieving unlimited directional sensitivity, and not affected by capacitive voltage transformer transients;
- Current transformer saturation detection and compensation;
- Compensation against the influence of a parallel line;
- Shortest tripping time is approx. 15 ms (f_N = 60 Hz) or 17 ms (f_N = 50 Hz);
- Phase segregated tripping (in conjunction with single-pole or single- and three-pole auto-reclosure);
- Non-delayed tripping after switching on to a fault.

Power Swing Suppplement (optional for Impedance Starting)

- Power swing detection with dZ/dt–measurement with three measuring systems;
- Power swing detection up to a maximum of 7 Hz swing frequency;
- In service also during single-pole dead times ;
- Settable power swing programs;
- Prevention of undesired tripping by the distance protection during power swings;
- Tripping for out-of-step conditions can also be configured.

Teleprotection Supplement

Can be configured to various schemes for:

- Permissive Underreach Transfer Trip (PUTT) (directly via pickup or via overreach zone that is set separately)

- Differential connections (release or blocking schemes, with separate overreach zone or directional pickup)
- Pilot protection / reverse interlocking (with direct voltage for local connections or extremely short lines)
- All lines are suited for 2 or 3 ends;
- Phase segregated transmission applicable for lines with 2 ends

Earth Fault Protection (optional)

- Earth fault overcurrent protection, with a maximum of three definite time stages (DT) and one inverse time stage (IDMT) for high resistance earth faults in earthed systems;
- For the IDMT protection a selection of various characteristics based on several standards is possible;
- A fourth definite time stage can be set for the IDMT
- High sensitivity from 3 mA (dependent on the version) is possible;
- Phase current stabilization against error currents during current transformer saturation;
- Inrush stabilization with second harmonic;
- Earth fault protection with a tripping time dependent on zero sequence voltage
- Each stage can be set to be non-directional or directional in the forward or reverse direction;
- Direction determination with zero sequence system quantities (I_0, U_0), with zero sequence current and transformer star-point current (I_0, I_Y). or with negative sequence system quantities (I_2, U_2);
- One or more stages may function in conjunction with a signal transmission supplement, also suited for lines with three ends
- Non-delayed tripping after switching on to a fault is possible with any stage.

Tripping/Echo at Line Ends with no Infeed or Weak Infeed

- Possible in conjunction with teleprotection schemes;
- Allows fast tripping at both line ends, even if there is no or only weak infeed available at one line end;
- Phase segregated tripping is possible.

External Direct and Remote Tripping

- Tripping at the local line end from an external device via a binary input;
- Tripping of the remote line end by internal protection functions or an external device via a binary input (with teleprotection);

Time Delayed Overcurrent Protection

- Selectable as emergency function in the case of measured voltage failure, or as back up function independent of the measured voltage;
- Maximally two definite time stages (DT) and one inverse time stage (IDMT), each for phase currents and earth current;
- For IDMT protection a selection from various characteristics based on several standards is possible;
- Blocking options e.g. for reverse interlocking with any stage;
- Non-delayed tripping in the case of switching onto a fault with any stage is possible;

- Stub protection: additional stage for fast tripping of faults between the current transformer and circuit breaker (when the isolator switching status feed back is available); particularly suited to sub-stations with $1^{1}/_{2}$ circuit breaker arrangements.

High Current Fast Switch-on-to-Fault Protection

- Fast tripping for switch-on-to-fault conditions;
- Selectable for manual closure or following each closure of the circuit breaker;
- With integrated line energization detection.

Sensitive Earth Fault Detection (optional)

For resonant-earthed or isolated systems with

- Detection of displacement voltage
- Determination of earth-faulted phases
- Sensitive determination of the earth fault direction
- Phase displacement correction for current transformers

Automatic Reclosure (optional)

- For reclosure after single-pole, three-pole or single and three-pole tripping;
- Single or multiple reclosure (up to 8 reclosure attempts);
- With separate action times for every reclosure attempt, optionally without action times;
- With separate dead times after single-pole and three-pole tripping, separate for the first four reclosure attempts;
- Controlled optionally by protection start with separate dead times after single, two and three-pole starting
- Optionally with adaptive dead time, phase-to-phase voltage and reduced dead time

Synchronism and Voltage Check (Dead-line / Dead-bus Check) (optional)

- Checking synchronism conditions before reclosure after three-pole switching;
- Fast measuring of voltage difference U diff of the phase angle difference φ diff and the frequency difference f diff;
- Alternative check of dead-line / dead-bus before reclosure;
- Switching under asynchronous network conditions with advance calculation of the synchro-time possible;
- Adjustable minimum and maximum voltage;
- Checking synchronism or dead-line / dead-bus also before manual closure of the circuit breaker, with separate limit values;
- Measurement via transformer also possible;
- Measuring voltages optionally phase-phase or phase-earth

Voltage Protection (optional)

Overvoltage and undervoltage detection with different stages

- Two overvoltage stages for the phase-earth voltages, with common time delay
- Two overvoltage stages for the phase-phase voltages, with common time delay
- Two overvoltage stages for the symmetrical positive sequence system of the voltages, with a time delay each
- Two overvoltage stages for the symmetrical negative sequence system of the voltages, with a time delay each
- Two overvoltage stages for the zero sequence system of the voltages or any other single-phase voltage, with a time delay each
- Settable drop-off to pick-up ratios for the overvoltage protection functions
- Two undervoltage stages for the phase-earth voltages with common time delay
- Two undervoltage stages for the phase-phase voltages with common time delay
- Two undervoltage stages for the symmetrical positive sequence system of the voltages, with a time delay each
- Settable current criterion for undervoltage protection functions

Fault Location

- Initiated by trip command or reset of the fault detection;
- Computation of the distance to fault with dedicated measured value registers;
- Fault location output in ohm, kilometers or miles and % of line length;
- Parallel line compensation can be selected;
- Optional function; taking into consideration the load current in case of single-phase earth faults fed from both sides
- Fault location output as BCD-code or analog value (dependent on the order variant)

Circuit Breaker Failure Protection (optional)

- With independent current stages for monitoring current flow through every pole of the circuit breaker;
- With independent monitoring time steps for single-pole and three-pole tripping;
- Start by trip command of every internal protection function;
- Start by external trip functions possible;
- Single or two stages
- Short drop off and overshoot times.

Thermal Overload Protection (optional)

- Thermal display of ohmic loss of the protected object
- R. m. s. measurement for all three phase currents
- Settable thermal and current alarm stages

Analog Outputs (optional)

- Output of up to four analog values (dependent on the order variant) is possible: measured values, fault location, breaking earth fault current

User Defined Logic Functions

- Freely programmable combination of internal and external signals for the implementation of user defined logic functions;
- All common logic functions;

- Time delays and measured value set point interrogation.

Command Processing

- Switching on and off switchgears manually via the local control keys, configurable function keys, via the system interface (e.g. of the SICAM® or LSA) or via the operator interface (by means of personal computers and the operating program DIGSI® 4)
- Feedback information on switching states via the circuit breaker auxiliary contacts (for commands with feedback information)
- Plausibility check of the circuit breaker positions and interlocking conditions, for switching operations

Monitoring Functions

- Monitoring of the internal measuring circuits, the auxiliary supply, as well as the hard- and software, resulting in increased reliability;
- Monitoring of the current and voltage transformer secondary circuits by means of summation and symmetry checks;
- Trip circuit supervision is possible;
- Checking for the load impedance, the measured direction and the phase sequence.

Further Functions

- Battery buffered real time clock, which may be sychronized via a synchronization signal (DCF77, IRIG B via satellite receiver), binary input or system interface;
- Fault event memory for the last 8 network faults (faults in the power system), with real time stamps (ms-resolution);
- Earth fault protocols for up to 8 earth faults (devices with sensitive earth fault detection)
- Fault recording memory and data transfer for analogue and user configurable binary signal traces with a maximum time range of 15 s;
- Switching statistic: the statistic comprises the number of trip and close commands issued by the device, the recorded fault data and interrupted fault currents;
- Commissioning aids such as connection and direction checks as well as circuit breaker test functions. All binary inputs and outputs can be displayed and set directly. This can simplify the wiring check process significantly for the user. ■

Hardware and Connections

2

This chapter describes the construction and connection of the 7SA6. The different housing versions and available termination techniques are described.

The recommended and permitted data for the wiring is stated and suitable accessories and tools are given.

2.1 Version of 7SA6 for Panel Flush Mounting (Cubicle Mounting)

The numerical Distance Protection SIPROTEC® 7SA6 for panel and cubicle flush mounting is enclosed in a 7XP20 housing. 3 housing sizes are available, namely $^1/_3$, $^1/_2$ and $^1/_1$ (of 19 inch).

Housing size $^1/_3$ is provided with a four-line display. The two other housing sizes can either be ordered with a four-line display or a graphic display.

Different termination techniques are available depending on the ordered version.

2.1.1 Housing

The housing consists of a rectangular tube with a rear plate and a front cover. Guide rail mats are mounted at the top and bottom on the inside of the tube, to guide the modules during mounting. Each guide rail mat has visible numbering from 1 to 42, designating the mounting positions of the modules. The modules and the front cover are connected by means of flat ribbon cables and the corresponding plug connectors. The rear plate screwed to the tube contains the required connectors for the external connections to the device.

The front cover can be taken off after removal of the covers located at the 4 corners of the front cover and the 4 screws that are then revealed. Housing size $^1/_1$ has 2 additional screw covers located at the centre of the top and bottom of the front cover frame; accordingly 6 screws must be removed in this case. The front cover has a membrane keypad containing the control and indication elements required for the user interface with the device. All terminations to the control and indication elements are combined by a converter module on the front cover, and routed to the processor module (CPU) via a plug connector.

The name plate containing the principal data of the device, such as auxiliary supply voltage, the rated test voltage and the ordering code (MLFB) is located on the external top of the housing and on the inside of the front cover.

The mechanical dimension drawings are located in Section 10.20.

View of Front Panel with Four-Line Display (Housing Size $^1/_3$)

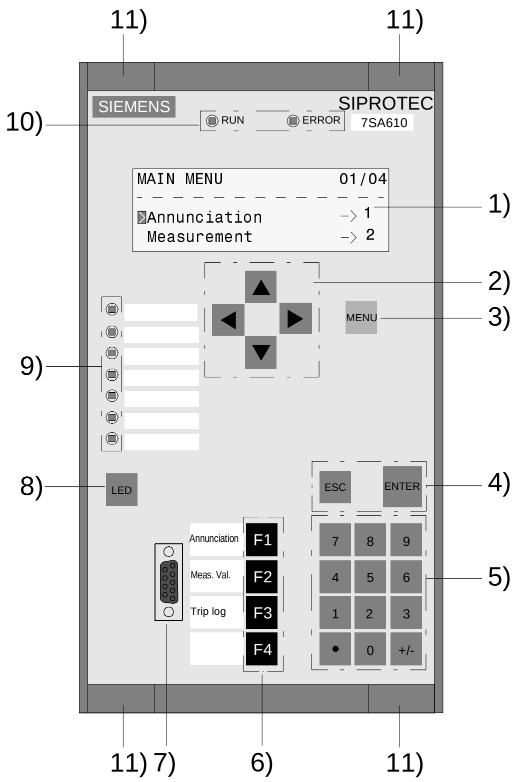


Figure 2-1 Front view of a 7SA61 (housing size $^1/_3$) for panel flush mounting or cubicle mounting

Referring to the operating and display elements in Figure 2-1:

1. Display (LCD)
   The LCD shows processing and device information as text in various lists. Commonly displayed information includes measured values, counter values, binary information regarding the condition of circuit breakers, status of the device, protection information, general reports, and alarms.
2. Navigation keys
   These keys serve for navigation through operating menus.
3. MENU key
   This key activates the main menu.
4. ESC and ENTER keys
   These keys serve to escape from specific menues or execute changes (such as setting changes).
5. Numerical keys
   These keys serve for entry of numerical values, such as limit value settings.
6. Function keys
   Four function keys (F1 to F4) allow the quick and simple execution of frequently used actions. Typical applications include, for example, jumping to a particular position in the menu tree such as the fault data in the Trip Log or the measured values. Three of the function keys were already configured in our factories, for displaying the lists of the event logs (F1), the operational measured value (F2) and the trip logs of the last system fault (F3). Key F4 is not allocated. All function keys are freely configurable. Next to the keypad, a labeling strip is provided on which the user-specified key functions may be written.

7. 9-pin female D-subminiature connector
   This serial interface is for the connection of a local PC running DIGSI$^{®}$ 4.
8. LED key
   This key has the dual purpose of resetting latched LEDs and the latched contacts of output relays, as well as testing all of the LEDs.
9. Light emitting diodes (LEDs)
   The function of the 7 LEDs can be programmed. There is a vast selection of signals from which to choose. Some examples are device status, processing or control information, and binary input or output status. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions may be written.
10. Operating condition indicators
    The two LEDs “RUN” (green) and “ERROR” (red) indicate the operating condition of the device.
11. Coverings for the screws that secure the front panel.

View of Front Panel with Four-Line Display (Housing Size $^1/_2$)

The significance of the operating and display elements is the same as explained after Figure 2-1. However, 14 LEDs are freely configurable.

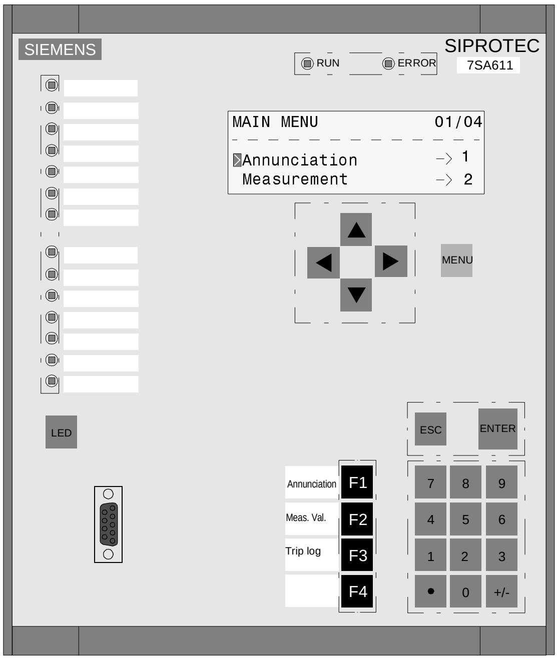


Figure 2-2 Front view of a 7SA61, housing size $^1/_2$, for panel flush mounting or cubicle mounting

View of Front Panel with Four-Line Display (Housing Size $^1/_1$)

The significance of the operating and display elements is the same as explained after Figure 2-1. However, 14 LEDs are freely configurable.

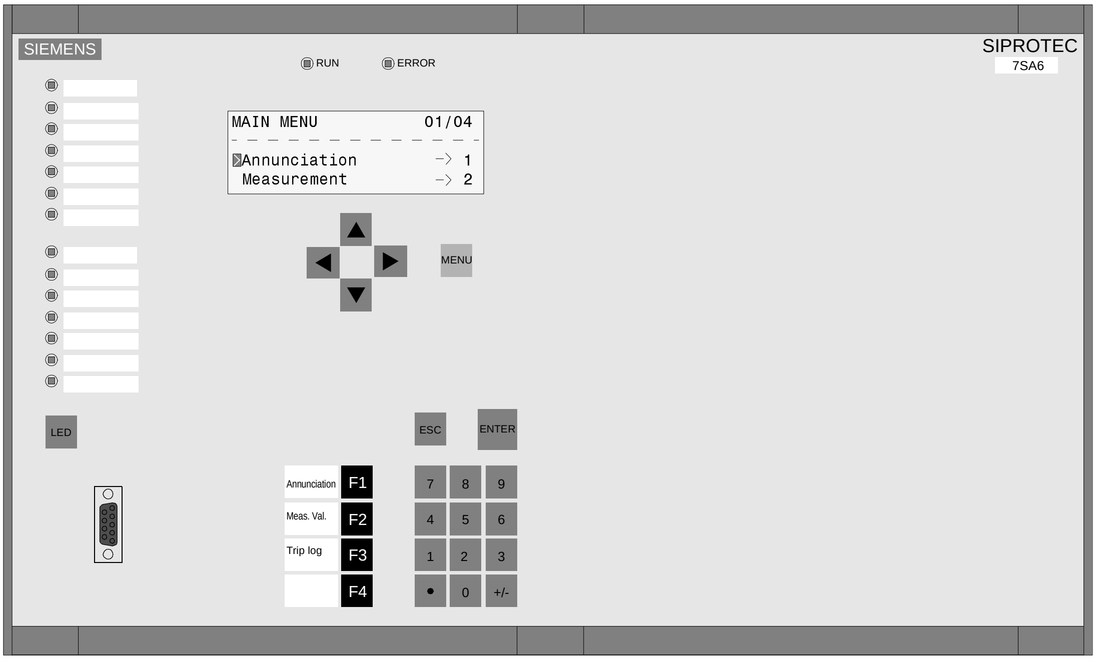


Figure 2-3 Front view of a 7SA61, housing size $^1/_1$, for panel flush mounting or cubicle mounting

View of Front Panel with Graphic Display (Housing Size $^1/_2$)

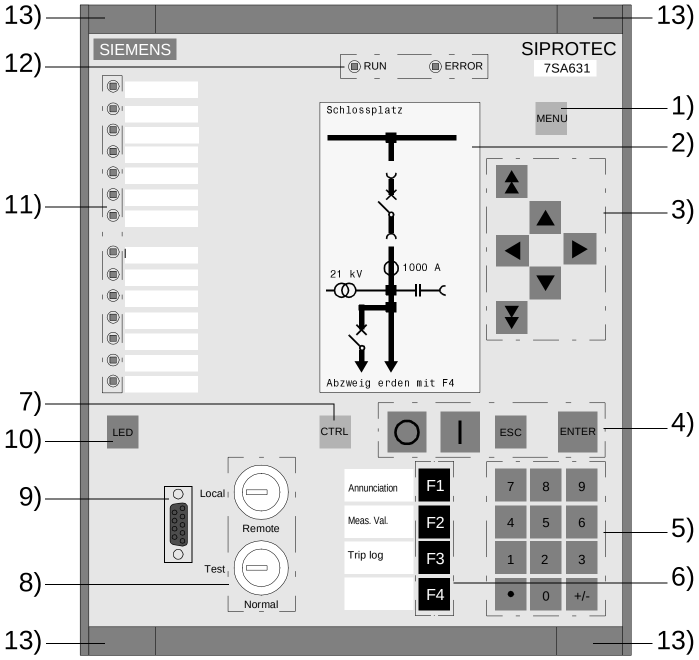


Figure 2-4 Front view of a 7SA63, housing size $^1/_2$, for panel flush mounting or cubicle mounting

Referring to the operating and display elements in Figure 2-4:

1. MENU key
   This key activates the main menu.
2. LC-Display (LCD)
   In the LCD the processing and device information can be illustrated in a control display or displayed in the form of text in various lists. Commonly displayed information includes the position of the switchgears, measured values, counter values, binary information regarding the condition of circuit breakers, status of the device, protection information, general reports, and alarms.
3. Navigation keys
   These keys serve for navigation through operating menus.
4. Control keys
   These keys serve for controlling the process. They are located below the LCD.
5. Numerical keys
   These keys serve for entry of numerical values, such as limit value settings.
6. Function keys
   Four function keys (F1 to F4) allow the quick and simple execution of frequently used actions. Typical applications include, for example, jumping to a particular position in the menu tree such as the fault data in the Trip Log or the measured values. Three of the function keys were already configured in our factories, for displaying the lists of the event logs (F1), the operational measured value (F2) and the trip logs of the last system fault (F3). The key F4 is not allocated. All function keys are freely configurable. Next to the keypad, a labeling strip is provided on which the user-specified key functions may be written.

7. CTRL key
   The function of this key is to show the control display.
8. Key-operated switch
   2 key-operated switches guarantee a fast, but save access to the functionalities „changing between local and remote“ and „changing between interlocked and non-interlocked operation”.
9. 9-pin female D-subminiature connector
   This serial interface is for the connection of a local PC running DIGSI® 4.
10. LED key
    This key has the dual purpose of resetting latched LEDs and the latched contacts of output relays, as well as testing all of the LEDs.
11. Light emitting diodes (LEDs)
    The function of the 7 LEDs can be programmed. There is a vast selection of signals from which to choose. Some examples are device status, processing or control information, and binary input or output status. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions may be written.
12. Operating condition indicators
    The two LEDs “RUN” (green) and “ERROR” (red) indicate the operating condition of the device.
13. Coverings for the screws that secure the front panel.

View of Front Panel with Graphic Display (Housing Size $^1/_1$)

The significance of the operating and display elements is the same as explained after Figure 2-4.

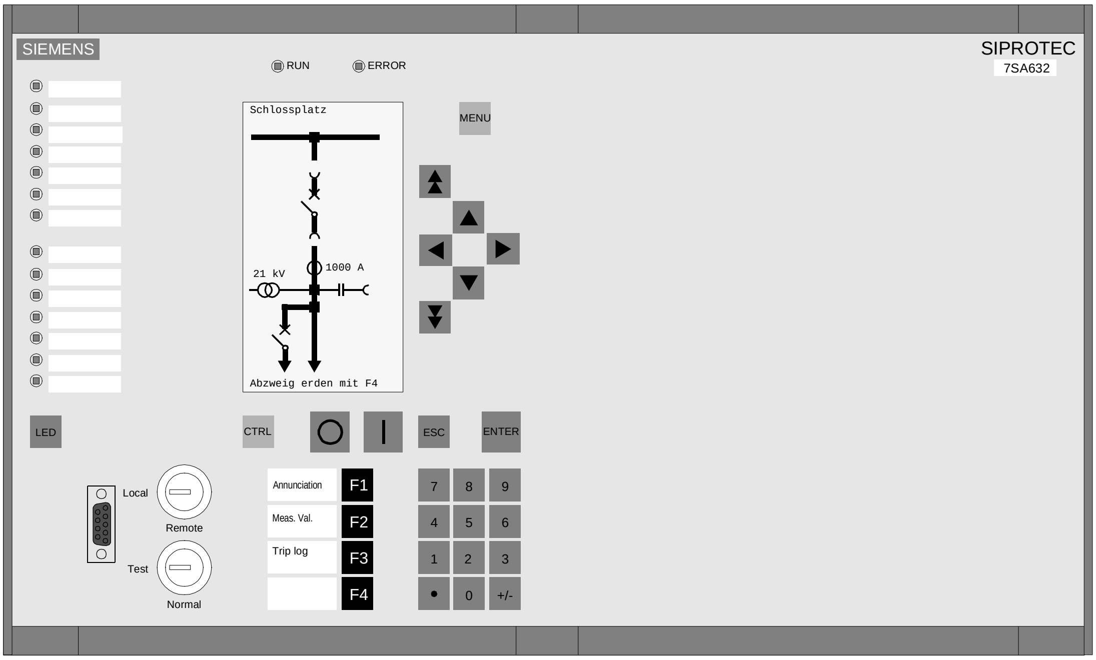


Figure 2-5 Front view of a 7SA63, housing size $^1/_1$, for panel flush mounting or cubicle mounting

View of Rear Panel (Housing Size $^1/_3$)

Figure 2-6 shows a simplified view of the rear panel of a device with screw-type terminals.

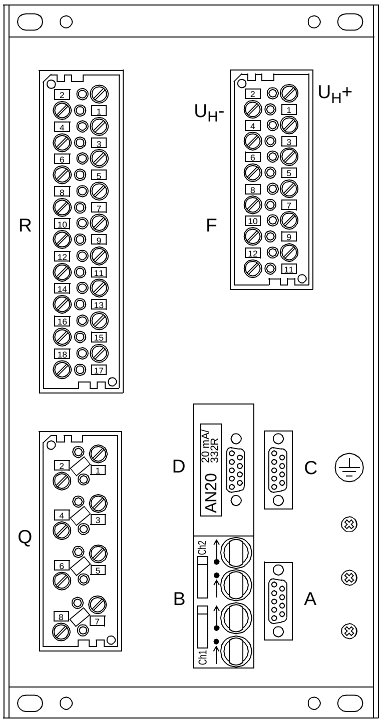


Figure 2-6 Rear view of a 7SA6, housing size $^1/_3$ (terminal arrangement example only)

View of Rear Panel (Housing Size $^1/_2$)

Figure 2-7 is a simplified view of the rear panel of the version of the device with screw-type terminals and optical fibre ports for the service interface at location B.

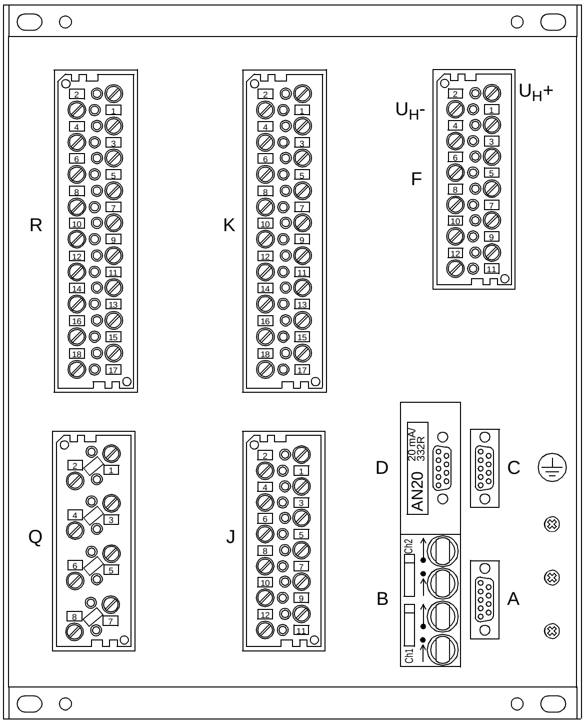


Figure 2-7 Rear view of a 7SA6, housing size $^1/_2$ (terminal arrangement example only)

View of Rear Panel (Housing Size $^1/_1$)

Figure 2-8 shows a simplified view of the rear panel of a device with screw-type terminals.

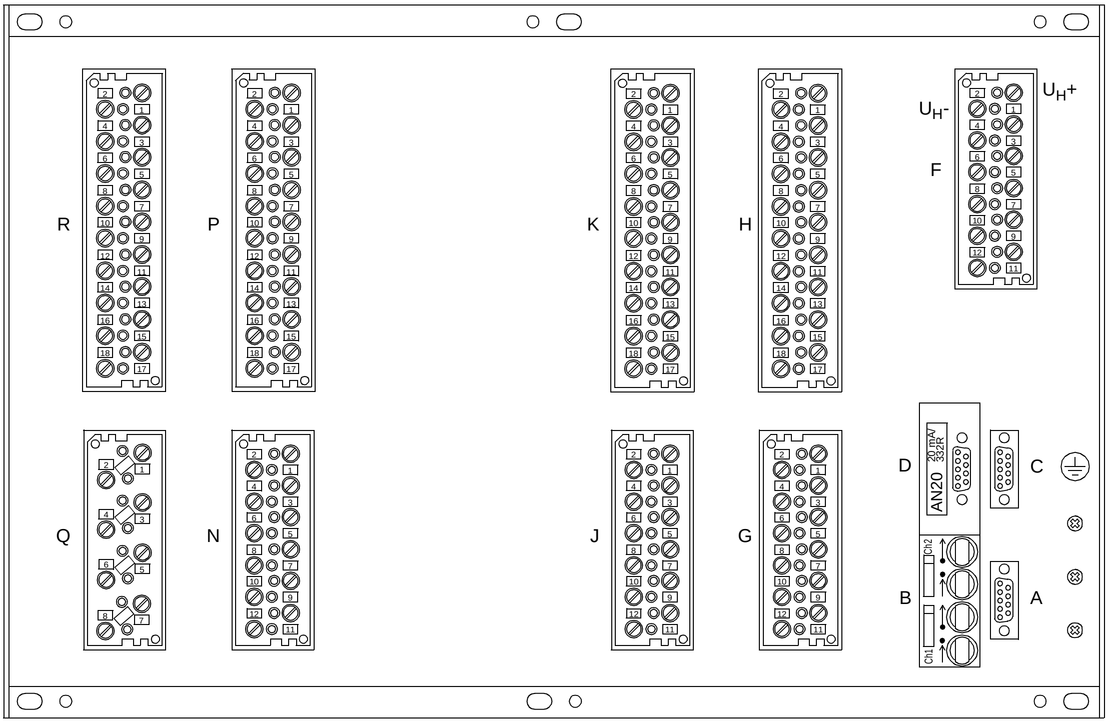


Figure 2-8 Rear view of a 7SA6, housing size $^1/_1$ (terminal arrangement example only)

2.1.2 Screw Terminal Connections

The following must be distinguished in the case of connection via screw terminals:

terminal plugs for voltage connections and
terminal plugs for current connections.

The terminal screws have a slot head for tightening or loosening with a flat screw driver, sized 6 x 1 mm.

Terminal Blocks for Voltage Connections

The voltage connection terminal modules are available in 2 variants:

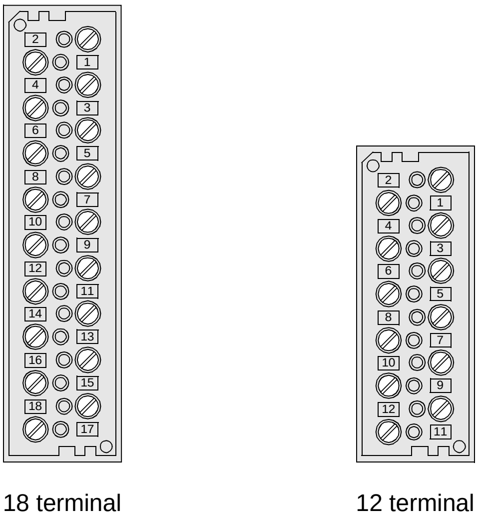


Figure 2-9 Connection plug module with screw terminals for voltage connections — rear view

The following figure shows an example of the allocation of an individual screw terminal to its terminal number.

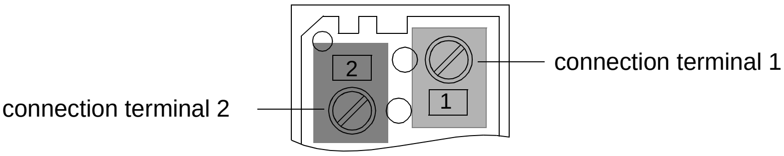
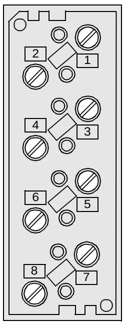


Figure 2-10 Allocation of screw terminal to terminal number — example

Terminal Block for Current Connections

There is one version of a terminal block for current connections to a 7SA6.



8 terminal

Figure 2-11 Terminal block of screw terminals for current connections — rear view

The correlation between terminals and connection numbers is the same for both the current connections and the voltage connections. Compare Figures 2-10 and 2-11.

In the terminal block for current connections, the terminals are grouped in pairs. Two neighboring terminals such as terminals 5 and 6 form one pair. The terminal block contains four pairs, one for each of the input currents.

The current transformers present low burden to the main current transformers.

When the I/O board is extracted, the current circuits are automatically short-circuited prior to the separation of the current transformers from the current circuits. This prevents hazards to service personnel due to the high voltages that can occur if the secondary circuits of the current transformers are open.

When the I/O board is properly inserted into the case, the short-circuits of the current paths are removed after the transformers of the device are connected to the terminal-pairs.

The short-circuit feature of the relay is an important and reliable safety feature; however, the feature does not relieve the user from exercising proper care when working with current transformer secondary circuits.

Connections to Voltage Terminals

Ring or spade lugs may be used. To maintain proper isolation of the circuits, the lugs must be insulated or insulating sleeves must be fitted to cover the exposed crimp zones.

The following must be observed:

Connections with cable lugs: inner diameter of lugs, 4 mm;
maximum outer width of lugs, 10 mm;
conductor with cross-section of 1 mm^2 to 2.6 mm^2 or AWG 16 to 14.
Use copper wires only!

Cable lugs of series PIDG from Messrs AMP Co. are recommended, e.g.
Ring cable lug: PIDG PN 320 565–0
Spade lug: PIDG PN 321 233–0.

Direct cable connections: solid or stranded conductor with connector sleeve;
conductor with cross-section of 0.5 mm^2 to 2.6 mm^2 (AWG 20 to 14).
Use copper wires only!

Plug the connection end of the line into the plug-in terminal in such a way that it can be tightened correctly by the terminal screw.

Strip 9 to 10 mm of the insulation on solid conductors

Maximum tightening torque: 1.8 Nm (1.3 ft-lb or 16 in-lb).

Connections to Current Terminals

Ring-type and fork-type lugs may be used. To ensure that the insulation paths are maintained, insulated lugs must be used. Alternatively, the crimping area must be insulated with other methods, e.g. by covering with a shrink sleeve.

The following must be observed:

Connections with cable lugs: inner diameter of lugs, 5 mm;
maximum outer diameter of lugs, 12 mm;
conductor with cross-section of 2.6 mm^2 to 6.6 mm^2 (AWG 14 to 10).
Use copper wires only!

Cable lugs of series PIDG from AMP Co. are recommended, e.g.,
Ring cable lug: PIDG PN 130 171–0
Spade lug: PIDG PN 326 865–0

Direct cable connections: solid or stranded conductor with connector sleeve; conductor with cross-section of 2.6 mm^2 to 3.3 mm^2 (AWG 14 to 12). Plug the connection end of the line into the plug-in terminal in such a way that it can be tightened correctly by the terminal screw.
Use copper wires only!

Strip 10 to 11 mm of the insulation on solid conductors

Maximum tightening torque: 2.7 Nm (2.0 ft-lb or 24 in-lb).

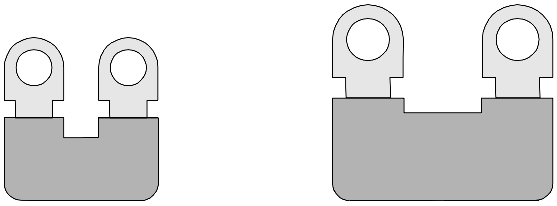
Short-Circuit Links

Short-circuit links are available for convenience in making terminal connections.

The short circuit links can connect two neighbouring terminals located on the same side of the terminal module. By connecting further links, neighbouring terminals can be included in the short circuit. On each terminal it is possible to connect two short-circuiting links, or one short-circuit link and one lug, or one individual conductor.

The links meet the safety requirements for protection against electric shock.

There are two types of links, one for voltage connections and one for current connections. The links are illustrated in Figure 2-12. Ordering information for the links is provided in Section 1.1 in the Appendix A.



Short-circuit links for voltage connections

Short-circuit links for current connections

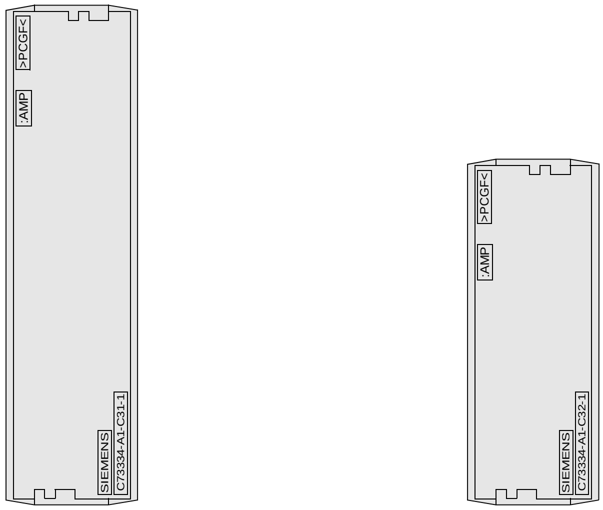
Figure 2-12 Short-circuit links for voltage connections and current connections

Covering Caps

Terminal covering caps are available for the screw terminal modules, to increase the protection of personnel against hazardous voltages (degree of protection against access to dangerous parts) on the terminal modules. The degree of protection is increased from the standard “back of the hand protection” (IP1x)“ to „finger protection (IP2x)“.

The terminal covering caps provide an enclosure which securely covers all voltage carrying components. They are simply snapped onto the terminal module. It must be noted that all screws on the terminal module must be screws in before snapping the cover on. The terminal covering cap can simply be removed with a screw driver 6x1 mm.

There are two types of covering caps, as shown in Figure 2-13. Ordering information is provided in Section 1.1 in the Appendix A.



Covering cap for
18 terminal voltage
connection terminal block

Covering cap for
12 terminal voltage
or 8 terminal current
connection terminal block

Figure 2-13 Covering caps for terminal blocks with screw terminals

2.1.3 Connections to Plug-In Terminals

Plug-in terminals are only available for voltage connections. Current connections are made with screw terminals on all 7SA6.

Terminal Blocks for Voltage Connections

There are two versions of plug-in terminal blocks. They are shown in Figure 2-14.

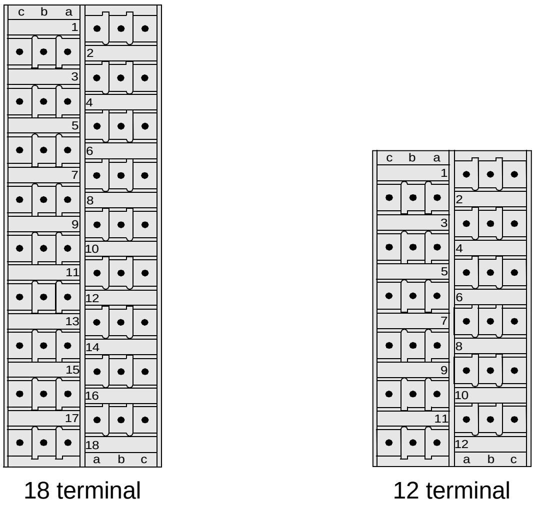


Figure 2-14 Terminal blocks of plug-in terminals for voltage connections — rear view

The system of numbers and letters used to designate the plug-in terminals is illustrated in Figure 2-15.

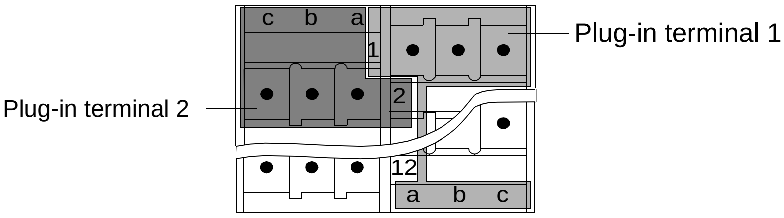


Figure 2-15 Correlation between plug-in terminals and connection numbers/letters

Each plug-in terminal forms a complete set of connections that consists of three pins arranged as follows:

Pin a:	Signal connection
Pin b:	Common connection
Pin c:	Shielding connection

The signal pins are the only terminal pins that are directly connected to the internal printed circuit boards of the 7SA6. Depending on the version of the terminal block, 18 or 12 signal connections are provided. Refer to Figure 2-16.

There are two isolated groups of common pins. Within a group the pins are inter-connected as shown in Figure 2-16. The common pins "b" are not connected to the boards inside the 7SA6. Each common group can, for example, be used for signal multiplication or as a common point for a signal (independent of the signals on the pin “a” terminals). Depending on the version of the terminal block, 18 or 12 common connections are available.

Grouping of common connections within a terminal block is as follows:

12 terminal block:	Group 1	Terminals 1 through 6
	Group 2	Terminals 7 through 12
18 terminal block:	Group 1	Terminals 1 through 9
	Group 2	Terminals 10 through 18

All shielding pins are connected together as shown in Figure 2-16. The shielding pins are also connected to the housing. Depending on the version of the terminal block, 18 or 12 shielding connections are provided.

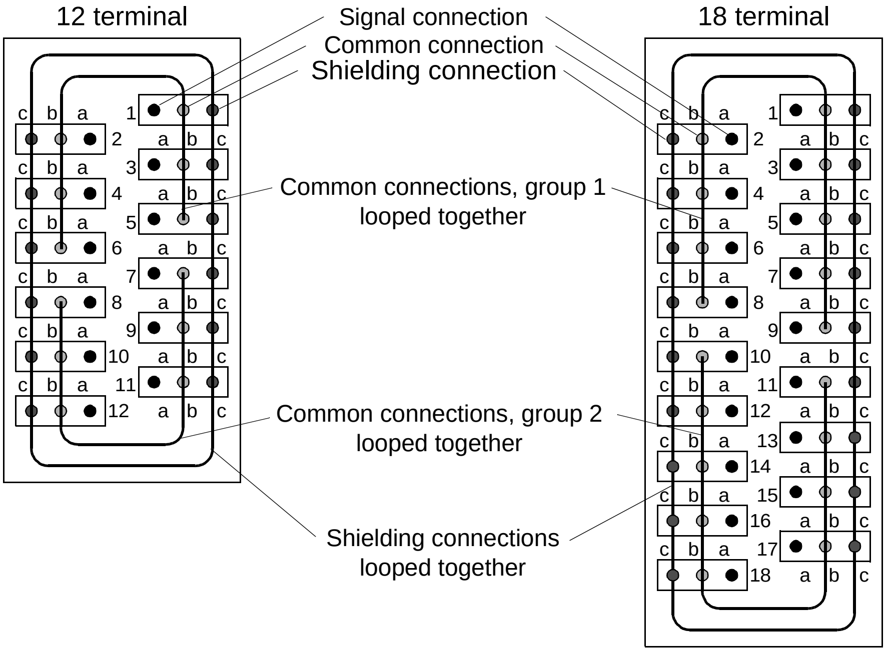


Figure 2-16 Schematic diagram of the plug-in terminal blocks

Connections to Plug-In Terminals

Connections to plug-in terminals are made with pin connectors.

There are two versions of pin connectors (Figure 2-13):

Version 1: 2-pin connector
Version 2: 3-pin connector

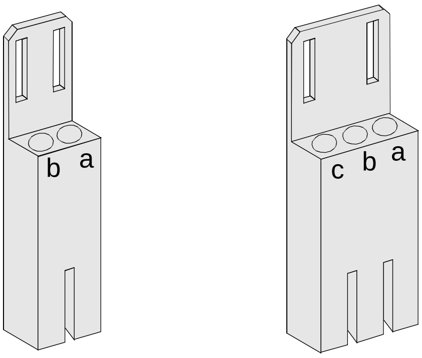


Figure 2-17 2-pin connector and 3-pin connector

Ordering information for the pin connectors is provided in Section 1.1 of Appendix A.

The design of the pin connectors is such that only correct connections can be made. For example, the design of the 2-pin connector allows connection only to pins “a” and “b”. An erroneous connection to pins “b” and “c” is excluded due to the construction of the pin connectors.

The pin connectors snap in to the plug-in terminals. The connectors can be removed without tools.

Control wires are connected to contacts of the pin connectors. Wires with 0.5 mm^2 to 2.5 mm^2 diameter (AWG 20 to 14) can be accommodated.

Use only flexible copper control wire!

The crimp connector required depends on the diameter of the conductor being used.
Section 0.5 mm^2 to 1.0 mm^2:

e.g.	Bandware 4000 pieces	type: 0-827039–1 from AMP Corp.
	Individual piece	type:0- 827396–1 from AMP Corp.

Section 1.0 mm^2 to 2.5 mm^2:

e.g.	Bandware 4000 pieces	type: 0-827040–1 from AMP Corp.
	Individual piece	type: 0-827397–1 from AMP Corp.

Connection of a conductor to a contact is performed using,

e.g.,	a hand crimping tool	type 0–734372-1 from AMP Corp.
	matrix	type 1-734387-1 from AMP Corp.

Individual pieces are recommended.

The gold-plated connector (recommended) depends on the diameter of the conductor that is used.
Section 0.75 mm^2 to 1.5 mm^2:

e.g.	Bandware 4000 pieces	type: 163083-7 from AMP Corp.
	Individual piece	type: 163084-7 from AMP Corp.

Connection of a conductor to a contact is performed using a hand crimping tool,

e.g.	a hand crimping tool	type: 0-539635–1 from AMP Corp.
	matrix	type: 0-539668–2 from AMP Corp.

Individual pieces are recommended.

After the wires are crimped, the contacts are pressed into the terminals of the connector until they snap into place..

Note:

Stress relief for individual pin connector must be provided with cable ties. Stress relief must also be provided for the entire set of cables, e.g., cable ties.

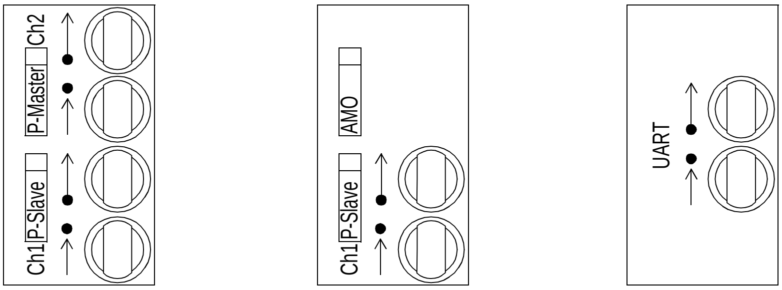
The following separation tool is needed to remove the contacts from the pin connectors:
Type: 725840–1 from AMP Corp.

The separation tool contains a small tube that is subject to wear. The tube can be ordered separately:
Type: 725841–1 from AMP Corp.

2.1.4 Connections to Optical Communication Interfaces

Optical Communication Interfaces with ST-connector

The three available versions of optical communication interfaces with ST-connector are shown in Figure 2-18. The ports are supplied with caps to protect the optical components against dust or other contaminants. The caps can be removed by turning them 90° to the left.



2 channel   1 channel   1 channel

Figure 2-18 Optical communication interfaces with protective caps

Connections to Optical Communication Interfaces with ST-connector

Optical connector type:	ST–connector
Fibre type:	Multimode graded-index (“G”) optical fibre G50/125 µm, G62.5/125 µm, G100/140 µm
Wavelength:	λ = 820 nm (approximately)
<u>Allowable bending radius:</u>	For indoor cable r_{min} = 5 cm (2 in) For outdoor cable r_{min} = 20 cm (8 in)

Laser class 1 (acc. EN 60825–1) is achieved with fibre type G50/125 µm and G62.5/125 µm.

2.1.5 Connections to Electrical Communication Interfaces

Electrical Communication Interfaces

9-pin D-subminiature female socket connectors are provided for all electrical communication interfaces of the 7SA6. The connector is illustrated in Figure 2-19. The pin assignments are described in Sub-section 8.2.1.

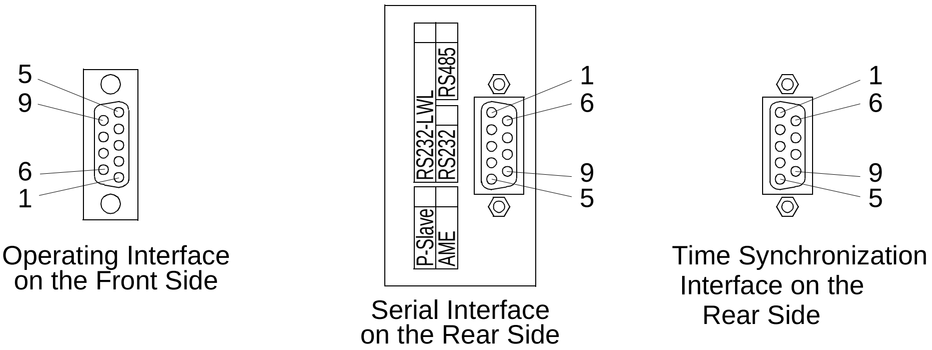


Figure 2-19 9 pin D-subminiature connectors

Connections to Electrical Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

The necessary communication cables are dependent on the type of interface:

- RS232/EIA232: Five-wire, twisted and shielded, e.g. interface cable 7XV5100–4.
- RS485/EIA485: Three-wire, twisted and shielded.
- Profibus: Two-wire or four-wire, twisted and shielded:
  Wire type A, DIN 19245, part 2 and EN 50170 vol. 2, twisted and shielded,
  Wire Resistance: 135 Ω to 165 Ω (f > 100 kHz)
  Capacitance: < 30 nF/km (48 nF/mile)
  Circuit resistance: < 110 Ω/km (177 Ω/mile)
  Conductor diameter: > 0.64 mm
  Conductor cross-sectional area: > 0.34 mm^2
  e.g., SINEC L2 Industrial twisted pair installation wire
  (see catalogue 1K 10 “SIMATIC NET, Industrial Communications Networks”).
- Time synchronization: At least two-wire, shielded.

2.1.6 Connections to Analog Outputs

Connections

9-pin D-subminiature female socket connectors are provided for all analog outputs of the 7SA6. The connector is illustrated in Figure 2-20. The pin assignments are described in Subsection 8.2.1.

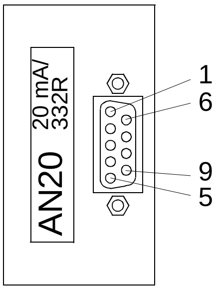


Figure 2-20 9 pin D-subminiature connectors

Connections to Serial Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

Communication cable: Two-wire / four-wire, shielded

Max. load impedance: 350 Ω

2.2 Version of 7SA6 for Panel Surface Mounting

The numerical Distance Protection SIPROTEC® 7SA6 for surface mounting is enclosed in a 7XP20 housing. 2 housing versions are available, $^1/_2$ und $^1/_1$ (of 19 inch). The device is fitted into a surface mounting housing.

2.2.1 Housing

The housing consists of a rectangular tube with a rear plate and a front cover. Guide rail mats are mounted at the top and bottom on the inside of the tube, to guide the modules during mounting. Each guide rail mat has visible numbering from 1 to 42, designating the mounting positions of the modules. The modules and the front cover are connected by means of flat ribbon cables and the corresponding plug connectors.

This tube is fitted into a surface mounting housing and secured with 4 screws, which are located behind screw covering caps at the four corners of the front cover. Two additional screw covering caps and associated securing screws, are located at the centre top and bottom of the front cover frame with the housing size $^1/_1$. The surface mounting housing contains the wiring from the back plate to the screw terminal.

The front cover can be taken off after removal of the covers located on the 4 corners of the front cover and the 4 screws that are then revealed. Housing size $^1/_1$ has 2 additional screw covers located at the centre of the top and bottom of the front cover frame; accordingly 6 screws must be removed in this case. The front cover has a membrane keypad containing the control and indication elements required for the user interface with the device. All terminations to the control and indication elements are combined by a converter module on the front cover, and routed to the processor module (CPU) via a plug connector.

The name plate containing the principal data of the device, such as auxiliary supply voltage, the rated test voltage and the ordering code (MLFB) is located on the external top of the housing and on the inside of the front cover.

The mechanical dimension drawings are located in Section 10.20.

View of Front Panel with Four-Line Display (Housing Size $^1/_3$)

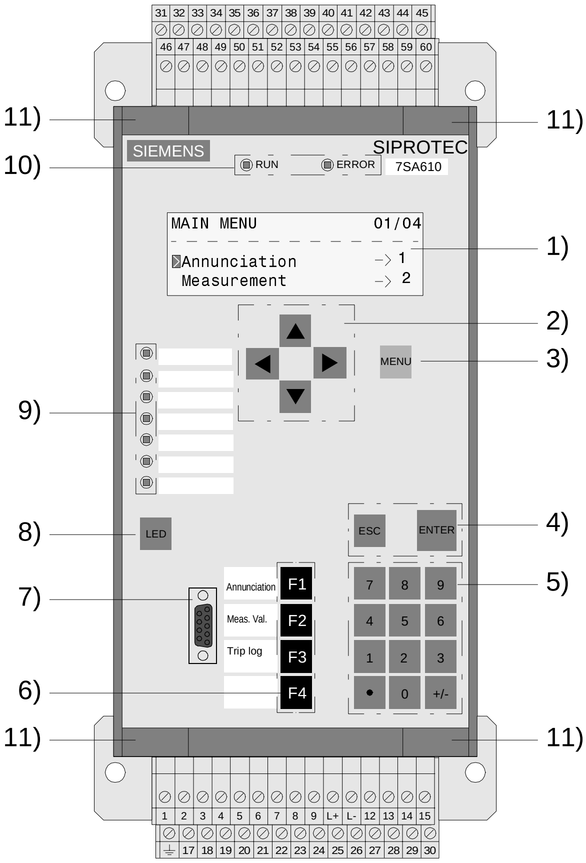


Figure 2-21 Front view of a 7SA61, housing size $^1/_3$, for panel surface mounting without optical communication interfaces

Referring to the operating and display elements in Figure 2-21:

1. Display (LCD)
   The LCD shows processing and device information as text in various lists. Commonly displayed information includes measured values, counter values, binary information regarding the condition of circuit breakers, status of the device, protection information, general reports, and alarms.
2. Navigation keys
   These keys serve for navigation through operating menus.
3. MENU key
   This key activates the main menu.
4. ESC and ENTER keys
   These keys serve to escape from specific menues or execute changes (such as setting changes).
5. Numerical keys
   These keys serve for entry of numerical values, such as limit value settings.
6. Function keys
   Four function keys allow the quick and simple execution of frequently used actions. Typical applications include, for example, jumping to a particular position in the menu tree such as the fault data in the Trip Log or the measured values. The

function keys are programmable, and may be used to execute control functions such as closing or tripping circuit breakers. Next to the keypad, a labeling strip is provided on which the user-specified key functions may be written.

7. 9-pin female D-subminiature connector
   This serial interface is for the connection of a local PC running DIGSI® 4.
8. LED key
   This key has the dual purpose of resetting latched LEDs and the latched contacts of output relays, as well as testing all of the LEDs.
9. Light emitting diodes (LEDs)
   The function of these indicators can be programmed. There is a vast selection of signals from which to choose. Some examples are device status, processing or control information, and binary input or output status. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions may be written.
10. Operating condition indicators
    The two LEDs “RUN” (green) and “ERROR” (red) indicate the operating condition of the device.
11. Coverings for the screws that secure the front panel.

View of Front Panel with Four-Line Display (Housing Size $^1/_2$)

The significance of the operating and display elements is the same as explained after Figure 2-21. However, 14 LEDs are freely configurable.

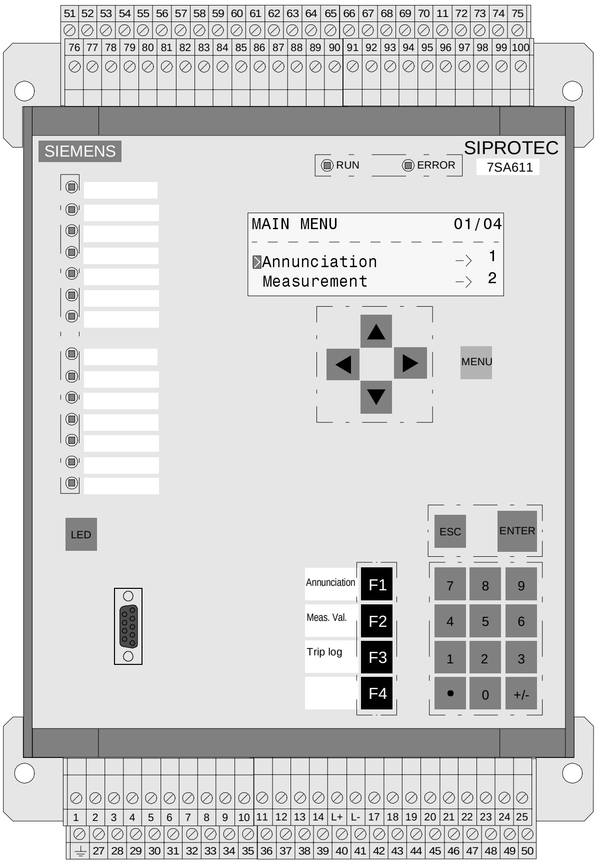


Figure 2-22 Front view of a 7SA61, housing size $^1/_2$, for panel flush mounting without optical communication interfaces

View of Front Panel with Four-Line Display (Housing Size$^1/_1$)

The significance of the operating and display elements is the same as explained after Figure 2-21.

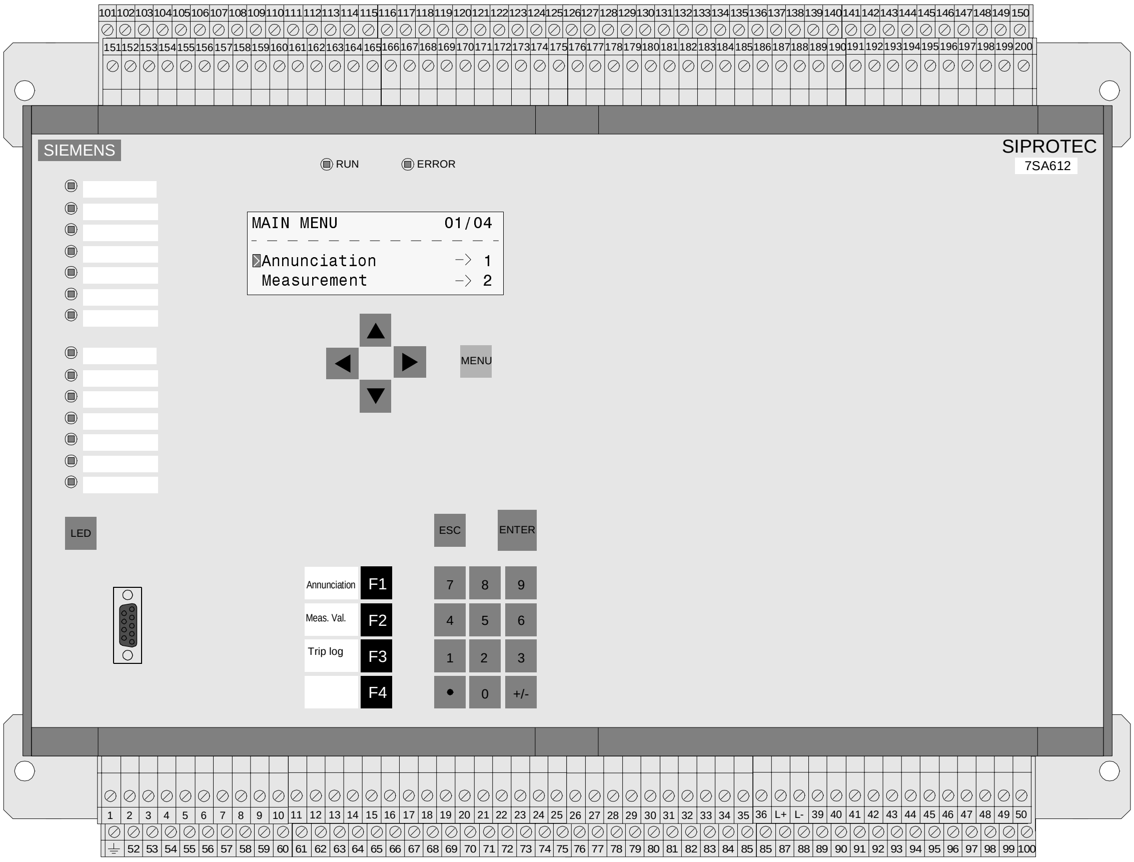


Figure 2-23 Front view of a 7SA6, housing size $^1/_1$, for panel surface mounting without optical communication interfaces

View of Front Panel with Graphic Display (Housing Size$^1/_2$)

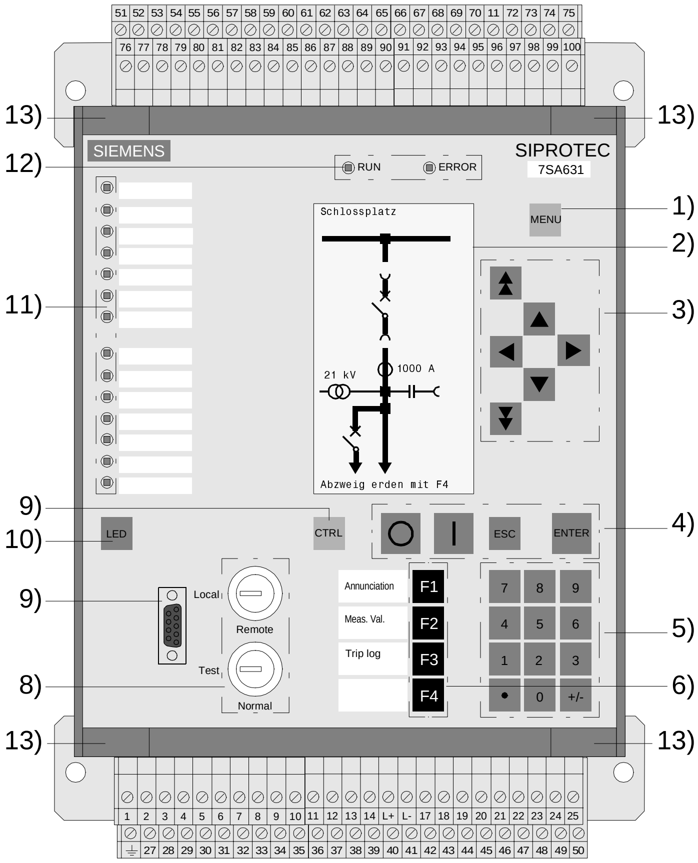


Figure 2-24 Front view of a 7SA63, housing size $^1/_2$, for panel surface mounting without optical communication interfaces

Referring to the operating and display elements in Figure 2-24:

1. MENU key
   This key activates the main menu.
2. Display (LCD)
   The LCD illustrates processing and device information in the form of a control display or of text in various lists. Commonly displayed information includes the position of the switchgears, measured values, counter values, binary information regarding the condition of circuit breakers, status of the device, protection information, general reports, and alarms.
3. Navigation keys
   These keys serve for navigation through operating menus.
4. Control keys
   These keys serve for controlling the process. They are located below the LCD.
5. Numerical keys
   These keys serve for entry of numerical values, such as limit value settings.
6. Function keys
   Four function keys (F1 to F4) allow the quick and simple execution of frequently used actions. Typical applications include, for example, jumping to a particular position in the menu tree such as the fault data in the Trip Log or the operational measured values. Three of the function keys were already configured in our fac-

tories, for displaying the lists of the event logs (F1), the operational measured value (F2) and the trip logs of the last fault (F3). The key F4 is not allocated. All function keys are freely configurable. Next to the keypad, a labeling strip is provided on which the user-specified key functions may be written.

7. CTRL key
   The function of this key is to show the control display.
8. Key-operated switch
   2 key-operated switches guarantee a fast, but save access to the functionalities „changing between local and remote“ and „changing between interlocked and non-interlocked operation”.
9. 9-pin female D-subminiature connector
   This serial interface is for the connection of a local PC running DIGSI® 4.
10. LED key
    This key has the dual purpose of resetting latched LEDs and the latched contacts of output relays, as well as testing all of the LEDs.
11. Light emitting diodes (LEDs)
    The function of the 14 LEDs are freely configurable. There is a vast selection of signals from which to choose. Some examples are device status, processing or control information, and binary input or output status. Next to the LEDs on the front panel, a labeling strip is provided on which the user-specified LED functions may be written.
12. Operating condition indicators
    The two LEDs “RUN” (green) and “ERROR” (red) indicate the operating condition of the device.
13. Coverings for the screws that secure the front panel.

View of Front Panel with Graphic Display (Housing Size $^1/_1$)

The significance of the operating and display elements is the same as explained after Figure 2-24.

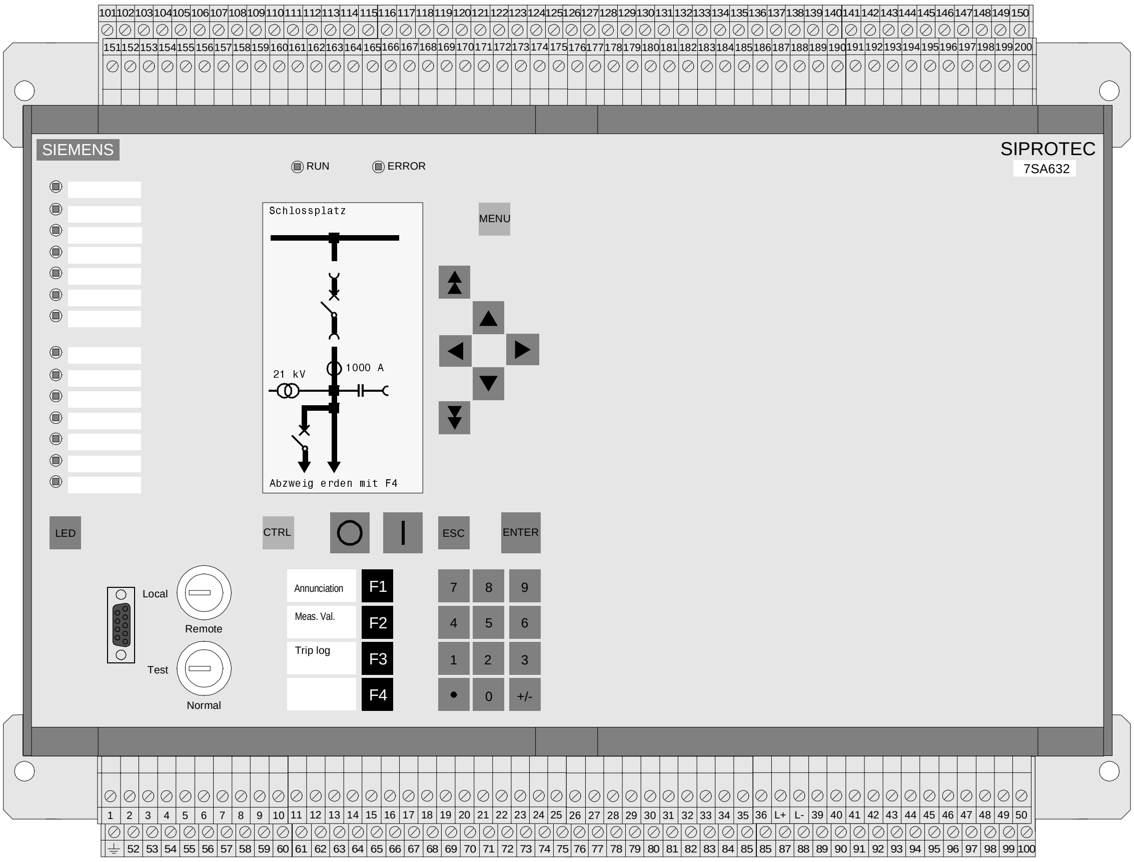


Figure 2-25 Front view of a 7SA63, housing size $^1/_1$, for panel surface mounting without optical communication interfaces

2.2.2 Screw Terminal Connections

Terminal Blocks

All connections to the device are located at the top and bottom of the surface mounting housing by means of two-tier terminals. For housing size $^1/_3$ there are 60 terminals, for the housing size $^1/_2$ there are 100 terminals and for the housing size $^1/_1$ there are 200 two-tier terminals.

The plug connection module in the device for the current terminals automatically short-circuits the current transformer circuits when the modules are withdrawn. This does not reduce necessary care that must be taken when working on the current transformer secondary circuits.

Connections to Terminals

Solid conductor or stranded wire with lugs can be used.
The following specifications must be observed:

Direct cable connections: solid or stranded conductor with connector sleeve conductor with cross-section of 0.5 mm^2 to 7 mm^2 (AWG 20 to 9).
Use copper wires only!

Maximum tightening torque: 1.2 Nm (0.9 ft-lb or 10.6 ft-in)).

2.2.3 Connections to Optical Communication Interfaces

Optical Communication Interfaces

Optical communication interfaces may be 1- to 4-channel. The ports are supplied with caps to protect the optical components against dust or other contaminants. The caps can be removed by turning them 90° to the left.

A maximum of two fibre optic channels are located in each inclined housing. In the case of device versions with 1 and 2 channels, the inclined housing is located at the bottom side of the device. With device versions having up to a maximum of 4 fitted optical channels, there is a second inclined housing mounted to the top side of the device (refer to Figure 2-26). If no inclined housing is fitted a cover plate is mounted instead. Unused fibre optic connections are replaced by plastic studs.

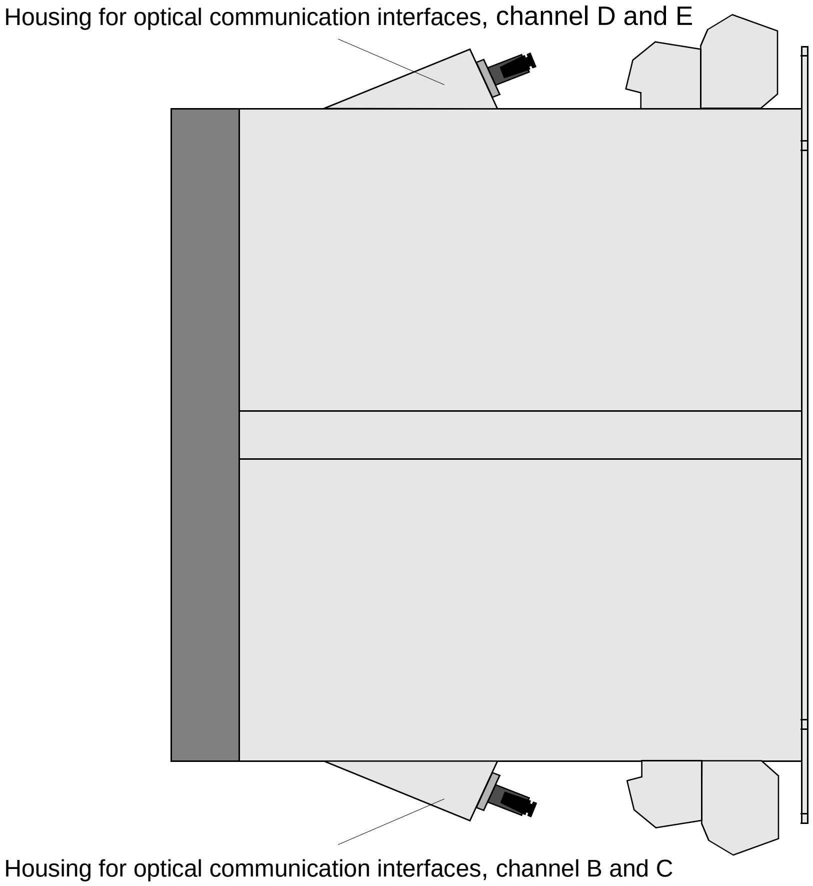


Figure 2-26 Side view of 7SA6, panel surface mounting, possible optical communication interfaces

A table indicating the available channel designations B to E is printed onto the inclined housing. In Figure 2-27 the channels B and C are fitted.

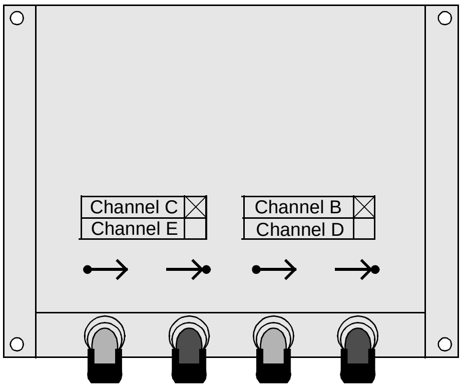


Figure 2-27 Inclined housing with optical communication interfaces (example: channel B and C fitted)

The device version with a Profibus interface RS 485 (electrical) has a DSUB socket instead of the optical communication interface B in the inclined housing located on the bottom side of the device (see Figure 2-28).

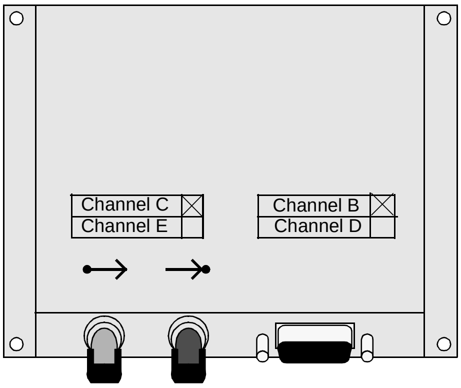


Figure 2-28 Inclined housing with optical communication interface B and DSUB socket for Profibus interface

Connections to Optical Communication Interfaces with ST-connector

Optical connector type: ST–connector

Fibre type: Multimode graded-index (“G”) optical fibre
G50/125 µm,
G62.5/125 µm,
G100/140 µm

Wavelength: λ = 820 nm (approximately)

<u>Allowable bending radius:</u>
For indoor cable r_{min} = 5 cm (2 in)
For outdoor cable r_{min} = 20 cm (8 in)

Laser class 1 (acc. EN 60825–1) is achieved with fibre type G50/125 µm and G62.5/125 µm.

Connections to Electrical Communication Interfaces

Electrical Communication Interfaces

9-pin D-subminiature female socket connectors are provided for all electrical communication interfaces of the 7SA6. The connector is illustrated in Figure 2-29. The pin assignments are described in Subsection 8.2.1.

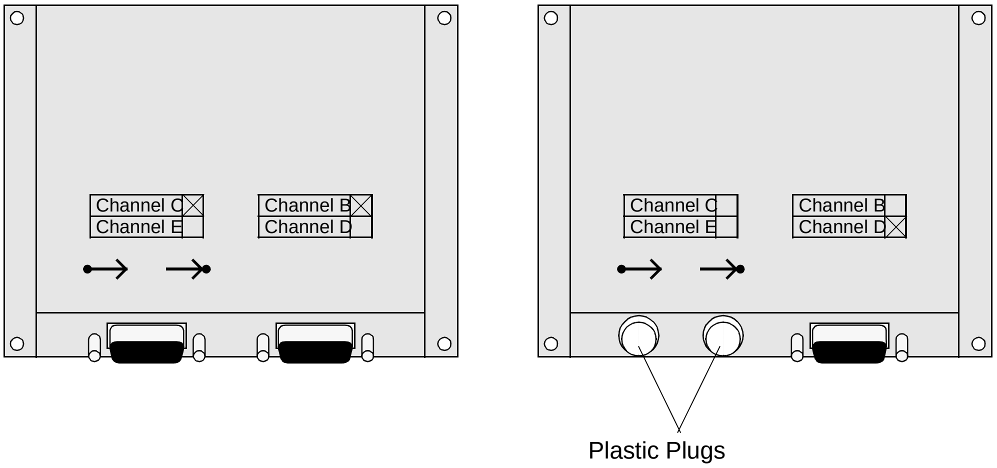


Figure 2-29 Inclined housing with 9-pin DSUB socket

Connections to Electrical Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

The necessary communication cables are dependent on the type of interface:

- RS232/EIA232: Five-wire, twisted and shielded, e.g. interface cable 7XV5100–4.
- RS485/EIA485: Three-wire, twisted and shielded.
- Profibus: Two-wire or four-wire, twisted and shielded:
  Wire type A, DIN 19245, part 2 and EN 50170 vol. 2, twisted and shielded,
  Wire Resistance: 135 Ω to 165 Ω (f > 100 kHz)
  Capacitance: < 30 nF/km (48 nF/mile)
  Circuit resistance: < 110 Ω/km (177 Ω/mile)
  Conductor diameter: > 0.64 mm
  Conductor cross-sectional area: > 0.34 mm^2
  e.g., SINEC L2 Industrial twisted pair installation wire
  (see catalogue 1K 10 “SIMATIC NET, Industrial Communications Networks”).

2.2.4 Connections to Analog Outputs

Connections

9-pin D-subminiature female socket connectors are provided for all analog outputs of the 7SA6. The connector is illustrated in Figure 2-30. The pin assignments are described in Subsection 8.2.1.

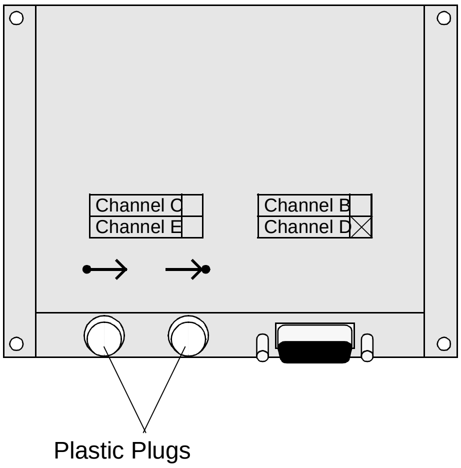


Figure 2-30 Inclined housing with 9 pin D-subminiature connectors

Connections to Serial Communication Interfaces

Standard 9 pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

Communication cable: Two-wire / four-wire, shielded

Max. load impedance: 350 Ω

2.3 Version of 7SA6 with Detached Operator Panel

The numerical Distance Protection SIPROTEC® 7SA6 with detached operator panel is intended for mounting it into a low-voltage box. It consists of a device in a 7XP20 housing for surface mounting and a detached operator panel for mounting onto a mounting plate. 2 housing sizes are available, namely $^1/_2$ and $^1/_1$ (of 19 inch).

The device and the detached operator panel are connected via a 68-pole cable 2.2 m long. The precut cable is part of the detached operator panel and connects it to the housing via a 68-pin connector (see also Figure 2-31 and 2-32).

Different termination techniques are available depending on the ordered version.

2.3.1 Housing and Detached Operator Panel

The housing consists of a rectangular tube with a rear plate specific to the device version and a front cover without operator or display elements. Guide rail mats are mounted at the top and bottom on the inside of the tube, to guide the modules during insertion. Each guide rail mat has visible numbering from 1 to 42, designating the mounting positions of the modules. The connection between the modules and to the front cover is by means of flat ribbon cables and the corresponding plug connectors. The rear plate screwed to the tube contains the required connectors for the external connections to the device.

The name plate containing the principal data of the device, such as auxiliary supply voltage, the rated test voltage and the ordering code (MLFB) is located on the external top of the housing and on the inside of the front cover.

For housing size $^1/_2$ threre are 3 wholes and for housing size $^1/_1$ 5 wholes located at the bottom and top angle to enable the mounting of the device.

Operator Panel

The operator control element is composed of a front cover and a housing. On the front cover there is a keypad with the operator and display elements. The device and keypad are connected via a communication cable with a plug connector inside the housing.

For mounting the operator control element onto the mounting plate the 4 covers located at the corners of front cover must firstly be taken off. The removal reveals elongated holes intended for the screws fastening the control element.

The operating and display elements are explained in the paragraph to be found directly after Figure 2-4.

View of Device and Operator Control Element (Housing Size $^1/_2$)

The following figure shows an 7SA6 device with detached operator panel, its housing with plug-in terminals and communication cable.

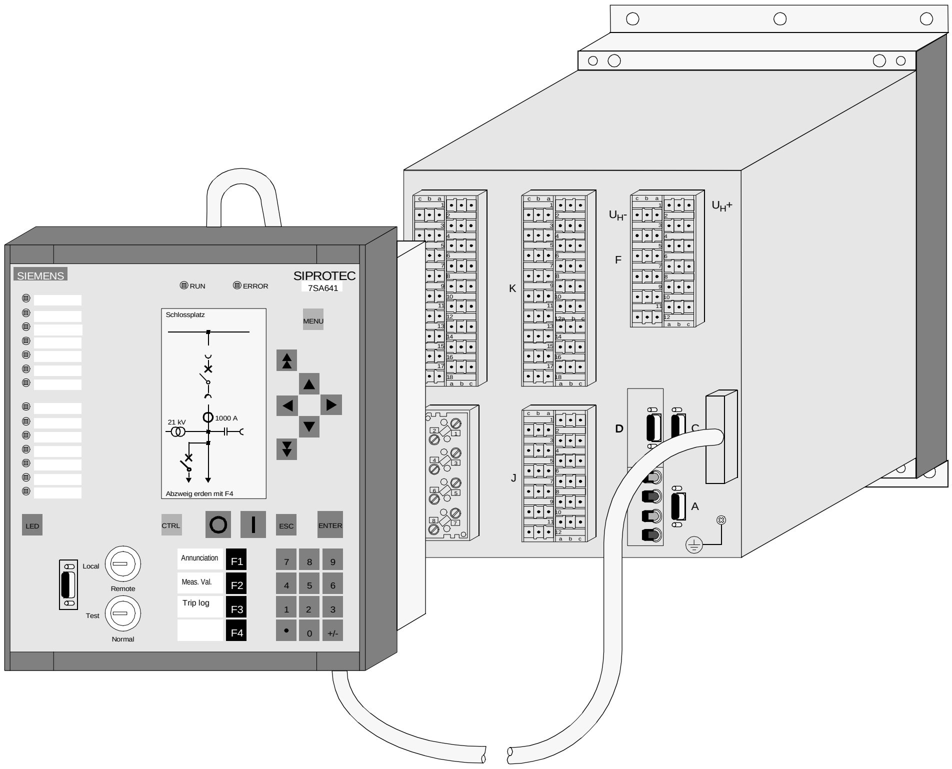


Figure 2-31 7SA64 with detached operator panel (housing size $^1/_2$)

View of Device and Operator Control Element (Housing Size $^1/_1$)

The following figure shows an 7SA6 device with detached operator panel, its housing with plug-in terminals and communication cable.

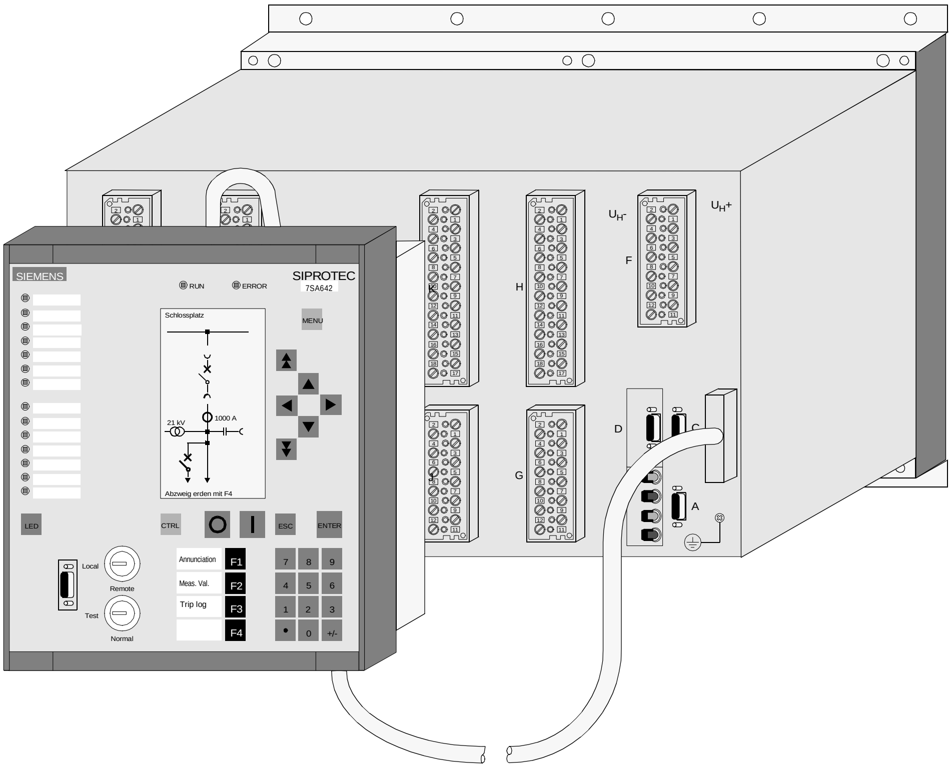


Figure 2-32 7SA64 with detached operator panel (housing size $^1/_1$)

2.3.2 Screw Terminal Connections

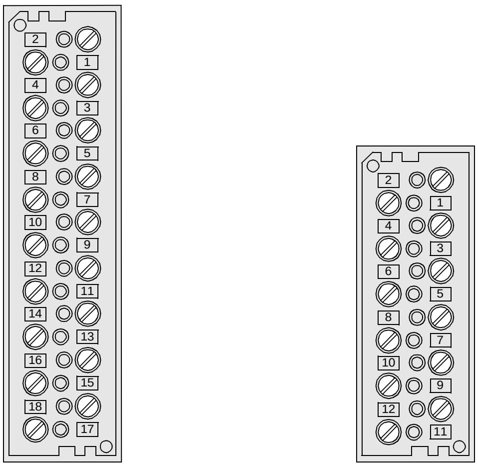
The following must be distinguished in the case of connection via screw terminals:

terminal plugs for voltage connections and
terminal plugs for current connections.

The terminal screws have a slot head for tightening or loosening with a flat screw driver, sized 6 x 1 mm.

Terminal Blocks for Voltage Connections

The voltage connection terminal modules are available in 2 variants:



18 terminal 12 terminal

Figure 2-33 Connection plug module with screw terminals for voltage connections — rear view

The following figure shows an example of the allocation of an individual screw terminal to its terminal number.

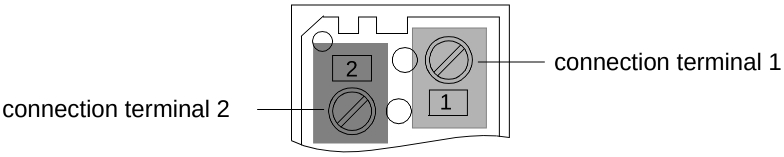
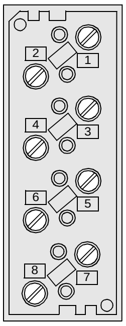


Figure 2-34 Allocation of screw terminal to terminal number — example

Terminal Block for Current Connections

There is one version of a terminal block for current connections to a 7SA6.



8 terminal

Figure 2-35 Terminal block of screw terminals for current connections — rear view

The correlation between terminals and connection numbers is the same for both the current connections and the voltage connections. Compare Figures 2-10 and 2-11.

In the terminal block for current connections, the terminals are grouped in pairs. Two neighboring terminals such as terminals 5 and 6 form one pair. The terminal block contains four pairs, one for each of the input currents.

The current transformers present low burden to the main current transformers.

When the I/O board is extracted, the current circuits are automatically short-circuited prior to the separation of the current transformers from the current circuits. This prevents hazards to service personnel due to the high voltages that can occur if the secondary circuits of the current transformers are open.

When the I/O board is properly inserted into the case, the short-circuits of the current paths are removed after the transformers of the device are connected to the terminal-pairs.

The short-circuit feature of the relay is an important and reliable safety feature; however, the feature does not relieve the user from exercising proper care when working with current transformer secondary circuits.

Connections to Voltage Terminals

Ring or spade lugs may be used. To maintain proper isolation of the circuits, the lugs must be insulated or insulating sleeves must be fitted to cover the exposed crimp zones.

The following must be observed:

Connections with cable lugs: inner diameter of lugs, 4 mm;
maximum outer width of lugs, 10 mm;
conductor with cross-section of 1 mm^2 to 2.6 mm^2 or AWG 16 to 14.
Use copper wires only!

Cable lugs of series PIDG from Messrs AMP Co. are recommended, e.g.
Ring cable lug: PIDG PN 320 565–0
Spade lug: PIDG PN 321 233–0.

Direct cable connections: solid or stranded conductor with connector sleeve;
conductor with cross-section of 0.5 mm^2 to 2.6 mm^2 (AWG 20 to 14).
Use copper wires only!

Plug the connection end of the line into the plug-in terminal in such a way that it can be tightened correctly by the terminal screw.

Strip 9 to 10 mm of the insulation on solid conductors

Maximum tightening torque: 1.8 Nm (1.3 ft-lb or 16 in-lb).

Connections to Current Terminals

Ring-type and fork-type lugs may be used. To ensure that the insulation paths are maintained, insulated lugs must be used. Alternatively, the crimping area must be insulated with other methods, e.g. by covering with a shrink sleeve.

The following must be observed:

Connections with cable lugs: inner diameter of lugs, 5 mm;
maximum outer diameter of lugs, 12 mm;
conductor with cross-section of 2.6 mm^2 to 6.6 mm^2 (AWG 14 to 10).
Use copper wires only!

Cable lugs of series PIDG from AMP Co. are recommended, e.g.,
Ring cable lug: PIDG PN 130 171–0
Spade lug: PIDG PN 326 865–0

Direct cable connections: solid or stranded conductor with connector sleeve; conductor with cross-section of 2.6 mm^2 to 3.3 mm^2 (AWG 14 to 12). Plug the connection end of the line into the plug-in terminal in such a way that it can be tightened correctly by the terminal screw.
Use copper wires only!

Strip 10 to 11 mm of the insulation on solid conductors

Maximum tightening torque: 2.7 Nm (2.0 ft-lb or 24 in-lb).

Short-Circuit Links

Short-circuit links are available for convenience in making terminal connections.

The short circuit links can connect two neighbouring terminals located on the same side of the terminal module. By connecting further links, neighbouring terminals can be included in the short circuit. On each terminal it is possible to connect two short-circuiting links, or one short-circuit link and one lug, or one individual conductor.

The links meet the safety requirements for protection against electric shock.

There are two types of links, one for voltage connections and one for current connections. The links are illustrated in Figure 2-12. Ordering information for the links is provided in Section 1.1 in the Appendix A.

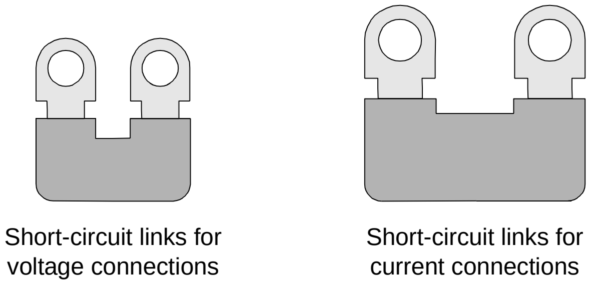


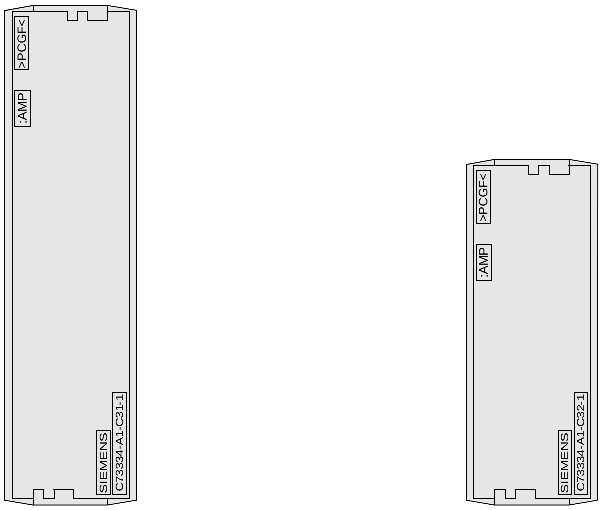
Figure 2-36 Short-circuit links for voltage connections and current connections

Covering Caps

Terminal covering caps are available for the screw terminal modules, to increase the protection of personnel against hazardous voltages (degree of protection against access to dangerous parts) on the terminal modules. The degree of protection is increased from the standard “back of the hand protection” (IP1x)“ to „finger protection (IP2x)“.

The terminal covering caps provide an enclosure which securely covers all voltage carrying components. They are simply snapped onto the terminal module. It must be noted that all screws on the terminal module must be screws in before snapping the cover on. The terminal covering cap can simply be removed with a screw driver 6x1 mm.

There are two types of covering caps, as shown in Figure 2-13. Ordering information is provided in Section 1.1 in the Appendix A.



Covering cap for
18 terminal voltage
connection terminal block

Covering cap for
12 terminal voltage
or 8 terminal current
connection terminal block

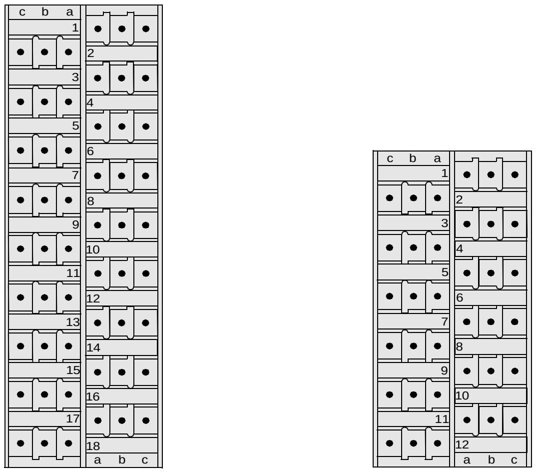
Figure 2-37 Covering caps for terminal blocks with screw terminals

2.3.3 Connections to Plug-In Terminals

Plug-in terminals are only available for voltage connections. Current connections are made with screw terminals on all 7SA6.

Terminal Blocks for Voltage Connections

There are two versions of plug-in terminal blocks. They are shown in Figure 2-14.



18 terminal

12 terminal

Figure 2-38 Terminal blocks of plug-in terminals for voltage connections — rear view

The system of numbers and letters used to designate the plug-in terminals is illustrated in Figure 2-15.

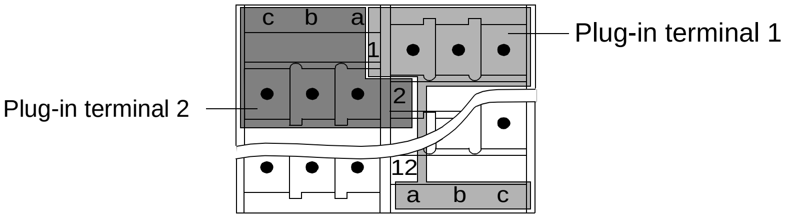


Figure 2-39 Correlation between plug-in terminals and connection numbers/letters

Each plug-in terminal forms a complete set of connections that consists of three pins arranged as follows:

Pin a:	Signal connection
Pin b:	Common connection
Pin c:	Shielding connection

The signal pins are the only terminal pins that are directly connected to the internal printed circuit boards of the 7SA6. Depending on the version of the terminal block, 18 or 12 signal connections are provided. Refer to Figure 2-16.

There are two isolated groups of common pins. Within a group the pins are inter-connected as shown in Figure 2-16. The common pins “b” are not connected to the boards inside the 7SA6. Each common group can, for example, be used for signal multiplication or as a common point for a signal (independent of the signals on the pin “a” terminals). Depending on the version of the terminal block, 18 or 12 common connections are available.

Grouping of common connections within a terminal block is as follows:

12 terminal block:	Group 1	Terminals 1 through 6
	Group 2	Terminals 7 through 12
18 terminal block:	Group 1	Terminals 1 through 9
	Group 2	Terminals 10 through 18

All shielding pins are connected together as shown in Figure 2-16. The shielding pins are also connected to the housing. Depending on the version of the terminal block, 18 or 12 shielding connections are provided.

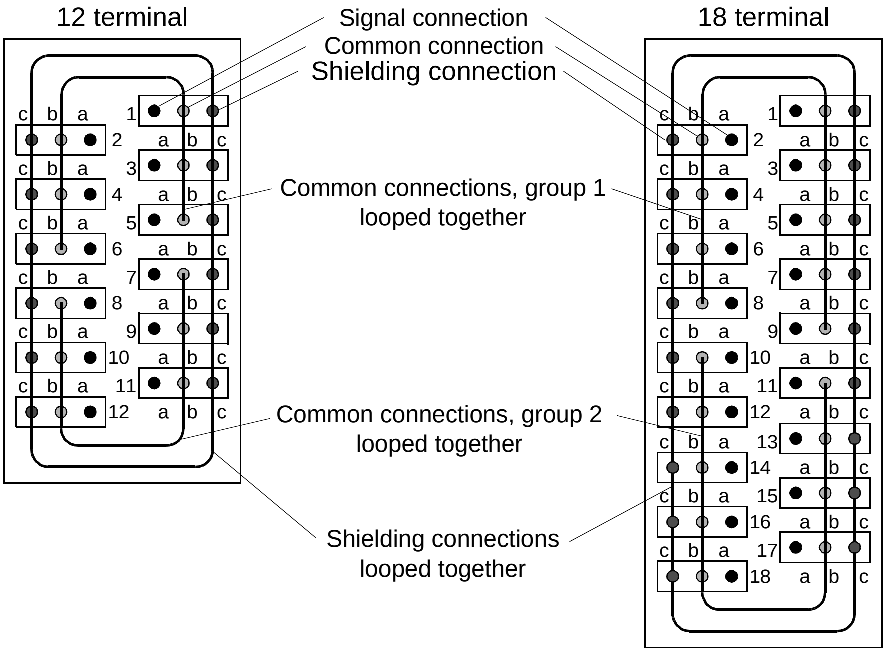


Figure 2-40 Schematic diagram of the plug-in terminal blocks

Connections to Plug-In Terminals

Connections to plug-in terminals are made with pin connectors.

There are two versions of pin connectors (Figure 2-13):

Version 1: 2-pin connector
Version 2: 3-pin connector

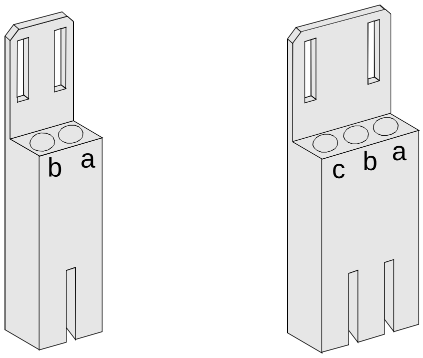


Figure 2-41 2-pin connector and 3-pin connector

Ordering information for the pin connectors is provided in Section 1.1 of Appendix A.

The design of the pin connectors is such that only correct connections can be made. For example, the design of the 2-pin connector allows connection only to pins “a” and “b”. An erroneous connection to pins “b” and “c” is excluded due to the construction of the pin connectors.

The pin connectors snap in to the plug-in terminals. The connectors can be removed without tools.

Control wires are connected to contacts of the pin connectors. Wires with 0.5 mm^2 to 2.5 mm^2 diameter (AWG 20 to 14) can be accommodated.

Use only flexible copper control wire!

The crimp connector required depends on the diameter of the conductor being used.
Section 0.5 mm^2 to 1.0 mm^2:

e.g.	Bandware 4000 pieces	type: 0-827039–1 from AMP Corp.
	Individual piece	type:0- 827396–1 from AMP Corp.

Section 1.0 mm^2 to 2.5 mm^2:

e.g.	Bandware 4000 pieces	type: 0-827040–1 from AMP Corp.
	Individual piece	type: 0-827397–1 from AMP Corp.

Connection of a conductor to a contact is performed using,

e.g.,	a hand crimping tool	type 0–734372-1 from AMP Corp.
	matrix	type 1-734387-1 from AMP Corp.

Individual pieces are recommended.

The gold-plated connector (recommended) depends on the diameter of the conductor that is used.
Section 0.75 mm^2 to 1.5 mm^2:

e.g.	Bandware 4000 pieces	type: 163083-7 from AMP Corp.
	Individual piece	type: 163084-7 from AMP Corp.

Connection of a conductor to a contact is performed using a hand crimping tool,

e.g.	a hand crimping tool	type: 0-539635–1 from AMP Corp.
	matrix	type: 0-539668–2 from AMP Corp.

Individual pieces are recommended.

After the wires are crimped, the contacts are pressed into the terminals of the connector until they snap into place..

Note:

Stress relief for individual pin connector must be provided with cable ties. Stress relief must also be provided for the entire set of cables, e.g., cable ties.

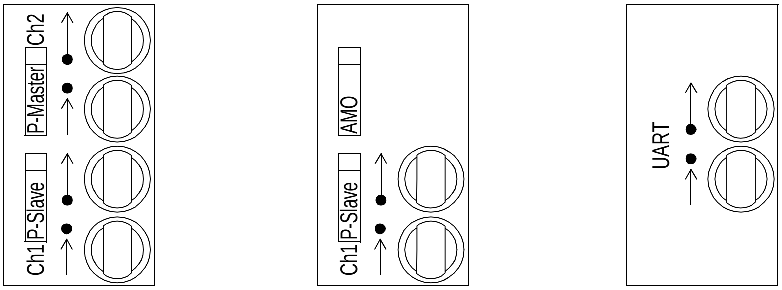
The following separation tool is needed to remove the contacts from the pin connectors:
Type: 725840–1 from AMP Corp.

The separation tool contains a small tube that is subject to wear. The tube can be ordered separately:
Type: 725841–1 from AMP Corp.

2.3.4 Connections to Optical Communication Interfaces

Optical Communication Interfaces with ST-connector

The three available versions of optical communication interfaces with ST-connector are shown in Figure 2-18. The ports are supplied with caps to protect the optical components against dust or other contaminants. The caps can be removed by turning them 90° to the left.



2 channel 1 channel 1 channel

Figure 2-42 Optical communication interfaces with protective caps

Connections to Optical Communication Interfaces with ST-connector

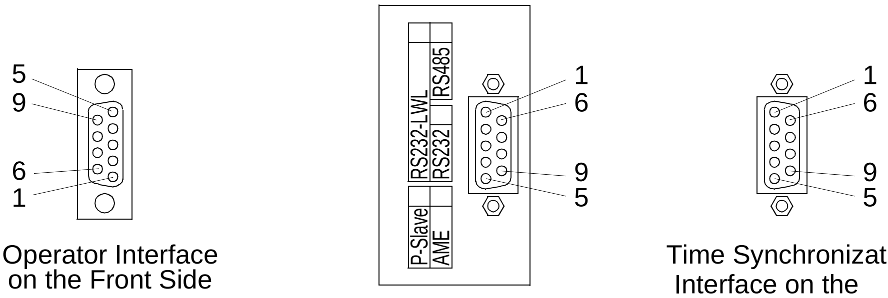
Optical connector type:	ST–connector
Fibre type:	Multimode graded-index (“G”) optical fibre G50/125 µm, G62.5/125 µm, G100/140 µm
Wavelength:	λ = 820 nm (approximately)
Allowable bending radius:	For indoor cable r_{min} = 5 cm (2 in) For outdoor cable r_{min} = 20 cm (8 in)

Laser class 1 (acc. EN 60825–1) is achieved with fibre type G50/125 µm and G62.5/125 µm.

2.3.5 Connections to Electrical Communication Interfaces

Electrical Communication Interfaces

9-pin D-subminiature female socket connectors are provided for all electrical communication interfaces of the 7SA6. The connector is illustrated in Figure 2-19. The pin assignments are described in Sub-section 8.2.1.



Operator Interface on the Front Side

Serial Interface on the Rear Side

Time Synchronization Interface on the Rear Side

Figure 2-43 9 pin D-subminiature connectors

Connections to Serial Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

The necessary communication cables are dependent on the type of interface:

- RS232/EIA232: Five-wire, twisted and shielded, e.g. interface cable 7XV5100–4.
- RS485/EIA485: Three-wire, twisted and shielded.
- Profibus: Two-wire or four-wire, twisted and shielded:
  Wire type A, DIN 19245, part 2 and EN 50170 vol. 2, twisted and shielded,
  Wire Resistance: 135 Ω to 165 Ω (f > 100 kHz)
  Capacitance: < 30 nF/km (48 nF/mile)
  Circuit resistance: < 110 Ω/km (177 Ω/mile)
  Conductor diameter: > 0.64 mm
  Conductor cross-sectional area: > 0.34 mm^2
  e.g., SINEC L2 Industrial twisted pair installation wire
  (see catalogue 1K 10 “SIMATIC NET, Industrial Communications Networks”).
- Time synchronization: At least two-wire, shielded.

2.3.6 Connections to Analog Outputs

Connections

9-pin D-subminiature female socket connectors are provided for all analog outputs of the 7SA6. The connector is illustrated in Figure 2-44. The pin assignments are described in Subsection 8.2.1.

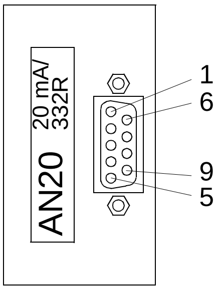


Figure 2-44 9 pin D-subminiature connectors

Connections to Serial Communication Interfaces

Standard 9-pin D-subminiature plug connectors per MIL–C–24308 and DIN 41652 can be used.

Communication cable:Two-wire / four-wire, shielded

Max. load impedance: 350 Ω

■

Initial Inspections

3

This Chapter describes the first steps that should be taken upon receiving the SIPROTEC® 4 7SA6.

Unpacking and re-packing is explained.

Visual and electrical checks that are appropriate for initial inspection are discussed. The electrical tests include navigating through the operating menus of the device using the operator control panel on the front of the device, and the operator control windows in DIGSI® 4. For personnel inexperienced with the 7SA6, these checks also provide a quick and simple method for understanding the operation of the control panel and DIGSI® 4. The electrical tests can be done without measuring quantities being applied.

Observations relevant to long-term storage of the device are noted.

3.1 Unpacking and Repacking

The 7SA6 is packaged at the factory to meet the requirements of IEC 60255–21.

Unpacking and packing must be done with usual care, without using force, and with appropriate tools. Visually check the device immediately upon arrival for correct mechanical condition.

Please observe also the brief reference booklet and all notes and hints that are enclosed in the packaging.

The transport packaging can be reused in the same manner for further transport. Storage packaging alone, for the individual devices, is not sufficient for transport. If alternative packaging is used, shock requirements according to IEC 60255–21–1 Class 2 and IEC 60255–21–2 Class 1 must be met.

The device should be in the final operating area for a minimum of two hours before the power source is first applied. This time allows the device to attain temperature equilibrium, and dampness and condensation to be avoided.

3.2 Inspections upon Receipt

3.2.1 Inspection of Features and Ratings

Ordering Number

Verify that the 7SA6 has the expected features by checking the complete ordering number with the ordering number codes given in Sub-section A.1 of the Appendix. Also check that the required and expected accessories are included with the device. The ordering number of the device is on the nameplate sticker attached to the top of the housing. The nameplate also indicates the current, voltage, and power supply ratings of the device. A verification that these ratings are the expected values is especially important. The jumpers for the control voltage of the binary inputs are set at the factory for a DC control voltage equal to the DC voltage rating of the power supply. The jumpers can be changed if a different control voltage is to be used.

3.2.2 Electrical Check

Operating conditions that meet VDE 0100/5.73 and VDE 0105 Part 1/7.83, or national and international standards, are to be observed.

Before applying power supply voltage or any measuring quantities for the first time, be sure the device has been in the operating area for at least two hours. This time period allows the device to attain temperature equilibrium, and prevents dampness and condensation from occurring.

Warning!

The following inspection steps are done in the presence of dangerous voltages. Only appropriately qualified personnel familiar with and adhering to safety requirements and precautionary measures shall perform these steps.

Power-Up

For a first electrical inspection of the device it is sufficient to ensure safe grounding of the housing and to apply the power supply voltage:

☐ Connect the ground of the device solidly to the ground of the location. The ground of a 7SA6 designed for flush mounting is on the rear panel; the ground of a device designed for surface mounting is on the terminal with the grounding symbol.

☐ With the protective switches (e.g. test switches, fuses, or miniature circuit breakers) for the power supply open, prepare the connections to the power supply. Verify that the power supply voltage has the correct magnitude. Check polarity connections to the device inputs. Follow the appropriate connection diagram in the Appendix, Section A.2.

☐ Close the protective switches to apply the power supply.

☐ The green “RUN” LED on the front panel must light after no more than 0.5 second, and the red “ERROR” LED must go out after no more than 10 seconds.

☐ After no more than 15 seconds, the start-up messages must vanish from the display (in which the complete ordering number, the version of firmware implemented, and the factory number are shown), and the default display must appear. Depending on the assignment of the LEDs, some indicators may light up during and after power-up.

3.3 User Interface

3.3.1 Operation Using the Operator Control Panel

Operator Control Panel

The device has a hierarchically structured operating tree, within which movements and actions are made using the ▲, ▼, ◀, ▶ keys and the MENU, ENTER, CTRL and ESC keys on the front panel.

The brief discussions below illustrate the navigation techniques using the integrated operations in the operator control panel. Some typical operations are covered. For easier understanding, the accompanying figures show the entire contents of the menus, while only a limited number of lines can be seen in the display at any time.

Reading Ordering Number/Version

To view the complete ordering number of the device, the version of firmware implemented, and the serial number:

- ❑ When the device is ready for operation, first press the MENU key. The **`MAIN MENU`** appears.
- ❑ Using the ▼ key, select the menu item ***`Settings`***, and move to the device settings using the ▶ key. The **`SETTINGS`** menu appears, as shown in Figure 3-1.
- ❑ Using the ▼ key, select the menu item ***`Setup/Extras`*** and switch to the selection **`SETUP/EXTRAS`** using the ▶ key. See Figure 3-2.

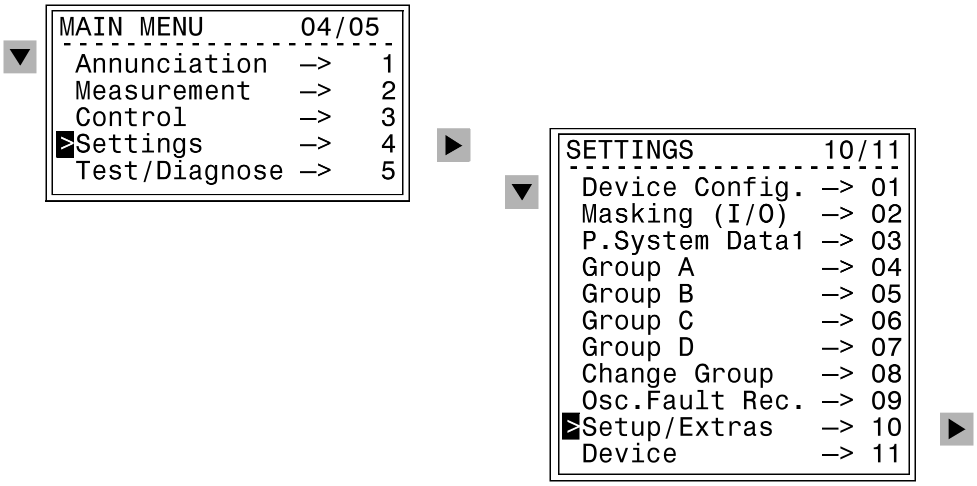
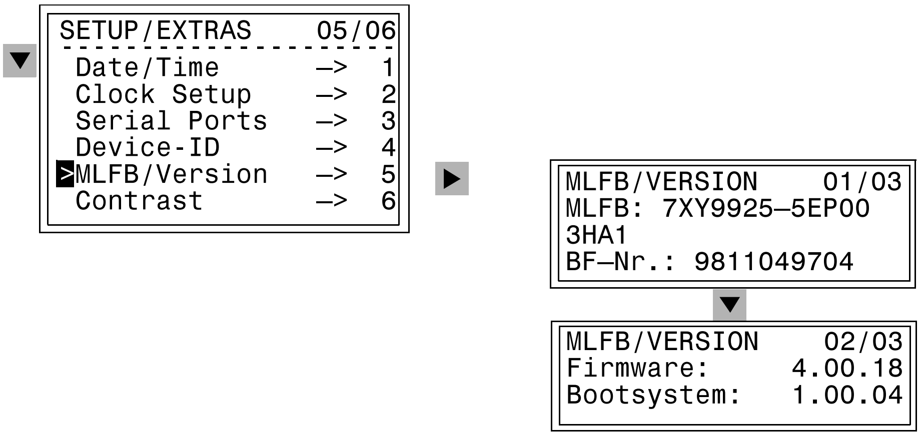


Figure 3-1 Main menu and sub-menu **`SETTINGS`**

- ❑ Using the ▼ key, select the menu **`MLFB/Version`** and view the selection **`MLFB/VERSION`** using the ▶ key.

The device-specific data appear in two or three lines. Press the ▼ key as necessary to view all of the data:



```
MLFB/VERSION    01/03
MLFB: 7XY9925–5EP00
3HA1
BF–Nr.: 9811049704
```

```
MLFB/VERSION    02/03
Firmware:     4.00.18
Bootsystem:   1.00.04
```

Figure 3-2 Display of device-specific data (example)

Viewing Measured Values

To view the measured values:

- If the main menu is not shown, press the MENU key. The **MAIN MENU** appears.
- Using the ▼ key, select the menu item ***Measurement***, and move to the measurement values using the ▶ key. The **MEASUREMENT** sub-menu appears.
- Using the ▼ key, select the menu item ***Operation. sec*** (operating measured values, secondary), and switch to the **OPERATION. SEC** sub-menu using the ▶ key.
- Using the ▲ and ▼ keys, all operating measured values can be viewed.

Since no measured AC voltages or currents are present at this time, all operating measured values show near zero. Deviations of the last digit are insignificant.

To return to the main menu, press the MENU key once, or repeatedly press the ESC key or the ◀ key.

Viewing Operational Messages

Reading the operational messages is described to serve as an additional example.

- If the main menu is not shown, press the MENU key. The **MAIN MENU** appears.
- Using the ▼ key, select the menu item ***Annunciation***, and switch to the annunciations using the ▶ key. The **ANNUNCIATION** sub-menu appears.
- Using the ▼ key, select the menu item ***Event Log***, and move to the **EVENT LOG** sub-menu using the ▶ key.

The last number in the upper right corner of the display indicates the number of operational messages stored in memory. The number before the slash indicates the message presently being displayed. Upon entering the menu, the latest (newest) message is shown. The date and time of the event are shown in the display line above the message.

- Use the ▲ key to read other operational messages.
- Press the LED key; all LEDs should illuminate. Press the ▼ key. The newest message in the event log should be “`Reset LED`”, and the number of messages in memory should increase by one (maximum of 200).

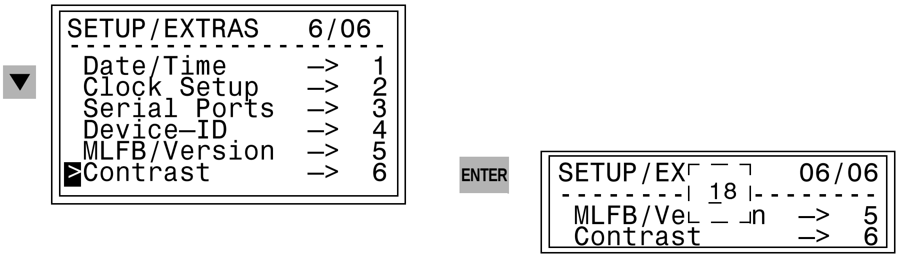
To return to the main menu, press the MENU key once, or repeatedly press the ESC key or the ◀ key.

Setting the Display Contrast

If the image in the integrated LCD does not have satisfactory contrast, adjustments can be made. A stronger contrast serves, among other purposes, to improve the readability of the image from an angle. With increasing numbers, the contrast is increased and the picture gets darker. If the contrast is too weak or too strong, there is a risk that the display will be unreadable and that no operation will be possible using the integrated operator control panel. Therefore, the preset contrast value should only be changed in small steps (1 or 2 levels).

- When the device is ready for operation, first press the MENU key. The **`MAIN MENU`** appears.
- Using the ▼ key, select the menu item ***`Settings`***, and switch to the settings using the ▶ key. The **`SETTINGS`** sub-menu appears.
- Using the ▼ key, select the menu item ***`Setup/Extras`*** and switch to the selection **`SETUP/EXTRAS`** using the ▶ key. See Figure 3-3.
- Using the ▼ key, select the sub-menu item ***`Contrast`***.
- If a change of the contrast of the integrated LCD is desired, press the ENTER key. Enter now the password. (000000 = default). The existing setting appears in a frame with a blinking cursor.
- Overwrite the present setting with the desired setting using the numerical keys. The setting range is 11 to 22.
- Confirm the change with the ENTER key, or cancel the change with the ESC key.

Exit the sub-menu using the ESC key, or return to the main menu using the MENU key.



```
SETUP/EXTRAS    6/06
--------------------
 Date/Time      ->  1
 Clock Setup    ->  2
 Serial Ports   ->  3
 Device-ID      ->  4
 MLFB/Version   ->  5
>Contrast       ->  6
```

```
SETUP/EX┌ ─ ┐   06/06
--------| 18 |--------
 MLFB/Ve└ ─ ┘n  ->  5
 Contrast       ->  6
```

Figure 3-3   Operating sub-menu for adjusting the display contrast

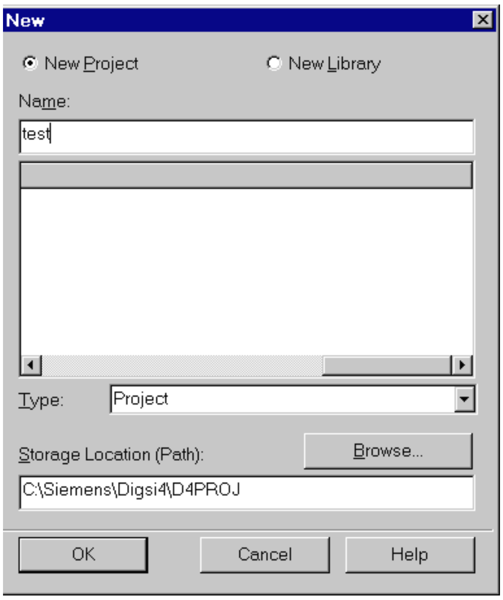
3.3.2 Operation Using DIGSI® 4

DIGSI® 4 User Interface

DIGSI® 4 has the typical PC application Windows operating environment to guide the user. The software has a modern, intuitive, user-interface. Further details are found in Section 4, as well as in the DIGSI® 4 handbook “Device Configuration”.

Some applications of DIGSI® 4 which are described below concern viewing the measurement values, reading messages, and setting the time clock. The handling of the operator control windows of DIGSI® 4 can be learned quickly by following the simple examples as described below. To perform the steps in the examples, first connect the SIPROTEC® 4 device to the PC and match the DIGSI® 4 interface data with the equipment. To accomplish this:

- Establish a physical connection between a serial interface of the PC and the operating serial interface of the device on the front panel.
- Open the DIGSI® 4 application in the PC.
- Generate a new project by clicking on **File** → **New** in the DIGSI® 4–Manager menu bar.



● New Project ○ New Library

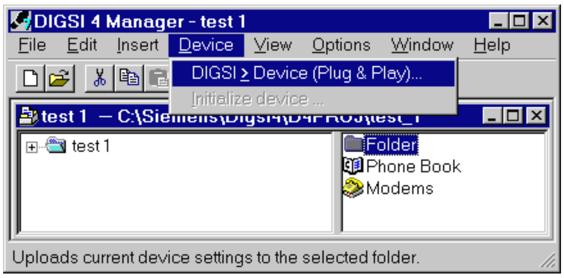
Name: test

Type: Project

Storage Location (Path): C:\Siemens\Digsi4\D4PROJ

Figure 3-4 Dialogue box to open a new project in DIGSI® 4

- Enter a name for the new project in the **Name** entry field (e.g. test 1) and close the box with **OK**.
- Select **Folder** by clicking on the item in the newly opened window. Then click in the menu bar the item **Device** and select the option **DIGSI > Device (Plug & Play)**, as shown in Figure 3-5. The **Plug & Play** dialogue box opens, as shown in Figure 3-6.



Uploads current device settings to the selected folder.

Figure 3-5 Window with selection of **Plug and Play**

- ☐ Enter the designation of the PC serial interface (COM 1,2, 3, or 4) and select in the dialogue box under **`Frame`** the transfer format, to be used in making the connection.
- ☐ Click on **`OK`**. DIGSI® 4 automatically determines the type of device present and reads the settings needed for communication (transfer format, transfer speed) through the interface.

Warning:
Plug & Play is only possible if the front device serial interface is linked to the PC directly via DIGSI protocol (DIGSI 1:1).

DIGSI (point-to-point)

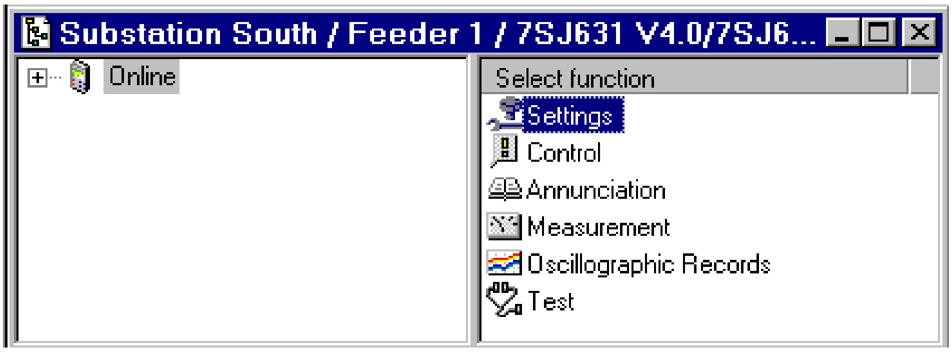
PC interface: COM1

Frame: 8 E(ven) 1

Figure 3-6 **Plug & Play** dialogue box for communication between device and PC

A direct connection is then established (on-line), the data are exchanged between the PC and the device, and the initial screen for DIGSI® 4 opens, as shown on Figure 3-7.

- ☐ By double clicking **`Online`** in the navigation window (left window), the structure opens (directory tree).
- ☐ By clicking on one of the menu items offered there, the associated contents become visible in the right window.



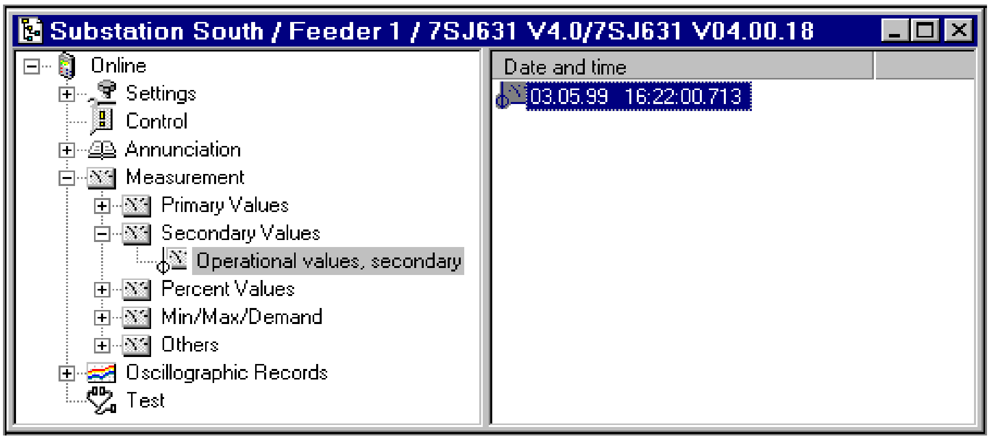
Substation South / Feeder 1 / 7SJ631 V4.0/7SJ6...

Figure 3-7 DIGSI® 4 — online initial screen — example

Viewing Measured Values

As an example the procedure for viewing the measured values is described.

- ❑ Double click on **`Measurement`** in the navigation window (left).
- ❑ Double click on the subdirectory **`Secondary Values`** in the navigation window.
- ❑ Click on **`Operational values, secondary`**.
- ❑ The present date and time are shown in the data window (right), as illustrated in Figure 3-8.
- ❑ Double click on this entry in the data window.



Substation South / Feeder 1 / 7SJ631 V4.0/7SJ631 V04.00.18

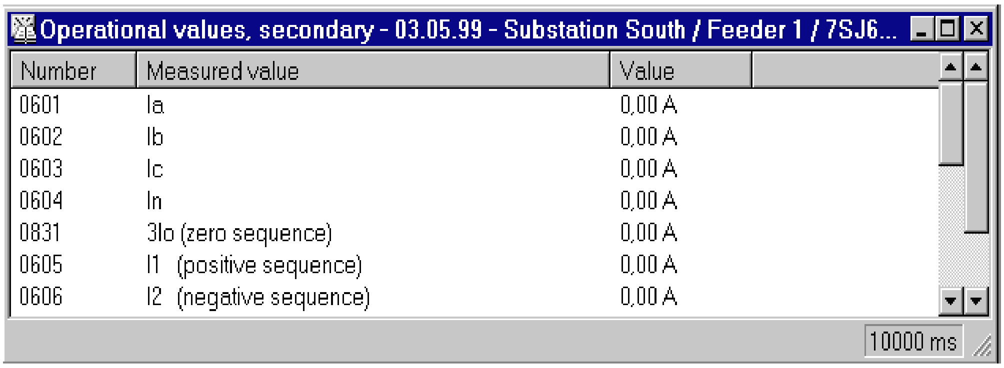
Date and time
03.05.99 16:22:00.713

Figure 3-8 DIGSI® 4 — Viewing the secondary operating measured values — example

A table of the secondary operating measured values appears, as shown in Figure 3-9.

Since no measured AC currents or voltages are present at this time, all operating measured values are close to zero. Deviations of the last digit are insignificant. The measured values are automatically updated.

In the same manner, other measured and counter values can be read out.



Operational values, secondary - 03.05.99 - Substation South / Feeder 1 / 7SJ6...

Number	Measured value	Value
0601	Ia	0,00 A
0602	Ib	0,00 A
0603	Ic	0,00 A
0604	In	0,00 A
0831	3Io (zero sequence)	0,00 A
0605	I1 (positive sequence)	0,00 A
0606	I2 (negative sequence)	0,00 A

Figure 3-9 DIGSI® 4 — Table of secondary operating measured values – example

Viewing Operational Messages

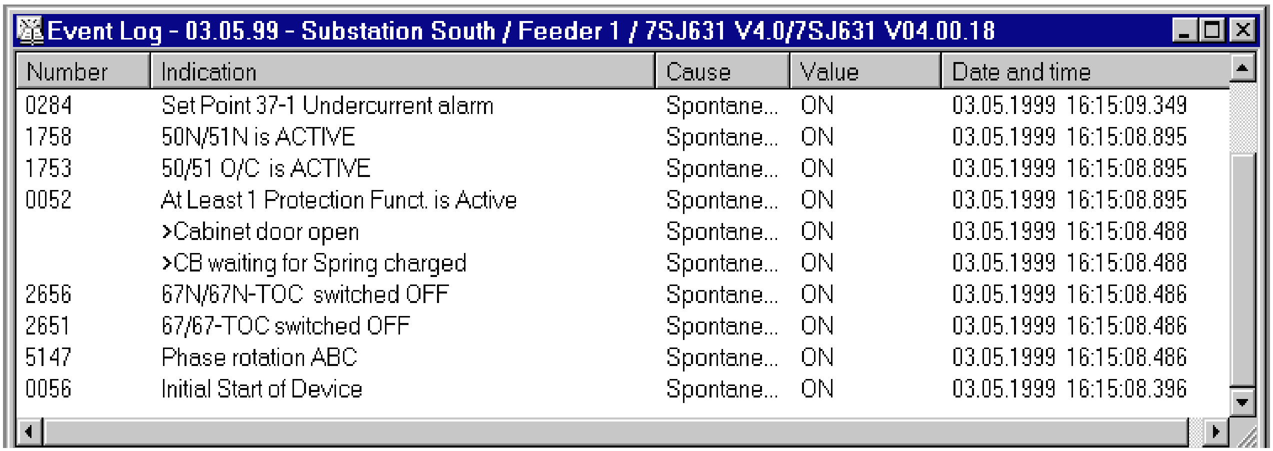
The read-out of operating messages is described to serve as an additional example.

- ☐ Double click on **`Annunciation`** in the navigation window.
- ☐ Click on **`Event Log`** in the function selection.

The present date and time are shown in the data window.

- ☐ Double click on this entry in the data window.

A table of the accumulated event messages is displayed. See Figure 3-10as an example. The number designation for an event is provided with a description of the message. The corresponding cause, value (ON or OFF), and date and time of the event are given. The events are listed chronologically; the newest message is shown first.



Event Log - 03.05.99 - Substation South / Feeder 1 / 7SJ631 V4.0/7SJ631 V04.00.18

Number	Indication	Cause	Value	Date and time
0284	Set Point 37-1 Undercurrent alarm	Spontane...	ON	03.05.1999 16:15:09.349
1758	50N/51N is ACTIVE	Spontane...	ON	03.05.1999 16:15:08.895
1753	50/51 O/C is ACTIVE	Spontane...	ON	03.05.1999 16:15:08.895
0052	At Least 1 Protection Funct. is Active	Spontane...	ON	03.05.1999 16:15:08.895
	>Cabinet door open	Spontane...	ON	03.05.1999 16:15:08.488
	>CB waiting for Spring charged	Spontane...	ON	03.05.1999 16:15:08.488
2656	67N/67N-TOC switched OFF	Spontane...	ON	03.05.1999 16:15:08.486
2651	67/67-TOC switched OFF	Spontane...	ON	03.05.1999 16:15:08.486
5147	Phase rotation ABC	Spontane...	ON	03.05.1999 16:15:08.486
0056	Initial Start of Device	Spontane...	ON	03.05.1999 16:15:08.396

Figure 3-10 DIGSI® 4 — Operational messages window — example

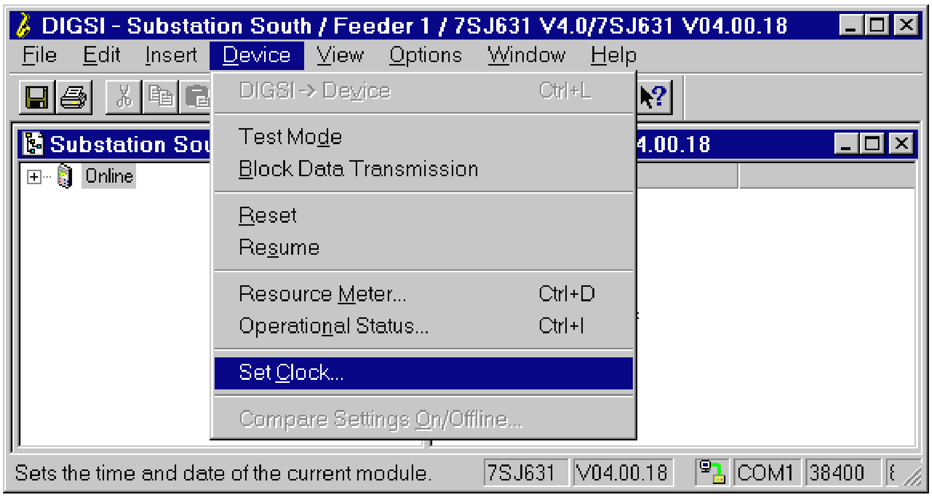
- ☐ Press the LED key on the device; all LEDs should light while the key is pressed.
- ☐ The message “Reset LED” appears as the newest message as soon as the window is updated. The window can be updated by clicking on **`View`** in the menu bar, and then on **`Refresh`**. Pressing the **F5** function key on the keyboard also updates the window.

The operating messages can be saved in DIGSI® 4, and also deleted from the device’s memory as described in Sub-section 7.1.1.

Setting Date and Time

To enter the date and time:

- Click on **`Device`** in the menu bar. See Figure 3-11.
- Select **`Set Clock`**.



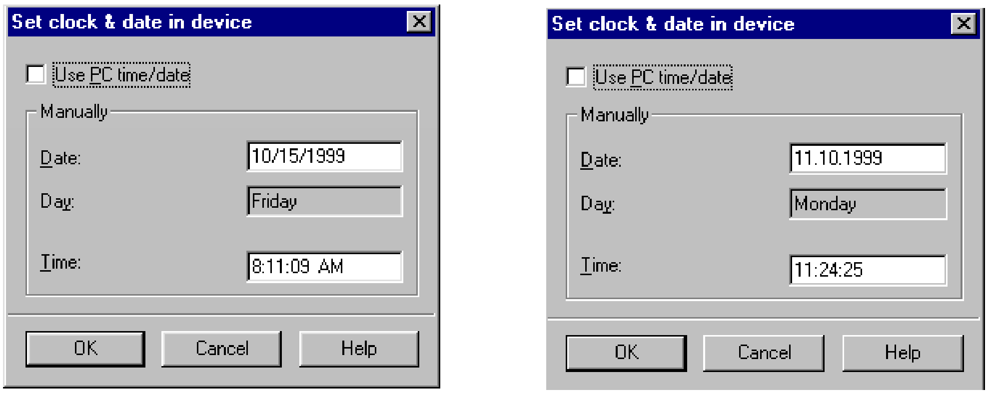
Sets the time and date of the current module.

Figure 3-11 DIGSI$^{®}$ 4 — Selection of the option **`Set Clock`** - example

The dialog field **`Set clock & date in device`** opens. The field shows the present date and the approximate present time according to the device. The day of the week is automatically derived from the date and cannot be edited.

- Edit the input fields **`Date`** and **`Time`**. The format depends on your regional settings of the PC. See Figure 3-12.
  Date: mm/dd/yyyy or dd.mm.yyyyy
  Time: hh.mm.ss

  Click **`OK`** to download the entered values to the device. The former values are changed and the dialog field is closed.



☐ Use PC time/date
Date: 10/15/1999
Day: Friday
Time: 8:11:09 AM

☐ Use PC time/date
Date: 11.10.1999
Day: Monday
Time: 11:24:25

Figure 3-12 DIGSI$^{®}$ 4 — Dialog Field: **`Set clock & date in device`**

3.4 Storage

If the device is to be stored, note:

SIPROTEC$^{®}$ 4 devices and associated assemblies should be stored in dry and clean rooms, with a maximum temperature range of –25° C to +55° C (–12° F to 131° F). See Sub-section 10.1.7 under Technical Data. To avoid premature aging of the electrolyte capacitors in the power supply, a temperature range of +10° C to +35° C (50° F to 95° F), is recommended for storage.

The relative humidity must not lead to condensation or ice buildup.

After extended storage, the power supply of the device should be energized, approximately every two years, for one or two days to regenerate the electrolytic capacitors in the power supply. This procedure should also be done prior to the device being put in service. Under extreme climatic conditions (tropics), pre-warming is achieved at the same time, and condensation is prevented.

After long storage, power should not be applied until the device has been in the operating area for a minimum of two hours. This time period allows the device to attain temperature equilibrium, and prevents dampness and condensation from occurring.

To save the energy of the buffer battery inside the device, the battery is switched off automatically without auxiliary supply voltage after a time period of 1 to 2 days.

■

SIPROTEC® 4 Devices

4

This chapter provides an overview of the family of SIPROTEC® 4 devices and the integration of the devices into power plants and substation control systems. Principle procedures are introduced for setting the devices, controlling primary equipment with the devices, and performing general operations with the devices.

Please note the SIPROTEC® 4 family of devices is described in general in this chapter, and the examples shown may differ in detail from a specific device. Also, depending on the type and version of a specific device, some of the functions discussed may not be available.

Details about the extent of the functions of the devices, the individual settings, and the representation structure of the system data are found in the following chapters and the DIGSI® 4 instruction book.

4.1 General

The SIPROTEC® 4 family is an innovative product series of numerical protective and control devices with open communication interfaces for remote control and remote setting, ergonomically designed operator panels, and highly flexible functionality.

4.1.1 Protection and Control

The devices utilize numerical measuring techniques. Complete numerical signal processing offers high measurement accuracy and long-term consistency, as well as reliable handling of harmonics and transients. Digital filtering techniques and adaptive stabilization of measured values ensure the highest security in establishing the devices' correct responses. Device errors are recognized and quickly annunciated by integrated self-monitoring routines. Failure of protection during a fault is therefore almost entirely prevented.

You may choose devices with separate protective and process control functions, or select a solution that implements both requirements.

The following solutions are available:

- Protection and control in separate devices,
- Protective devices that provide the capability to control the circuit breaker or primary switching device through a communication interface,
- Devices with combined features that, in addition to protective functions, allow on-site operation for several circuit breakers and primary switching devices and that provide extensive substation control functions.

4.1.2 Communication

SIPROTEC® 4 devices are completely suited for the requirements of modern communication technology. They have interfaces that allow for integration into higher-level control centres, and user friendly operation through an on-site PC or via a modem connection. Simple, comfortable device setup and operation are provided.

SIPROTEC® 4 devices support the widespread, internationally accepted communication standards

☐ IEC 60870-5-103.

Prepared for

☐ PROFIBUS FMS

☐ DNP 3.0

☐ Modbus

☐ Profibus DP

☐ UCA II / Ethernet (future)

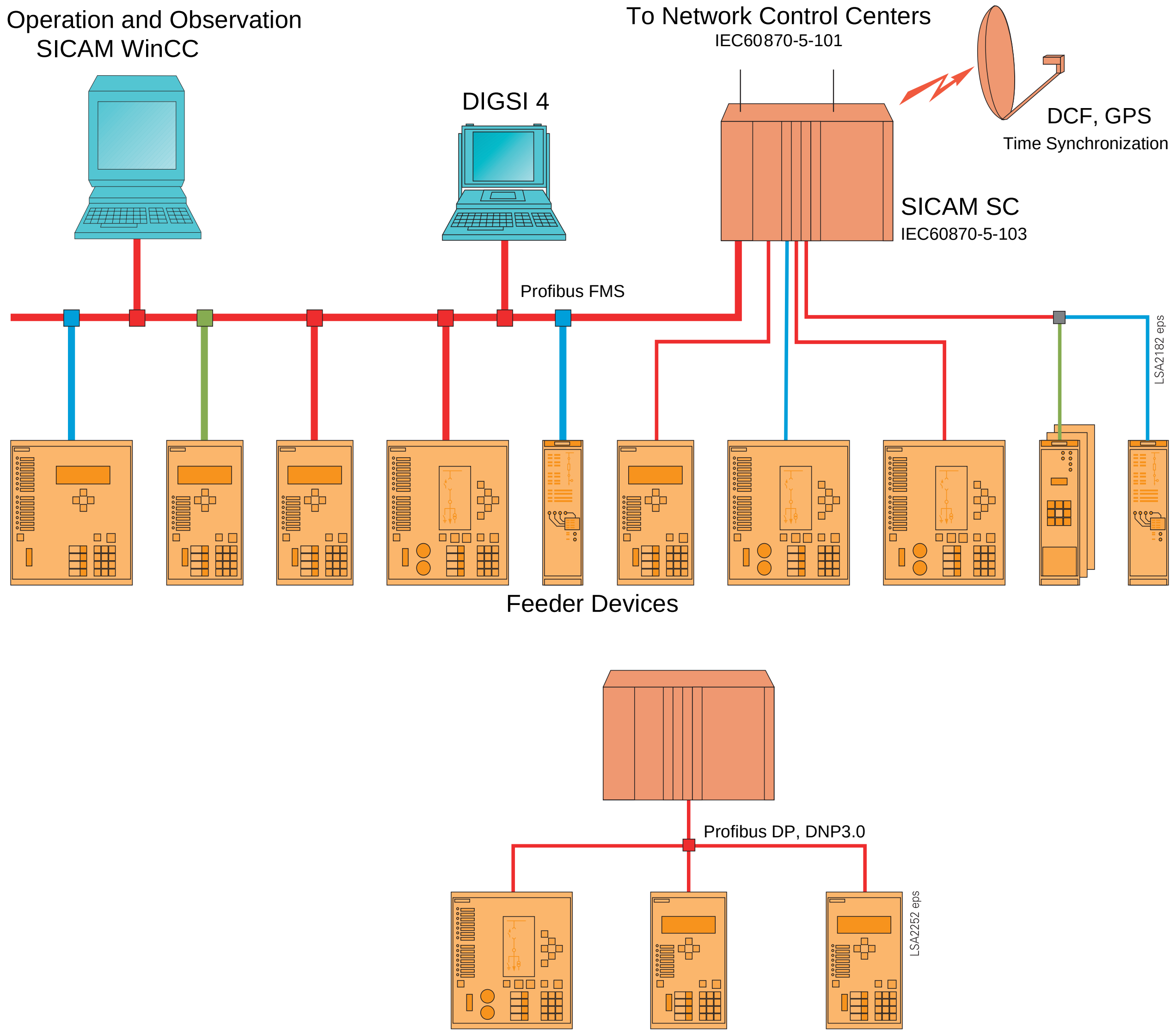


Figure 4-1 Integration of feeder devices in the SICAM substation control system — example

In the sample configuration in Figure 4-1, data transmitted from the feeder devices can be processed in the sub-station control device SICAM SC, displayed at the operating and observation station SICAM WinCC, and transferred by the remote terminal unit interfaces (via the network channels) to network control centres (SCADA).

In the case when commands are sent to the devices, equally flexible processing is possible; that is, substation switching operations can be initiated from the network control centres, as well as from the operation and observation unit of the substation control system.

Note:

All SIPROTEC® 4 devices also operate with the proven star coupler (e.g. 7XV5). Thus, for simple applications, you can retrieve all information from your office or while on the road.

The PROFIBUS DP protocol facilitates the connection of SIPROTEC®–devices to SPS-based process control systems (e.g. SIMATIC S5/S7). The protocols DNP3.0 and MODBUS ASCII/RTU allow the connection to a wide range of control systems by other manufacturers.

4.1.3 Settings

The devices in the SIPROTEC® 4 family are delivered with default settings. After settings are made for specific applications, the devices are suitable for direct use in power systems.

The windows-based DIGSI® 4 software program offers an application-oriented interface with thorough guidance for quick and simple setting of the devices.

DIGSI® 4 is installed on a normal personal computer. For local use, the PC is connected to the operating serial interface on the front panel of the device.

4.1.4 Operations

All on-site operations of a SIPROTEC® 4 device can be done with DIGSI® 4. Examples of operations are switching, retrieval of information, or changing of setting groups. These operations can also be performed using the operator control panel on the front of the SIPROTEC® 4 device.

4.1.5 Oscillographic Fault Records

DIGSI® 4 can also be used to retrieve oscillographic fault data captured by the SIPROTEC® 4 device. The **DIGRA® 4** software program can then be used to provide several different graphical representations of the captured signals. DIGRA® 4 also calculates additional values on the basis of the captured signals. The program presents the data in analogue curves with time base, phasor diagrams, locus diagrams, and harmonic charts.

4.2 Operator Control Facilities

4.2.1 Operator Control Panel On Device

The operating panels of SIPROTEC® 4 devices are ergonomically designed and easy to read. The operating panels allow on-site control operations to be done, individual settings to be entered, and all information required for operations to be displayed.

The operating panel contains either a full graphical display or a four-line display, depending on the specific device of the SIPROTEC® 4 family.

Operating Panel with Four-Line Display

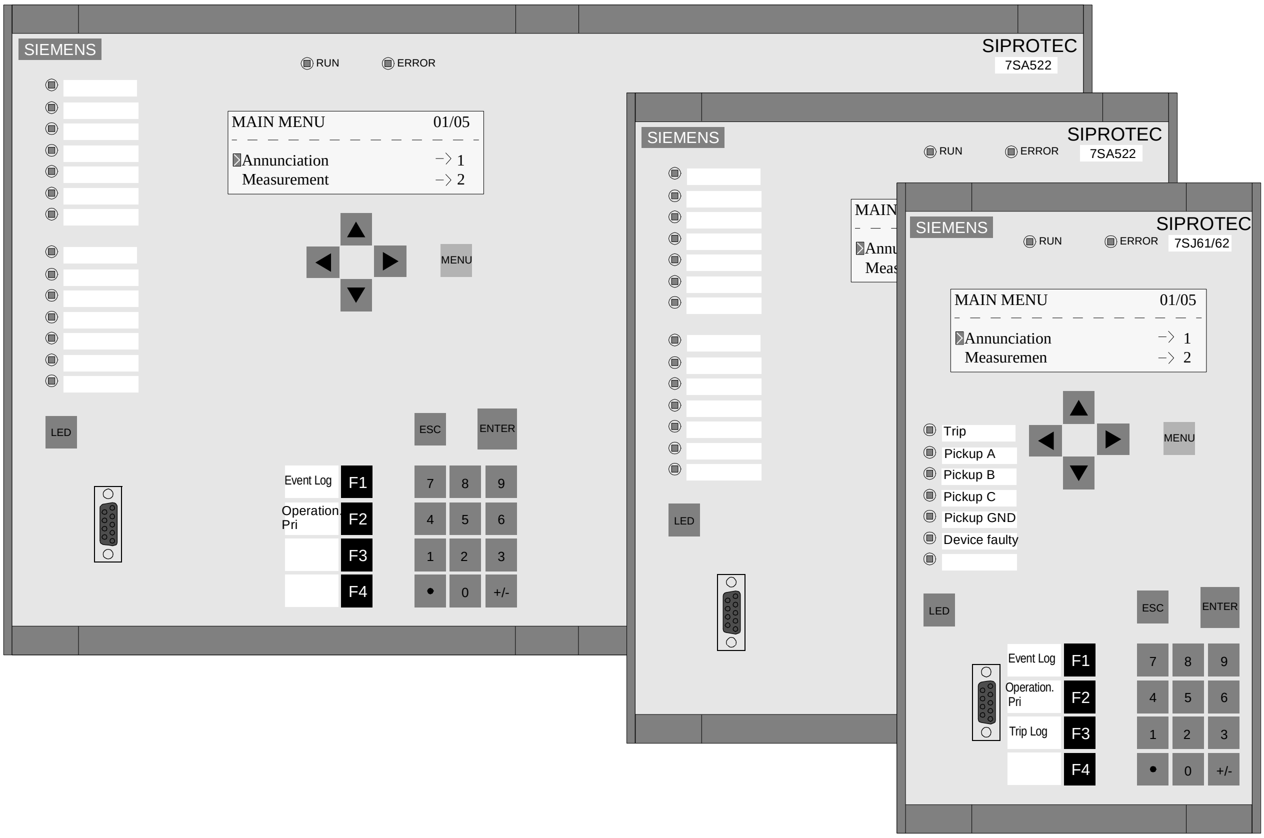


Figure 4-2 SIPROTEC® 4 Device, operator control panel with four-line display — examples

Note:

Refer to Chapter 2 to determine the type of operating field for your specific SIPROTEC®4 device.

The functions of the operating and display elements on the operator control panel are described below.

Display

Process and device information are displayed in the LCD display. Commonly displayed information includes circuit breaker status, measured values, counter values, binary information regarding the condition of the device, protection information, general messages, and alarms.

The light for the display is normally off. The light automatically turns on whenever a key is pressed on the operating field. If no input from the operator control panel occurs for ten minutes, then the light turns off again. The light can be controlled via a binary input that is configured (programmed) for this purpose.

Keys

The keys have various functions.

- Navigation through the operating menus of the device and movement within the operator control display are accomplished with the ◀, ▶, ▲, ▼ keys.
- The main menu is opened with the MENU key.
- Changes are cancelled or confirmed with the ESC and ENTER keys, respectively.
- Numerical values are entered with the 0 to 9 keys, the . key for a decimal point, and the +/– key for a negative sign. If a value of infinity (∞) is desired, press the decimal point key twice; ∞ appears in the display.
- The F1 to F4 keys are programmable. The keys are typically used to execute commonly performed actions. Labelling strips are provided.
- Latched LEDs and output relays are reset and the group of LEDs are tested with the LED key.

LEDs

- "**RUN**" and "**ERROR**" LEDs indicate the condition of the device.
- All other **LEDs** are freely configured to indicate process information, status, events, etc. Labelling strips are provided.

Operating Serial Interface

Local communication with the device is established through the front operating serial interface with a PC running DIGSI® 4. The interface on the device is a 9-pin, female, D-subminiature port.

4.2.2 DIGSI® 4 Tool

DIGSI® 4 uses the familiar Windows operating environment.

User Guide

In DIGSI® 4 only the settings that are available within a specific device are shown in the specific windows. If a protective feature is changed from disabled to enabled in the Device Configuration, then the settings relevant to that feature become available.

Entering settings for SIPROTEC® 4 devices is easy due to many types of assistance offered, such as context menus, pop-up lists for the selection of available options, and specific limits for the entry of numerical values.

Configuring Inputs and Outputs

A configuration matrix is used to assign the binary inputs, output relays, and LEDs. Information to be stored in the various buffers and transmitted via the system interface is also selected in this matrix. The setting options are presented in an easy-to-read tabular format. Parts of the matrix can be minimized or expanded as desired to simplify the displayed sections, and therefore the setting process. Filter functions can reduce the size of the matrix to display only relevant information.

Passwords

Password entry is required for tasks such as changing settings, executing control commands, or exercising the test and diagnostics features. The passwords protect against unauthorized access to these critical tasks.

Commissioning Aids

DIGSI® 4 simplifies commissioning with test functions for the binary inputs, outputs and LEDs. Control of primary equipment can be done. The measured values of the device can be viewed with the program. Oscillographic fault records can be triggered with DIGSI® 4.

Help System

The help system clarifies the individual functions and settings, and provides additional support.

Note:

Detailed information about DIGSI® 4 can be found in the DIGSI® 4 Manual, order number E50417-H1176-C097.

4.3 Information Retrieval

A SIPROTEC® 4 device has an abundance of information that can be used to obtain an overview of the present and past operating conditions of the device and the portion of the power system being protected or controlled by the device. The information is represented in separate groups:

- ☐ Annunciations,
- ☐ Measurements,
- ☐ Oscillographic fault records.

Remote

If the device is integrated into a substation control system, then information transfer can take place, via a connection to the system interface of the SIPROTEC® 4 device, to:

- ☐ higher level control systems, or
- ☐ substation control devices, e.g. SICAM SC.

Local

On site, the operator control panel of the SIPROTEC® 4 device can be used to retrieve information.

DIGSI® 4

Information retrieval is simple and fast when DIGSI® 4 is used. For local use, connect a PC to the operating serial interface at the front of the SIPROTEC® 4 device. For remote retrieval of information, communication occurs via a modem connected to the service serial interface. DIGSI® 4 must operate in the **Online** mode to obtain information from the device.

4.3.1 Annunciations

The scope of the indication (messages) that are given under Annunciation is determined when settings for the configuration of functions are applied to the SIPROTEC® device.

The messages are divided into the following categories, and displayed using DIGSI® 4 or the operator control panel of the device:

- Event Log: Operating messages: independent of network faults, e.g. messages about switching operations or monitoring functions;
- Trip Log: Fault messages;
- General interrogation: display of present condition messages;
- Spontaneous messages; continuous display of important messages from the device; e.g., after faults, switching operations, etc.

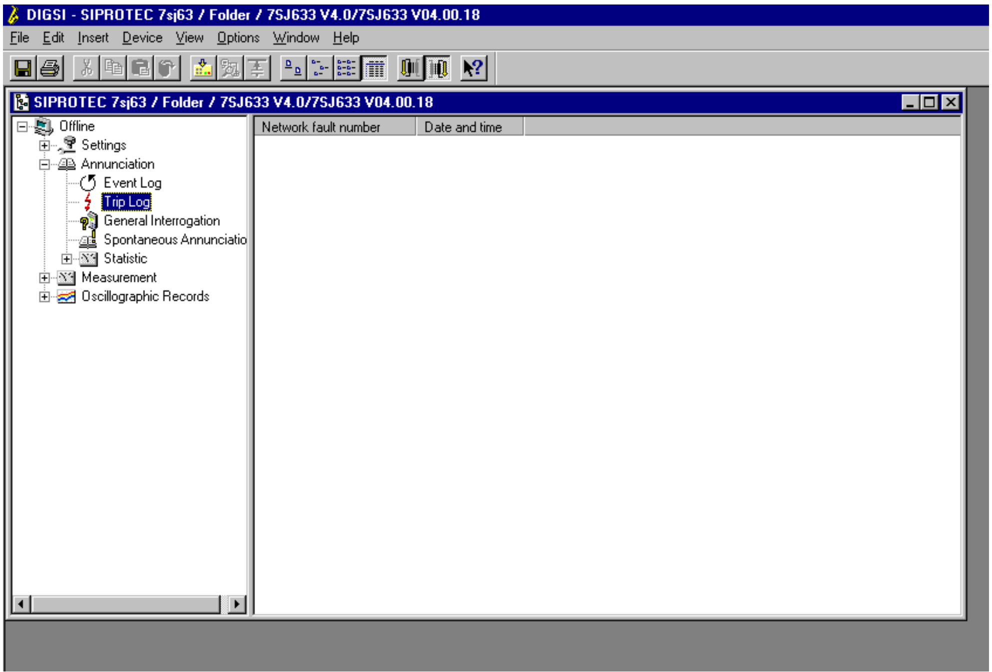


Figure 4-3 DIGSI® 4, annunciations – example

Display in DIGSI® 4

To view the indications in DIGSI® 4 **`Online`**:

- Select **`Annunciation`** in the navigation (left) window.

All annunciation groups are shown in the data (right) window.

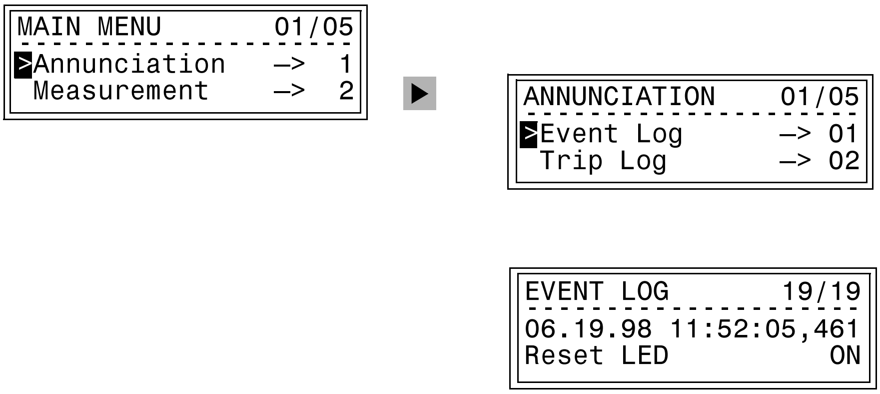
- Double click on an annunciation group in the data window, such as **`Event Log`**.

The data and time appear. Double click on the entry. The list of indications appears.

Display on the Device

To display messages in the operating field of the SIPROTEC® 4 device:

- Select **`Main Menu`** → **`Annunciation`** → e.g. **`Event Log`** or **`Trip Log`**.

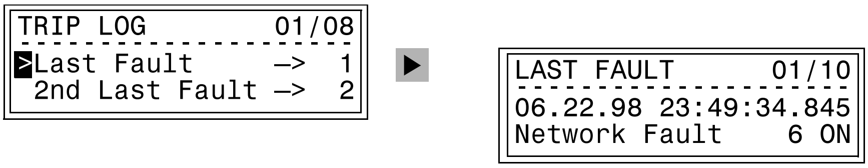


```
MAIN MENU        01/05
---------------------
>Annunciation   –>  1
 Measurement    –>  2
```

```
ANNUNCIATION    01/05
---------------------
>Event Log      –> 01
 Trip Log       –> 02
```

```
EVENT LOG       19/19
---------------------
06.19.98 11:52:05,461
Reset LED          ON
```

Figure 4-4 SIPROTEC® 4, device display of operating messages in the event log — example



```
TRIP LOG         01/08
---------------------
>Last Fault     –>  1
 2nd Last Fault –>  2
```

```
LAST FAULT      01/10
---------------------
06.22.98 23:49:34.845
Network Fault    6 ON
```

Figure 4-5 SIPROTEC® 4, device display of fault messages— example

4.3.2 Measurements

The registered measured values are classified into the following categories for display in DIGSI® 4 or on the operating field of the device:

- Primary values, based on the measured secondary values and the settings entered for the current transformers and voltage transformers.
- Secondary values, which are the measured values or are derived from the measured values.
- Percentage values, relative to nominal ratings.
- Other values calculated by the device, e.g. thermal values or user-defined values.
- Statistics values.

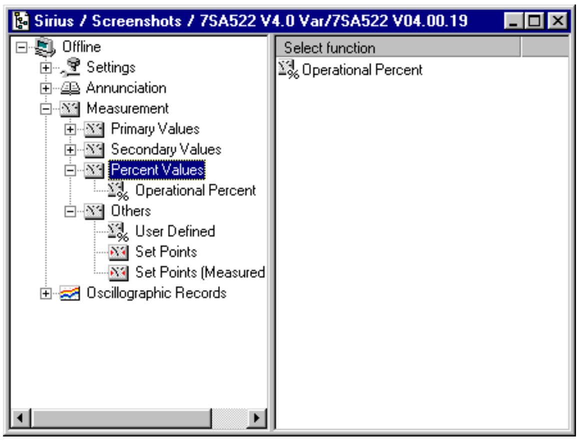


Figure 4-6 DIGSI® 4 measured value display — example

Display in DIGSI® 4

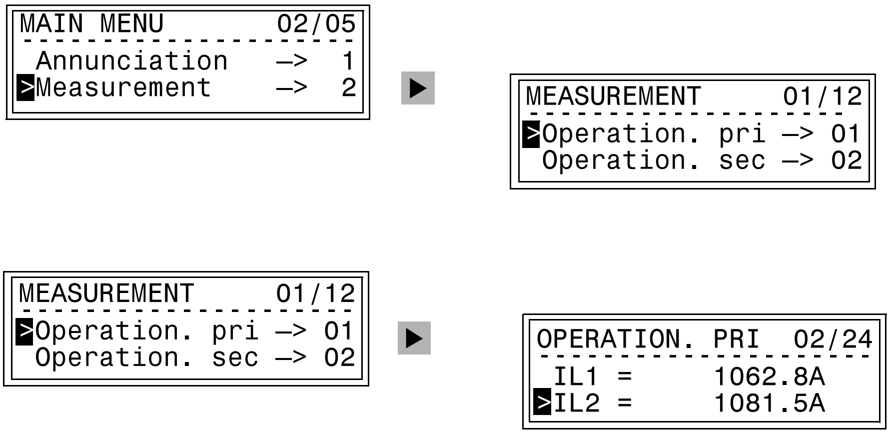
To display the measured values in the DIGSI® 4 **`Online`**:

- Select **`Measurement`** in the navigation (left) window. The measured value groups appear in the data (right) window.
- Double click on a group, for example **`Primary Values`**.
- Double click on the next item in the data window, **`Operational values, primary`** in the example. The date and time appear.
- Double click on the date and time, and the measured values appear.

Display on the Device

To display the measured values in the operating field of the SIPROTEC® 4 device:

- Select **`Main Menu`** → **`Measurement`** → e.g. **`Operation. pri`**.



```
MAIN MENU        02/05
----------------------
 Annunciation   –>  1
>Measurement    –>  2
```

```
MEASUREMENT      01/12
----------------------
>Operation. pri –> 01
 Operation. sec –> 02
```

```
MEASUREMENT      01/12
----------------------
>Operation. pri –> 01
 Operation. sec –> 02
```

```
OPERATION. PRI  02/24
----------------------
 IL1 =      1062.8A
>IL2 =      1081.5A
```

Figure 4-7 SIPROTEC® 4, device display of measured values — example

Note:

Measured values can also be displayed in the default display and the control display. Prior to this the measured values to be indicated have to be configured in the configuration matrix under settings in DIGSI® 4. Then their position within the LCD displays can be designed using the Display Editor.

4.3.3 Oscillographic Fault Records

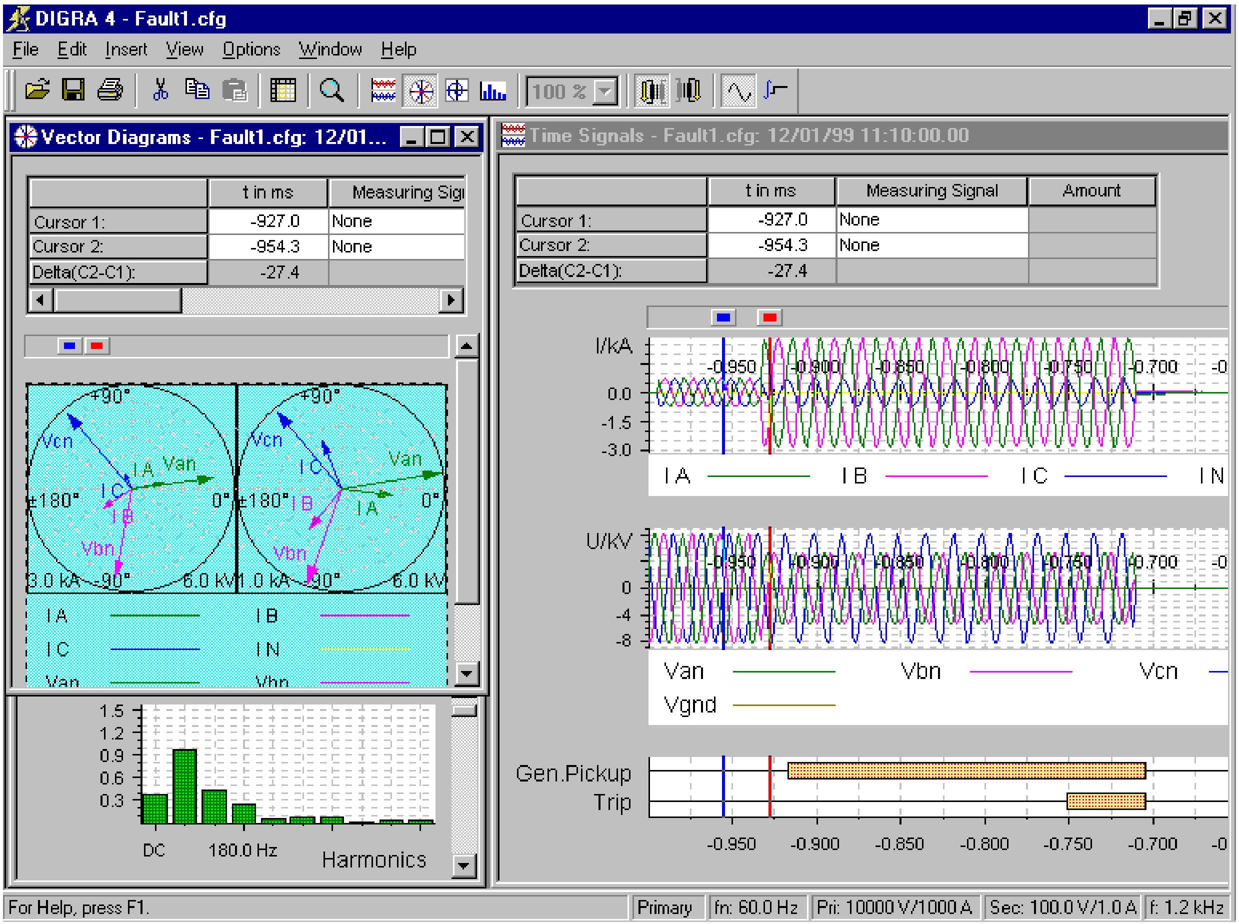
As an option, SIPROTEC® 4 devices can have waveform capturing and event recording. Furthermore, the elements that are shown in the fault records can be selected by the user.

The fault record data are retrieved from the device memory by DIGSI® 4 and are stored as oscillographic records in standard COMTRADE format.

The DIGRA® 4 program is used to convert the oscillographic data into graphical representations that can be used to analyse the fault or the event captured by the device.

DIGRA® 4 calculates additional values from the waveform data, e.g. impedances and rms values, and displays the captured and calculated values in:

- ❑ analogue curves with timebase (time signals),
- ❑ phasor diagrams,
- ❑ locus diagrams, and
- ❑ harmonic graphs.



	t in ms	Measuring Sig
Cursor 1:	-927.0	None
Cursor 2:	-954.3	None
Delta(C2-C1):	-27.4	

	t in ms	Measuring Signal	Amount
Cursor 1:	-927.0	None	
Cursor 2:	-954.3	None	
Delta(C2-C1):	-27.4		

For Help, press F1. | Primary | fn: 60.0 Hz | Pri: 10000 V/1000 A | Sec: 100.0 V/1.0 A | f: 1.2 kHz

Figure 4-8 DIGRA® 4 graphical representations of the waveform data — view examples

Details can be found in the DIGSI® 4 manual, order number E50417-H1176-C097, and the DIGRA® 4 manual, order number E50417-H1176-C070.

4.4 Control

The multiple application possibilities for SIPROTEC® 4 devices allow an equally flexible concept for command processing and control.

Remote

If the device is integrated into a master control system, then command outputs can be remotely controlled via the system interface using telegrams from

- ❑ Higher-level control systems, or
- ❑ substation control devices such as SICAM SC.

Local

On-site, the SIPROTEC® 4 device offers the possibility to control a circuit breaker or primary switching equipment using the operator control panel.

For devices with a four-line display, switching operations are controlled using:

- **`Main menu`** → **`Control`** → **`Breaker/Switch`** → **`Control`** → Equipment and intended direction ***ON*** or ***OFF*** (Figure 4-9), or
- The Function Keys F1 to F4.

The functionality of these keys is programmable.

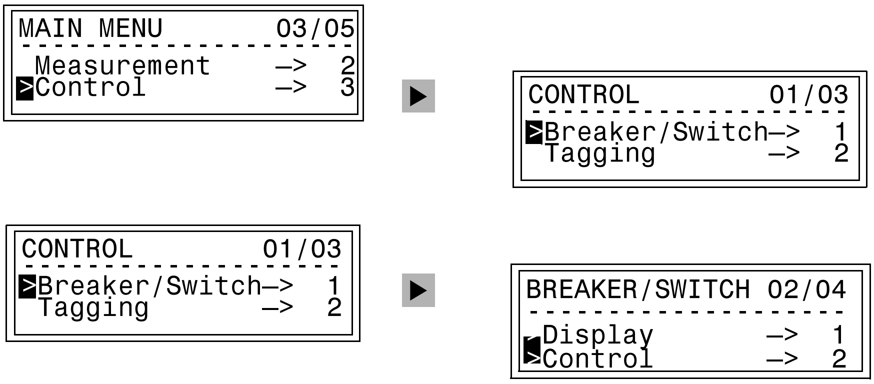
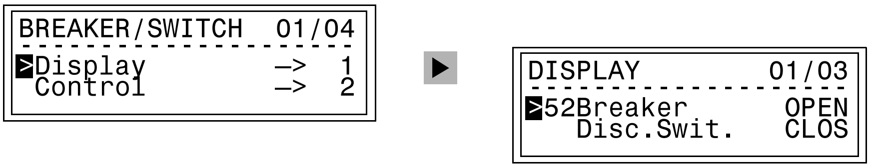


Figure 4-9 On-site control using the operator control panel

The status of a primary switch can be read out on the display using **`BREAKER/SWITCH`** → **`Display`** (Figure 4-10).



```
BREAKER/SWITCH  01/04
--------------------
>Display         –>  1
 Control         –>  2
```

```
DISPLAY          01/03
--------------------
>52Breaker      OPEN
   Disc.Swit.   CLOS
```

Figure 4-10 Determining primary switch status using the operator control panel

DIGSI® 4

Control operations can be carried out using the DIGSI® 4 Tool. Connect a PC to the operating interface of the device on site, or communicate with the SIPROTEC® device using a modem and the service interface.

DIGSI® 4 must operate in the **Online** mode for this function.

- Select **`Control`** in the Navigation window and double click on **`Breaker / Switches`** in the data window.

In the dialogue window that follows, all relevant primary switching equipment is displayed in a table with the present status.

- Enter the intended switching direction in the **Scheduled** column. Answer the question with **`Yes`**.

The password is requested, the interlocking conditions are checked, and the command is issued.

Note:

The control option of DIGSI® 4 is typically used during commissioning, and for test and diagnostic purposes.

CFC

Using the graphically supported design tool CFC for logic functions in DIGSI® 4, information can be logically combined. Command outputs can be derived from the output of logic functions. The link of the output of the CFC functions to the respective device outputs is determined in the configuration matrix.

Passwords

Only authorized personnel can perform switching operations. Switching operations are protected by passwords.

Interlocking

Command outputs may be subject to interlocking checks, which can be configured individually and graphically using the CFC logic too. Standard interlocking, such as ground switch closed status indication, may be already contained in the basic settings of certain device types when delivered from the factory.

Command Processing Times

Details about the command output time, checkback indication monitoring time, etc., are entered within the framework of the settings.

Event Recording

All switching operations are recorded in the message list with date and time.

4.5 Manual Overwrite / Tagging

Manual Overwrite

If the breaker/switch position is not available from the switch-gear, the status of the switchgear device can be manually set to the actual present position using the operator control panel: **`Main Menu`** → **`Control`** → **`Breaker/Switch`** → **`Man. Overwrite`**. The simulated switching status is used for interlocking checks, and for automatically initiated switching operations.

Set Status

For convenience during commissioning or at other times, decoupling of the information exchange between the switchgear and the protective device may be desired for a short period, without disconnecting the wires. This function is activated using the operator control panel: **`Main Menu`** → **`Control`** → **`Breaker/Switch`** → **`Set Status`**.

Tagging

To identify unusual operating conditions in the power system, tagging can be done. The tagging can, for example, be entered as additional operating conditions in interlocking checks, which are set up with CFC. Tagging is configured in the same way as for operating devices.

- The status of the tagging is displayed on the operating panel, **`Main Menu`** → **`Control`** → **`Tagging`** → **`Display`** (Figure 4-11),

or changed using

- **`Main Menu`** → **`Control`** → **`Tagging`** → **`Set`**.

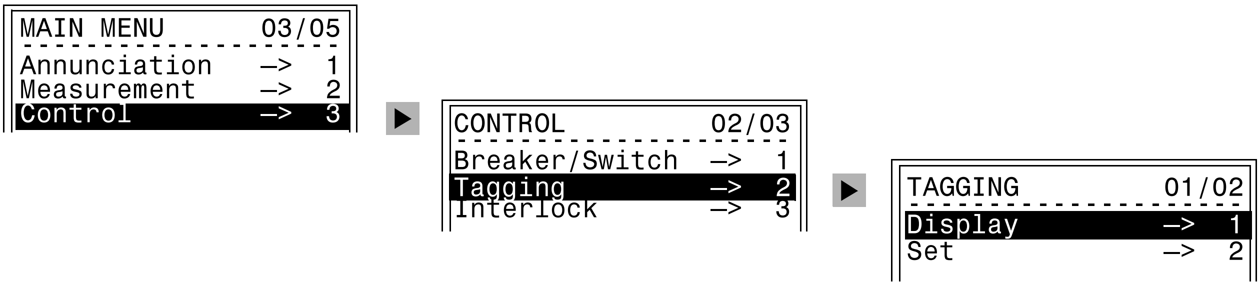


Figure 4-11 Tagging equipment from the operator control panel

Note:

The Manual Overwrite function is always done using the operator control panel on the SIPROTEC® 4 devices.

4.6 General about the Setting Procedures

The SIPROTEC® 4 devices are delivered with standard default settings. Changes to the settings are done with DIGSI® 4.

The setting procedure for a SIPROTEC® 4 device consists of

- Overall Protection and Control Design:
  - determining the functions that are to be used (device configuration),
  - assigning the binary inputs, outputs, LEDs, buffers, system port, etc. (I/O-configuration
  - defining user-definable logic functions (CFC).
- Specific Settings:
  - settings for all elements to be used,
  - settings of the protective functions,
  - settings of the process control functions.

Settings are first done **Off-line**. The settings are then loaded into the SIPROTEC® 4 device on-site using the operating serial interface, or remotely by modem and the service interface.

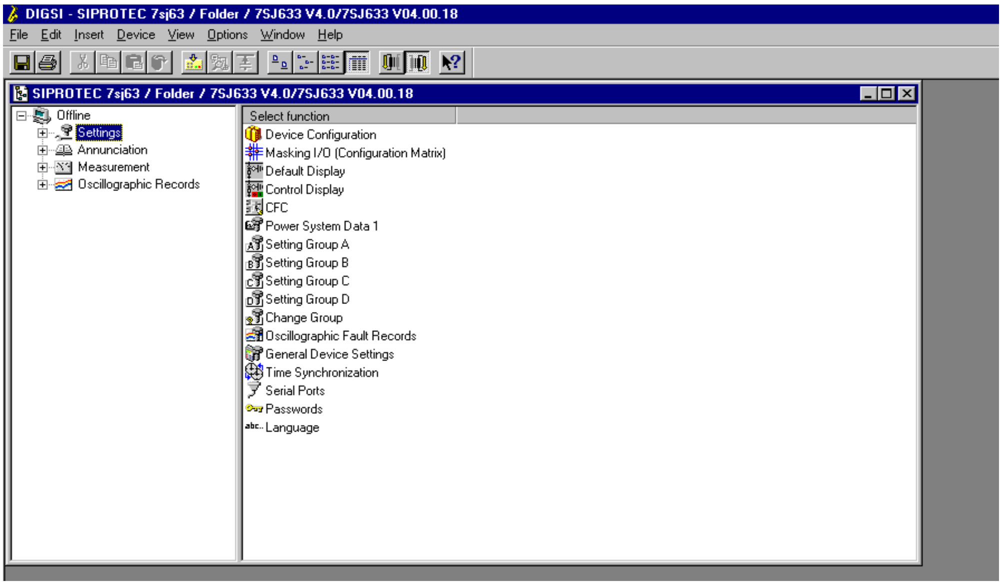
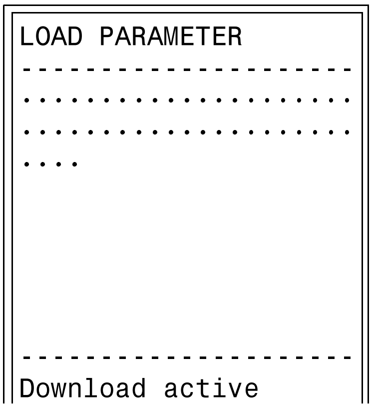


Figure 4-12 Setting a SIPROTEC® 4 device using DIGSI® 4 – example

The transfer of data from DIGSI® 4 to the SIPROTEC® 4 device is indicated in the display. The progress of the transfer is displayed. See Figure 4-13.



```
LOAD PARAMETER
---------------------
.....................
.....................
....




---------------------
Download active
```

Figure 4-13 Screen of Device during Settings Transfer

Setting Sequence

When setting a SIPROTEC® 4 device, adhere to the following sequence:

- Specify the interfaces, the device data, and the time synchronization,
- Determine the device functions to be used,
- Carry out routing
- Design the assignment of the inputs and outputs using the configuration matrix,
- Design all of the special logic that is to be employed using CFC (optional),
- Enter the power system data,
- Apply the settings to groups A to D (groups B to D optional),
- Set the passwords.

Setting steps partially build on the decisions from the previous steps. By following the sequence listed, unnecessary changes and rework are avoided. The sequence ensures that information required for an individual step will be available.

To design the control display, for example, the physical connections between the device and the primary equipment must be known. These connections are determined and setup during configuration of the inputs and outputs in the matrix. During the display design, simply select the relevant available equipment indications, and assign these indications with selected graphic symbols.

Note:

Changes to the configuration matrix and the control display are protected by password No. 7 (Password for parameter set).

Settings for Protective Elements

Setting changes to individual protective elements and functions can be done using the operator control panel on the SIPROTEC® 4 device.

Other settings such as input/output and device configuration can be viewed from the front panel, but not changed.

- Display the settings on the LCD using **`Main Menu`** → **`Settings`** → e.g. **`Masking (I/O)`**.
- Change settings such as date and time using **`Main Menu`** → **`Settings`** → **`Setup/Extras`**.

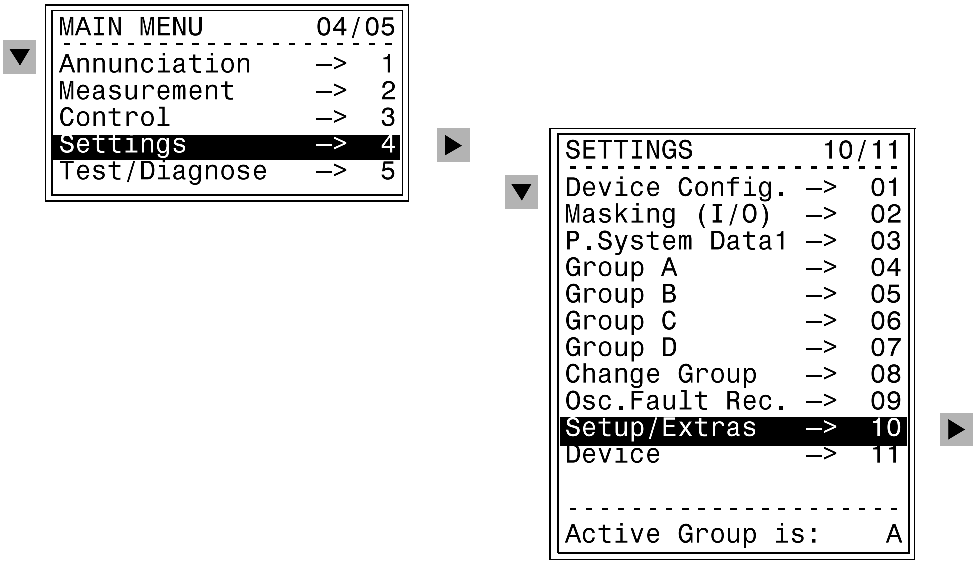


Figure 4-14 Changing settings using the operator control panel — example

Note:

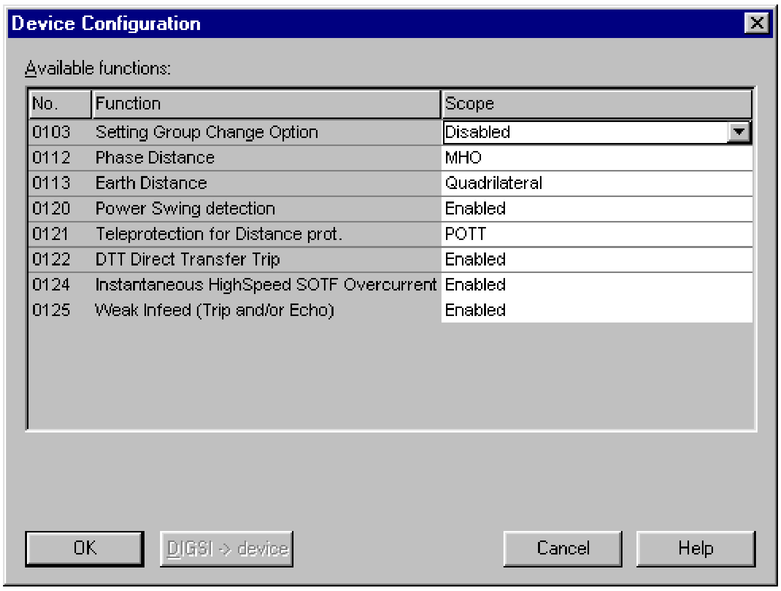
Changes to the individual settings are protected by Password No. 5 (Password for single settings).

4.7 Configuration of the Scope of Device Functions

The individual devices within the SIPROTEC® 4 family can be supplied with various protective functions. The ordering number of the device determines the available functions. The functions are specified more precisely through the process of enabling and disabling in the **Device Configuration** area of the settings.

To specify the active functions using DIGSI® 4:

- Double click on **`Device Configuration`** in the data window.
- Click on the individual fields and select the functions to be enabled.

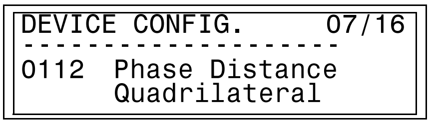


No.	Function	Scope
0103	Setting Group Change Option	Disabled
0112	Phase Distance	MHO
0113	Earth Distance	Quadrilateral
0120	Power Swing detection	Enabled
0121	Teleprotection for Distance prot.	POTT
0122	DTT Direct Transfer Trip	Enabled
0124	Instantaneous HighSpeed SOTF Overcurrent	Enabled
0125	Weak Infeed (Trip and/or Echo)	Enabled

Figure 4-15 DIGSI® 4, setting the device configuration — example

The device configuration can be viewed from the operator control panel on the SIPROTEC® 4 device.

- In the main menu, select **`Settings`** → **`Device Config`**.



```
DEVICE CONFIG.      07/16
---------------------
0112  Phase Distance
      Quadrilateral
```

Figure 4-16 Viewing device configuration from the operator control panel — example

4.8 Configuration of Inputs and Outputs (Configuration Matrix)

A configuration matrix is used to determine processing of the binary inputs, outputs, LEDs, and indication buffers.

Configuration is performed with DIGSI® 4.

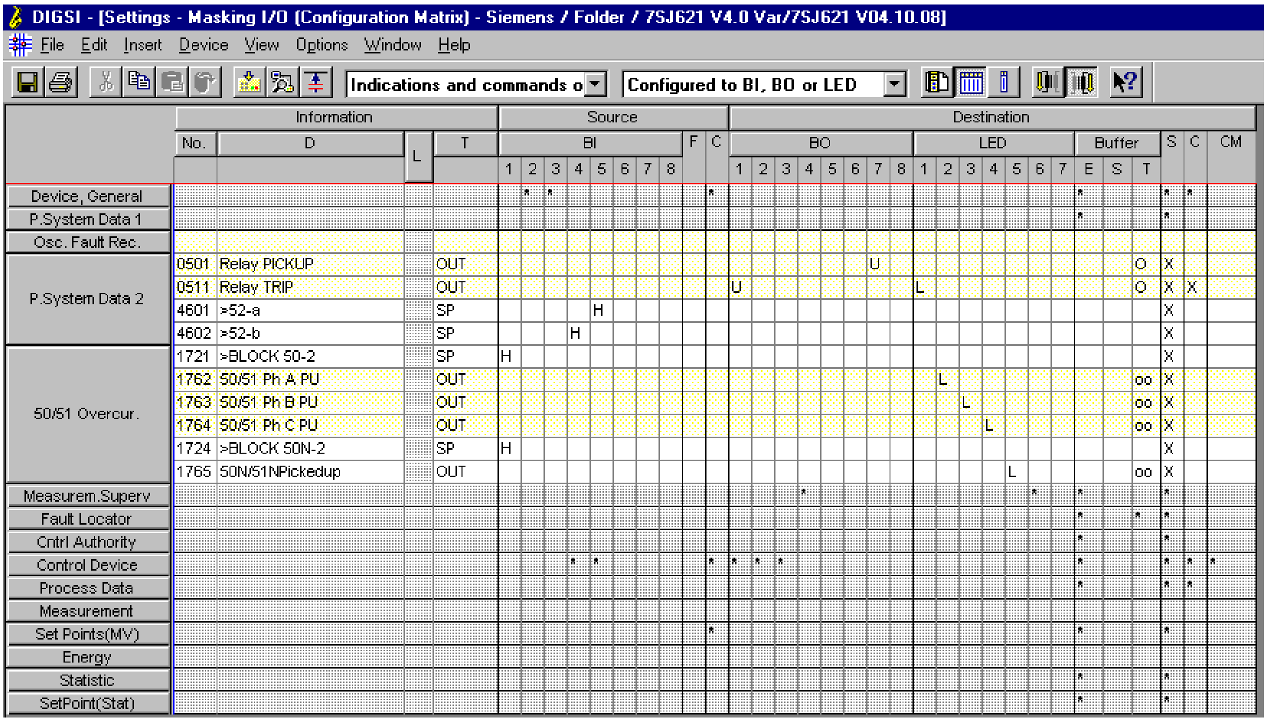
The configuration matrix is primarily divided into the following columns:

- Device functions
- Information, e.g. indications or command with
  - information number, identification of the information,
  - display text, representative brief text of the information on the device display,
  - long text, extensive description of the information,
  - type, identification of the information, e.g. CF_D2 double command with feedback indication;
- Source, that is, origin of the information with
  - binary inputs, for the input of binary information
  - function keys, freely programmable keys on the operating field, e.g. assigned switching operations, etc. as the origin of the information,
  - CFC (programmable logic), user-specific logic outputs as the origin of the information;
- Destination of the information, with
  - binary outputs for the output of signals,
  - LED, display of information on the device front, e.g. messages,
  - system interface, transmission of information, e.g. to a substation control system,
  - CFC (programmable logic), information as an input to a user-specified logic,
  - buffer, in which the information should be entered,
    – event log or
    – earth fault message
    – trip log,
  - display, information shown in
    – control display
    – default display
  - control menu, primary device can be controlled or tagging can be set.

The user determines the configurations by

- clicking on the appropriate column, or by
- Using the context menu: L (latched), U (unlatched), H (activate high), L (activate low), (not configured), (configured) etc.

DIGSI® 4 checks the entry for plausibility and locks the input field if necessary. A locked input field is shown in gray.



	Information				Source										Destination																				
	No.	D	L	T	BI								F	C	BO								LED							Buffer			S	C	CM
					1	2	3	4	5	6	7	8			1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	E	S	T			
Device, General						*	*							*																*			*	*	
P.System Data 1																														*			*		
Osc. Fault Rec.																																			
P.System Data 2	0501	Relay PICKUP		OUT																	U											O	X		
	0511	Relay TRIP		OUT											U								L									O	X	X	
	4601	>52-a		SP					H																								X		
	4602	>52-b		SP				H																									X		
50/51 Overcur.	1721	>BLOCK 50-2		SP	H																												X		
	1762	50/51 Ph A PU		OUT																				L								oo	X		
	1763	50/51 Ph B PU		OUT																					L							oo	X		
	1764	50/51 Ph C PU		OUT																						L						oo	X		
	1724	>BLOCK 50N-2		SP	H																												X		
	1765	50N/51NPickedup		OUT																							L					oo	X		
Measurem.Superv																		*										*		*			*		
Fault Locator																														*		*	*		
Cntrl Authority																														*			*		
Control Device								*	*					*	*	*	*													*			*	*	*
Process Data																														*			*	*	
Measurement																																			
Set Points(MV)														*																*			*		
Energy																																			
Statistic																														*			*		
SetPoint(Stat)																														*			*		

Figure 4-17 DIGSI® 4, Input/Output Masking with the Configuration Matrix, Example

Filter Functions

With the use of filters, either all information can be displayed or a selection can be done according to indications, commands, or measured values.

Additionally, there is a filter setting that differentiates between information configured and not configured.

The filters allows for a quick overview and simple checking of the configuration settings.

Also, columns and rows can be temporarily hidden from view, so that you can view only the sections of the total matrix that are relevant.

New Information

A further function of the configuration matrix is the capability to define new information. This is accomplished by inserting a new line, defining the appropriate information type, and assigning it to a source and a destination. The new information can also be displayed in the LCD of the SIPROTEC® 4 device after it has been downloaded to the device.

Function Keys

The function keys on the operator control panel of the SIPROTEC® 4 device can be assigned to commonly performed operating functions, e.g. initiation of a switching operation. Select the appropriate function key F1 to F4 in the **Source F** column for the related information (e.g. switching command).

CFC

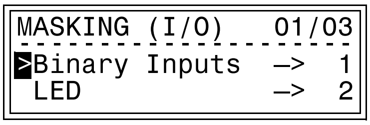
SIPROTEC® 4 device information can be connected in a user-specified manner using the programmable logic components of the DIGSI® 4 CFC. For example, the user can implement interlocking checks, create grouped messages, or derive limit value violation messages.

Information can be both a source and a destination in combined CFC editing. The specific logic's inputs, e.g. the individual messages that are to be combined to form a grouped message, must be marked in the **Destination C** column. The logic's output, the grouped message in this example, is derived from the **Source C** column.

Viewing the Configuration on the Operating Panel

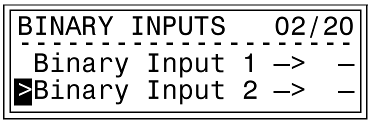
The configuration can be seen on the operating panel of the SIPROTEC® 4 device.

- In the main menu, select **`Settings`** → **`Masking (I/O)`**.



```
MASKING (I/O)    01/03
---------------------
>Binary Inputs  –>  1
 LED            –>  2
```

- In the next menu, select **`Masking (I/O)`** → e.g. **`Binary Inputs`**.



```
BINARY INPUTS    02/20
---------------------
 Binary Input 1 –>  –
>Binary Input 2 –>  –
```

Figure 4-18 Reading the configuration using the operator control panel, example assignment of binary input 2

4.9 Programmable Logic CFC

The CFC program in DIGSI® 4 can be used to create additional logic in SIPROTEC® 4 devices. For example, special interlocking conditions for controlled equipment can be designed. Limit checks for measured values can be created, and corresponding control can be designed.

SIPROTEC® 4 devices may have some CFC functions set at the factory, according to the type and version of the device.

User-defined CFC functions are done in graphical form. Generic logic modules (AND, OR, NAND, etc.) and analog modules that are specially created for the requirements of process control engineering (e.g., MAX, MIN, etc.) are available.

The CFC-modules are combined to form complete CFC-logic functions in order to

- perform system-specific checks (e.g. interlocking),
- generate messages if measured values approach a critical value, or
- build group messages for transfer to a substation control systems.

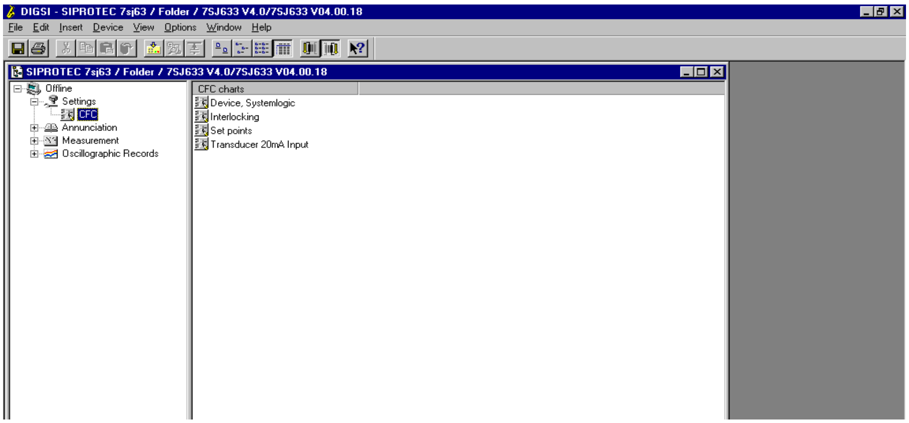


Figure 4-19 DIGSI® 4, CFC basic options — example

CFC Designing

Figure 4-20 shows the graphical nature of the CFC logic tool, and some of the components that can be used to build the logic.

Note:

CFC settings are protected in DIGSI® 4 by Password No. 7 (Password for parameter set).

Details about designing with the CFC program can be found in the instruction book, order number E50417-H1176-C098.

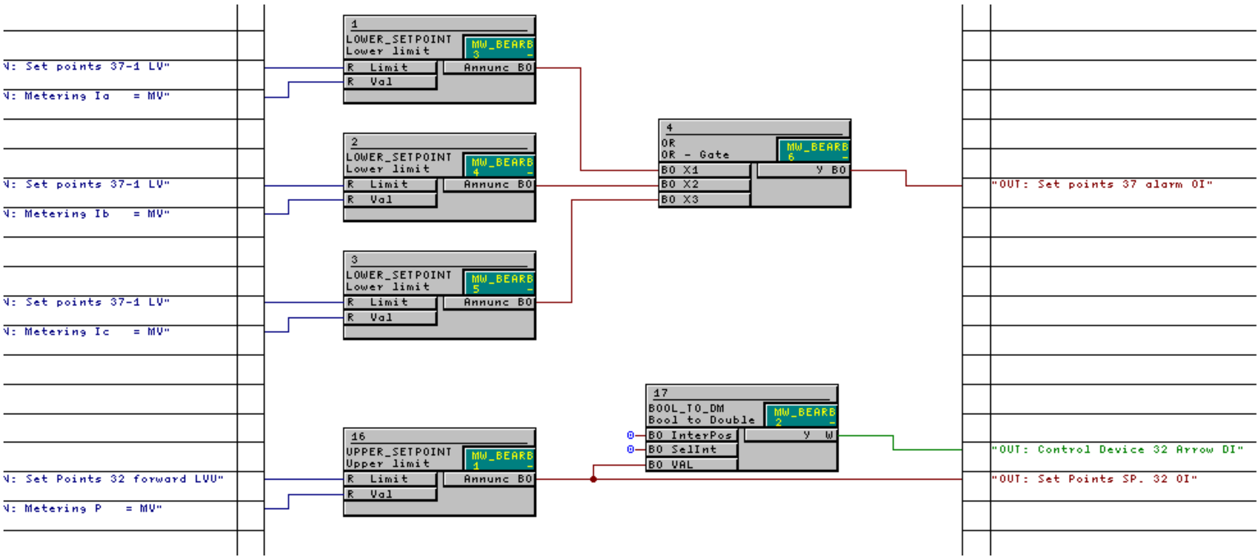


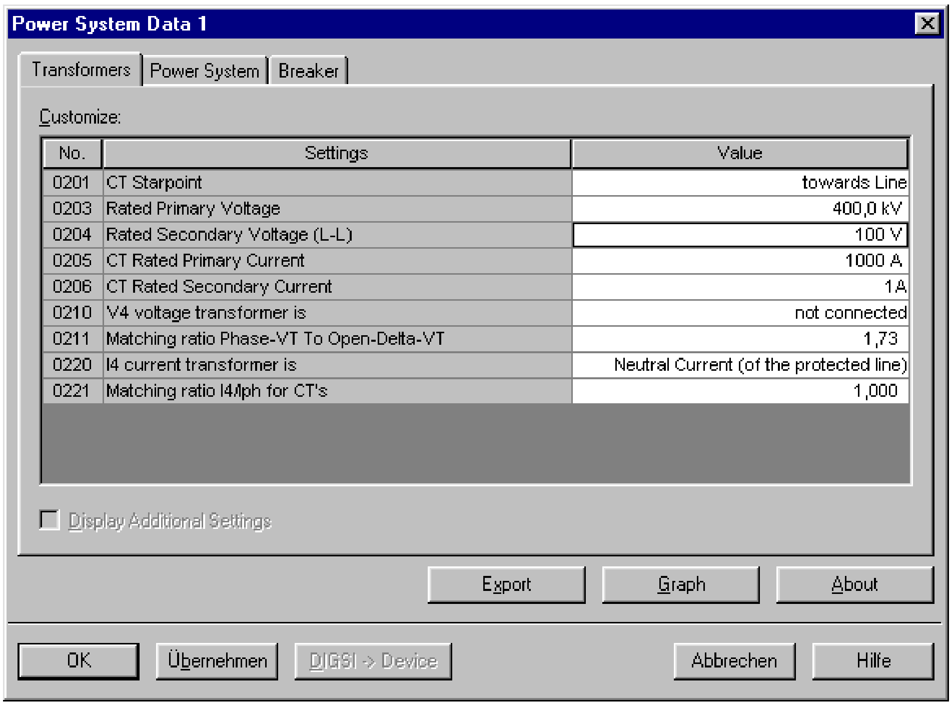
Figure 4-20 CFC Logic — example

4.10 Power System Data

Power System Data 1

In the window for **Power System Data 1**, important settings are entered that relate to the power system and primary equipment connected to the device. The settings include:

- ❑ system data such as frequency, voltage, etc.
- ❑ data for the main current transformers and voltage transformers,
- ❑ circuit breaker or primary switch-gear information.



No.	Settings	Value
0201	CT Starpoint	towards Line
0203	Rated Primary Voltage	400,0 kV
0204	Rated Secondary Voltage (L-L)	100 V
0205	CT Rated Primary Current	1000 A
0206	CT Rated Secondary Current	1 A
0210	V4 voltage transformer is	not connected
0211	Matching ratio Phase-VT To Open-Delta-VT	1,73
0220	I4 current transformer is	Neutral Current (of the protected line)
0221	Matching ratio I4/Iph for CT's	1,000

Figure 4-21 DIGSI® 4 setting the power system data — example

Power System Data 2

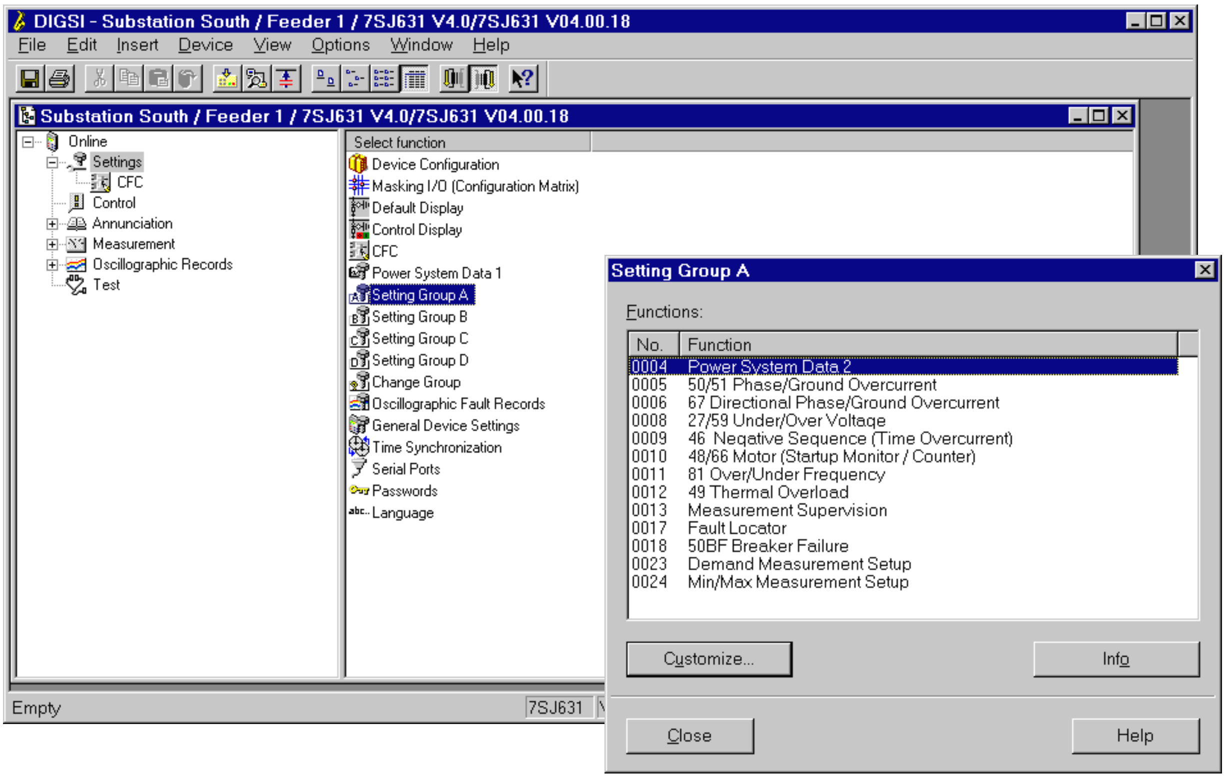
Power System Data 2 are part of the setting groups, which can be switched over during operation (see chapter 4.11). These include for example:

- ❑ Primary Operating Voltage
- ❑ Primary Operating Current
- ❑ Characteristic Data of the protected object etc.

4.11 Setting Groups

A SIPROTEC® 4 device has up to four setting groups A through D. The setting options for each group are the same; however, the applied settings can be, and are typically intended to be, different in each group. The active setting group can easily be changed while the device is in-service. A major advantage of multiple setting groups is the capability of optimizing the protection and control for the existing configuration of the network being protected. In other words, the protection and control can be changed as the network changes.

The setting groups are saved in the device. The setting groups can be changed during operation using DIGSI® 4, from the operator control panel on the device, by triggering binary inputs, or via the system interface.



No.	Function
0004	Power System Data 2
0005	50/51 Phase/Ground Overcurrent
0006	67 Directional Phase/Ground Overcurrent
0008	27/59 Under/Over Voltage
0009	46 Negative Sequence (Time Overcurrent)
0010	48/66 Motor (Startup Monitor / Counter)
0011	81 Over/Under Frequency
0012	49 Thermal Overload
0013	Measurement Supervision
0017	Fault Locator
0018	50BF Breaker Failure
0023	Demand Measurement Setup
0024	Min/Max Measurement Setup

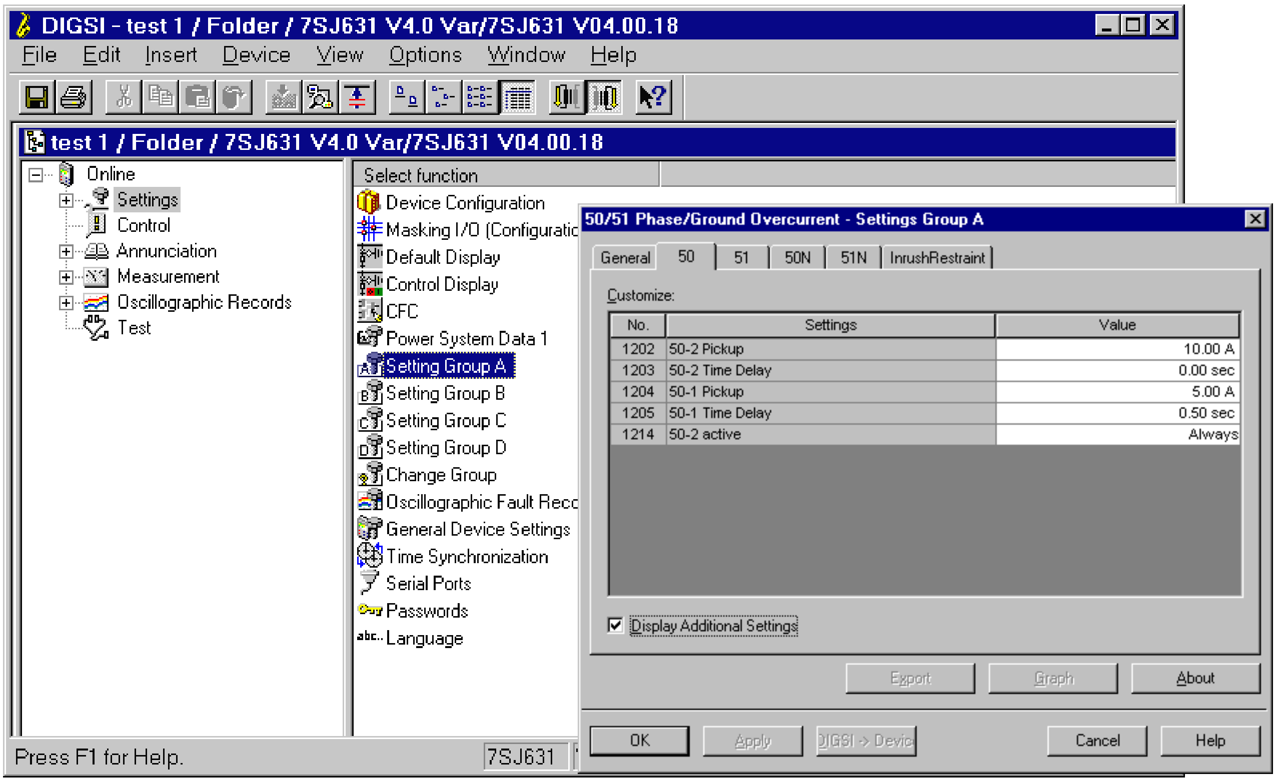
Figure 4-22 DIGSI® 4, Entering Settings in Setting Group A; Other Groups are Similar

Note:

Settings that are common to all protective functions, of one setting group are available in Power System Data 2.

Settings

Double click on a protective function shown in the listbox of Figure 4-22 to obtain a dialogue box for entering the settings associated with this function (Figure 4-23).



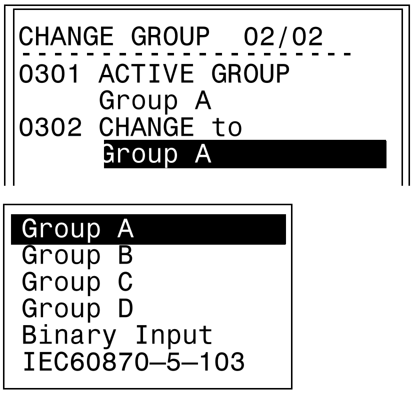
No.	Settings	Value
1202	50-2 Pickup	10.00 A
1203	50-2 Time Delay	0.00 sec
1204	50-1 Pickup	5.00 A
1205	50-1 Time Delay	0.50 sec
1214	50-2 active	Always

☑ Display Additional Settings

Figure 4-23 DIGSI® 4, entering settings for a protective function — example

Changing Setting Groups

The setting groups can be changed during operation using DIGSI® 4, from the operator control panel on the device, by triggering binary inputs, or via the system interface. The active setting group is indicated.



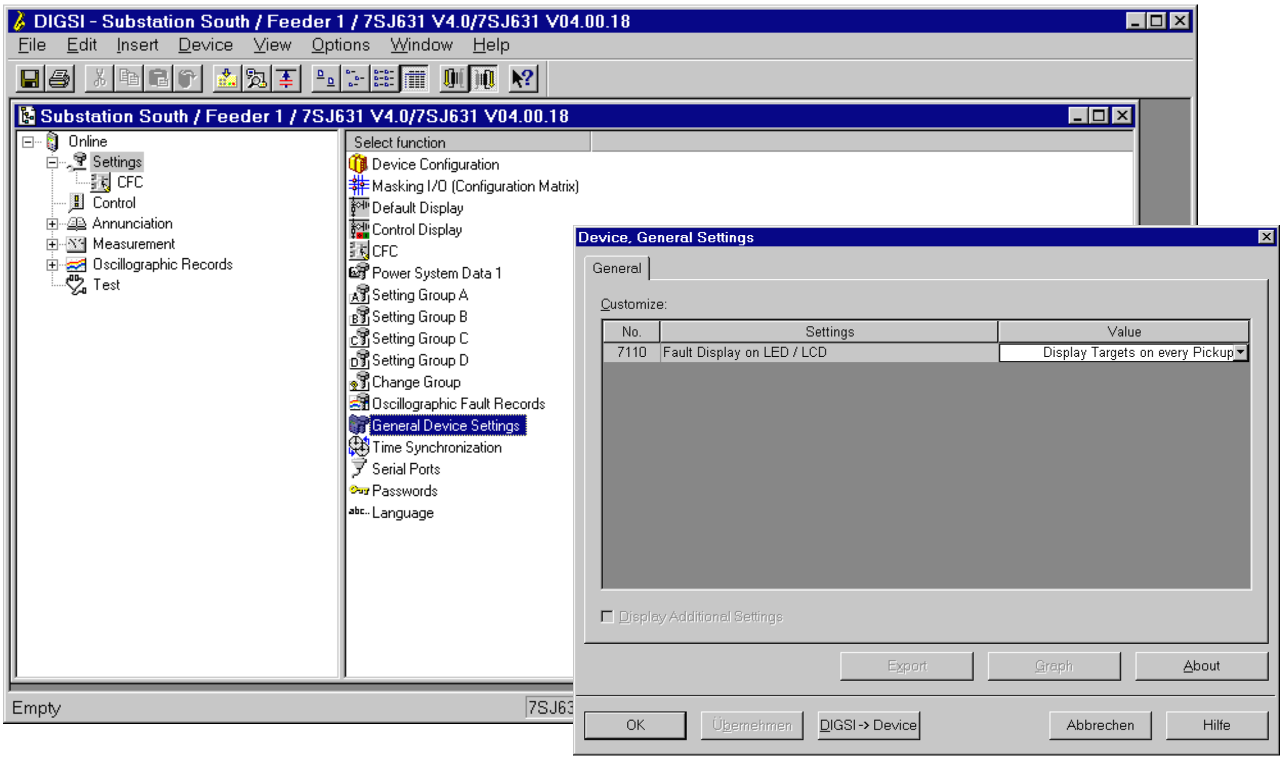
```
CHANGE GROUP   02/02
--------------------
0301 ACTIVE GROUP
     Group A
0302 CHANGE to
     Group A
```

```
Group A
Group B
Group C
Group D
Binary Input
IEC60870–5–103
```

Figure 4-24 SIPROTEC® 4 device, changing setting groups on the operator control panel

4.12 General Device Settings

The settings of the display to show information of network faults on the LEDs and the LCD on the front of the SIPROTEC® 4 device are defined in the DIGSI® 4 window shown in Figure 4-25.



No.	Settings	Value
7110	Fault Display on LED / LCD	Display Targets on every Pickup

Figure 4-25 DIGSI® 4, general device settings (targets) — example

The setting can also be changed at any time using the operator control panel on the SIPROTEC® 4 device: **`Main Menu`** → **`Settings`** → **`Device`**.

4.13 Time Synchronization

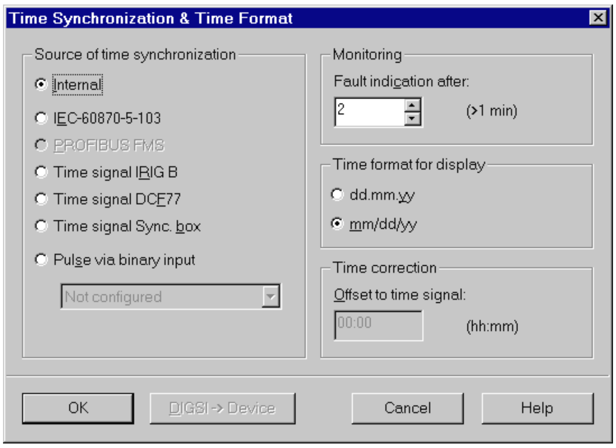
Time tracking in a SIPROTEC® 4 device can be implemented using:

- ❑ DCF77 Radio Receiver (Time Signal from PTB Braunschweig),
- ❑ IRIG-B Radio Receiver (Time Signal from the global positioning satellite (GPS) system),
- ❑ signals via the system interface from, for example, a substation control system,
- ❑ radio clock using a system-specific synchronizer box,
- ❑ minute impulses on a binary input.

Time signal generators are connected via a 9-pin D-subminiature port on the back panel of the device.

Setting of the time synchronization is done exclusively with DIGSI® 4:

- Double click on **`Time Synchronization`** in the data window and enter the settings.



Time Synchronization & Time Format

Source of time synchronization

- ● Internal
- ○ IEC-60870-5-103
- ○ PROFIBUS FMS
- ○ Time signal IRIG B
- ○ Time signal DCF77
- ○ Time signal Sync. box
- ○ Pulse via binary input

Not configured

Monitoring

Fault indication after: 2 (>1 min)

Time format for display

- ○ dd.mm.yy
- ● mm/dd/yy

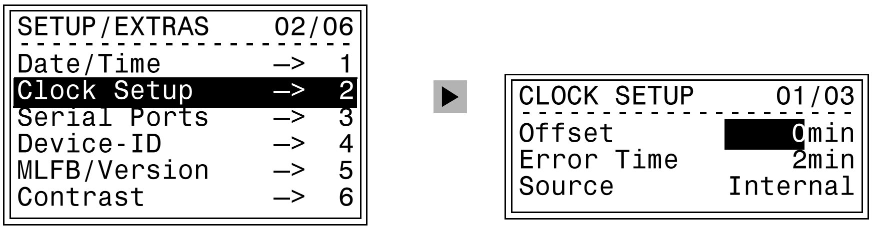
Time correction

Offset to time signal: 00:00 (hh:mm)

Figure 4-26 DIGSI® 4, setting of the time synchronization — example

Read-out on the Operator Control Panel

Using the SIPROTEC® 4 device operator control panel, the time synchronization settings can be retrieved: **`Main Menu`** → **`Settings`** → **`Setup/Extras`** → **`Clock Setup`**.



```
SETUP/EXTRAS       02/06
---------------------
Date/Time          –>  1
Clock Setup        –>  2
Serial Ports       –>  3
Device-ID          –>  4
MLFB/Version       –>  5
Contrast           –>  6
```

```
CLOCK SETUP       01/03
---------------------
Offset             0min
Error Time         2min
Source         Internal
```

Figure 4-27 Read-out of time synchronization settings from the operator control panel

4.14 Serial Interfaces

Devices in the SIPROTEC® 4 family can be equipped with up to four serial interfaces.

❑ The system interface on the back panel of the device is for connection to a central master control system. Depending on the type and the version of the device the following protocols are available:

- IEC 60870–5–103,
- PROFIBUS FMS,
- PROFIBUS DP,
- DNP3.0 Level 2,
- MODBUS ASCII/RTU

❑ The time control interface on the back panel of the device is used for connection of a radio-controlled clock (see Section 4.13).

❑ The operating interface is used for on-site connection to a PC, on which DIGSI® 4 is installed. Via this interface the settings can be loaded and all DIGSI® 4 operations can be applied, e.g. read-out of oscillographic fault records or event logs.

❑ The service interface on the back panel is for connection to a PC of remote diagnostic facilities, e.g. DIGSI® 4 via modem and/or a star connection. All DIGSI® 4 operations are possible via this interface.

In the DIGSI® 4 interface settings window (under “Serial Ports”) there are, among other items, settings for:

– transmission protocols and

– transmission speeds.

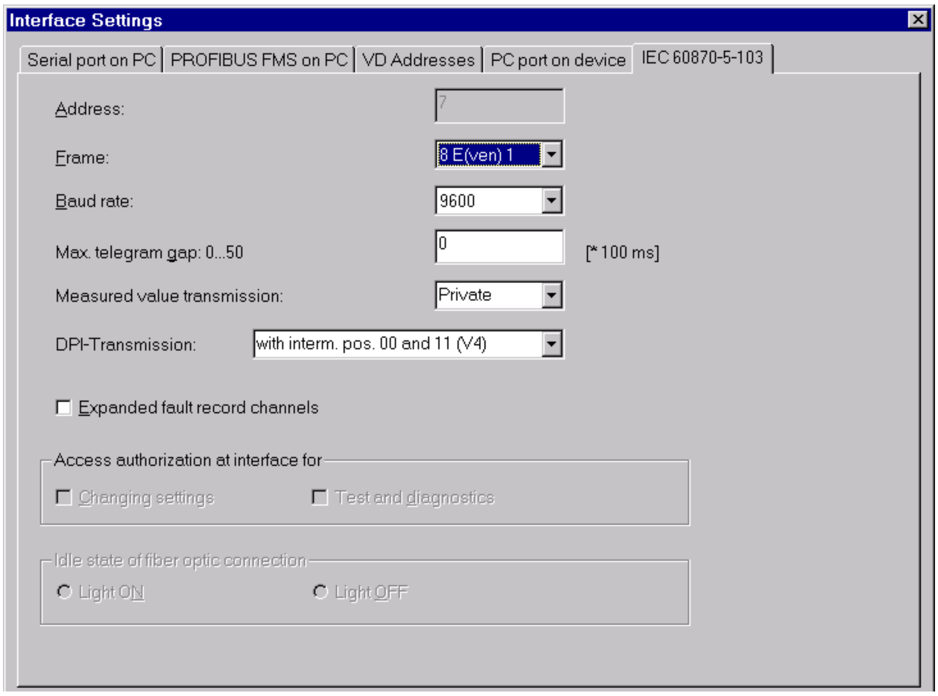
Note:

The system interface can be equipped with different modules for connection to other devices via optical fibres, RS485 (EIA485) bus or RS232 interface.

An example of how to proceed during the configuration of an IEC-interface is shown on the next page. In Chapter 5 there are more examples concerning the configuration of protocols.

To set the framing and baud rate:

- Double click on **`Serial Ports`** in the data window and enter the specific settings in the window that follows.



Address: 7

Frame: 8 E(ven) 1

Baud rate: 9600

Max. telegram gap: 0...50 0 [* 100 ms]

Measured value transmission: Private

DPI-Transmission: with interm. pos. 00 and 11 (V4)

☐ Expanded fault record channels

Access authorization at interface for

☐ Changing settings ☐ Test and diagnostics

Idle state of fiber optic connection

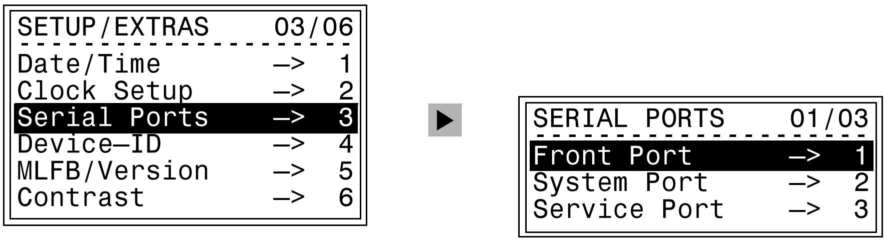
○ Light ON ○ Light OFF

Figure 4-28 DIGSI® 4, Interface Settings Window

- Read-out on the Operator Control Panel

The interface settings can be checked using the SIPROTEC® 4 device operator control panel.

In the main menu, select **`Settings`** → **`Setup/Extras`** → **`Serial Ports`** → following menus.



```
SETUP/EXTRAS     03/06
---------------------
Date/Time        ->  1
Clock Setup      ->  2
Serial Ports     ->  3
Device-ID        ->  4
MLFB/Version     ->  5
Contrast         ->  6
```

```
SERIAL PORTS     01/03
---------------------
Front Port       ->  1
System Port      ->  2
Service Port     ->  3
```

Figure 4-29 Read-out of serial interface settings from the operator control panel, example

Note:

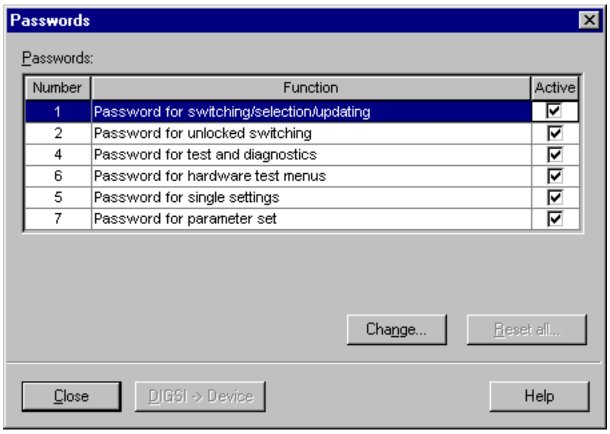
The serial interface for the connection of a time control device is described in the Subsection 4.14, Time Synchronization.

4.15 Passwords

Passwords are assigned to a SIPROTEC® 4 device to protect against unintended changes to the device or unauthorized operations from the device, such as switching.

The following access levels are defined:

- Switching/tagging/manual overwrite,
- Non-interlocked switching,
- Test and diagnostics,
- Hardware test menus,
- Individual settings,
- Setting Groups.



Number	Function	Active
1	Password for switching/selection/updating	☑
2	Password for unlocked switching	☑
4	Password for test and diagnostics	☑
6	Password for hardware test menus	☑
5	Password for single settings	☑
7	Password for parameter set	☑

Figure 4-30 DIGSI® 4, window indicating the active passwords — example

When using DIGSI® 4 or the operator control panel on the SIPROTEC® 4 device, a password is requested for the specific functions.

Note:

Password protection against unauthorized access is only in place during on-line operation. The passwords for setting changes are first activated when the settings are loaded into the device. The passwords are irrelevant in the DIGSI® 4 off-line mode.

To deactivate a password, you must know the password.

Passwords can only be changed using DIGSI® 4.

To change an existing password:

- In the Passwords window shown in Figure 4-30, double click on the password to be changed. In the next window (Figure 4-31), enter the present password, the new password, and confirm with the new password again and **OK**.

Figure 4-31 DIGSI® 4, changing passwords

Passwords are numbers up to 8 digits.

At delivery all passwords are set to **000000**.

Note:

If the password for setting group switching has been forgotten, a temporary password can be received from Siemens. The temporary password can be used to define a new password for this function.

The registration number of the **DIGSI® 4** ***software package will be required to receive the temporary password.***

■

Configuration

5

Configuration is the process of customizing the relay for the intended application.

To accomplish this, the following questions must be answered:

- Which functions are needed?
- Which data and measured quantities need to be retrieved via which inputs?
- Which information, measured data, and control actions need to be issued via which outputs?
- Which user-definable functions need to be performed in CFC (Continuous Function Chart)?
- Which information should be displayed on the front panel of the device?
- Which interfaces are to be used?
- Which time source is to be used to synchronize the internal clock?

This chapter describes in details how to configure the 7SA6.

5.1 Configuration of Functions

General

The 7SA6 relay contains a series of protective and additional functions. The scope of hardware and firmware is matched to these functions. Furthermore, commands (control actions) can be suited to individual needs of the protected object. In addition, individual functions may be enabled or disabled during configuration, or interaction between functions may be adjusted.

In the following, an example for the configuration of the functions:
A substation has overhead line and transformer feeders. Fault location must only be carried out on the overhead lines. This function therefore is disabled for devices on transformer feeders.

The available functions must be configured as ***`enabled`*** or ***`disabled`***. For individual functions, the choice between several alternatives may be presented, as described below.

Functions configured as ***`disabled`*** are not processed by the 7SA6. There are no messages, and corresponding settings (functions, limit values) are not displayed during detailed settings.

Note:

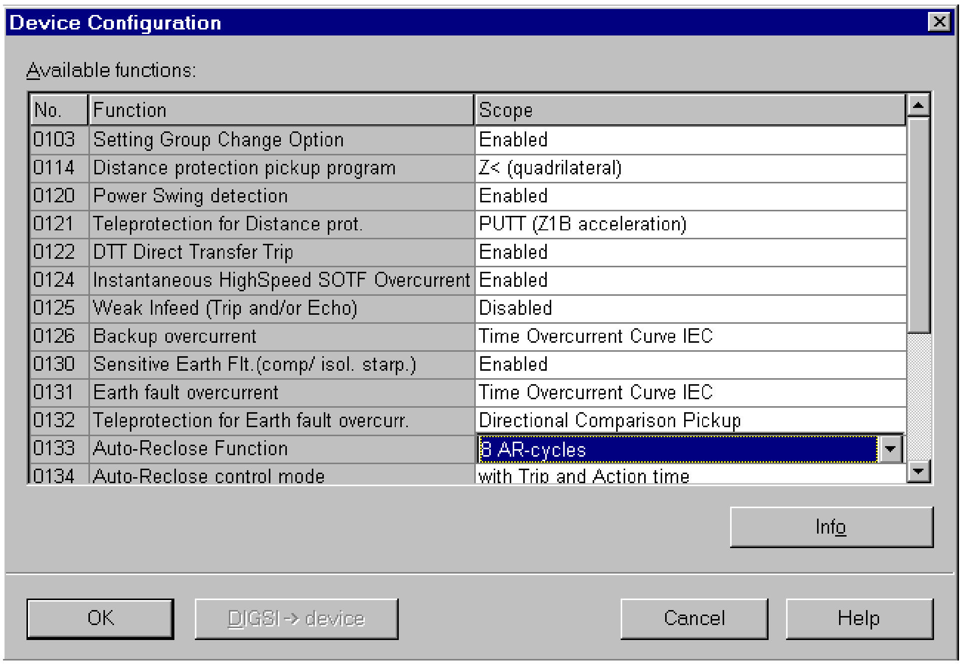
Available functions and default settings depend on the ordering code of the relay (see ordering code in the appendix for details).

Determination of Functional Scope

Configuration settings can be entered using a PC and the software program DIGSI® 4 and transferred via the operating interface on the device front, or via the rear serial service interface. Operation via DIGSI® 4 is described in Chapter 4 as well as in the DIGSI® 4 manual, order number E50417–H1176–C097.

Entry of password No. 7 (for setting modification, default 000000) is required to modify configuration settings (see Chapter 4, last paragraph). Without the password, the settings may be read, but cannot be modified and transmitted to the device.

The functional scope with the available options is set in the **`Device Configuration`** dialogue box (see Figure 5-1) to match equipment requirements. To change a function, click on the corresponding line under **`Scope`**, and select the desired option in the list which appears. The drop-down list closes automatically upon selection of an item.



No.	Function	Scope
0103	Setting Group Change Option	Enabled
0114	Distance protection pickup program	Z< (quadrilateral)
0120	Power Swing detection	Enabled
0121	Teleprotection for Distance prot.	PUTT (Z1B acceleration)
0122	DTT Direct Transfer Trip	Enabled
0124	Instantaneous HighSpeed SOTF Overcurrent	Enabled
0125	Weak Infeed (Trip and/or Echo)	Disabled
0126	Backup overcurrent	Time Overcurrent Curve IEC
0130	Sensitive Earth Flt.(comp/ isol. starp.)	Enabled
0131	Earth fault overcurrent	Time Overcurrent Curve IEC
0132	Teleprotection for Earth fault overcurr.	Directional Comparison Pickup
0133	Auto-Reclose Function	8 AR-cycles
0134	Auto-Reclose control mode	with Trip and Action time

Figure 5-1 **Device Configuration** dialogue box in DIGSI® 4 — example

Before closing the dialogue box, transfer the modified functional setting to the relay by clicking on the item **DIGSI** → **Device**. The data is stored in the relay in a non-volatile memory buffer.

The configured functional scope can be *viewed* at the front of the relay itself, but cannot be modified there. The settings associated with the functional scope can be found in the **MAIN MENU** under → **Settings** → **Device Config**.

Special Cases

Most settings are self-explanatory. Special cases are described below.

If the setting group change-over function is used, the setting in address 0103 **Grp Chge OPTION** must be set to ***Enabled***. In this case, it is possible to apply up to four different groups of function parameters (refer also to Subsection 6.1.2). During normal operation, a convenient and fast switch-over between these setting groups is possible. The setting ***Disabled*** implies that only one function parameter setting group can be applied and used.

Address 0110 **Trip mode** is only applicable for devices that can trip single-pole or three-pole. Set **1-/3pole** if single-pole tripping is also desired, i.e. if 1pole or 1-/3pole automatic reclosure is used. A prerequisite is that the device is provided with the internal automatic reclosure function or that an external automatic reclosure is used. Furthermore the circuit breaker is suited for single-pole control.

Note:

When having changed address 0110, first save the changes by clicking onto the **OK** button. Then open the dialogue box again, since other setting options depend on address 0110.

Different pickup modes can be selected for the Distance Protection. The characteristics of these modes are described in detail in Subsection 6.2.2. If the fault current magnitude is a reliable criterion for the distinction between fault closure and load operation (including tolerable overloading), set address 0114 **Dis. PICKUP** = ***I> (overcurr.)*** (overcurrent pickup, Subsubsection 6.2.2.1). If the voltage drop is also required as pickup criterion, select ***U/I*** (voltage-controlled overcurrent pickup, Subsubsection 6.2.2.2). For HV and EHV lines address setting **U/I/<phi>** (voltage & phase-angle dependent current pickup, see Subsubsection 6.2.2.3) may be needed. For the impedance starting the larges-set R-Zones and X-Zones of the distance zones form the pickup criteria. If the 0114 **Dis. PICKUP** = ***Disabled*** is set, the Distance Protection function and all functions related to it are not available.

Please take into consideration that the power swing supplement (refer also to Section 6.3) can only operate in conjunction with the impedance starting. Otherwise the supplement is disabled, even if address 0120 **Power Swing** is set to ***Enabled.***

If the Distance Protection is to be supplemented with a teleprotection system, the desired scheme can be selected in address 0121 **Teleprot. Dist.**. The following schemes are available: the permissive underreach transfer scheme via pickup ***PUTT (Pickup)*** and via the permissive overreach transfer scheme ***POTT***, the signal comparison scheme ***signal comparison***, the **Dir.Comp.Pickup** scheme, the ***UNBLOCKING*** scheme, the ***BLOCKING*** scheme as well as the schemes via Pilot wire comparison (**Pilot wire comp**) and reverse interlocking **Rev. Interlock.** These schemes are described in detail in Subsection 6.4.1. If the teleprotection supplement is not required for the distance protection, the setting must be ***Disabled***.

The tripping characteristic group of the time delayed overcurrent protection can be set in address 0126 **Backup overcurrent (Back-Up O/C)**. In addition to the definite time overcurrent protection (DT), an inverse time overcurrent protection can be configured in two different ways (depending on the order variant): either corresponding to the IEC characteristics (***TOC IEC***), or to the ANSI characteristics (***TOC ANSI***). The various characteristics are shown in the technical data. The time delayed overcurrent protection may naturally also be disabled (***Disabled***).

The tripping characteristic of the earth fault protection can also be selected, in this case in address 0131 **Earth fault overcurrent (Earth Fault O/C)**. In addition to the definite time overcurrent stage (DT), with up to three sub-stages, it is also possible (depending on the order variant) to configure an inverse earth fault stage. This inverse stage may either correspond to the IEC characteristic (***TOC IEC***) or to the ANSI characteristic (***TOC ANSI***), or to an inverse logarithmic characteristic (***TOC Logarithm.***). If an inverse tripping stage is not required, the stage that is usually referred to as “inverse” may also be used as a fourth definite time stage ***Definite Time***. Alternatively the earth fault protection function controlled by zero sequence voltage ***U0 inverse*** can be selected. The various characteristics are shown in the technical data. The earth fault protection may naturally also be disabled (***Disabled***).

If the device has an automatic reclosure, the addresses 0133 and 0134 are significant. If no reclosure is desired at the feeder for which 7SA6 is used or only an external device is used for reclosure, address 0133 **AUTO RECLOSE** is switched to ***Disabled***. Automatic reclosure is only permitted for overhead lines. It may not be used in any other case. If the protected object consists of a combination of overhead lines and other equipment (e.g. overhead line in a block with a transformer or overheadline/cable), reclosure is only permissible if it can be ensured that it can only take place in the event of a fault on the overhead line.

Otherwise set the number of desired reclosure attempts there. You can select ***1 AR cycle*** to ***8 AR cycles***. You can also set ***ADT*** (adaptive dead time): in this case the behavior of the automatic reclosure depends on the cycles of the remote end. However, the number of cycles must be set at least at one end of the line and this end must have a reliable infeed. The other end or ends may operate with adaptive dead time. See section 6.12.1 for detailed explanations.

The ***AR Control Mode*** under address 0134 allows a total of four options. You can determine whether the sequence of automatic reclosure cycles is defined by the fault situation of the *pick-up* of the starting protection function(s) (only for three-pole tripping) or by the type of *trip command*. The automatic reclosure can also operate *with* or *without* action time.

The ***Trip with T-action*** or ***Trip without T-action*** command setting is preferred when single-pole or single/three-pole automatic reclosure cycles are planned and are possible. In this case different dead times (for every interrupt cycle) are possible after single-pole tripping and after three-pole tripping. The tripping protection function determines the type of tripping: single-pole or three-pole. The dead time is controlled dependent on this.

Using the ***Pickup with T-action*** or ***Pickup without T-action*** setting, different dead times can be set for the auto-reclosure cycles after single, two and three-phase faults. The fault detection configuration of the protection functions at the time the trip command disappears is decisive. This operating mode also enables the dead times to be made dependent on the type of fault for three-pole interrupt cycles. Tripping is always three-pole.

The ***Trip with T-action*** setting provides an action time for every interrupt cycle. This is started by the general starting signal (i. e. logic OR combination of all internal and external start signals of all protection functions which are configured to start the automatic reclosure function. If there is still no trip command when the action time expired, the corresponding automatic reclosure cycle cannot be executed. See section 6.12.1 for further explanations. For the time graded protection this setting is recommended. If the protection function to operate with reclosure does not have a general fault detection signal for starting the action times, select the setting ***Trip without T-action***.

In address 0138 **Fault Locator** for fault location the user determines not only the settings ***Enabled*** and ***Disabled***, but also the function that the fault distance is directed via binary outputs as BCD-Code (4 bit units, 4 bit tens, 1 Bit hundreds as well as “Data valid” (***with BCD-output***). The required number of output relays (FNo 1153 to 1152) must therefore be available and allocated.

For the trip circuit supervision the number of trip circuits that shall be monitored is set in address 0140 **TripCirc.Superv** with the following settings: ***1 Trip circuit***, ***2 Trip circuits*** or ***3 Trip circuits*** if they are required (Disabled).

According to the order variant the device is provided with analog outputs (0 to 20 mA). 2 outputs can be located on Port B (Mounting location “B”), another 2 on Port D (mounting location “D”). In address 0150 to 0153 the user can select which analog values shall be output. Some measured values and the location of the fault are also available.

5.1.1 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	3pole only 1-/3pole	3pole only	Trip mode

Addr.	Setting Title	Setting Options	Default Setting	Comments
114	Dis. PICKUP	Z< (quadrilat.) I> (overcurr.) U/I U/I/<phi> Disabled	I> (overcurr.)	Distance protection pickup program
120	Power Swing	Disabled Enabled	Disabled	Power Swing detection
121	Teleprot. Dist.	PUTT (Z1B) PUTT (Pickup) POTT Dir.Comp.Pickup UNBLOCKING BLOCKING Rev. Interlock Pilot wire comp Disabled	Disabled	Teleprotection for Distance prot.
122	DTT Direct Trip	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	SOTF Overcurr.	Disabled Enabled	Disabled	Instantaneous HighSpeed SOTF Overcurrent
125	Weak Infeed	Disabled Enabled	Disabled	Weak Infeed (Trip and/or Echo)
126	Back-Up O/C	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent
130	Sens. Earth Flt	Disabled Enabled	Disabled	Sensitive Earth Flt.(comp/ isol. starp.)
131	Earth Fault O/C	Disabled TOC IEC TOC ANSI TOC Logarithm. Definite Time U0 inverse	Disabled	Earth fault overcurrent
132	Teleprot. E/F	Dir.Comp.Pickup UNBLOCKING BLOCKING Disabled	Disabled	Teleprotection for Earth fault overcurr.
133	Auto Reclose	Disabled 1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT	Disabled	Auto-Reclose Function
134	AR control mode	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Pickup w/ Tact	Auto-Reclose control mode

Addr.	Setting Title	Setting Options	Default Setting	Comments
135	Synchro-Check	Disabled Enabled	Disabled	Synchronism and Voltage Check
137	Overvoltage	Disabled Enabled	Disabled	Overvoltage
138	Fault Locator	Disabled Enabled with BCD-output	Enabled	Fault Locator
139	BREAKER FAILURE	Disabled Enabled	Disabled	Breaker Failure Protection
140	TripCirc.Superv	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
142	Ther. OVERLOAD	Disabled Enabled	Disabled	Thermal overload protection
150	AnalogOutput B1	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output B1 (Port B)
151	AnalogOutput B2	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output B2 (Port B)
152	AnalogOutput D1	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output D1 (Port D)
153	AnalogOutput D2	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output D2 (Port D)

5.2 Configuration of the Binary Inputs and Outputs

General

Upon delivery, the display on the front panel of the relay, some of the function keys, the binary inputs and outputs (output contacts) are assigned to certain information. These assignments may be modified, for most information, allowing adaptation to the local requirements.

During configuration, certain information within the relay is assigned to certain physical interfaces (e.g., binary inputs and output contacts) or logical interfaces (e.g., user-defined logic, CFC).

It must be determined *which information* should be linked *with which device interface*. It may also be determined which properties the information and the interfaces should have.

Messages and statistical values from earlier events can be lost during configuration; therefore, operational and fault data and statistic counters which are memorized in the relay should be read and saved if desired, prior to changing the configuration.

5.2.1 Preparation

Before configuration is started, the overall interfacing requirements must be assessed. The required inputs and outputs must be compared with the number of physical inputs and outputs present on the relay. The types of indications and commands, and their requirements, should be taken into account.

Indications

Indications may be device information regarding events and conditions that can be transmitted via output contacts (e.g. start-up of the processor system or a trip signal initiated by a protective function). These are defined as **output indications**.

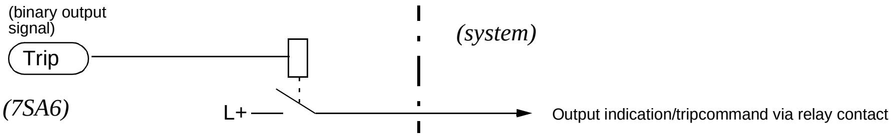


Figure 5-2 Output indication (OUT)

Indications also include information from the substation to the relay regarding events and conditions in the system (e.g. position or condition of a circuit breaker). These are defined as **input indications**. Input indications with one binary input are **single point indications** (SP). Two binary inputs whose normal conditions are opposite, and which are monitored by the relay, are required for a **double point indication** (DP).

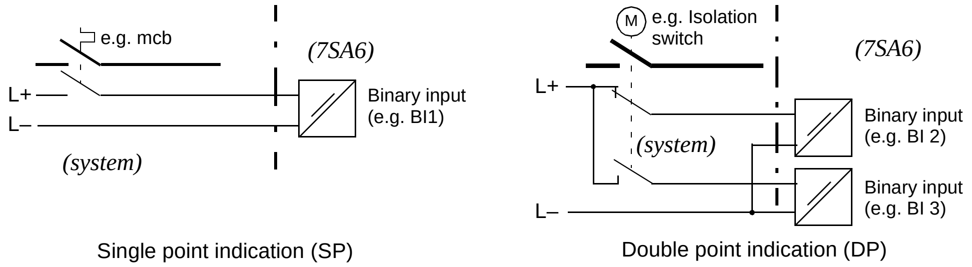


Figure 5-3 Input indications

Additionally to the predefined input and output indications new customer specific indications and even control commands for switching devices may be created.

Commands

Commands are output indications that are especially designed for the output of control signals to switchgears in the system.

- ☐ Set for each device whether it should trip 1pole, $1^1/_2$pole or 2pole, with single or double point indication, with or without feedback (see Table 5-1 and Figure 5-5 to 5-10). Thus the necessary quantity of the information to be processed is calculated and the type of command is determined.
- ☐ Allocate the available binary inputs and outputs according to the requirements. Please observe the following:
  - The annunciations and commands of a switchgear must be allocated to binary inputs and outputs numbered consecutively;
  - The trip command must always be located before the close command;
  - There may be restrictions due to grouping of binary inputs and outputs of a SIPROTEC®-device

As soon as the type of command is defined DIGSI® 4 allocates the necessary number of binary outputs of a device. The corresponding outputs relays are numbered consecutively. This has to be observed for the assignment of the output relay to the control functions.

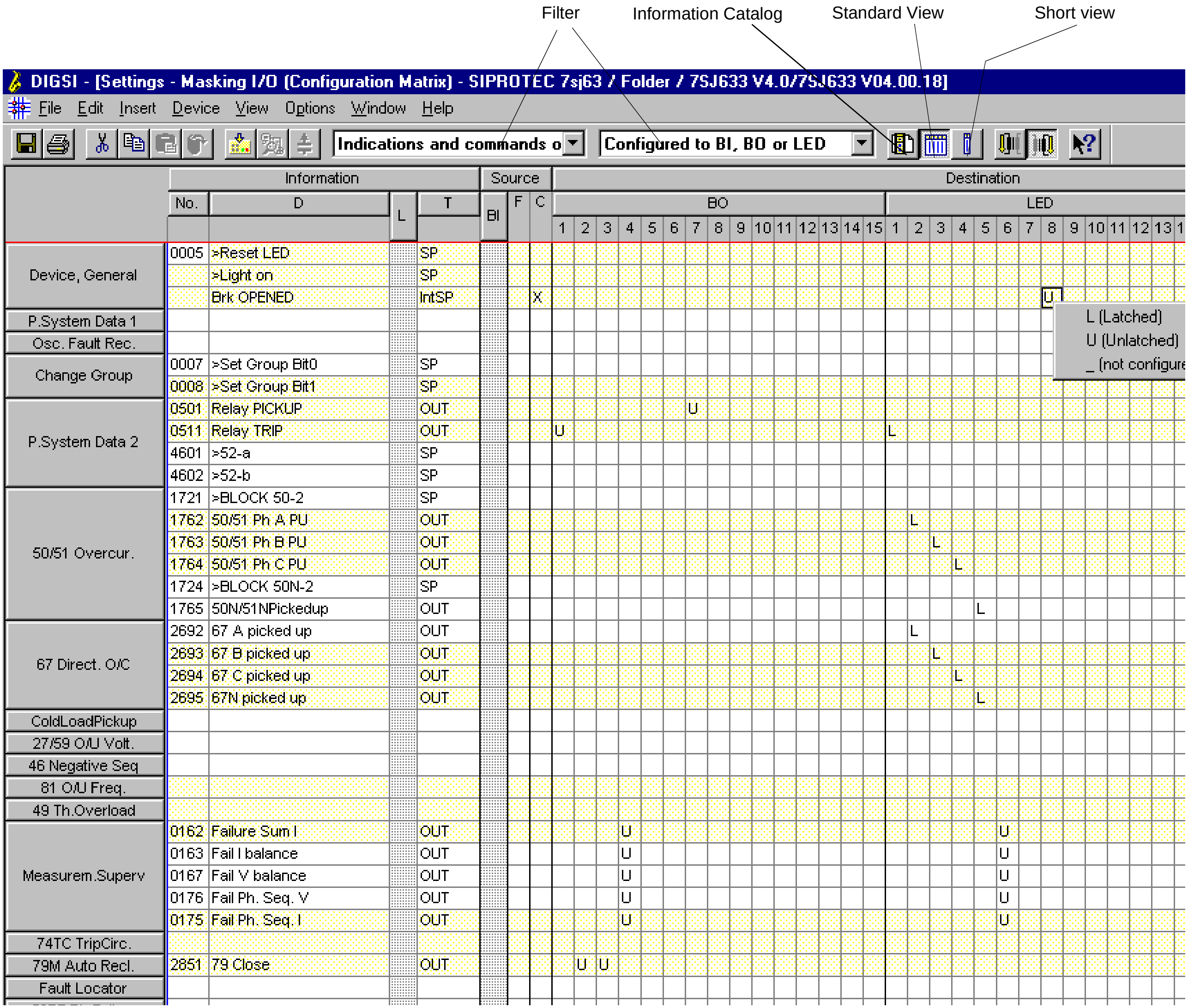
Table 5-1 lists the most important command types as they are offered in the configuration matrix (also refer to the paragraph “Binary Outputs for Switching Devices” in Subsection 5.2.5). All double commands (with or without feedback) are also available as transformer tap commands. The following figures (from 5-5 to 5-13) show timing diagrams, control settings, and the order of relay allocations for frequently used command types.

5.2.2 Structure and Operation of the Configuration Matrix

General

This section deals with the structure and operation of the configuration matrix. The configuration matrix can be viewed without making any configuration changes. Information characteristics and configuration steps are described in Sub-section 5.2.4, and configuration is demonstrated in Sub-section 5.2.5.

Configuration of information is performed, using a PC and the DIGSI® 4 software program, via the operator or service interface. The configuration is represented in DIGSI® 4 as a matrix (Figure 5-4). Each row is assigned to an information of the device. It is identified by a function number **No**, LCD text (display text **D**), an explanation (long text **L**, minimized in Figure 5-4), and an information type **T**. The columns give the interfaces which should be the sources and/or destinations of the information. In addition to physical device inputs and outputs, there may be internal interfaces for user definable logic (CFC) (see also Section 5.3), message buffers, or the device display.



Indications and commands o

Configured to BI, BO or LED

	Information				Source			Destination																												
	No.	D	L	T	BI	F	C	BO															LED													
								1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	1
Device, General	0005	>Reset LED		SP																																
		>Light on		SP																																
		Brk OPENED		IntSP			X																							U						
P.System Data 1																																				
Osc. Fault Rec.																																				
Change Group	0007	>Set Group Bit0		SP																																
	0008	>Set Group Bit1		SP																																
P.System Data 2	0501	Relay PICKUP		OUT										U																						
	0511	Relay TRIP		OUT				U															L													
	4601	>52-a		SP																																
	4602	>52-b		SP																																
50/51 Overcur.	1721	>BLOCK 50-2		SP																																
	1762	50/51 Ph A PU		OUT																				L												
	1763	50/51 Ph B PU		OUT																					L											
	1764	50/51 Ph C PU		OUT																						L										
	1724	>BLOCK 50N-2		SP																																
	1765	50N/51NPickedup		OUT																							L									
67 Direct. O/C	2692	67 A picked up		OUT																				L												
	2693	67 B picked up		OUT																					L											
	2694	67 C picked up		OUT																						L										
	2695	67N picked up		OUT																							L									
ColdLoadPickup																																				
27/59 O/U Volt.																																				
46 Negative Seq																																				
81 O/U Freq.																																				
49 Th.Overload																																				
Measurem.Superv	0162	Failure Sum I		OUT							U																	U								
	0163	Fail I balance		OUT							U																	U								
	0167	Fail V balance		OUT							U																	U								
	0176	Fail Ph. Seq. V		OUT							U																	U								
	0175	Fail Ph. Seq. I		OUT							U																	U								
74TC TripCirc.																																				
79M Auto Recl.	2851	79 Close		OUT					U	U																										
Fault Locator																																				

L (Latched)
U (Unlatched)
_ (not configure

Figure 5-4 Extract from the configuration matrix in the DIGSI® 4 user interface — example

Information in the rows is assigned to appropriate interfaces in the columns via an entry in the intersecting cell. This establishes which information controls which destination, or from which source information is received.

In the configuration matrix, not only the configuration is shown, but also the type of configuration. For example, information regarding an event which is configured for display on a LED may be latched or unlatched.

The possible combinations of information and interfaces is dependent on the information type. Impossible combinations are filtered out by DIGSI® 4 plausibility checks.

The matrix columns are divided into three types: Information, Source, and Destination. To the left of the matrix, information is divided into information groups.

Reducing the Matrix

The matrix may become very extensive because of the amount of information contained within. Therefore, it is useful to limit the display via filtering to certain information, thus reducing the number of rows.

The tool-bar below the menu bar contains two pull-down menus by which information may be filtered. Using the first menu, the rows can be limited to indications, commands, indications and commands, or measured and metered values. The second menu allows to display only configured information, information configured to physical inputs and outputs, or non-configured information.

A further reduction in the number of rows is possible, by compressing an information group to one row. This is done by double-clicking on the group label area (located to the far left). If this is done, the number of rows is reduced, allowing the user to focus on the information groups of interest. A second double-click restores all rows in the information group.

To limit the width of the matrix, two possibilities exist: The tool bar allows to switch between standard view and short view, or individual columns can be hidden.

In the latter case you double-click on the field with the column heading thus hiding the contents of the associated column. In the example of Figure 5-4, the long text (**L**) under **Information** is not shown. By double-clicking on long text field (**L**), the long text becomes visible again, and vice versa.

With two options on the tool bar you may switch between standard view and short view, thus modifying the *all* columns under the **Source** and **Destination** title blocks. The columns associated with the **Information** block remain unchanged.

In standard view, all binary inputs, binary outputs, and LEDs are accessible, as shown in Figure 5-4 for the binary outputs and LEDs.

In short view (not illustrated in the figure), a common column is displayed for each of the sources and destinations. Within the individual cells of a common column, information regarding the configuration type is available in an abbreviated form. For example, the abbreviation **H1** in a cell of the common binary input (BI) column means that the corresponding information is configured with active voltage (**H**igh) to binary input **1**. If an information is assigned to several sources or destinations, the abbreviations of all destinations are shown, separated by commas. If there is not enough space in the cell for the simultaneous display of all abbreviations, a double-click on the cell and movement of the text cursor within the cell allows to scroll through the entire contents of the cell.

To switch between standard view and short view, the menu item **View** can also be used.

Information Groups

All information is organized into information groups. In addition to general relay information, information regarding individual device functions is also included.

By clicking on an information group title area with the *right* mouse button, a context menu can be viewed, which contains information regarding the properties of that information group. This is particularly useful if the information group is associated with a function that contains parameter settings.

If the information group belongs to a protective function for the relay, a dialogue window can be accessed in which the settings of the protective function may be read out and modified. The procedure for entering settings of a protective function is described in general in Chapter 4. Details regarding the settings for various functions are found in Chapter 6.

The settings group to be processed may be selected via the menu item **View** → **Setting Group**.

Information

The column header **Information** contains the function number, the LCD text (display text), an explanation (long text), and the information type. The following abbreviations are used for the information types:

- Annunciations:

– SP	Single Point Indication (binary input, e.g. LED reset, refer also to subsection 5.2.1)
– DP	Double Point Indication (binary input, refer also to subsection 5.2.1)
– OUT	Output Indication (protection output signals e.g. pickup, trip ...)
– IntSP	Internal Single Point Indication,
– IntDP	Internal Double Point Indication.
– TxTap	Transformer Tap Indication

- Control Commands for switching devices (refer to subsection 5.2.3):

– C_S	Single Command with Single Output without Feedback,
– CF_S	Single Command with Single Output with Feedback,
– C_SN	Single Command with Single Output Negated without Feedback,
– C_D2	Double Command (2 relays) with Single Outputs without Feedback,
– CF_D2	Double Command (2 relays) with Single Outputs with Feedback,
– C_D12	Double Command with Single Trip Outputs and Double Close Outputs without Feedback,
– CF_D12	Double Command with Single Trip Outputs and Double Close Outputs with Feedback,
– C_D3	Double Command (3 relays) with Single Outputs and Common Output without Feedback,
– CF_D3	Double Command (3 relays) with Single Outputs and Common Output with Feedback,
– C_D4	Double Command (4 relays) with Double Outputs without Feedback,
– CF_D4	Double Command (4 relays) with Double Outputs with Feedback,
– C_D2N	Double Command (2 relays) with Single Outputs Negated without Feedback,
– CF_D2N	Double Command (2 relays) with Single Outputs Negated with Feedback.

- Measured Values:

– MV	Measured Value,
– MVU	Measured Value, User Defined,
– MVT	Measured Value with Time,
– LV	Limit Value,
– LVU	Limit Value, User Defined.

- Metered Values:

– MVMV	Metered Value of Measured Value,
– PMV	Pulse Measured Value.

The information contains various properties depending on the information type, which are partially fixed and may be partially influenced.

Source

The source denotes the origin of the information which the matrix receives for further processing. Possible sources are:

- BI Binary Input,
- F Function key, which may serve to introduce a switching action,
- C CFC, i.e., message comes from user-definable logic,
- S System Interface.

Destination

The destination indicates to which interface the information is forwarded. Possible destinations are:

- BO Binary Output,
- LED LED display on the Device Front Panel,
- O Indication Buffers of the Device (Operational Indication Buffer, Sensitive Ground Fault Indication Buffer (if available), Trip Log Buffer,
- S System Interface,
- C CFC, Information is processed by CFC Program of the User-definable Logic
- B Control Display (C), if an information is to be displayed in the Control Display of the device), Default Display (D), if an information is to be displayed in the Default Display of the device
- CM Control of switchgears, if a switchgears is to be indicated in the Control Menu of the device

5.2.3 Control Commands for Switching Devices

Control commands are output indications which are specially configured for the transmission of control signals to power plant switching devices (circuit breakers, isolators, etc.). Once the type of a command has been established, DIGSI® 4 reserves a corresponding number of output relay contacts. For this, the corresponding output relays are numbered consecutively. This must be observed when wiring the relays to the corresponding power plant to be controlled.

Table 5-1 lists the most important command types as they are offered for the configuration of the matrix (also refer to the paragraph “Binary Outputs for Switching Devices” in Subsection 5.2.5). All double commands (with or without feedback) are also available as transformer tap commands. The following Figures (from 5-5 to 5-13) show timing diagrams, control settings, and the order of relay allocations for frequently used command types.

Table 5-1 Most important command types

Single **C**ommand with Single Output	With 1 relay	without feedback with **f**eedback	**C_S** **CF_S**
Double **C**ommand with Single Output	With **2** relays	without feedback with **f**eedback	**C_D2** **CF_D2**
Double **C**ommand with Single Outputs plus Common Output	With **3** relays	without feedback with **f**eedback	**C_D3** **CF_D3**
Double **C**ommand with Single Output (common to a bus)	With at least **3** relays	without feedback with **f**eedback	**C_D2** **CF_D2**

Table 5-1 Most important command types

Double **C**ommand with Double Output	With 4 relays	without feedback with **f**eedback	**C_D4** **CF_D4**
Double **C**ommand with Double (Close) and Single (Trip) Output	With 3 relays	without feedback with **f**eedback	**C_D12** **CF_D12**
Double **C**ommand Motor Control (Anti-Clockwise Rotation / Clockwise Rotation)	With **2** relays, 2 contacts each	without feedback with **f**eedback	**C_D2** **CF_D2**
Double **C**ommand with Single Output for Three-Position Disconnector **D**ouble **C**ommand with Single Output, Negated	With **2** common relays, 2 contacts each	for disconnector function (with feedback) for earth switch function	**CF_D2** **CF_D2N**

For double commands, the first output relay is selected using DIGSI® 4. The other output relays will be automatically selected by DIGSI® 4. In the sequence of output relays, **each TRIP command is placed before the associated CLOSE command**. For commands with feedback indications, DIGSI® 4 reserves another line in the configuration matrix for the switching device feedback indications. Here, **the OPEN position feedback is placed before the CLOSED position feedback** as well.

For Figures 5-5 through 5-10, the following abbreviations apply:

– C+	Relay contact for closing
– C–	Relay contact for tripping
– CC	Relay contact is common
– CCC	Relay contact is common to a bus
– L+; L–	Control voltage

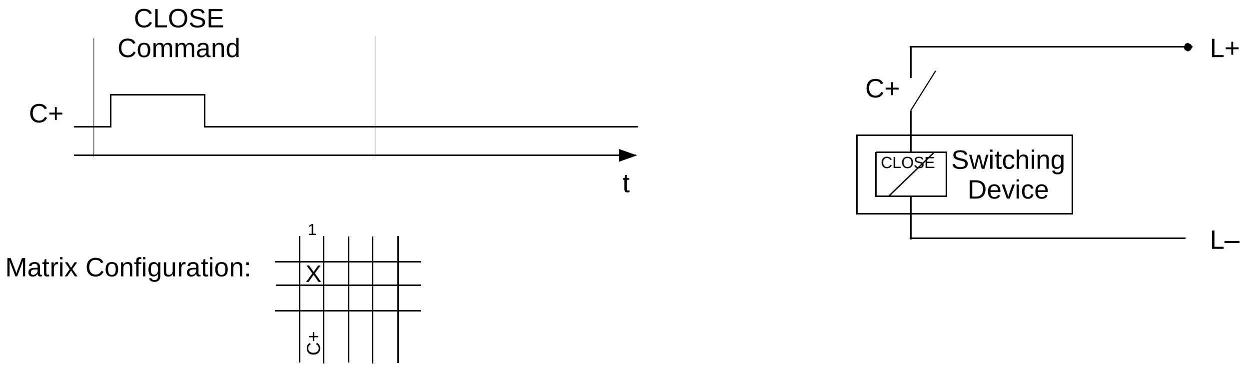


Figure 5-5 Single command with single contact

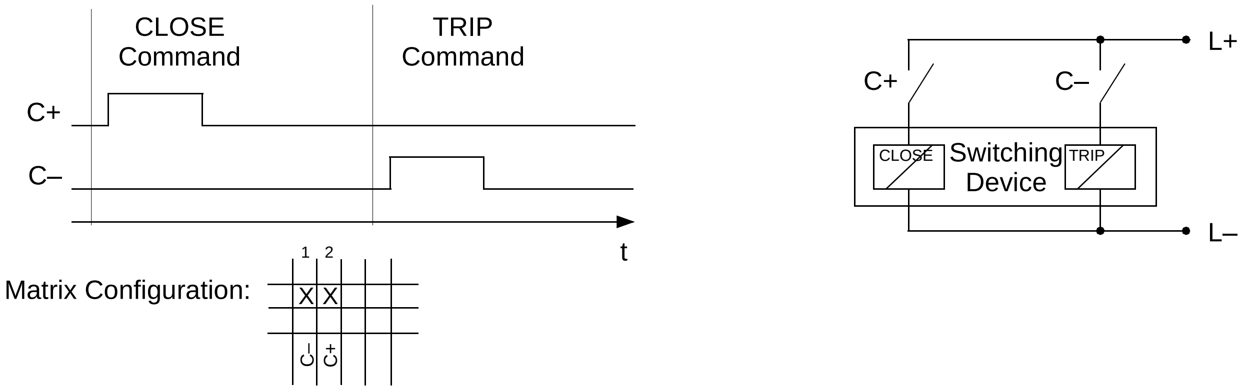


Figure 5-6 Double command with single contacts

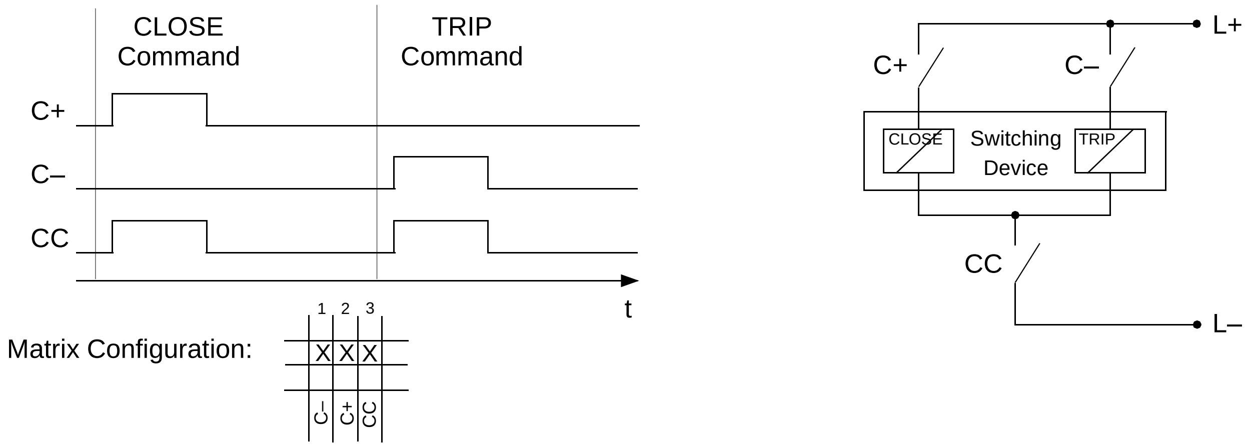


Figure 5-7 Double command with single contacts plus common contact

In contrast to other output relays the relay common to a bus is allocated to different switching devices (see Figure 5-8). For security reasons the switching devices cannot be switched at the same time.

The relay common to a bus automatically adopts the properties of the controlling relay, i. e. it is not configured individually. The output is single-pole.

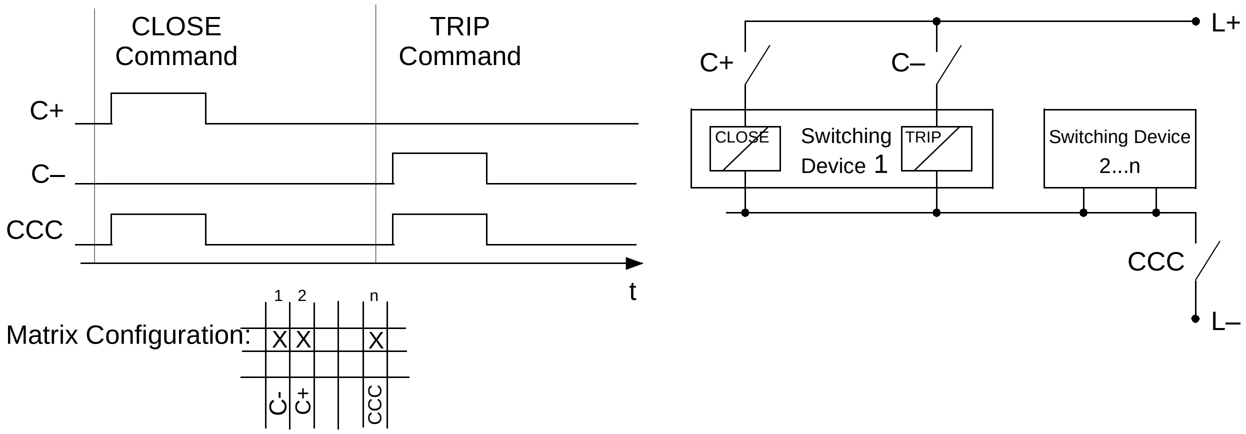


Figure 5-8 Double command with single output common to a bus

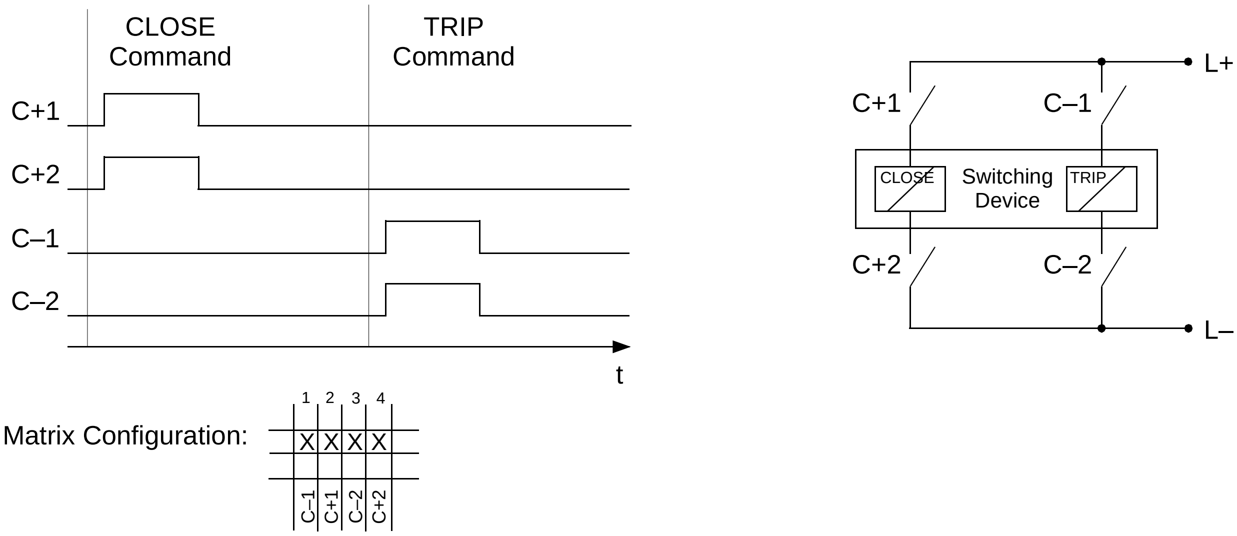


Figure 5-9 Double command with double contacts (with 4 relays)

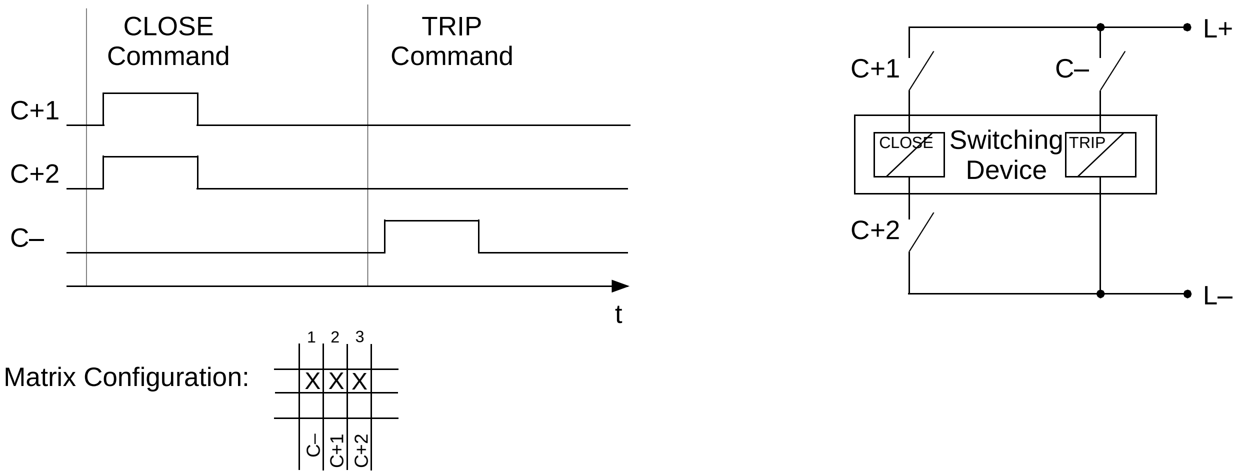


Figure 5-10 Double command with double and single contacts (with 3 relays)

For the motor control illustrated in Figure 5-11 the following can be realized:

– via CLOSE command	anti-clockwise rotation
– via TRIP command	clockwise rotation
– and in quiescient state	TRIP

The power relays with 2 NO contacts (each) to be used for this purpose are interlocked against eachother so that only *one* relay can be connected.

When using the power relay for a motor controlled **three-position disconnector** please observe the following:

For the disconnector and earth switch function the same output relays are controlled by two different commands. Since both end positions are achieved by different rotation of the motor, one of the two commands must be negated. Therefore the command types e. g. **`CF_D2`** and **`CF_D2N`** are to be applied in this case.

Due to the hardware platform **a double command with single output** via 2 relays with one pair of contacts each can only be applied with restrictions. For this purpose use the 2 power relays provided for motor control (only available in device versions with power relays) (see Figure 5-12 and 5-13). Observe the internal grouping (see also “General Diagrams” in Subsection 1.2, Appendix A, Figures A-4, A-7, A-11, A-14, A-16 and A-19).

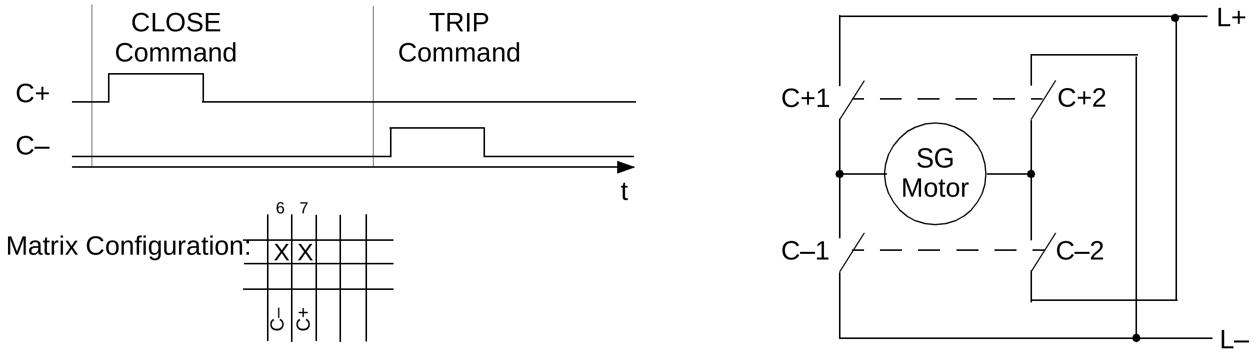


Figure 5-11 Double command motor control (anti-clockwise rotation / clockwise rotation) via two power relays with two contacts each

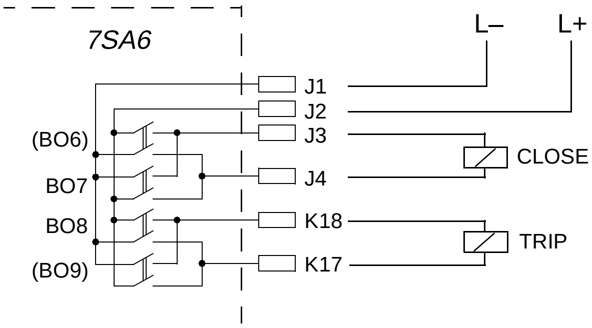
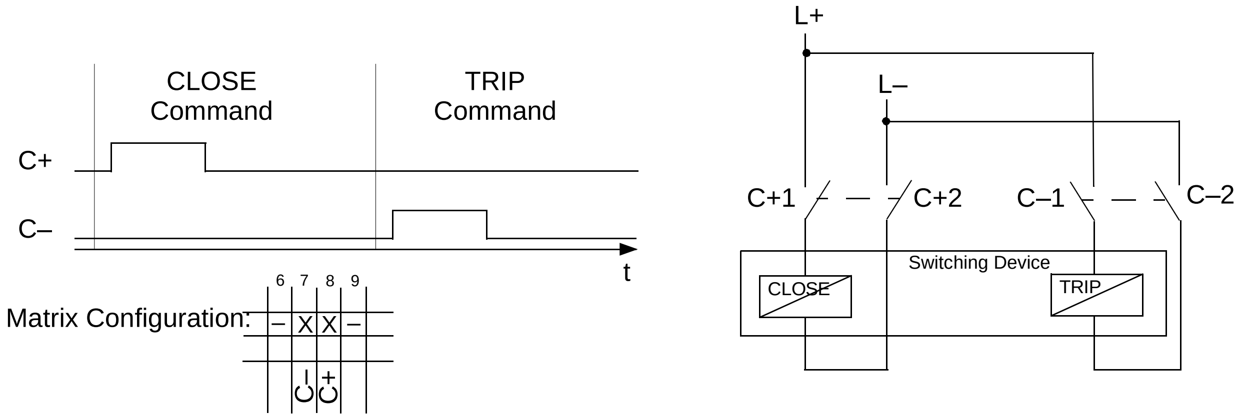


Figure 5-12 Extract of a general diagram of the variants with power relays BO 6 to BO 9 (as an example) showing the external connections according to Figure 5-13



The relays characterized with a minus-symbol must not be connected in different way !

Figure 5-13 Single command with 2 outputs via 2 power relays with 2 contacts each (setting: “Double Command with Single Output”) - example

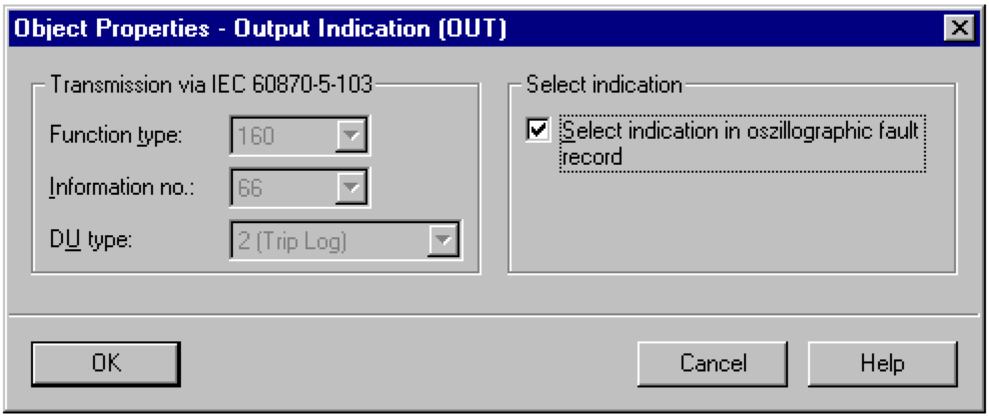
5.2.4 Establishing Information Properties

General

Different types of information contain different types of properties. To view the properties associated with a specific information unit (indication, command, etc.), position the mouse on the specific row under `Information`, and then use the *right* mouse button to access a context menu where `Properties` can be selected.

For example, if the cursor is positioned on a specific output indication, the *right* mouse button is pressed, and the menu item `Properties` is selected, then a choice of whether the indication should appear in the oscillographic fault records (Figures 5-14, 5-15, and 5-16) is presented. For internal single point indications, the default status of the indication (on, off, or undefined) after device reset can be selected as well (Figure 5-15).

Output Indication (OUT)



Object Properties - Output Indication (OUT)

Transmission via IEC 60870-5-103

Function type: 160

Information no.: 66

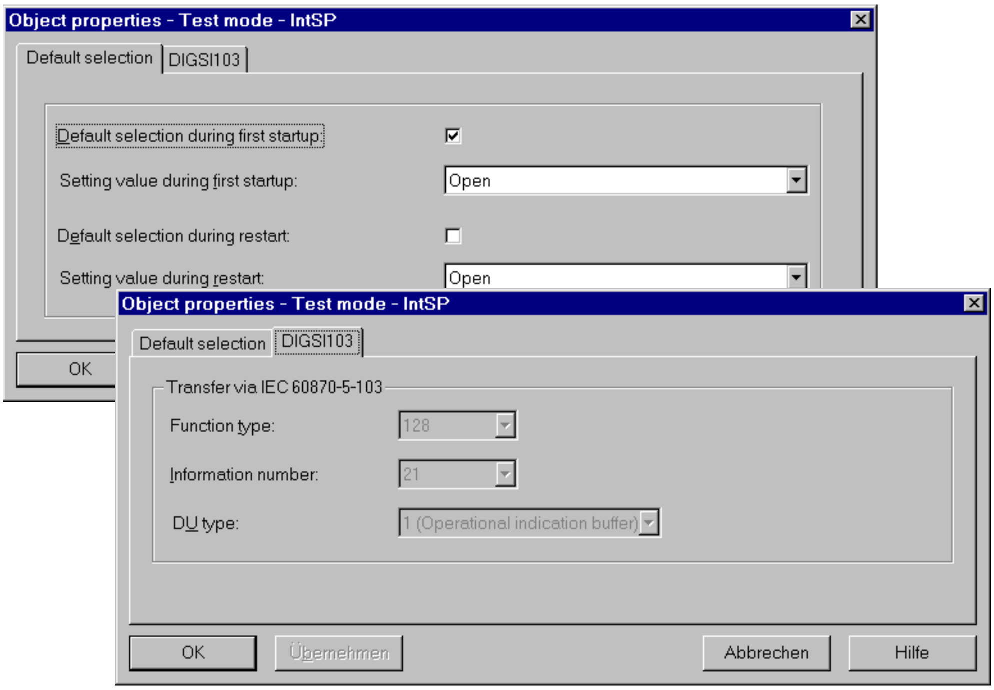
DU type: 2 (Trip Log)

Select indication

☑ Select indication in oszillographic fault record

Figure 5-14 Information properties — example for the information type “Output Indication” (OUT)

Internal Single Point Indication (IntSP)



Default selection during first startup: ☑

Setting value during first startup: Open

Default selection during restart: ☐

Setting value during restart: Open

Transfer via IEC 60870-5-103

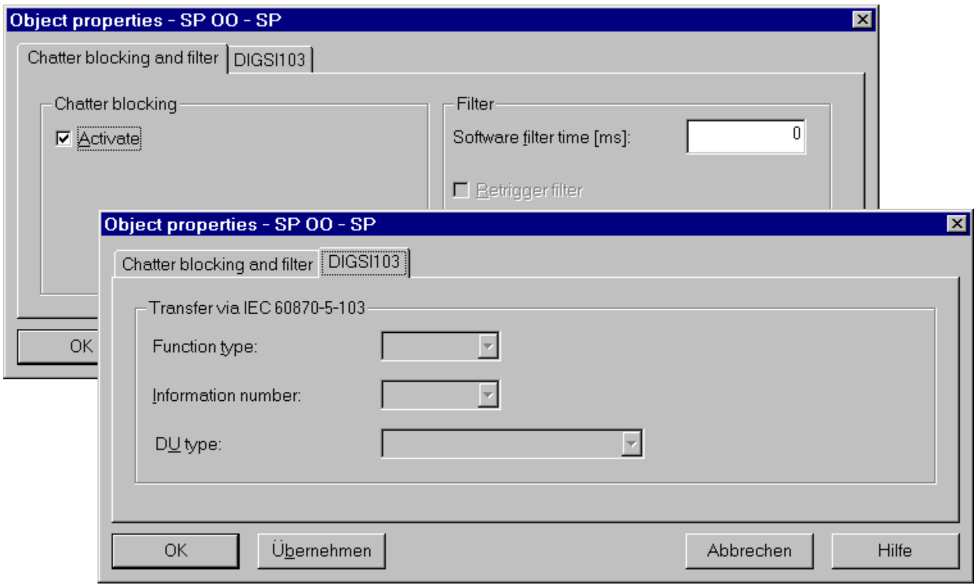
Function type: 128

Information number: 21

DU type: 1 (Operational indication buffer)

Figure 5-15 Information properties — example for the information type “Internal Single Point Indication” (IntSP)

Singe Point Indication (SP)



Chatter blocking

☑ Activate

Filter

Software filter time [ms]: 0

☐ Retrigger filter

Transfer via IEC 60870-5-103

Function type:

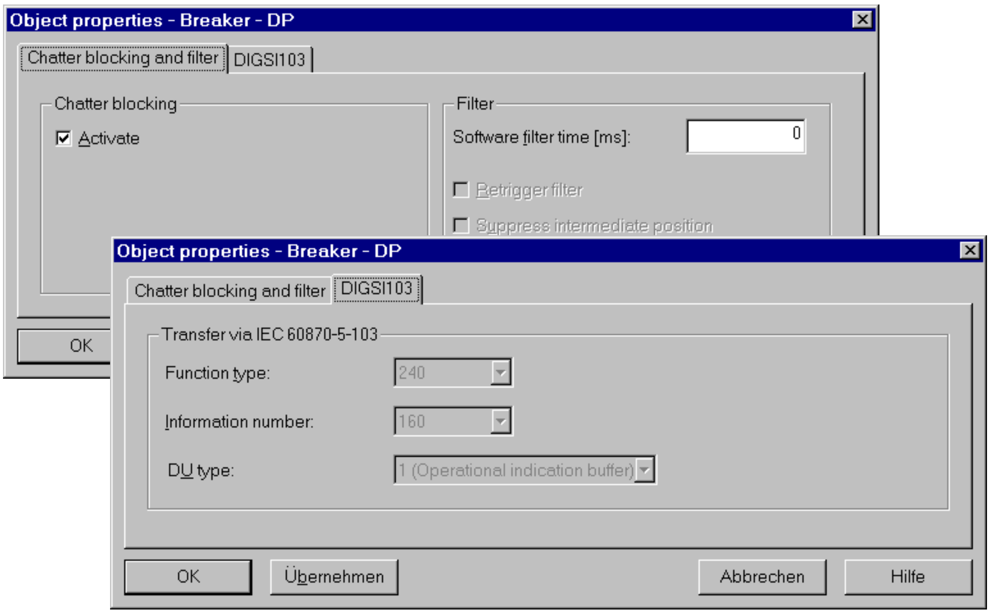
Information number:

DU type:

Figure 5-16 Information properties — example for information type “Single Point Indication” (SP)

Double Point Indication (DP)

In addition to the properties entered for single point indications, a “Suppress intermediate position” check box is available, which may be checked to suppress the intermediate indication during operations. If this field is marked, then the filter time, which can also be set (see margin heading “Filtering/Contact Chatter Suppression” below), is only effective for the intermediate (= undefined position) indication. Hence, briefly undefined conditions or contact chattering will not lead to an alarm; however, defined changes in the condition (final positions) are immediately reported.



Chatter blocking

☑ Activate

Filter

Software filter time [ms]: 0

☐ Retrigger filter

☐ Suppress intermediate position

Transfer via IEC 60870-5-103

Function type: 240

Information number: 160

DU type: 1 (Operational indication buffer)

Figure 5-17 Information properties — example for information type “Double Point Indication” (DP)

Filtering / Contact Chatter Suppression

For input indications (single point indications **SP**, double point indications **DP**), transformer tap indication **TxTap** (if available), filter times may be entered (pick-up and drop-out delays) to suppress momentary changes in potential at the binary input (e.g. contact chatter), refer also to Figure 5-16 and 5-17. Filtering occurs during an input change of state, with the same setting values whether coming or going. Information is only distributed when the new state continues to exist after a preset time interval (in milliseconds). The setting range is from 0 to 86,400,000 ms or 24 hours. Whether or not the filter interval is restarted for each change of state during the filtering (filter re-triggering) is selectable.

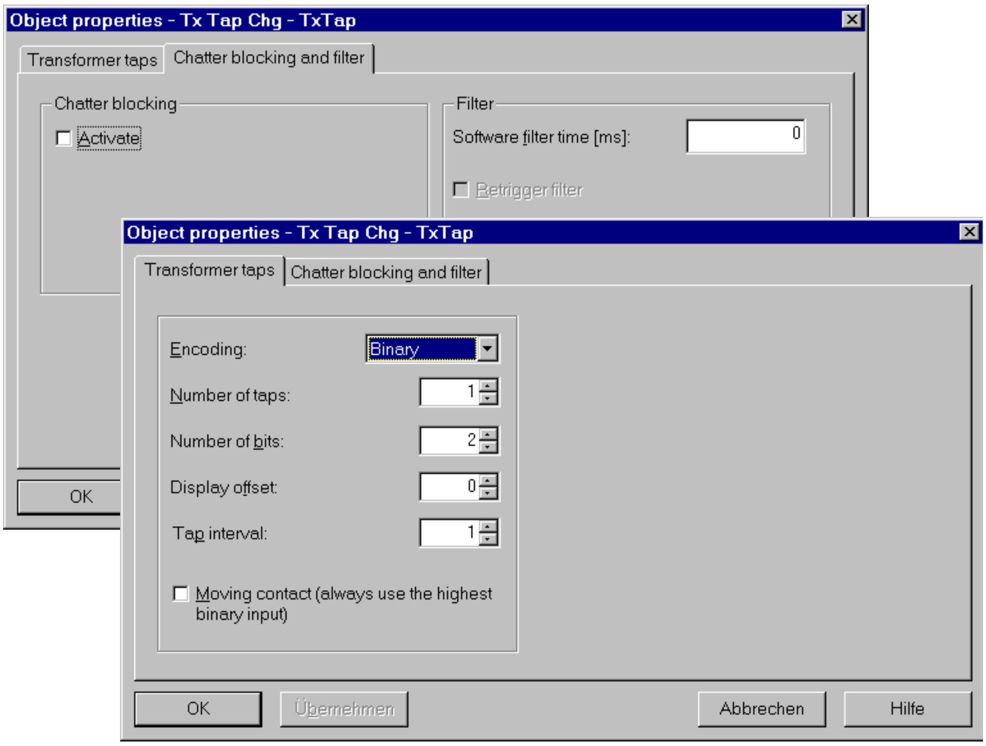
It is also possible to set chatter suppression for each indication (Figure 5-16 and 5-17). The contact chatter settings, themselves, are set the same for all input indications (see Sub-section 5.2.7).

Transformer Tap Changer (TxTap)

The transformer tap changer position is communicated, via binary inputs, in a specified encoding format (maximum of 62 positions). Only binary inputs that are in direct order with regard to numbering can be used.

For the encoding formats available (binary code, BCD code, “1 of n” code), four settings (number of positions, number of bits, display offset, and position change) may be programmed. Their bit pattern corresponds to an individual transformer tap changer position which is represented in the device display and in the indication buffers (Figure 5-18).

Having set “with moving” the stage setting is only recognized as valid and accepted when the moving contact signals that the stage has been achieved.



Chatter blocking

☐ Activate

Filter

Software filter time [ms]: 0

☐ Retrigger filter

Encoding: Binary

Number of taps: 1

Number of bits: 2

Display offset: 0

Tap interval: 1

☐ Moving contact (always use the highest binary input)

Figure 5-18 Information Properties Example for Information Type “Transformer Tap Changer” (TxTap)

If none of the available encoding formats are selected, each individual tap changer position may be set in a table. The table is accessed after the pull-down menu **`Table`** for encoding is opened, by selecting the button to the side.

The encoded transformer tap changer position bit pattern is transformed into digital values between 1 and 62. An unrecognized pattern is interpreted as position 63.

The number of bits coincides with the number of the binary inputs to be configured, and limits the number of positions to be represented.

Using the display offset, the beginning of the evaluated bits may have an offset of a programmed number. The stepping of the transfomer taps may be modified, using the tap interval feature (see example).

<u>Example</u>: Four transformer position settings are to be represented by three binary inputs, using the designators 3 through 6. The encoding is binary.

Orientation			**Desired representation**
BI1	**BI2**	**BI3**	
-	-	-	63.00
X	-	-	3.00
-	X	-	4.00
X	X	-	5.00
-	-	X	6.00
X	-	X	63.00

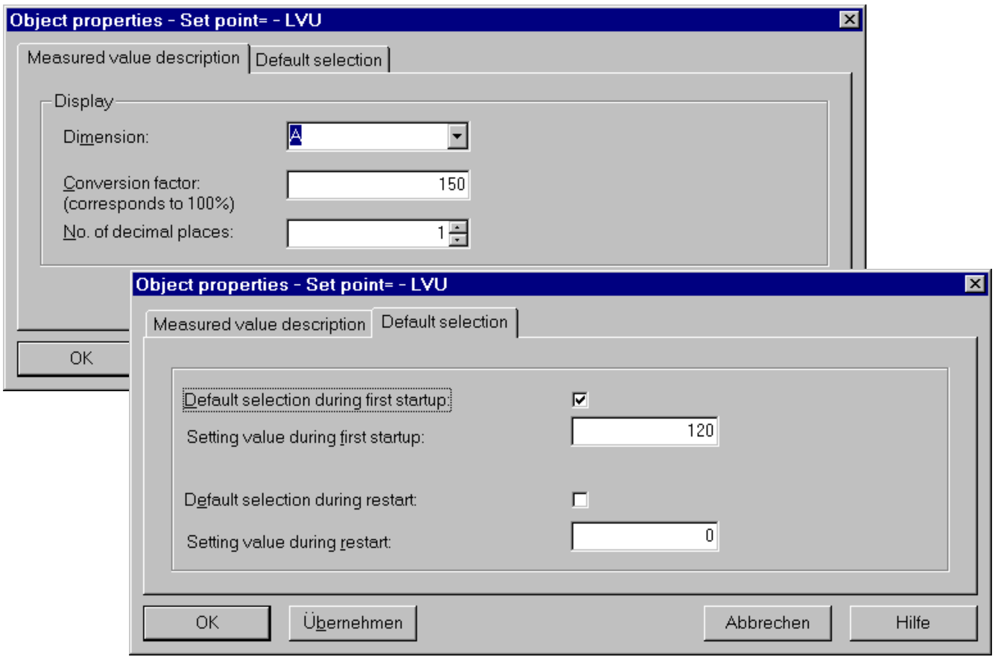
Using three binary inputs (= 3 bits), a maximum of $2^3 = 8$ position settings may be represented in binary code. In order to begin the representation of transformer tap changer positions with the value 3, the display offset is chosen accordingly. The following must be set on the information property window:

Encoding	`Binary`
Number of positions	4
Number of bits	3
Display offset	2
Position change	1

The three binary inputs used for this must have sequential numbers, such as BI 1, BI 2, and BI 3.

User Defined Measured Values (MVU) and Limit Values (LVU)

For the information type “Measured Values User Defined” (**`MVU`**), the units, the conversion factor, and the number of significant digits following the decimal point may be specified. For the information type “Limit Values User Defined” (**`LVU`**), a limit value may be programmed (Figure 5-19).



Dimension: A

Conversion factor: (corresponds to 100%) 150

No. of decimal places: 1

Default selection during first startup: ☑

Setting value during first startup: 120

Default selection during restart: ☐

Setting value during restart: 0

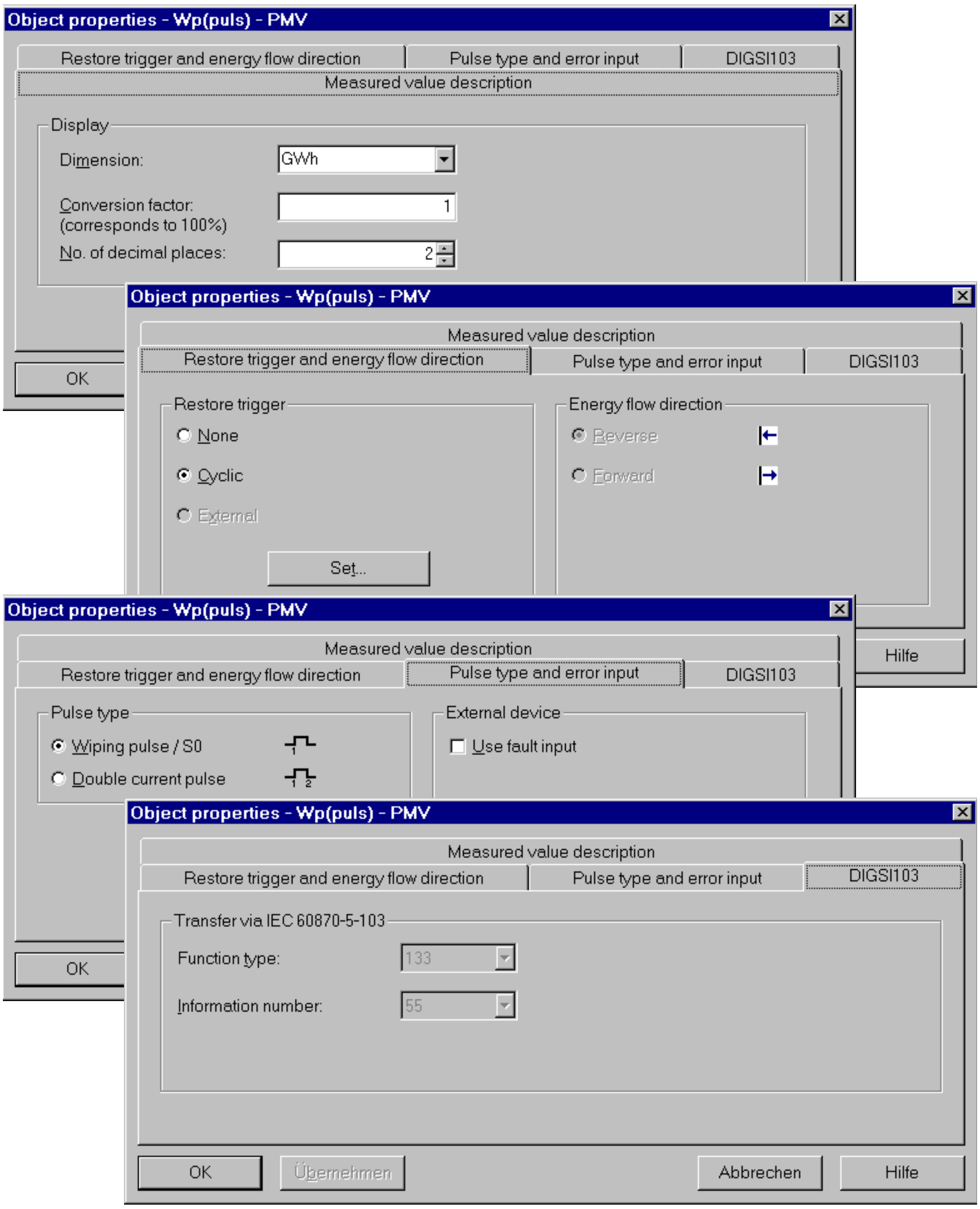
Figure 5-19 Information properties example for information type “Limit Value User Defined” (LVU)

If, for example, a low current reporter should be established using the CFC logic, and the percentage of the measured current should be matched to a certain amp value, the following values are entered in window according to Figure 5-19:

The **`Dimension`** is A (amps). The **`Conversion Factor`** is 150: 150 A corresponds to 100 % input current. The limit value upon start-up is set for 120 A.

Metered Values

For metered values, the polarity (+/–) is an indicator for the direction of the power flow (Figure 5-20 and 5-21). For the metered values of measured values (MVMV) the user may also define the units for pulsed measured values (**`PMV`**) (Figure 5-20), the conversion factor, and the number of decimal places (Figure 5-21). If **`wiping pulse/S0`** is selected, each individual impulse increases the counter by one. If the double current pulse option is selected, then each individual transition (positive or negative) increases the counter by one. If, for example, MVARh is entered as the units and 1000 is entered as the conversion factor, then 1000 impulses are equal to 1 MVARh.



Display

Dimension: GWh

Conversion factor: (corresponds to 100%) 1

No. of decimal places: 2

Restore trigger

○ None

● Cyclic

○ External

Energy flow direction

● Reverse

○ Forward

Pulse type

● Wiping pulse / S0

○ Double current pulse

External device

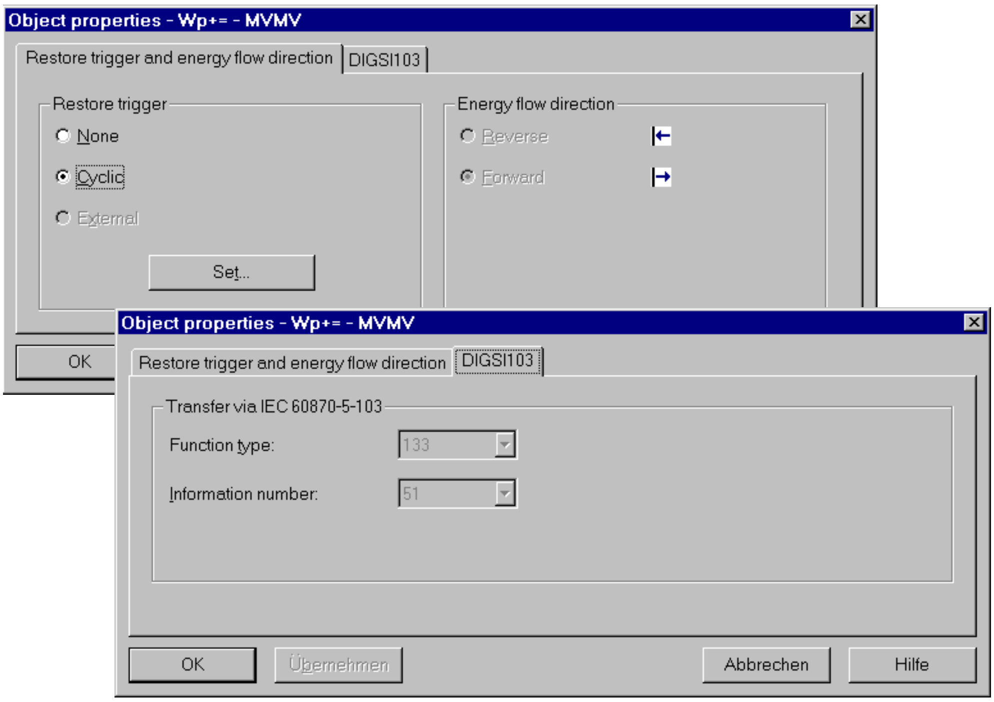
☐ Use fault input

Transfer via IEC 60870-5-103

Function type: 133

Information number: 55

Figure 5-20 Information Properties, Example for Information Type “Pulse Measured Value” (PMV)



Restore trigger
○ None
● Cyclic
○ External

Energy flow direction
○ Reverse
● Forward

Transfer via IEC 60870-5-103
Function type: 133
Information number: 51

Figure 5-21 Information Properties Example for Information Type “Metered Value of Measured Value” (MVMV)

Entering Your Own Information

The available information in the configuration matrix is determined by the device type and the configured functional scope. If necessary, you may extend the configuration matrix to information groups or individual information defined and entered by yourself. Such user defined groups and information may be deleted at any time, in contrast to predefined groups and information.

In order to insert a new information group, click on a cell within a group that is next to the location where the new group should be located. After pressing the *right* mouse button, a context menu appears (Figure 5-22).

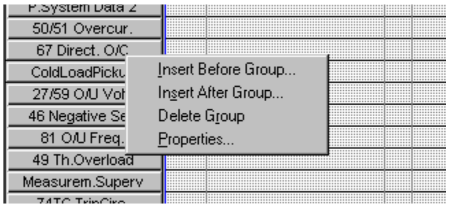
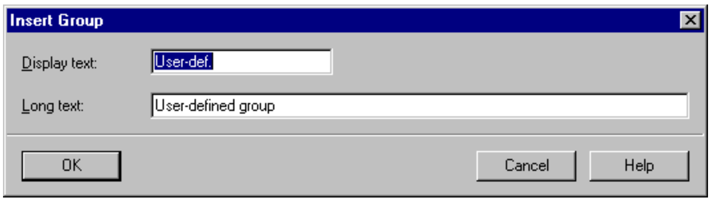


Figure 5-22 Dialogue box to insert a new information group

If one of the first two alternatives is selected, a second dialogue box opens, in which the name of the new information group is entered, in short text (display text) and in long text (Figure 5-23). After clicking **OK**, the new group is positioned.

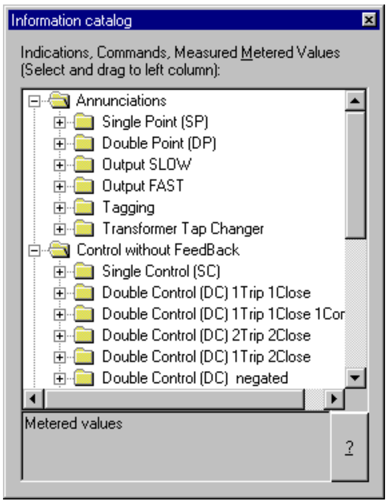


Display text: User-def.

Long text: User-defined group

Figure 5-23 Entry of the name of a user defined information group

Information may be entered into the new information group using the information catalog (Figure 5-24). The information catalog is found in the menu bar under the **`View`** option, or via an icon in the toolbar. User information may be entered into both the user defined groups and any other available information group.



Indications, Commands, Measured Metered Values
(Select and drag to left column):

- Annunciations
  - Single Point (SP)
  - Double Point (DP)
  - Output SLOW
  - Output FAST
  - Tagging
  - Transformer Tap Changer
- Control without FeedBack
  - Single Control (SC)
  - Double Control (DC) 1Trip 1Close
  - Double Control (DC) 1Trip 1Close 1Cor
  - Double Control (DC) 2Trip 2Close
  - Double Control (DC) 1Trip 2Close
  - Double Control (DC) negated

Metered values

Figure 5-24 Information catalog window

The information catalog is basically structured the same way as the DIGSI® 4 Manager with folders and sub-folders. To proceed to information of sub-folders in the catalog, click on a plus symbol or double-click on an folder icon. The designation of the initial levels of the catalog correspond to the information groups **`Annunciations`**, **`Commands`**, **`Measured Values`** and **`Metered Values`**.

To insert a specific information unit into an information group, first select it in the catalog. Using the left mouse button, it should then be dragged from the **`information catalog`** window to a group area on the left margin of the matrix. The new information unit is then dropped into the appropriate group.

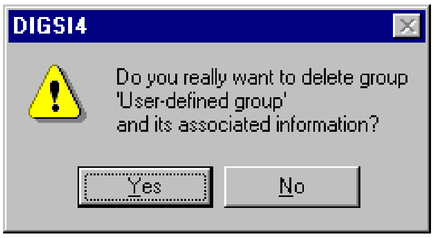
In order to change the user defined information, double-click on the item **`display text`** and **`long text`** and edit the new text.

Note:

When inserting information of the type **`Control with FeedBack`**, *two* new rows will be created within the group: one line for the actual command, and one for the associated feedback message.

Deleting Groups and Information

Only user defined groups and information can be deleted. To delete an entire group, click on the field containing the group designator, then press the *right* mouse button to open the context menu, and select **`Delete Group`**. A confirmation window will appear (Figure 5-25).



Do you really want to delete group 'User-defined group' and its associated information?

Figure 5-25 Confirmation window before deleting a user defined group

Click **`Yes`** if you actually want to delete the group.

Note:

When deleting a group, all information definitions within this group will be deleted.

To delete individual entries, click on **`Information`** in the line with the entry to be deleted. Then press the *right* mouse button to open the context menu, and select **`Delete Information`**. The remaining steps are the same as those for deleting a group.

5.2.5 Performing Configuration

The actual assignment between the information (rows) and the sources and destinations (columns) of the information is made in the cell of intersection. You click into the cell and press the *right* mouse button. A pull down menu appears where you may determine the properties of the assignment.

In certain cases, the pull down menu will offer **`X`** (allocated) or **_** (not allocated) as the configuration choices. In other cases, three options will be offered (e.g. **`L`** = latched, **`U`** = unlatched, and **_** = not allocated). Entries resulting in an implausible configuration are blocked and inaccessible to the user.

Configuring Binary Inputs as Sources

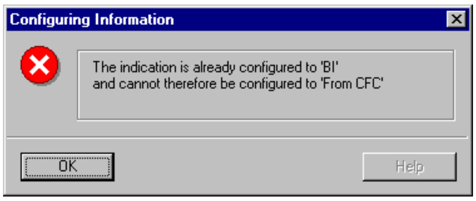
Single point indications, double point indications, transformer tap indications and pulse metered values can all be configured as binary inputs. In addition, whether or not binary inputs are activated by the presence of control voltage can be established. That is,

- “**H**” (**H**igh with voltage active): Control voltage at the binary input terminals activates the indication;
- “**L**” (**L**ow with voltage active): Control voltage at the binary input terminals deactivates the indication.

Note:

A single logical indication should not be configured to two binary inputs, since an OR-combination of both signals is not ensured. The operating program allows only *one* combination, and deletes the first combination when a second is established.

In addition, a single point indication cannot be configured to a binary input *and* to CFC as a source at the same time. In this case, an error message would be displayed. Click on **`OK`**, and select another configuration.



The indication is already configured to 'BI'
and cannot therefore be configured to 'From CFC'

Figure 5-26 Error message resulting from double configuration

If a double point indication (DP) is configured to one binary input (e.g. feedback indications from switching devices), the next binary input is also set in the matrix. If this configuration is undone, the second binary input is automatically de-configured. The order of the binary input channels is already defined. The trip command is always followed by the close command.

If a transformer tap indication is allocated to a binary input (n), further binary inputs (n+1...) may also be allocated. The total of it is identical with the number of the bits configured for the transformer tap indications. If one of the configurations is reset, all other configurations to binary inputs depending on the one deleted, will automatically be set to **`not allocated`**.

Configuring a Function Key as a Source

The four function keys on the front of the relay may also be configured as sources in order to establish a link using CFC. In this situation, each function key may be linked with a customer created Internal Single Point Indication (IntSP). A function key may be occupied because it has already been set as an operating function for the relay. As delivered from the factory, the device's function keys F1, F2, and F3 are pre-configured:

F1	operating messages
F2	primary measured values
F3	overview of the last eight fault messages

Note:

When an indication is configured to a function key, its factory-assigned function is deleted. Re-establishment of the factory default function of the F-keys is only possible by initializing the relay with a new factory parameter set created within DIGSI® 4. All device settings have to be re-entered.

In order to configure a new indication, select one of the options (OPEN/CLOSE, ON/OFF, etc.) from the indication group in the information catalog and drag it to the left side of the matrix. Upon release, a new row appears in the matrix. If the mouse is positioned at the intersection of this row with column F, and the *right* mouse button is pressed, a context menu opens (Figure 5-27) in which the function key may be set as a source by clicking the proper choice.

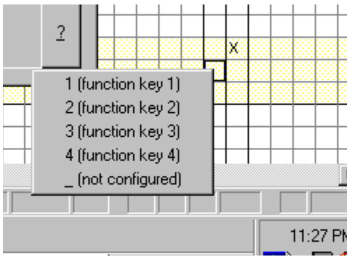


Figure 5-27 Selecting a function key as an information source

Configuring CFC as a Source

If certain information should be created as a result of the implementation of a user defined logic function (CFC), this information must appear in the matrix as a source from CFC. Otherwise, this information will not be available to the user when editing the CFC logic.

You must not configure information to CFC as a source if it is already configured to a binary input.

Configuring Binary Outputs as a Destination

Up to ten (10) information units (commands and indications) may be configured to *one* binary output (output relay). One indication may be configured to up to ten (10) binary outputs (LEDs and output relays).

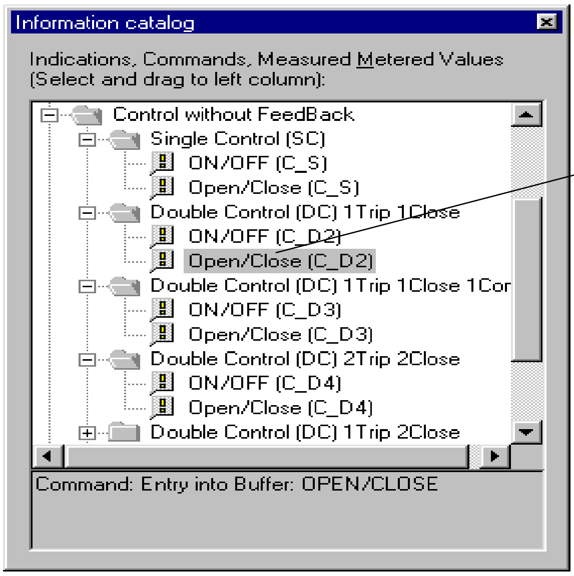
During configuration of binary outputs, you may select, for each output relay (besides of the logic function itself), whether it should be latched (**L**) or unlatched (**U**). If you select latched, the output relay remains energized, even after the indication is no longer present. It must be manually reset by pressing the LED Reset button on the front panel of the device, or via a binary input with the indication function “`>LED Reset`”, or via the serial system interface. If unlatched is selected, the output relay disengages as soon as the indication disappears.

Fast Binary Outputs

Some binary outputs of device 7SA6 - depending on the order variant, refer to “General Diagrams” in Section A.2 of Appendix A - have a response time which is approx. 3 ms shorter. Therefore they are very suited for sending trip commands as well as for issuing initiate signals to signal transmission equipment for teleprotection.

Binary Outputs for Switching Devices

Take care when configuring binary outputs for switching devices. For switching devices, the type of command (e.g., single or double commands, with or without feedback) is defined and configured to the output relay. If the preset command types are not desired, then appropriate command types can be selected from the Information catalog (see also “Entering Your Own Information” in the previous sub-section) and inserted into the configuration matrix.



Information catalog

Indications, Commands, Measured Metered Values
(Select and drag to left column):

- Control without FeedBack
  - Single Control (SC)
    - ON/OFF (C_S)
    - Open/Close (C_S)
  - Double Control (DC) 1Trip 1Close
    - ON/OFF (C_D2)
    - Open/Close (C_D2)
  - Double Control (DC) 1Trip 1Close 1Cor
    - ON/OFF (C_D3)
    - Open/Close (C_D3)
  - Double Control (DC) 2Trip 2Close
    - ON/OFF (C_D4)
    - Open/Close (C_D4)
  - Double Control (DC) 1Trip 2Close

Command: Entry into Buffer: OPEN/CLOSE

Example:
Double **C**ommand with
2 relays (acc. Table 5-1)

Figure 5-28 Window information catalog (example for different command types)

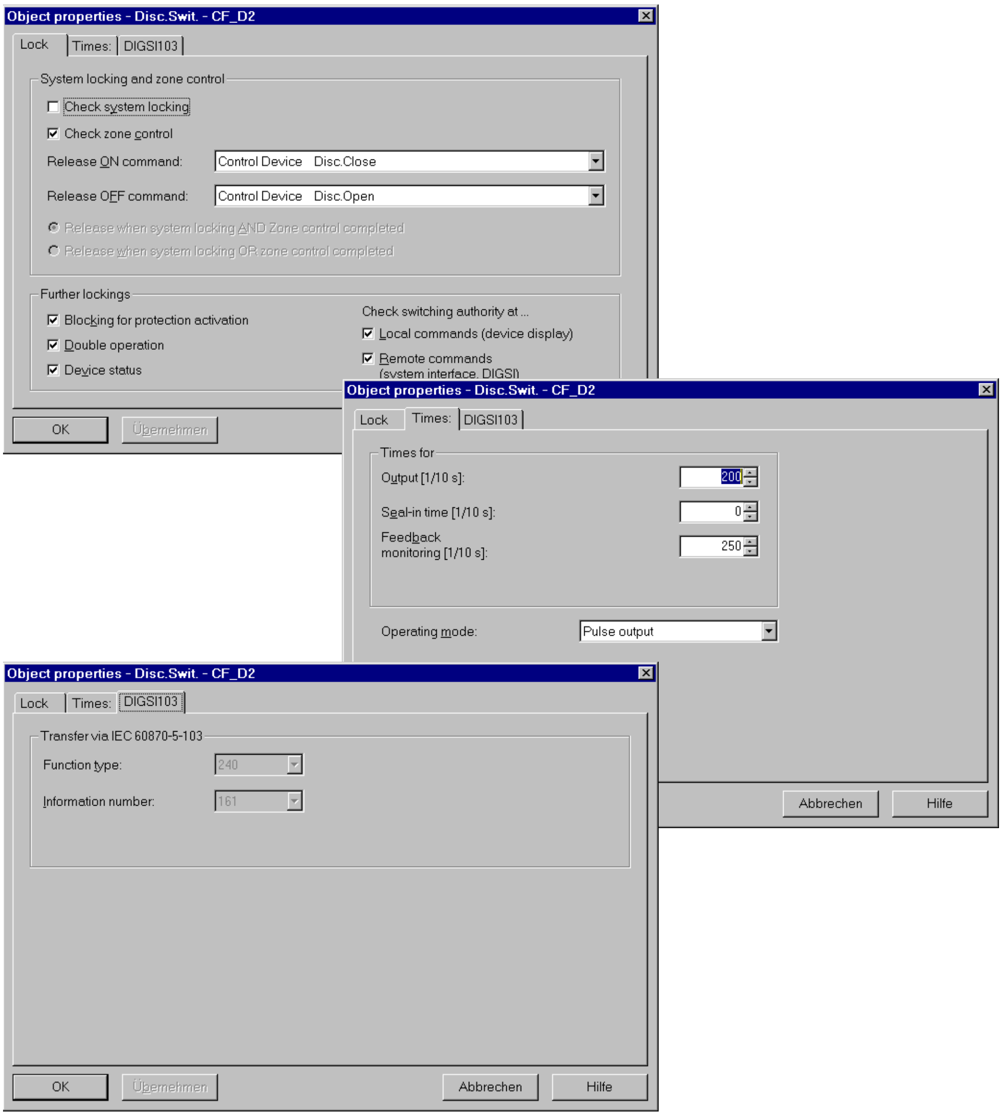
If a command with multiple outputs is configured, all binary outputs required in the matrix for the configuration are automatically defined. If one of these outputs is de-configured, all other binary outputs associated with the command will be automatically de-configured.

Please pay attention to the comments and switching examples in Section 5.2.1, particularly the fixed defined sequence of relay assignments (TRIP before CLOSE).

When configuring commands (C_), the context menu is dependent on the type of command. In some cases, the selection latched/unlatched is not available. Instead, the alternatives are **`X`** (configured), **`_`** (not configured), and **`F`** (busy flag). The latter means, independent of the switching direction, an indication is issued during each operation of the switching device.

For double commands with a common output, a fourth alternative **`C`** (Common contact) appears. Using this, the binary output may be defined as the common output (common contact). When this is the case, several double commands with common contacts may be assigned to the same common output (common contact), thus saving binary outputs. This assumes the signals at the common outputs have the same potential.

Using the **`Object Properties`** dialogue window, additional properties for commands issued to the switching device may be defined. Thus, the operating mode (pulse or latched output of a switching command), the seal-in time for pulse commands, the output delay of the command, and feedback monitoring may be set (see Figure 5-29). The output delay is relevant for equipment which removes an indication before the switching is completed.



System locking and zone control
☐ Check system locking
☑ Check zone control
Release ON command: Control Device Disc.Close
Release OFF command: Control Device Disc.Open
● Release when system locking AND Zone control completed
○ Release when system locking OR zone control completed

Further lockings
☑ Blocking for protection activation
☑ Double operation
☑ Device status

Check switching authority at ...
☑ Local commands (device display)
☑ Remote commands (system interface, DIGSI)

Times for
Output [1/10 s]: 200
Seal-in time [1/10 s]: 0
Feedback monitoring [1/10 s]: 250
Operating mode: Pulse output

Transfer via IEC 60870-5-103
Function type: 240
Information number: 161

Figure 5-29 Dialogue box: object properties for a command with feedback

The conditional checks that should be conducted before execution of a switching command can also be defined:

- Substation interlocking: interlocking of substations is carried out (configuration via a substation)
- Zone controlled (Bay Specific Interlocking): Logic functions in the device created with CFC are processed for interlocked switching.
- Switching direction check (scheduled/actual): The switching command is negated and a corresponding indication is issued if the circuit-breaker is already in the scheduled position. As soon as this check is activated, the switching direction check will not only be enabled for interlocked, but also for non-interlocked switching.
- Blocked by protection: CLOSE commands to the switchgear are blocked as soon as one of the protective functions in the device picks up a fault. TRIP commands, in contrast, can always be executed.

Please be aware of the fact that also pickups from the overload protection or the sensitive earth current supervision can cause and maintain a fault and therefore block a close command. When resetting the interlocking also take into consideration that the automatic reclosure lockout for motors in this case does not automatically negate a close command sent to the motor. The automatic reclosure must then be interlocked differently, e.g. via bay specific interlocking with CFC.

- Double operation: Parallel switching operations are blocked with respect to each other: while one switching operation is being conducted, a second one cannot be performed.
- Switching Authority – Local Commands: A local control switching command is only allowed if local control is enabled on the relay (via lockswitch or setting).
- Switching Authority – Remote Commands: A remote control switching command is only allowed if remote control is enabled on the relay (via lockswitch or setting).

Configuring a LED Display as a Destination

Single point indications (SP), output indications (OUT), and internal single point indications (IntSP) may be assigned to LEDs. When this is done, you may select whether the indications are to be latched (**L**) or unlatched (**U**).

Up to ten (10) indications may be assigned to a LED display. One indication may be assigned to a maximum of ten (10) outputs (LEDs and output relays).

Configuring an Indication Buffer as a Destination

A maximum of three indication buffers may be available for messages: Operation (Event Log) Buffer (**0**), Fault (Trip Log) Buffer (**T**) and Earth Fault Message Buffer (**E**). The indications from protective functions are firmly assigned to these indication buffers. For the others, Table 5-2 provides an overview of which indication type may be configured to which buffer.

Table 5-2 Overview of Indication Buffers

Information Type ↓ \Message Buffer →	**O**	**E**	**T**
Single Point Indications (SP)	X	X	X
Double Point Indications (DP)	X		
Output Indications (OUT)	X	X	X
Internal Single Point Indications (IntSP)	X	X	X
Internal Double Point Indications (DP)	X		
Transformer Tap Indication (TxTap)	X		

Select one of the following options for the named indication types:

- **0** (**o**n or coming) – the indication is stored in the buffer with the time of its arrival
- **00** (**o**n/**o**ff or coming/going) – the indication is stored in the buffer with the time of its arrival and departure
- **_** (not configured) – the indication is not stored in a buffer.

Table 5-3 Overview of indications via the system interface

Information Type ↓ \Message Buffer →	IEC	Profibus
Single Point Indications (SP)	X	X
Double Point Indications (DP)	X	X
Output Indications (OUT)	X	X
Internal Single Point Indications (IntSP)	X	X
Internal Double Point Indications (DP)	X	X
Command with/without Feedback (C_**)	X	X
Measurement Value (MV)		X
Measurement Value with Time (MVT)		X
Measurement Value, User Defined (MVU)		X
Pulse Metered Value (PMV)		X

Configuring CFC as a Destination

Single point, double point, and output indications, as well as limit and measured values, may be configured to CFC as the destination.

Configuring the System Interface as a Destination

The information listed in Table 5-3 can be allocated according to the type of the system interface. Setting an „**X**“ in the matrix cell the information is transferred via the system interface to its connected components.

Configuring the Default and Control Display as a Destination

Except for thresholds all informations can be allocated into both the default and the control display. By setting an “**X**” in the matrix cell the information can be used in the default and control display.

Configuring the Control as a Destination

Single point and double point indications as well as all types of commands can be allocated to the control as a destination. Thus they are available for the operational control in the display of the device and the DIGSI® 4 Menu **`Control.`**

Configuring the Measured Value Window as a Destination

In addition to the measured values available in the relay, user defined measured and limit values may be configured into the measured value window. These values also become available in the device display in the corresponding measured value window and in the DIGSI® 4 Menu **`Measurement`**.

Configuring the Metered Value Window as a Destination

User defined pulse values and metered values derived from the measured values may be configured into the metered value window so that they may be displayed at the front relay panel. They are then available in the corresponding measured value window in the display of the device.

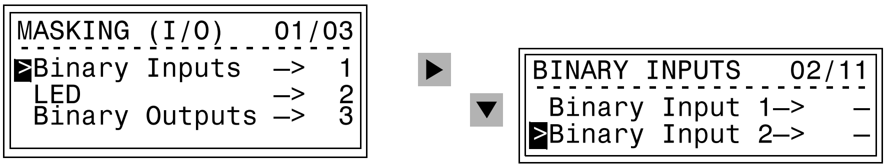
Retrieving Device Configurations from the Device Front

Retrieving the configurations is also possible from the device front. You may access configuration information under **`Main Menu`**: → **`Settings`** → **`Masking (I/O)`**.

The menu title **`MASKING (I/O)`** appears in the title bar. Configuration information regarding each (physical) input and output is indicated in the display.

Any new user defined information is also shown in the display once loaded into the relay from DIGSI® 4.

When selecting the **`MASKING (I/O)`** menu, either binary inputs, LEDs, or binary outputs may be selected. Selection of binary inputs is illustrated in Figure 5-30.

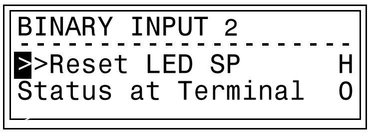


```
MASKING (I/O)   01/03
---------------------
>Binary Inputs  –>  1
 LED            –>  2
 Binary Outputs –>  3
```

```
BINARY INPUTS   02/11
---------------------
 Binary Input 1–>   –
>Binary Input 2–>   –
```

Figure 5-30 Reading the configuration in the front display of the device — example

Information regarding a binary input may be displayed by using the navigation keys to select the binary input. See Figure 5-31.



```
BINARY INPUT 2
---------------------
>>Reset LED SP      H
Status at Terminal  O
```

Figure 5-31 Selection of binary input 2 — example

In the example of Figure 5-31, information is displayed regarding binary input 2. The display for binary input 2 indicates that it is configured as reset of the latched LEDs using a single point indication with voltage active (High). The present conditions of binary input 2 is also given as 0 (not active). If a binary input is active, a 1 is displayed.

Assignment of LEDs may be indicated at the relay, itself, using a replaceable labelling strip with plain text on the front panel located, directly next to the LEDs.

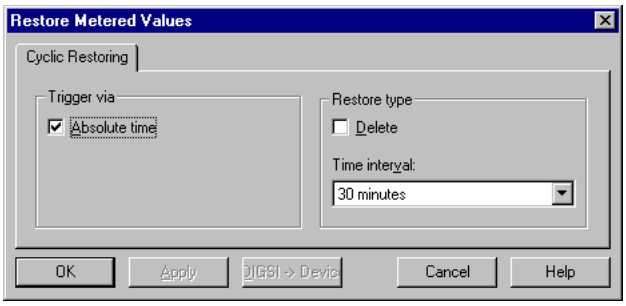
5.2.6 Transferring Metered Values

The transferring of metered values from the buffer of a SIPROTEC®-device or substation controller may be performed both cyclically and/or by external polling.

In the configuration matrix, click on **`Options`** and then on **`Restore Metered Values`**. A dialog box, which contains a register for editing the individual values for cyclical transferring will open.

Cyclical Restoration

Here, the user may specify the source of the cyclical trigger for the transfer. Also, the user may set the time interval and determine whether the metered value buffer should be deleted after transfer to the SIPROTEC®-device has taken place.



Trigger via

☑ Absolute time

Restore type

☐ Delete

Time interval: 30 minutes

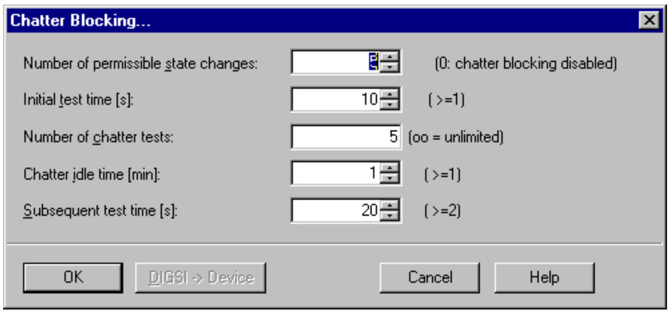
Figure 5-32 Dialog Box to Restore Metered Values and Program Cyclical Restoration

In the current version of DIGSI® 4, triggering occurs based on the programmed Absolute time.

5.2.7 Settings for Contact Chatter Blocking

Contact Chatter Blocking

The contact chatter filter checks whether the number of condition changes at a binary input exceeds a preset value during a predetermined time interval. If this occurs, the binary input will be blocked for a certain time, so the event list does not contain a large number of unnecessary entries. The setting values necessary for this feature may be entered in a dialogue box, as shown in Figure 5-33. This dialogue box can be found from the open configuration matrix by clicking **`Options`** in the menu bar and then selecting **`Chatter Blocking`**.



Number of permissible state changes: 5 (0: chatter blocking disabled)

Initial test time [s]: 10 (>=1)

Number of chatter tests: 5 (oo = unlimited)

Chatter idle time [min]: 1 (>=1)

Subsequent test time [s]: 20 (>=2)

Figure 5-33 DIGSI® 4: Setting the chatter blocking feature

Defining the Monitoring Criteria

The operating mode of the chatter blocking feature is determined by five settings:

- **`Number of permissible state changes`**
  This setting establishes how often the state of a binary input within the **`Initial Test Time`** may change. If this number is exceeded, the binary input is or remains blocked. If the setting is ***0*** the chatter blocking is disabled.

- **`Initial test time`**
  Within this time interval (in seconds), the number of state changes of a binary input is checked. The time interval begins with the first activation of a signal to the binary input.

- **`Number of chatter tests`**
  This number represents how many check cycles should be conducted before the binary input is finally blocked. Please consider that even a high set value can be reached over the normal life span of the device and could lead to blocking of the binary input. Therefore this value can also be set to infinity. For this, enter the character sequence of ***oo***.

- **`Chatter Idle Time`**
  If the **`Number of permissible state changes`** at a binary input is exceeded during the **`Initial test time`** or the **`Subsequent test time`**, the **`Chatter idle time`** interval is initiated. The affected binary input is blocked for this time interval. The **`Chatter idle time`** setting is entered in minutes. This settings can only be programmed if the **`Number of chatter tests`** is not set to zero.

- **`Subsequent test time`** – Within this time interval, the number of state changes at a binary input is checked again. This interval begins after the **`Chatter idle time`** interval has expired. If the number of state changes is within allowable limits, the binary input is released. Otherwise, the idle interval is restarted, until the maximum **`Number chatter tests`** is reached again. The **`Subsequent test time`** setting is entered in seconds. This settings can only be programmed if the **`Number of chatter`** tests is not set to zero.

The settings for the monitoring criteria of the chatter blocking feature are set only once for all binary inputs; however, the status of the chatter suppression can be set individually for each binary input. See “Filtering / Contact Chatter Suppression” in Subsection 5.2.3.

Note:

Chatter blocking cannot be activated for any of the standard protective indications.

The following should be noted:

- If there is contact chatter at a binary input and the input is blocked, the corresponding indication will be displayed with “CCF” (example: “`>Door open CCF ON`”). Also, the indication “`Contact chatter filter`” reports this condition. Both messages are shown in the operating buffer.
- Chattering of a single point indication is set as ON (coming) if the binary input has been in an active state.
- Chattering of a single point indication is set as OFF (going) if the binary input has been in an inactive state.
- If this behaviour causes undesired results in individual situations, a blocking may be configured in CFC.
- Chattering of a double point indication will be considered an “intermediate” condition.

5.3 Creating User Defined Functions with CFC

General

The 7SA6 relay is capable of implementing user defined logic functions which may be processed by the relay. This CFC feature (Continuous Function Chart) is needed to process user defined supervision functions and logic conditions (e.g. interlocking conditions for switching devices) or to process measured values. Interlocking conditions and command sequences, for example, may be programmed, using pre-defined function modules, by persons without any specialized software programming abilities. A total of 21 types of functional modules (FM), with which the desired functions may be composed, are saved in a library. Detailed explanations are in the CFC manual, order number E50417–H1176–C098, or in the DIGSI® 4 manual, order number E50417–H1176–C097.

The creation of a logical PLC function is performed by means of a personal computer using application DIGSI® 4 and transferred via the operator or service interface. In order to create user defined logic functions, the indications and measured values required by these functions must first be configured in the matrix with CFC as the source or destination (see Section 5.2).

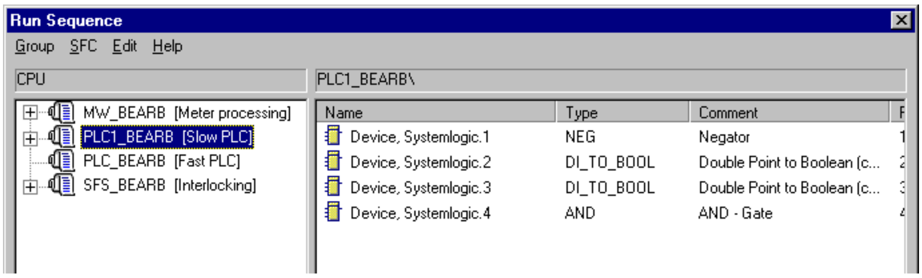
CFC can be started by double-clicking on **CFC**. The names of all available CFC charts will appear. The desired CFC chart for processing can be selected via a double-click of the mouse. The CFC program will start, and the chart will be displayed. If no chart is available yet, you can create a new chart via the menu **Create** → **CFC–Chart**.

Run-Time Properties

The functions to be implemented in CFC may be divided into four task levels:

- Measured values: This task is processed cyclically every 600 milliseconds (**MV_BEARB** = measurement value processing) and might become slower if the device is in pick-up state.
- System logic: Operation is triggered by events (i.e. these functions are processed for each change of state at one of its inputs). System logic has lower priority than a protection function and will be suppressed as soon as the relay picks up (**PLC1_BEARB** = slow PLC processing).
- Protective functions: These functions have the highest priority, and, like the system logic functions, are event-controlled and processed immediately after a change of state (**PLC_BEARB** = fast PLC processing).
- Switchgear Interlocking: This task is triggered by commands. In addition it is processed cyclically approximately every second. It might becomes slower if device is in pick-up state (**SFS_BEARB** = interlocking).

The function to be implemented must be associated to one of these four task levels. To implement a function from the **Settings** → **CFC** menu, activate the menu by selecting **Edit**, and then **Run Sequence**, and then the desired task level (See Figure 5-34).

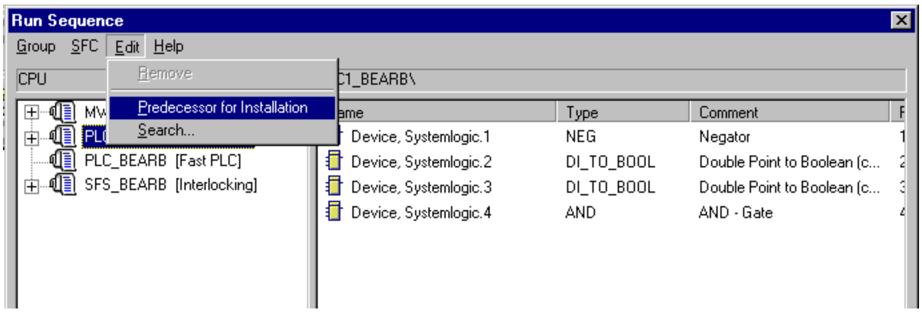


MW_BEARB [Meter processing]
PLC1_BEARB [Slow PLC]
PLC_BEARB [Fast PLC]
SFS_BEARB [Interlocking]

Name	Type	Comment
Device, Systemlogic.1	NEG	Negator
Device, Systemlogic.2	DI_TO_BOOL	Double Point to Boolean (c...
Device, Systemlogic.3	DI_TO_BOOL	Double Point to Boolean (c...
Device, Systemlogic.4	AND	AND - Gate

Figure 5-34 Establishing the task level

Within the Run Sequence menu, select **`Edit`**, and then **`Predecessor for Installation`**, to ensure that the function modules selected from the library will be implemented into the desired task level (Figure 5-35).



PLC_BEARB [Fast PLC]
SFS_BEARB [Interlocking]

ame	Type	Comment
Device, Systemlogic.1	NEG	Negator
Device, Systemlogic.2	DI_TO_BOOL	Double Point to Boolean (c...
Device, Systemlogic.3	DI_TO_BOOL	Double Point to Boolean (c...
Device, Systemlogic.4	AND	AND - Gate

Figure 5-35 Assignment of function modules to the selected task level

The proper assignment is important for several reasons. For example, if interlocking logic were to be set up in the measured values task level, indications would constantly be created by the cyclical processing, filling the buffer unnecessarily. On the other hand, the interlocking condition at the moment of a switching operation may not be processed at the right time, since measured value processing is done cyclically every 600 ms.

Table 5-4 Selection guide for function modules and task levels

Function Modules	**Description**	**Run-Time Level**			
		MW_BEARB Meter processing	**PLC1_BEARB Slow PLC**	**PLC_BEARB Fast PLC**	**SFS_BEARB Interlocking**
ABSVALUE	Magnitude calculation	X	–	–	–
AND	AND-gate	–	X	X	X
BOOL_TO_CO	Boolean to control, conversion	–	X	X	–
BOOL_TO_DI	Boolean to double point, conversion	–	X	X	X
BOOL_TO_IC	Boolean to internal single point, conversion		X	X	X
BUILD_DI	Create double point annunciation	–	X	X	X
CMD_INF	Test	–	–	–	X

Table 5-4 Selection guide for function modules and task levels

Function Modules	Description	Run-Time Level			
		MW_BEARB Meter processing	**PLC1_BEARB Slow PLC**	**PLC_BEARB Fast PLC**	**SFS_BEARB Interlocking**
CONNECT	Connection	–	X	X	X
D_FF	D-flipflop	–	X	X	X
DI_TO_BOOL	Double point to boolean, conversion	–	X	X	X
LIVE_ZERO	Live-zero, non linear curve	X	–	–	–
LOWER_SETPOINT	Lower limit	X	–	–	–
NAND	NAND-gate	–	X	X	X
NEG	Negator	–	X	X	X
NOR	NOR-gate	–	X	X	X
OR	OR-gate	–	X	X	X
RS_FF	RS-flipflop	–	X	X	X
SR_FF	SR-flipflop	–	X	X	X
TIMER	Timer	–	X	X	–
LONG_TIMER	Long timer (max. 1193 h)	–	X	X	–
UPPER_SETPOINT	Upper limit	X	–	–	–
X_OR	XOR-gate	–	X	X	X
ZERO_POINT	Zero suppression	X	–	–	–

Configuration Sheet

The configuration is performed within the configuration sheets (see Figure 5-36).

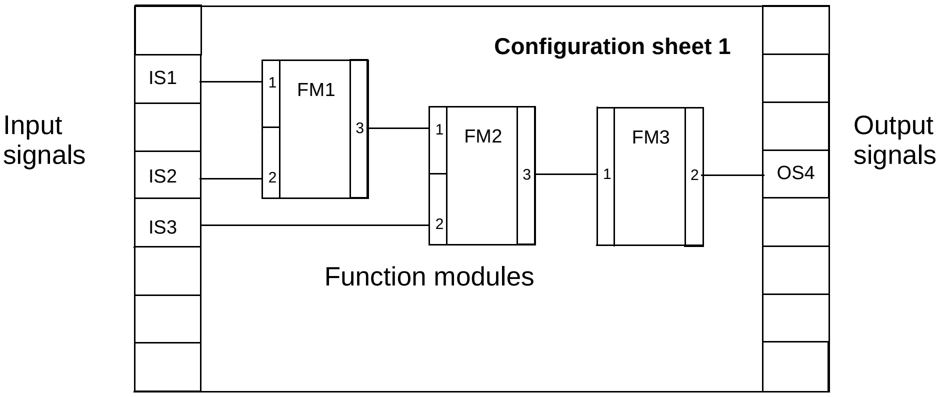


Figure 5-36 Principal representation of function modules in a CFC working page

The left border column of the configuration sheet shows the inputs; the right border column shows the outputs of a function. In the above diagram the inputs are connected with input signals IS1 to IS3. These may be indications from the breaker (via binary inputs), from device function keys, or from a protective function. The output signal (OS4 in the diagram) may control an output relay, for example, and can create entries in the message buffers, depending on the preset configuration.

Configuring and Connecting Function Modules

The default run-time sequence is determined by the sequence of the insertion of the logic modules. You may redefine the run-time sequence by pressing <CTRL> – <F11> on the PC keyboard. Please refer to the CFC manual. The necessary function modules (FM) are contained in a library located to the right of the configuration chart. The module also indicates to which of the four run-time levels (MW_BEARB, PLC1_BEARB, PLC_BEARB, SFS_BEARB) it is assigned. The modules possess at least one input and one output. In addition to these inputs and outputs, which are displayed on the configuration sheet, a module may have additional inputs. The additional inputs can be made visible by selecting the module title block, pressing the *right* mouse button, selecting the menu option **Number Of I/Os...** (see Figure 5-37), and then increasing the number.

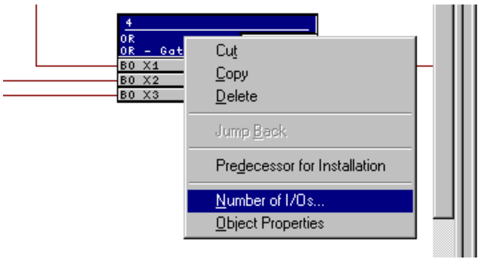


Figure 5-37 Example of an OR gate: module menu

Under the **Object Properties** menu, you may edit the name of the module, insert a comment, or edit run-time properties and connection parameters.

Connecting modules with each other, and linking them with system input and output signals, is performed by selection of the desired modules input or output and subsequently pressing the *right* mouse button, and selecting the menu option **Insert Connection to Operand** (see Figure 5-38).

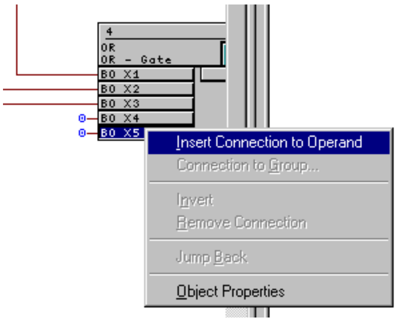


Figure 5-38 Example of module input menu

A window with a list of input signals will appear. By selecting one of these signals and activating with **OK**, the selected signal is entered into the left border panel and, from there, a connection is created to the module input. Selection of an output is done in the same manner. A connection between two modules is established by a simple sequential clicking on the two connections.

If the link line display becomes unwieldy or impossible because of space limitations, the CFC editor creates a pair of connectors (target icons) instead. The link is recognizable via correlated numbering (see Figure 5-39).

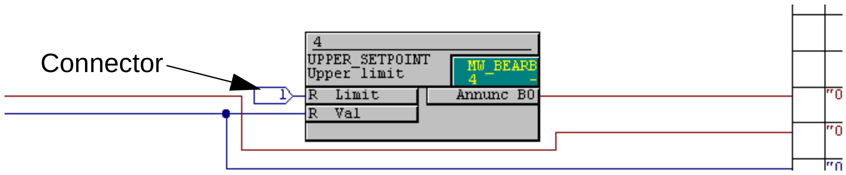


Figure 5-39 Connector

Events

Events (SP_Ev, DP_Ev) are not suitable for processing in CFC, and should therefore not be used as input signals.

Consistency Check

In addition to the sample configuration chart 1, other configuration sheets may exist. The contents of any particular configuration sheet is compiled by DIGSI® 4 into a program and processed by the protective device. For CFC charts developed by the user, syntactic correctness can be verified by clicking the menu command **Chart**, and then **Check Consistency**. The consistency check will determine if the modules violate conventions of various task levels, or any of the space limitations described below.

Check of functional correctness must be performed manually.

The completed CFC chart can be saved via menu item **Chart**, and **Close**. Likewise, the CFC chart may be reopened and edited by clicking on **Chart**, selecting the appropriate chart, and clicking on **Open**.

Please note that certain limits and restrictions exist due to the available memory and processing time required. For each of the four PLC task levels there is only a finite processing time available within the processor system. Each module, each input to a module (whether connected or not), each link generated from the border columns demands a specific amount of processing time. The sum total of the individual processing times in a task level may not exceed the defined maximum processing time for this level.

The processing time is measured in so called TICKS. In the 7SA6 the following maximum TICKS are permitted in the various task levels:

Table 5-5 Maximum number of TICKS in the task levels of 7SA6

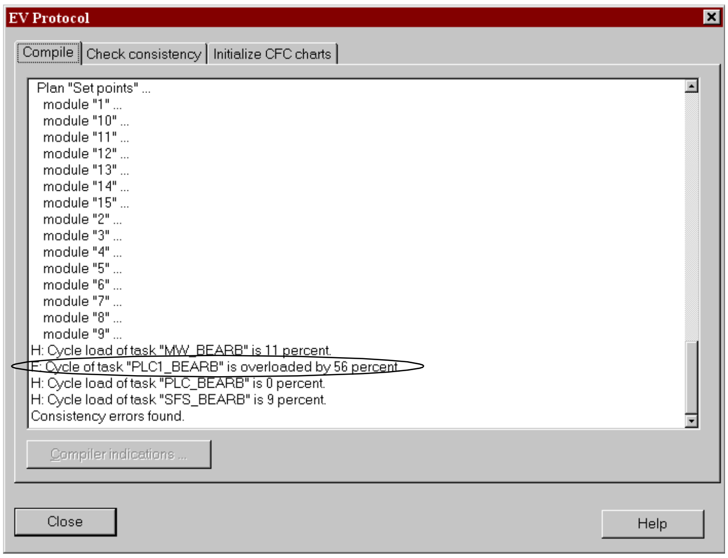
Run-Time Level	Limits in TICKS
MW_BEARB (Measured value processing)	10000
PLC1_BEARB (Slow PLC processing)	1900
PLC_BEARB (Fast PLC processing)	200
SFS_BEARB (Interlocking)	10000

In the following table, the amount of TICKS required by the individual elements of a CFC chart is shown. A generic module refers to a module for which the number of inputs can be changed. Typical examples are the logic modules *AND*, *NAND*, *OR*, *NOR*.

Table 5-6 Processing times in TICKS required by the individual elements

Individual Element	Amount of TICKS
Module, basic requirement	5
each input more than 3 inputs for generic modules	1
Connection to an input	6
Connection to an output signal	7
Additional for each configuration sheet	1

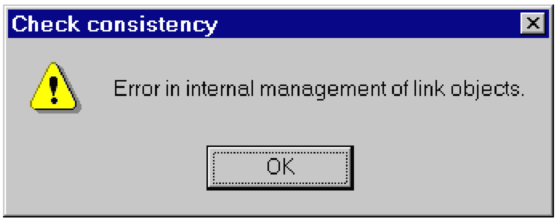
The utilized processor capacity which is available for the CFC can be checked under **`Option`** → **`Reports`** in the register **`Check consistency`**. By scrolling, an area is reached, where information regarding the cumulated memory consumption of the memory reserved for CFC can be read in percent. Figure 5-40 is an example showing an over-utilization by 56 % in the task level PLC_BEARB (marked in the Figure), while the other task levels are within the permissible range.



```
Plan "Set points" ...
  module "1" ...
  module "10" ...
  module "11" ...
  module "12" ...
  module "13" ...
  module "14" ...
  module "15" ...
  module "2" ...
  module "3" ...
  module "4" ...
  module "5" ...
  module "6" ...
  module "7" ...
  module "8" ...
  module "9" ...
H: Cycle load of task "MW_BEARB" is 11 percent.
F: Cycle of task "PLC1_BEARB" is overloaded by 56 percent
H: Cycle load of task "PLC_BEARB" is 0 percent.
H: Cycle load of task "SFS_BEARB" is 9 percent.
Consistency errors found.
```

Figure 5-40 Read-out of the CFC configuration degree of utilization

If the limits are exceeded during configuration of the CFC, DIGSI® 4 issues a warning (refer to Figure 5-41). After acknowledgement of this alarm, the system utilisation can be viewed as described above.



Error in internal management of link objects.

Figure 5-41 Warning message on reaching the limits

A few examples are given below.

Example 1 (MW): Low Current Monitor

A configuration for low-current monitoring alarm (see Figure 5-42) which can be produced using CFC, should be a first example. This element may be used to detect operation without load, or to recognize open circuited conditions. By connecting measured current values with a limit function via an *OR* function, an indication may be generated which can be used to cause switching operations.

- The configuration sheet is assigned to task level MW_BEARB.
- Four function modules (3 lower-value limit modules and an OR gate), are taken from the function module library and copied into the configuration sheet.
- In the left panel, the measurement values to be monitored (I_{L1}, I_{L2}, I_{L3} in % of the nominal current) are each selected and connected with the measured value inputs of each limit module function.
- A lower limit setpoint value (IL<) is linked with the limit inputs of each of three limit sensor functions.
- The limit value function outputs are passed on to the OR gate.
- The output of the OR gate is connected to the right border column at annunciation "`I< alarm`".

The limit value message is triggered when the preset limit value is below the setpoint (low current) in at least one of the three phases. The hysteresis of the limit values is fixed and need not be entered (5 % of set point plus 0.5 % of nominal value).

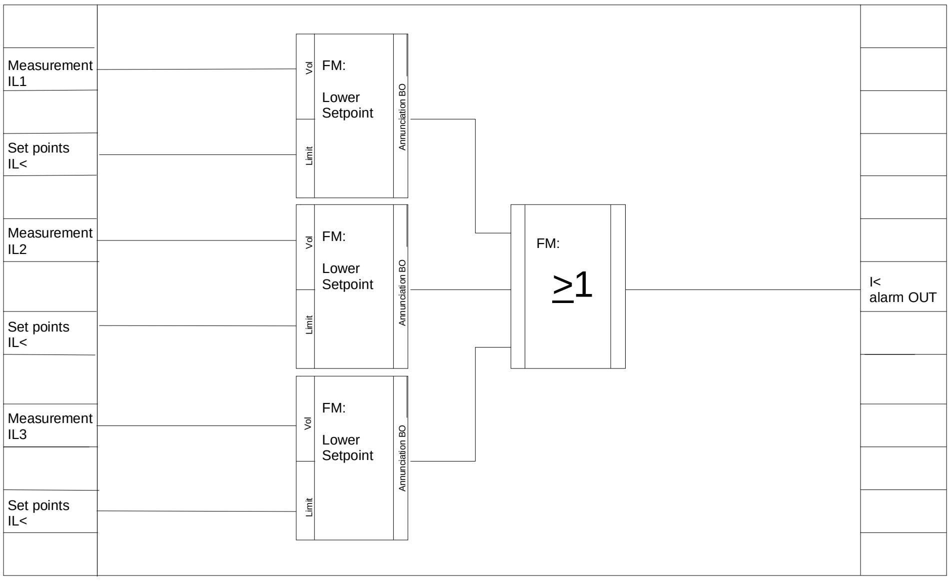


Figure 5-42 Under-current monitoring as an example of user defined measurement value processing

Example 2: Isolation Switch Interlocking

Interlocking logic (see Figure 5-43) is to be implemented for the operation of an isolating switch using function key 4. The user must take the switch position indications of the corresponding isolation switch and the grounding switch into account. The CLOSE and TRIP indications from the auxiliary contacts of each switch are used.

- Function modules NOR (2 required), XOR, and AND are taken from the library and copied into the working page.
- The number of inputs of the AND gate is increased to 7.
- The CLOSE indications from the circuit breaker (CB) and from the grounding switch (GS) are supplied to the inputs of the NOR functions.
- The OPEN indications from the circuit breaker (CB) and from the grounding switch (GS) are supplied to the inputs of the AND function.
- The switch position indications from the disconnect switch (IS) are linked to the inputs of the XOR function.
- The outputs of the NOR and XOR gates are connected to the inputs of the AND function.
- Function key 4 is linked with an input of the AND function.
- The output of the AND gate is linked to the right border column at the switching command “Disconnector Close”.

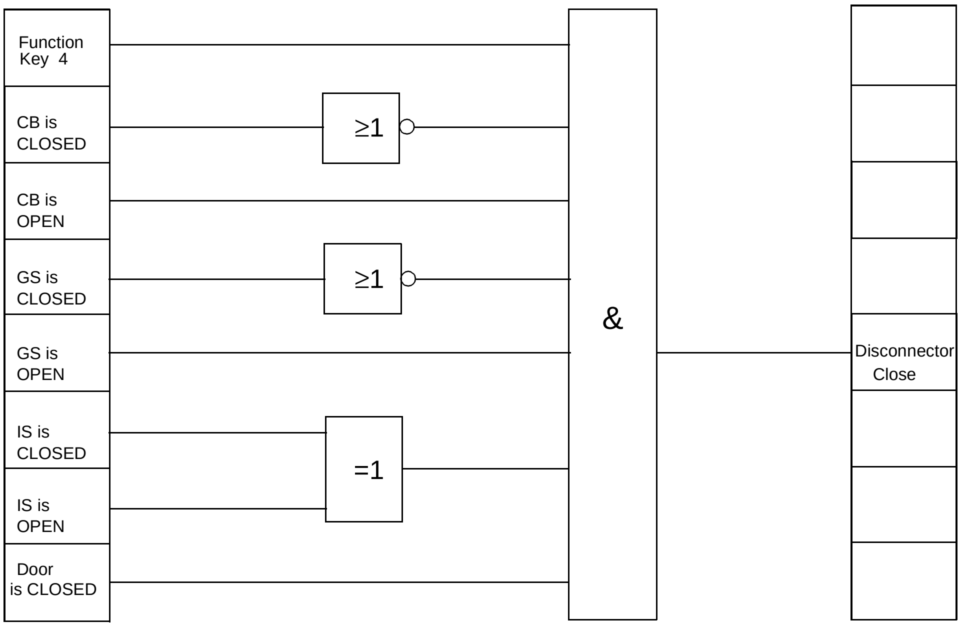


Figure 5-43 Interlocking an disconnect switch as an example of a user defined interlock protective function

Example 3 (PLC1): Additional Logic

By using slow PLC processing, an additional, event-driven logic condition may be constructed which delivers indications regarding switch-gear operating status. These indications may be passed externally via LEDs or relay contacts, or used as input signals for further logical links. In the example (see Figure 5-44), the output information indication from the circuit breaker interlocking logic (CB TRIP) and a joint indication from all protective element trip signals (Protection TRIP) are linked to a new “`Circuit Breaker Operation`” message. Furthermore, the single point indication (SP) **`Test Oper`**, which may be coupled via a binary input, is linked with an internal reusable “`Test oper.`” message.

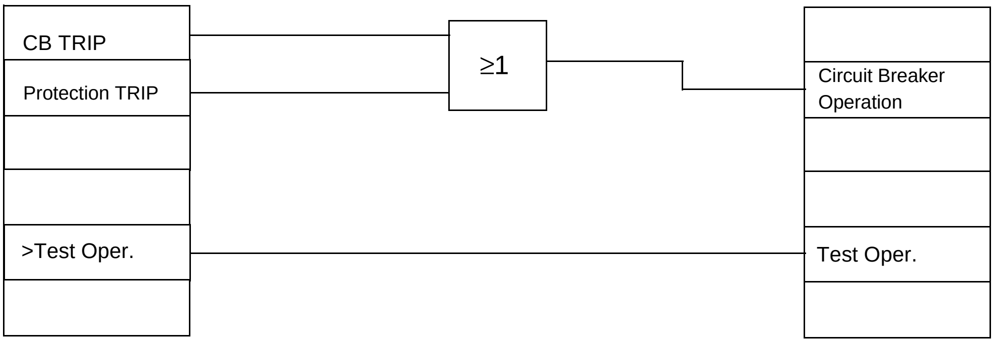


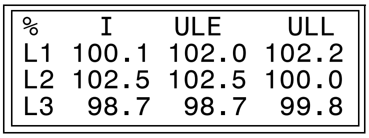
Figure 5-44 Additional logic as an example for a PLC_1 event-driven logic condition

5.4 Establishing a Default Display

The default display is the display appearing automatically after the initialization of the processor system. There are two types of displays, the 4-line LC display and the graphic display.

4-line LC Display

Under normal conditions, the so-called default display is the default image in the relay display. It shows operating information and/or measured values of the protected equipment. Depending on the relay type, a number of predefined basic displays are available. Using the ▲ and ▼ keys, one of the displayed images may be selected (see example in the following figure), causing it to appear as the default display under normal conditions.



```
%    I    ULE    ULL
L1 100.1 102.0 102.2
L2 102.5 102.5 100.0
L3  98.7  98.7  99.8
```

Figure 5-45 Default display

Default Display of a Graphic Display

In the idle state the so-called default display appears on the display of the device as a continuous display. It can be configured by the user. Normally, a schematic plan of the feeder is chosen as a basis so that a graphical overview of the switching state of the station is always available. It is not possible to operate the switching objects via this default display. However, the default display can be supplemented by further information, e.g. the most important measured operational values (current and voltage in the feeder) can continuously be displayed.

When the device is delivered, it might provide one or more pre-assembled default displays (for example, see Figure 5-46). These can be modified or replaced to adapt to the actual substation conditions. However, it is also possible to display other information than the station image on a default display. The display, for example, can be used to view a variety of operational measured values.

Under normal conditions, a preset image is shown as the default display. The layout of this default display may be configured by the user. In general, a single-line diagram of the protected system is designed as the default display in order to show a continuous graphical image of the switching condition of the protected equipment. Operation of switching devices from this display is not possible. The display, however, may be enhanced with additional information. So, for example, the most significant operating values (system currents and voltages) may be displayed continuously.

As delivered, the relay shows a basic default image (see Figure 5-46) which may be modified or replaced to show the actual equipment conditions. It is also possible, however, to show information in addition to the single-line diagram. The display may also be used, for example, to show a number of measured values.

Procedure

The Display Editor in DIGSI® 4 is used to create or modify the default or control display. The basic procedure is described in Section 4.9. For detailed information, consult the Display Editor Manual (order number E50417–H1176–C095).

A precondition for modification or creation of dynamic objects within this display is, the information which is to appear must be configured in the configuration matrix (see Section 5.2), i.e. the information of the respective lines in the **`Destination`** column **B** and sub-column **D** must have been linked. A cross in the small box will enable the link.

A library is provided which contains symbols for circuit breakers, isolation switches, and grounding switches, and other devices. The standard setup may be modified, at any time, using the DIGSI® 4 diagram editor. User defined symbols may also be created and saved in the library.

The user may assign various symbols to any operating equipment condition in the dialog window presented (e.g. CLOSE / OPEN / INTERMEDIATE) for the circuit breaker.

The layout of the image may be displayed enlarged or reduced to show details or an overview of the entire image.

A title bar is provided at the top of the display. It can contain the user defined name of the substation or feeder. The status bar at the bottom may not be configured.

Proceed as follows:

- In DIGSI® 4, select the default display under the **Setting** option. The Display Editor is started and the default display is opened (see Figure 5-46). *Right-click* in the title bar and select **Open** in the context menu which appears. The desired text may be entered.
- Draw the desired topology (e.g., common busbars, lines, and grounding path). Select nodes, horizontal lines, and vertical lines from the library, mark them, and confirm the selection with **OK**.
- Locate the operating equipment and symbols (e.g., switching devices, instrument transformers, measured values) by selecting from the library, and click in the drawing area on the desired location. Link the equipment with the respective information.
- Use dynamic symbols for breaker and switches (See Figure 5-50).

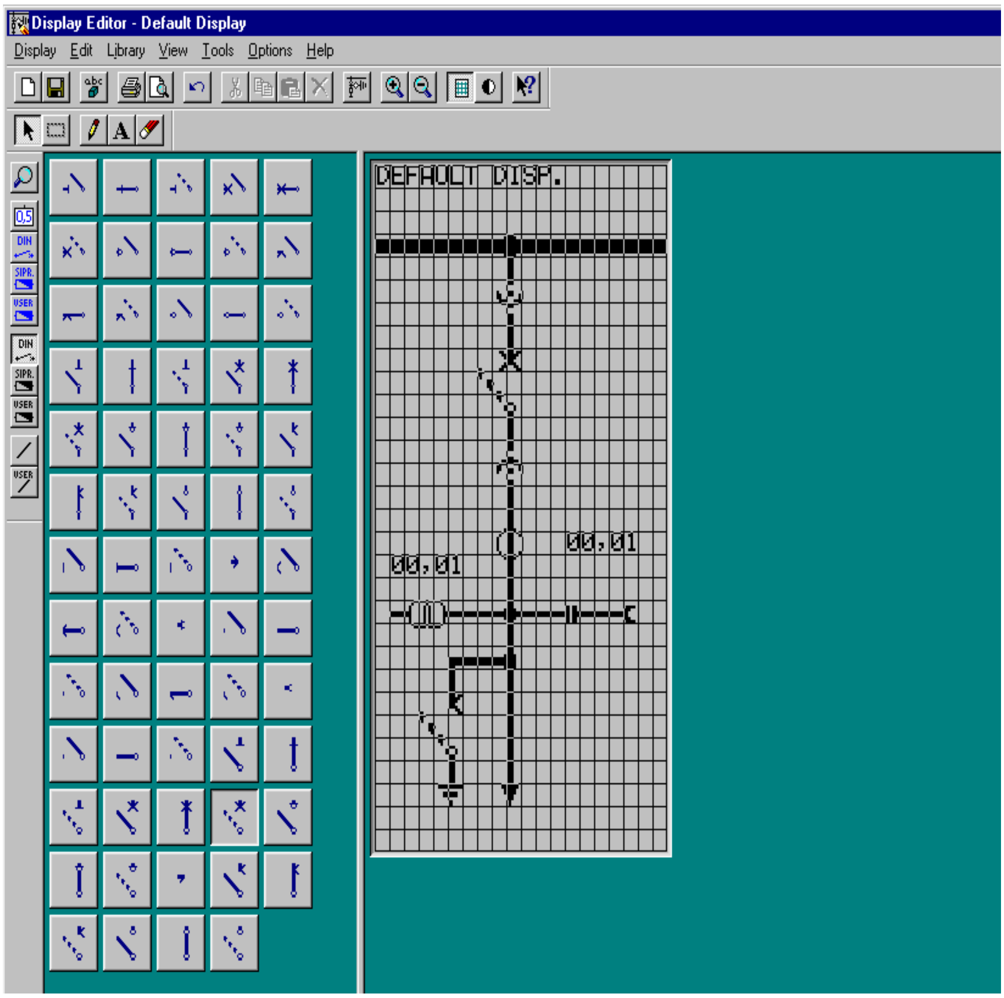
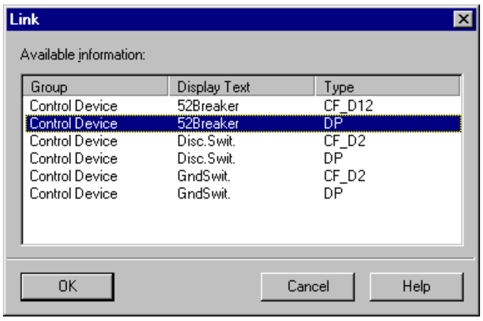


Figure 5-46 Standard default display after opening the Display Editor

- The information corresponding to the equipment and configured previously in the configuration matrix can now be selected in a **`Link`** dialog window (see Figure 5-47), from which the user may click on the desired option and confirm with **`OK`**. In this manner, the user may link the graphical diagram with configuration settings.
- Position text as necessary by clicking on **`Tools`**, and then **`Insert Text`**, and then on the text insertion location in the diagram.



Group	Display Text	Type
Control Device	52Breaker	CF_D12
Control Device	52Breaker	DP
Control Device	Disc.Swit.	CF_D2
Control Device	Disc.Swit.	DP
Control Device	GndSwit.	CF_D2
Control Device	GndSwit.	DP

Figure 5-47 DIGSI® 4, Selection Window for Switching Equipment (example)

- Check the finished default display. The grid may be hidden by clicking **View** → **Grid**, equipment may be selected (brought to the front) by clicking **View** → **Make active**, and a view of the overall relay with default display may be selected by clicking **View** → **Normal size** (see Figure 5-48).
- Save the default display, and end the Display Editor session by clicking **Display** → **Close**. Answer the confirmation with **Yes**.

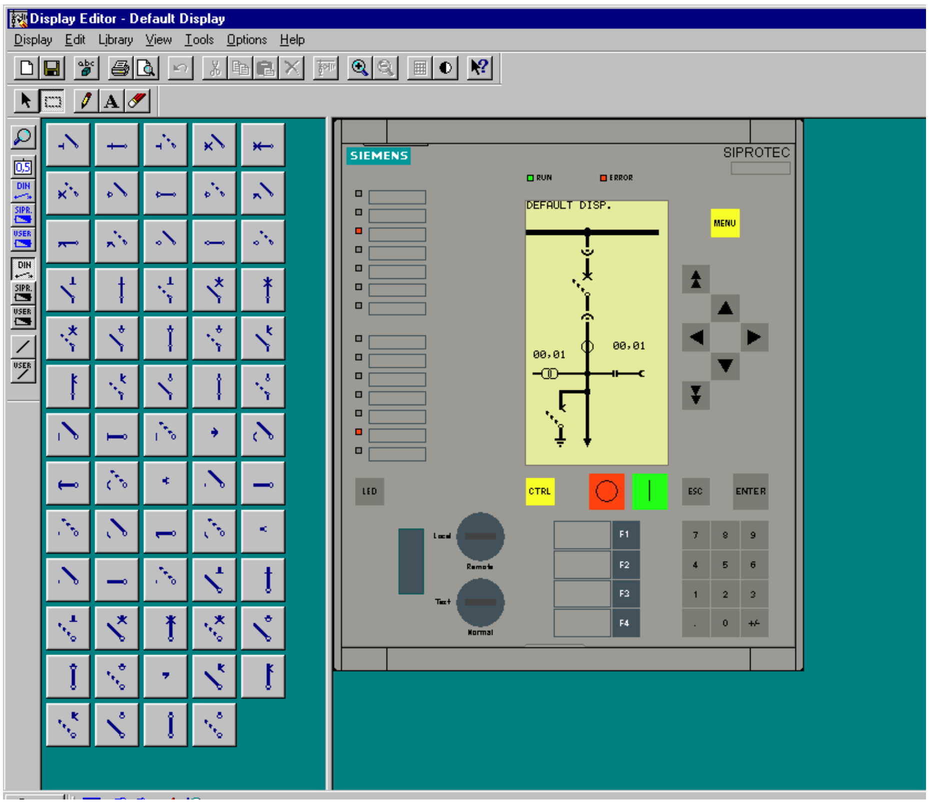


Figure 5-48 Default Display in Normal Size View

In order to use the default display for further applications (e.g. as a template in other bays or for a control diagram), click on **Display** → **Template** → **Save as....** Select the desired save path and enter the new filename. Click on **Save**.

5.5 Draft of a Feeder Control Display

General Information

The feeder control display is used to visualize the switch positions and to control the switching objects. That is why only the objects relevant for the switching process are usually displayed while measured values and such have been omitted. The feeder control display must be selected.

Upon delivery, the control display of the device is preset (see Figure 5-49). It can be altered or replaced in accordance with the actual system conditions.

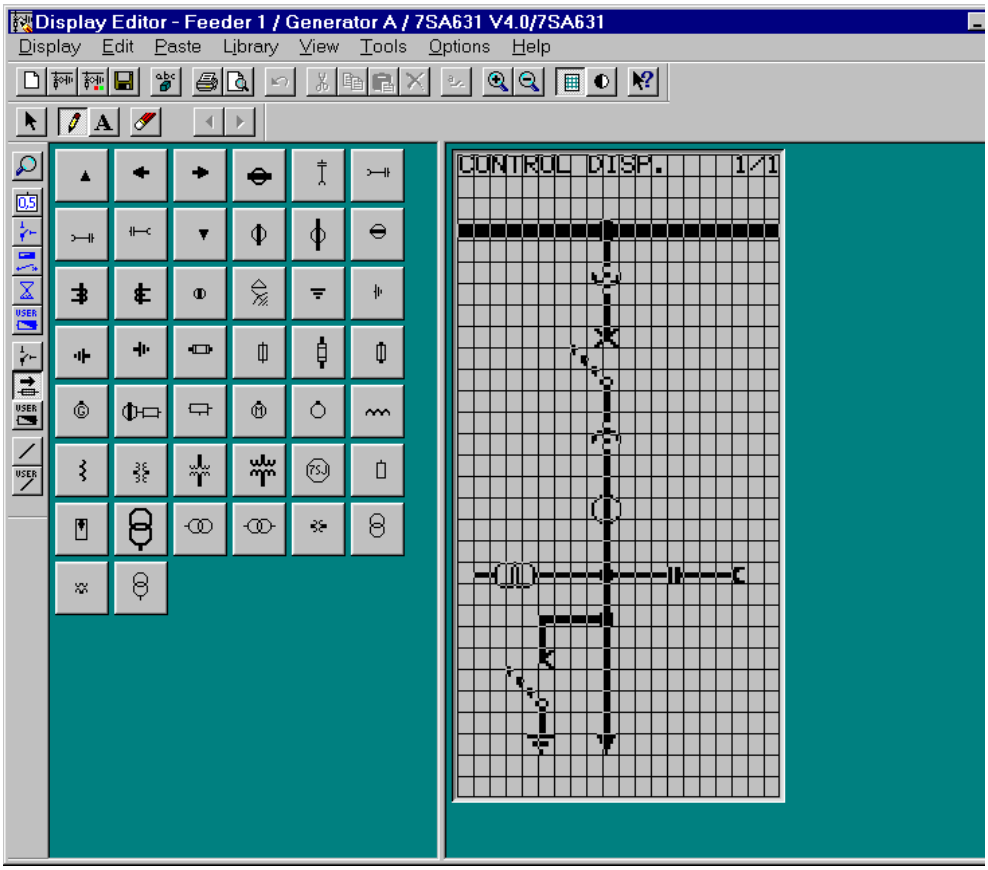


Figure 5-49 A preset control display

Procedure

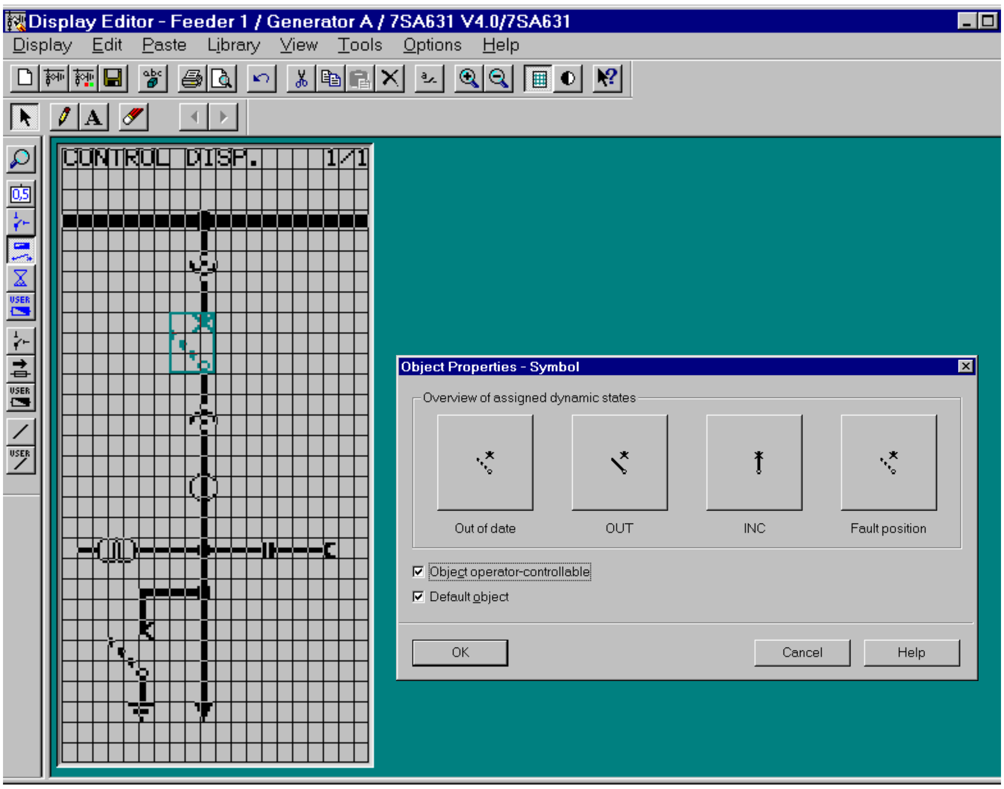
The creation or alteration of the control display is carried out via the Display Editor of the DIGSI® 4 operating program. The standard procedure is the same as when creating a default display (see section 5.4).

The prerequisite for the alteration or creation of a control display is the allocation of the switching objects located in the control display as described in Section 5.2 and of the controlling signals. This is the only way to enable a dynamic adaptation of the picture to the respective switching state.

For the modification of the factory settings and for design purposes the same tools as with the default display are used.

Proceed as follows:

- If you saved the default display as a template and want to use it as basis for the control display, open the template via **`Display`** → **`Template`** → **`Open...`** into an empty control display.
- As the switching devices in the bay are to be controlled via the feeder control display, you need to make the respective device controllable for the operator. Double click on the device in the active control display (see Figure 5-50). Then select **`Options devices`** in the active dialog window and highlight **`Object operator-controllable`**.
- In addition to this, determine the device which should be controlled first after calling the control display in the SIPROTEC® device. For this, select the option **`Default object`**. Confirm your setting with **`OK`**.



☑ Object operator-controllable

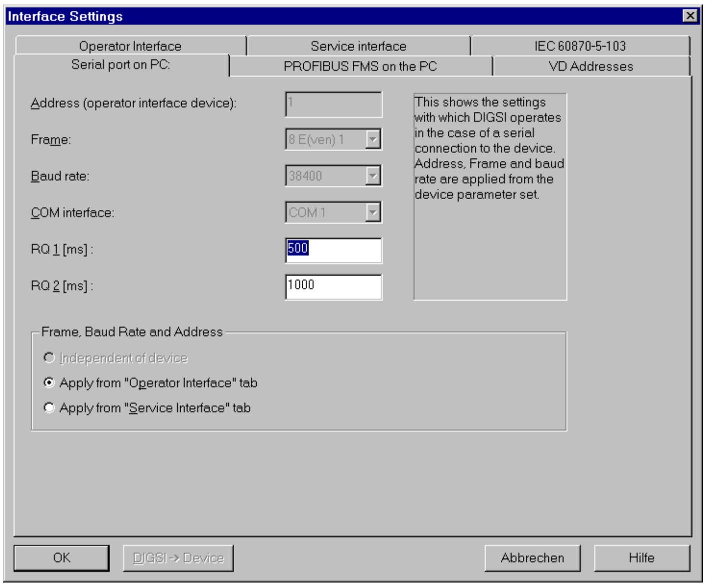
☑ Default object

Figure 5-50 Procedure to make devices operator-controllable and get them offered first for switching

5.6 Serial Interfaces

The device contains one or more serial interfaces: an operator interface integrated into the front panel, and — depending on the model ordered — a rear service interface and a system interface for connection of a central control system. Certain standards are necessary for communication via these interfaces, which contain device identification, transfer protocol, and transfer speed.

Configuration of these interfaces is performed using the DIGSI® 4 software program. Click on **`Setting`** in the navigation window and double-click in the data window on **`Interfaces`**. Next, select the specific data in the resulting dialogue box (Figure 5-51). The dialogue box contains a varying number of tabs (depending on the capabilities of the PC and the relay) with setting options for the interfaces.



Address (operator interface device): 1

Frame: 8 E(ven) 1

Baud rate: 38400

COM interface: COM 1

RQ 1 [ms] : 500

RQ 2 [ms] : 1000

This shows the settings with which DIGSI operates in the case of a serial connection to the device. Address, Frame and baud rate are applied from the device parameter set.

Frame, Baud Rate and Address

○ Independent of device

● Apply from "Operator Interface" tab

○ Apply from "Service Interface" tab

Figure 5-51 DIGSI® 4, Settings of the PC interface

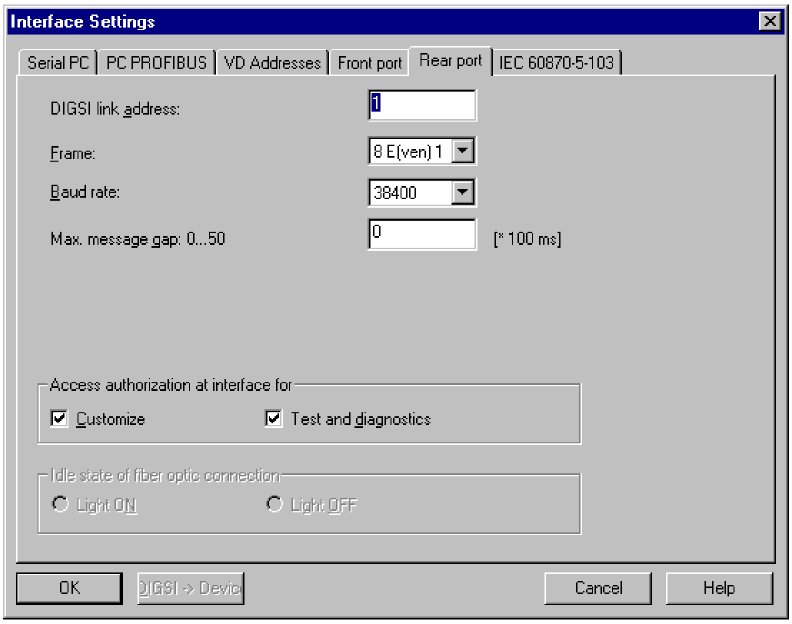
Serial Interface at the PC

In the first tab, you enter the communication interface of the PC which is connected to the 7SA6 relay (***`COM1, COM2,`*** etc.). Manual entry of settings for data format and baud-rate need not be made if these values were taken from the “**`device front`**” tab or the “**`device rear`**” tab (if present). In fact, many settings are read from DIGSI® 4 directly via the interface, and the corresponding setting fields are then inaccessible (see Figure 5-51). Alternatively, the option **`Independent of device`** may be selected.

Data exchange is monitored by the PC for the reaction times of the device. You may, within preset limits, configure maximum relay reaction times. The displayed values RQ 1 and RQ 2 correspond to the preset reaction times in milliseconds. In general, these values should not be modified. Modification is only necessary if a time-out often occurs during communication with the device. In order to modify these values, enter an integer value for RQ 1, between 200 and 9999, and for RQ 2, from 0 to 9999.

Front Port and Rear Port

Settings for the interfaces at the device can performed in these tabs. The link addresses and maximum message gap appear in the **`Front port`** and **`Rear port`** tab besides the settings for data format and transfer speed (example Figure 5-52).



DIGSI link address: 1

Frame: 8 E(ven) 1

Baud rate: 38400

Max. message gap: 0...50: 0 [* 100 ms]

Access authorization at interface for

☑ Customize ☑ Test and diagnostics

Idle state of fiber optic connection

○ Light ON ○ Light OFF

Figure 5-52 DIGSI® 4, Settings for the rear port — example

For the IEC communication, each SIPROTEC® device must have a unique IEC address assigned to it. There is a total of 254 IEC addresses available. Select an address from the pull-down menu **IEC link address**. Only the addresses which are within the current address range and have not yet been occupied are displayed.

The setting for the maximum message gap is only applicable when the device is to communicate using a modem via one of the interfaces. A gap is the maximum allowable time duration of interrupted transmission within one telegram transmission. Transfer gaps are created when using modems as a result of data compression, error correction, and baud-rate differences. For good data transmission between modems, a setting of ***1.0*** sec is recommended. For poor connections, this value should be increased.

Large values slow down communications in case of errors. When using a direct PC connection, **Max. message gaps** may be set to ***0.0*** sec.

Note:

Do not use front port for modem communication!.

Other Interfaces

Enter specific settings and addresses to identify devices in the other tabs, if necessary, or check the preset values.

Device addresses are used by the system to identify each device and must be unique throughout the substation. Detailed instructions for setting the interfaces are available in the “DIGSI® 4 Communications” manual.

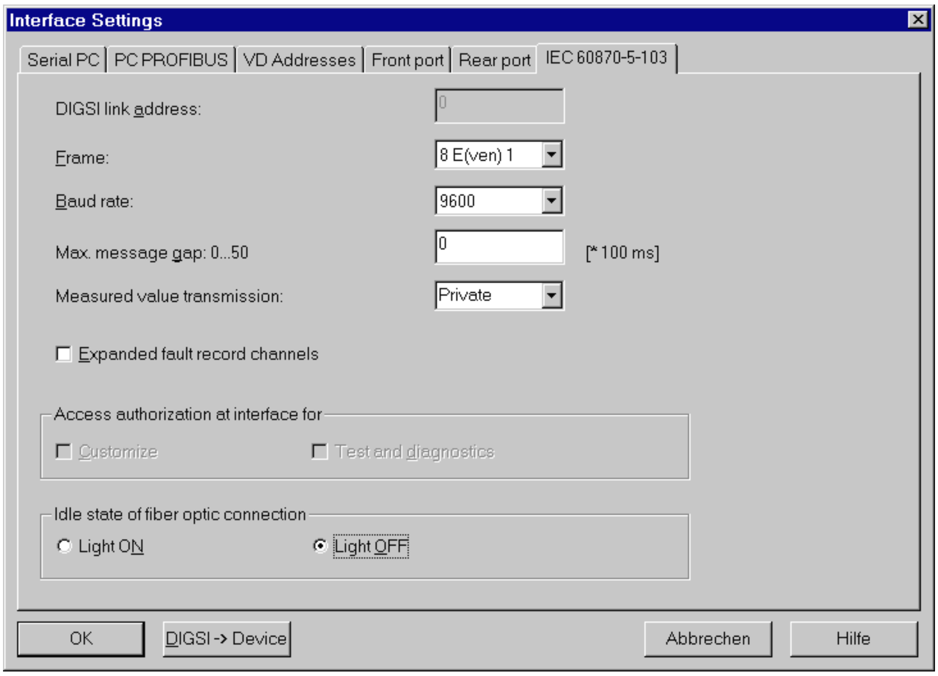
If you desire to expand or modify interfaces later, refer to the modification instructions for the interfaces, and if necessary for the hardware, see also instructions in Subsection 8.1.3 of this manual.

Profibus Connection

For a Profibus connection — if available — between a SIPROTEC® device and the SICAM® SAS or DIGSI® 4, a minimum transfer rate of 500 kBaud is recommended for disturbance-free communication.

Signal Idle State

For optical connections, the signal idle state is preset for “light off.” Modification of the signal idle state is accomplished in the tab for the interface settings (see Figure 5-53).



DIGSI link address: 0

Frame: 8 E(ven) 1

Baud rate: 9600

Max. message gap: 0...50 0 [* 100 ms]

Measured value transmission: Private

☐ Expanded fault record channels

Access authorization at interface for
☐ Customize ☐ Test and diagnostics

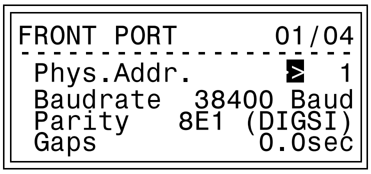
Idle state of fiber optic connection
○ Light ON ● Light OFF

Figure 5-53 Settings for an optical interface — example

Reading and Modifying Interface Settings at the Device

Reading and partial modification of the most important interface settings is possible, using the key-pad and display on the device panel. You may access the setting page for the interface via **`MAIN MENU`** through **`Settings`** → **`Setup/Extras`** → **`Serial Ports`**.

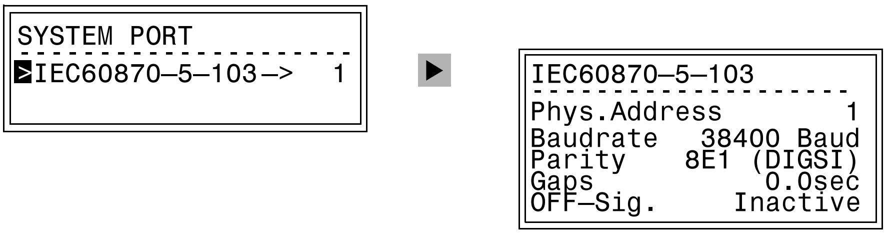
Under the sub-menu title **`SERIAL PORTS`**, you will find ***`Front`***, ***`System`***, and ***`Service Port`***, and selections may be made using the ▼ navigation button. By pressing the ▶ button, the sub-menu for a particular interface can be accessed. The display and the ability to change settings directly at the device are the same at both the front and service interfaces. Figure 5-54 shows the data of the front (operator) interface, as an example.



```
FRONT PORT        01/04
-----------------------
 Phys.Addr.        ⧗  1
 Baudrate   38400 Baud
 Parity    8E1 (DIGSI)
 Gaps          0.0sec
```

Figure 5-54 Reading and setting the front interface at the device panel

The type and number of system interface(s) is dependent on the device type and version and might be completely missing. The system interface data may be read at the device, but cannot be modified there, whereas the data for the operator and service interface can be modified. In addition to the settings already mentioned for the operator and service interfaces, the signal idle state for an optical link may also be read at the device. For an electrical interface, the response “`OFF–Sig. Inactive`” appears as shown in Figure 5-55.



```
SYSTEM PORT
---------------------
>IEC60870–5–103–>   1
```

```
IEC60870–5–103
--------------------
Phys.Address       1
Baudrate  38400 Baud
Parity   8E1 (DIGSI)
Gaps          0.0sec
OFF–Sig.    Inactive
```

Figure 5-55 Read-out of system interface setting values in the device display — example

5.7 Date and Time Stamping

Integrated date and time stamping allows an exact evaluation of the sequence of events (e.g. event logs and trip logs or limit violations). The following clock settings are available:

- Internal RTC clock (Real Time Clock),
- External synchronization sources (DCF, IRIG B, SyncBox, IEC 60870-5-103),
- External minute impulses via binary input.

Note:

The device is delivered from the factory with the internal RTC clock selected as the time source, independent of whether the device is equipped with a SCADA interface or not.

Time Synchronization

Settings for time synchronization may be found in DIGSI® 4 under **`Settings`** → **`Time synchronization`** (Figure 5-56).

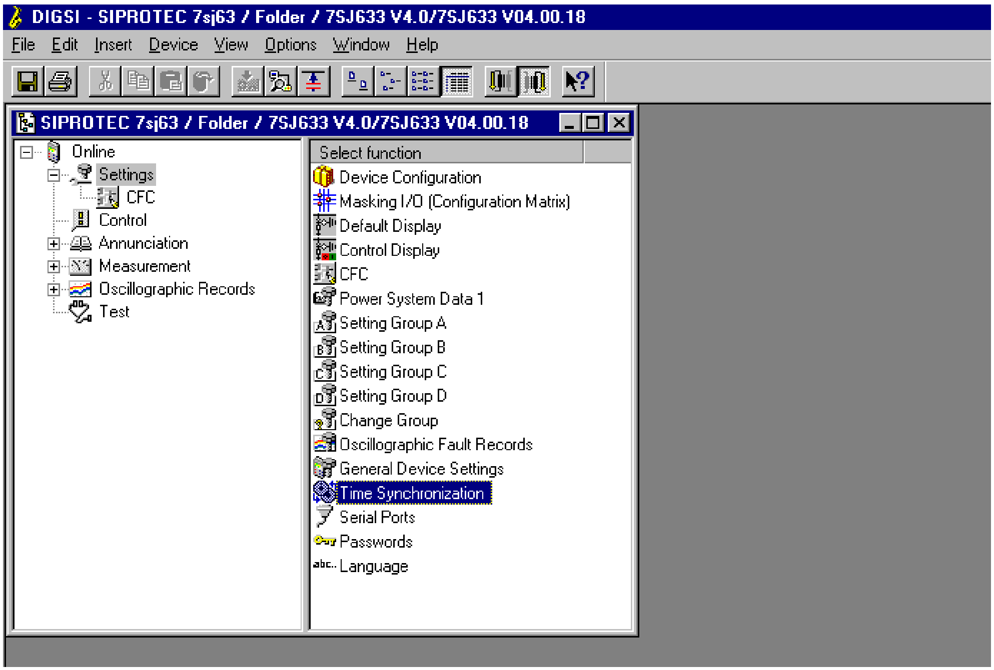
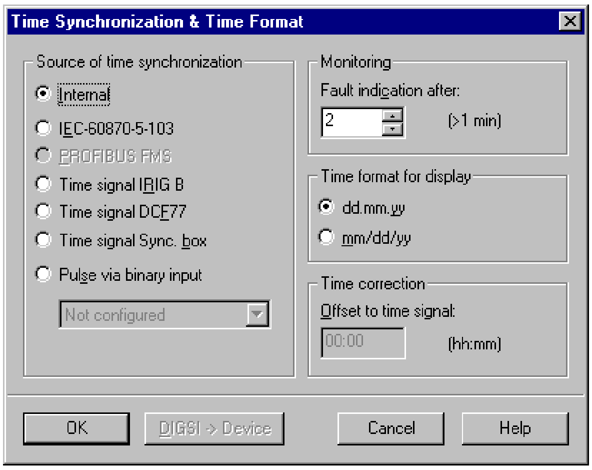


Figure 5-56 Setting Window in DIGSI® 4 – example

To open the **`Time Synchronization & Format`** window, the user should double-click on **`Time Synchronization`**. See Figure 5-57.



Time Synchronization & Time Format

Source of time synchronization

● Internal
○ IEC-60870-5-103
○ PROFIBUS FMS
○ Time signal IRIG B
○ Time signal DCF77
○ Time signal Sync. box
○ Pulse via binary input
Not configured

Monitoring

Fault indication after: 2 (>1 min)

Time format for display

● dd.mm.yy
○ mm/dd/yy

Time correction

Offset to time signal: 00:00 (hh:mm)

Figure 5-57 Dialogue box for time synchronization and format in DIGSI® 4

Here you may select the time standard for internal time stamping by selecting from the following modes:

Table 5-7 Operating modes for time synchronization

Item	Operating Mode	Explanations
1	**Internal**	Internal synchronization using RTC (pre-set)
2	**IEC 60870–5–103**	External synchronization using the system interface and the IEC 60870–5–103 protocol
3	**PROFIBUS FMS***	External synchronization using PROFIBUS interface
4	**IRIG B Time signal**	External synchronization using IRIG B
5	**DCF77 Time signal**	External synchronization using DCF 77
6	SIMEAS Time signal **Sync. Box**	External synchronization using SIMEAS Sync. Box
7	**Pulse via binary input**	External synchronization with pulse via binary input

The RTC continues running, even when the auxiliary voltage is temporary absent, by means of an internal battery. During the device powering up, or if the auxiliary voltage has failed, this RTC is the first synchronization source for the internal clock, independent of operating mode selected.

In **Internal** mode, the system time is controlled using only the RTC as the synchronization source. It may be set manually. The procedure for manual date/time setting is given in Section 7.2.1.

If an external source is selected, only the selected synchronization source is used. If the source fails, the internal clock continues unsynchronized.

If time synchronization is to take place via a master control system, the option **IEC–60870–5–103** or **PROFIBUS FMS*** must be selected (Figure 5-57).

*: not available in firmware Version 4.0 and 4.1

When using radio clock signals, you must take into account that it can take up to three minutes after device start-up or restored reception for the received time signal to be decoded. The internal clock is not re-synchronized until then.

With IRIG B, the year must be set manually, because this standard does not include a year value.

For synchronization using pulses via a binary input, the present device time will advance to 00 seconds of the next minute for values greater than 30 seconds when the positive slope of the pulse arrives. For second values less than 30, the device time will be set to 00 seconds of the current minute. Because this signal is not monitored, each pulse has a direct effect on the internal clock.

Synchronization Offset

The “Synchronization Offset” (**`Offset`**) setting allows correlation of the time signal received from the radio clock to local time (time zone). The maximum settable offset is ± 23 h 59 min = ±1439 min.

Annunciation due to Missing Synchronization

The tolerance time (**`Error Time`** / **`Fault indication after`**) for time synchronization fault indicates how long cyclical synchronization may be absent until an alarm is given.

External or internal synchronization normally occurs every minute. The setting for the tolerance time must, therefore, always be at least two minutes. Under poor radio clock reception conditions, you may delay the trigger of the “error” status condition even longer.

Changing the Synchronization Mode

When changing synchronization mode, the hardware will change over to the new source within one second. This causes breakdown of cyclical synchronization, and the internal clock will be disrupted — as at start-up — until the new synchronization source takes over.

After modification to the synchronization offset in the time signal/operating mode, or when changing year in IRIG B, the cyclical synchronization is not lost, but there is a jump. To call attention to this, the time value causing a jump is reported with “`Time interruption ON`” — without the synchronization offset, and subsequently with “`Time interruption OFF`” — with the synchronization offset.

Operating Messages from the Timing System

After the “`Time interruption ON`” message, you must take into account that the clock will jump. This message is issued under the following circumstances:

– if a synchronization interruption lasts longer than the tolerance time interval mentioned above, or as mentioned above, if the synchronization mode is changed;

– if a time jump is anticipated. The message itself is stamped with the old time.

The message “`Time interruption OFF`” is triggered:

– when the synchronization is re-established (e.g., after a break in reception by the radio clock);

– immediately after a time jump. This message is stamped with the new time after the jump, thus allowing determination of the jump interval.

Time Format

The time display may be set using either the European format (DD.MM.YYYY) or the US format (MM/DD/YYYY).

■

Functions

6

This chapter describes the numerous functions available in the SIPROTEC® 7SA6 relay. The setting options for each function are defined, including instructions for reporting setting values and formulae where required.

6.1 General

A few seconds after the device is switched on, the initial display appears in the LCD. Depending on the device version either measured values (four-line display) or a single-phase switching diagram of the feeder status (graphic display) is displayed in the 7SA6.

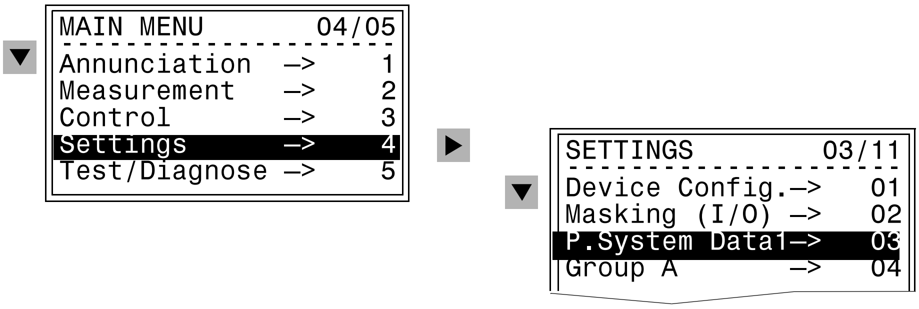
The setting parameters can be entered via the keypad and display on the front of the device, or by means of a personal computer connected to the front or service interface of the device utilising the DIGSI® 4 software package. The level 5 password (individual parameters) is required.

From the Device Front

Select the **`MAIN MENU`** by pressing the MENU key. Using the ▼ key, select ***`Settings`***, and then press the ▶ key to navigate to the **`SETTINGS`** display (see Figure 6-1).

In the **`SETTINGS`** display, use the ▼ key to select the desired function, and then use the ▶ key to navigate to that function (e.g., use the ▼ key to select the ***`P.System Data1`*** function, and then use the ▶ key to navigate to the **`P.SYSTEM DATA1`** display, as shown in Figure 6-2.

In general, an item number appears in the menu list to the right of each selection. Navigation can be accomplished using the item number in place of the ▲ and ▼ keys. This feature is particularly helpful in large menus (e.g., setting lists). Based on the example above, from the **`MAIN MENU`**, the **`SETTINGS`** display can be reached by pressing 4 on the keypad, and then the **`P.SYSTEM DATA1`** display can be reached by pressing 0 3 on the keypad.

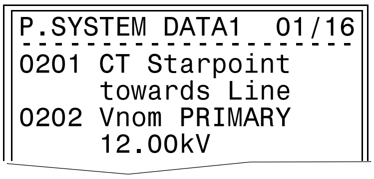


```
MAIN MENU        04/05
----------------------
Annunciation  ->     1
Measurement   ->     2
Control       ->     3
Settings      ->     4
Test/Diagnose ->     5
```

```
SETTINGS          03/11
-----------------------
Device Config.->    01
Masking (I/O) ->    02
P.System Data1->    03
Group A       ->    04
```

Figure 6-1 Example of navigation from the front control panel

Each setting contains a four-digit address number followed by the setting title as shown in Figure 6-2. The value of the current setting is displayed in the line just below the setting address number and title. The value may be text (Figure 6-2, Address 0201) or numerical (Figure 6-2, Address 0202).



```
P.SYSTEM DATA1  01/16
---------------------
0201 CT Starpoint
     towards Line
0202 Vnom PRIMARY
     12.00kV
```

Figure 6-2 Example of power system data display

Settings are selected using the ▲ and ▼ keys. When the ENTER key is pressed, the user is prompted for a password. The user should enter Password No. 5 and then press the ENTER key. The current value of the setting appears in a text box, with a blinking text insertion cursor.

Text Values

A text setting may be modified using the ▲ and ▼ keys to select one of two or more options.

Numerical Values (including ∞)

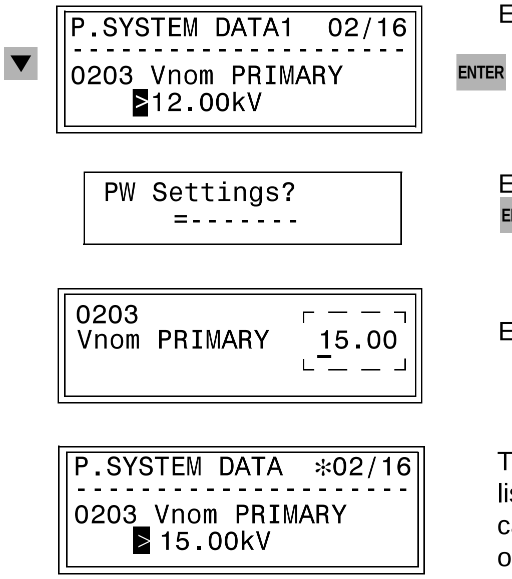
A numerical setting may be modified by overwriting the current value using the numerical keypad. See Figure 6-3. A value of "**infinity**" may be entered by pressing the decimal key twice . . . The "∞"–symbol will appear in the display.

If the number entered is not within allowable limits, the maximum or minimum allowable value will appear in the lower portion of the display. To enter a new, allowable value, the ENTER key should be pressed again.

Note that measured values and limit values must be entered in secondary quantities when using the front control panel of the device.

Confirmation

Any modification to a setting value must be confirmed by pressing the ENTER key. A blinking asterisk is an indication that setting modification mode is still open. Other modifications can be made to settings, even in sub-menus (if present), as long as setting modification mode is still open. The actual modification of settings occurs once setting modification mode is closed (see below, "Exiting the Setting Mode").



```
P.SYSTEM DATA1  02/16
---------------------
0203 Vnom PRIMARY
    >12.00kV
```

Example for numerical setting:

```
PW Settings?
     =-------
```

Enter password No. 5 and confirm with ENTER

```
0203
Vnom PRIMARY    15.00
```

Enter the new value and confirm with ENTER

```
P.SYSTEM DATA  *02/16
---------------------
0203 Vnom PRIMARY
    > 15.00kV
```

The modified setting value appears in the list; a blinking asterisk in the title bar indicates setting modification mode is still open.

Figure 6-3 Example of setting modification using the front control panel

If a setting modification is not confirmed with the ENTER key, the original value reappears after one minute, and a message window appears after three minutes notifying the user that the setting modification period has expired. When the ENTER key is pressed, a further message window appears, notifying the user that the setting modifications were discarded. Further modification of settings is possible by pressing the ENTER key and re-entering the password.

Exiting the Setting Mode

If an attempt is made to exit setting modification mode using the ◀ key or the MENU key, the message **`Are you sure?`** will be displayed followed by the responses **`Yes, No,`** and **`Escape`** (see Figure 6-4). If the response **`Yes`** is selected, modification of settings can be confirmed by pressing the ENTER key. To cancel pending modifications to settings and exit setting modification mode, the response **`No`** must be selected. Press the ▶ key until the response **`No`** is highlighted. Press the ENTER key to confirm and exit. Incorrect entries may be retracted in this manner. To remain in the setting modification mode, press the ▶ key until the response **`Escape`** is highlighted. Press the ENTER key to confirm, and the user can remain in setting modification mode without down-loading modifications.

```
Are you sure?
>Yes No Escape
```

ENTER

```
Settings are ok
     >Continue
```

ENTER

Figure 6-4 Ending the setting mode using the front control panel

From PC with DIGSI® 4

To select a function, double-click on **`Settings`**, and then double-click on the desired setting function (e.g., **`Power System Data 1`** is selected by double-clicking **`Settings`**, and then double-clicking **`Power System Data 1`** as illustrated in Figure 6-5).

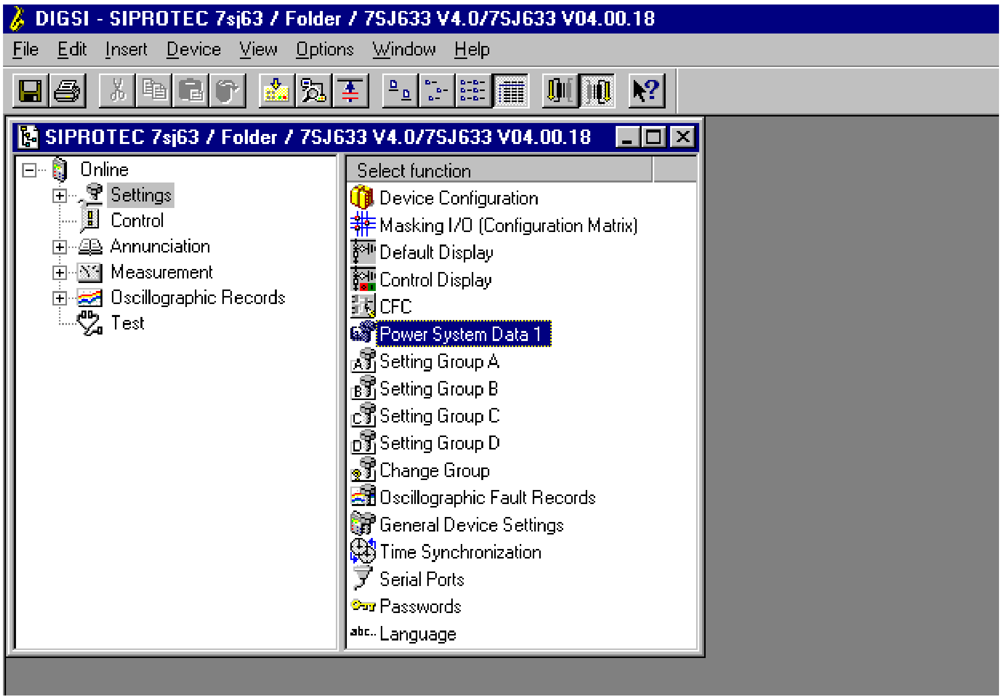
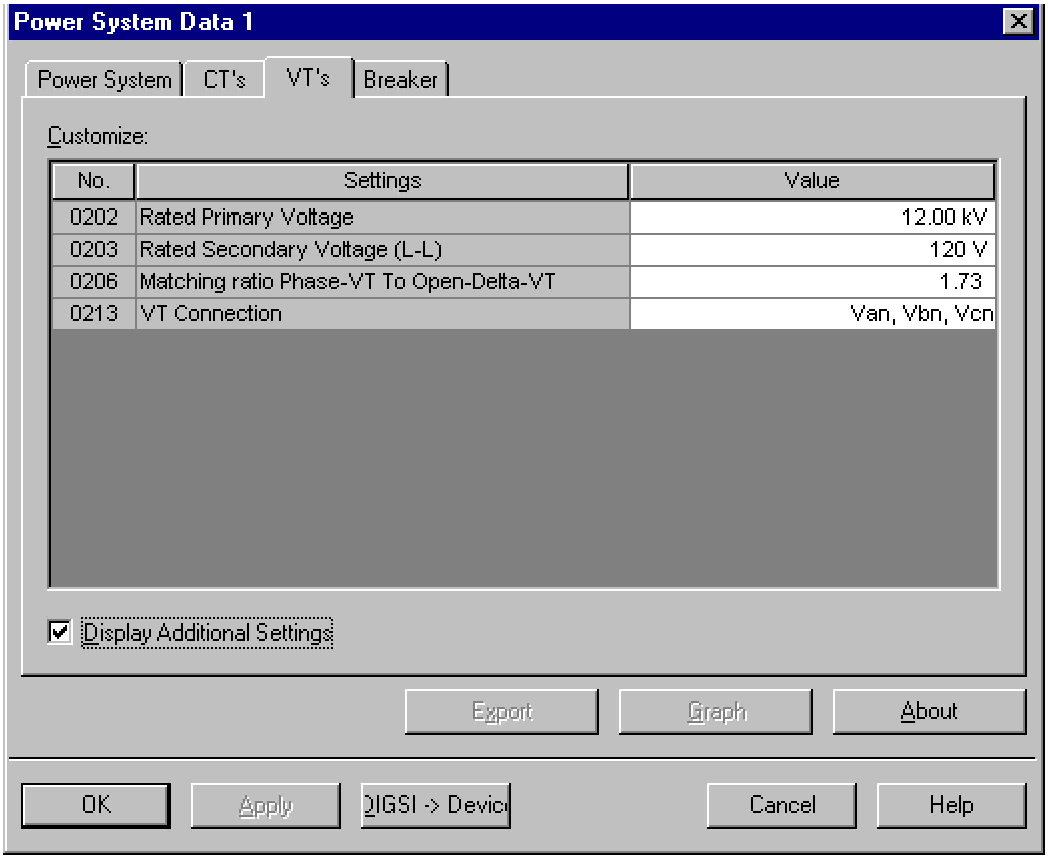


Figure 6-5 Navigating using DIGSI® 4 — example

A dialogue box associated with the selected function is displayed (e.g., if **`Power System Data 1`** function is selected, the dialogue box shown in Figure 6-6 will appear). If a function contains many settings, the dialogue box may include multiple windows. In this situation, the user can select individual windows via tabs located at the top of the dialogue box (e.g., in Figure 6-6, tabs exist for **`Power System`**, **`CT’s`**, **`VT’s`**, and **`Breaker`**).



No.	Settings	Value
0202	Rated Primary Voltage	12.00 kV
0203	Rated Secondary Voltage (L-L)	120 V
0206	Matching ratio Phase-VT To Open-Delta-VT	1.73
0213	VT Connection	Van, Vbn, Vcn

☑ Display Additional Settings

Figure 6-6 Power system data dialogue box in DIGSI® 4 — example

The left column of the dialogue box (identified as the **`No.`** column) contains the four-digit address number of the setting. The middle column of the dialogue box (identified as the **`Settings`** column) contains the title of the setting, and the right column of the dialogue box (identified as the **`Value`** column) contains the current value of the setting in text or numerical format. When the mouse cursor is positioned over a numerical field in the **`Value`** column, the allowable range is shown.

To modify a setting, click on the setting value which is displayed in the **`Value`** column.

Text Values

When a text setting value is selected, a pull-down menu of possible setting options is displayed. To modify the setting, simply click on the desired option. The pull-down menu closes, and the new setting value appears in the **`Value`** column.

Numerical Values (including ∞)

When a numerical setting value is selected, the setting is modified using the number keys, if applicable, with a decimal comma (not a decimal point). A value of **“infinity”** may be entered by pressing the small **o** key twice. Confirm the setting modification by clicking on **`Apply`**, or select another setting to modify.

If the value entered is outside the allowable range, a message block appears on the screen describing the error and displaying the acceptable range of values. To acknowledge the message, click **OK**, and the original value reappears. A new entry can be made or another setting value can be modified.

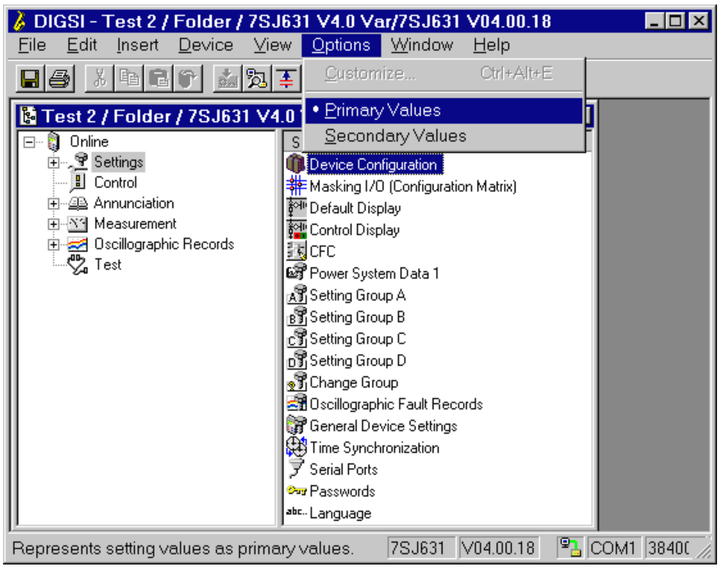
Primary or Secondary Values

Setting values can be entered and displayed in primary terms or secondary terms, as desired. DIGSI® 4 automatically performs the conversions based on the settings entered for the transformer data and conversion ratios.

To switch between primary values and secondary values:

- ☐ Click on **Options** in the menu bar, as shown in Figure 6-7.
- ☐ Click on the desired alternative.

Another method is available by using the buttons on the toolbar.



Represents setting values as primary values.

Figure 6-7 Selection of primary or secondary value entry — example

Additional Settings

Those settings that are modified only in special cases are typically hidden. They may be made visible by checking on **Display Additional Settings**.

Confirmation

Each entry may be confirmed by clicking **Apply**. Valid values are accepted automatically when another field is selected.

The final acceptance of a modified setting takes place once the setting mode is exited (see below “Exiting the Setting Mode”).

The dialogue box may be closed by clicking **OK**. Once closed, another function may be selected for setting modification, or you can exit the setting mode.

Exiting the Setting Mode

In order to transfer the modified setting values to the relay, the user should click on **DIGSI** → **Device**. The user will be prompted for Password No. 5. After entering the password and confirming with **OK**, data is transferred to the relay where modifications become effective.

6.1.1 Power System Data 1

Some system and plant data are required by the device, so that it may adapt its functions to these data, according to its mode of operation. Amongst others, the plant and instrument transformer ratings, polarity and termination of the measured values, parameters of the circuit breaker, etc. These data are summarized in **Power System Data 1 (P.System Data 1)**.

If the key MENU is operated, the main menu is displayed. With the key ▼ the option **Settings** is selected and by pushing the key ▶ the selection of ***Settings*** is confirmed. To enter the plant data **Power System Data 1 (P.System Data 1)** must be selected in the menu **Settings**.

With DIGSI® 4 the corresponding selection is reached by double click on **Settings**.

Polarity of Current Transformers

In address 0201 **CT Starpoint** the polarity of the current transformers must be entered, in other words, the location of the CT star-point (Figure 6-8). This setting determines the measuring direction of the device (forward = line direction). A change of this parameter also results in the polarity reversal of the earth current input.

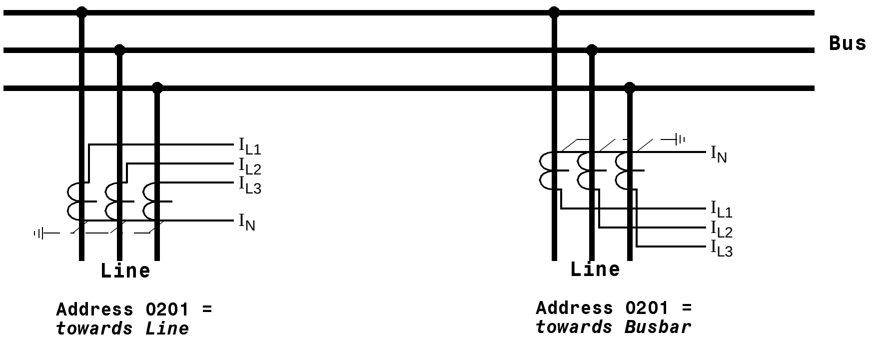


Figure 6-8 Current transformer polarity

Instrument Transformer Nominal Values

In the address 0203 **Unom PRIMARY** and 0204 **Unom SECONDARY** the device is informed of the primary and secondary rated voltage (line voltage) of the voltage transformers. In the address 0205 **CT PRIMARY** and 0206 **CT SECONDARY** the primary and secondary rated current (phase current) of the current transformers are entered.

Please observe that the rated current transformer secondary current must corresponds to the rated current of the device, as the device would otherwise compute incorrect primary data.

Correct entry of the primary data is a prerequisite for the correct computation of operational measured values with primary magnitude. If DIGSI® 4 is used to enter parameters as primary quantities, the correct entry of the primary data is an important prerequisite for the correct operation of the device.

Voltage Transformer Connection

The device contains four voltage measuring inputs, three of which are connected to the set of voltage transformers. For the fourth voltage transformer U_4 input several options are available:

- Connection of the U_4 input to the open delta connection e–n of a set of voltage transformers, refer to Appendix A, Figure A-25:

Address 0210 is then set to: **U4 transformer** = ***Udelta transf.***.
When connected to the e-n winding of a set of voltage transformers, the voltage transformation ratio of the voltage transformers is usually:

$$\frac{U_{Nprim}}{\sqrt{3}} \Big/ \frac{U_{Nsec}}{\sqrt{3}} \Big/ \frac{U_{Nsec}}{3}$$

In this case the factor **Uph / Udelta** (address 0211, matching ratio for the secondary nominal voltages of phase voltage transformers and open-delta voltage) must be set to $3/\sqrt{3} = \sqrt{3} \approx$ **1.73**. For other transformation ratios, e.g. when the displacement voltage is generated by means of interposing transformers, this factor must be adjusted accordingly. This factor is of importance for the monitoring of the measured values and the scaling of the measurement and disturbance recording signals.

- In case the busbar voltage is connected to the U4 input for synchronism check, refer also to Appendix A, e.g. Figure A-15. In this case address 0210 is set to: **U4 transformer** = ***Usync transf.***
  If the transformation ratio differs from that of the line voltage transformers this can be adapted with the setting in address 0215 **U-line / Usync**. In address 0212 **Usync connect.**, the type of voltage used for synchronism check is configured. According to this setting, the device automatically selects the appropriate phase to phase or phase to ground voltage. If the two voltages used for synchronism check — i.e. line voltage and busbar voltage — are not separated by a unit that causes a relative phase shift of the measured voltages (e.g. star-delta power transformer) then the parameter in address 0214 φ **Usync-Uline** is not required. If however a transformer with a vector group unequal to zero separates the two voltage sources, this setting must be used to compensate the phase shift according to the vector group of the transformer. This setting is only available in DIGSI 4 under **Additional Settings**. The phase angle setting is defined as follows: place Usync at zero degrees as reference voltage, draw in Uline with the correct phase relationship relative to Usync; the setting corresponds to the angle of **Usync** measured in counter-clockwise direction.

Example (refer also to Figure 6-9):

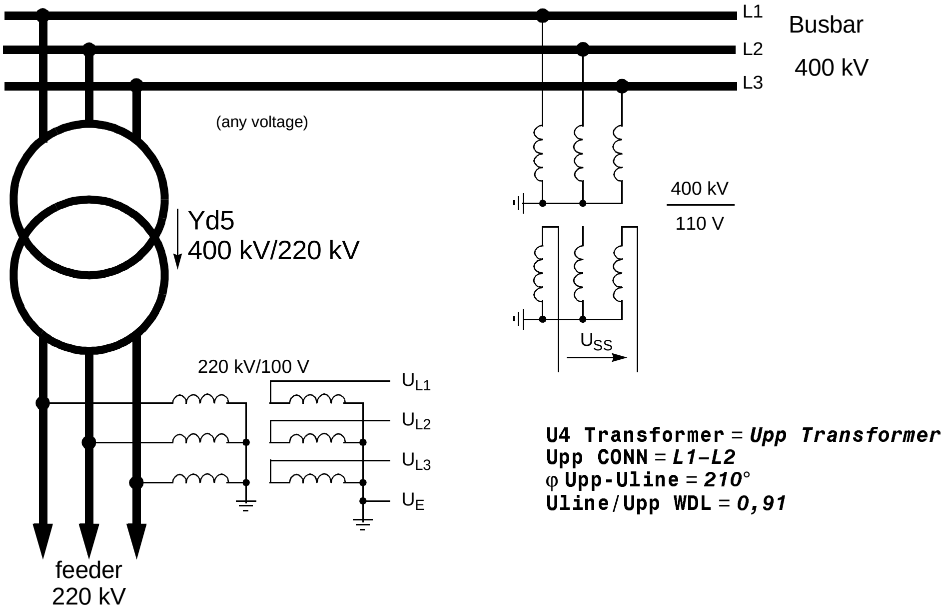
Busbar	400kV primary 110 V secondary
Feeder	220 kV primary 100 V secondary
Transformer	400 kV / 220 kV
Vector group	Dy(n) 5

The vector group of the transformer defines the phase shift of the voltage from the high voltage to the low voltage side (Vector group 5 corresponds to a phase shift of 5 x 30° in the clockwise direction of the low voltage side relative to the high voltage side). In this example, the feeder voltage is connected to the low voltage side of the transformer. If Usync (busbar or high voltage side) is placed at zero degrees, then Uline is at 5 x 30° in the clockwise direction, i.e. at –150°. According to the definition for the setting, the angle from **Usync** to **U-line** in the counter-clockwise direction must be taken, i.e. +210°.

Address 0214A: φ **Usync-Uline** = 360° - 150° = ***210°***

Since the busbar voltage transformer provides 110 V secondary with nominal primary voltage and the line voltage transformer 100 V under the same conditions, this difference must also be considered:

Address 0215: **U-line / Usync** = 100 V/ 110 V = ***0.91***



U4 Transformer = ***Upp Transformer***
Upp CONN = ***L1–L2***
φ **Upp-Uline** = ***210***°
Uline/Upp WDL = ***0,91***

Figure 6-9 Busbar voltage, measured across a power transformer

- Connection of the U$_4$ input to any other voltage signal U$_X$, which may be processed by the overvoltage protection function, refer to Appendix A, Figure A-27:
  Address 0210 is then set: **U4 transformer** = ***Ux transformer***.
  It is assumed, that the Ux transformer ratio is equal to the phase voltage transformer ratio.
- If the U$_4$ input is not required, the following setting is applied:
  Address 0210 **U4 transformer** = ***Not connected***.
  Also in this case the factor **Uph / Udelta** (Address 0211, refer to the above) is of importance, as it is utilised for the scaling of the measurement and disturbance recording signals.

Current Transformer Connection

The device contains four current measurement inputs, three of which are connected to the set of current transformers. The fourth current measuring input I$_4$ may be utilised in various ways:

- Connection of the I$_4$ input to the earth current in the starpoint of the set of current transformers on the protected feeder (normal connection, refer to Appendix A, Figure A-20):
  Address 0220 is then set to: **I4 transformer** = ***In prot. line*** and
  Address 0221 to **I4/Iph CT** = *1*.
- Connection of the I$_4$ input to a separate earth current transformer on the protected feeder (e.g. a summation CT or cable-type current transformer, refer to Appendix A, e.g. Figure A-21).
  Address 0220 is then set to: **I4 transformer** = ***In prot. line*** and
  Address 0221 is set to **I4/Iph CT**:

$$I_4/I_{ph\ CT} = \frac{\text{Ratio of earth current transformer}}{\text{Ratio of phase current transformers}}$$

This is independent on whether the device has a normal measured current input for I_4 or a sensitive measured current input for I_4 (for sensitive earth fault detection in non-earthed systems)

Example:

Phase current transformers 500 A/5 A
Cable core balance current transformer 60 A/1 A

$$I_4/I_{ph\ CT} = \frac{60/1}{500/5} = 0.600$$

- Connection of the I_4 input to the earth current of the parallel line (for parallel line compensation of the distance protection and/or fault location function, refer to Appendix A, Figure A-22):
  Address 0220 is then set to: **I4 transformer** = ***In paral. line*** and usually address 0221 is set to **I4/Iph CT** = *1*.
  If the set of current transformers on the parallel line however has a different ratio to those on the protected line, this must be taken into account in address 0221:
  Address 0220 is then set so that: **I4 transformer** = ***In paral. line*** and Address 0221 so that **I4/Iph CT** = $I_{N\ paral.\ line}/I_{N\ prot.\ line}$.

  Example:

  Current transformers on protected feeder 1200 A
  Current transformers on parallel feeder 1500 A

$$I_4/I_{ph} = \frac{1500}{1200} = 1.250$$

- Connection of the I_4 input to the neutral current of a power transformer; this connection can be used for the polarisation of the directional earth fault protection (refer to Appendix A, Figure A-23):
  Address 0220 is then set to: **I4 transformer** = ***IY starpoint***, and address 0221 **I4/Iph CT** according to the ratio of the transformation ratios of the current transformer in the transformer neutral and the set of current transformers on the protected feeder.
- If the I_4 input is not required, the following settings are applied:
  Address 0220 **I4 transformer** = ***Not connected***,
  Address 0221 **I4/Iph CT** is then irrelevant.
  In this case the zero sequence current for the protection functions is computed by means of the sum of the phase currents.

Rated Frequency

Address 0230 **Rated Frequency** corresponds to the frequency at which the power system operates. The preset value is dependent on the model number of the relay purchased, and must be in accordance with the nominal frequency of the power system.

System Starpoint

The system starpoint must be observed for the correct processing of earth faults and double earth faults. Therefore address 0207 **SystemStarpoint** ***Solid Earthed*** or ***Peterson-Coil earthed*** or ***Isolated*** must be set correspondingly. For low-resistant earthed systems set ***earthed.***

Phase Rotation

Address 0235 **PHASE SEQ.** is used to establish the phase rotation. The preset phase sequence is "***L1 L3 L2***". For systems that use a phase sequence of "***L1 L3 L2***", address 0235 must be set accordingly.

Units of Length

Address 0236 **Distance Unit** corresponds to the units of length (miles or km) applicable to fault locating. Changing the length unit will not result in an automatic conversion. The new setting values must be entered at the appropriate addresses.

Mode of Earth Impedance (Residual) Compensation

Matching of the earth to line impedance ratio is an essential prerequisite for the accurate measurement of the fault distance (distance protection, fault location) during earth faults. In address 0237 **Format Z0/Z1** the format for entering the residual compensation is determined. It is possible to either use the ratio **RE/RL** and **XE/XL** or to enter the complex earth (residual) impedance factor **K0**. The actual setting of the earth (residual) impedance factors is done in conjunction with the general protection data (refer to Section 6.1.3).

Closing Time of the Circuit Breaker

The closing time of the circuit breaker **T-CB close** (address 0239) is necessary if the synchro-check function of the relay is used also for asynchronous switching. In this case, the relay calculates the ideal closing instant such that the two voltages (bus bar and feeder) are in synchronism at the instant when the breaker primary contacts close.

Trip/Close Command Duration

Under address 0240A the minimum trip command duration **TMin TRIP CMD** is set. This applies to all protection and control functions which may issue a trip command. This also determines the length of the trip command pulse when a circuit breaker trip test is initiated via the device. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Under address 0241A the maximum close command duration **TMax CLOSE CMD** is set. This applies to all close commands issued by the device. It also determines the length of the close command pulse when a circuit breaker test cycle is issued via the device. It must be set long enough to ensure that the circuit breaker has securely closed. There is no risk in setting this time too long, as the close command will in any event be terminated following a new trip command from a protection function. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Circuit Breaker Test

With the 7SA6 it is possible to initiate from the front of the device or with DIGSI® 4 an on load circuit breaker test consisting of a trip and close command. The duration of the commands is determined by the command duration settings above. With address 0242 **T-CBtest-dead** the duration from the end of the trip command up to the start of the close command for this test is determined. This setting should not be shorter than 0.1 s.

6.1.1.1 Settings

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A these values are to be multiplied by 5.

Addr.	Setting Title	Function	Setting Options	Default Setting
201	CT Starpoint	Power System Data 1	towards Line towards Busbar	towards Line
203	Unom PRIMARY	Power System Data 1	1.0..1200.0 kV	400.0 kV

Addr.	Setting Title	Function	Setting Options	Default Setting
204	Unom SECONDARY	Power System Data 1	80..125 V	100 V
205	CT PRIMARY	Power System Data 1	10..5000 A	1000 A
206	CT SECONDARY	Power System Data 1	1A 5A	1A
207	SystemStarpoint	Power System Data 1	Solid Earthed Peterson-Coil earthed Isolated	Solid Earthed
210	U4 transformer	Power System Data 1	not connected Udelta transformer Usync transformer Ux reference transformer	not connected
211	Uph / Udelta	Power System Data 1	0.10..9.99	1.73
212	Usync connect.	Power System Data 1	L1-E L2-E L3-E L1-L2 L2-L3 L3-L1	L1-L2
214A	φ Usync-Uline	Power System Data 1	0..360 °	0 °
215	U-line / Usync	Power System Data 1	0.80..1.20	1.00
220	I4 transformer	Power System Data 1	not connected Neutral Current (of the protected line) Neutral Current of the parallel line Starpoint Curr. of earthed power transf.	Neutral Current (of the protected line)
221	I4/Iph CT	Power System Data 1	0.010..5.000	1.000
230	Rated Frequency	Power System Data 1	50 Hz 60 Hz	50 Hz
235	PHASE SEQ.	Power System Data 1	L1 L2 L3 L1 L3 L2	L1 L2 L3
236	Distance Unit	Power System Data 1	km Miles	km
237	Format Z0/Z1	Power System Data 1	Zero seq. comp. factors RE/RL and XE/XL Zero seq. comp. factor K0 and angle(K0)	Zero seq. comp. factors RE/RL and XE/XL
239	T-CB close	Power System Data 1	0.01..0.60 sec	0.06 sec
240A	TMin TRIP CMD	Power System Data 1	0.02..30.00 sec	0.10 sec
241A	TMax CLOSE CMD	Power System Data 1	0.01..30.00 sec	0.10 sec
242	T-CBtest-dead	Power System Data 1	0.00..30.00 sec	0.10 sec

6.1.2 Setting Groups

Purpose of Setting Groups

A setting group is a collection of setting values to be used for a particular application. In the 7SA6 relay, four independent setting groups (A to D) are possible. The user can switch between setting groups locally, via binary inputs (if so configured), via the operator or service interface using a personal computer, or via the system interface.

A setting group includes the setting values for all functions that have been selected as ***Enabled*** during configuration (see Chapter 5). Whilst setting values may vary among the four setting groups, the selected functions of each setting group remain the same.

Multiple setting groups allows a specific relay to be used for more than one application. While all setting groups are stored in the relay, only one setting group may be active at a given time.

If multiple setting groups are not required, Group A is the default selection, and the rest of this sub-section is of no importance.

If multiple setting groups are desired, address **0103 Grp Chge OPTION** must have been set to ***Enabled*** in the relay configuration. Refer to Chapter 5. Each of these sets (A to D) is adjusted one after the other.

Copying Setting Groups

In most cases, only a few settings will vary from setting group to setting group. For this reason, an option exists to copy stored setting values from one setting group to another setting group using DIGSI® 4:

To copy the setting values from setting group to another setting group, you should highlight the setting group in the list whose setting values are to be copied. Next, go to the menu bar, click on **Edit** and select **Copy** (see Figure 6-10).

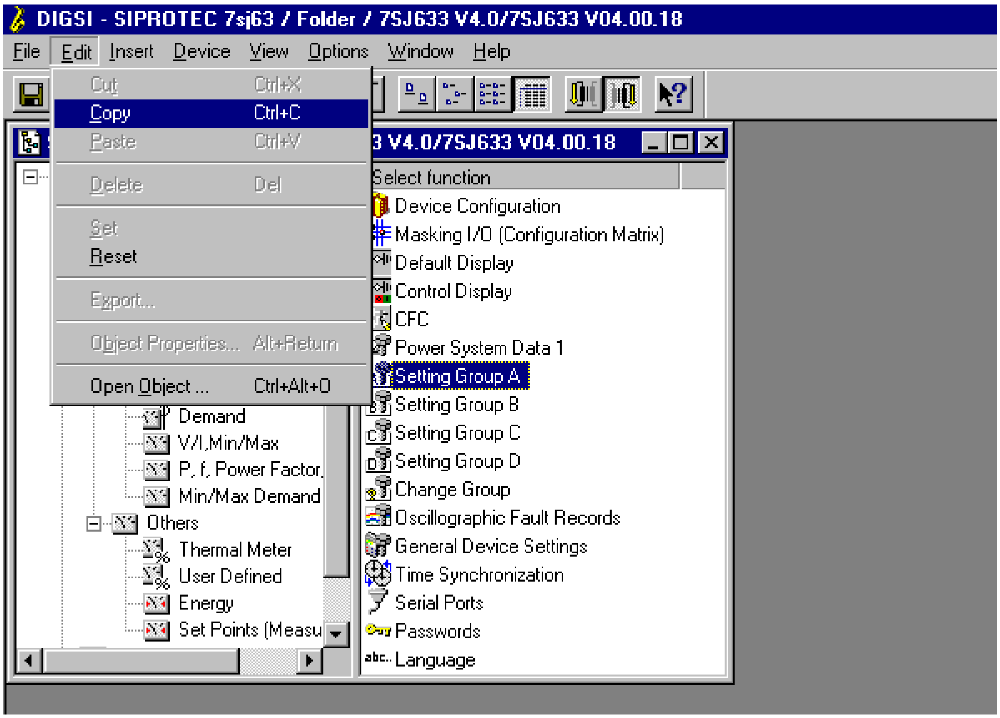
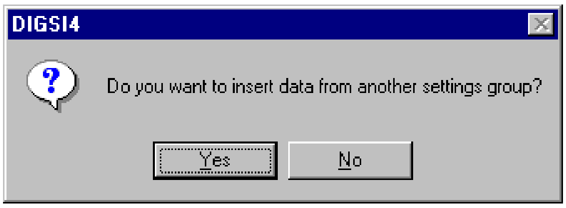


Figure 6-10 Copying a setting group in DIGSI® 4 – example

The next step is to highlight the name of setting group in the list into which the setting values should be copied. Go to the menu bar, click on **`Edit`** and select **`Paste`**. A confirmation box will appear (see Figure 6-11). Select **`Yes`** to copy the setting values.

Note:

All existing setting values in the setting group that has been copied to will be overwritten. An inadvertent copy operation can be reversed by closing and reopening the DIGSI® 4 session without saving changes.



Do you want to insert data from another settings group?

Figure 6-11 DIGSI® 4: Confirmation before copying a setting group

Setting groups may be copied more easily using the “Drag & Drop” feature. To use the “Drag & Drop” feature, the name of the setting group in the list whose setting values are to be copied should be highlighted. Holding down the left mouse button, the cursor can then be dragged to the name of the setting group into which the setting values are to be copied.

After copying setting groups, it is only necessary to modify those setting values that are to be set differently.

Restoring Factory Settings

The factory settings may be restored for a modified setting group. To restore factory settings to a setting group, the name of the setting group whose settings are to be restored is highlighted. Next, select the menu option **`Edit`** and then click on **`Reset`**. A confirmation box appears, click on **`Yes`** to confirm restoration of factory settings.

Note:

All setting values in the setting group being restored to factory settings will be overwritten. An inadvertent reset operation can be reversed by closing and reopening the DIGSI® 4 session without saving changes.

Switching between Setting Groups

The procedure to switch from one setting group to another during operations is described in Sub-section 7.2.2. The option of switching between several setting groups externally via binary inputs is described in Subsection 8.1.2.

6.1.2.1 Settings

Addr.	Setting Title	Function	Setting Options	Default Setting
302	CHANGE	Change Group	Group A Group B Group C Group D Binary Input Protocol	Group A

6.1.2.2 Information Overview

FNr.	Setting Title	Default Setting
7	>Set Group Bit0	>Setting Group Select Bit 0
8	>Set Group Bit1	>Setting Group Select Bit 1
	Group A	Group A
	Group B	Group B
	Group C	Group C
	Group D	Group D

6.1.3 General Protection Data

General protection data (**`P.System Data 2`**) includes settings associated with all functions rather than a specific protective or monitoring function. In contrast to the Power System Data 1 (**`P.System Data 1`**) as discussed in Sub-section 6.1.1, these settings can be changed over with the setting groups. To modify these settings, select the **`SETTINGS`** menu option ***`Group A`*** (setting group A), and then **`Power System Data 2 (P.System Data 2)`**.

The other setting groups are ***`Group B, Group C`***, and ***`Group D`***, as described in Subsection 6.1.2.

Rating of the Protected System

The rated primary voltage (line voltage) and rated primary current (phase) of the protected system are entered in the address **`1103 FullScaleVolt.`** and **`1104 FullScaleCurr.`**. These parameters influence the display of the operational measured values in percent. If these ratings correspond to those of the voltage and current transformers, the settings are the same as those in address **`0203`** and **`0205`** (Section 6.1.1).

General Line Data

The settings of the line data in this case refers to the common data which is independent on the actual distance protection grading.

The line angle (Address **`1105 Line Angle`**) may be derived from the line parameters. The following applies:

$$\tan\varphi = \frac{X_L}{R_L} \qquad \text{or} \qquad \varphi = \arctan\left(\frac{X_L}{R_L}\right)$$

where R_L being the resistance and X_L the reactance of the protected line. The line parameters may either apply to the entire line length, or be per unit of line length as the quotient is independent of length. Furthermore it makes no difference if the quotients were calculated with primary or secondary values.

The line angle plays an important role e.g. for the form of the polygons in the distance protection or in the earth impedance matching with magnitude and angle.

Calculation example:

110 kV overhead line 150 mm^2 with the following data

R'_1 = 0.19 Ω/km
X'_1 = 0.42 Ω/km

The line angle is computed as follows

$$\tan\varphi = \frac{X_L}{R_L} = \frac{X'_1}{R'_1} = \frac{0.42\ \Omega/km}{0.19\ \Omega/km} = 2.21 \qquad \varphi = 65.7°$$

In address 1105 the setting **`Line Angle`** = ***66***° is entered.

The per unit length reactance X' is entered as relative quantity **`x'`**, in address **`1110`** in Ω/km, when for example the unit of length is given in ***`km`*** (Address **`0236`**, refer to Section 6.1.1 under “**`Units of Length`**” or under address **`1112`** in Ω/mile, when the unit of length is given in ***`Miles`***. The corresponding line length is entered in address **`1111 Line Length`** in kilometres or under address **`1113 Line Length`** in miles. If the unit of length in address 0236 is changed after the per unit length impedances in address 1110 or 1112 or the line length in address 1111 or 1113 have been entered, the line data must be entered again for the revised unit of length.

When entering the parameters with a personal computer and DIGSI® 4 the values may optionally also be entered as primary values. The following conversion to secondary quantities is then not required.

For the conversion from primary to secondary values the following applies in general:

$$Z_{sec} = \frac{\text{Ratio of current transformers}}{\text{Ratio of voltage transformers}} \cdot Z_{prim}$$

Correspondingly the following applies to the per unit length reactance of a line:

$$X'_{sek} = \frac{N_{CT}}{N_{VT}} \cdot X'_{prim}$$

with
N_{CT} — Ratio of the current transformers
N_{VT} — Ratio of the voltage transformers

Calculation example:

110 kV overhead line 150 mm^2 similar to above

R'_1 = 0.19 Ω/km
X'_1 = 0.42 Ω/km

Current transformers600 A/1 A

Voltage transformers110 kV/0.1 kV

The secondary per unit length reactance is therefore:

$$X'_{sec} = \frac{N_{CT}}{N_{VT}} \cdot X'_{prim} = \frac{600\ A/1\ A}{110\ kV/0.1\ kV} \cdot 0.42\ \Omega/km = 0.229\ \Omega/km$$

In address **1110** the following is set **x'** = ***0.229*** Ω/km.

Earth Impedance (Residual) Compensation

Matching of the earth to line impedance is an essential prerequisite for the accurate measurement of the fault distance (distance protection, fault locator) during earth faults. This compensation is either achieved by entering the resistance ratio R_E/R_L and the reactance ratio X_E/X_L or by entry of the complex earth (residual) compensation factor $\underline{K}_0$. Which of these two entry options applies was determined by the setting in address 0237 **FORMAT Z0/Z1** (refer to Section 6.1.1). Corresponding to the option determined there, only the relevant addresses appear here.

Earth Impedance (Residual) Compensation with Scalar Factors R_E/R_L and X_E/X_L

When entering the resistance ratio R_E/R_L and the reactance ratio X_E/X_L the addresses **1116** to **1119** apply. These ratios are simply formally calculated and are not identical with the real and imaginary part of $\underline{Z}_E/\underline{Z}_L$. A computation with complex numbers is therefore not necessary! The values may derived from the line data using the following equations:

Resistance ratio:

$$\frac{R_E}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right)$$

Reactance ratio:

$$\frac{X_E}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right)$$

Whereby the following applies
R_0 — Zero sequence resistance of the line
X_0 — Zero sequence reactance of the line
R_1 — Positive sequence resistance of the line
X_1 — Positive sequence reactance of the line

These values may either apply to the entire line length or be based on a per unit of line length, as the quotient is independent of length. Furthermore it makes no difference if the quotients are calculated with primary or secondary values.

Calculation example:

110 kV overhead line 150 mm^2 with the following data

$R_1/s = 0.19\ \Omega/\text{km}$ $X_1/s = 0.42\ \Omega/\text{km}$	Positive sequence impedance
$R_0/s = 0.53\ \Omega/\text{km}$ $X_0/s = 1.19\ \Omega/\text{km}$	Zero sequence impedance

(where s = line length)

The following results are obtained for the earth impedance ratio:

$$\frac{R_E}{R_L} = \frac{1}{3} \cdot \left(\frac{R_0}{R_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{0.53\ \Omega/km}{0.19\ \Omega/km} - 1\right) = 0.60$$

$$\frac{X_E}{X_L} = \frac{1}{3} \cdot \left(\frac{X_0}{X_1} - 1\right) = \frac{1}{3} \cdot \left(\frac{1.19\ \Omega/km}{0.42\ \Omega/km} - 1\right) = 0.61$$

The earth impedance (residual) compensation factor setting for the first zone Z1 may be different from that of the remaining zones of the distance protection. This allows the setting of the exact values for the protected line, while at the same time the setting for the back-up zones may be a close approximation even when the following lines have substantially different earth impedance ratios (e.g. cable after an overhead line). Accordingly, the settings for the address **1116 RE/RL(Z1)** and **1117 XE/XL(Z1)** are determined with the data of the protected line while the addresses **1118 RE/RL(Z1B...Z5)** and **1119 XE/XL(Z1B...Z5)** apply to the remaining zones Z1B and Z2 up to Z5 (as seen from the relay location).

Earth Impedance (Residual) Compensation with Magnitude and Angle ($\underline{K}_0$–Factor)

When the complex earth impedance (residual) compensation factor $\underline{K}_0$ is set, the addresses **1120** to **1123** apply.

In this case it is most relevant that the line angle is set correctly (cf Address 1105, see paragraph “General Line Data”, page 6-16) as the device needs the line angle to calculate the compensation components from the $\underline{K}_0$–factor. These factors are defined with their magnitude and angle which may be calculated with the line data using the following equation:

$$\underline{K}_0 = \frac{\underline{Z}_E}{\underline{Z}_L} = \frac{1}{3} \cdot \left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right)$$

Whereby the following applies
$\underline{Z}_0$ — (complex) zero sequence impedance of the line
$\underline{Z}_1$ — (complex) positive sequence impedance of the line

These values may either apply to the entire line length or be based on a per unit of line length, as the quotients are independent of length. Furthermore it makes no difference if the quotients are calculated with primary or secondary values.

For overhead lines it is generally possible to calculate with scalar quantities as the angle of the zero sequence and positive sequence system only differ by an insignificant amount. With cables however, significant angle differences may exist as illustrated by the following example.

Calculation example:

110 kV single conductor oil-filled cable 3×185 mm^2 Cu with the following data

$\underline{Z}_1/s = 0.408\cdot e^{j73°}\ \Omega/km$	positive sequence impedance
$\underline{Z}_0/s = 0.632\cdot e^{j18,4°}\ \Omega/km$	zero sequence impedance

(where s = line length)

The calculation of the earth impedance (residual) compensation factor $\underline{K}_0$ results in:

$$\frac{\underline{Z}_0}{\underline{Z}_1} = \frac{0.632}{0.408}\cdot e^{j(18.4°-73°)} = 1.55\cdot e^{-j54.6°} = 1.55\cdot(0.579 - j0.815)$$

$$= 0.898 - j1.263$$

$$\underline{K}_0 = \frac{1}{3}\cdot\left(\frac{\underline{Z}_0}{\underline{Z}_1} - 1\right) = \frac{1}{3}\cdot(0.898 - j1.263 - 1) = \frac{1}{3}\cdot(-0.102 - j1.263)$$

The magnitude of K0 is therefore

$$K_0 = \frac{1}{3}\cdot\sqrt{(-0.102^2) + (-1.263^2)} = 0.42$$

When determining the angle, the quadrant of the result must be considered. The following table indicates the quadrant and range of the angle which is determined by the signs of the calculated real and imaginary part of $\underline{K}_0$.

Table 6-1 Quadrants and range of the angle of $\underline{K}_0$

Real part	Imaginary part	tan φ(K0)	Quadrant/Range	Rules for calculation
+	+	+	I 0° ... +90°	arctan(|Im|/|Re|)
+	–	–	IV –90° ... 0°	–arctan(|Im|/|Re|)
–	–	+	III –90° ... –180°	arctan(|Im|/|Re|) – 180°

In this example the following result is obtained:

$$\varphi(\underline{K}_0) = \arctan\left(\frac{1.263}{0.102}\right) - 180° = -94.6°$$

The magnitude and angle of the earth impedance (residual) compensation factors setting for the first zone Z1 and the remaining zones of the distance protection may be different. This allows to set the exact values for the protected line, while at the same time the setting for the back-up zones may be a close approximate even when the following lines have substantially different earth impedance ratios (e.g. cable after an overhead line). Accordingly, the settings for the address **`1120 K0 (Z1)`** and **`1121 Angle K0(Z1)`** are determined with the data of the protected line while the addresses

1122 K0 (> Z1) and **1123 AngleI K0(> Z1)** apply to the remaining zones Z1B and Z2 up to Z5 (as seen from the relay location).

Note:

If a combination of values is set which is not recognized by the device, it operates with preset values $\underline{K}_0 = 1 \cdot e^{0°}$. The event logs show the following information: „DisErrorK0(>Z1)" (FNo 3655) or "Dis.ErrorK0(Z1)" (FNo 3654)

Parallel Line Mutual Impedance

If the device is applied to a double circuit line (parallel lines) and parallel line compensation for the distance and/or fault location function is used, the mutual coupling of the two lines must be considered. A prerequisite for this is that the earth (residual) current of the parallel line has been connected to the measuring input I_4 of the device and that this was configured with the power system data (Section 6.1.1) by setting the appropriate parameters.

The coupling factors may be determined using the following equations:

Resistance ratio:

$$\frac{R_M}{R_L} = \frac{1}{3} \cdot \frac{R_{0M}}{R_1}$$

Reactance ratio:

$$\frac{X_M}{X_L} = \frac{1}{3} \cdot \frac{X_{0M}}{X_1}$$

with

R_{0M} — mutual zero sequence resistance (coupling resistance) of the line
X_{0M} — mutual zero sequence reactance (coupling reactance) of the line
R_1 — positive sequence resistance of the line
X_1 — positive sequence reactance of the line

These values may either apply to the entire double circuit line length or be based on a per unit of line length, as the quotient is independent on length. Furthermore it makes no difference if the quotients are calculated with primary or secondary values.

These setting values only apply to the protected line and are entered in the addresses **1126 RM/RL ParalLine** and **1127 XM/XL ParalLine**.

For earth faults on the protected feeder there is in theory no additional distance protection or fault locator measuring error when the parallel line compensation is used. The setting in address **1128 RATIO Par. Comp** is therefore only relevant for earth faults outside the protected feeder. It provides the current ratio I_E/I_{EP} for the earth current balance of the distance protection (in Figure 6-12 for the device at location II), above which compensation should take place. In general, a presetting of 85% is sufficient. A more sensitive (larger) setting has no advantage. Only in the case of a severe system un-symmetry, or a very small coupling factor (X_M/X_L below approximately 0.4), a smaller setting may be useful. A more detailed explanation of parallel line compensation can be found in section 6.2.3.1, under distance protection.

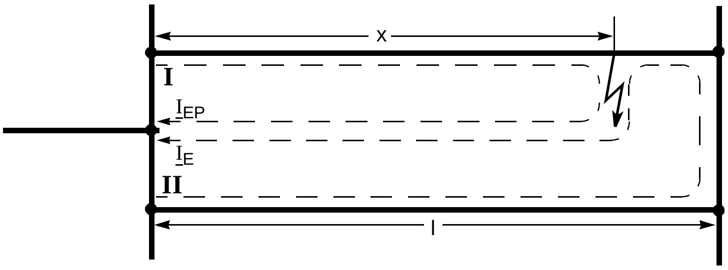


Figure 6-12 reach with Parallel Line Compensation at II

The current ratio may also be calculated from the desired reach of the parallel line compensation and vice versa. The following applies (refer to Figure 6-12):

$$\frac{I_E}{I_{EP}} = \frac{x/l}{2 - x/l} \qquad \text{or} \qquad \frac{x}{l} = \frac{2}{1 + \frac{1}{I_E/I_{EP}}}$$

Current Transformer Saturation

The 7SA6 contains a saturation detector which largely eliminates the measuring errors resulting from the saturation of the current transformers. The threshold above which it picks up can be set in address 1140A **`I-CTsat. Thres.`**. This is the current level above which saturation may be present. The setting ∞ disables the saturation detector. This setting can only be changed with DIGSI® 4 under "**Additional Settings**". If current transformer saturation is expected, the following equation may be used as a thumb rule for this setting:

$$\textit{Setting value I-CTsat. Thres.} = \frac{n'}{1 + \omega\tau_N} \cdot I_{nom}$$

where

n' $= n \cdot \dfrac{P_N + P_i}{P' + P_i}$ = actual over-current factor (accuracy limit factor)

P_N = rated burden of the current transformer [VA]

P_i = internal burden of the current transformer [VA]

P' = actual connected burden (protection device + connection cable)

ω = $2\pi f$ = system frequency

τ_N = system time constant

Circuit Breaker Status

In order to function optimally, several protection and supplementary functions require information regarding the state of the circuit breaker. The device contains a circuit breaker state recognition function which processes the status of the circuit breaker auxiliary contacts as well as recognising switching operations, close and open, by processing of measured values (refer also to Section 6.20).

In address 1130A the remaining current **`PoleOpenCurrent`**, which will definitely not be exceeded when the circuit breaker pole is open, is set. If parasitic currents (e.g. through induction) can be excluded when the circuit breaker is open, this setting may be very sensitive. Otherwise this setting must be increased correspondingly. In most cases the preset value is sufficient. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

The remaining voltage **`PoleOpenVoltage`** which will definitely not be exceeded when the circuit breaker pole is open, is set in address 1131A. Voltage transformers are presumed to be on the line side. The setting should not be too sensitive because of possible parasitic voltages (e.g. due to capacitive coupling). It must in any event be set below the smallest phase-earth voltage which may be expected during normal operation. The preset value is usually sufficient. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

The switch-on-to-fault activation (seal-in) time **`SI Time all Cl.`** (address 1132A) determines the activation period of the protection functions enabled during each energization of the line (e.g. fast tripping high-current stage). This time is started by the internal circuit breaker switching detection when it recognizes energization of the line or by the circuit breaker auxiliary contacts, if these are connected to the device via binary input to provide information that the circuit breaker has closed. The time should therefore be set to be longer than the circuit breaker operating time during closing plus the operating time of this protection function plus the circuit breaker operating time during opening. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

In address 1134 **`Line Closure`** the criteria for the internal recognition of line energization are determined. In the case of ***`only with ManCl`*** only the manual close signal derived via binary input is used to recognize the circuit breaker closing condition. With the setting ***`I OR U or ManCl`*** the measured currents or voltages are used as an additional criterion to recognise energization of the line. ***`CB OR I or M/C`*** on the other hand implies that either the currents or the circuit breaker auxiliary contact state is used to determine closing of the circuit breaker. If the voltage transformers are not situated on the line side, the setting ***`CB OR I or M/C`*** must be used. In the case of ***`I or Man.Close`*** only the currents or the manual close signals are used to recognize closing of the circuit breaker.

While the seal-in time after all closures (**`SI Time all Cl.`** address 1132A, refer above) is activated following each recognition of line energization, the seal-in time after manual closures (**`SI Time Man.Cl`** address 1150A) is the time following *manual* closure during which special influence of the protection functions is activated (e.g. increased reach of the distance protection). This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

Note:

For CB Test and automatic reclosure the CB auxiliary contact status derived with the binary inputs > CB1 ... (FNo. 366 - 371, 410 and 411) are relevant for indicating the CB switching status. The other binary inputs > CB ... (FNo. 351 - 353, 379 and 380) apply to the recognition of line status (address 1134) and reset of trip command (address 1135) which is used by the other protection functions, e.g. echo function, switch-onto-fault overcurrent etc. For applications with only one CB, both binary input functions e.g. 366 and 351 can be allocated to the same physical input.

In address 1151 **`SYN.MAN.CL`** the selection is made whether the synchronism check between the busbar voltage and the voltage of the switched feeder must be done for a manual close. To do this, either the device must have integrated synchronism check function or an external device for synchronism check must be connected.

In the former case the synchronism check function must be configured (Section 5.1) as available, a busbar voltage must be connected to the device and this must be correctly parameterized in the system data (Section 6.1.1, address **`0210 U4 transformer`** = **`Usync transf.`** as well as the corresponding factors).

If no synchronism check is to be performed with manual closing, set **`SYN.MAN.CL`** = ***`without Synchronism-check`***. If on the other hand synchronism check is required, set ***`with Synchronism-check.`*** If the manual close function of the device is not to be used at all, set **`SYN.MAN.CL`** to ***`No`***.

Address **`1135 Reset Trip CMD`** determines which criteria allow for the reset of an issued trip command. The setting ***`CurrentOpenPole`*** ensures that the trip command resets after the current disappears. The measured current must drop below the value set in address **`1130A PoleOpenCurrent`** before the trip command resets (see above). With the setting ***`Current AND CB`*** the circuit breaker auxiliary contact must additionally indicate that the circuit breaker has opened. This setting demands that the status of the auxiliary contacts is marshalled to a binary input.

Three-pole Coupling

Address **`1155 3pole coupling`** determines whether each trip command resulting from *pickup* in more than one phase is three-pole, or if three-pole coupling of the trip command only results when more than one phase is *trip*ped. This setting is only relevant with one- and three-pole tripping and therefore only available in this version. Additional information can be found in Section 6.20.3 fault detection logic of the device.

With the setting ***`with PICKUP`*** every *pickup* in more than one phase leads to three-pole coupling of the trip outputs, even if only a single-phase earth fault is situated within the tripping area, and further faults only affect the higher zones, or are located in the reverse direction. Even if a single-phase trip command has already been issued, each further fault detection will lead to three-pole coupling of the trip outputs.

If, on the other hand, this address is set to ***`with TRIP`***, three-pole coupling of the trip output (three-pole tripping) only occurs when more than one pole is *trip*ped. Therefore if a single-phase fault is located within the zone of tripping, and a further arbitrary fault is outside the tripping zone, single-phase tripping is possible. Even a further fault during the single-pole tripping will only cause three-pole coupling if it is located within the tripping zone.

This parameter is only available in the single- and three-pole tripping version. It applies to all protection functions of the 7SA6, which can trip single-pole.

The difference made by this parameter becomes apparent when multiple faults are cleared, i.e. faults occurring almost simultaneously at different locations in the network.

If, as shown in the example (Figure 6-13), two single phase to ground faults occur on different lines – in this example parallel lines – the protection relays on the two faulted lines, at all four line ends, pick up. In this example, all four relays detect a L1-L2-E fault, in other words a two phase to ground fault. However, each individual line is only subjected to a single phase to ground fault. If single pole tripping and reclosure is employed, it is therefore desirable that each line only trips and recloses single pole. This is achieved by setting **`1155 3pole coupling`** to ***with TRIP***. In this manner each of the four relays at the four line ends recognises that single pole tripping for the fault on the respective line is required.

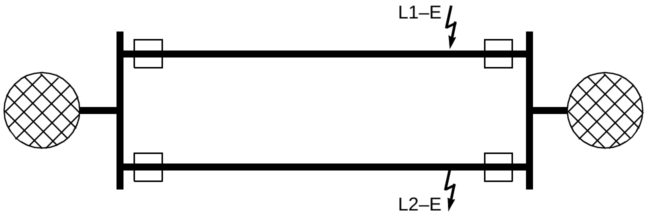


Figure 6-13 Multiple fault on a double-circuit line

In some cases, however, a three-pole trip would be preferable for this fault scenario, e.g. if the double-circuit line is located next to a large generator unit (Figure 6-14). This is because the generator considers the two single-phase to ground faults as one double-phase ground fault, with correspondingly high dynamic load on the turbine shaft. With **`1155 3pole coupling`** set to ***`With fault detection`***, the two lines are switched off three-pole, since each device picks up as with L1–L2–E, i.e. as with a multi-phase fault.

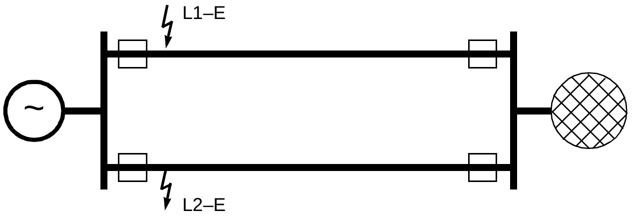


Figure 6-14 Multiple fault on a double-circuit line next to a generator

Address **`1156A Trip2phFlt`** determines that the short-circuit protection functions perform only a single-pole trip in case of isolated two-phase faults (clear of ground), provided that single-pole tripping is possible and permitted. This allows a single-pole rapid automatic reclosure cycle for this kind of fault. The trip type can be set to ***`1pole leading phase`*** or ***`1pole lagging phase`***. The parameter is only available in versions with single-pole tripping. This setting can only be changed with DIGSI® 4 under "**Additional Settings**". If this option is used, it must be born in mind that the phase preference should be the same throughout the entire network and that it must be the same at all ends of one line. More information on the function is also contained in Section 6.20.3 Overall Fault Detection Logic of the Device. The default setting is ***`triple-pole`***.

6.1.3.1 Settings

Note: The indicated secondary current values and values of impedance for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5. The values of impedance are divided by 5.

Addr.	Setting Title	Function	Setting Options	Default Setting
1103	FullScaleVolt.	Power System Data 2	1.0..1200.0 kV	400.0 kV
1104	FullScaleCurr.	Power System Data 2	10..5000 A	1000 A
1105	Line Angle	Power System Data 2	30..89 °	85 °
1110	x'	Power System Data 2	0.005..6.500 Ohm / km	0.150 Ohm / km
1111	Line Length	Power System Data 2	1.0..1000.0 km	100.0 km
1112	x'	Power System Data 2	0.005..10.000 Ohm / mile	0.242 Ohm / mile
1113	Line Length	Power System Data 2	0.6..650.0 Miles	62.1 Miles
1116	RE/RL(Z1)	Power System Data 2	-.33..7.00	1.00
1117	XE/XL(Z1)	Power System Data 2	-.33..7.00	1.00
1118	RE/RL(Z1B...Z5)	Power System Data 2	-.33..7.00	1.00
1119	XE/XL(Z1B...Z5)	Power System Data 2	-.33..7.00	1.00
1120	K0 (Z1)	Power System Data 2	0.000..4.000	1.000
1121	Angle K0(Z1)	Power System Data 2	-135.00..135.00 °	0.00 °
1122	K0 (> Z1)	Power System Data 2	0.000..4.000	1.000
1123	AngleI K0(> Z1)	Power System Data 2	-135.00..135.00 °	0.00 °

Addr.	Setting Title	Function	Setting Options	Default Setting
1126	RM/RL ParalLine	Power System Data 2	0.00..8.00	0.00
1127	XM/XL ParalLine	Power System Data 2	0.00..8.00	0.00
1128	RATIO Par. Comp	Power System Data 2	50..95 %	85 %
1130A	PoleOpenCurrent	Power System Data 2	0.05..1.00 A	0.10 A
1131A	PoleOpenVoltage	Power System Data 2	2..70 V	30 V
1132A	SI Time all Cl.	Power System Data 2	0.01..30.00 sec	0.05 sec
1134	Line Closure	Power System Data 2	Manual Close BI only Current OR Voltage or Manual close BI CBaux OR Current or Manual close BI Current flow or Manual close BI	Manual Close BI only
1135	Reset Trip CMD	Power System Data 2	with Pole Open Current Threshold only with CBaux AND Pole Open Current	with Pole Open Current Threshold only
1140A	I-CTsat. Thres.	Power System Data 2	0.2..50.0 A; ∞	10.0 A
1150A	SI Time Man.Cl	Power System Data 2	0.01..30.00 sec	0.30 sec
1151	SYN.MAN.CL	Power System Data 2	with Synchronism-check without Synchronism-check NO	without Synchronism-check
1155	3pole coupling	Power System Data 2	with Pickup with Trip	with Trip
1156A	Trip2phFlt	Power System Data 2	3pole 1pole, leading phase 1pole, lagging phase	3pole

6.1.3.2 Information Overview

F.No.	Alarm	Comments
351	>CB Aux. L1	>Circuit breaker aux. contact: Pole L1
352	>CB Aux. L2	>Circuit breaker aux. contact: Pole L2
353	>CB Aux. L3	>Circuit breaker aux. contact: Pole L3
379	>CB 3p Closed	>CB aux. contact 3pole Closed
380	>CB 3p Open	>CB aux. contact 3pole Open
356	>Manual Close	>Manual close signal
357	>Close Cmd. Blk	>Block all Close commands from external
361	>FAIL:Feeder VT	>Failure: Feeder VT (MCB tripped)
362	>FAIL:Bus VT	>Failure: Busbar VT (MCB tripped)

F.No.	Alarm	Comments
366	>CB1 Pole L1	>CB1 Pole L1 (for AR,CB-Test)
367	>CB1 Pole L2	>CB1 Pole L2 (for AR,CB-Test)
368	>CB1 Pole L3	>CB1 Pole L3 (for AR,CB-Test)
410	>CB1 3p Closed	>CB1 aux. 3p Closed (for AR, CB-Test)
411	>CB1 3p Open	>CB1 aux. 3p Open (for AR, CB-Test)
371	>CB1 Ready	>CB1 READY (for AR,CB-Test)
378	>CB faulty	>CB faulty
381	>1p Trip Perm	>Single-phase trip permitted from ext.AR
382	>Only 1ph AR	>External AR programmed for 1phase only
383	>Enable ARzones	>Enable all AR Zones / Stages
385	>Lockout SET	>Lockout SET
386	>Lockout RESET	>Lockout RESET
530	LOCKOUT	LOCKOUT is active
501	Relay PICKUP	Relay PICKUP
503	Relay PIKKUP L1	Relay PICKUP Phase L1
504	Relay PIKKUP L2	Relay PICKUP Phase L2
505	Relay PIKKUP L3	Relay PICKUP Phase L3
506	Relay PICKUP E	Relay PICKUP Earth
507	Relay TRIP L1	Relay TRIP command Phase L1
508	Relay TRIP L2	Relay TRIP command Phase L2
509	Relay TRIP L3	Relay TRIP command Phase L3
511	Relay TRIP	Relay GENERAL TRIP command
512	Relay TRIP 1pL1	Relay TRIP command - Only Phase L1
513	Relay TRIP 1pL2	Relay TRIP command - Only Phase L2
514	Relay TRIP 1pL3	Relay TRIP command - Only Phase L3
515	Relay TRIP 3ph.	Relay TRIP command Phases L123
536	Definitive TRIP	Relay Definitive TRIP
510	Relay CLOSE	Relay GENERAL CLOSE command
563	CB Alarm Supp	CB alarm suppressed
533	IL1 =	Primary fault current IL1
534	IL2 =	Primary fault current IL2
535	IL3 =	Primary fault current IL3
545	PU Time	Time from Pickup to drop out
546	TRIP Time	Time from Pickup to TRIP
560	Trip Coupled 3p	Single-phase trip was coupled 3phase
561	Man.Clos.Detect	Manual close signal detected

F.No.	Alarm	Comments
562	Man.Close Cmd	CB CLOSE command for manual closing

6.2 Distance Protection

Distance protection is the main function of the device. It is characterized by high measuring accuracy and the ability to adapt to the given system conditions. It is supplemented by a number of additional functions.

6.2.1 Earth Fault Recognition

6.2.1.1 Method of Operation

Recognition of an earth fault is an important element in identifying the type of fault, as the determination of the valid loops for measurement of the fault distance and the shape of the distance zone characteristics substantially depend on whether the fault at hand is an earth fault or not. The 7SA6 has a stabilised earth current measurement, a zero sequence current/negative sequence current comparison as well as a displacement voltage measurement. Furthermore, special measures are taken to avoid a pickup for low-current earth faults in an isolated or resonant-earthed system.

Earth Current $3 \cdot I_0$

For earth current measurement, the fundamental sum of the numerically filtered phase currents $3 \cdot I_0$ is monitored to detect if it exceeds the set value (parameter **`3I0> Threshold`**, address **`1203`**). It is stabilized against over-operation resulting from unsymmetrical operating currents and error currents in the secondary circuits of the current transformers due to different degrees of current transformer saturation during short-circuits without earth: the actual pick-up threshold automatically increases as the phase current increases (Figure 6-15). The reset value is approximately 95 % relative to the pick-up value.

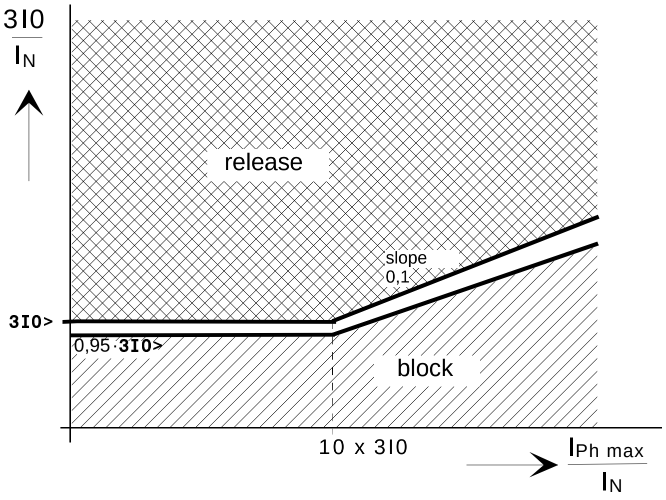


Figure 6-15 Earth current stage: pick-up characteristic — example

Negative Sequence Current $3I_2$

On long, heavily loaded lines, the earth current measurement could be overstabilized by large currents (ref. Figure 6-15). To ensure secure detection of earth faults in this case, a negative sequence comparison stage is additionally provided. In the event of a single-phase fault, the negative sequence current I_2 has approximately the same magnitude as the zero sequence current I_0. When the ratio zero sequence current/ negative sequence current exceeds a preset ratio, this stage picks up. It is also stabilized in the event of large negative sequence currents by a parabolic characteristic. Figure 6-16 illustrates this relationship. A release by means of the negative sequence current comparison requires a current of at least $0{,}2 \cdot I_N$ for $3I_0$ and $3I_2$.

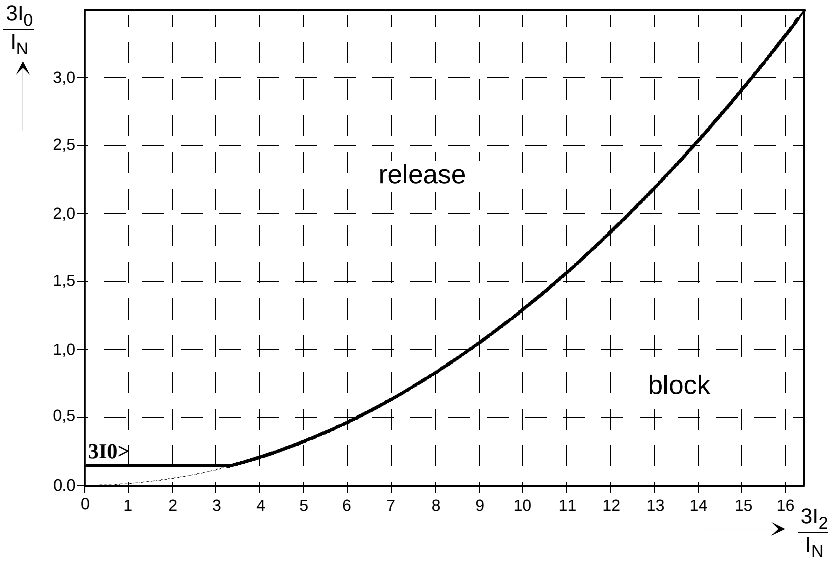


Figure 6-16 Characteristic of the I_0/I_2–stage

Neutral Displacement Voltage $3U_0$

For the neutral displacement voltage recognition the displacement voltage (**3U0>**) is numerically filtered and the fundamental frequency is monitored to recognize whether it exceeds the set threshold ($(3 \cdot U_0)$. The reset threshold is approximately 95 % of the pick-up threshold. The U_0–criterion may be disabled by applying the ∞ setting.

Earth Fault Detection for Earthed Systems

The current and voltage criteria supplement each other, as the displacement voltage increases when the zero sequence to positive sequence impedance ratio is large, whereas the earth current increases when the zero sequence to positive sequence impedance ratio is smaller.

For earthed systems the current and voltage criteria are logically combined with an *OR*-function (Figure 6-17). The earth fault recognition *on its own* does not cause a general fault detection of the distance protection, but merely controls the further fault detection modules. It is only alarmed in case of a general fault detection.

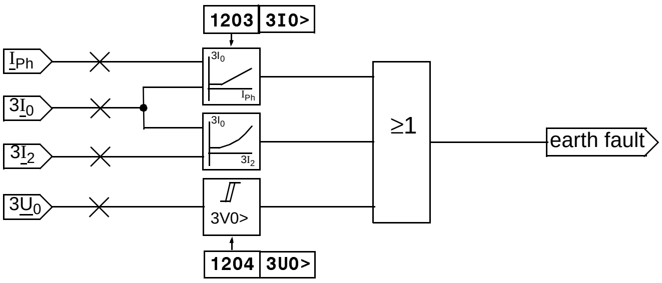


Figure 6-17 Logic of the earth fault recognition

Earth Fault Recognition during Single-Pole Open Condition

The earth fault recognition is modified during the single-pole open condition with single-pole automatic reclosure in an earthed system (Figure 6-18). In this case, the magnitudes of the currents and voltages are monitored in addition to the angles between the currents.

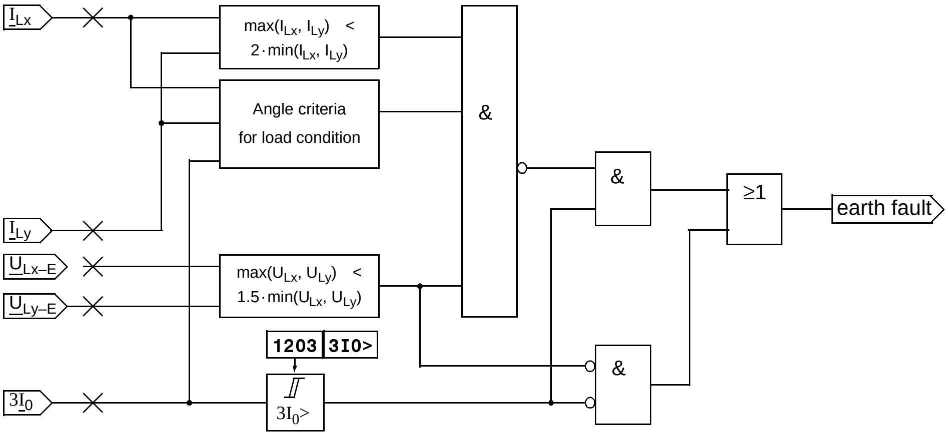


Figure 6-18 Earth fault recognition during single-pole open condition

Earth Fault Detection for Non-Earthed Systems

In non-earthed systems (isolated system star point or resonant-earthed by means of a Peterson coil) the measured displacement voltage is not used for fault detection. Furthermore, in these systems a simple earth fault is assumed initially in case of a single-phase fault and the fault detection is suppressed in order to avoid an erroneous pickup as a result of the earth fault initiation transients. After a time delay **T3I0 1PHAS**, which can be set, the fault detection is released again; this is necessary for the distance protection to still be able to detect a double earth fault with one base point on a dead-end feeder.

If, however, an earth fault is already present in the system, it is detected by the displacement voltage detection (**3U0> COMP/ISOL.**). In this case, there is no delay time: an earth fault now occurring in a different phase can only be due to a double earth fault. If, apart from the displacement measurement (**3U0> COMP/ISOL.**), there is a fault detection in more than one phase, this is also rated as a double earth fault. In this way, double earth faults can be detected even if no or only little earth current flows via the measuring point.

6.2.1.2 Setting of the Parameters for this Function

In systems with earthed star-point, the setting **`3I0> Threshold`** (Address **1203**) is set somewhat below the minimum expected earth short-circuit current. $3I_0$ is defined as the sum of the phase currents $|\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}|$, which equals the star-point current of the set of current transformers. In non-earthed systems the setting value is somewhat below the earth current value for double earth faults.

With regard to the setting **`3U0> Threshold`** (Address **1204**), in systems with earthed starpoint, care must be taken that operational unsymmetries do not cause a pick-up. $3U_0$ is defined as the sum of the phase-earth voltages $|\underline{U}_{L1-E} + \underline{U}_{L2-E} + \underline{U}_{L3-E}|$. If the U_0–criterion should be ignored, the address **1204** is set to ∞. In non-earthed systems this setting is not relevant and therefore not accessible.

The preset value **`3I0>/Iphmax`** = ***`0.1`*** (Address 1207) usually is sufficient for the slope of **`3I0`**–characteristic **`3I0>/ Iphmax`** (Address **1207**). This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

These settings are listed in a table in Subsection 6.2.2.4.

6.2.2 Fault detection

Fault detection has to detect a faulty condition in the power system and to initiate all the necessary procedures for selective clearance of the fault:

- Start the delay times for the directional and non-directional final stages
- Determination of the faulted loops
- Release of impedance calculation and direction determination
- Release of tripping command
- Initiation of supplementary functions
- Indication/output of the faulty phase(s)

Depending on the ordered version, the 7SA6 distance protection has a range of fault detection modes, from which the appropriate type for the particular system conditions can be selected. If, according to the ordering code, the device only has impedance fault detection, or if you set **`DIS. PICKUP`** = ***`Z< (quadrilat.)`*** (address 0114) as detection mode, this Section 6.2.2 is of no importance. This type of fault detection works implicitly, i.e the above-mentioned operations are executed automatically as soon as a fault is detected in one of the distance zones.

6.2.2.1 Overcurrent Fault Detection

Overcurrent pick-up is a per phase fault detection mode. After numerical filtering, the currents are monitored to check if they exceed the set values in every phase. An output signal is given for the phase(s) where the set threshold is exceeded.

For the processing of the measured values (see Section 6.2.3) the per phase pick-up signals are converted into loop information. This is done subject to earth-fault detection according to Section 6.2.1 and — in the earthed network — subject to the parameter **`1ph FAULTS`** (address 1630A) according to Table 6-2. In the non-earthed network, the phase–to–phase loop is always selected for single–phase pick-up without earth-fault detection.

The phases that have picked-up are signalled. If an earth fault has been detected, it is also indicated. Pick-up will drop off if the signal falls below 95 % of the pick-up value.

Table 6-2 Loop and phase indication for single–phase overcurrent pick-up

Pick-up module	**Earth-fault detection**	**Parameter `1Ph FAULTS.`**	**Valid loop**	**Signalled phase(s)**
L1 L2 L3	no no no	phase–phase	L3–L1 L1–L2 L2–L3	L1, L3 L1, L2 L2, L3
L1 L2 L3	no no no	phase–earth [1])	L1–E L2–E L3–E	L1 L2 L3
L1 L2 L3	yes yes yes	any	L1–E L2–E L3–E	L1, E L2, E L3, E
[1]) Only possible in earthed networks				

6.2.2.2 Voltage-Dependent Current Fault Detection U/I

Mode of Operation and Characteristic

The U/I pick-up is a per phase and per loop pick-up mode. Here the phase currents must exceed a threshold , while the threshold value depends on the magnitude of the loop voltage.

Pick-up due to earth faults in systems with a non-earthed system star point is effectively suppressed by means of the measures described in Section 6.2.1.

The basic characteristics of the U/I pick-up can be seen from the current–voltage characteristic shown in Figure 6-19. The first requirement for every phase pick-up is that of the minimum current **`Iph>`** is exceeded. For the evaluation of phase–phase loops both relevant phase currents have to exceed this value. Above this current the current pick-up is voltage-dependent with the slope being determined by the settings **U(I>)** and **U(I>>)**. For short-circuits with large currents the overcurrent pick-up **`Iph>>`** (Section 6.2.2.1) is superimposed. The bold dots in Figure 6-19 designate the settings which determine the geometry of the current/voltage characteristic.

Loop pick-up will drop off if the signal falls below 95 % of the relevant current value or exceeds 105 % of the relevant voltage value.

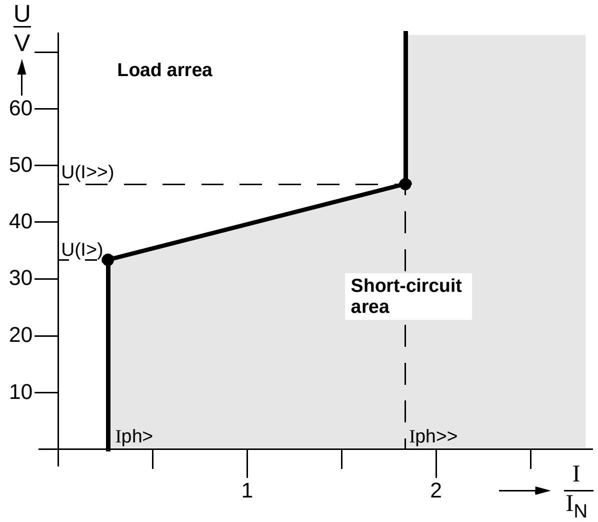


Figure 6-19 U/I characteristic

Pick-up Mode

The setting 1601 (**PROG U/I**) determines if the phase–earth loops or the phase–phase loops are always valid or if this depends on the earth-fault detection according to Section 6.2.1. This allows a very flexible adaptation to the network conditions. The optimum selection mainly depends on whether the network neutral is not earthed (isolated or compensated), is earthed low–resistance (“semi–solidly”) or solid-earthed (see Section 6.2.3). Setting notes are given in Section 6.2.2.4.

The evaluation of phase–earth loops is characterized by a high sensitivity in the event of earth faults and is highly advantageous in networks with earthed star points. It automatically adapts to the prevailing infeed conditions; i.e. in the weak-infeed operation mode it becomes more current-sensitive, with high load currents the pick-up threshold will be higher. This applies in particular if the network star-point is earthed low–resistance. If only the phase–earth loops are evaluated, it must be ensured that the overcurrent stage **Iph>>** responds in the event of phase–phase faults. If only one measuring system picks up, it can be decided whether this shall result in a pick-up of the phase–earth loops or the phase–phase loops in the earthed network (see Table 6-3).

Tabelle 6-3 Loop and phase indication for single-phase U/I pickup; Phase–earth voltage program

Pick-up module	Measured current	Measured voltage	Earth–fault detection	Parameter `1Ph FAULTS.`	Valid loop	Signalled Phase(s)
L1	L1	L1–E	no	Phase–phase	L3–L1	L1, L3
L2	L2	L2–E	no		L1–L2	L1, L2
L3	L3	L3–E	no		L2–L3	L2, L3
L1	L1	L1–E	no	Phase–earth [1])	L1–E	L1
L2	L2	L2–E	no		L2–E	L2
L3	L3	L3–E	no		L3–E	L3
L1	L1	L1–E	yes	any	L1–E	L1, E
L2	L2	L2–E	yes		L2–E	L2, E
L3	L3	L3–E	yes		L3–E	L3, E

[1]) Only effective in earthed networks

When evaluating phase–phase loops, the sensitivity towards phase–phase faults is particularly high. In extensive compensated networks this selection is advantageous because it excludes pick-up as a result of single earth faults on principle. With two- and three-phase faults it automatically adapts to the prevailing infeed conditions, i.e. in the weak-infeed operation mode it becomes more current-sensitive, with strong infeed and high load currents the pick-up threshold will be higher. If only phase–phase faults are evaluated, the measuring loop is independent of the earth-fault detection, therefore this procedure is not suitable for earthed networks (see Table 6-4).

Table 6-4 Loop and phase indication for single–phase U/I pick-up; Phase–phase voltage program (address 1601)

Pick-up module	Measured current	Measured voltage	Earth fault detection	Parameter `1Ph FAULTS.`	Valid loop	Signalled Phase(s)
L1 L2 L3	L1 L2 L3	L1–L2 L2–L3 L3–L1	any	any	L1–L2 L2–L3 L3–L1	L1, L2 L2, L3 L1, L3

If the option has been chosen whereby voltage loop selection is dependent on earth-fault detection, then high sensitivity applies to phase-earth faults and to phase–phase faults. On principle, this option is independent of the treatment of the network neutral point, however, it requires that the earth–fault criteria according to Section 6.2.1 are met for all earth faults or double earth faults (see Table 6-5).

Table 6-5 Loop and phase indication for single–phase U/I pick-up; Phase–phase voltage program in the event of earth faults, phase–phase voltages without earth faults (address 1601)

Pick-up module	Measured current	Measured voltage	Earth–fault detection	Parameter `1Ph ANR.`	Valid loop	Signalled Phase(s)
L1 L2 L3	L1 L2 L3	L1–L2 L2–L3 L3–L1	no no no	any	L1–L2 L2–L3 L3–L1	L1, L2 L2, L3 L1, L3
L1 L2 L3	L1 L2 L3	L1–E L2–E L3–E	yes yes yes	any	L1–E L2–E L3–E	L1, E L2, E L3, E

Finally, it is also possible to only evaluate phase-earth voltage loops if an earth fault has been detected. For phase–phase faults only the overcurrent **`Iph>>`** will then pick up. This is advantageous in networks with neutral points that have been earthed low–resistance, i.e. using earth-fault current limiting means (so-called “semi–solid” earthing). In these cases only earth faults shall be detected by the U/I pick-up. In this network it is often undesirable that phase–phase short-circuits shall result in a U/I pick-up.

The measuring loop is independent of the setting **`1ph FAULTS`** (address 1630A). Table 6-6 shows the assignment of phase currents, loop voltages and measuring results.

Table 6-6 Loop and phase indication for single–phase U/I pick-up; Phase–phase voltage program in the event of earth faults, phase–phase voltages without earth faults (address `1601`)

Pick-up module	Measured current	Measured voltage	Earth–fault detection	Parameter `1Ph FAULTS`	Valid loop	Signalled Phase(s)
L1 L2 L3	L1 L2 L3	L1–E L2–E L3–E	yes yes yes	any	L1–E L2–E L3–E	L1, E L2, E L3, E
L1 L2 L3	L1 L2 L3	L1–E L2–E L3–E	no no no	any	no pick-up, no indications by U_{Ph-E}</I>	

The pick-up signals of the loop are transformed into phase signals so that faulty phase(s) can be indicated. If an earth fault has been detected according to 6.2.1, it will also be indicated.

6.2.2.3 Voltage and Phase-Angle Dependent Current Fault Detection U/I/φ

Function and Characteristic

Phase-angle controlled U/I fault detection can be applied when the U/I characteristic criteria according to Section 6.2.2.2 can no longer distinguish reliably between load and short-circuit conditions. This is the case with small source impedances together with long lines or sequence of lines and intermediate infeed. In the event of a short-circuit at the end of the line or within the back-up zones of the distance protection the local measuring voltage will only drop to a small extent so that the phase angle between current and voltage is required as an additional criterion for fault detection.

U/I/φ pick-up is a per phase and per loop pick-up mode. It is crucial for the phase currents to exceed the pick-up threshold, whereby the pick-up value is dependent on the size of the loop voltages and the phase angle between current and voltage.

A precondition for measuring the phase–phase angles is that the associated phase currents as well as the current difference relevant for the loop have exceeded a minimum value **`Iph>`** that can be set. The angle is determined by the phase–to–phase voltage and its corresponding current difference.

A precondition for measuring the phase–earth angle is that the associated phase current has exceeded a settable minimum value **`Iph>`** and that an earth fault according to Section 6.2.1 has been detected or only phase–to–earth measurements have been stipulated by setting parameters. The angle is determined by the phase–to–earth voltage and its corresponding phase current without considering the earth current.

Pick-up on earth faults is effectively suppressed in networks with non-earthed neutral points by means of the measures described in Section 6.2.1.

The basic characteristic of the U/I/φ pick-up can be seen in the current–voltage characteristic curve Figure 6-20. Initially it is shaped like the U/I pick-up characteristic (Figure 6-19).

For angles with large phase angle difference (V and I), i.e. in the short-circuit angle area above the threshold angle φ>, the characteristic between **U(I>)** and **U(Iφ>)** which is cut off by the overcurrent stage **Iφ>** also comes into effect. The bold dots mark the settings which determine the geometry of the current/voltage characteristic. The angle-dependent area which is shaded dark grey within the short-circuit angle area can either have an effect in forward direction (in direction of line) or in both directions (settable).

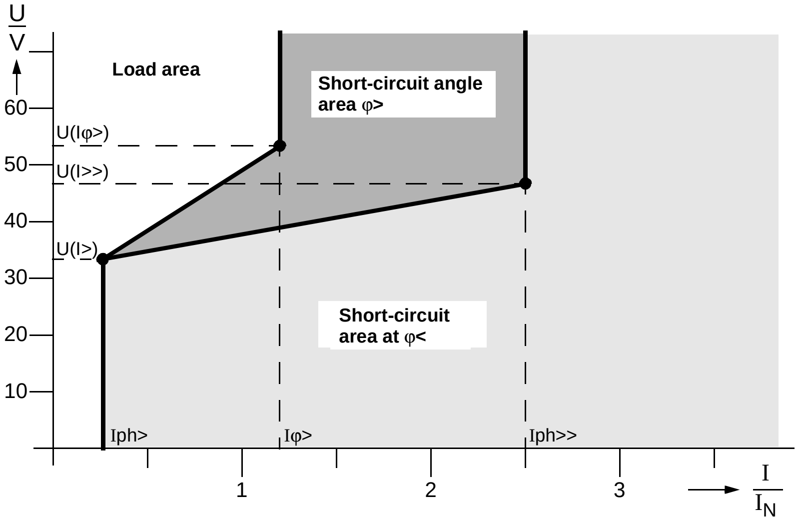


Figure 6-20 U/I/φ characteristic

Loop pick-up will drop off if the signal falls below 95 % of the respective current value or exceeds 105 % of the respective voltage value. A hysteresis of 5° applies to phase-angle measuring.

Pickup Modes

As the U/I/φ fault detection represents an extension of the U/I fault detection according to Section 6.2.2.2 the same program options apply. Tables 6-3 to 6-6 also apply for single–phase pick-up.

6.2.2.4 Applying the Function Parameter Settings

Pickup Mode

Depending on the ordered version, the 7SA6 distance protection has a series of pick-up modes from which the one matching the respective network conditions best can be selected (also see order data in the Appendix).

If the device does not have an explicit pick-up function or, if you set **DIS ANR** = ***Impedance*** (address 0114) for pick-up type when configuring the protection functions (Section 5.1), all settings dealt with in this section are irrelevant and cannot be selected.

Available pick-up modes are described in Section 6.2.2.1 and 6.2.2.2 in detail. If the device has several alternative pick-up modes, one option has been selected when configuring in address 0114 (see Section 5.1). Below, parameters are given and discussed for all pick-up modes. With the following settings, only those parameters will appear that apply for the selected pick-up mode.

With the U/I(/φ) pick-up mode you have the option to determine the voltage measuring and, if applicable, the phase-angle measuring for phase–to–earth measuring units, and for phase–to–phase measuring loops separately. Address 1601 **PROGAM U/I** states which loop voltages shall apply to phase–to–earth (***Ph-E:***) and which ones to phase–to–phase (***Ph-Ph:***).

In networks with **earthed** star point, a selection using $U_{Ph–E}$ with earth faults and $U_{Ph–Ph}$ with non-earthed faults is often preferred (address 1601 **PROGAM U/I** = ***Ph-E: Uphe / Ph-Ph: Uphph***). This mode has a maximum sensitivity for all fault types, however it requires the unambiguous detection of earth faults via the earth-fault detection function (also see Section 6.2.1). Otherwise, a mode using U_{Ph-E} for all fault types may be useful (address **1601 PROGAM U/I** = ***Ph-E: Uphe/Ph-Ph: Uphe***), accepting lesser sensitivity for earth-free faults, as the overcurrent stage Iph>> usually picks up here.

In networks with **low–resistance earthed** neutral point, the U/I/φ pick-up should only come into effect on earth faults as phase–to–phase faults are detected by the overcurrent pick-up. Therefore, the address **1601 PROGAM U/I** = ***Ph-E: Uphe/Ph-Ph: I>>*** is useful in this case.

As far as there is a danger of the earth fault detection picking up when a applicable earth fault occurs in **isolated** or **resonant-earthed** networks owing to the starting transient, this can be delayed using a parameter **T3I0 1PHAS**. If the earth fault pick-up can also be exceeded during steady-state conditions, **T3I0 1PHAS** (address 1206) should be set to ∞. As a result of this, pickup by one phase alone will not be possible even with a large earth current. Double earth faults are however correctly detected and measured according to the preference program (also see Section 6.2.3.1, “Double Earth-Faults in Non-earthed Systems”).

In **isolated** or **resonant-earthed** networks it is possible to control the U/I/φ pick-up using phase–to–phase voltages only (address **1601 PROGAM U/I** = ***Ph-E: Uphph/Ph-Ph: Uphph***). Naturally, this excludes pick-up by single earth faults, however, it also does not allow a correct double earth fault detection, therefore it is suitable only for small isolated cable networks.

General Settings for Pick-Up

The maximum operational load current that can occur is crucial for the setting of **overcurrent pick-up**. Pick-up due to overload must be ruled out! Therefore the pick-up value must be set above the maximum (over-)load current that is expected (approx. 1.2 times). Then, it must be ensured that the minimum short-circuit current is above this value. If this is not the case, U/I pick-up is required.

Arithmetic example:

Maximum operational current (incl. overload) is 680 A, for current transformers 600 A/ 5 A, minimum short circuit is 1200 A. the following has to be set:

Iph>> = $I_{L\ max} \cdot 1.2 = 680\ A \cdot 1.2 = 816\ A$

This value is sufficiently below the minimum short-circuit current of 1200 A. When configuring via PC and DIGSI® 4 this value can be entered directly. Conversion to secondary quantities is

$$Iph{>>} = 816\ A \cdot \frac{5\ A}{600\ A} = 6.8\ A$$

The condition for minimum short-circuit current also applies to earth faults (in the earthed network) or for double earth faults as long as overcurrent pick-up is solely used.

If U/I pick-up is required because the minimum short-circuit current is below the maximum load current (incl. a safety factor of 1.2), the condition for maximum load current in respect to **Iph>>** still has to be observed. Then, the **minimum current limit Iph>** (address 1611) is set to below the minimum short-circuit current (approx. 10 %). This also applies to the phase currents during earth faults or double earth faults.

In address 1630 **1ph FAULTS** you can choose whether a phase–to–earth loop shall be selected in an earthed network during single–phase pickup without earth current (I_E–release). The setting **1ph FAULTS** = ***phase-earth*** is useful if no or only little earth current can flow via the measuring point in the event of earth faults. With **1ph FAULTS** = ***phase to phase only*** the leading phase–phase loop is measured in the event of a single–phase pick-up in the earthed network.

Two further general settings refer to the final times, i.e. the tripping times in a worst case scenario for faults outside all distance zones. They should be set above the delay times for distance zones providing a final back-up option (also see “Independent Zones Z1 up to Z5” in Section 6.2.4.2).

The directional final time **DELAY FORW. PU** (address 1602) only works with short circuits in forward (line) direction if there is no impedance within a distance zone after pick-up.

The non-directional final time **DELAY NON-DIR.** (address 1603) works for all short-circuits if there is no impedance within a distance zone after pick-up.

U/I(/φ) Pickup

The meaning of the settings can be seen from Figure 6-21. **Iph>** (section a, address 1611) is the minimum current as described in the previous section, **Iph>>** (section c) is the overcurrent pick-up.

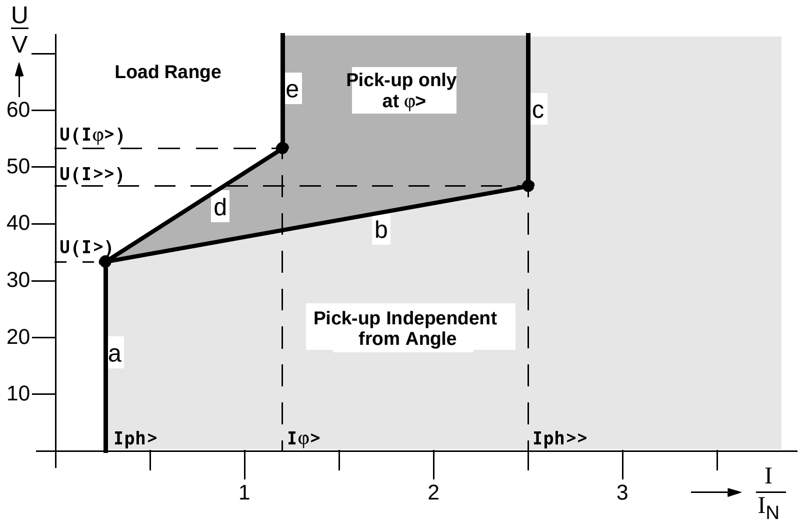


Figure 6-21 Parameters of U/I/φ pick-up

In most cases the angular dependence is not required. Then the voltage-dependent section b is valid which results in the characteristic a-b-c. When controlling with *Uphe* in the addresses 1612 **Uph-e (I>)** and 1613 **Uph-e (I>>)** the voltages for phase–to–earth are inserted to determine the voltage-dependent branch b; correspondingly when using *Uphph* the voltages for phase–to–phase are set in the addresses 1614 **Uph-ph (I>)** and 1615 **Uph-ph (I>>)**. The relevant settings are determined according to the “Pickup Mode” (see above).

The characteristic has to be set such that it is just below the minimum expected voltage at the maximum expected load current. If in doubt, check the pick-up conditions in accordance with the U/I characteristic.

Angular Dependence

If a distinction between short circuit and load conditions is not always possible using the U/I characteristic which is independent of the phase angle, the angular dependent section d-e can additionally be used. This is required for long lines and section of lines with intermediate infeed in combination with small source source impedances. Then the local measured voltage will only drop to a small extent in the event of a short circuit at the line end or in the back-up range of the distance protection so that the phase angle between current and voltage is required as an additional criterion for fault detection.

The parameters **Iφ>** (address 1616) and **Uphe(Iφ>)** (address 1617) or **Uphph(Iφ>)** (address 1618) determine the characteristic in the range of large angles φ_K, i.e. in the short-circuit angle range. The threshold angles themselves, which define the short-circuit angle range φ_K, are set in the addresses 1620 **φ>** and 1621 **φ<**. The short-circuit angle range φ_K is between these two angles. Here too, the required voltage settings according to the “Pickup Mode” (see above) are relevant.

The characteristic for the load angle range has to be set in a way that is just below the minimum expected operating voltage at the maximum expected load current. In the range of the short circuit angle φ_K it must be ensured that load current may not cause pick-up in this area. If reactive power has to be tranferred via this line it must be ensured that the maximum reactive current at minimum operating voltage is not within the pick-up range, i.e. the short-circuit angle range φ_K. If in doubt, pick-up conditions should be checked in accordance with the U/I/φ characteristic. An arithmetic short-circuit calculation is recommended for extensive networks.

The lower threshold angle should be between the load angle and the short-circuit angle. Therefore, it must be set smaller than the line angle $\varphi_L = \arctan(X_L/R_L)$ (approx. 10° to 20°). Further, you should check that the angle is not exceeded during load conditions. If this is the case, for instance because the reactive power has to be transferred via this line, it must be ensured that the parameters of the voltage-dependent segment d, that is **Iphi>** and **Uph-e (Iphi>)** or **Uph-ph (Iphi>)** rule out a pick-up as the result of reactive power (see above).

The upper threshold angle **φ<** (address 1621) is not critical. 100° to 120° should be sufficient.

Angular dependence, i.e. increasing the sensitivity for a large short-circuit angle with section d and e in the characteristic, can be limited to the forward direction (line direction) using address 1619 **EFFECT φ**. In this case **EFFECT φ** is set to ***Forward.*** Otherwise it remains **EFFECT φ** = ***forward & reverse***. This setting can only be made with DIGSI® 4 “**Additional Settings**“.

6.2.2.5 Settings

Note: The indicated secondary current values and values of impedance for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5. The values of impedance are divided by 5.

Addr.	Setting Title	Function	Setting Options	Default Setting
1601	PROGAM U/I	Distance protection, general settings	Ph-E: Uphe/ Ph-Ph: Uphph Ph-E: Uphph/Ph-Ph: Uphph Ph-E: Uphe/Ph-Ph: Uphe Ph-E: Uphe/Ph-Ph: I>>	Ph-E: Uphe/ Ph-Ph: Uphph
1602	DELAY FORW. PU	Distance protection, general settings	0.00..30.00 sec; ∞	1.20 sec
1603	DELAY NON-DIR.	Distance protection, general settings	0.00..30.00 sec; ∞	1.20 sec
1630A	1ph FAULTS	Distance protection, general settings	phase-earth phase to phase only	phase-earth
1610	Iph>>	Distance protection, general settings	0.25..10.00 A	1.80 A
1611	Iph>	Distance protection, general settings	0.10..4.00 A	0.20 A
1612	Uph-e (I>>)	Distance protection, general settings	20..70 V	48 V
1613	Uph-e (I>)	Distance protection, general settings	20..70 V	48 V
1614	Uph-ph (I>>)	Distance protection, general settings	40..130 V	80 V
1615	Uph-ph (I>)	Distance protection, general settings	40..130 V	80 V
1616	Iphi>	Distance protection, general settings	0.10..8.00 A	0.50 A
1617	Uph-e (Iphi>)	Distance protection, general settings	20..70 V	48 V
1618	Uph-ph (Iphi>)	Distance protection, general settings	40..130 V	80 V
1619A	EFFECT φ	Distance protection, general settings	forward and reverse Forward	forward and reverse
1620	φ >	Distance protection, general settings	30..60 °	50 °
1621	φ <	Distance protection, general settings	90..120 °	110 °

6.2.2.6 Information Overview

F.No.	Alarm	Comments
3781	Dis.TimeOut Tfw	DistanceTime Out Forward PICKUP
3782	Dis.TimeOut Tnd	DistanceTime Out Reverse/Non-dir. PICKUP
3695	Dis Pickup φ L1	Dist.: Phi phase L1 Pickup
3696	Dis Pickup φ L2	Dist.: Phi phase L2 Pickup
3697	Dis Pickup φ L3	Dist.: Phi phase L3 Pickup

6.2.3 Calculation of the Impedances

6.2.3.1 Method of Operation

A separate measuring system is provided for each of the six possible impedance loops L1–E, L2–E, L3–E, L1–L2, L2–L3, L3–L1. The phase-earth loops are evaluated when an earth fault detection according to section 6.2.1 is recognized and the phase current exceeds a settable minimum value **`Minimum Iph>`** (address **1202**). The phase-phase loops are evaluated when the phase currents in both of the affected phases exceed the minimum value **`Minimum Iph>`**.

A jump detector synchronizes all the calculations with the fault inception. If a further fault occurs during the evaluation, the new measured values are immediately used for the calculation. The fault evaluation is therefore always done with the measured values of the current fault condition.

Phase–Phase Loops

To calculate the phase-phase loop, for instance during a two-phase fault L1–L2 (Figure 6-22), the loop equation is:

$$\underline{I}_{L1} \cdot \underline{Z}_L - \underline{I}_{L2} \cdot \underline{Z}_L = \underline{U}_{L1-E} - \underline{U}_{L2-E}$$

where
$\underline{U}$, $\underline{I}$ are the (complex) measured values and
$\underline{Z}$ = R+ jX is the (complex) line impedance.

The line impedance is computed to be

$$\underline{Z}_L = \frac{\underline{U}_{L1-E} - \underline{U}_{L2-E}}{\underline{I}_{L1} - \underline{I}_{L2}}$$

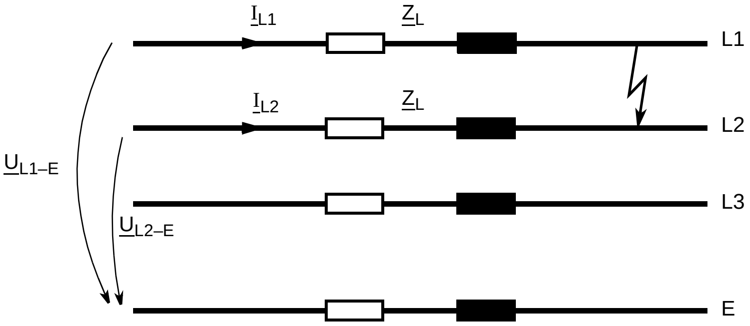


Figure 6-22 Short circuit of a phase-phase loop

The calculation of the phase-phase loop does not take place as long as one of the concerned phases is switched off (during single-pole dead time), to avoid an incorrect measurement with the undefined measured values existing during this state. A state recognition (refer to Section 6.20) provides the corresponding block signal. A logic block diagram of the phase-phase measuring system is shown in Figure 6-23.

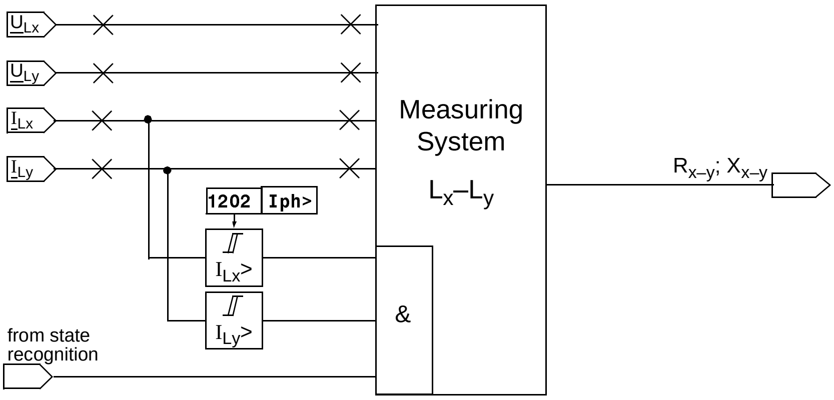


Figure 6-23 Logic of the phase-phase measuring system

Phase–Earth Loops For the calculation of the phase-earth loop, for example during a L3–E short-circuit (Figure 6-24) it must be noted that the impedance of the earth return path does not correspond to the impedance of the phase. In the loop equation

$$\underline{I}_{L3} \cdot \underline{Z}_L - \underline{I}_E \cdot \underline{Z}_E = \underline{U}_{L3-E}$$

$\underline{Z}_E$ is replaced by $(\underline{Z}_E/\underline{Z}_L) \cdot \underline{Z}_L$ and the result is:

$$\underline{I}_{L3} \cdot \underline{Z}_L - \underline{I}_E \cdot \underline{Z}_L \cdot \frac{\underline{Z}_E}{\underline{Z}_L} = \underline{U}_{L3-E}$$

From this the line impedance can be extracted

$$\underline{Z}_L = \frac{\underline{U}_{L3-E}}{\underline{I}_{L3} - \underline{Z}_E/\underline{Z}_L \cdot \underline{I}_E}$$

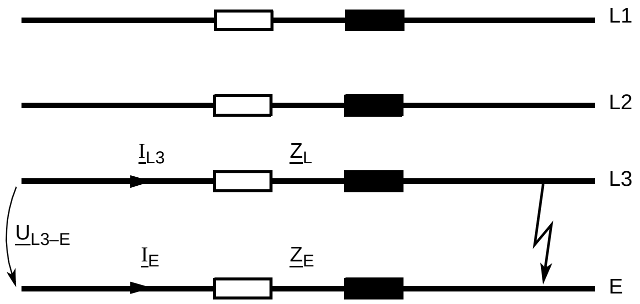


Figure 6-24 Short circuit of a phase-earth loop

The factor $\underline{Z}_E/\underline{Z}_L$ only depends on the line parameters and no longer on the fault distance.

The evaluation of the phase-earth loop does not take place as long as the affected phase is switched off (during single-pole dead time), to avoid an incorrect measurement with the undefined measured values existing in this state. A state recognition (refer to Section 6.20) provides the corresponding block signal. A logic block diagram of the phase-earth measuring system is shown in Figure 6-25.

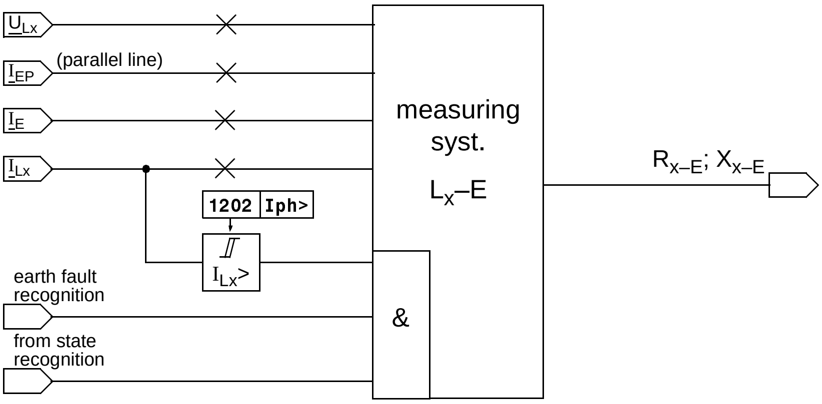


Figure 6-25 Logic of the phase-earth measuring system

Unfaulted Loops

The above considerations apply to the relevant short-circuited loop. A pick-up with the current-based fault detection modes (I, U/I, U/I/φ) guarantees that only the faulty loop(s) are released for the distance calculation. In the impedance pick-up, however, all six loops are calculated, the impedances of the healthy loops are also influenced by the fault currents and voltages in the short-circuited phases. During a L1–E fault for example, the fault current in phase L1 also appears in the measuring loops L1-L2 and L3-L1. The earth current is also measured in the loops L2–E and L3–E. Combined with load currents which may flow, the unfaulted loops produce the so-called “apparent impedances“, which have nothing to do with the actual fault distance.

These “apparent impedances” in the unfaulted loops are usually larger than the short-circuit impedance of the faulted loop because the unfaulted loop only carries a part of the fault current and always has a higher voltage than the faulted loop. For the selectivity of the zones, the “apparent impedances” are therefore of no consequence.

Apart from the *zone selectivity*, the *phase selectivity* is also important to achieve correct identification of the faulted phases, required to alarm the faulted phase and especially to enable single-pole automatic reclosure. Depending on the infeed conditions, close-in short circuits may cause unfaulted loops to “see” the fault further away than the faulted loop, but still within the tripping zone. This would cause three-pole tripping and therefore void the possibility of single-pole automatic reclosure. As a result power transfer via the line would be lost.

In the 7SA6 this is avoided by the implementation of a loop verification function which operates in two steps:

Initially, the calculated loop impedances and its components (phase and/or earth) are used to simulate a replica of the line impedance. If this simulation returns a plausible line image, the corresponding loop pick-up is designated as a definitely valid loop.

If the impedances of more than one loop are now located within the range of the zone, the smallest is still declared to be a valid loop. Furthermore, all loops that have an impedance which does not exceed the smallest loop impedance by more than 50 % are declared as being valid. Loops with larger impedance are eliminated. Those loops which were declared as being valid in the initial stage, cannot be eliminated by this stage, even if they have larger impedances.

In this manner unfaulted “apparent impedances” are eliminated on the one hand, while on the other hand, unsymmetrical multi-phase faults and multiple short circuits are recognized correctly.

The loops that were designated as being valid are converted to phase information so that the fault detection correctly alarms the faulted phases.

Double Earth-Faults in Earthed Systems

In systems with earthed starpoint (effective or low-resistant), each contact of a phase with earth results in a short-circuit condition which must be isolated immediately by the closest protection systems. Fault detection occurs in the faulted loop associated with the faulted phase.

With double earth faults, fault detection is generally in two phase-earth loops. If both earth loops are in the same direction, a phase-phase loop may also pick-up. It is possible to restrict the fault detection to particular loops in this case. It is often desirable to block the phase-earth loop of the leading phase, as this loop tends to overreach when there is infeed from both ends to a fault with a common earth fault resistance (address 1221 **2Ph-E faults** = ***Block leading Ø***). Alternatively, it is also possible to block the lagging phase-earth loop (address **2Ph-E faults** = ***Block lagging Ø***). All the affected loops can also be evaluated (address **2Ph-E faults** = ***All loops***), or only the phase-phase loop (address 1221 **2Ph-E faults** = ***Ø-Ø loops only***) or only the phase-earth loops (address **2Ph-E faults** = ***Ø-E loops only***).

A prerequisite for these restrictions is that the relevant loops indicate fault locations which are close together and within the reach of the first zone Z1. The loops are considered to be close together when they have the same direction and do not differ by more than a factor 1,5 (largest to smallest impedance). This is to avoid in case of multiple faults with separate fault location the closer fault is eliminated from the evaluation by configured restrictions. Furthermore, the measurement phase-phase can only be carried out if two earth faults are close to each other in the determined direction.

In Table 6-7 the measured values used for the distance measurement in earthed systems during double earth faults are shown.

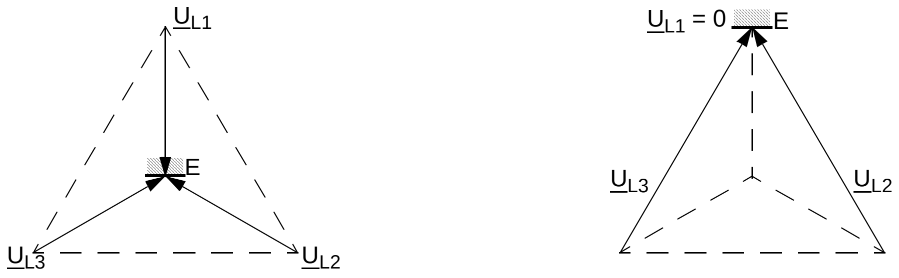
Table 6-7 Evaluation of the measured loops for double loop faults in an earthed system in case both earth faults are close to each other

Fault detection Loop	Evaluated Loop	Setting Parameter 1221
L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	L2–E, L1–L2 L3–E, L2–L3 L1–E, L3–L1	**`2Ph-E faults = Block leading Ø`**
L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	L1–E, L1–L2 L2–E, L2–L3 L3–E, L3–L1	**`2Ph-E faults = Block lagging Ø`**
L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	**`2Ph-E faults = All loops`**
L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	L1–L2 L2–L3 L3–L1	**`2Ph-E faults = Ø-Ø loops only`**
L1–E, L2–E, L1–L2 L2–E, L3–E, L2–L3 L1–E, L3–E, L3–L1	L1–E, L2–E L2–E, L3–E L1–E, L3–E	**`2Ph-E faults = Ø-E loops only`**

During three phase faults the fault detection of all three phase-phase loops usually occurs. In this case the three phase-phase loops are evaluated. If earth fault detection also occurs, the phase-earth loops are also evaluated.

Double Earth-Faults in Non-earthed Systems

In isolated or resonant-earthed networks a single earth fault does not result in a short circuit current flow. There is only a displacement of the voltage triangle (Figure 6-26). For the system operation this state is no immediate danger. The distance protection must not pick up in this case even though the voltage of the phase with the earth fault is equal to zero in the whole galvanically connected system. Any load currents will result in an impedance value that is equal to zero. Therefore a single-phase pick-up phase-earth without earth current pickup is avoided in the 7SA6.



a) Healthy System, without Earth Fault

b) Earth Fault in Phase L1

Figure 6-26 Earth fault in non-earthed systems

With the occurrence of earth faults — especially in large resonant-earthed systems — large fault inception transient currents can appear that may evoke the earth current pick-up. In case of an overcurrent pick-up there may also be a phase current pick-up.

There are special measures against such undesirable pick-ups (see Subsection 6.2.1).

With the occurrence of a double earth fault in isolated or resonant-earthed systems it is sufficient to switch off one of the faults. The second fault may remain in the system as a simple earth fault. Which of the faults is switched off depends on the double earth fault preference which is set the same in the whole galvanically-connected system. With 7SA6 the following double earth fault preferences **`PHASE PREF.2phe`** can be selected:

- acyclic L3 before L1 before L2, short form: ***`L3 (L1) acyclic`***;
- acyclic L1 before L3 before L2, short form: ***`L1 (L3) acyclic`***;
- acyclic L2 before L1 before L3, short form: ***`L2 (L1) acyclic`***;
- acyclic L1 before L2 before L3, short form: ***`L1 (L2) acyclic`***;
- acyclic L3 before L2 before L1, short form: ***`L3 (L2) acyclic`***;
- acyclic L2 before L3 before L1, short form: ***`L2 (L3) acyclic`***;
- cyclic L3 before L1 before L2 before L3, short form: ***`L3 (L1) cyclic`***;
- cyclic L1 before L3 before L2 before L1, short form: ***`L1 (L3) cyclic`***;
- all loops are measured (no preference) ***`All loops`***.

In all eight preference options one earth fault is switched off according to the preference scheme. The second fault can remain in the system as a simple earth fault. It can be detected with the ordering option “Earth Fault Detection in Non-earthed Systems” (see Section 6.11).

The 7SA6 also enables the user to switch off both fault locations of a double earth fault. Set the double earth fault preference to ***`All loops`***.

Table 6-8 lists all measured values used for the distance measuring in isolated or resonant-earthed systems.

Table 6-8 Evaluation of measured loops for a multiple pick-up in non-earthed systems

Fault detection Loops	Evaluated Loop(s)	Setting Parameter 1221
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L1–E L3–E L3–E	**`PHASE PREF.2phe`** = ***`L3 (L1) acyclic`***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L1–E L3–E L1–E	**`PHASE PREF.2phe`** = ***`L1 (L3) acyclic`***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L2–E L2–E L1–E	**`PHASE PREF.2phe`** = ***`L2 (L1) acyclic`***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L1–E L2–E L1–E	**`PHASE PREF.2phe`** = ***`L1 (L2) acyclic`***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L2–E L3–E L3–E	**`PHASE PREF.2phe`** = ***`L3 (L2) acyclic`***

Table 6-8 Evaluation of measured loops for a multiple pick-up in non-earthed systems

Fault detection Loops	Evaluated Loop(s)	Setting Parameter 1221
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L2–E L2–E L3–E	**PHASE PREF.2phe** = ***L2 (L3) acyclic***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L1–E L2–E L3–E	**PHASE PREF.2phe** = ***L3 (L1) cyclic***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L2–E L3–E L1–E	**PHASE PREF.2phe** = ***L1 (L3) cyclic***
L1–E, L2–E, (L1–L2) L2–E, L3–E, (L2–L3) L1–E, L3–E, (L3–L1)	L1–E, L2–E L2–E, L3–E L3–E, L1–E	**PHASE PREF.2phe** = ***All loops***

Measured Value Correction for Parallel Lines

During earth faults on parallel lines, the impedance values calculated by means of the loop equations are influenced by the coupling of the earth impedance of the two conductor systems (Figure 6-27). Unless special measures are employed, this results in measuring errors in the result of the impedance computation. A parallel line compensation may therefore be activated. In this manner the earth current of the parallel line is taken into consideration by the line equation and thereby allows for compensation of the coupling influence. The earth current of the parallel line must be connected to the device for this purpose. The loop equation is then modified as shown below, refer also to Figure 6-24

$$\underline{I}_{L3}\cdot\underline{Z}_{L}-\underline{I}_{E}\cdot\underline{Z}_{E}-\underline{I}_{EP}\cdot\underline{Z}_{M}=\underline{U}_{L3-E}$$

$$\underline{I}_{L3}\cdot\underline{Z}_{L}-\underline{I}_{E}\cdot\underline{Z}_{L}\cdot\frac{\underline{Z}_{E}}{\underline{Z}_{L}}-\underline{I}_{EP}\cdot\underline{Z}_{L}\cdot\frac{\underline{Z}_{M}}{\underline{Z}_{L}}=\underline{U}_{L3-E}$$

where $\underline{I}_{EP}$ is the earth current of the parallel line and the ratio $\underline{Z}_{M}/\underline{Z}_{L}$ is a constant line parameter, resulting from the geometry of the double circuit line and the nature of the ground below the line. These line parameters are input to the device — along with all the other line data — during the parameterisation of the device. The line impedance is calculated with the equation below similar to the calculation shown earlier.

$$\underline{Z}_{L}=\frac{\underline{U}_{L3-E}}{\underline{I}_{L3}-\underline{Z}_{E}/\underline{Z}_{L}\cdot\underline{I}_{E}-\underline{Z}_{M}/\underline{Z}_{L}\cdot\underline{I}_{EP}}$$

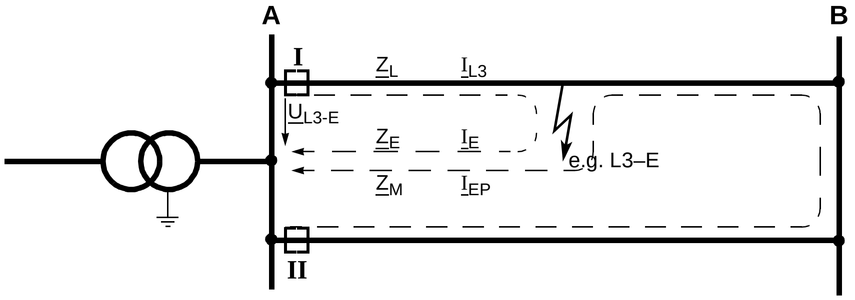


Figure 6-27 Earth fault on a double circuit line

Without parallel line compensation, the earth current on the parallel line will in most cases cause the reach threshold of the distance protection to be shortened (underreach of the distance measurement). In some cases — for example when the two feeders are terminated to different busbars, and the location of the earth fault is on one of the remote busbars (at B in Figure 6-27) — it is possible that an overreach may occur.

The parallel line compensation only applies to faults on the protected line. For faults on the parallel line, the compensation may not be carried out, as this would cause severe overreach. The relay located in position II in Figure 6-27 may therefore not be compensated.

An earth current balance is therefore additionally provided in the device, which carries out a cross comparison of the earth currents in the two lines. The compensation is only applied to the line end where the earth current of the parallel line is not substantially larger than the earth current in the line itself. In example Figure 6-27, the current I_E is larger than I_{EP}: compensation is applied at I in that $Z_M \cdot I_{EP}$ is included in the evaluation; at II compensation is not applied.

Switching onto a Fault

When the circuit breaker is switched onto a fault with a manual close command, fast tripping by the distance protection is possible. By setting parameters it may be determined which zone(s) is/are released following a manual close (refer to Figure 6-28). The line energization information (input “SOTF”) are derived from the state recognition, refer also to Sub-section 6.20.1.

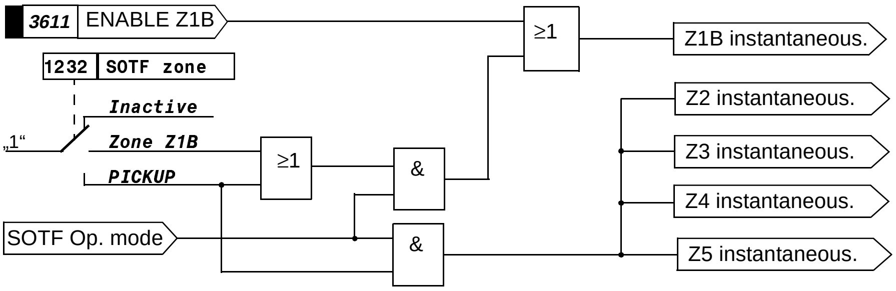


Figure 6-28 Circuit breaker closure onto a fault

6.2.3.2 Applying the Function Parameter Settings

General Function Parameters

The distance protection can be switched on or off with the parameter in address **1201 FCT Distance** ***ON***/***OFF***

The minimum current for fault detection **Minimum Iph>** (address **1202**) is set somewhat (approx. 10 %) below the minimum short-circuit current that may occur.

The setting parameters for the treatment of earth faults **1203 3I0> Threshold** and **1204 3U0> Threshold** were already discussed in Sub-section 6.2.1.2.

Correction of Measured Values on Parallel Lines

The mutual coupling between the two lines of a double-circuit configuration is only relevant to the 7SA6 when it is applied on a double-circuit line and when it is intended to implement parallel line compensation. A prerequisite is that the earth current of the parallel line is connected to the I_4 measuring input of the 7SA6 and this is entered in the configuration settings.

In this case, the setting **Paral.Line Comp** = ***YES*** must be set in address **1215**; otherwise the presetting ***NO*** remains.

The coupling factors were already set as part of the general protection data (Subsection 6.1.3), as was the reach of the parallel line compensation.

Double Earth Faults in Earthed Systems

The loop selection for double earth faults is set in address **1221 2Ph-E faults** (Phase–Phase–Earth–fault detection). This setting can only be changed with DIGSI® 4 under "**Additional Settings**". In general the ***Block leading Ø*** (blocking of the leading phase, presetting) is favourable, because the leading phase-earth loop tends to overreach, especially in conjunction with large earth fault resistance. In certain cases (fault resistance phase-phase larger than phase-earth) the setting ***Block lagging Ø*** (blocking of the lagging phase) may be more favourable. The selection of all affected loops with the setting ***All loops*** allows a maximum degree of redundancy. Alternatively, ***Ø-Ø loops only*** may be evaluated. This ensures the most accuracy for two phase to earth faults. Ultimately it is possible to declare the ***Ø-E loops only*** as valid.

Double Earth Faults in Non-earthed Systems

In isolated or resonant-earthed systems it must be guaranteed that the preference for double earth faults in whole galvanically-connected systems is consistent. The double earth fault preference is set in address 1220 **PHASE PREF.2phe**.

The 7SA6 enables the user to detect all foot points of a multiple earth fault. **PHASE PREF.2phe** = ***All loops*** means that each earth fault point on a protected line is switched off independent of the preference. It can also be combined with a different preference. For a transformer feeder, for example, any foot point can be switched off following occurrence of a double earth fault, whereas **L1 (L3) acyclic** is consistently valid for the remainder of the system.

If the earth fault detection threatens to pick up due to fault inception transients following the occurrence of a single earth fault, the detection can be delayed with setting address 1206 **T3I0 1PHAS.** Usually the presetting (0.04 s) is sufficient. For large resonant-earthed systems the time delay should be increased. Set parameter **T3I0 1PHAS** to ∞ if the earth current threshold can also be exceeded during steady-state conditions. Then, even with high earth current, no single-phase pick up is possible anymore. Double earth faults are, however, detected correctly and evaluated according to the preference mode (Section 6.2.3.1, paragraph "Double Earth Faults in Non-earthed Systems").

If a double earth fault occurs right after a single earth fault, it is detected and evaluated according to the preference scheme. The already existing earth fault is detected by the zero-sequence voltage (address 1205 **3U0> COMP/ISOL.**). Please note that three times the zero-sequence voltage $3U_0$ is relevant. With a full displacement its value will be $\sqrt{3}$-times the phase-to-phase voltage. After detection of $3U_0$, the time delay **T3I0 1PHAS** is not active anymore: an earth fault ocurring then in a different phase can only be a double earth fault.

Line Energization onto a Dead Fault

To determine the reaction of the distance protection during closure of the circuit breaker onto a dead fault, the parameter in address **1232 SOTF zone** is used. The setting ***Inactive*** specifies that there is no special reaction, i.e. all distance stages operate according to their set zone parameters. The setting ***Zone Z1B*** causes all faults inside the overreaching zone Z1B to be cleared without delay following closure of the circuit breaker. The setting ***Pickup*** implies that the non-delayed tripping following line energization is activated for all recognized faults in any zone (i.e. with general fault detection of the distance protection).

Load Area
(only for
Impedance Pick-up)

On long heavily loaded lines, the risk of encroachment of the load impedance into the tripping characteristic of the distance protection may exist. To exclude the risk of unwanted fault detection by the distance protection during heavy load flow, a load trapezoid characteristic may be set for tripping characteristics with a large R-reach, which excludes such unwanted fault detection by overload. This load area is considered in the description of the tripping characteristics (refer to Figure 6-29, Subsubsection 6.2.4.1).

The R–values **`R load (Ø-E)`** (address **1241**) and **`R load (Ø-Ø)`** (address **1243**) must be set somewhat (approx. 10 %) smaller than the minimum load impedance which may occur. The minimum load impedance results when the maximum load current and minimum operating voltage exist.

Calculation example:

110 kV overhead line 150 mm^2 with the following data:

maximum transferrable load
P_{max} = 100 MVA corresponding to
I_{max} = 525 A

minimum operating voltage
U_{min} = 0.9 U_N

current transformers600 A/5 A

voltage transformers110 kV/0.1 kV

The resulting minimum load impedance is therefore:

$$R_{Load\ prim} = \frac{U_{min}}{\sqrt{3}\cdot I_{L\ max}} = \frac{0.9\cdot 110\ kV}{\sqrt{3}\cdot 525\ A} = 108.87\ \Omega$$

When applying the settings with a personal computer and DIGSI® 4 these values may be entered as primary values. The conversion to secondary values is

$$R_{Load\ sec} = \frac{N_{CT}}{N_{VT}}\cdot R_{Load\ prim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV}\cdot 108.87\ \Omega = 11.88\ \Omega$$

when applying a security margin of 10 % the following is set:

primary: **`R load (Ø-E)`** = ***97.98*** Ω or
secondary: **`R load (Ø-E)`** = ***10.69*** Ω.

The spread angle of the load trapezoid `φ load (Ø-E)`(address **1242**) and φ load (Ø-Ø) (address **1244**) must be greater (approx. 5°) than the maximum arising load angle (corresponding to the minimum power factor cos φ).

Calculation example:

minimum power factor
cos φ_{min} = 0.63
φ_{max} = 51°

Setting *j* load (Ø-E) = φ_{max} + 5° = ***56***°.

6.2.3.3 Settings

Note: The indicated secondary current values and values of impedance for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5. The values of impedance are divided by 5.

Addr.	Setting Title	Function	Setting Options	Default Setting
1201	FCT Distance	Distance protection, general settings	ON OFF	ON
1202	Minimum Iph>	Distance protection, general settings	0.10..4.00 A	0.10 A
1215	Paral.Line Comp	Distance protection, general settings	NO YES	NO
1232	SOTF zone	Distance protection, general settings	with Pickup (non-directional) with Zone Z1B Inactive	Inactive
1241	R load (Ø-E)	Distance protection, general settings	0.10..250.00 Ohm; ∞	∞ Ohm
1242	φ load (Ø-E)	Distance protection, general settings	20..60 °	45 °
1243	R load (Ø-Ø)	Distance protection, general settings	0.10..250.00 Ohm; ∞	∞ Ohm
1244	φ load (Ø-Ø)	Distance protection, general settings	20..60 °	45 °
1203	3I0> Threshold	Distance protection, general settings	0.05..4.00 A	0.10 A
1204	3U0> Threshold	Distance protection, general settings	1..100 V; ∞	5 V
1205	3U0> COMP/ ISOL.	Distance protection, general settings	10..200 V	40 V
1206	T3I0 1PHAS	Distance protection, general settings	0.00..0.50 sec	0.04 sec
1207A	3I0>/ Iphmax	Distance protection, general settings	0.05..0.30	0.10
1220	PHASE PREF.2phe	Distance protection, general settings	L3 (L1) acyclic L1 (L3) acyclic L2 (L1) acyclic L1 (L2) acyclic L3 (L2) acyclic L2 (L3) acyclic L3 (L1) cyclic L1 (L3) cyclic all loops	L3 (L1) acyclic
1221A	2Ph-E faults	Distance protection, general settings	block leading ph-e loop block lagging ph-e loop all loops only phase-phase loops only phase-earth loops	block leading ph-e loop

6.2.3.4 Information Overview

F.No.	Alarm	Comments
3603	>BLOCK Distance	>BLOCK Distance protection
3611	>ENABLE Z1B	>ENABLE Z1B (with setted Time Delay)
3613	>ENABLE Z1Binst	>ENABLE Z1B instantanous (w/o T-Delay)
3617	>BLOCK Z4-Trip	>BLOCK Z4-Trip
3618	>BLOCK Z5-Trip	>BLOCK Z5-Trip
3651	Dist. OFF	Distance is switched off
3652	Dist. BLOCK	Distance is BLOCKED
3653	Dist. ACTIVE	Distance is ACTIVE
3654	Dis.ErrorK0(Z1)	Setting error K0(Z1) or Angle K0(Z1)
3655	DisErrorK0(>Z1)	Setting error K0(>Z1) or Angle K0(>Z1)
3671	Dis. PICKUP	Distance PICKED UP
3672	Dis.Pickup L1	Distance PICKUP L1
3673	Dis.Pickup L2	Distance PICKUP L2
3674	Dis.Pickup L3	Distance PICKUP L3
3675	Dis.Pickup E	Distance PICKUP Earth
3681	Dis.Pickup 1pL1	Distance Pickup Phase L1 (only)
3682	Dis.Pickup L1E	Distance Pickup L1E
3683	Dis.Pickup 1pL2	Distance Pickup Phase L2 (only)
3684	Dis.Pickup L2E	Distance Pickup L2E
3685	Dis.Pickup L12	Distance Pickup L12
3686	Dis.Pickup L12E	Distance Pickup L12E
3687	Dis.Pickup 1pL3	Distance Pickup Phase L3 (only)
3688	Dis.Pickup L3E	Distance Pickup L3E
3689	Dis.Pickup L31	Distance Pickup L31
3690	Dis.Pickup L31E	Distance Pickup L31E
3691	Dis.Pickup L23	Distance Pickup L23
3692	Dis.Pickup L23E	Distance Pickup L23E
3693	Dis.Pickup L123	Distance Pickup L123
3694	Dis.Pickup123E	Distance Pickup123E
3701	Dis.Loop L1-E f	Distance Loop L1E selected forward
3702	Dis.Loop L2-E f	Distance Loop L2E selected forward
3703	Dis.Loop L3-E f	Distance Loop L3E selected forward
3704	Dis.Loop L1-2 f	Distance Loop L12 selected forward
3705	Dis.Loop L2-3 f	Distance Loop L23 selected forward
3706	Dis.Loop L3-1 f	Distance Loop L31 selected forward

F.No.	Alarm	Comments
3707	Dis.Loop L1-E r	Distance Loop L1E selected reverse
3708	Dis.Loop L2-E r	Distance Loop L2E selected reverse
3709	Dis.Loop L3-E r	Distance Loop L3E selected reverse
3710	Dis.Loop L1-2 r	Distance Loop L12 selected reverse
3711	Dis.Loop L2-3 r	Distance Loop L23 selected reverse
3712	Dis.Loop L3-1 r	Distance Loop L31 selected reverse
3713	Dis.Loop L1E<->	Distance Loop L1E selected non-direct.
3714	Dis.Loop L2E<->	Distance Loop L2E selected non-direct.
3715	Dis.Loop L3E<->	Distance Loop L3E selected non-direct.
3716	Dis.Loop L12<->	Distance Loop L12 selected non-direct.
3717	Dis.Loop L23<->	Distance Loop L23 selected non-direct.
3718	Dis.Loop L31<->	Distance Loop L31 selected non-direct.
3719	Dis. forward	Distance Pickup FORWARD
3720	Dis. reverse	Distance Pickup REVERSE
3741	Dis. Z1 L1E	Distance Pickup Z1, Loop L1E
3742	Dis. Z1 L2E	Distance Pickup Z1, Loop L2E
3743	Dis. Z1 L3E	Distance Pickup Z1, Loop L3E
3744	Dis. Z1 L12	Distance Pickup Z1, Loop L12
3745	Dis. Z1 L23	Distance Pickup Z1, Loop L23
3746	Dis. Z1 L31	Distance Pickup Z1, Loop L31
3747	Dis. Z1B L1E	Distance Pickup Z1B, Loop L1E
3748	Dis. Z1B L2E	Distance Pickup Z1B, Loop L2E
3749	Dis. Z1B L3E	Distance Pickup Z1B, Loop L3E
3750	Dis. Z1B L12	Distance Pickup Z1B, Loop L12
3751	Dis. Z1B L23	Distance Pickup Z1B, Loop L23
3752	Dis. Z1B L31	Distance Pickup Z1B, Loop L31
3755	Dis. Pickup Z2	Distance Pickup Z2
3758	Dis. Pickup Z3	Distance Pickup Z3
3759	Dis. Pickup Z4	Distance Pickup Z4
3760	Dis. Pickup Z5	Distance Pickup Z5
3771	Dis.Time Out T1	DistanceTime Out T1
3774	Dis.Time Out T2	DistanceTime Out T2
3777	Dis.Time Out T3	DistanceTime Out T3
3778	Dis.Time Out T4	DistanceTime Out T4
3779	Dis.Time Out T5	DistanceTime Out T5
3780	Dis.TimeOut T1B	DistanceTime Out T1B

F.No.	Alarm	Comments
3781	Dis.TimeOut Tfw	DistanceTime Out Forward PICKUP
3782	Dis.TimeOut Trv	DistanceTime Out Reverse/Non-dir. PICKUP
3801	Dis.Gen. Trip	Distance protection: General trip
3802	Dis.Trip 1pL1	Distance TRIP command - Only Phase L1
3803	Dis.Trip 1pL2	Distance TRIP command - Only Phase L2
3804	Dis.Trip 1pL3	Distance TRIP command - Only Phase L3
3805	Dis.Trip 3p	Distance TRIP command Phases L123
3811	Dis.TripZ1/1p	Distance TRIP single-phase Z1
3823	DisTRIP3p. Z1sf	DisTRIP 3phase in Z1 with single-ph Flt.
3824	DisTRIP3p. Z1mf	DisTRIP 3phase in Z1 with multi-ph Flt.
3813	Dis.TripZ1B1p	Distance TRIP single-phase Z1B
3825	DisTRIP3p.Z1Bsf	DisTRIP 3phase in Z1B with single-ph Flt
3826	DisTRIP3p Z1Bmf	DisTRIP 3phase in Z1B with multi-ph Flt.
3816	Dis.TripZ2/1p	Distance TRIP single-phase Z2
3817	Dis.TripZ2/3p	Distance TRIP 3phase in Z2
3818	Dis.TripZ3/T3	Distance TRIP 3phase in Z3
3821	Dis.TRIP 3p. Z4	Distance TRIP 3phase in Z4
3822	Dis.TRIP 3p. Z5	Distance TRIP 3phase in Z5
3850	DisTRIP Z1B Tel	DisTRIP Z1B with Teleprotection scheme
3819	Dis.Trip FD->	Dist.: Trip by fault detection, forward
3820	Dis.Trip <->	Dist.: Trip by fault detec, rev/non-dir.

6.2.4 Distance Protection with Polygonal Tripping Characteristic

6.2.4.1 Method of Operation

Operating Polygons

A tripping characteristic in the shape of a polygon is defined for each of the distance zones. In total, there are five independent zones and one additional controlled zone for each fault impedance loop. In Figure 6-29 the shape of a polygon is illustrated. The first zone is shaded and forward directional, the third zone is reverse directional.

In general, the polygon is defined by means of a parallelogram which intersects the axes with the values R and X as well as the tilt φ_{Line}. A load trapezoid with the setting R_{Load} und φ_{Load} may be used to cut the area of the load impedance out of the polygon. The axial coordinates can be set individually for each zone; φ_{Line}, R_{Load} und φ_{Load} are common for all zones. The parallelogram is symmetrical with respect to the origin of the R–X–coordinate system; the directional characteristic however limits the tripping range to the desired quadrants (refer to “Direction Determination” below).

The R-reach may be set separately for the phase–phase faults and the phase–earth faults to achieve a larger fault resistance coverage for earth faults if this is desired.

For the first zone an additional tilt α exists, which may be used to prevent overreach resulting from angle variance and/or two ended infeed to short-circuits with fault resistance. For Z1B and the higher zones this tilt does not exist.

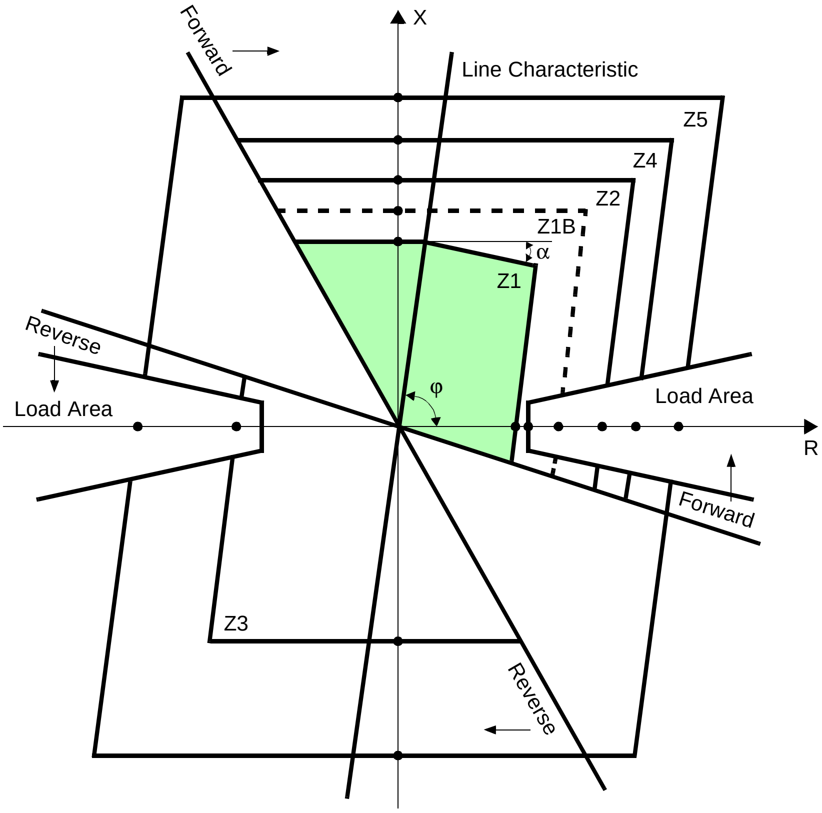
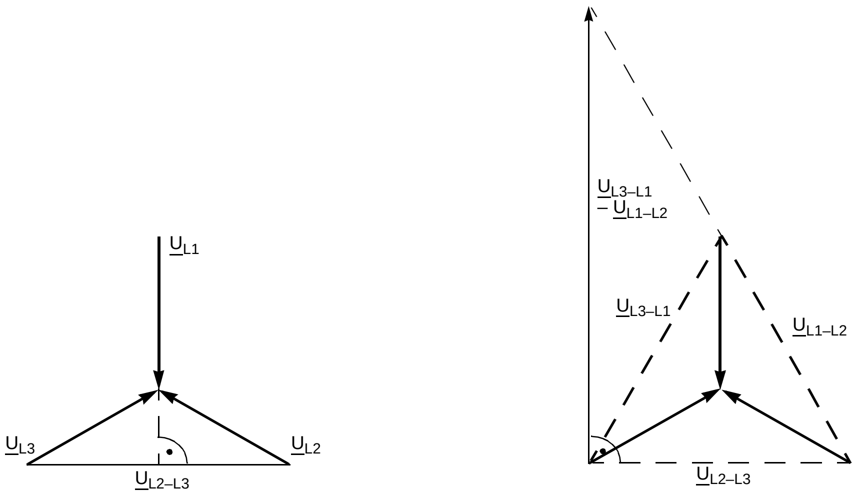


Figure 6-29 Polygonal characteristic

Direction Determination

For each loop an impedance vector is also used to determine the direction of the short-circuit. Usually similar to the distance calculation, $\underline{Z}_L$ is used. However, depending on the "quality" of the measured values, different computation techniques are used. Immediately after fault inception, the short circuit voltage is disturbed by transients. The voltage memorized prior to fault inception is therefore used in this situation. If the steady-state short-circuit voltage (during a close-in fault) is even too small for direction determination, an unfaulted voltage is used. This voltage is in theory quadrilateral to the actual short-circuit voltage for both phase–earth loops as well as for phase–phase loops (refer to Figure 6-30). This is taken into account when computing the direction vector by means of a 90°–rotation. In Table 6-9 the allocation of the measured values to the six fault loops for the determination of the fault direction is shown.



a) Phase–earth loop (L1–E)

b) Phase–phase loop (L2–L3)

Figure 6-30 Direction determination with quadrature voltages

Table 6-9 Allocation of the measured values for the direction determination

Loop	Measured current (direction)	Short-circuit loop voltage	Quadrature voltage
L1 – E	$\underline{I}_{L1}$	$\underline{U}_{L1-E}$	$\underline{U}_{L2} - \underline{U}_{L3}$
L2 – E	$\underline{I}_{L2}$	$\underline{U}_{L2-E}$	$\underline{U}_{L3} - \underline{U}_{L1}$
L3 – E	$\underline{I}_{L3}$	$\underline{U}_{L3-E}$	$\underline{U}_{L1} - \underline{U}_{L2}$
L1 – E*)	$\underline{I}_{L1} - \underline{k}_E \cdot \underline{I}_E$*)	$\underline{U}_{L1-E}$	$\underline{U}_{L2} - \underline{U}_{L3}$
L2 – E*)	$\underline{I}_{L2} - \underline{k}_E \cdot \underline{I}_E$*)	$\underline{U}_{L2-E}$	$\underline{U}_{L3} - \underline{U}_{L1}$
L3 – E*)	$\underline{I}_{L3} - \underline{k}_E \cdot \underline{I}_E$*)	$\underline{U}_{L3-E}$	$\underline{U}_{L1} - \underline{U}_{L2}$
L1 – L2	$\underline{I}_{L1} - \underline{I}_{L2}$	$\underline{U}_{L1} - \underline{U}_{L2}$	$\underline{U}_{L2-L3} - \underline{U}_{L3-L1}$
L2 – L3	$\underline{I}_{L2} - \underline{I}_{L3}$	$\underline{U}_{L2} - \underline{U}_{L3}$	$\underline{U}_{L3-L1} - \underline{U}_{L1-L2}$
L3 – L1	$\underline{I}_{L3} - \underline{I}_{L1}$	$\underline{U}_{L3} - \underline{U}_{L1}$	$\underline{U}_{L1-L2} - \underline{U}_{L2-L3}$

*) $\underline{k}_E = \underline{Z}_E/\underline{Z}_L$; if only *one* phase-earth loop is picked up, the earth current $\underline{I}_E$ is considered

If there is neither a current measured voltage nor a memorized voltage available which is sufficient for measuring the direction, the relay selects the “forward” direction. In practice this can only occur when the circuit breaker closes onto a de-energized line, and there is a fault on this line (e.g. closing onto an earthed line).

Figure 6-31 shows the theoretical steady-state characteristic. In practice, the position of the directional characteristic when using memorized voltages is dependent on both the source impedance as well as the load transferred across the line prior to fault inception. Accordingly the directional characteristic includes a safety margin with respect to the borders of the first quadrant in the R–X diagram (Figure 6-31).

As each zone may be set ***Forward***, ***Reverse*** or ***Non-Directional*** there is a separate (mirrored) directional characteristic for the “forward” and “reverse” direction.

A non-directional zone has no directional characteristic. The entire tripping area applies here.

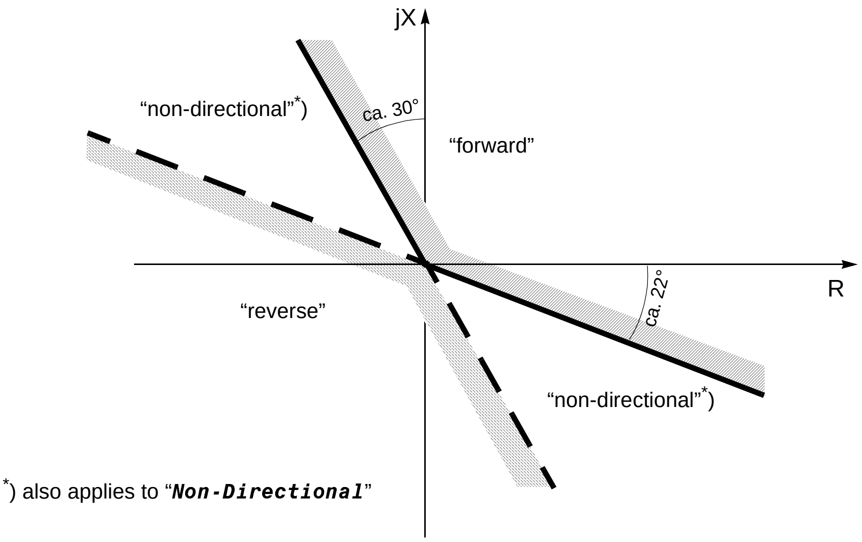


Figure 6-31 Directional characteristic in the R–X–diagram

Characteristics of the Directional Measurement

The theoretical steady-state directional characteristic shown in Figure 6-31 applies to faulted loop voltages. In the case of quadrature voltages or memorized voltage, the position of the directional characteristic is dependant on both the source impedance as well as the load transferred across the line prior to fault inception.

Figure 6-32 shows the directional characteristic using quadrature or memorized voltage as well as taking the source impedance into account (no load transfer). As these voltages are equal to the corresponding generator e.m.f. $\underline{E}$ and they do not change after fault inception, the directional characteristic is shifted in the impedance diagram by the source impedance $\underline{Z}_{S1} = \underline{E}_1/\underline{I}_1$. In the case of a fault located at F_1 (Figure 6-32a), the short-circuit is located in the forward direction, and the source impedance in the reverse direction. For all fault locations, right up to the device location (current transformers), a definite "forward" decision is made (Figure 6-32b). If the current direction is reversed, the position of the directional characteristic changes abruptly (Figure 6-32c). The current flowing via the measuring point (current transformer) is now reversed $\underline{I}_2$, and is determined by the source impedance $\underline{Z}_{S2} + \underline{Z}_L$. When load is transferred across the line, the directional characteristic may additionally be rotated by the load angle.

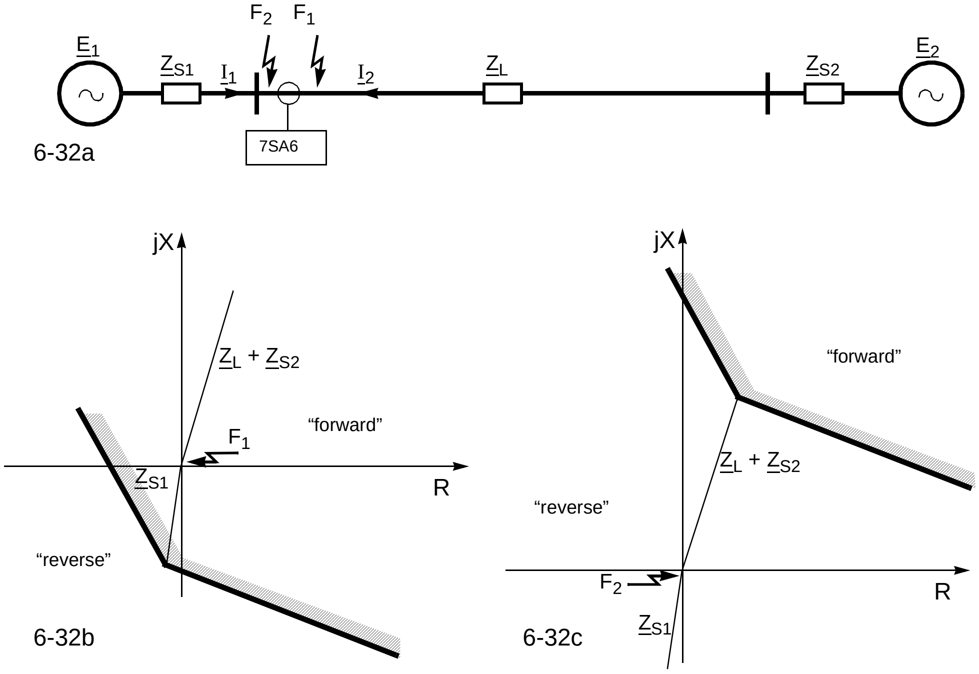


Figure 6-32 Directional characteristic with quadrature or memorized voltages

Pick-up and Assignment to the Polygons

Using the fault detection modes I, U/I or U/I/φ according to Subsection 6.2.2 the impedances, that were calculated from the valid loops, are assigned, after the pick-up, to the zone characteristics set for the distance protection. To avoid unstable signals at the boundaries of a polygon, the characteristics have a hysteresis of approximately 5 % i.e. as soon as it has been determined that the fault impedance lies within a polygon, the boundaries are increased by 5 % in all directions. The loop information is also converted to faulted phase indication

Using the impedance pick-up the loop impedances calculated according to Subsection 6.2.3 are also assigned to the zone characteristics set for the distance protection, but without a query of an explicite fault detection scheme. The pick-up range of the distance protection is determined from the thresholds of the largest-set polygon taking into consideration the respective direction. Here the loop information is also converted into faulted phase indication.

“Pick-up” signals are also generated for each zone and converted into phase information, e.g. `Dis.Pickup L1 Z1` for zone `Z1` and phase `L1`. This means that each phase and each zone is provided with separate pick-up information. The information is then processed in the zone logic (see Subsection 6.2.5) and by additional functions (e.g. signal transmission logic, Subsection 6.4.1).

The loop information is also converted to phase indications. Further conditions for the “pick-up” of a zone are that the direction must be in accordance with the configured direction for the zone and that the zone is not blocked by the power swing blocking (see Subsection 6.3.1). Furthermore the distance protection system must not be switched off totally or blocked. Figure 6-33 shows the conditions mentioned.

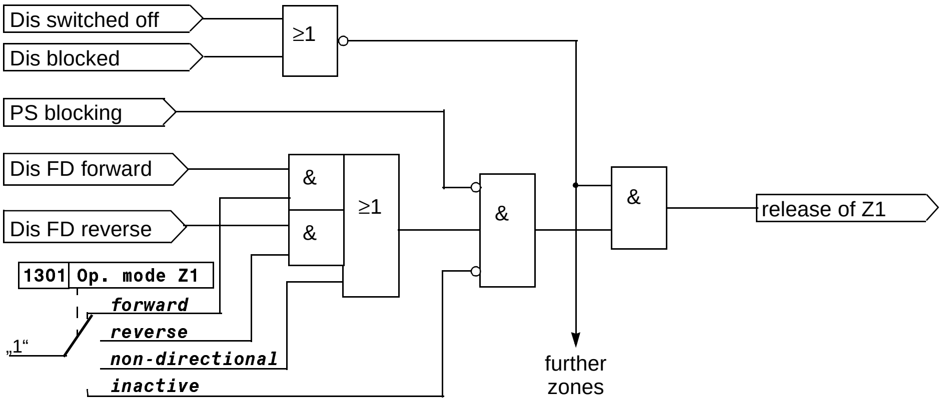


Figure 6-33 Release logic for a zone (example for Z1)

In total the following zones are available:

Independent zones:

- 1st zone (fast tripping zone) Z1 with **R(Z1)**, **X(Z1)**; may be delayed by **T1-1phase** and **T1-multi-phase**
- 2nd zone (back up zone) Z2 with **R(Z2)**, **X(Z2)**; may be delayed by **T2-1phase** and **T2-multi-phase**
- 3rd zone (back up zone) Z3 with **R(Z3)**, **X(Z3)**; may be delayed by **T3 DELAY**
- 4th zone (back up zone) Z4 with **R(Z4)**, **X(Z4)**; may be delayed by **T4 DELAY**
- 5th zone (back up zone) Z5 with **R(Z5)**, **X(Z5)+** (forward) and **X (Z5)-** (reverse); may be delayed by **T5 DELAY**

Dependent (controlled) zone:

- Overreaching zone Z1B with **R(Z1B)**, **X(Z1B)**; may be delayed by **T1B-1phase** and **T1B-multi-phase**

6.2.4.2 Applying the Function Parameter Settings

Grading Coordination Chart

It is recommended to initially create a grading coordination chart for the entire galvanically interconnected system. This diagram should reflect the line lengths with their primary reactance X in Ω/phase. For the reach of the distance zones, the reactances X are the deciding quantities.

The first zone Z1 is usually set to cover 85 % of the protected line without any trip time delay (i.e. T1 = 0.00 s). The protection clears faults in this range without additional time delay, i.e. the tripping time is the relay basic operating time.

The tripping time of the higher zones is sequentially increased by one time grading margin. The grading margin must take into account the circuit breaker operating time including the spread of this time, the resetting time of the protection equipment as well as the spread of the protection delay timers. Typical values are 0.2 s to 0.4 s. The reach is selected to cover up to approximately 80 % of the zone with the same set time delay on the shortest neighbouring feeder.

When entering the relay parameters with a personal computer and DIGSI® 4 it can be selected whether the settings are entered as primary or secondary values.

In the case of parameterization with secondary quantities, the values derived from the grading coordination chart must be converted to the secondary side of the current and voltage transformers. In general the following applies:

$$Z_{secondary} = \frac{\textbf{Current transformer ratio}}{\textbf{Voltage transformer ratio}} \cdot Z_{primary}$$

Accordingly, the reach for any distance zone can be specified as follows:

$$X_{sec} = \frac{N_{CT}}{N_{VT}} \cdot X_{prim}$$

where
N_{CT} — is the transformation ratio of the current transformers
N_{VT} — is the transformation ratio of the voltage transformers

<u>Calculation example:</u>

110 kV overhead line 150 mm^2 with the following data:

s (length) = 35 km
R_1/s = 0.19 Ω/km
X_1/s = 0.42 Ω/km
R_0/s = 0.53 Ω/km
X_0/s = 1.19 Ω/km

Current transformers 600 A/5 A

Voltage transformers110 kV/0,1 kV

The line data is calculated with these values as follows:

R_L = 0.19 Ω/km · 35 km = 6.65 Ω
X_L = 0.42 Ω/km · 35 km = 14.70 Ω

The first zone should be set to 85 % of the line length; the result is <u>primary</u>:

$X1_{prim}$ = 0.85 · X_L = 0.85 · 14.70 Ω = 12.49 Ω

or <u>secondary</u>:

$$X1_{sec} = \frac{N_{CT}}{N_{VT}} \cdot X1_{prim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV} \cdot 12.49\ \Omega = 1.36\ \Omega$$

Resistance Margin

The resistance setting R allows a margin for fault resistance which appears as an additional resistance at the fault location and is added to the impedance of the line conductors. It comprises, for example, the resistance in arcs, the tower footing resistance and others. The setting must allow for these fault resistance, but should at the same time not be larger than necessary. On long heavily loaded lines, the setting may extend into the load impedance range. Fault detection due to overload conditions is then prevented with the load trapezoid. Refer to the margin heading “Load Area (only for Impedance Pick-up)” in Subsubsection 6.2.3.2. The resistance margin setting may be separately set for the phase–phase faults on the one hand and the phase–earth faults on the other hand. It is therefore possible to allow for a larger fault resistance for earth faults for example.

Most important for this setting on overhead lines, is the resistance of the fault arc. In cables on the other hand, an appreciable arc is not possible. On very short cables, care should however be taken that an arc fault on the local cable termination is inside the set resistance of the first zone.

The resistance of the line need not be taken into consideration since it was considered through the shape of the polygon, provided the line angle in address 1105 **`Line Angle`** (see Subsection 6.1.3, margin heading „General Line Data“) had been set correctly.

Example:

In the following example a maximum arc voltage of 8 kV is assumed for phase–phase faults (line data as above). If the minimum primary fault current is assumed to be 1000 A this corresponds to 8 Ω primary. This results in the following setting for the resistance reach of the first zone:
primary:

$$R1_{prim} = \frac{1}{2} \cdot R_{arc} = \frac{1}{2} \cdot 8\ \Omega = 4\ \Omega$$

or secondary:

$$R1_{sec} = \frac{N_{CT}}{N_{VT}} \cdot R1_{prim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV} \cdot 4\ \Omega = 0.44\ \Omega$$

Only half the arc resistance was applied in the equation, as it is added to the *loop* impedance and therefore only half the arc resistance appears in the *per phase* impedance.

A separate resistance margin can be set for earth faults. An arc resistance of 6 Ω and a tower footing resistance of 12 Ω is assumed. This results in the following primary:

$$R1E_{prim} = R_{arc} + R_{tower} = 6\ \Omega + 12\ \Omega = 18\ \Omega$$

or secondary:

$$R1E_{sec} = \frac{N_{CT}}{N_{VT}} \cdot R1_{prim} = \frac{600\ A/5\ A}{110\ kV/0.1\ kV} \cdot 18\ \Omega = 1.96\ \Omega$$

In this case the least favourable condition was assumed, whereby the earth current does not return via the measuring point. If all the earth current, or a portion of the earth current flows via the measuring point, the measured resistance decreases. If the infeed comes from the remote end, the measured resistance may be increased.

Independent Zones Z1 up to Z5

By means of the setting parameter **`MODE`** each zone can be set ***`Forward`*** or ***`Reverse`*** or ***`Non-Directional`*** (Address **1301 `Op. mode Z1`**, **1311 `Op. mode Z2`**, **1321 `Op. mode Z3`**, **1331 `Op. mode Z4`** and **1341 `Op. mode Z5`**). This allows any combination of forward, reverse or non-directional graded zones, for example on transformers, generators or bus couplers. In the fifth zone different reach in the X direction can be set for forward or reverse. Zones that are not required, are set ***`Inactive`***.

The values derived from the grading coordination chart are set for each of the required zones. The setting parameters are grouped for each zone. For the first zone, Z1, these are the parameters **`R(Z1)`** (address **1302**) for the R intersection of the polygon applicable to phase-phase faults, **`X(Z1)`** (address **1303**) for the X intersection of the polygon (reach), **`RE(Z1)`** (address **1304**) for the R intersection of the polygon applicable to phase-earth faults as well as the relevant delay time settings.

For the first zone, Z1, an additional tilt α (Figure 6-29) can be set by means of the parameter in address **1307** **Zone Reduction**. This setting is required if short circuits with a large fault resistance (e.g. overhead lines without earth/shield wire) are expected on lines with an infeed at both ends and load transfer in the direction of the line (export).

Different delay times can be set for single- and multiple-phase faults in the first zone: **T1-1phase** (address **1305**) and **T1-multi-phase** (address **1306**). The first zone is typically set to operate without additional time delay.

The corresponding parameters for the higher zones are:
R(Z2) (address **1312**), **X(Z2)** (address **1313**), **RE(Z2)** (address **1314**);
R(Z3) (address **1322**), **X(Z3)** (address **1323**), **RE(Z3)** (address **1324**);
R(Z4) (address **1332**), **X(Z4)** (address **1333**), **RE(Z4)** (address **1334**);
R(Z5) (address **1342**), **X(Z5)+** (address **1343**) for forward direction, **X (Z5)-** (address **1346**) for reverse direction, **RE(Z5)** (address **1344**);

For the second zone it is also possible to set separate delay times for single- and multi-phase faults. In general the delay times are set the same. If stability problems are expected during multiple-phase faults, a shorter time delay **T2-multi-phase** (address **1316**) may be considered under the given circumstances while a higher setting for **T2-1phase** (address **1315**) for single-phase faults may be tolerated.

The zone timers for the remaining zones are set with the parameters **T3 DELAY** (address **1325**), **T4 DELAY** (address **1335**) and **T5 DELAY** (address **1345**).

If the device is provided with the capability to trip single-pole, single-pole tripping is then possible in the zones Z1 and Z2. While single-pole tripping then usually applies to single-phase faults in Z1(if the other conditions for single-pole tripping are satisfied), this may also be selected for the second zone with address **1317** **Trip 1pole Z2**. Single pole tripping in zone 2 is only possible if this address is set to ***YES.*** The presetting is ***NO***.

Note:

For fast tripping (undelayed) in the forward direction the first zone **Z1** should always be used, as only the Z1 and Z1B are guaranteed to trip with the shortest operating time of the device. The further zones should be used sequentially for grading in the forward direction.

If fast tripping (undelayed) is required in the reverse direction, the zone **Z3** should be used for this purpose, as only this zone is guaranteed to trip with the shortest device operating time for faults in the reverse direction. Zone **Z3** is also recommended as reverse looking zone in teleprotection **Blocking** schemes.

Controlled Zone Z1B

The overreaching zone Z1B is a controlled zone. The normal zones Z1 to Z5 are not influenced by Z1B. There is therefore no zone switching, but rather the overreaching zone is activated or deactivated by the corresponding criteria. Z1B can also be selected in address **1351** to be **Op. mode Z1B** = ***Forward***, ***Reverse*** or ***Non-Directional***. If this stage is not required, it is set to ***Inactive*** in address **1351**. The setting options are similar to those of zone Z1: address **1352** **R(Z1B) Ø-Ø**, address **1353** **X(Z1B)**, address **1354** **RE(Z1B) Ø-E**. The delay times for single-phase and multiple-phase faults can again be set separately: **T1B-1phase** (address **1355**) and **T1B-multi-phase** (address **1356**).

Zone Z1B is usually used in combination with automatic reclosure and/or teleprotection systems. It can be activated internally by the teleprotection functions (see also section 6.4) or the integrated automatic reclosure (if available, see also section 6.1) or externally by a binary input. It is generally set to at least 120% of the line length. On three-terminal line applications (teed feeders), it must be set to securely reach beyond the longest line section, even when there is additional infeed via the tee-off point. The delay times are set in accordance with the type of application, usually to zero or a very small delay. When used in conjunction with teleprotection comparison systems, the dependence on the fault detection must be considered (refer to margin heading “Distance Protection Prerequisites” in Sub-section 6.4.2.

If the distance protection is used in conjunction with an automatic recloser, it may be determined in address 1357 **`1st AR -> Z1B`** which distance zones are released prior to a rapid automatic reclosure. Usually the overreaching zone Z1B is used for the first cycle (**`1st AR -> Z1B`** = ***Yes***). This may be suppressed by changing the setting to **`1st AR -> Z1B`** equals ***No***. In this case the overreaching zone Z1B is not released before and during the 1^{st} automatic reclose cycle. Zone Z1 is always released. The setting only has an effect when the service condition of the automatic reclose function is input to the device via binary input “`>Enable ARzones`” (FNo. 383, power system data 2).

6.2.4.3 Settings

Note: The indicated secondary values of impedance for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the values of impedance are to be divided by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
1301	Op. mode Z1	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z1
1302	R(Z1) Ø-Ø	0.05..250.00 Ohm	1.25 Ohm	R(Z1), Resistance for ph-ph-faults
1303	X(Z1)	0.05..250.00 Ohm	2.50 Ohm	X(Z1), Reactance
1304	RE(Z1) Ø-E	0.05..250.00 Ohm	2.50 Ohm	RE(Z1), Resistance for ph-e faults
1305	T1-1phase	0.00..30.00 sec; ∞	0.00 sec	T1-1phase, delay for single phase faults
1306	T1-multi-phase	0.00..30.00 sec; ∞	0.00 sec	T1multi-ph, delay for multi phase faults
1307	Zone Reduction	0..30 °; Ø	0 °	Zone Reduction Angle (load compensation)
1351	Op. mode Z1B	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z1B (overr-reach zone)
1352	R(Z1B) Ø-Ø	0.05..250.00 Ohm	1.50 Ohm	R(Z1B), Resistance for ph-ph-faults
1353	X(Z1B)	0.05..250.00 Ohm	3.00 Ohm	X(Z1B), Reactance

Addr.	Setting Title	Setting Options	Default Setting	Comments
1354	RE(Z1B) Ø-E	0.05..250.00 Ohm	3.00 Ohm	RE(Z1B), Resistance for ph-e faults
1355	T1B-1phase	0.00..30.00 sec; ∞	0.00 sec	T1B-1phase, delay for single ph. faults
1356	T1B-multi-phase	0.00..30.00 sec; ∞	0.00 sec	T1B-multi-ph, delay for multi ph. faults
1357	1st AR -> Z1B	NO YES	YES	Z1B enabled before 1st AR (int. or ext.)
1311	Op. mode Z2	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z2
1312	R(Z2) Ø-Ø	0.05..250.00 Ohm	2.50 Ohm	R(Z2), Resistance for ph-ph-faults
1313	X(Z2)	0.05..250.00 Ohm	5.00 Ohm	X(Z2), Reactance
1314	RE(Z2) Ø-E	0.05..250.00 Ohm	5.00 Ohm	RE(Z2), Resistance for ph-e faults
1315	T2-1phase	0.00..30.00 sec; ∞	0.30 sec	T2-1phase, delay for single phase faults
1316	T2-multi-phase	0.00..30.00 sec; ∞	0.30 sec	T2multi-ph, delay for multi phase faults
1317A	Trip 1pole Z2	NO YES	NO	Single pole trip for faults in Z2
1321	Op. mode Z3	Forward Reverse Non-Directional Inactive	Reverse	Operating mode Z3
1322	R(Z3) Ø-Ø	0.05..250.00 Ohm	5.00 Ohm	R(Z3), Resistance for ph-ph-faults
1323	X(Z3)	0.05..250.00 Ohm	10.00 Ohm	X(Z3), Reactance
1324	RE(Z3) Ø-E	0.05..250.00 Ohm	10.00 Ohm	RE(Z3), Resistance for ph-e faults
1325	T3 DELAY	0.00..30.00 sec; ∞	0.60 sec	T3 delay
1331	Op. mode Z4	Forward Reverse Non-Directional Inactive	Non-Directional	Operating mode Z4
1332	R(Z4) Ø-Ø	0.05..250.00 Ohm	12.00 Ohm	R(Z4), Resistance for ph-ph-faults
1333	X(Z4)	0.05..250.00 Ohm	12.00 Ohm	X(Z4), Reactance
1334	RE(Z4) Ø-E	0.05..250.00 Ohm	12.00 Ohm	RE(Z4), Resistance for ph-e faults
1335	T4 DELAY	0.00..30.00 sec; ∞	0.90 sec	T4 delay

Addr.	Setting Title	Setting Options	Default Setting	Comments
1341	Op. mode Z5	Forward Reverse Non-Directional Inactive	Inactive	Operating mode Z5
1342	R(Z5) Ø-Ø	0.05..250.00 Ohm	12.00 Ohm	R(Z5), Resistance for ph-ph-faults
1343	X(Z5)+	0.05..250.00 Ohm	12.00 Ohm	X(Z5)+, Reactance for Forward direction
1344	RE(Z5) Ø-E	0.05..250.00 Ohm	12.00 Ohm	RE(Z5), Resistance for ph-e faults
1345	T5 DELAY	0.00..30.00 sec; ∞	0.90 sec	T5 delay
1346	X(Z5)-	0.05..250.00 Ohm	4.00 Ohm	X(Z5)-, Reactance for Reverse direction

6.2.5 Tripping Logic of the Distance Protection

6.2.5.1 Method of Operation

General Fault Detection

As soon as any one of the distance zones has determined with certainty that the fault is inside its tripping range, the signal "`Dis. PICKUP`" (general fault detection of the distance protection) is generated. This signal is alarmed and made available for the initialization of internal and external supplementary functions. (e.g. teleprotection signal transmission, automatic reclosure).

Zone Logic of the Independent Zones Z1 up to Z5

As was mentioned in the description of the measuring technique, each distance zone generates an output signal which is associated with the zone and the affected phase. The zone logic combines these zone fault detections with possible further internal and external signals, starts the associated delay times and arrives at the reaches the possible trip decision. The simplified zone logic is shown in Figure 6-34 using for zone 1, Figure 6-35 for zone 2 and Figure 6-36 for the third zone. Zones Z4 and Z5 function according to Figure 6-37.

In the case of zones Z1, Z2 and Z1B single-pole tripping is possible for single-phase faults, if the device version includes the single-pole tripping option. Therefore the event output in these cases is provided for each pole. Different trip delay times can be set for single-phase and multiple-phase faults in these zones. For multiple-phase faults and faults in the other zones, the tripping is always three pole.

Note:

The input `>1p Trip Perm.` (`F.No 0381`) must be activated to achieve single-pole tripping. The binary input is usually controlled by an external automatic reclosure device.

The trip delay times of the zones (except for Z1 which is usually always set without delay) can be bypassed. The undelayed release results from the line energization logic, which may be externally initiated via the circuit breaker close signal derived from the circuit breaker control switch or from an internal line energization detection (refer to Sub-section 6.20.1). Zones Z4 and Z5 may be blocked by external criteria.

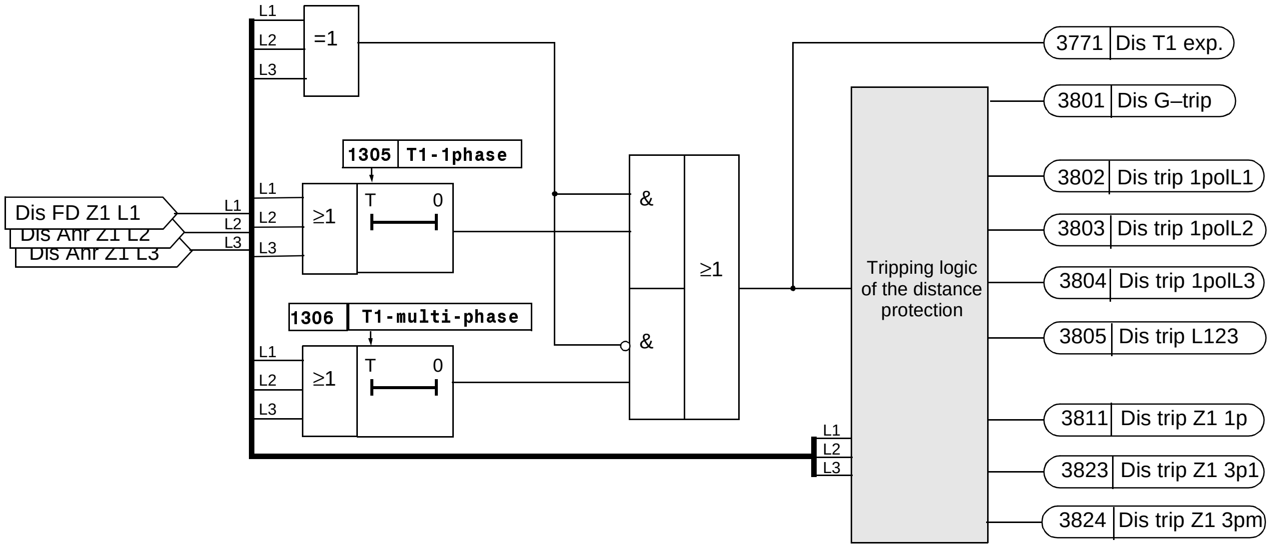


Figure 6-34 Tripping logic for the 1st Zone

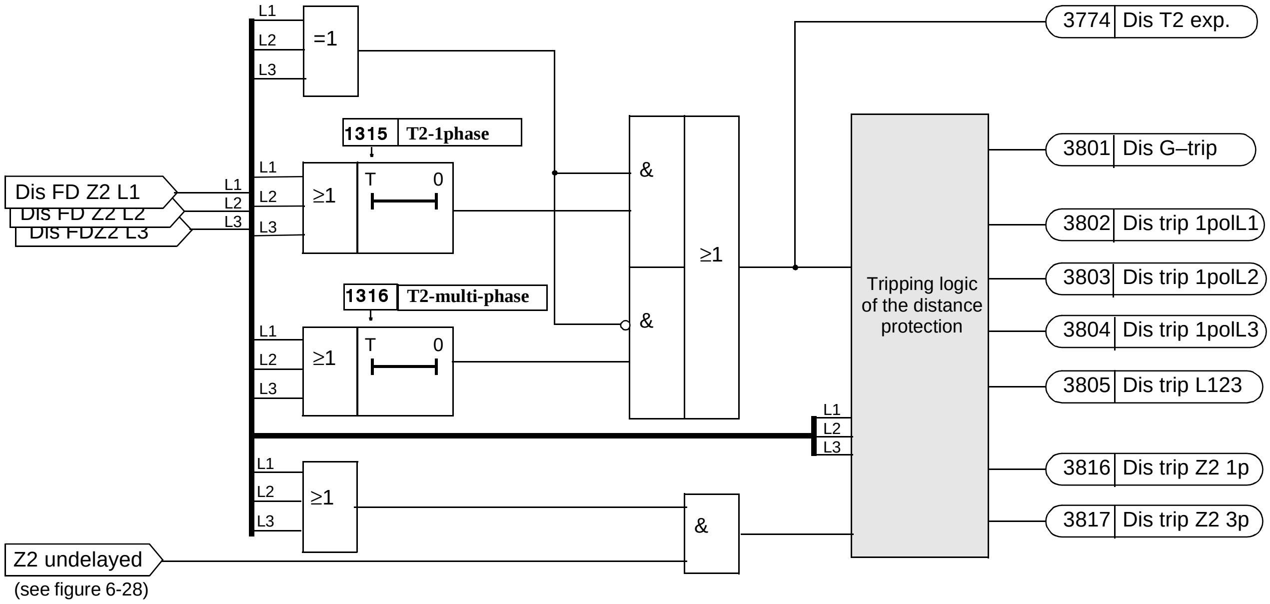


Figure 6-35 Tripping logic for the 2nd Zone

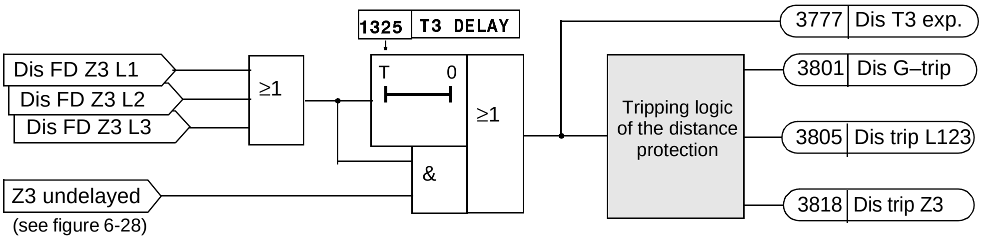


Figure 6-36 Tripping logic for the 3rd Zone

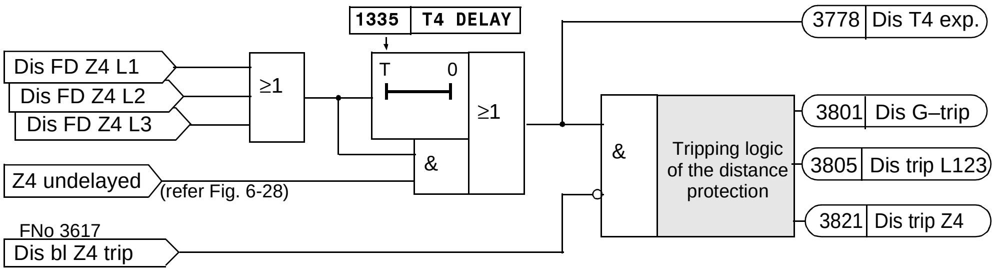


Figure 6-37 Tripping logic for the 4th and 5th Zone, shown is zone Z4

Zone Logic of the Controlled Zone Z1B

The controlled zone Z1B is usually applied as an overreaching zone. The logic is shown in Figure 6-38. It may be activated via various internal and external functions. The binary inputs for external activation are “**`>ENABLE Z1B`**” and “**`>Enable ARzones`**”. The former can for example be from an external teleprotection device, and only affects Z1B of the distance protection. The latter affects all protection functions that include a rapid auto-reclosure stage; it may for example be derived from an external automatic reclose device. In addition, it is possible to use the zone Z1B as a rapid auto-reclosure stage that only operates for single-pole faults, if for example only single-pole automatic reclose cycles are executed.

It is possible for the 7SA6 to trip single-pole during two-phase faults without earth-connection in the overreaching zone when single-pole automatic reclosure is used.

As the device has an integrated teleprotection function (refer to Section 6.4), release signals from this function may activate the zone Z1B, provided that the internal teleprotection signal transmission function has been configured to one of the available techniques with parameter **`0121 Teleprot. Dist.,`** i.o.w. the function has not been set to ***`Disabled.`***

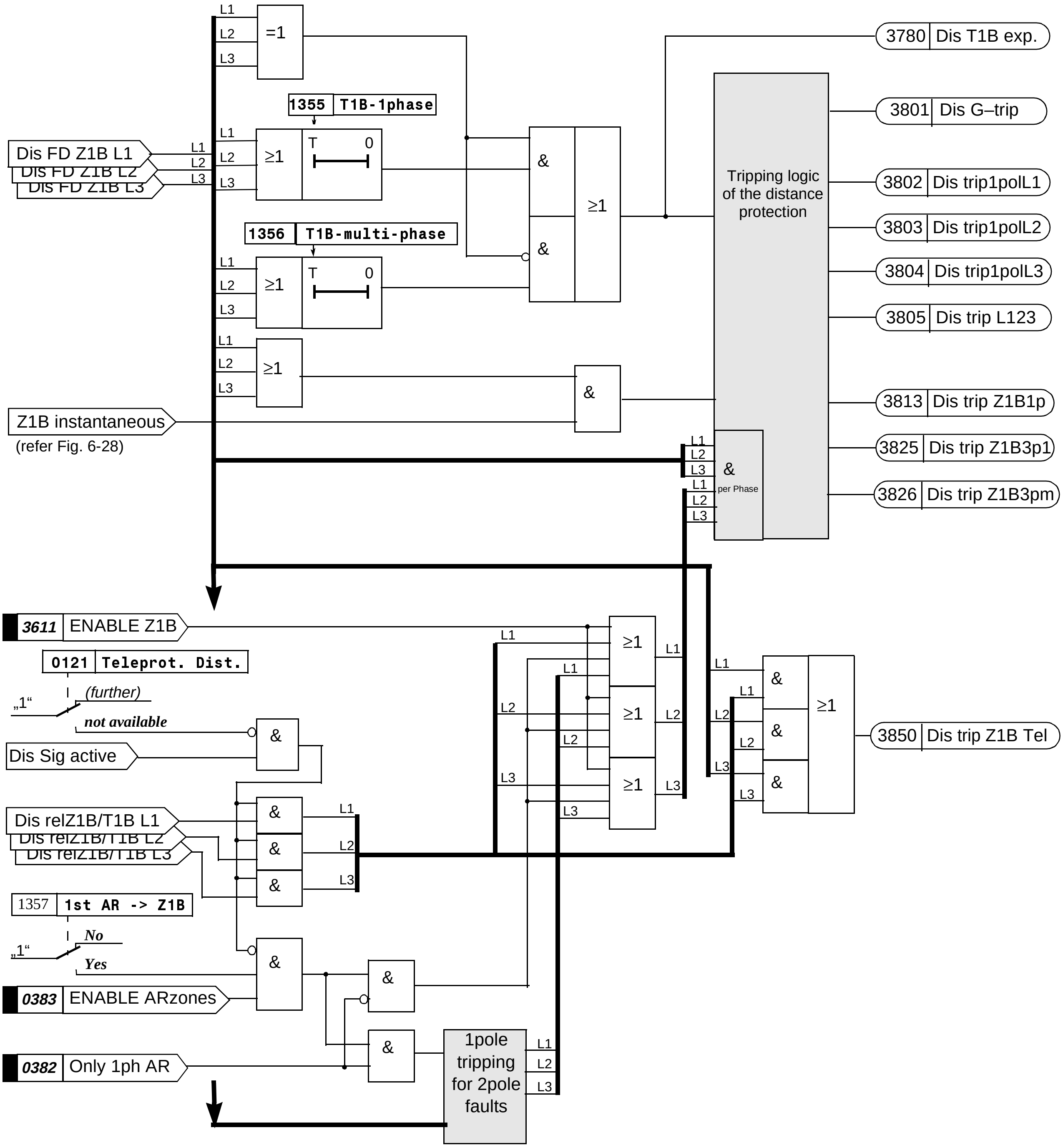


Figure 6-38 Tripping logic for the controlled zone Z1B

Tripping Logic

The output signals generated by the individual zones are combined in the actual tripping logic to form the trip output signals. The signal **`Dis.Gen. Trip`** is the general trip command. The single-pole information **`Dis.Trip 1pL1, Dis.Trip 1pL2, Dis.Trip 1pL3`** implies that tripping will take place single-pole only. The **`Dis Trip L123`** signal indicates the three-pole trip command. Furthermore, the zone that initiated the tripping is identified; if single-pole tripping is possible, this is also alarmed, as shown in the zone logic diagrams (Figures 6-34 up to 6-38). The actual generation of the commands for the trip relay takes place in the tripping logic of the device. (refer to Sub-section 6.20.4).

6.2.5.2 Applying the Function Parameter Settings

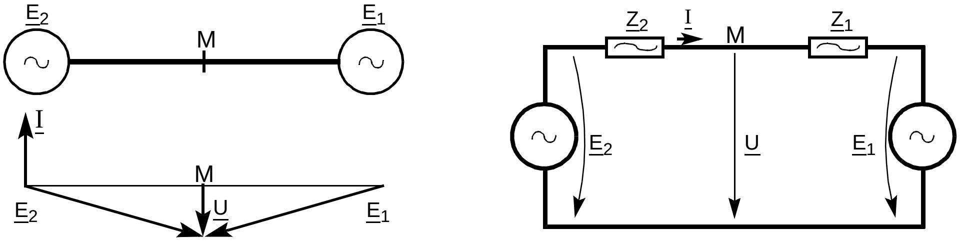
The trip delay times of the distance stages and intervention options which are also processed in the tripping logic of the distance protection were already considered with the zone settings (Sub-sections 6.2.4.2).

The parameter in address **1232 SOTF zone** which determines the response during switching onto a short-circuit was already set as part of the general data of the distance protection (Sub-section 6.2.3.2).

Further setting options which affect the tripping are described as part of the tripping logic of the device (refer to Sub-section 6.20.4).

6.3 Measures to Be Taken in Case of Power Swings

Following dynamic events such as load jumps, short-circuits, reclose dead times or switching actions it is possible that the generators must realign themselves, in an oscillatory manner, with the new load balance of the system. The distance protection registers large transient currents during the power swing and, especially at the electrical centre, small voltages (Figure 6-39). Small voltages with simultaneous large currents apparently imply small impedances, which again could lead to tripping by the distance protection. In expansive networks with large transferred power, even the stability of the energy transfer could be endangered by such power swings.



$$\underline{I} = \frac{\underline{E}_1 - \underline{E}_2}{\underline{Z}_1 + \underline{Z}_2}$$

at the Measuring Location M

Figure 6-39 Power swing

To avoid uncontrolled tripping, the distance protection devices are supplemented with power swing blocking functions. At particular locations in the system, out-of-step tripping devices are also applied to split the system into islanded networks at selected locations, when system stability (synchronism) is lost due to severe (unstable) power swings.

The 7SA6 has an integrated power swing supplement which allows both the blocking of trips by the distance protection during power swings (power swing blocking) and the calculated tripping during unstable power swings (out-of-step tripping).

Note:

The power swing supplement operates only in conjunction with the impedance pick-up mode.

6.3.1 Method of Operation

Detection of Power Swings

System power swings are three phase symmetrical processes. Therefore in general a certain degree of measured value symmetry may be assumed. System power swings may however also occur during unsymmetrical processes, e.g. during two-phase short-circuits or during single-pole dead times. The power swing detection in the 7SA6 is therefore based on three measuring systems. For each phase, a dedicated measuring system is available. Even if a power swing has been detected, any short-circuits that may occur during this period result in the fast cancellation of the power swing block in the affected phases, thereby allowing the tripping of the distance protection.

To detect a power swing, the rate of change of the impedance vector is measured. The measurement is started when the impedance vector enters the power swing measuring range PPOL (refer to Figure 6-40). The fault detection range APOL is made up of the largest set values for R and X of all the activated zones. The power swing range has a minimum distance Z_{diff} of 5 Ω (at I_N = 1 A) or 1 Ω (at I_N = 5 A) in all directions from the fault detection range. In the event of a short-circuit (1), the impedance vector abruptly changes from the load condition into this fault detection range. However, in the event of a power swing, the apparent impedance vector initially enters the power swing range PPOL and only later enters the fault detection range APOL (2). It is also possible that a power swing vector will enter the area of the power swing range and leave it again without coming into contact with the fault detection range (3). If the vector enters the power swing polygon and passes through it leaving on the opposite side, then the sections of the network seen from the relay location have lost synchronism (4): The power transfer is unstable.

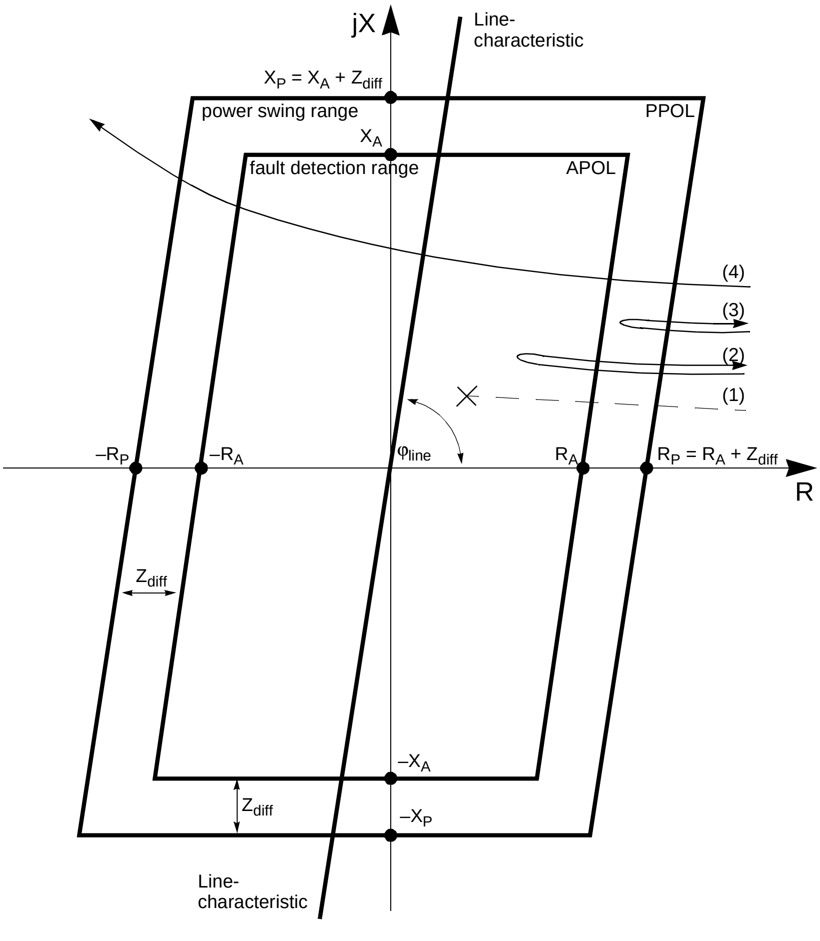


Figure 6-40 Pick up characteristic of the power swing detection for a polygon.

The rate of change of the three impedance vectors is monitored in $^1/_4$–period–cycles. If an impedance vectors, moving on a continuous curve, enters the power swing measuring range PPOL, a power swing condition is assumed. If on the other hand an impedance vector changes abruptly, this can only result from a load jump or short circuit.

A power swing is detected, if during the last eight measuring cycles (corresponding to two periods), the continuity of the changing impedance vector is confirmed. In this way, slip frequencies of up to at least 7 Hz are detected.

Power Swing Blocking

The power swing blocking affects the distance protection. If the criteria for power swing detection have been fulfilled in at least one phase, the following reactions are possible in relation to the power swing blocking function (set in address **`2002 P/S Op. mode:`**

- Blocking of all zones (***`All zones block`***):
  All zones of the distance protection are blocked during a power swing.
- Blocking of the first zone only (***`Z1/Z1B block`***):
  The first zone (Z1) and the overreaching zone (Z1B) are blocked during a power swing. Faults in other zones are tripped with the associated grading time.
- Blocking of only the higher zones (***`Z2 to Z5 block`***):
  The higher zones (Z2 to Z5) are blocked during a power swing. Only the first and the overreaching zone (Z1 and Z1B) remain active.
- Blocking of the first two zones (***`Z1,Z1B,Z2 block`***):
  The first and second zone (Z1 and Z2) and the overreaching zone (Z1B) are blocked during a power swing. The higher zones Z3 to Z5 remain active.

The associated measures taken only apply to those phases in which the power swing has been detected. They are active for as long as the measured impedance vector is inside the power swing range PPOL, or if due to an abrupt change of the associated impedance vector the power swing criteria are no longer satisfied.

If the distance protection recognizes a short-circuit which results in a trip, during a power swing, this trip signal is always three-pole.

Power Swing Tripping

If tripping in the event of an instable power swing (out-of-step condition) is desired, the parameter **`PowerSwing trip`** = ***`Yes`*** is set. If the criteria for power swing detection are satisfied, the distance protection is initially blocked according to the configured program for power swing blocking, to avoid tripping by the distance protection.

When the impedance vectors identified by the power swing detection exit the power swing characteristic PPOL, the R components are used to check if the vectors have the same sign as was the case when they entered the power swing characteristic. If this is the case, the power swing process is inclined to stabilize. Otherwise, the vector passed through the power swing characteristic (loss of synchronism, case (4) in Figure 6-40). The device issues a three-pole trip command, thereby isolating the two system segments from each other. Power swing tripping is alarmed.

As the operating range of the power swing supplement depends on the distance protection settings, the power swing tripping can also only be active, when the distance protection has been activated.

6.3.2 Applying the Function Parameter Settings

The power swing supplement is only active if it has been set to **`Power Swing`** = **`Enabled`** (address **`0120`**) during the configuration.

The four possible programs may be set in address **2002 P/S Op. mode**, as described in Sub-section 6.3.1: ***All zones block*** or ***Z1/Z1B block*** or ***Z2 to Z5 block*** or ***Z1,Z1B,Z2 block***.

Additionally the tripping function for unstable oscillations (out-of-step condition, loss of system synchronism) can be set with parameter ***PowerSwing trip*** (address **2006**), which should be set to ***Yes*** if required (presetting is ***No***). In the event of power swing tripping it is sensible to set **P/S Op. mode** = ***All zones block*** for the power swing blocking, to avoid premature tripping by the distance protection.

6.3.3 Settings

Addr.	Setting Title	Function	Setting Options	Default Setting
2002	P/S Op. mode	Power Swing	all zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1,Z1B,Z2 blocked	all zones blocked
2006	PowerSwing trip	Power Swing	NO YES	NO

6.3.4 Information Overview

F.No.	Alarm	Comments
4164	Power Swing	Power Swing detected
4166	Pow. Swing TRIP	Power Swing TRIP command
4167	Pow. Swing L1	Power Swing detected in L1
4168	Pow. Swing L2	Power Swing detected in L2
4169	Pow. Swing L3	Power Swing detected in L3

6.4 Teleprotection Schemes with Distance Protection

Purpose of Teleprotection

Short-circuits which occur on the protected line, beyond the first distance zone, can only be cleared selectively by the distance protection after a delay time. On line sections that are shorter than the smallest sensible distance setting, short-circuits can also not be selectively cleared instantaneously.

To achieve non-delayed *and* selective tripping on 100 % of the line length for all faults by the distance protection, the distance protection can exchange and process information from the opposite line end by means of signal transmission systems. For this purpose, the device has signal send outputs and receive inputs as well as associated logic functions.

Teleprotection Schemes

The distance protection is set with normal zone grading characteristic. An additional fast overreaching zone Z1B is available for teleprotection schemes. Signal transmission and trip release methods depend on the teleprotection scheme. At least one reverse looking distance zone may be required for some teleprotection schemes. It is recommended to use zone Z3 for this purpose.

The 7SA6 permits:

- PUTT (Pickup)
- Permissive Underreach Transfer Trip with Zone Acceleration Z1B (**PUTT**)
- Direct Transfer Trip without Pickup

In the comparison scheme of the distance protection an accelerated overreach zone applies from the outset. It can only trip if a fault is also recognized at the other line end in an overreach zone. A release signal or a blocking signal is transmitted. The following are available:

Release scheme:

- Permissive Overreach Transfer Trip (**POTT**)
- Directional Comparison Pickup
- Unblocking with Overreach Zone Z1B

Blocking scheme:

- Blocking with Overreach Zone Z1B

Schemes via pilot wire:

- Pilot Wire Comparison
- Reverse Interlocking

As the distance zones Z1 ... Z5 (without Z1B) function independently, instantaneous tripping in Z1 without a release signal is always possible. If instantaneous tripping in Z1 is not required (e.g. in very short lines), then Z1 must be delayed with T1.

Signal Transmission Channels

The pilot wire comparison, that is exclusively applied to short tie lines, enables the user to operate a pilot wire pair (pilot wires or control wires) with direct current to guarantee the exchange of information between the line ends. Also the reverse interlocking operates with DC control signals.

For the other schemes at least one communication channel in each direction is required. For example, fibre optic connections or voice frequency modulated high frequency channels via pilot cables, power line carrier or microwave radio links can be used for this purpose.

The 7SA6 also makes provision for the transmission of phase segregated signals. For this purpose, three transmission channels are required in each direction. The additional expense for the signal transmission is weighed up by the advantage that dependable single-pole automatic reclosure can be carried out even when two single-phase faults occur on different lines in the system.

The signal transmission schemes are also suited to three terminal lines (teed feeders). In this case, signal transmission channels are required from each of the three ends to the each of the others in both directions. Phase segregated signal transmission is however not provided for three terminal line applications.

During disturbances in the receiver or on the transmission path, the teleprotection supplement may be blocked via a binary input, without affecting the normal time graded distance protection. The measuring reach control (enable zone Z1B) can be obtained via the binary input "`>Enable ARzones`" (see also Figure 6-38 above) from an external reclosure device or from the internal automatic reclose function.

6.4.1 Method of Operation

Switching On and Off

The teleprotection function can be switched on and off by means of the parameter **`2101 FCT Telep. E/F`**, or via the system interface (if available) and via binary input (if this is allocated). The switched state is saved internally (refer to Figure 6-41) and secured against loss of auxiliary supply. It is only possible to switch on from the source where previously it had been switched off from. To be active, it is necessary that the function is switched on from all three switching sources.

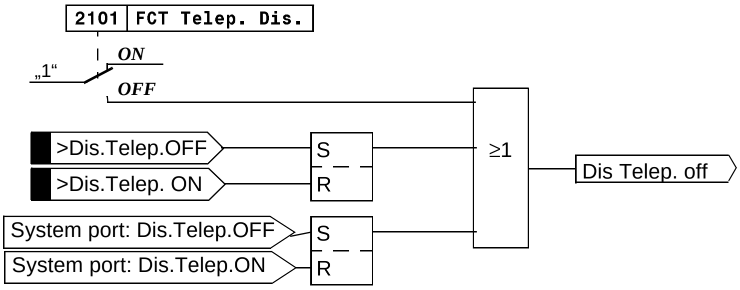


Figure 6-41 Switching on and off of the teleprotection

6.4.1.1 Permissive Underreach Transfer Trip with Pick-up (PUTT)

Principle

Figure 6-42 shows the operation scheme of the permissive underreach transfer trip scheme. In the case of a fault inside zone Z1, the transfer trip signal is sent to the opposite line end. The signal received at that end causes the tripping if the corresponding protection function picked up. The transmitted signal may be prolonged by T_S (settable in address 2103 **Send Prolong.**), to compensate for possible differences in the pick-up times at the two line ends. The distance protection is set in such a way that the first zone reaches up to approximately 85 % of the line length. In three-end lines Z1 is also set to approx. 85 % of the shorter line section, at least, however, up to the T-point.

The overreach zone Z1B is not relevant for this signal transmission scheme, but it can be controlled by the automatic reclosure (see also Subsection 6.12.1).

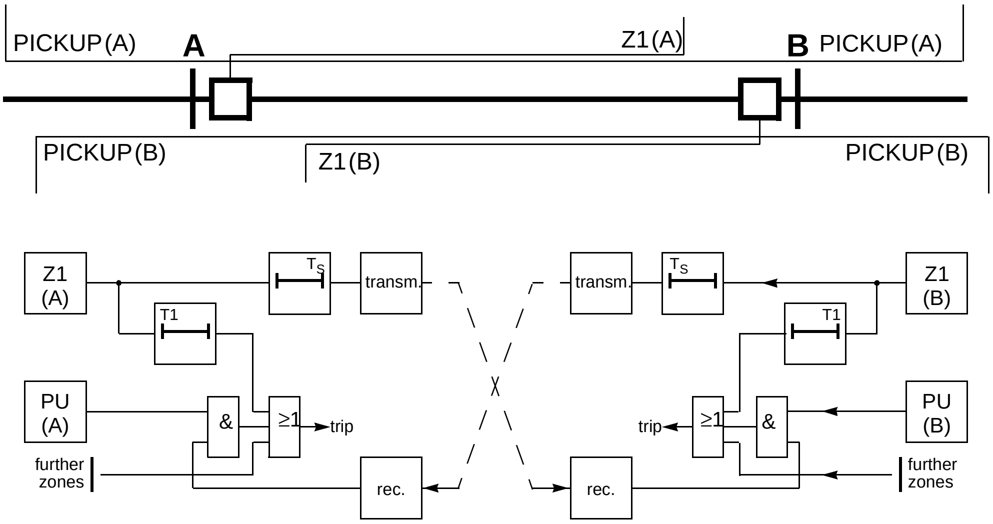


Figure 6-42 Operation scheme of the permissive underreach transfer trip method via pickup

Sequence

Figure 6-43 shows the logic diagram of the permissive underreach transfer trip scheme for one line end.

The permissive transfer trip should only trip for faults in the ***Forward*** direction. Accordingly, the first zone Z1of the distance protection must definitely be set to ***Forward*** in address **1301 Op. mode Z1**, refer also to Subsection 6.2.4.2 under the margin heading “Independent Zones Z1 up to Z5”.

On two terminal lines, the signal transmission may be done phase segregated. On three end lines, the transmit signal is sent to both opposite line ends. The receive signals are then combined with an *OR* logic function. By means of the parameter **Line Config.** (address **2102**) the device is informed whether it has one or two opposite ends.

If at one line end there is weak or zero infeed, so that the distance protection does not pick up, the circuit breaker can still be tripped. This “weak-infeed tripping” is referred to in Section 6.7.

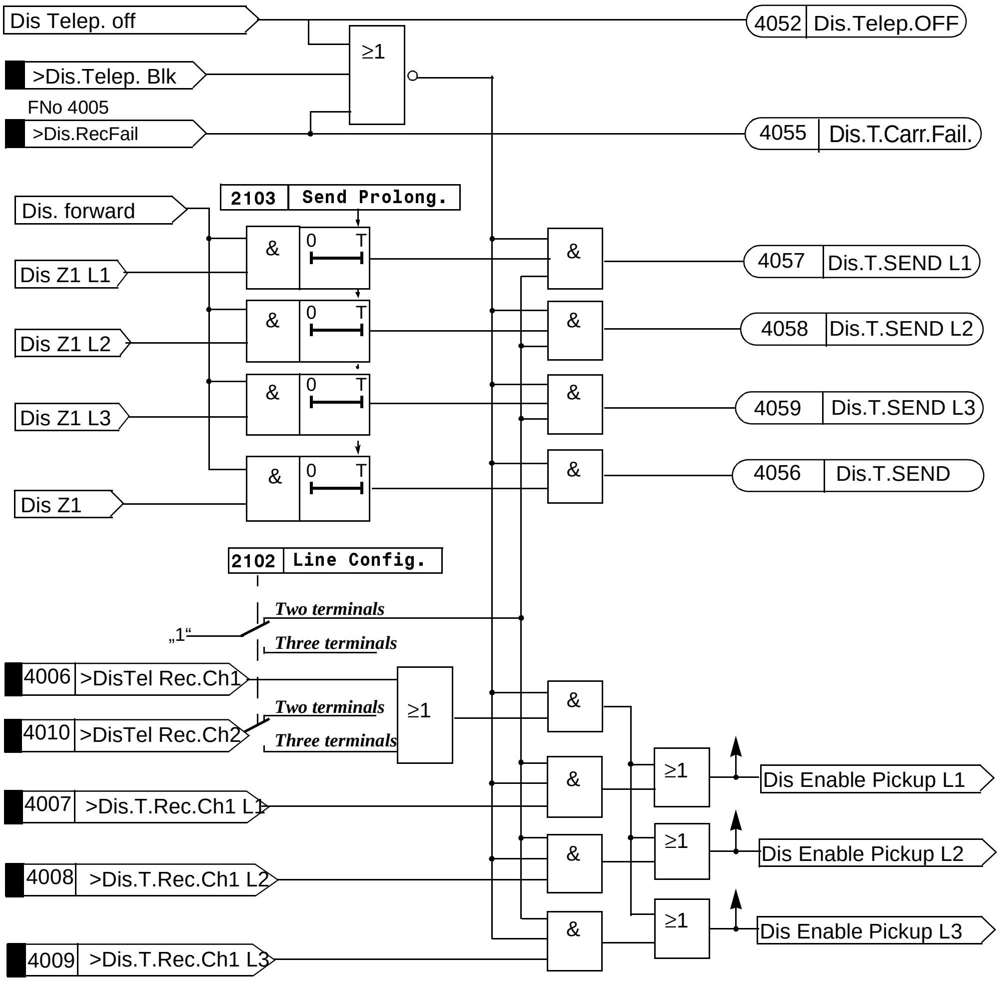


Figure 6-43 Logic diagram of the permissive underreach transfer trip (PUTT) scheme with pick-up (one line end)

6.4.1.2 Permissive Underreach Transfer Trip with Zone Acceleration Z1B (PUTT)

Principle

Figure 6-44 shows the operation scheme for this permissive underreach transfer trip scheme with zone acceleration Z1B. In the case of a fault inside zone Z1, the transfer trip signal is sent to the opposite line end. The signal received there causes tripping if the fault is detected in the pre-set direction inside the zone Z1B. The transmitted signal may be prolonged by T_S (settable in address **`2103 Send Prolong.`**), to compensate for possible differences in the pick-up times at the two line ends. The distance protection is set such that the first zone reaches up to approximately 85 % of the line length, the overreaching zone however is set to reach beyond the opposite substation (approximately 120 % of the line length). In the case of three terminal lines, Z1 is also set to approximately 85 % of the shortest line section but at least beyond the tee off point. Z1B must securely reach beyond the longer line section, even when additional infeed is possible via the tee point.

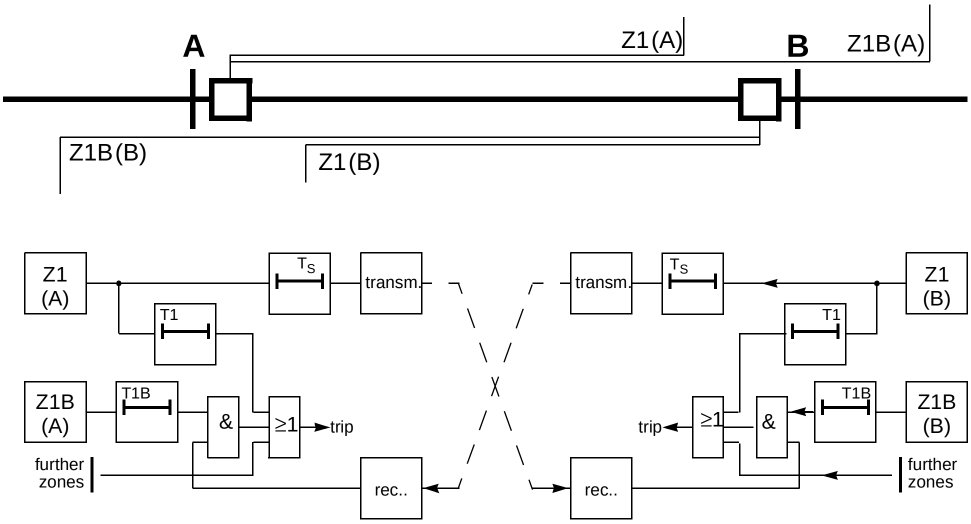


Figure 6-44 Operation scheme of the permissive underreach transfer trip method via Z1B

Sequence

Figure 6-45 shows the logic diagram of the permissive underreach transfer trip scheme for one line end.

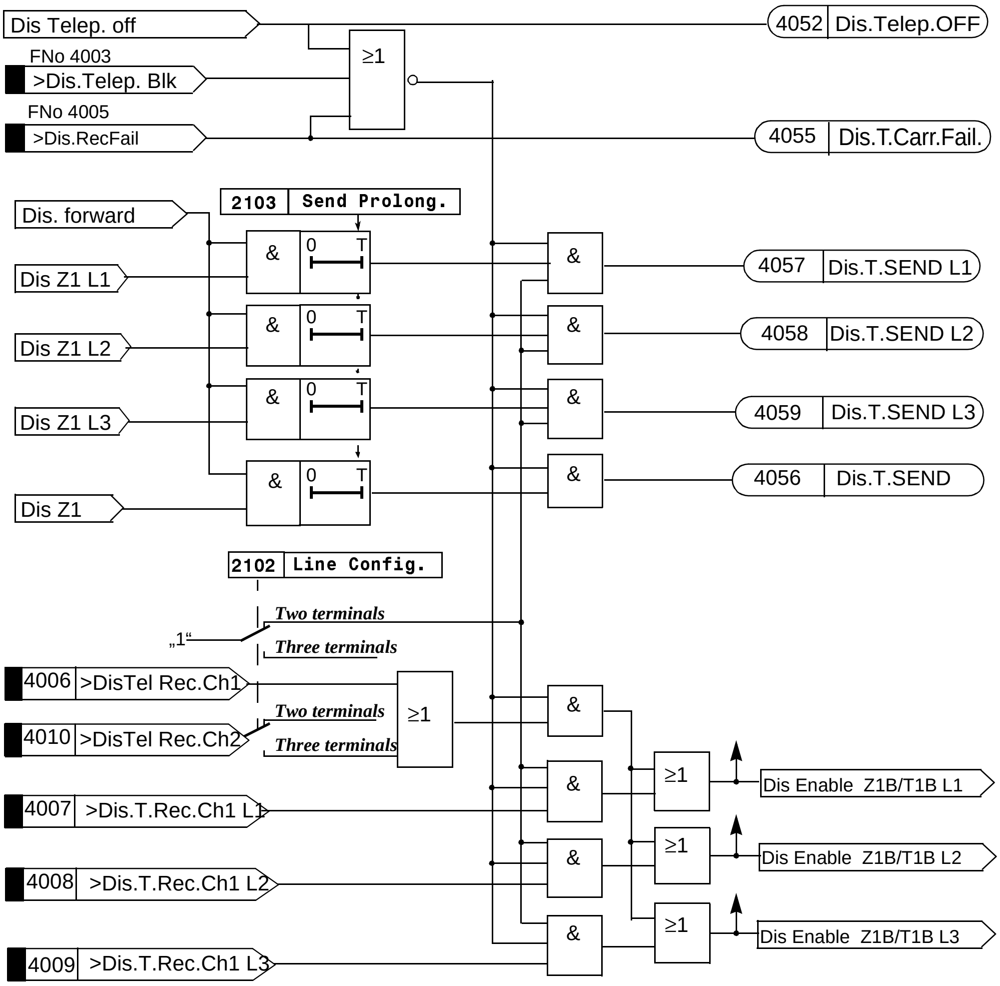


Figure 6-45 Logic diagram of the permissive underreach transfer trip (PUTT) scheme using Z1B (one line end)

The permissive transfer trip only functions for faults in the forward direction. Accordingly, the first zone Z1 and the overreaching zone Z1B of the distance protection must definitely be set to ***`Forward`***: address **`1301 Op. mode Z1`** and **`1351 Op. mode Z1B`**, refer also to Sub-section 6.2.4.2 under the margin heading “Independent Zones Z1 up to Z5” and “Controlled Zone Z1B”.

On two terminal lines, the signal transmission may be done phase segregated. On three terminal lines, the transmit signal is sent to both opposite line ends. The receive signals are then combined with an *OR* logic function. By means of the parameter **`Line Config.`** (address **`2102`**) the device is informed whether it has one or two opposite ends.

During disturbance of the signal transmission path, the overreaching zone Z1B may be activated by an automatic reclosure via the binary input “`>Enable ARzones`” and address `1357` “`1st AR -> Z1B`” set to “Yes” (refer also to Figure 6-38 bottom).

If at one line end there is weak or zero infeed, so that the distance protection does not pick up, the circuit breaker can still be tripped. This “weak-infeed tripping” is referred to in Section 6.7.

6.4.1.3 Direct Underreach Transfer Trip

Principle

As is the case with permissive transfer trip via pick-up or zone acceleration, a fault in the first zone Z1 is transmitted to the opposite line end by means of a transfer trip signal. The signal received there causes a trip without further queries after a short security margin T_V (settable under address **`2202 Trip Time DELAY`**) (Figure 6-46). The transmit signal can be prolonged by T_S (settable under address **`2103 Send Prolong.`**), to compensate for possible differences in the pick-up time at the two line ends. The distance protection is set such that the first zone reaches up to approximately 80 % of the line length. On three terminal lines Z1 is also set to approximately 80 % of the shorter line section, but at least beyond the tee off point. The overreaching zone Z1B is not required here. It may however be activated by internal automatic reclosure or external criteria via the binary input “`>Enable ARzones`” (refer also to Figure 6-38 bottom).

The advantage compared to the other permissive underreach transfer trip schemes lies in the fact that both line ends are tripped without the necessity for any further measures, even if one line end has no infeed. There is however no further supervision of the trip signal at the receiving end.

The direct underreach transfer trip application is not provided by its own selectable teleprotection scheme setting, but implemented by setting the teleprotection supplement to operate in one of the permissive underreach transfer trip schemes (address **`0121 Teleprot. Dist.`** = ***`PUTT`*** or ***`PUTT with pick-up`***), and using the binary inputs for direct external trip at the receiving end. Accordingly, the transmit circuit in Subsection 6.4.1.1 (Figure 6-43) or 6.4.1.2 (Figure 6-45) applies. For the receive circuit the logic of the “external trip” as described in Section 6.8 applies.

On two terminal lines, the transmission can be phase segregated. On three terminal lines the transmit signal is sent to both opposite line ends. The receive signals are then combined with a logical *OR* function.

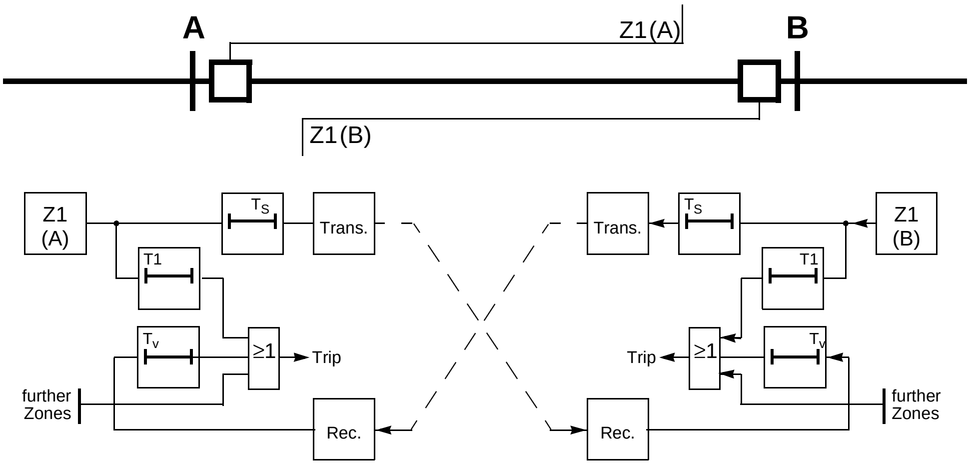


Figure 6-46 Operation scheme of the direct underreach transfer trip method

6.4.1.4 Permissive Overreach Transfer Trip (POTT)

Principle

The permissive overreach transfer mode uses a permissive release principle. The overreaching zone Z1B set beyond the opposite station is decisive. This mode can also be used on extremely short lines where a setting of 85 % of line length for zone Z1 is not possible and accordingly selective non-delayed tripping could not be achieved. In this case however zone Z1 must be delayed by T1, to avoid non selective tripping by zone Z1.

Figure 6-47 shows the operation scheme.

If the distance protection recognizes a fault inside the overreaching zone Z1B, it initially sends a release signal to the opposite line end. If a release signal from the opposite line end is received, a trip signal is initiated via the tripping relay. A prerequisite for fast tripping is therefore that the fault is recognized inside Z1B in the forward direction at both line ends. The distance protection is set such that the overreaching zone Z1B reaches beyond the opposite station (approximately 120% of line length). On three terminal lines, Z1B must be set to reliably reach beyond the longer line section even with intermediate infeed via the tee point. The first zone is set in accordance with the normal time grading, i.e. approximately 85 % of the line length, on three terminal lines, at least beyond the tee point.

The transmit signal can be prolonged by T_S (settable under address **2103 Send Prolong.**). This extension of the transmit signal is only active when the protection has already issued a trip command. This ensures the release of the opposite line end, even when the short-circuit has been locally cleared very fast by the independent zone Z1.

For all zones, except for Z1B, the tripping takes place without a release signal from the opposite line end. This allows the protection to operate with the normal grading characteristic independent of the signal transmission.

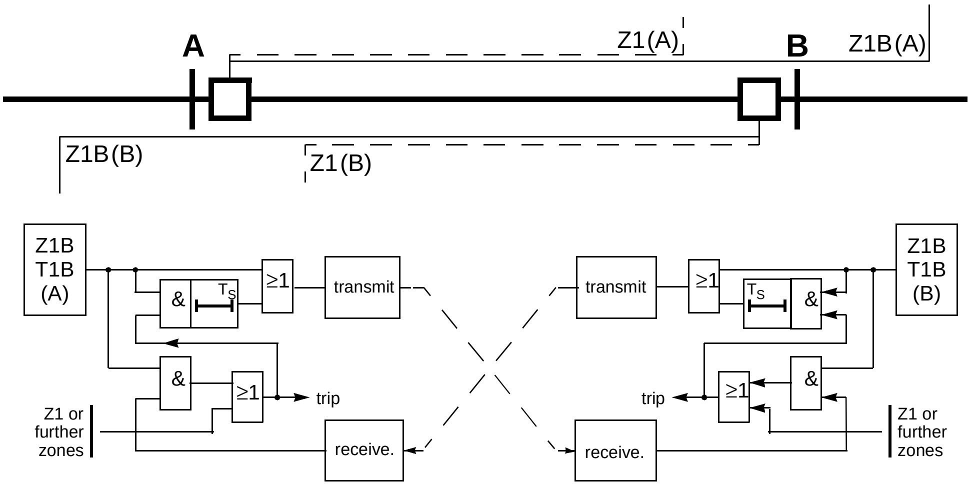


Figure 6-47 Operation scheme of the permissive overreach transfer trip method

Sequence

Figure 6-48 shows the logic diagram of the signal comparison scheme for one line end.

The permissive overreach transfer trip only functions for faults in the forward direction. Accordingly, the overreaching zone Z1B of the distance protection must definitely be set to ***Forward***: address **1351 Op. mode Z1B**, refer also to Sub-section 6.2.4.2 under margin heading “Controlled Zone Z1B”.

On lines with two ends the signal transmission may be phase segregated. Send and receive circuits in this case are built up for each phase. On three terminal lines the send signal is transmitted to both opposite ends. The receive signals are then combined with the logical *AND* function, as all three line ends must transmit during an internal fault. Via the setting **Line Config.** (address **2102**) the device is informed as to whether it has one or two opposite line ends.

In the case of faults in the transmission path, the overreaching zone Z1B can be activated by an automatic reclose device, via the binary input “`>Enable ARzones`” and address **1357** “1st AR -> Z1B” set to “Yes” (refer to Figure 6-38 bottom).

The influence of signals resulting from transients during clearance of external faults or from direction reversal during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking” (refer to Sub-section 6.4.1.10).

On feeders with single-sided infeed, the line end with no infeed cannot generate a release signal, as no fault detection occurs there. To achieve tripping by the permissive overreach transfer scheme even in this case, the device contains a special function. This “Weak Infeed Function” (echo function) is referred to in Sub-section 6.4.1.11. It is activated when a signal is received from the opposite line end — in the case of three terminal lines from at least one of the opposite line ends — without the device having detected a fault.

The circuit breaker can also be tripped at the line end that has only weak or no infeed. This “Weak-Infeed Tripping” is referred to in Section 6.7.

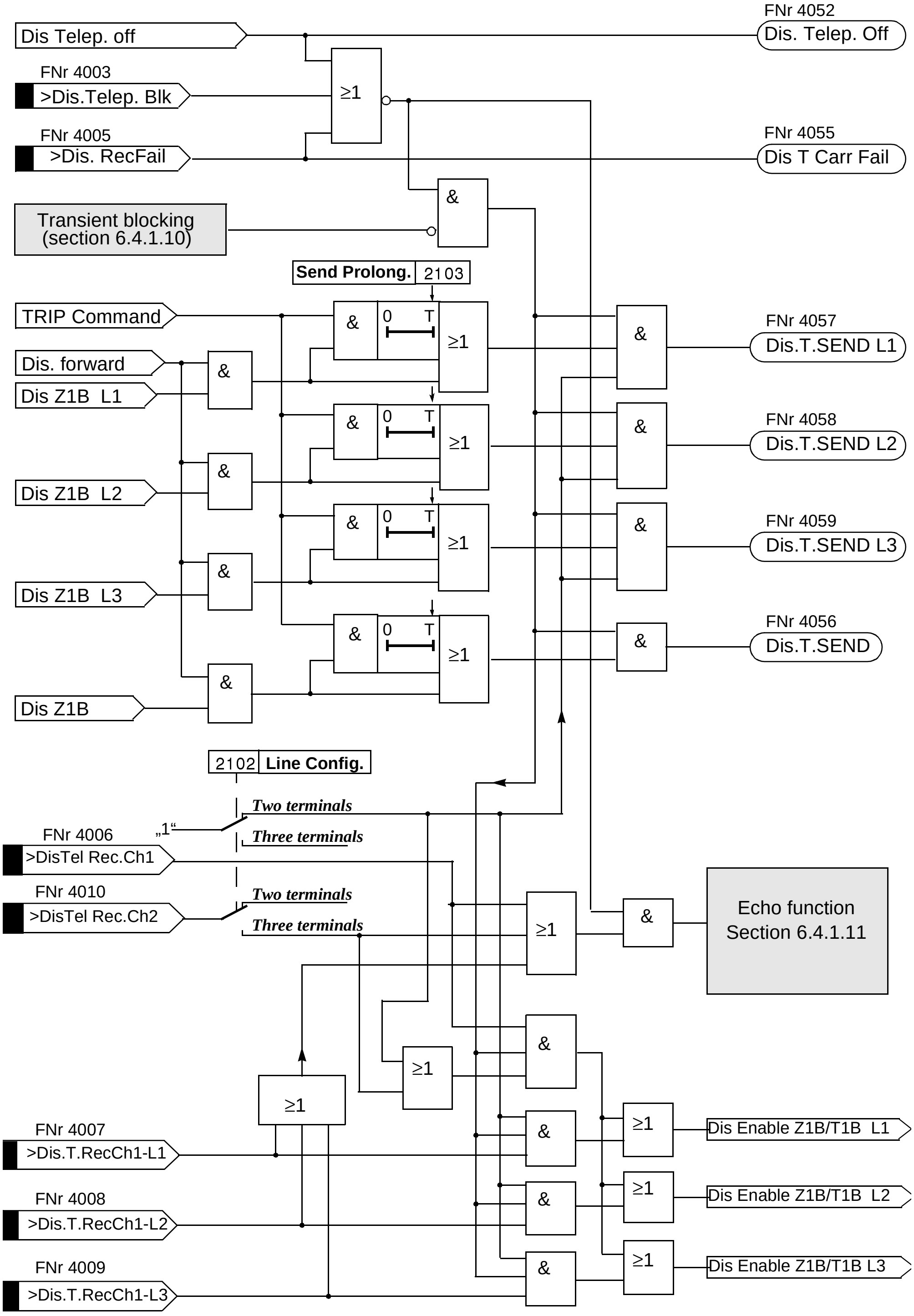


Figure 6-48 Logic diagram of the permissive overreach transfer trip (POTT) scheme (one line end)

6.4.1.5 Directional Comparison Pickup

Principle

The directional comparison pickup uses a permissive release principle.

Figure 6-49 shows the operation scheme.

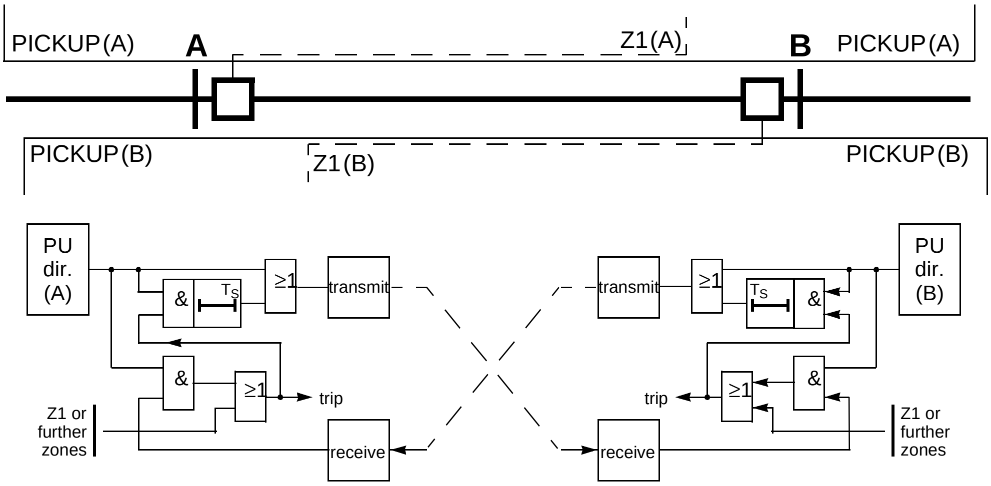


Figure 6-49 Operation scheme of the directional comparison pickup

If the distance protection detects a fault in line direction, it initially sends a release signal to the opposite line end. If a release signal is also received from the opposite line end, a trip signal is transmitted to the trip relay. This is only the case if the opposite line end also detects a fault in line direction. A prerequisite for fast tripping is therefore that the fault is recognized in *both* line ends as well as in line direction. The distance stages operate independent from the directional comparison pickup.

The send signal can be prolonged by T_S (settable under address **`2103 Send Prolong.`**). The prolongation of the send signal is only active when the protection has already issued a trip command. This ensures the release from the opposite line end, even when the fault was cleared locally very fast by the independent zone Z1.

Sequence

Figure 6-50 shows the logic diagram of the signal comparison scheme for one line end.

On lines with two ends, the signal transmission may be phase segregated. Send and receive circuits in this case are built up for each phase. On three terminal lines the send signal is transmitted to both opposite ends. The receive signals are then combined with the logical *AND* function, as all three line ends must transmit during an internal fault. Via the setting **`Line Config.`** (address **`2102`**) the device is informed as to whether it has one or two opposite line ends.

The influence of fault messages resulting from transients during clearance of external faults or from direction reversal during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking” (refer to Subsubsection 6.4.1.10).

On feeders with single-end infeed, the line end with no infeed cannot generate a release signal, as no fault detection occurs there. To achieve tripping by the permissive overreach transfer scheme even in this case, the device contains a special function. This “Weak Infeed Function” (echo function) is referred to in Sub-section 6.4.1.11. It is activated when a signal is received from the opposite line end — in the case of three terminal lines from at least one of the opposite line ends — without the device having detected a fault.

The circuit breaker can also be tripped at the line end that has only weak or no infeed. This “Weak-Infeed Tripping” is referred to in Section 6.7.

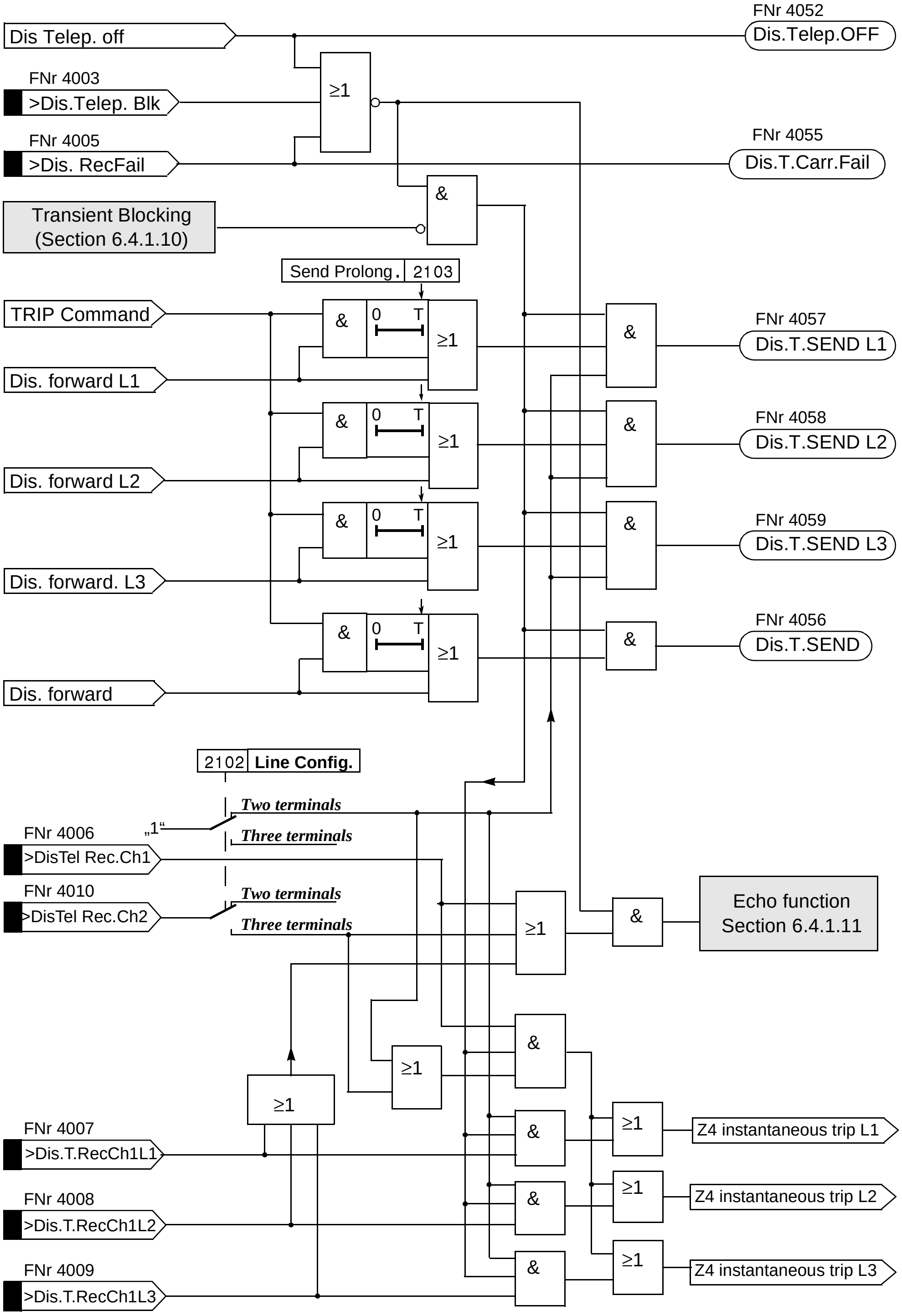


Figure 6-50 Logic diagram of the directional comparison pick-up scheme (one line end)

6.4.1.6 Unblocking with Z1B

Principle

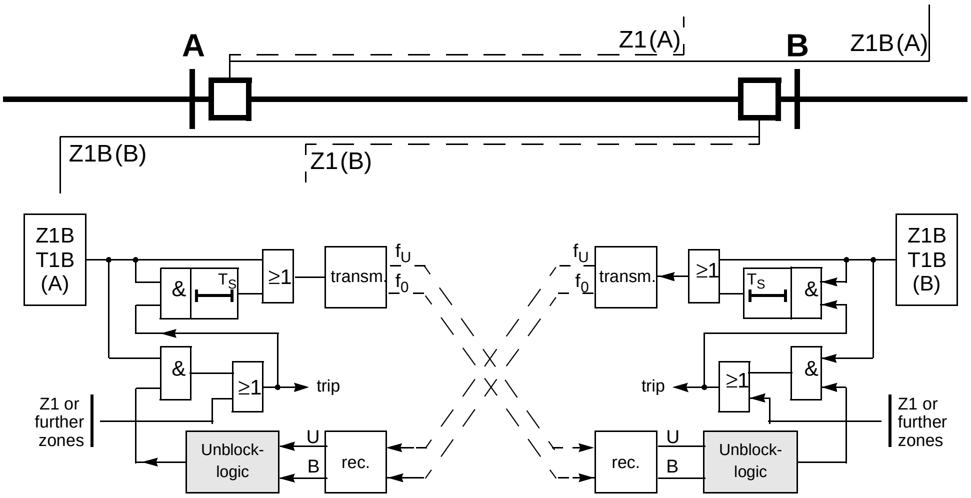
The unblocking method uses a permissive release principle. It differs from the permissive overreach transfer scheme (Sub-section 6.4.1.4) in that tripping is possible also when no release signal is received from the opposite line end. It is accordingly mainly used on long lines, if the signal is transmitted via the protected line with power line carrier (PLC), and the attenuation of the transmitted signals at the fault location can be so severe that the reception at the other line end cannot be guaranteed in all cases. Here, a special unblocking logic takes effect.

Figure 6-51 shows the operation scheme.

Two signal frequencies which are keyed by the transmit output of the 7SA6 are required for the transmission. If the transmission device has a channel monitoring, then the monitoring frequency f_0 is keyed over to the working frequency f_U (unblocking frequency) f_U. When the protection recognizes a fault inside the overreaching zone Z1B, it initiates the transmission of the unblock frequency f_U. During the quiescent state or during a fault outside Z1B, or in the reverse direction, the monitoring frequency f_0 is transmitted.

If the unblock frequency f_U is faultlessly received from the opposite end, a release signal is routed to the trip logic. Accordingly, it is a prerequisite for fast tripping, that the fault is recognized inside Z1B in the forward direction at both line ends. The distance protection is set such that the overreaching zone Z1B reaches beyond the opposite station (approximately 120 % of line length). On three terminal lines Z1B must be set to definitely reach beyond the longer line section even when intermediate infeed via the tee point is present. The first zone is set in accordance with the usual grading scheme, i.e. approximately 80 % of the line length; on three terminal lines at least beyond the tee point.

The transmit signal can be prolonged by T_S (settable under address **2103 Send Prolong.**). The extension of the transmit signal is only effective when the protection has already issued a trip command. This ensures release of the opposite line end even when the short circuit has been switched off rapidly by the independent zone Z1.



f_0 – Off frequency (monitoring frequency)
f_U – Unblock frequency (send frequency)

U – Unblocking signal
B – Blocking signal

Figure 6-51 Operation scheme of the unblocking method with Z1B

For all zones except Z1B, tripping results without release from the opposite line end, allowing the protection to function with the usual grading characteristic independent of the signal transmission.

Sequence

Figure 6-52 shows the logic diagram of the unblock scheme for one line end.

The unblock scheme only functions for faults in the forward direction. Accordingly, the overreaching zone Z1B of the distance protection must definitely be set to ***Forward***: address **1351 Op. mode Z1B**, refer also to Subsubsection 6.2.4.2 under margin heading “Controlled Zone Z1B”.

On two terminal lines, the signal transmission may be phase segregated. Send and receive circuits in this case are built up for each phase. On three terminal lines the send signal is transmitted to both opposite ends. The receive signals are then combined with the logical *AND* function, as all three line ends must transmit during an internal fault. Via the setting **Line Config.** (address **2102**) the device is informed as to whether it has one or two opposite line ends.

An unblock logic is inserted before the receive logic, which latter in essence corresponds to that of the permissive overreach transfer scheme. The unblock logic is shown in Figure 6-53. If an interference free unblock signal is received, a receive signal e.g. “**>Dis.T.UB ub 1**”, appears and the blocking signal e.g. “**>Dis.T.UB bl 1**” disappears. The internal signal “Unblock 1” is passed on to the receive logic, where it initiates the release of the overreaching zone Z1B of the distance protection (when all remaining conditions have been fulfilled).

If the transmitted signal is not received at the other line end because the short-circuit on the line causes too severe an attenuation or reflection of the signal, neither the unblock signal e.g. “**>Dis.T.UB ub 1**”, nor the block signal “**>Dis.T.UB bl 1**” is received at the receiving end. In this case, the release ““>Unblock 1” is issued after a security delay time of 20 ms and passed onto the receive logic. This release is however removed after a further 100 ms via the timer stage 100/100 ms. When the transmission is functional again, one of the two receive signals must appear again, either “**>Dis.T.UB ub 1**” or “**>Dis.T.UB bl 1**”; after a further 100 ms (drop-off delay of the timer stage 100/100 ms) the quiescent state is reached again i.e. the direct release path to the signal “Unblock L1” and thereby the usual release is possible.

If none of the signals is received for a period of more than 10 s the alarm (address 2107) “**Dis.T.Carr.Fail**” (F.No. 4055) is generated.

In the case of faults in the transmission path, the overreaching zone Z1B can be activated by an automatic reclose device, via the binary input “>Enable ARzones” and address **1357** “**1st AR -> Z1B**” set to “Yes” (refer to Figure 6-38 bottom).

The occurrence of erroneous signals resulting from transients during clearance of external faults or from direction reversal resulting during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking” (refer to Sub-section 6.4.1.10).

On feeders with single-sided infeed, the line end with no infeed cannot generate a release signal, as no fault detection occurs there. To achieve tripping by the permissive overreach transfer scheme even in this case, the device contains a special function. This “Weak Infeed Function” (echo function) is referred to in Subsubsection 6.4.1.11. It is activated when a signal is received from the opposite line end — in the case of three terminal lines from at least one of the opposite line ends — without the device having detected a fault.

The circuit breaker can also be tripped at the line end that has only weak or no infeed. This “Weak-Infeed Tripping” is referred to in Section 6.7.

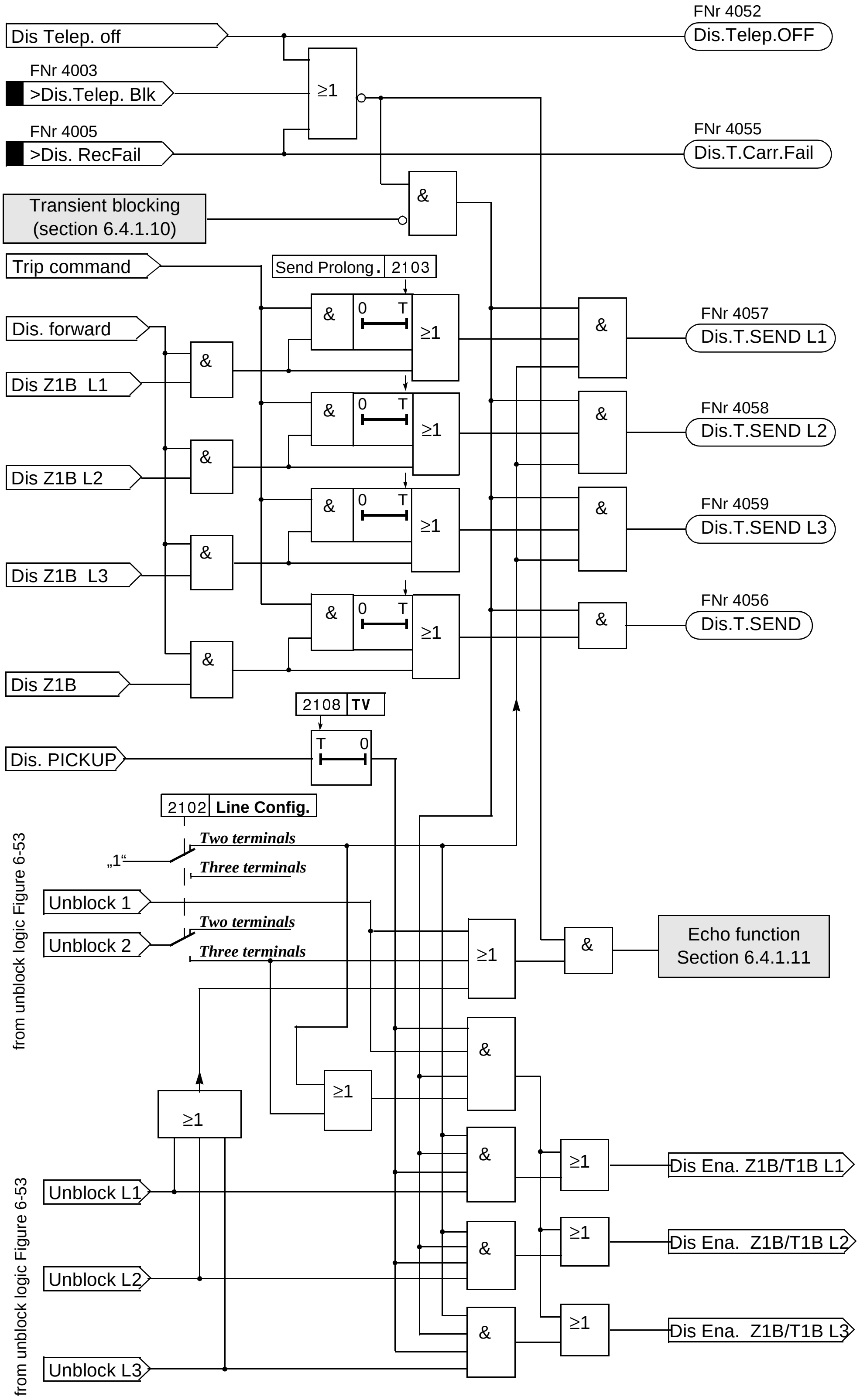


Figure 6-52 Logic diagram of the unblock scheme with Z1B (one line end)

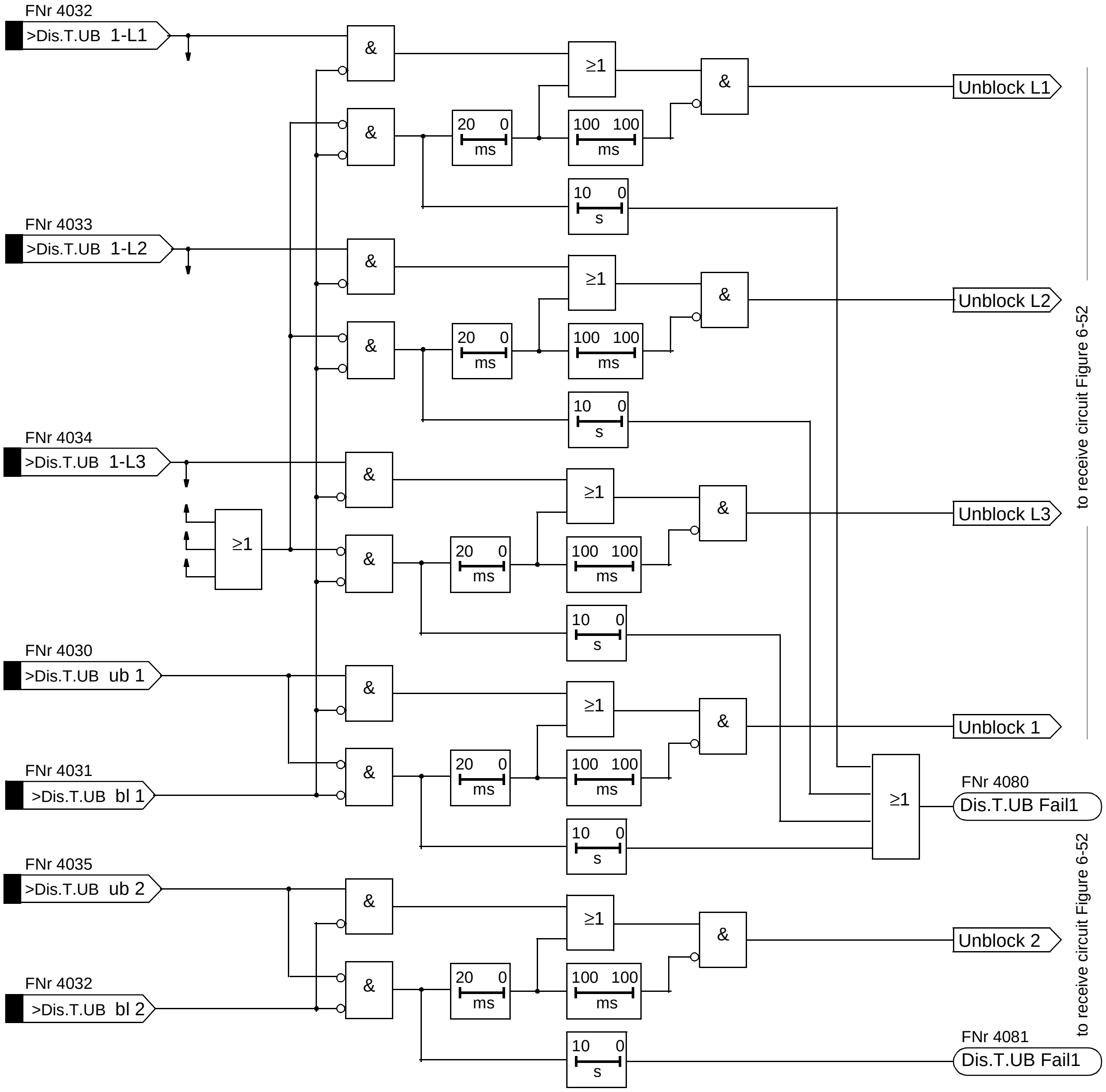


Figure 6-53 Unblock–logic

6.4.1.7 Blocking scheme

Principle

The blocking scheme uses the transmission channel to send a block signal from one line end to the other. The signal is sent as soon as the protection function has detected a fault in reverse direction, optionally also directly after fault inception (jump detector via the dashed line in Figure 6-54). It is stopped, as soon as the distance protection detects a fault in the forward direction, alternatively the signal is only sent when the distance protection detects the fault in the reverse direction. The signal will be maintained if the fault is in reverse direction. If the signal is sent with jump detection (i.e. `4060` **`DisJumpBlocking`** routed in parallel with `4056 - 4059`) only a short delay to allow for signal transmission is required before Z1b trips. A trip can be achieved with this scheme even if no signal reaches the opposite end. It is therefore mainly used on long lines, when the signal must be transmitted via the protected line with power line carrier (PLC), and the attenuation of the transmitted signal could be so severe at the fault location, that reception at the other line end cannot necessarily be guaranteed.

Figure 6-54 shows the operation scheme.

Faults inside the overreaching zone Z1B, which is set to approximately 120% of the line length, will initiate tripping if a blocking signal is not received from the other line end. On three terminal lines, Z1B must be set to reliably reach beyond the longer line section, even if there is an additional infeed via the tee point. Due to possible differences in the pick-up times of the devices at the two line ends, and because of the signal transmission time, the tripping must in this case be somewhat delayed by means of T_V (address **2108**, **Release Delay**).

Similarly, to avoid race conditions of the signals, a transmit signal can be prolonged by the settable time T_S once it has been initiated.

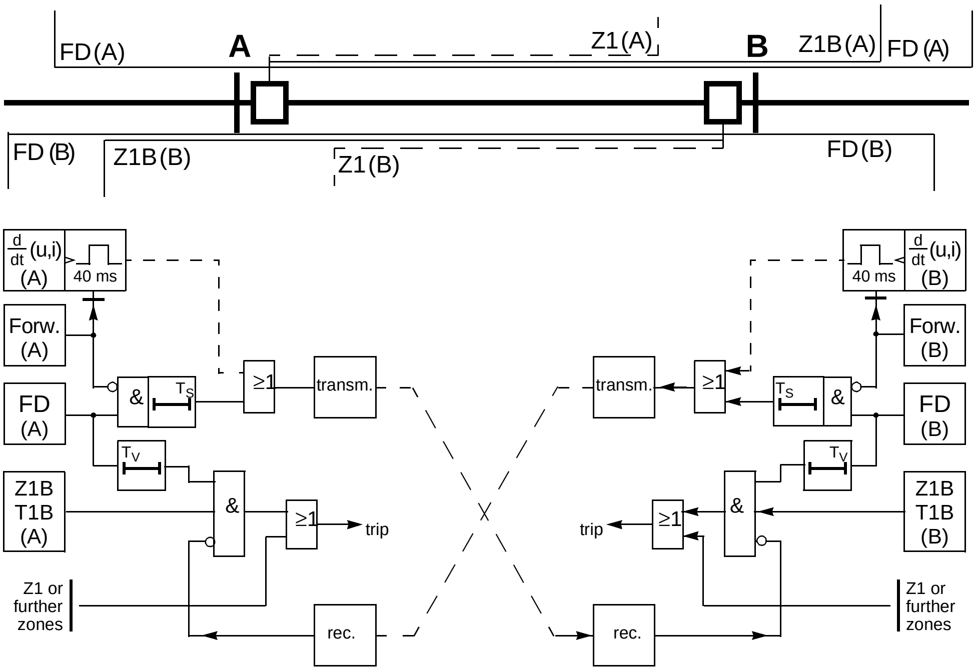


Figure 6-54 Operation scheme of the blocking method

Sequence

Figure 6-55 shows the logic diagram of the blocking scheme for one line end.

The relevant distance zone for this scheme is the overreach zone Z1B. Its reach direction must therefore be set to ***Forward***: address **1351 Op. mode Z1B**, refer also to Sub-section 6.2.4.2 under margin heading “Controlled Zone Z1B”.

On lines with two ends, the signal transmission may be phase segregated. Send and receive circuits in this case are built up for each phase. On three terminal lines the send signal is transmitted to both opposite ends. The receive signal are then combined with the logical *OR* function, as in the case of an internal fault, no blocking signal must be received from any line end. Via the setting **Line Config.** (address **2102**)
the device is informed as to whether it has one or two opposite line ends.

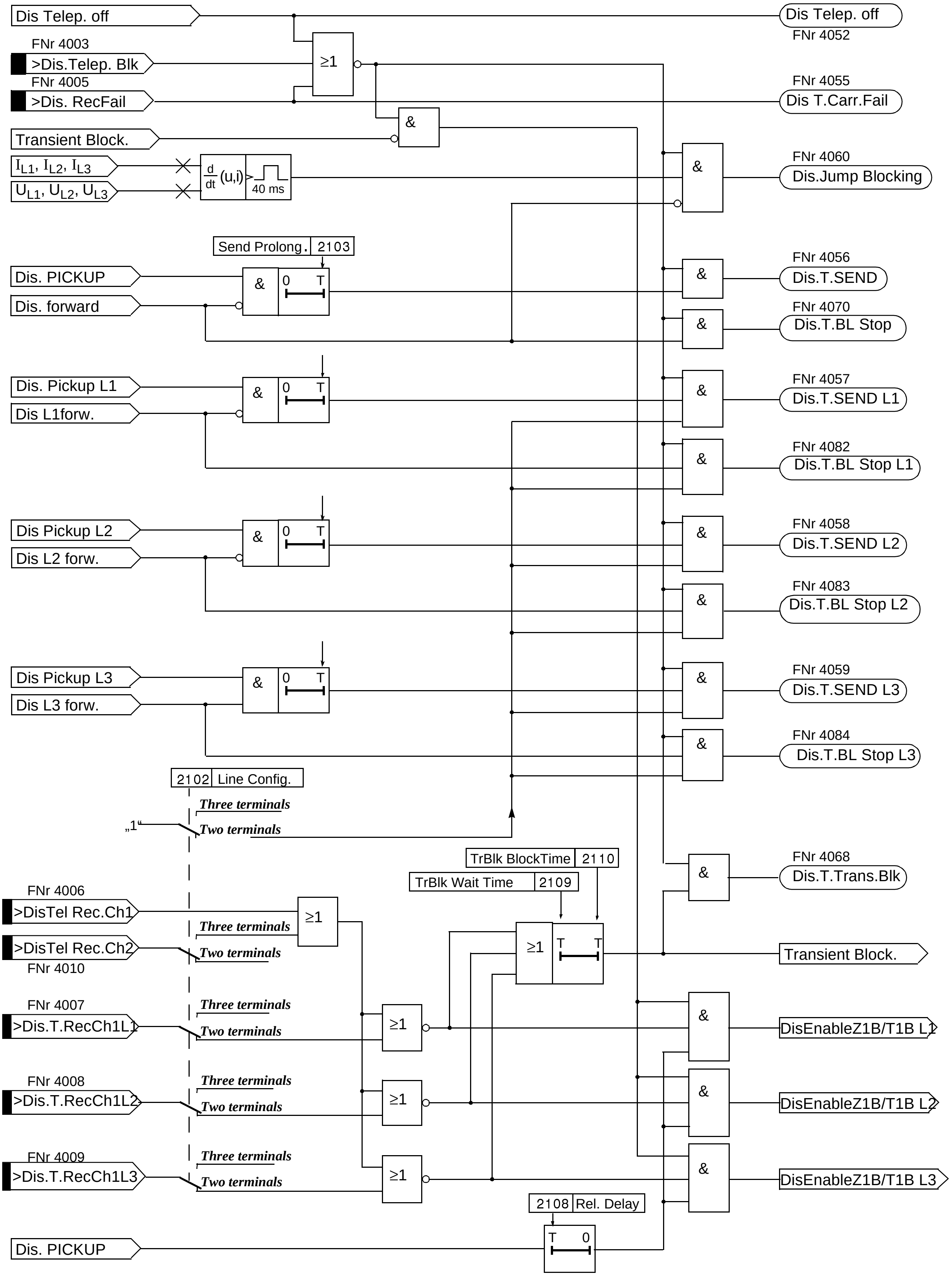


Figure 6-55 Logic diagram of the blocking scheme (one line end)

As soon as the distance protection has detected a fault in reverse direction, the blocking signal is sent (e.g. “`Dis.T.SEND`”, FNo `4056`). The send signal can be prolonged in address `2103`. If the fault is in forward direction, the blocking signal is stopped (e.g. „`Dis.T.BL STOP`“, FNo `4070`). To achieve a very fast-reacting blocking scheme include the output signal of the jump detector for the send signal. Therefore allocate the output “`DisJumpBlocking`” (FNo `4060`) also to the output relay to the signal transmitting equipment during configuration. Since this jump signal usually appears when a measured value suddenly changes, the latter should only be applied, if guaranteed that the transmission channel has a fast response to the reset of the send signal.

If there is a disturbance in the signal transmission path the overreaching zone can be blocked via a binary input. The distance protection operates with the usual time grading characteristic (non delayed trip in Z1). The overreaching zone Z1B can then be activated by an automatic reclose function via the binary input “**`>Enable ARzones`**” and address **`1357` “`1st AR -> Z1B`”** set to “Yes” (refer also to Figure 6-38 bottom).

The influence of signals resulting from transients during clearance of external faults or from direction reversal during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking”. It prolongs the blocking signal by the transient blocking time **`TrBlk BlockTime`** (address **`2110`**), if it has been present for the minimum duration equal to the waiting time **`TrBlk Wait Time`** (address **`2109`**).

It lies in the nature of the blocking scheme that single end fed short circuits can also be tripped rapidly without any special measures, as the non feeding end cannot generate a blocking signal.

6.4.1.8 Pilot Wire Comparison

In the pilot wire comparison the overreaching zone Z1B functions as instantaneous zone at both ends of the protected line. Zone Z1B is set to reach beyond the next station. The pilot wire comparison avoids non-selective tripping.

The information exchange between both line ends is carried out via a closed quiescent current loop (Figure 6-56) that is fed by a substation battery. One NC contact must be allocated for each signal output, the receiving input must be configured to “low-active”. Alternatively two auxiliary relay combinations (e.g. 7PA5210–2A) can be used for inverting the contact.

In the quiescent state the pilot wires carry direct current that, at the same time, monitors the healthy state of the connection.

If the distance protection picks up, the following signal appears: “`Dis.T.SEND`”. The NC contact is opened and the pilot wire loop is initially interrupted. A trip by Z1B is blocked via the receiving input „`>DisTel Rec.Ch1`“. If the protection system then detects a fault within the overreaching zone Z1B, the send signal resets. The NC contact returns to its quiescent state (closed). If the loop in the remote station is also closed after the same sequence, the loop is energized again: the tripping is again released at both ends.

In case the short-circuit occurred outside the protected line the pilot wire loop is also interrupted by the pickup of both devices (both NC contacts “Dis.T.SEND” are opened). Since the send signal will not reset at least one of the line ends (fault is not in line direction in zone Z1B), the loop at that end will remain open. Both receiving inputs are deenergized and block the tripping (because of “L-active”). The other distance stages including Z1, however, operate independently so that the back-up protection function is not affected.

For lines shorter than the shortest settable line please take into consideration that the first distance zone is either set to “disabled” or that T1 is delayed for at least one selective time interval.

If the line has single-end infeed an instantaneous trip for the whole line is possible. Since no pick-up occurs on the non-feeding line end, the loop is not interrupted at that point, but only on the feeding line end. After the fault is detected within Z1B, the loop will be closed again and the trip command is executed.

To guarantee that the time period between pickup and tripping of the protection function is sufficient to open and close the pilot wire loop, T1B must be delayed for a short period. If the pilot wire comparison is used with two different types of devices at both line ends (e.g. 7SA6 at one line end and a standard protection function at the other end). Care must be taken that the difference in pick-up and trip delay of the two devices, which may be considerable, does not lead to an unwanted release of the Z1B.

The quiescent state loop ensures a steady check of the pilot wire connections against interruptions. Since the loop is interrupted during each fault, the signal for pilot wire failure is delayed by 10 s. The pilot wire comparison supplement is then blocked. It does not need to be blocked from external as the pilot wire failure is recognized internally. The other stages of the distance protection continue operating according to the normal grading coordination chart.

Due to the low current consumption of the binary inputs it may be necessary to additionally burden the pilot wire loop with an external shunt connected resistor so that the binary inputs are not blocked by the wire capacitance after an interruption of the loop. Alternatively combinations of auxiliary relays (e.g. 7PA5210) can be connected.

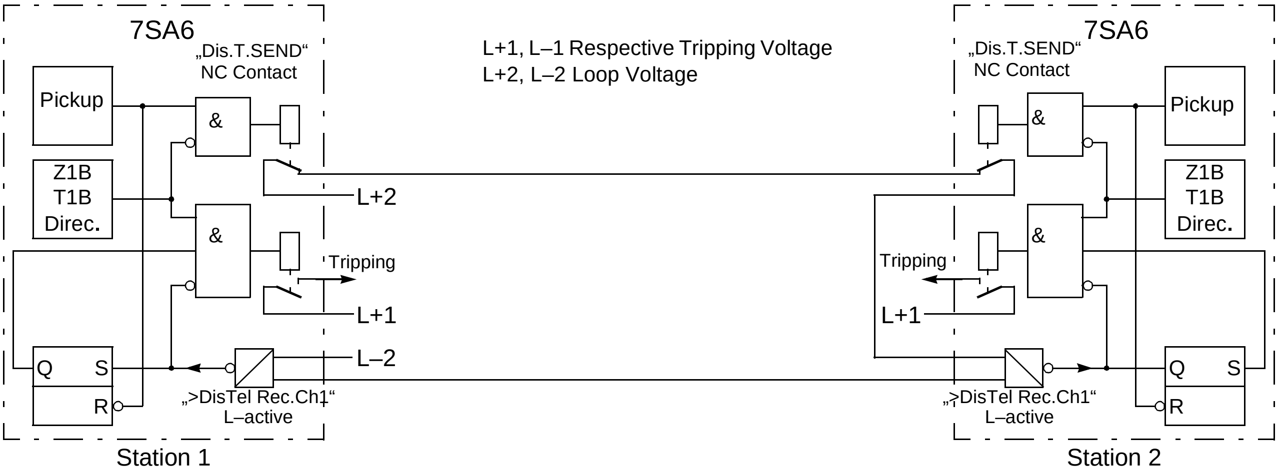


Figure 6-56 Pilot wire protection — principle

Please take note that both binary inputs are connected in series with each other and the resistance of the pilot wires. Accordingly the loop voltage must be high or the pickup voltage of the binary inputs must be low.

The isolation voltage of the pilot wires and the binary inputs and outputs must also be taken into account.

In the event of an earth fault the induced longitudinal voltage must neither exceed 60 % of the isolation voltage of the pilot wires nor 60 % of the isolation of the device. The pilot wire comparison is therefore only suited for short lines.

6.4.1.9 Reverse Interlocking

If the distance protection 7SA6 is used as back-up protection in single-end fed transformer feeders, the reverse interlocking function ensures a fast protection of the busbar without endangering the selectivity for faults on the outgoing feeders.

According to Figure 6-57 the distance zones Z1 and Z2 serve as back-up stages for faults on the outgoing lines, for example a fault in **F2**. For distance grading the shortest outgoing line is to be used.

The overreach zone Z1B, whose delay time T1B must be set longer than the pickup time Ta of the protection devices of the outgoing lines, is blocked after the pickup of an inferior protection. The pickup signal is sent (according to Figure 6-57) via the receive input of the distance protection.

If no signal is received this zone guarantees fast tripping of the busbar for

- faults on the busbar, such as for example in **F1**,

- failure of the line protection during a fault, such as for example in **F2**.

The reverse interlocking of the distance protection is performed by specific release or blocking of the overreach zone Z1B. It can be realized by the blocking mode (see Figure 6-57) or the release mode.

To avoid transient false signals after clearance of external faults, the blocking condition of the reverse interlocking is extended by a transient blocking time (TB in Figure 6-57).

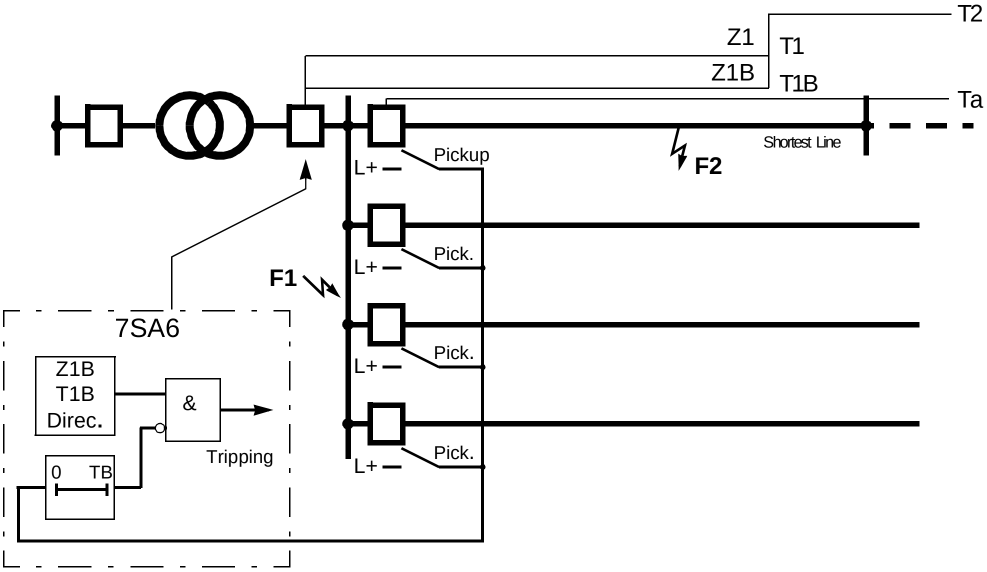


Figure 6-57 Reverse interlocking — functional principle and grading example

6.4.1.10 Transient Blocking

In the overreach schemes, the transient blocking provides additional security against erroneous signals due to transients caused by clearance of an external fault or by fault direction reversal during clearance of a fault on a parallel line.

The principle of transient blocking scheme is that following the incidence of an external fault, the formation of a release signal is prevented for a certain (settable) time. In the case of permissive schemes, this is achieved by blocking of the transmit and receive circuit.

Figure 6-58 shows the principle of the transient blocking function.

If, following fault detection, a fault in the reverse direction is determined within the waiting time **`TrBlk Wait Time`** (address **2109**), the transmit circuit and the release of the overreaching zone Z1B are prevented. This blocking condition is maintained for the duration of the transient blocking time **`TrBlk BlockTime`** (address **2110**) even after reset of the blocking criterion.

In the case of the blocking scheme, the transient blocking prolongs the received block signal as shown in the logic diagram Figure 6-55.

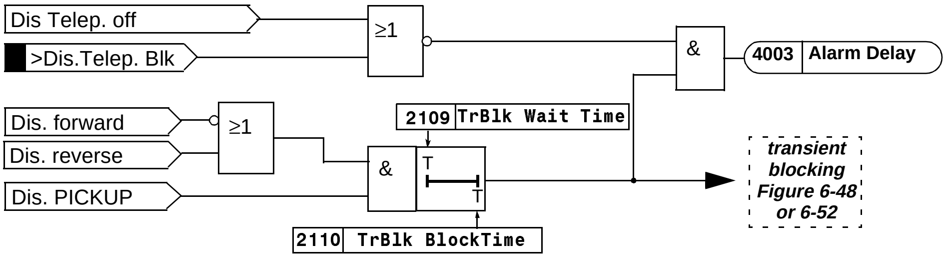


Figure 6-58 Transient blocking with POTT and Unblocking schemes

6.4.1.11 Measures for Weak and Zero Infeed

In cases where there is weak or no infeed present at one line end, the distance protection will not pick up. Neither a trip nor a send signal can therefore be generated there. The permissive overreach schemes with release signals would not even be able to trip at the strong infeed end without time delay, unless special measures are employed, as no permissive signal is received from the end with the weak infeed condition.

To achieve fast tripping at both line ends in such cases, 7SA6 provides special supplements for feeders with weak infeed.

To enable the line end with the weak infeed condition to trip independently, 7SA6 has a special tripping function for weak infeed conditions. As this is a separate protection function with its own trip command, it is described in a separate section (6.7).

Echo Function

In Figure 6-59 the method of operation of the echo function is shown. It may be set with **`FCT Weak Infeed`** in address **2501** to be on (***`ECHO only`***) or off (***`OFF`***). By means of this “switch” the weak infeed tripping can also be switched on (***`ECHO and TRIP`***, refer also to Section 6.7). This setting applies to both the distance protection and the earth fault protection teleprotection scheme.

If there is no fault detection, the echo function causes the received signal to be sent back to the other line end as an “echo”, where it is used to initiate permissive tripping.

The detection of the weak infeed and accordingly the requirement for an echo are combined in the central *AND* gate (Figure 6-59). The distance protection must neither be switched off nor blocked, as it would otherwise always produce an echo due to the missing fault detection. If however the time delayed overcurrent protection is used as an emergency function, an echo is nevertheless possible if the distance protection is out of service, because the fault detection of the emergency overcurrent protection replaces the distance protection fault detection. During this mode of operation, the emergency overcurrent protection must naturally not also be blocked or switched off.

The essential condition for an echo is the absence of distance protection or overcurrent protection fault detection with the simultaneous reception of a signal from the teleprotection scheme logic, as shown in the corresponding logic diagrams (Figure 6-48 or 6-52).

To avoid an incorrect echo following switching off of the line and reset of the fault detection, the RS flip-flop in Figure 6-59 latches the fault detection condition until the signal receive condition resets, thereby barring the release of an echo. The echo can in any event be blocked via the binary input „**>Dis.T.BlkEcho**“.

If the conditions for an echo signal are met, a short delay **Trip/Echo DELAY** is initially activated. This delay is necessary to avoid transmission of the echo if the protection at the weak line end has a longer fault detection time during reverse faults or if it picks up a little later due to unfavourable fault current distribution. If however the circuit breaker at the non-feeding line end is open, this delay of the echo signal is not required. The echo delay time may then be bypassed. The circuit breaker switching state is provided by the central information control functions. (refer to Subsection 6.20.2).

The echo impulse is then issued (event output “**ECHO SIGNAL**”). It’s length is set with the parameter **Trip EXTENSION**.

Note:

The “**ECHO SIGNAL**” (F.No. 4246) must be separately assigned to the output relay(s) for signal transmission, as it is not contained in the transmit signals “**Dis.T.SEND**” or “**Dis.T.SEND L***”.

After issue of the echo impulse, the transmission of a new echo is prevented for at least 20 ms. This prevents the repetition of an echo after the line has been switched off.

In the case of the blocking scheme and the underreach transfer trip scheme, the echo function is not required and therefore ineffective.

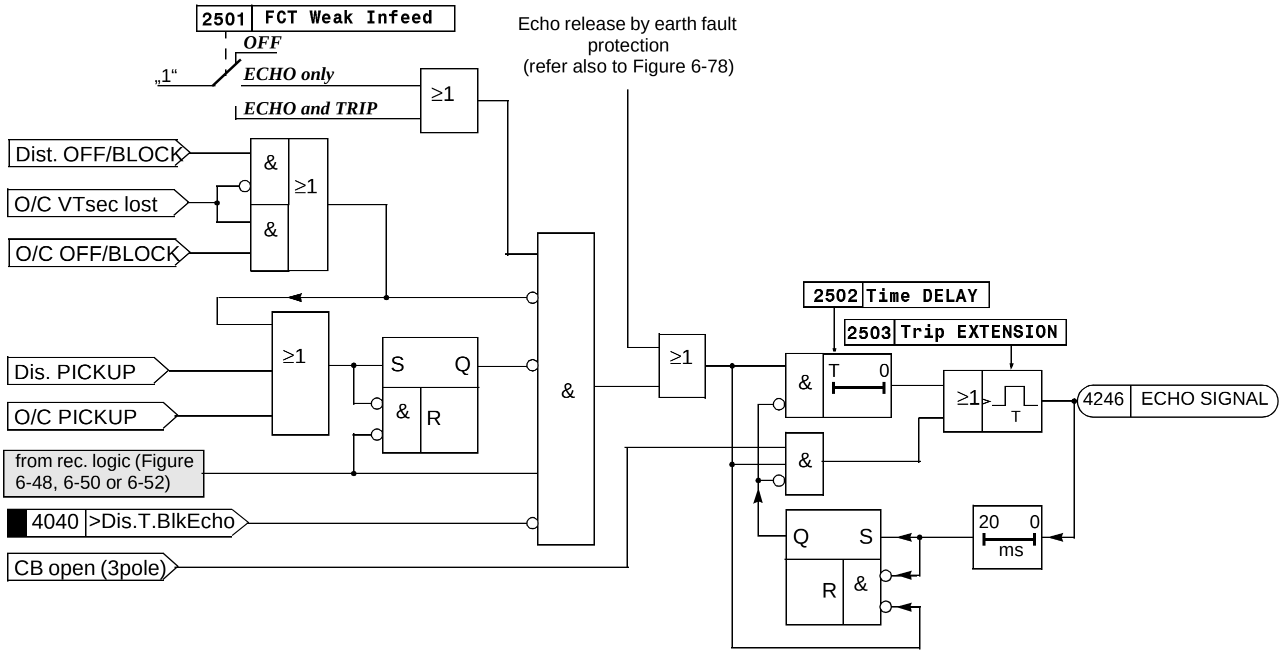


Figure 6-59 Logic diagram of the echo function with distance protection teleprotection

6.4.2 Applying the Function Parameter Settings

General

The distance protection teleprotection supplement is only in service if it is set during the configuration to one of the possible modes of operation in address **`0121`**. Depending on this configuration setting, only those parameters that are relevant to the selected mode of operation will appear here. If the teleprotection supplement is not required, address **`0121`** is **`Teleprot. Dist.`** = ***`Disabled`***.

The following teleprotection schemes are available:

- ***`PUTT (Pickup)`*** = Permissive underreach transfer trip with pickup, as referred to in Subsubsection 6.4.1.1,
- ***`PUTT`*** = Permissive underreach transfer trip with zone acceleration Z1B, as referred to in Subsubsection 6.4.1.2,
- ***`POTT`*** = Permissive overreach transfer trip, as referred to in Subsubsection 6.4.1.4,
- ***`Directional Comparison Pickup`*** = Directional comparison pickup, as referred to in Subsubsection 6.4.1.5,
- ***`Unblocking`*** = Unblocking with Z1B, as referred to in Sub-section 6.4.1.6,
- ***`Blocking`*** = Blocking scheme, as referred to in Sub-section 6.4.1.7,

– ***Pilot Wire Comparison*** = Pilot wire comparison with control wires, as referred to in Sub-section 6.4.1.10,

– ***Reverse Interlocking*** = Reverse interlocking with control wires, as referred to in Sub-section 6.4.1.11.

In address **2101 FCT Telep. Dis.** the application of a teleprotection scheme can be switched ***ON*** or ***OFF***.

If the teleprotection is applied to a line with three ends, the address **2102** must be set to **Line Config.** = ***Three terminals***, otherwise it remains at the setting ***Two Terminals***.

Distance Protection Prerequisites

For all applications of teleprotection schemes (except PUTT), it must be ensured that the fault detection of the distance protection in the reverse direction has a greater reach than the overreaching zone of the opposite line end (refer to the shaded areas in Figure 6-60 on the right hand side)! This is normally predefined for the U/I/φ–pickup since the local voltage of a reverse fault is smaller than the voltage of the remote supplied end. In the case of the impedance pickup at least one of the distance stages must be set to ***Reverse*** or ***Non-Directional***. During a fault in the shaded area at the left of Figure 6-60, this fault would be in zone Z1B of the protection at B as zone Z1B is set incorrectly. The distance protection at A would not pick up and therefore interpret this as a fault with single end infeed from B (echo from A or no block signal at A). This would result in a false trip!

To produce a blocking signal the blocking scheme additionally requires a fast reverse stage. For this purpose, the third zone is to be applied without time delay (see also "*Note*" on page 6-62 in Subsection 6.2.4.2).

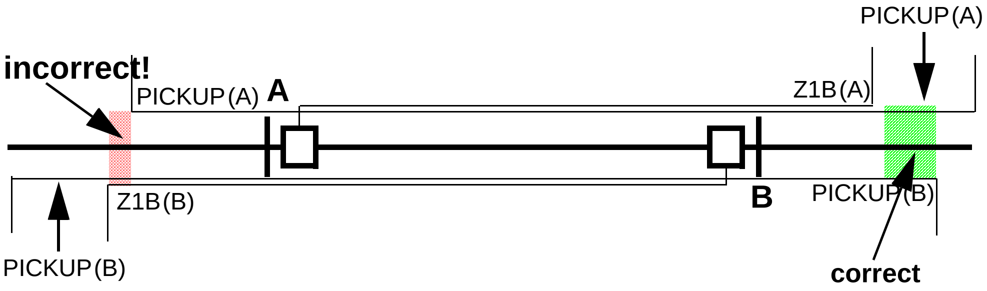


Figure 6-60 Distance protection setting with permissive overreach schemes

Time Settings

The send signal prolongation **Send Prolong.** (address **2103**) must ensure that the send signal reliably reaches the opposite line end, even if there is very fast tripping at the sending line end and/or the signal transmission time is relatively long. In the case of the permissive overreaching schemes ***POTT***, ***Directional Comparison Pickup*** and ***Unblocking*** this signal prolongation time is only effective if the device has already issued a trip command. This ensures the release of the other line ends even if the short-circuit has been cleared very rapidly by the instantaneous zone Z1. In the case of the blocking scheme ***Blocking*** the send signal is always prolonged by this time. In this case it corresponds to a transient blocking following a reverse fault. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

With the release delay **Release Delay** (address **2108**) the release of the zone Z1B can be delayed. This is only necessary for the blocking scheme ***Blocking***, to allow sufficient transmission time for the blocking signal during external faults. This delay *only* has an effect on the receive circuit of the teleprotection; conversely the permissive signal is not delayed by the set time delay T1B of the overreaching zone Z1B. For ***pilot wire comparison*** and ***reverse interlocking*** T1B must be delayed so that there is enough time between the pickup of the distance protection function and the trip signal of zone Z1B.

Transient Blocking

The parameters **TrBlk Wait Time** and **TrBlk BlockTime** serve the transient blocking with the permissive overreaching schemes PUTT and UNBLOCKING. With permissive underreach transfer trip they are of no consequence. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

The time **TrBlk Wait Time** (address **2109**) is a waiting time before transient blocking. Only once the distance protection recognizes a reverse fault inside this time after fault detection, will the transient blocking become activated in the permissive overreach transfer schemes. With the blocking scheme this waiting time prevents a transient blocking if the blocking signal from the opposite line end is received very rapidly. There is no transient blocking with the setting ∞.

The transient blocking time **TrBlk BlockTime** (address **2110**) must be definitely longer than the duration of severe transients resulting from the inception or clearance of external faults. The send signal is delayed by this time with the permissive overreach schemes ***POTT*** and ***Unblocking*** if the protection had initially detected a reverse fault. With the blocking scheme ***Blocking*** the (blocking) receive signal is prolonged by this time.

The preset value is generally sufficient.

Echo Function

In the case of line ends with weak infeed, the echo function is sensible in conjunction with permissive overreach transfer schemes POTT and UNBLOCKING with release signal, so that the feeding line end is also released. The echo function can be enabled under address **2501 FCT Weak Infeed** (***ECHO only***) or disabled (***OFF***). With this “switch” the weak infeed tripping function can also be activated (***ECHO and TRIP***, refer also to Section 6.7).

The notes regarding the setting of the distance stages above, and the margin headings “Distance Protection Prerequisites” must in any event be noted.

The echo delay time **Trip/Echo DELAY** (address **2502**) must be set long enough to avoid incorrect echo signals resulting from the difference in fault detection pick-up time of the distance protection functions at the two line ends during external faults (through-fault current). A typical setting is approximately 40 ms (presetting). This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

The echo impulse duration **Trip EXTENSION** (address **2503**) can be set to adapt to the circumstances of the signal transmission equipment. It must be long enough to ensure that the receive signal is recognized even with different pick-up times by the protection devices at the line ends and different response times of the transmission equipment. Generally a setting of approximately 50 ms (presetting) is sufficient. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

The setting for the echo function is the same for all measures taken against weak infeed and summarised in tabular form in Section 6.7.

6.4.3 Settings

Addr.	Setting Title	Function	Setting Options	Default Setting
2101	FCT Telep. Dis.	Teleprotection for Distance prot.	ON OFF	ON
2102	Type of Line	Teleprotection for Distance prot.	Two Terminals Three Terminals	Two Terminals
2103A	Send Prolong.	Teleprotection for Distance prot.	0.00..30.00 sec	0.05 sec
2107A	Delay for alarm	Teleprotection for Distance prot.	0.00..30.00 sec	10.00 sec
2108	Release Delay	Teleprotection for Distance prot.	0.000..30.000 sec	0.000 sec
2109A	TrBlk Wait Time	Teleprotection for Distance prot.	0.00..30.00 sec; ∞	0.04 sec
2110A	TrBlk BlockTime	Teleprotection for Distance prot.	0.00..30.00 sec	0.05 sec

6.4.4 Information Overview

F.No.	Alarm	Comments
4001	>Dis.Telep. ON	>Distance Teleprotection ON
4002	>Dis.Telep.OFF	>Distance Teleprotection OFF
4003	>Dis.Telep. Blk	>Distance Teleprotection BLOCK
4006	>DisTel Rec.Ch1	>Dis.Tele. Carrier RECEPTION Channel 1
4007	>Dis.T.RecCh1L1	>Dis.Tele.Carrier RECEPTION Channel 1,L1
4008	>Dis.T.RecCh1L2	>Dis.Tele.Carrier RECEPTION Channel 1,L2
4009	>Dis.T.RecCh1L3	>Dis.Tele.Carrier RECEPTION Channel 1,L3
4010	>Dis.T.Rec.Ch2	>Dis.Tele. Carrier RECEPTION Channel 2
4005	>Dis.RecFail	>Dist. teleprotection: Carrier faulty
4030	>Dis.T.UB ub 1	>Dis.Tele. Unblocking: UNBLOCK Channel 1
4031	>Dis.T.UB bl 1	>Dis.Tele. Unblocking: BLOCK Channel 1
4032	>Dis.T.UB ub1L1	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L1
4033	>Dis.T.UB ub1L2	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L2
4034	>Dis.T.UB ub1L3	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L3
4035	>Dis.T.UB ub 2	>Dis.Tele. Unblocking: UNBLOCK Channel 2
4036	>Dis.T.UB bl 2	>Dis.Tele. Unblocking: BLOCK Channel 2
4040	>Dis.T.BlkEcho	>Dis.Tele. BLOCK Echo Signal
4050	Dis.T.on/off BI	Dis. Teleprotection ON/OFF via BI
4052	Dis.Telep. OFF	Dis. Teleprotection is switched OFF

F.No.	Alarm	Comments
4054	Dis.T.Carr.rec.	Dis. Telep. Carrier signal received
4055	Dis.T.Carr.Fail	Dis. Telep. Carrier CHANNEL FAILURE
4056	Dis.T.SEND	Dis. Telep. Carrier SEND signal
4057	Dis.T.SEND L1	Dis. Telep. Carrier SEND signal, L1
4058	Dis.T.SEND L2	Dis. Telep. Carrier SEND signal, L2
4059	Dis.T.SEND L3	Dis. Telep. Carrier SEND signal, L3
4068	Dis.T.Trans.Blk	Dis. Telep. Transient Blocking
4070	Dis.T.BL STOP	Dis. Tele.Blocking: carrier STOP signal
4060	DisJumpBlocking	Dis.Tele.Blocking: Send signal with jump
4080	Dis.T.UB Fail1	Dis. Tele.Unblocking: FAILURE Channel 1
4081	Dis.T.UB Fail2	Dis. Tele.Unblocking: FAILURE Channel 2
4082	Dis.T.BL STOPL1	DisTel Blocking: carrier STOP signal, L1
4083	Dis.T.BL STOPL2	DisTel Blocking: carrier STOP signal, L2
4084	Dis.T.BL STOPL3	DisTel Blocking: carrier STOP signal, L3

6.5 Earth Fault Protection in Earthed Systems

General

In earthed systems, where extremely large fault resistance may exist during earth faults (e.g. overhead lines without earth wire, sandy soil, or high tower footing resistance) the fault detection of the distance protection will often not pick up because the resulting earth fault impedance could be outside the fault detection characteristic of the distance protection.

The distance protection 7SA6 has protection functions for such high resistance earth faults. These options are available:

- three overcurrent stages with definite time tripping characteristic (definite time),
- one overcurrent time stage with inverse time characteristic (IDMT) *or*
- one zero sequence voltage stage with inverse time characteristic

These four stages are independent of each other and are freely combinable. If the inverse time stage is not required, it may be employed as a fourth definite time stage.

Each stage may also be set to be non directional or directional — forward or reverse. A signal transmission may be combined with these four stages. For each stage it may be determined if it should coordinate with the signal transmission (refer also to Section 6.6). If the protection is applied in the proximity of transformers, an inrush stabilization can be activated. Furthermore, blocking by external criteria is possible via binary inputs (e.g. for reverse interlocking or external automatic reclosure). During energization of the protected feeder onto a short circuit, any stage — or several stages — may be switched to undelayed tripping. If a stage is not required it can be deactivated.

6.5.1 Method of Operation

Measured Value

The earth current is the negative sum of the three phase currents, i.o.w. $\underline{I}_E = -3\cdot\underline{I}_0 = -(\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3})$. Depending on the version ordered, and the configured application for the fourth current input I_4 of the device, the earth current can be measured or calculated.

If the input I_4 is connected in the starpoint of the set of current transformers or to a separate earth current transformer, on the protected feeder, the earth current is directly available as a measured value.

If the device is fitted with the highly sensitive current input for I_4, this current I_4 is used with the matching factor **I4/Iph CT** (address **0221**, refer to Sub-section 6.1.1). As the linear range of this measuring input is severely limited (maximum 1.6 A), this current is only evaluated up to an amplitude of approximately 1.6 A. In the case of larger currents the device automatically switches over to the evaluation of the zero sequence current derived from the phase currents. Naturally, all three phase currents from three current transformers connected in a star arrangement must be available and connected. This allows the processing of the earth current both when very small and also larger earth fault currents may occur.

If the fourth current input I_4 is otherwise utilized, e.g. for a transformer starpoint current or for the earth current of a parallel line, the device calculates the earth current from the phase currents. Naturally, in this case also, all three phase currents from three current transformers connected in a star arrangement must be available and connected.

Definite Time Very High Set Current Stage $3I_0$>>>

The earth current $I_E = 3I_0$ is passed through a numerical filter and then compared with the set value **`3I0>>>`**. If this value is exceeded and alarm is issued. After the corresponding delay times **`T 3I0>>>`** have expired, a trip command is issued which is also alarmed. The reset threshold is approximately 5 % + 0,5 mA below the pick-up threshold.

The possibilities of selection are referred to in the heading “General”. Figure 6-61 shows the logic diagram of the $3I_0$>>>–stage. The function modules “direction determination”, “permissive teleprotection”, “switch onto fault”, and “inrush stabilization” are common to all stages and described below. They may however affect each stage individually. This is done with the following parameters:

- **`Op. mode 3I0>>>`**, determines the operating direction of the stage: ***`Forward`***, ***`Reverse`*** or ***`Non-Directional`***,
- **`3I0>>> Telep/BI`**, determines whether a non-delayed trip with the teleprotection scheme is possible (***`Yes`***) or not possible (***`No`***),
- **`3I0>>>SOTF-Trip`**, determines whether during energization of the feeder onto a fault tripping with this stage shall be non-delayed (***`Yes`***) or not (***`No`***) and
- **`3I0>>>InrushBlk`**, which is used to switch the inrush stabilization (rush blocking) on (***`Yes`***) or off (***`No`***).

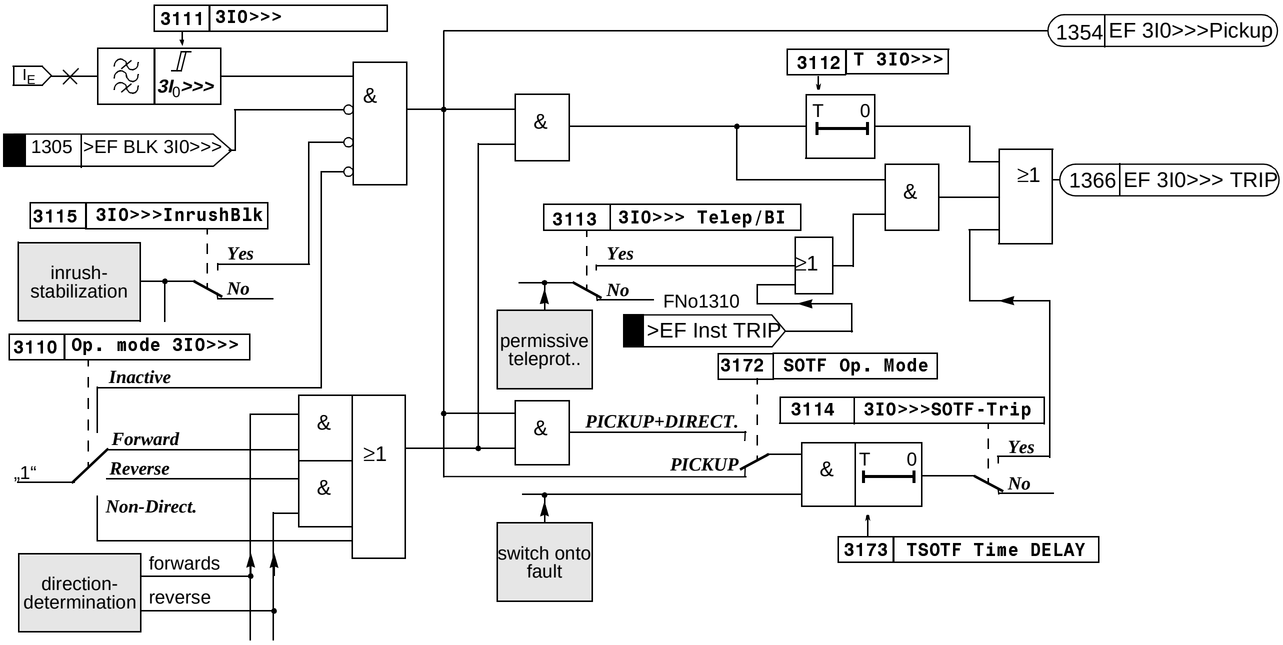


Figure 6-61 Logic diagram of the $3I_0$>>>–stage

Definite Time High Set Current Stage $3I_0$>>

The logic of the high set current stage $3I_0$>> is the same as that of the $3I_0$>>>–stage. 3I0>>> is therefore to be replaced by **`3I0>>`**, then, Figure 6-61 also applies for $3I_0$>>.

Definite Time Overcurrent Stage $3I_0>$

The logic of the overcurrent stage $3I_0>$ is the same as that of the $3I_0>>>$–stage. 3I0>>> is therefore replaced with **3I0>**, then, Figure 6-61 also applies for $3I_0>$.

This stage operates with a specially optimized digital filter that completely suppresses all harmonic components beginning with the 2nd harmonic. Therefore it is particularly suited for a highly-sensitive earth fault detection. A fourth, definite time stage can be implemented by setting the “inverse” stage (refer to the next paragraph) to a definite time stage.

Inverse Time Overcurrent Stage $3I_{0P}$

The logic of the inverse time stage in principle functions the same as the other stages. This stage operates with a specially optimized digital filter that completely suppresses all harmonic components beginning with the 2nd harmonic. Therefore it is particularly suited for a very sensitive earth fault detection. The delay times in this case are however determined by the set characteristic (Parameter **IEC Curve**), the magnitude of the earth current and the time multiplier **3I0p Time Dial** (Figure 6-62). A pre-selection of the optional characteristics was already done during the configuration of the protection functions. Furthermore, an additional fixed delay **Add.T-DELAY** may be selected. The optional characteristics are illustrated in the technical data of Section 10.5.

Figure 6-62 shows the logic diagram. As an example, the setting addresses for the IEC curves are shown in the diagram. The different setting addresses are referred to in more detail in the setting information (Sub-section 6.5.2)

It is also possible to implement this stage as a further definite time stage. In this case **3I0p PICKUP** is the pick up threshold and **Add.T-DELAY** the definite time delay. The inverse time characteristic is then effectively bypassed.

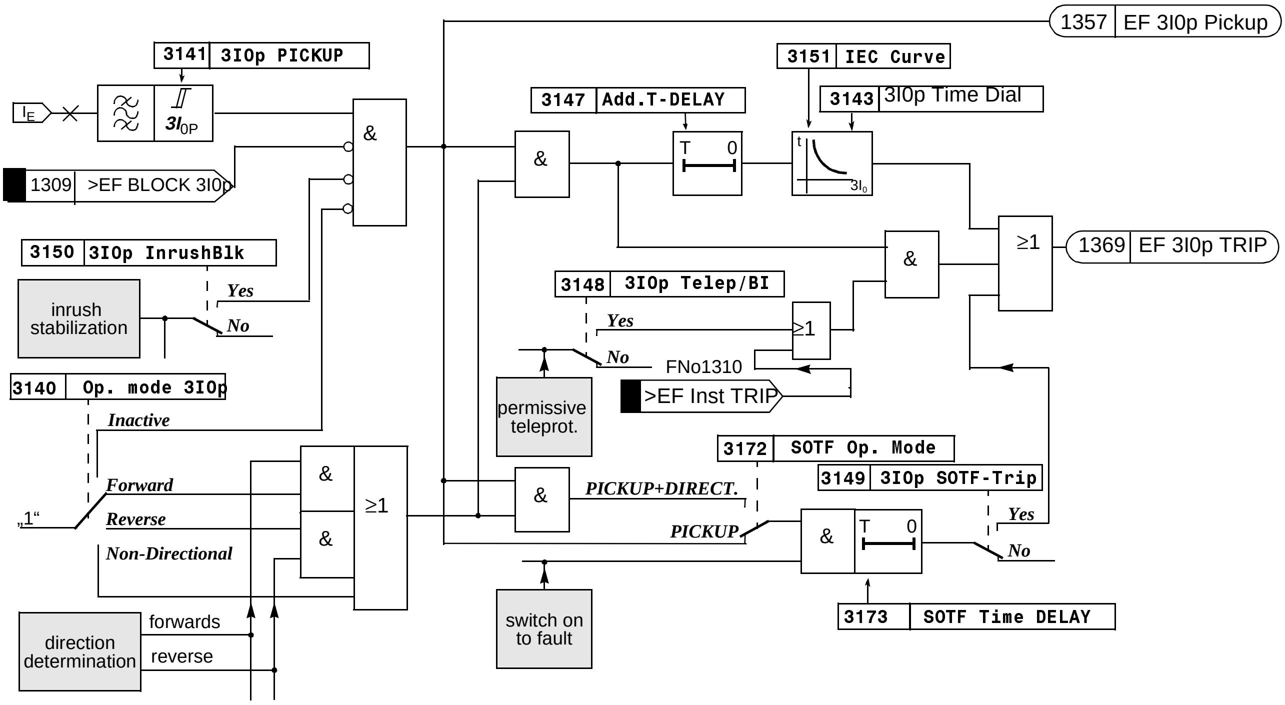


Figure 6-62 Logic diagram of the $3I_{0P}$–stage (inverse time overcurrent protection), for example IEC curves

Inverse Time Overcurrent Stage with Inverse Logarithmic Characteristic

The inverse logarithmic characteristic differs from the other inverse characteristics mainly by the fact that the shape of the curve can be influenced by a number of parameters. The slope **3I0p Time Dial** and a time shift **T IOPmax** which directly affect the curve, can be changed. The curves are illustrated in the technical date in Section 10.5, Figure 10-4.

The logic diagram is shown in Figure 6-63. In addition to the curve parameters, a minimum time **3I0p MinT-DELAY** can be determined; below this time no tripping can occur. Below a current factor of **3I0p Startpoint**, which is set as a multiple of the basic setting **3I0p PICKUP**, no tripping can take place.

Further information regarding the effect of the various parameters can be found in the setting information of the function parameters in Sub-section 6.5.2, refer also to Figure 6-68.

The remaining setting options are the same as for the other curves.

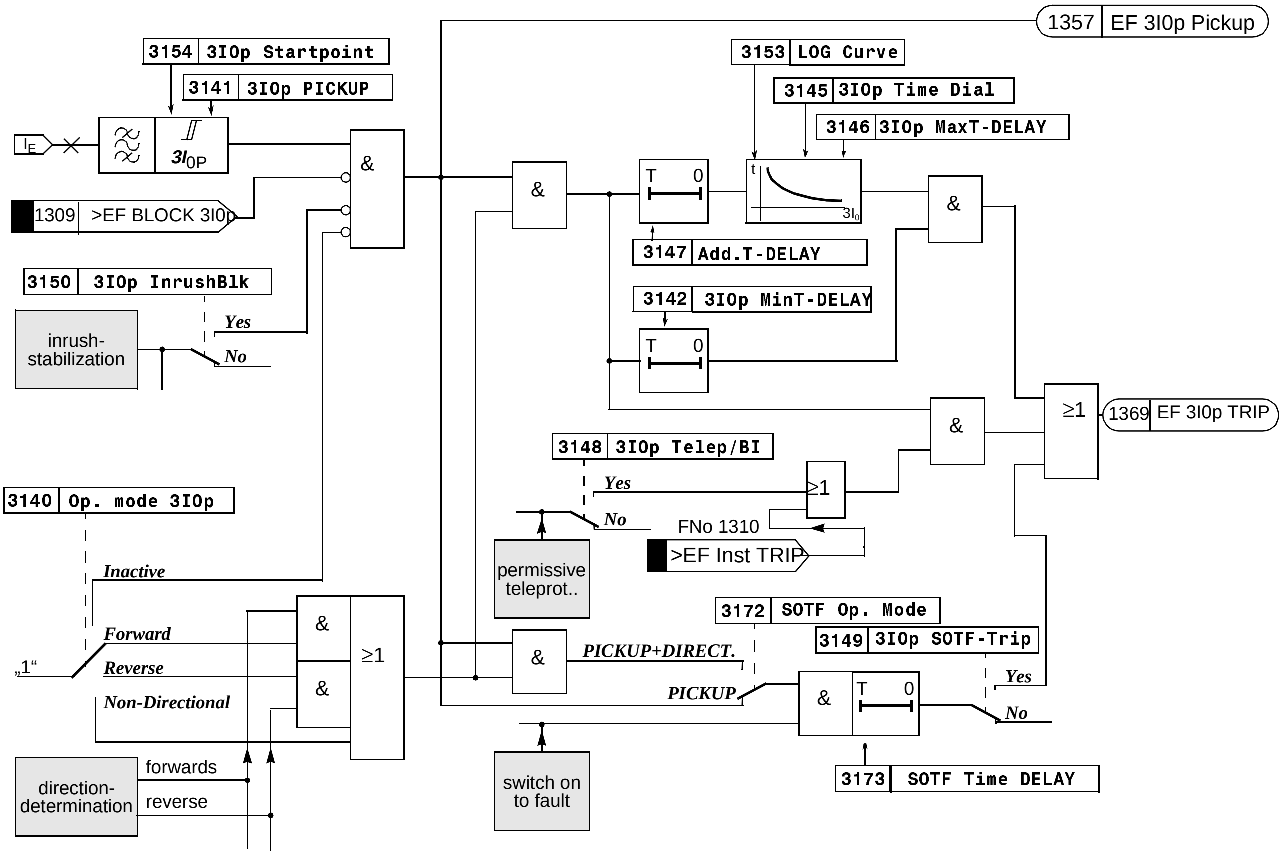


Figure 6-63 Logic diagram of the $3I_{0P}$–stage for the inverse logarithmic curve

Zero Sequence Voltage Time Protection (U_0-Inverse)

The zero sequence voltage time protection operates according to a voltage-dependent trip time characteristic. It can be used instead of an inverse time overcurrent stage.

The voltage/time characteristic can be displaced in voltage direction for a determined constant voltage (**UOinv. minimum**, valid for $t \to \infty$) and in time direction by a determined constant time (**T forw. (UOinv)**). The different characteristics and their underlying formulae are shown in the Technical Data Section (10.5, Figure 10-5).

Figure 6-64 illustrates the functional principle. The tripping time depends on the level of the zero sequence voltage U_0. For meshed earthed systems the zero sequence voltage increases towards the earth fault location. The inverse characteristic results in the shortest command time for the relay closest to the fault. The other relays then reset.

A further time stage **`T rev. (U0inv)`** provokes non-directional tripping with a voltage-independent delay. This stage can be set above the directional stage. When tripping with this stage it is, however, a prerequisite that the time of the voltage-controlled stage has already expired (without directional check). In case the zero voltage is too low or the voltage transformer circuit-breaker is tripped, this stage is also disabled.

The function of the zero sequence voltage time protection can be blocked by the distance protection. This gives the selective fault detection, carried out by the distance protection with preference over the tripping by the zero sequence voltage time protection.

The zero sequence voltage time protection can also be blocked during a single-pole auto-reclosure cycle. This prevents from false measurement caused by the zero-sequence values then appearing.

If the device operates with external automatic reclosure or if single-pole tripping is possible via a different protection (operating in parallel), the zero sequence voltage time protection must be blocked during the single-pole open condition via a binary input.

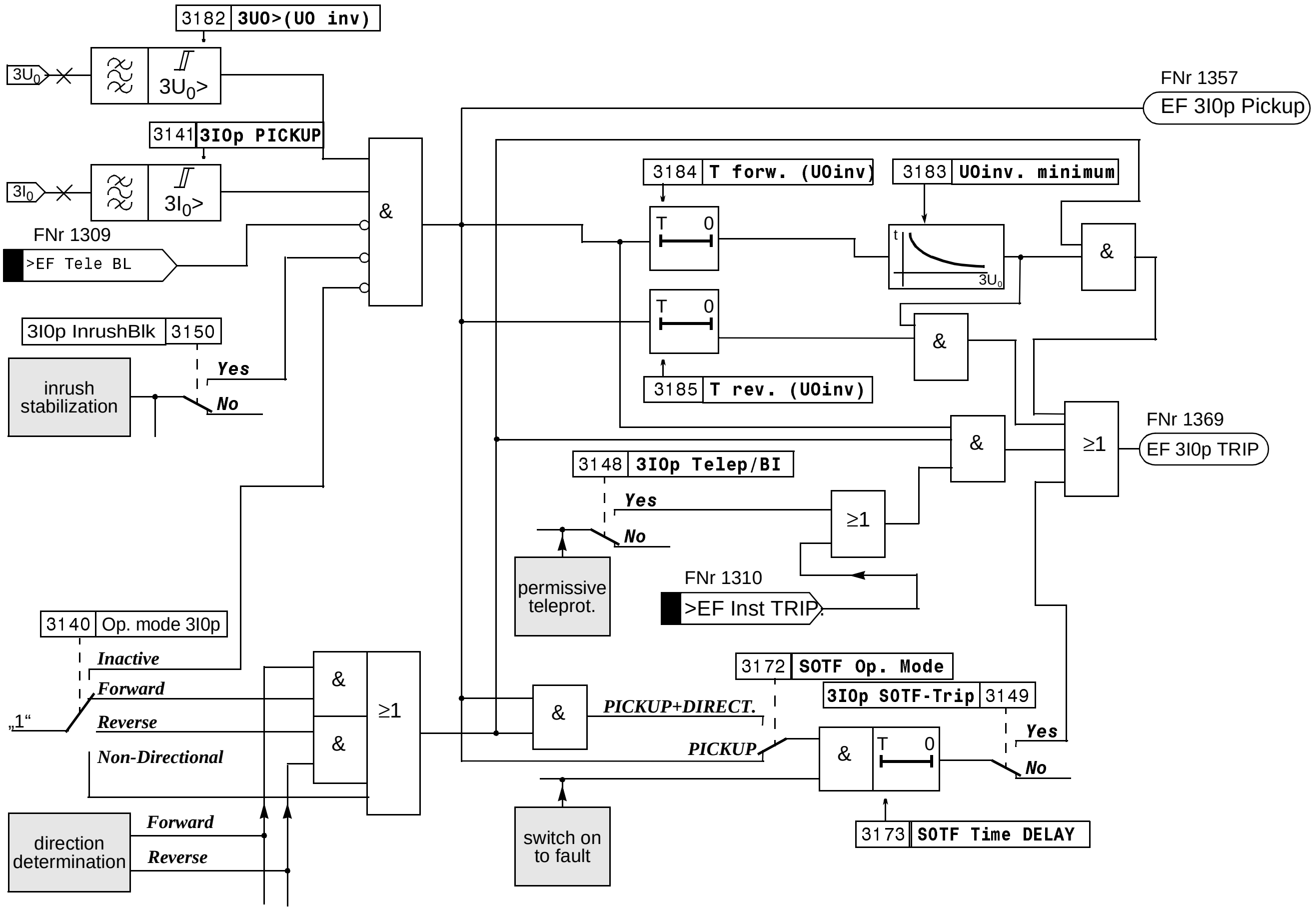


Figure 6-64 Directional zero voltage time protection with non-directional back-up stage

Phase Current Stabilization

Non-symmetrical load conditions in multiple-earthed systems or different current transformer errors can result in a zero sequence current. This zero sequence current could cause faulty pick-up of the earth current stages if low pick-up thresholds are set. To avoid this, the earth current stages are stabilized by the phase current: As the phase currents increase, the pick up thresholds are increased (Figure 6-65). The stabilization factor (=slope) may be changed by means of the parameter **`Iph-STAB. Slope`** (setting address 3104, Subsection 6.5.2). It applies to all stages.

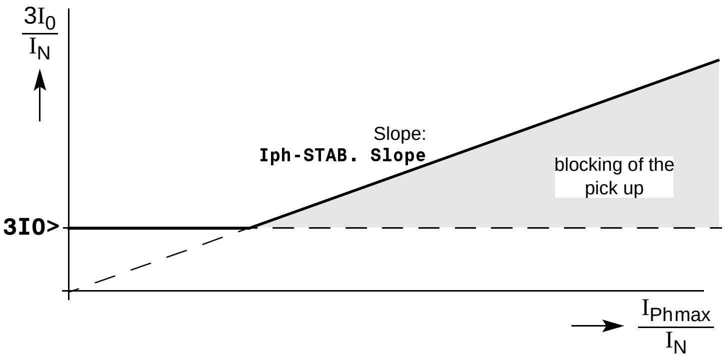


Figure 6-65 Phase current stabilization

Inrush Stabilization

If the device is applied to a transformer feeder, large inrush currents can be expected when the transformer is energized; if the transformer star-point is earthed, also in the zero sequence path. The inrush current may be a multiple of the rated current and flow for several tens of milliseconds up to several minutes.

Although the fundamental current is evaluated by filtering of the measured current, an incorrect pick-up during energization of the transformer may result if very short delay times are set. In the rush current there is a substantial portion of fundamental current depending on the type and size of the transformer that is being energized.

The inrush stabilization blocks tripping of all those stages for which it has been activated, for as long as the rush current is recognized.

The inrush current is characterized by a relatively large amount of second harmonic (twice rated frequency). This second harmonic is almost non-existent in the short-circuit current. Numerical filters that carry out a Fourier analysis of the current are used for the frequency analysis. As soon as the harmonic content is greater than the set value, the affected stage is blocked.

Direction Determination with Zero Sequence System

The direction determination is carried out with the measured current $\underline{I}_E$ (= $-3 \cdot \underline{I}_0$), which is compared to a polarization voltage $\underline{U}_P$, which results from the measured voltage $\underline{U}_E$ (= $3 \cdot \underline{U}_0$) (refer to Figure 6-66).

The direction determination may also be carried out with the earth current $\underline{I}_E$ and the star-point current $\underline{I}_Y$ of an earthed transformer (source transformer) as polarization value $\underline{I}_P$ (Figure 6-67) provided that the star-point current is available (CT in the star-point connection of the transformer).

It is furthermore possible to polarize with the star-point current of the transformer as well as the zero sequence voltage. The polarization value has the amount of the voltage $\underline{U}_P$ and a voltage part which is proportional to the current $\underline{I}_P$. This voltage part equals 20 V if $\underline{I}_P$ has the amount of the rated current.

The directional polarization using the transformer star-point current is independent of voltage transformers and therefore also functions reliably during a fault in the voltage transformer secondary circuit. It is however a requirement that not all but at least a substantial amount of the earth fault current flows via the transformer, the star-point current of which is measured.

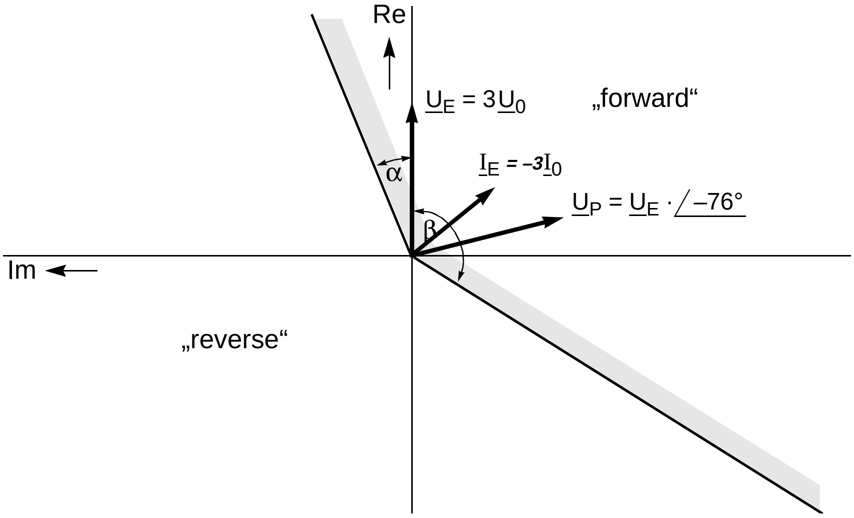


Figure 6-66 Directional characteristic using $\underline{U}_E$ as polarization quantity

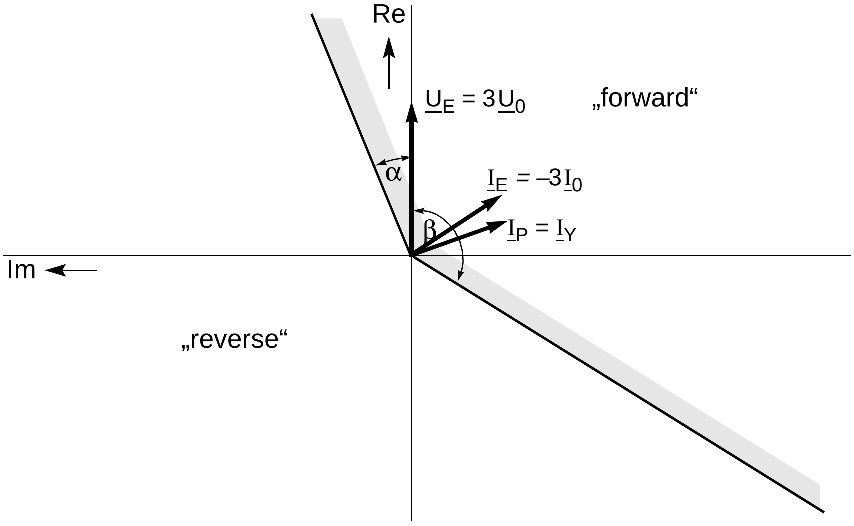


Figure 6-67 Directional characteristic using $\underline{I}_Y$ as polarization quantity

For the determination of direction a minimum current and a minimum polarization quantity is required. The minimum polarizing voltage set as **3U0>**. If the displacement voltage is too small, the direction can only be determined if it is polarized with the transformer star-point current and this exceeds a minimum value corresponding to the setting **IY>**. The direction determination with $\underline{U}_E$ is inhibited when a trip of the voltage transformer mcb is reported via binary input.

Direction Determination with Negative Sequence System

It is advantageous to use negative sequence system values for the direction measurement if the resulting zero sequence voltages during earth faults are too small for an accurate measurement or when the zero sequence values are subject to interference by for example mutual coupling from a parallel line.

Otherwise this function operates the same as the direction measurement with zero sequence current and zero sequence voltage. The negative sequence signals $3\underline{I}_2$ und $3\underline{U}_2$ are simply used instead of the signals $3\underline{I}_0$ und $3\underline{U}_0$. These signals must also have a minimum magnitude of **3I2>** or **3U2>**.

Blocking

The earth fault protection can be blocked by the distance protection. If in this case a fault is detected by the distance protection, the earth fault protection will not operate. This gives the selective fault clearance by the distance protection preference over tripping by the earth fault protection.

The earth fault protection can also be blocked during the single-pole dead time of an automatic reclose cycle. This prevents an incorrect measurement resulting from the zero sequence current and voltage signals arising in this state. If the device is combined with an external automatic reclose device or if single-pole tripping can result from a separate (parallel tripping) protection device, the earth fault protection must be blocked via binary input during the single-pole open condition.

Switching onto an Earth Fault

To achieve fast tripping following manual closure of the circuit breaker on to an earth fault, the manual close command from the control switch can be routed to the device via a binary input. The earth fault protection can then trip three-pole without delay. The stage(s) that should be activated for instantaneous tripping after manual closure can be selected with setting parameters. (refer to logic diagrams Figure 6-61 to 6-63).

The instantaneous tripping following manual closure is blocked as long as the inrush-stabilization recognizes a rush current. This prevents instantaneous tripping by a stage which, under normal conditions, is sufficiently delayed during energization of a transformer.

6.5.2 Applying the Function Parameter Settings

During the configuration of the device functions (refer to Section 5.1, address **0131 Earth Fault O/C**) it was determined which characteristics of the overcurrent time protection would be available. Depending on the configuration selected there, and the ordered version of the relay, only those parameters applicable to the available curves are accessible now.

By means of the parameter **3101 FCT EarthFltO/C** the earth fault protection can be switched ***On*** or ***Off***. This refers to all functions of the earth fault protection.

Each individual stage, if not required, can be set to ***Inactive*** (see below).

Blocking

The earth fault protection can be blocked by the distance protection to give preference to the selective fault clearance by the distance protection over tripping by the earth fault protection. In setting address **3102 BLOCK for Dist.** it is determined whether blocking is done during each fault detection of the distance protection (***every Pickup***) or only during single-phase fault detection by the distance protection (***single-phase Pickup***) or only during multiple-phase fault detection by the distance protection (***multi-phase Pickup***). If blocking is not required, the setting ***No*** is applied.

The earth fault protection should be blocked during single-pole automatic reclose dead time, to avoid pick-up with the false zero sequence values arising during this state (address **3103 BLOCK 1pDeadTim**). A setting of ***Yes*** is therefore only required if single-pole tripping is possible. Otherwise the setting ***No*** (presetting) remains.

Definite Time Stages

First of all, the mode for each stage is set: **Op. mode 3I0>>>** (address **3110**), **Op. mode 3I0>>** (address **3120**) and **Op. mode 3I0>** (address **3130**). Each stage can be set to operate ***Forward*** (usually towards line) or ***Reverse*** direction (usually towards busbar) or ***Non-Directional*** (in both directions). If a single stage is not required, set its mode to ***Inactive***.

The definite time stages **3I0>>>** (address **3111**), **3I0>>** (address **3121**) and **3I0>** (address **3131**) can be used for a three-stage definite time overcurrent protection. They can also be combined with the inverse time stage **3I0p PICKUP** (address **3141**, see below). The pick up thresholds should in general be selected such that the most sensitive stage picks up with the smallest expected earth fault current.

The $3I_0$>> und $3I_0$>>> stages are best suited for fast tripping stages (instantaneous), as these stages use an abridged filter with shorter response time. On the other hand, the stages 3I0> and 3I0p are best-suited for very sensitive earth fault detection due to their effective method of suppressing harmonics.

If no inverse time stage but rather a fourth definite time stage is required, the “inverse time” stage can be implemented as a definite time stage. This must already be taken regard of during the configuration of the protection functions (refer to Section 5.1, address **0131 Earth Fault O/C** = ***Definite Time***). For this stage, the address

3141 3I0p PICKUP then determines the current pick-up threshold and address **3146 3I0p MaxT-DELAY** the definite time delay.

The values for the time delay settings **T 3I0>>>** (address **3112**), **T 3I0>>** (address **3122**) and **T 3I0>** (address **3132**) are derived from the earth fault grading coordination diagram of the system.

If the distance protection implements single-pole tripping, the earth fault protection may be delayed by one grading margin to give preference to the phase selective tripping by the distance protection over of the earth fault protection which always trips three-pole. It is however also possible to block the earth fault protection with the distance protection (See “Blocking” above).

During the selection of the current and time settings, regard must be taken of whether a stage should be direction dependent and whether it uses teleprotection. Refer to also to the margin headings “Direction Determination” and “Teleprotection with Earth Fault Protection” below.

The set time delays are pure additional time delays which do not include the response time (measuring time) of the protection.

Inverse Time Overcurrent Stage with IEC–Characteristic

Also for the inverse time overcurrent stage the operating mode must initially be set: **Op. mode 3I0p** (address **3140**). This stage can be set to operate ***Forward*** (usually towards line) or ***Reverse*** direction (usually towards busbar) or ***Non-Directional*** (in both directions). If a particular stage is not required, set its mode to ***Inactive***.

For the inverse time overcurrent stage $3I_{0P}$ it is possible to select from a variety of curves depending on the version of the relay and the configuration (Section 5.1, address **0131**) that was selected. If an inverse overcurrent stage is not required, the address **0131** is set to **Earth Fault O/C** = ***Definite Time***. The $3I_{0P}$–stage can then be used as a fourth definite time stage (refer to “Definite Time Stages” above) or deactivated. In the case of the IEC–curves (address **0131 Earth Fault O/C** = ***TOC IEC***) the following alternatives are available in the address **3151 IEC Curve**:

Inverse (*normal inverse*, Type A according to IEC 60255–3),
Very inverse (*very inverse*, Type B according to IEC 60255–3),
Extremely inv. (*extremely inverse*, Type C according to IEC 60255–3), and
LongTimeInverse (*longtime*, Type B according to IEC 60255–3).

The curves and equations the curves are based on are illustrated in the technical data (Section 10.5, Figure 10-1).

Similar considerations as for the definite time stages (see above) apply to the setting of the pick-up threshold **3I0p PICKUP** (address **3141**). In this case it must be considered that a safety margin has already been included between the pick-up threshold and the setting value. The stage only picks up when the measured signal is approximately 10 % above the setting value.

The time multiplier setting **T 3I0p TimeDial** (address **3143**) is derived from the grading coordination chart which was set up for earth faults in the system.

In addition to the inverse current dependant time delay, a constant (fixed length) time delay can also be set if this is required. The setting **Add.T-DELAY** (address **3147**) is added to the time of the set curve.

Inverse Time Overcurrent Stage with ANSI–Characteristic

Also for the inverse time overcurrent stage the operating mode is initially set: **Op. mode 3I0p** (address **3140**). This stage can be set to operate ***Forward*** (usually towards line) or ***Reverse*** direction (usually towards busbar) or ***Non-Directional*** (in both directions). If a particular stage is not required, set its mode to ***Inactive***.

For the inverse time overcurrent stage $3I_{0P}$ it is possible to select from a variety of curves depending on the version of the relay and the configuration (Section 5.1, address **0131**) that was selected. If an inverse overcurrent stage is not required, the address **0131** is set to **Earth Fault O/C** = ***Definite Time***. The $3I_{0P}$–stage can then be used as a fourth definite time stage (refer to "Definite Time Stages" above) or deactivated. In the case of the ANSI–curves (address **0131 Earth Fault O/C** = ***TOC ANSI***) the following alternatives are available in the address **3151 ANSI Curve**:

Inverse,
Short inverse,
Long inverse,
Moderately inv.,
Very inverse,
Extremely inv. and
Definite inv.

The curves and equations the curves are based on are illustrated in the technical data (Section 10.5, Figure 10-1 and 10-3).

The setting of the pick-up threshold **3I0p PICKUP** (address **3141**) is similar to the setting of definite time stages (see above). In this case it must be considered that a safety margin has already been included between the pick-up threshold and the setting value. The stage only picks up when the measured signal is approximately 10 % above the setting value.

The time multiplier setting **3I0p Time Dial** (address **3144**) is derived from the grading coordination chart which was set up for earth faults in the system.

In addition to the inverse current dependant time delay, a constant (fixed length) time delay can also be set if this is required. The setting **Add.T-DELAY** (address **3147**) is added to the time of the set curve.

Inverse Time Overcurrent Stage with Logarithmic–Inverse Characteristic

For the inverse time overcurrent stage with logarithmic inverse characteristic the operating mode is initially set: **Op. mode 3I0p** (address **3140**). This stage can be set to operate ***Forward*** (usually towards line) or ***Reverse*** direction (usually towards busbar) or ***Non-Directional*** (in both directions). If this stage is not required, set its mode to ***Inactive***.

For the inverse logarithmic curves (address **0131 Earth Fault O/C** = ***TOC Logarithm.***) the following can be set: address **3153 LOG Curve** = ***Log. inverse***.

The curves and equations the curves are based on are illustrated in the technical data (Section 10.5, Figure 10-4). Figure 6-68 illustrates the influence of the most important setting parameters on the curve. **3I0p PICKUP** (address **3141**) is the reference value for all current values, while **3I0p Startpoint** (address **3154**) determines the beginning of the curve, i.e. the lowest operating range on the current axis (referred to **3I0p PICKUP**). The timer setting **3I0p MaxT-DELAY** (address **3146**) determines the starting point of the curve (for $3I_0$ = **3I0p PICKUP**). The time factor **3I0p Time Dial** (address **3145**) changes the slope of the curve. For large currents, **3I0p MinT-DELAY** (address **3142**) determines the lower limit on the time axis. For currents larger than 30·**3I0p PICKUP** the operating time no longer decreases.

Finally in address **3147 Add.T-DELAY** a fixed time delay can be set as was done for other curves. This, however, has almost the same effect on the characteristic as an increase of **3I0p MaxT-DELAY** (address **3146**), but no effect on **3I0p MinT-DELAY** (address **3142**).

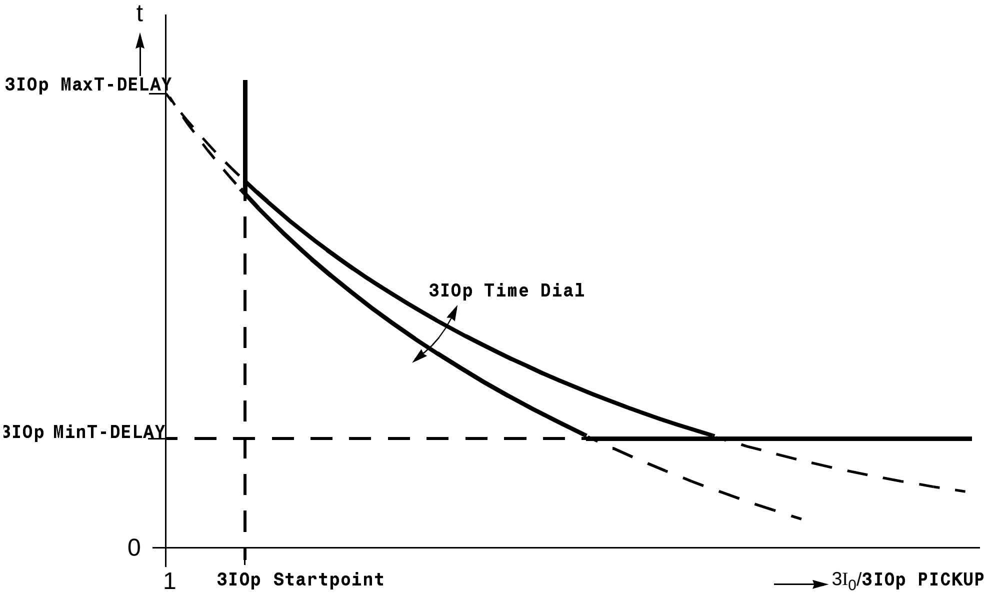


Figure 6-68 Setting parameter characteristics in the logarithmic–inverse curve

Zero Sequence Voltage Stage with Inverse Characteristic

For the zero sequence voltage controlled stage (address 0131 **`Earth Fault O/C`** = ***`U0 inverse`***) the operating mode is initially set: address 3140 **`Op. mode 3I0p`**. This stage can be set to operate ***`Forward`*** (usually towards line) or ***`Reverse`*** (usually towards busbar) or ***`Non-Directional`*** (in both directions). If this stage is not required, set its mode to ***`Inactive`***.

Address 3141 **`3I0p PICKUP`** indicates the minimum current value above which this stage is required to operate. The value must be exceeded by the minimum earth fault current value.

The voltage-controlled characteristic is based on the following formula:

$$t = \frac{2\,s}{0{,}25\; U_0/V - U_{0\,min}/V}$$

U_0 is the actual zero sequence voltage. $U_{0\ min}$ is the setting value **`U0inv. minimum`** (Address 3183). Please take into consideration that the formulae is based on the zero sequence voltage U_0, not on $3U_0$. The function is illustrated in the Technical Data Section (10.5, Figure 10-5).

Figure 6-69 shows the most important parameters. **`U0inv. minimum`** displaces the voltage-controlled characteristic in direction of $3U_0$. The set value is the asymptote for this characteristic ($t \rightarrow \infty$). In Figure 6-69 **a'** shows an asymptote that belongs to the characteristic **a**.

The minimum voltage **`3U0>(U0 inv)`** (address 3182) is the lower voltage threshold. It corresponds to the line **c** in Figure 6-69. In characteristic **b** the curve is cut by the minimum voltage **`3U0>(U0 inv)`** (line **c**).

An additional time **`T forw. (U0inv)`** (address 3184) that is added to the voltage-controlled characteristic can be set for directional-controlled tripping. The directional additional time is usually not required and set to **`0`**.

With the non-directional time **`T rev. (U0inv)`** (Address 3185) a non-directional back-up stage can be generated.

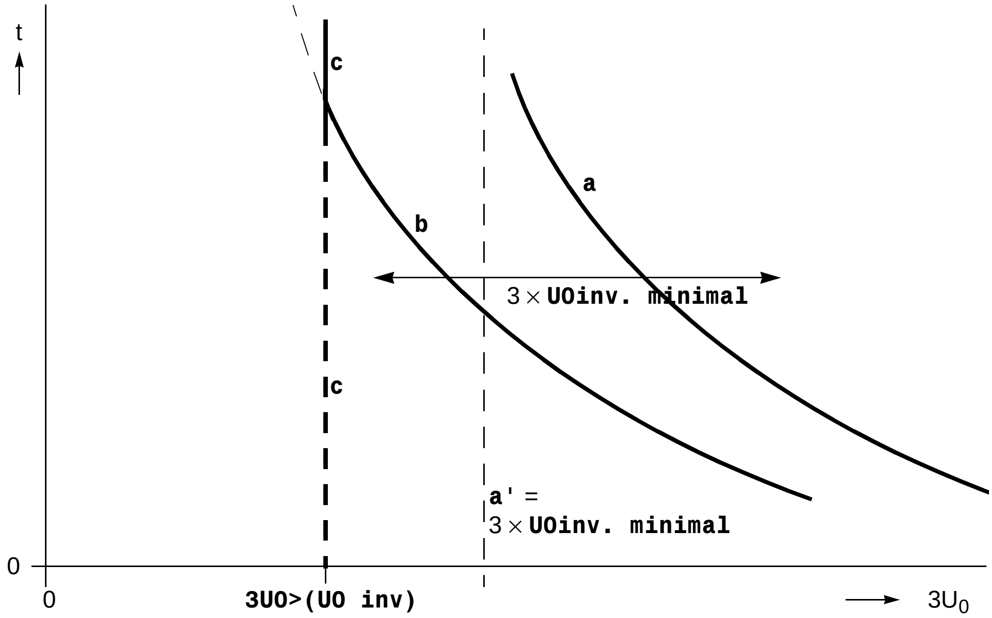


Figure 6-69 Characteristic settings of the zero sequence voltage time dependent stage — without additional times.

Direction Determination

The direction of each required stage was already determined when setting the different stages.

According to the requirements of the application, the directionality of each stage is individually selected. If for instance a directional earth fault protection with a non-directional back-up stage is required, this can be implemented by setting the $3I_0$>>–stage directional with a short or no delay time and the $3I_0$>–stage with the same pick-up threshold but a longer delay time as directional back-up stage. The $3I_0$>>>–stage could be applied as an additional high set instantaneous stage.

If a stage is to operate with teleprotection according to Section 6.6, it may operate without delay in conjunction with a permissive scheme. In the blocking scheme, a short delay equal to the signal transmission time, plus a small reserve margin of approx. 20 ms is sufficient.

The direction is usually determined with the earth current $\underline{I}_E = -3I_0$ as the measured value the angle of which is compared to a polarizing quantity (Sub-section 6.5.1). The desired polarizing signal(s) is set in **POLARIZATION** (address **3160**). The presetting ***with Uo and IY*** generally also applies when only $\underline{U}_E = 3\underline{U}_0$ is used as a polarizing signal. If there is no transformer star-point current $\underline{I}_Y$ connected to the device, automatically only $\underline{U}_E$ influences the direction determination.

If the direction determination must be carried out using only $\underline{I}_Y$ as reference signal, the setting ***with IY only*** is applied. This makes sense if a reliable transformer star-point current $\underline{I}_Y$ is always available at the device input I_4. The direction determination is then not affected by disturbances in the voltage transformer secondary circuits provided that the device is equipped with a normal sensitivity current input I_4 and the transformer star-point current is connected to I_4.

If direction determination must be carried out using the negative sequence system signals $3\underline{I}_2$ and $3\underline{U}_2$ the setting ***with U2 and I2*** is applied. In this case, only the negative sequence system signals computed by the device are used for the direction determination.

The position of the directional characteristic is determined with the setting parameters **`Dir. ALPHA`** and **`Dir. BETA`** (addresses **3162** und **3163**). As these set values are not critical, the pre-settings may be left unchanged. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

Finally, the threshold values of the polarizing signals must be set. **`3U0>`** (address **3164**) determines the minimum operating voltage for direction determination with $\underline{U}_E$. If $\underline{U}_E$ is not used for the direction determination, this setting is of no consequence. The set threshold should not be exceeded by unsymmetries in the operational measured voltage. $\underline{U}_E$ is the sum of the phase voltages, i.o.w.

$$\underline{U}_E = \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} = 3 \cdot \underline{U}_0$$

If the voltage dependent characteristic (U_0 inverse) is used as directional stage, it is reasonable for the minimum polarizing voltage to use a value that is equal to or below the minimum voltage of the voltage-controlled characteristic (address 3182).

Only if the connection of the fourth current transformer **`I4 transformer`** (address **220**) = ***`IY starpoint`*** is registered in the **`Power System Data 1 (P.System Data 1)`** (see 6.1.1), the address **3165 `IY>`** will appear. It is the lower threshold for the current measured in the starpoint of a source transformer. A relatively sensitive setting can be applied for this value, as the measurement of the starpoint current is quite accurate by nature.

If the direction determination must be done with the negative sequence system signals, the setting values **`3U2>`** (address **3166**) and **`3I2>`** (address **3167**) are decisive for the lower limit of the direction determination. The setting values must in this case also be selected such that operational unsymmetry in the system does not lead to a pick-up.

Teleprotection with Earth Fault Protection

The earth fault protection in the 7SA6 may be expanded to a directional comparison protection using the integrated teleprotection logic. Additional information regarding the available teleprotection schemes and their mode of operation may be obtained from Section 6.6. If this is to be used, certain preconditions must already be observed when setting the associated earth current stage.

Initially it must be determined which stage must operate in conjunction with the teleprotection. This stage must be set directional in the forward direction. If for example the $3I_0$>–stage should operate as directional comparison, the address **3130 `Op. mode 3I0>`** is set to ***`Forward`*** (refer to “Definite Time Stages” above, page 6-110).

Furthermore, the device must be informed that the applicable stage has to function together with the teleprotection to allow undelayed release of the tripping during internal faults. For the $3I_0$>–stage this means that address **3133 `3I0p Telep/BI`** is set to ***`Yes`***. The time delay set for this stage **`T 3I0>`** (address **3132**) then functions as a back-up stage, e.g. during failure of the signal transmission. For the remaining stages the corresponding setting parameter is set to ***`No`***, therefore, in this example: address **3123 `3I0>> Telep/BI`** for the $3I_0$>>–stage, address **3113 `3I0>>> Telep/BI`** for the $3I_0$>>>–stage, address **3148 `3I0p Telep/BI`** for the $3I_{0P}$–stage (if this is used).

If the echo function is used in conjunction with the teleprotection scheme, or if the weak-infeed tripping function should be used, the additional teleprotection stage **`3IoMin Teleprot`** (address **3105A**) must be set to avoid non-selective tripping during through-fault earth current measurement. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”. Further comments are given in Sub-section 6.6.2 under the margin heading “Earth Fault Protection Prerequisites”.

Switching on to a Dead Earth Fault

It is possible to determine with a setting which stage trips without delay following closure onto a dead fault. The stages have the setting parameters **`3I0>>>SOTF-Trip`** (address **3114**), **`3I0>> SOTF-Trip`** (address **3124**), **`3I0> SOTF-Trip`** (address **3134**) and if required **`3I0p SOTF-Trip`** (address **3149**), which must accordingly be set for each stage to either ***Yes*** or ***No***. Selection of the most sensitive stage is usually not reasonable as a solid short-circuit may be assumed following switching onto a fault, whereas the most sensitive stage often also has to detect high resistance faults. Transient pick-up of the selected stage, during energization of a healthy line, must be avoided.

On the other hand, it does not matter if a selected stage may pick up due to inrush conditions on transformers (see “Inrush Stabilization” below). The switch-onto-fault tripping of a stage is blocked by the inrush stabilization even if it is set as instantaneous switch-onto-fault stage.

To avoid faulty pick up as a result of transient overcurrents, a time delay **`SOTF Time DELAY`** (address **3173**) can be set. The presetting ***0*** is usually correct. In the case of long cables, where large peak inrush currents can occur, a short delay may be useful. This delay depends on how severe and how long the transient is, and which stages are used for the switch-onto-fault tripping.

With the parameter **`SOTF Op. Mode`** (address **3172**) it is finally possible to determine whether the fault direction must be checked (***PICKUP+DIRECT.***) or not (***PICKUP***), before a switch-onto-fault tripping is generated. It is the direction setting for each stage that applies for this direction check.

Phase Current Stabilization

To avoid a faulty pick-up of the stages in the case of unsymmetrical load conditions or different current transformer measuring errors in earth systems, the earth current stages are stabilized by the phase currents: the pick up thresholds are increased as the phase currents increase (refer also to Figure 6-65). By means of the setting in address **3104** **`Iph-STAB. Slope`** the preset value of 10 % for all stages can be jointly changed for all stages. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

Inrush Stabilization

The inrush stabilization is only required if the device is applied to transformer feeders or on lines that end on a transformer; in this case also only for such stages that have a pick-up threshold below the inrush current and have a very short or zero delay. The parameter **`3I0>>>InrushBlk`** (address **3115**), **`3I0>> InrushBlk`** (address **3125**), **`3I0> InrushBlk`** (address **3135**) and **`3I0p InrushBlk`** (address **3150**) may be set to ***Yes*** (inrush stabilization activated) or ***No*** (inrush stabilization disabled) for each stage. If the inrush stabilization has been disabled for all stages, the following parameters are of no consequence.

For the recognition of the inrush current, the portion of second harmonic current content referred to the fundamental current component can be set in address **3170** **`2nd InrushRest`**. Above this threshold the inrush blocking is effective. The preset value (15 %) should be sufficient in most cases. Lower values imply higher sensitivity of the inrush blocking (smaller portion of second harmonic current results in blocking).

In applications on transformer feeders or lines that are terminated on transformers it may be assumed that, if very large currents occur, a short circuit has occurred in front of the transformer. In the event of such large currents, the inrush stabilization is inhibited. This threshold value which is set in the address **3171** **`Imax InrushRest`**, should be larger than the maximum expected inrush current (RMS value).

6.5.3 Settings

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
3101	FCT EarthFltO/C	ON OFF	ON	Earth Fault overcurrent function is
3102	BLOCK for Dist.	with every Pickup with single-phase Pickup with multi-phase Pickup NO	with every Pickup	Block E/F for Distance protection
3103	BLOCK 1pDeadTim	YES NO	NO	Block E/F for 1pole Dead time
3104A	Iph-STAB. Slope	0..30 %	10 %	Stabilisation Slope with Iphase
3105A	3IoMin Teleprot	0.01..1.00 A	0.50 A	3Io-Min threshold for Teleprot. schemes
3105A	3IoMin Teleprot	0.003..1.000 A	0.500 A	3Io-Min threshold for Teleprot. schemes
3170	2nd InrushRest	10..45 %	15 %	2nd harmonic ratio for inrush restraint
3171	Imax InrushRest	0.50..25.00 A	7.50 A	Max.Current, overriding inrush restraint
3172	SOTF Op. Mode	with Pickup (non-directional) with Pickup and direction	with Pickup and direction	Instantaneous mode after SwitchOnToFault
3173	SOTF Time DELAY	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
3110	Op. mode 3I0>>>	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3111	3I0>>>	0.50..25.00 A	4.00 A	3I0>>> Pickup
3112	T 3I0>>>	0.00..30.00 sec; ∞	0.30 sec	T 3I0>>> Time delay
3113	3I0>>> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI
3114	3I0>>>SOTF-Trip	NO YES	NO	Instantaneous trip after Switch-OnToFault
3115	3I0>>>InrushBlk	NO YES	NO	Inrush Blocking
3120	Op. mode 3I0>>	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3121	3I0>>	0.20..25.00 A	2.00 A	3I0>> Pickup
3122	T 3I0>>	0.00..30.00 sec; ∞	0.60 sec	T 3I0>> Time Delay
3123	3I0>> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI

3172	SOTF Op. Mode	with Pickup (non-directional) with Pickup and direction	with Pickup and direction	Instantaneous mode after SwitchOnToFault
3173	SOTF Time DELAY	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
3110	Op. mode 3I0>>>	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3111	3I0>>>	0.50..25.00 A	4.00 A	3I0>>> Pickup
3112	T 3I0>>>	0.00..30.00 sec; ∞	0.30 sec	T 3I0>>> Time delay
3113	3I0>>> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./BI
3114	3I0>>>SOTF-Trip	NO YES	NO	Instantaneous trip after Switch-OnToFault
3115	3I0>>>InrushBlk	NO YES	NO	Inrush Blocking
3120	Op. mode 3I0>>	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3121	3I0>>	0.20..25.00 A	2.00 A	3I0>> Pickup
3122	T 3I0>>	0.00..30.00 sec; ∞	0.60 sec	T 3I0>> Time Delay
3123	3I0>> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./BI

Addr.	Setting Title	Setting Options	Default Setting	Comments
3141	3I0p PICKUP	0.003..25.000 A	1.000 A	3I0p Pickup
3142	3I0p MinT-DELAY	0.00..30.00 sec	1.20 sec	3I0p Minimum Time Delay
3143	3I0p Time Dial	0.05..3.00 sec; ∞	0.50 sec	3I0p Time Dial
3144	3I0p Time Dial	0.50..15.00; ∞	5.00	3I0p Time Dial
3145	3I0p Time Dial	0.05..15.00 sec; ∞	1.35 sec	3I0p Time Dial
3146	3I0p MaxT-DELAY	0.00..30.00 sec	5.80 sec	3I0p Maximum Time Delay
3147	Add.T-DELAY	0.00..30.00 sec; ∞	1.20 sec	Additional Time Delay
3148	3I0p Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./BI
3149	3I0p SOTF-Trip	NO YES	NO	Instantaneous trip after Switch-OnToFault
3150	3I0p InrushBlk	NO YES	NO	Inrush Blocking
3151	IEC Curve	Normal Inverse Very Inverse Extremely Inverse Long time inverse	Normal Inverse	IEC Curve
3152	ANSI Curve	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
3153	LOG Curve	Logarithmic inverse	Logarithmic inverse	LOGARITHMIC Curve
3154	3I0p Startpoint	1.0..4.0	1.1	Start point of inverse characteristic
3182	3U0>(U0 inv)	1.0..10.0 V	5.0 V	3U0> setpoint
3183	U0inv. minimum	0.1..5.0 V	0.2 V	Minimum voltage U0min for T->oo
3184	T forw. (U0inv)	0.00..32.00 sec	0.90 sec	T-forward Time delay (U0inv)
3185	T rev. (U0inv)	0.00..32.00 sec	1.20 sec	T-reverse Time delay (U0inv)
3160	POLARIZATION	with U0 and IY (dual polarized) with IY (transformer star point current) with U2 and I2 (negative sequence)	with U0 and IY (dual polarized)	Polarization
3162A	Dir. ALPHA	0..360 °; Ø	338 °	ALPHA, lower angle for forward direction
3163A	Dir. BETA	0..360 °; Ø	122 °	BETA, upper angle for forward direction
3164	3U0>	0.5..10.0 V	0.5 V	Min. zero seq.voltage 3U0 for polarizing

Addr.	Setting Title	Setting Options	Default Setting	Comments
3165	IY>	0.05..1.00 A	0.05 A	Min. earth current IY for polarizing
3166	3U2>	0.5..10.0 V	0.5 V	Min. neg. seq. polarizing voltage 3U2
3167	3I2>	0.05..1.00 A	0.05 A	Min. neg. seq. polarizing current 3I2

6.5.4 Information Overview

F.No.	Alarm	Comments
1305	>EF BLK 3I0>>>	>Earth Fault O/C Block 3I0>>>
1307	>EF BLOCK 3I0>>	>Earth Fault O/C Block 3I0>>
1308	>EF BLOCK 3I0>	>Earth Fault O/C Block 3I0>
1309	>EF BLOCK 3I0p	>Earth Fault O/C Block 3I0p
1310	>EF InstTRIP	>Earth Fault O/C Instantaneous trip
1331	E/F Prot. OFF	Earth fault protection is switched OFF
1332	E/F BLOCK	Earth fault protection is BLOCKED
1333	E/F ACTIVE	Earth fault protection is ACTIVE
1345	EF Pickup	Earth fault protection PICKED UP
1354	EF 3I0>>>Pickup	E/F 3I0>>> PICKED UP
1355	EF 3I0>> Pickup	E/F 3I0>> PICKED UP
1356	EF 3I0> Pickup	E/F 3I0> PICKED UP
1357	EF 3I0p Pickup	E/F 3I0p PICKED UP
1358	EF forward	E/F picked up FORWARD
1359	EF reverse	E/F picked up REVERSE
1361	EF Trip	E/F General TRIP command
1366	EF 3I0>>> TRIP	E/F 3I0>>> TRIP
1367	EF 3I0>> TRIP	E/F 3I0>> TRIP
1368	EF 3I0> TRIP	E/F 3I0> TRIP
1369	EF 3I0p TRIP	E/F 3I0p TRIP
1370	EF InrushPU	E/F Inrush picked up

6.6 Earth Fault Protection Teleprotection Schemes

With the aid of the integrated comparison logic, the directional earth fault protection according to Section 6.5 can be expanded to a directional comparison protection scheme.

Teleprotection Methods

One of the stages which must be directional and set **`Forward`** is used for the directional comparison. This stage can only trip if a fault is also seen in the forward direction at the other line end. A release (unblock) signal or a block signal can be transmitted. The following teleprotection schemes are differentiated:

Permissive (release) schemes:

- Directional comparison,
- Directional unblock scheme.

Blocking scheme:

- Blocking of the directional stage.

A further stage may be set as a non directional back up stage.

Signal Transmission Channels

For the signal transmission, one channel in each direction is required. For example, fibre optic connections or voice frequency modulated high frequency channels via pilot cables, power line carrier or microwave radio links can be used for this purpose. If the same transmission channel as for the transmission by the distance protection (section 6.4) is used, the teleprotection scheme must also be the same!

The signal transmission schemes are also suited to three terminal lines (teed feeders). In this case, signal transmission channels are required from each of the three ends to the each of the others in both directions.

During disturbances in the receiver or on the transmission path, the teleprotection supplement may be blocked via a binary input.

6.6.1 Method of Operation

Switching On and Off

The teleprotection function can be switched on and off by means of the parameter **3201 FCT Telep. E/F**, or via the system interface (if available) and via binary inputs (if these are allocated). The switched state is saved internally (refer to Figure 6-70) and secured against loss of auxiliary supply. It is only possible to switch on from the source where previously it had been switched off from. To be active, it is necessary that the function is switched on from all three switching sources.

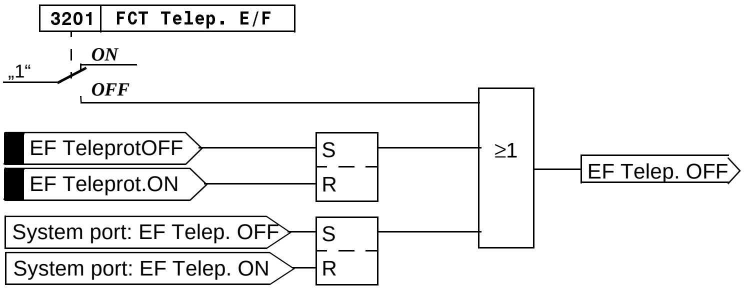


Figure 6-70 Switching on and off of the signal transmission logic

6.6.1.1 Directional Comparison Scheme

Principle

The directional comparison scheme is a permissive scheme. In Figure 6-71 the operation scheme is shown.

When the earth fault protection recognizes a fault in the forward direction, it initially sends a permissive signal to the opposite line end. If a permissive signal is also received from the remote end, the trip signal is passed on to the tripping relay. Accordingly it is a prerequisite for fast tripping that the fault is recognized in the forward direction at both line ends.

The send signal can be prolonged by T_S (parameter setting). The prolongation of the send signal only comes into effect if the protection has already issued a trip command. This ensures that the permissive signal releases the opposite line end even if the earth fault is very rapidly cleared by a different independent protection.

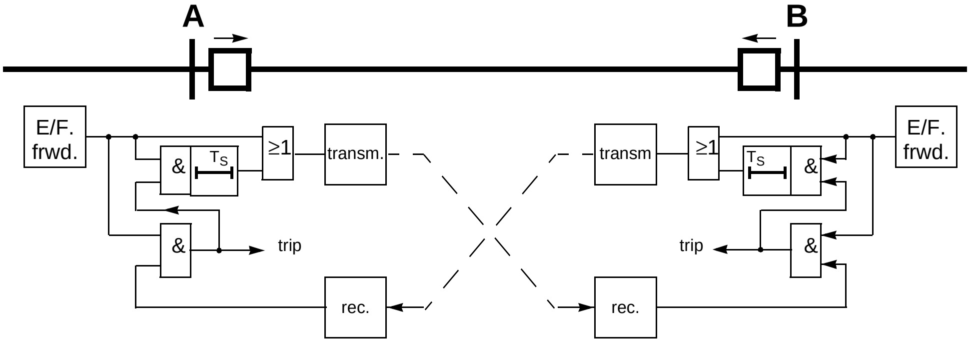


Figure 6-71 Operation scheme of the directional comparison method

Sequence

Figure 6-72 shows the logic diagram of the directional comparison scheme for one line end.

The directional comparison only functions for faults in the “forward” direction. Accordingly the overcurrent stage intended for operation in the direction comparison mode must definitely be set to ***Forward*** (**3I0... DIRECTION**); refer also to Sub-section 6.5.2 under the margin heading “Teleprotection with Earth Fault Protection”.

On three terminal lines, the send signal is routed to both opposite line ends. The receive signals are then combined with a logical *AND* gate, as all three line ends must transmit a send signal during an internal fault. Via the setting parameter **Line Config.** (address **3202**), the device is informed as to whether it has one or two opposite line ends.

The occurrence of erroneous signals resulting from transients during clearance of external faults or from direction reversal resulting during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking” (refer to Sub-section 6.6.1.4).

On feeders with only a single-sided infeed or where the system starpoint is only earthed behind one line end, the line end without zero sequence current cannot generate a permissive signal, as fault detection does not take place there. To ensure tripping by the directional comparison even in this case the device contains a special function. This “Weak Infeed Function” (echo function) is referred to in Sub-section 6.6.1.5. It is activated when a signal is received from the opposite line end — in the case of three terminal lines from at least one of the opposite line ends — without the device having detected a fault.

The circuit breaker can also be tripped at the line end with no or only weak infeed. This “Weak-Infeed Tripping” is referred to in Section 6.7.

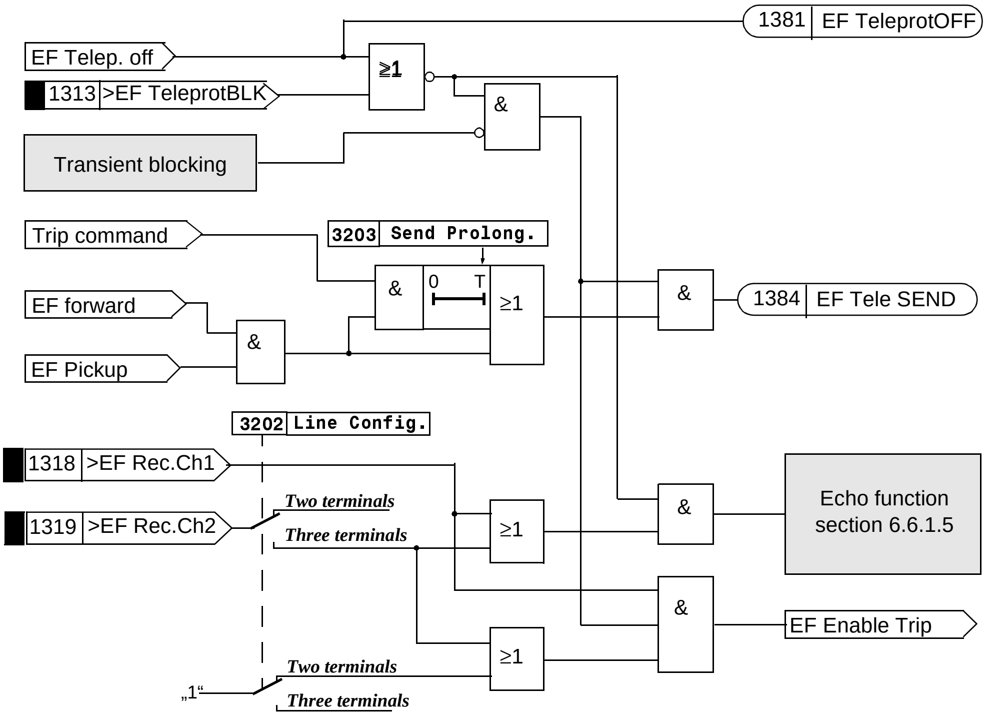


Figure 6-72 Logic diagram of the directional comparison scheme (one line end)

6.6.1.2 Directional Unblocking Scheme

Principle

The unblocking method is a permissive scheme. The difference to the Directional Comparison Scheme (Sub-section 6.6.1.1) lies in that tripping is also possible when no permissive signal from the opposite line end is received. Accordingly it is mainly used on long lines where the signal is transmitted via the protected feeder by means of power line carrier (PLC) and the attenuation in the signal transmission path at the fault location can be so severe that reception of the signal from the opposite line end cannot necessarily be guaranteed. A special unblock logic takes effect here.

Figure 6-73 shows the operation scheme.

Two signal frequencies which are keyed by the transmit output of the 7SA6 are required for the transmission. If the transmission device has a channel monitoring, then the monitoring frequency f_0 is keyed over to the working frequency (unblocking frequency) f_U. When the protection recognizes an earth fault in the forward direction, it initiates the transmission of the unblock frequency f_U. During the quiescent state or during an earth fault in the reverse direction, the monitoring frequency f_0 is transmitted.

If the unblock frequency f_U is faultlessly received from the opposite end, a release signal is routed to the trip logic. A pre-condition for fast fault clearance is therefore that the earth fault is recognized in the forward direction at both line ends.

The send signal can be prolonged by T_S (parameter setting). The prolongation of the send signal only comes into effect if the protection has already issued a trip command. This ensures that the permissive signal releases the opposite line end even if the earth fault is very rapidly cleared by a different independent protection.

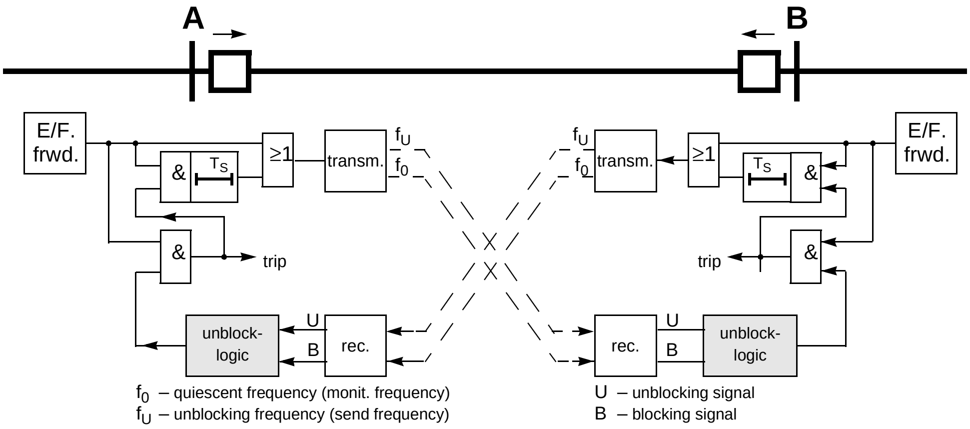


Figure 6-73 Operation scheme of the directional unblocking method

Sequence

Figure 6-74 shows the logic diagram of the unblocking scheme for one line end.

The directional unblocking scheme only functions for faults in the “forward” direction. Accordingly the overcurrent stage intended for operation in the direction comparison mode must definitely be set to ***Forward*** (**3I0... DIRECTION**); refer also to Sub-section 6.5.2 under the margin heading “Teleprotection with Earth Fault Protection”.

On three terminal lines, the send signal is routed to both opposite line ends. The receive signals are then combined with a logical *AND* gate, as all three line ends must transmit a send signal during an internal fault. Via the setting parameter **Line**

Config. (address **3202**), the device is informed as to whether it has one or two opposite line ends.

If the unblock frequency f_U is received without interference — in the case of three terminal lines both receive signals combined by *AND* — it is used to release tripping. If the transmitted signal does not reach the other line end because the short circuit on the protected feeder causes too much attenuation or reflection of the transmitted signal, the unblock logic takes effect: neither the unblock signal “>**EF UB ub 1**” nor the monitoring signal “>**EF UB bl 1**” are received. In this event, the release state in the logic is set after a security margin of 20 ms. With the timer stage 100/100 ms this release is however removed after a further 100 ms. If the interference signal disappears again the quiescent state is reached again after a further 100 ms (reset delay of the timer 100/100 ms). On three terminal lines, the unblock logic can be controlled via both receive channels.

The occurrence of erroneous signals resulting from transients during clearance of external faults or from direction reversal resulting during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking” (refer to Sub-section 6.6.1.4).

On lines where there is only a single sided infeed or where the system starpoint is only earthed behind one line end, the line end without zero sequence current cannot generate a permissive signal, as fault detection does not take place there. To ensure tripping by the directional comparison even in this case the device has special features. This “Weak Infeed Function” is referred to in Sub-section 6.6.1.5. It is activated when a signal is received from the opposite line end — on three terminal lines, from at least one of the opposite ends — without the device recognizing an earth fault.

The circuit breaker can also be tripped at the line end with no or only weak infeed. This “Weak-Infeed Tripping” is referred to in Section 6.7.

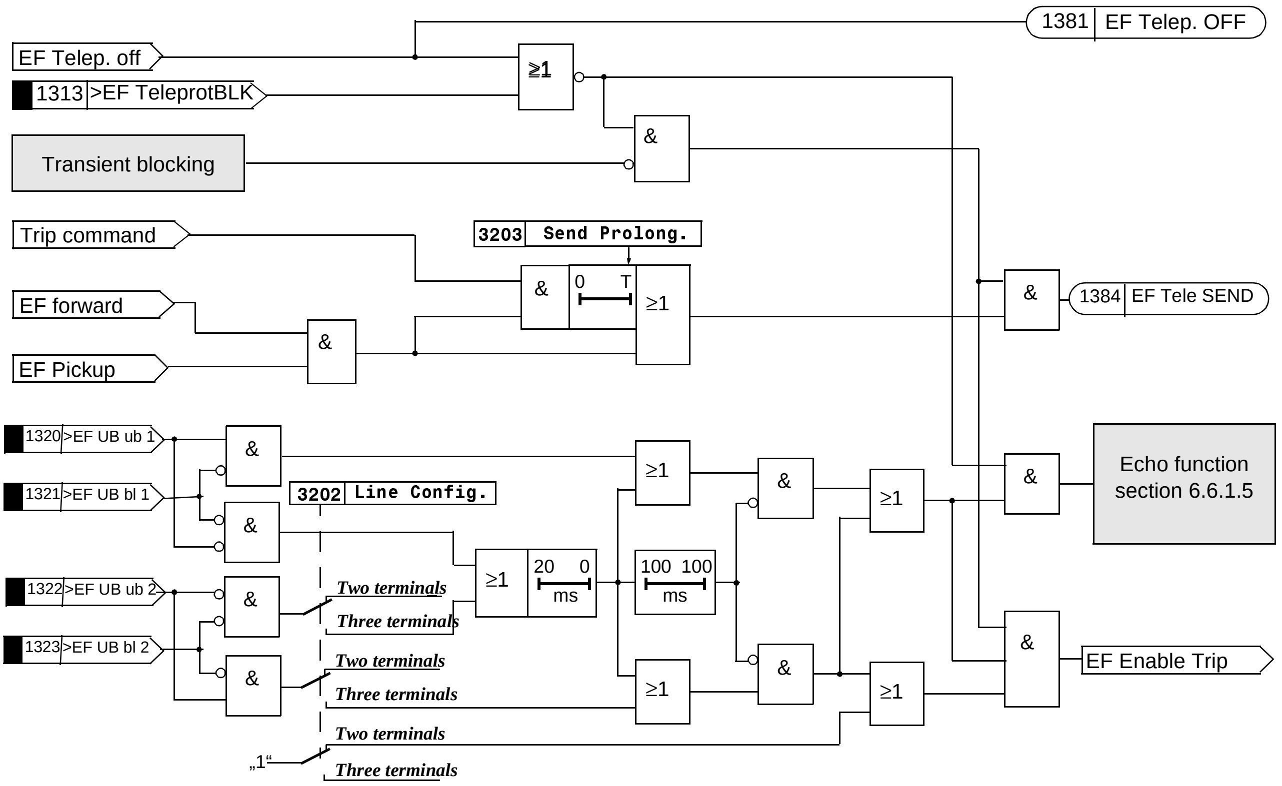


Figure 6-74 Logic diagram of the unblocking scheme (one line end)

6.6.1.3 Directional Blocking Scheme

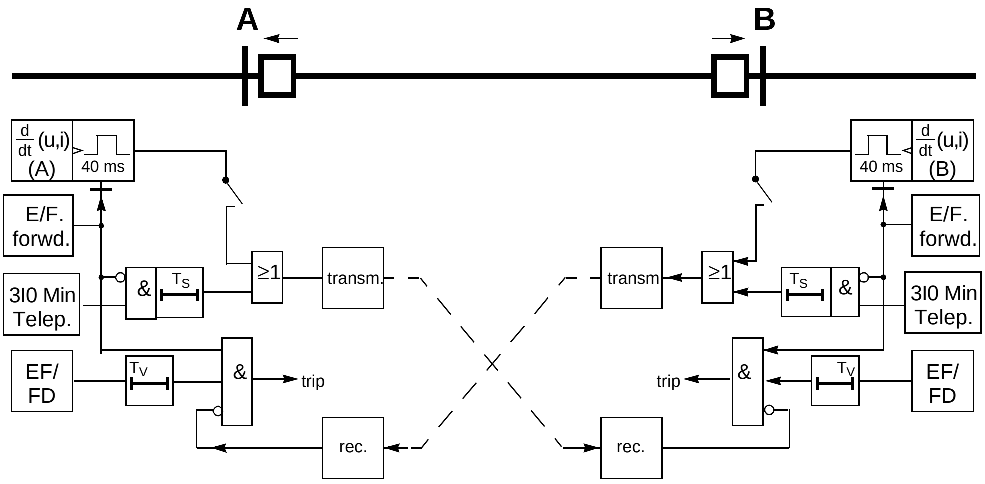
Principle

In the case of the blocking scheme, the transmission channel is used to send a block signal from one line end to the other. The signal transmission is started as soon as a fault in reverse direction is detected, optionally also right after fault inception (jump detector via dashed line). It is stopped as soon as the earth fault protection detects a fault in forward direction, alternatively the signal is only sent when the earth fault protection detects the fault in the reverse direction. On the other hand the signal will be maintained if the fault is in reverse direction. If the signal is sent with jump detections (i. e. 1390 **EF Tele BL Jump** is routed in parallel with 1384 **EF Tele SEND**), only a short delay to allow for signal transmission is required before the directional E/F trips. Tripping is possible with this scheme even if no signal is received from the opposite line end. It is therefore mainly used for long lines when the signal must be transmitted across the protected feeder by means of power line carrier (PLC) and the attenuation of the transmitted signal at the fault location may be so severe that reception at the other line cannot necessarily be guaranteed.

In Figure 6-75 the operation scheme is shown.

Earth faults in the forward direction cause tripping if a blocking signal is not received from the opposite line end. Due to possible differences in the pick up time delays of the devices at both line ends and due to the signal transmission time delay, the tripping must be somewhat delayed by T_V in this case.

To avoid signal race conditions, a transmit signal can be prolonged by the settable time T_S once it has been initiated.



EF/FD = Pickup by any E/F stage

Figure 6-75 Operation scheme of the directional blocking method

Sequence

Figure 6-76 shows the logic diagram of the blocking scheme for one line end.

The stage to be blocked must be set to ***Forward*** (**`3I0... DIRECTION`**); also refer to Sub-section 6.5.2 under margin heading „Teleprotection with Earth Fault Protection“.

The occurrence of erroneous signals resulting from transients during clearance of external faults or from direction reversal resulting during the clearance of faults on parallel lines, is neutralized by the “Transient Blocking”. It prolongs the blocking signal by the transient blocking time **`TrBlk BlockTime`** (address **`3210`**), if it has been present for the minimum duration equal to the waiting time **`TrBlk Wait Time`** (address **`3209`**).

It lies in the nature of the blocking scheme that earth faults with single sided infeed can be rapidly cleared without any special measures, as the non feeding end does not generate a blocking signal.

On three terminal lines, the transmit signal is sent to both opposite line ends. The receive signal is then combined with a logical *OR* gate as no blocking signal must be received from any line end during an internal fault. With the setting parameter **`Line Config.`** (address **`3202`**) the device is informed as to whether it has one or two opposite line ends.

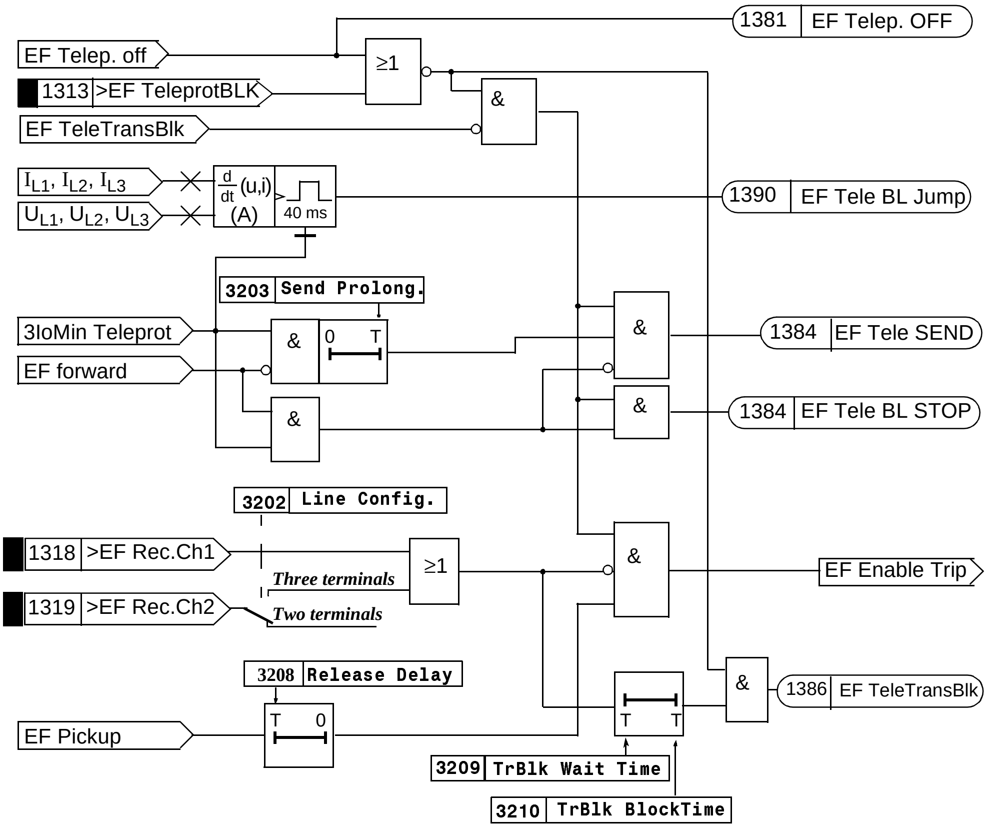


Figure 6-76 Logic diagram of the blocking scheme (one line end)

6.6.1.4 Transient Blocking

Transient blocking provides additional security against erroneous signals due to transients caused by clearance of an external fault or by fault direction reversal during clearance of a fault on a parallel line.

The principle of transient blocking scheme is that following the incidence of an external fault, the formation of a release signal is prevented for a certain (settable) time. In the case of permissive schemes, this is achieved by blocking of the transmit and receive circuit.

Figure 6-77 shows the principle of the transient blocking for a directional comparison and directional unblocking scheme.

If a fault in the reverse direction is detected within the waiting time **TrBlk Wait Time** (address **3209**) following fault detection, the transmit circuit and the trip release are inhibited. This blocking is maintained for the duration of the transient blocking time **TrBlk BlockTime** (address **3210**) also after the reset of the blocking criterion.

In the case of the blocking scheme, the transient blocking prolongs the received blocking signal as shown in the logic diagram Figure 6-76.

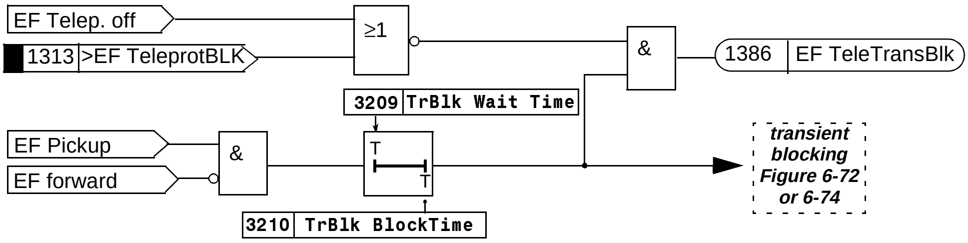


Figure 6-77 Transient blocking for a directional comparison and directional unblocking schemes

6.6.1.5 Measures for Weak or Zero Infeed

On lines where there is only a single sided infeed or where the system starpoint is only earthed behind one line end, the line end without zero sequence current cannot generate a permissive signal, as fault detection does not take place there. With the comparison schemes, using a permissive signal, fast tripping could not even be achieved at the line end with strong infeed without special measures, as the end with weak infeed does not transmit a permissive release signal.

To achieve rapid tripping at both line ends under these conditions, the device has a special supplement for lines with weak zero sequence current infeed.

To enable even the line end with the weak infeed to trip, 7SA6 provides a weak infeed tripping supplement. As this is a separate protection function with a dedicated trip command, it is described in a separate section (6.7).

Echo Function

Figure 6-78 shows the method of operation of the echo function. It may be switched in address **2501 FCT Weak Infeed** (Weak Infeed MODE) to be activated (***ECHO only***) or to be deactivated (***OFF***). By means of this “switch” the weak infeed tripping function can also be activated (***ECHO and TRIP***, refer also to Section 6.7). This setting is common to the teleprotection function for the distance protection and for the earth fault protection.

The received signal at the line end that has no earth current is returned to the other line end as an “echo” by the echo function. The received echo signal at the other line end enables the release of the trip command.

The detection of the weak infeed condition and accordingly the requirement for an echo are combined in the central *AND* gate (Figure 6-78). The earth fault protection must neither be switched off nor blocked, as it would otherwise always produce an echo due to the missing fault detection.

The essential condition for an echo is the absence of an earth current (current stage **3IoMin Teleprot**) with the simultaneous reception signal from the teleprotection scheme logic, as shown in the corresponding logic diagrams (Figure 6-72 or 6-74).

To prevent the generation of an echo signal after the line has been tripped and the earth current stage **3IoMin Teleprot** has reset, it is not possible to generate an echo if a fault detection by the earth current stage had already been present (RS flip-flop in Figure 6-78). In any event, the echo may be blocked at any time via the binary input „**>EF BlkEcho**“.

If the conditions for an echo signal are met, a short delay **Trip/Echo DELAY** is initially activated. This delay is necessary to avoid transmission of the echo if the protection at the weak line end has a longer fault detection time during reverse faults or if it picks up a little later due to unfavourable fault current distribution. If however the circuit breaker at the non-feeding line end is open, this delay of the echo signal is not required. The echo delay time may then be bypassed. The circuit breaker switching state is provided by the central information function control. (refer to Section 6.20).

The echo impulse is then transmitted (alarm output “`ECHO SIGNAL`”), the duration of which can be set with the parameter **`Trip EXTENSION`**.

Note:

The “**`ECHO SIGNAL`**” (F.No. 4246) must be separately assigned to the output relay that is used for signal transmission, as it is not included in the transmit signal “`EF Tele SEND`”.

After transmission of the echo impulse, the transmission of a new echo is prevented for at least 20 ms. This prevents from repetition of an echo after the line has been switched off.

The echo function is not required for the blocking scheme, and is therefore ineffective.

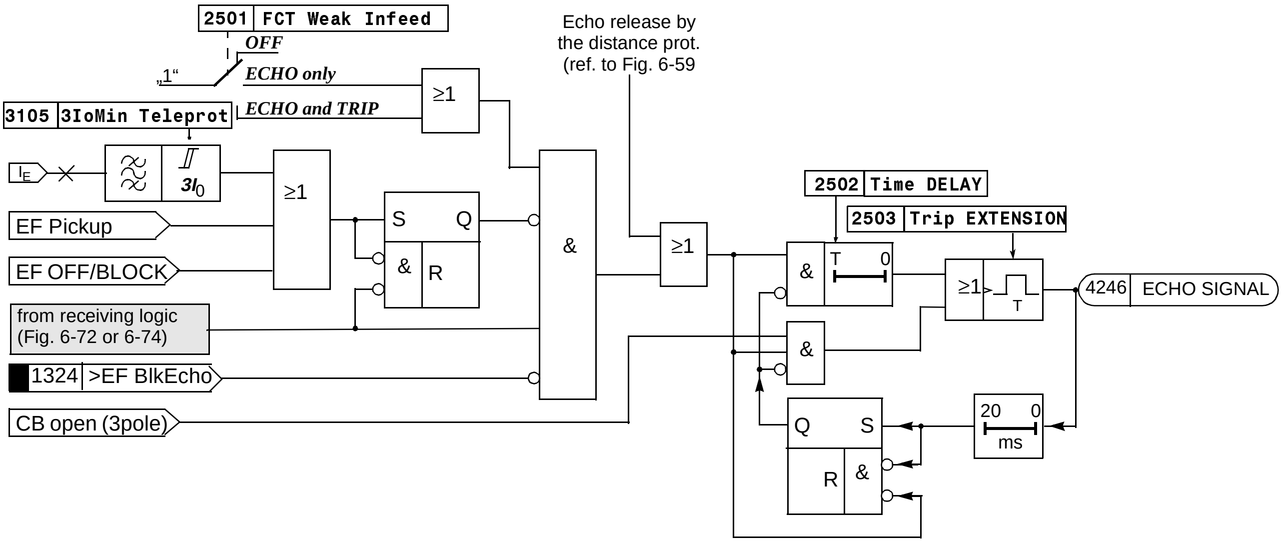


Figure 6-78 Logic diagram of the echo function for the earth fault protection with teleprotection

6.6.2 Applying the Function Parameter Settings

General

The teleprotection supplement for earth fault protection is only operational if it was set to one of the available modes during the configuration of the device (address **0132**). Depending on this configuration, only those parameters which are applicable to the selected mode appear here. If the teleprotection supplement is not required the address **0132** is set to **Teleprot. E/F** = ***Disabled***.

The following teleprotection schemes can be selected:

- ***Dir.Comp.Pickup*** = Directional Comparison Scheme, as described in Sub-section 6.6.1.1,
- ***Unblocking*** = Directional Unblocking Scheme, as described in Sub-section 6.6.1.2,
- ***Blocking*** = Directional Blocking Scheme, as described in Sub-section 6.6.1.3.

In address **3201 FCT Telep. E/F** the application of teleprotection can be switched ***ON*** or ***OFF***.

If the teleprotection has to be applied to a three terminal line the setting in address **3202** must be **Line Config.** = ***Three terminals***, if not, the setting remains ***Two terminals***.

Earth Fault Protection Prerequisites

In the application of the comparison schemes, absolute care must be taken that both line ends recognize an external earth fault (earth fault through-current) in order to avoid a faulty echo signal in the case of the permissive schemes, or in order to ensure the blocking signal in the case of the blocking scheme. If, during an earth fault according to Figure 6-79, the protection at B does not recognize the fault, this would be interpreted as a fault with single sided infeed from A (echo from B or no blocking signal from B), which would lead to unwanted tripping by the protection at A. For this reason, the earth fault protection has an earth current stage **3IoMin Teleprot** (address **3105**). This stage must be set more sensitive than the earth current stage used for the teleprotection. The larger the capacitive earth current ($\underline{I}_{EC}$ in Figure 6-79) is the smaller this stage must be set. On overhead lines a setting equal to 70 % to 80 % of the earth current stage is usually adequate. On cables or very long lines where the capacitive currents in the event of an earth fault are of the same order of magnitude as the earth fault currents the echo function should not be used or restricted to the case where the circuit breaker is open; the blocking scheme should not be used under these conditions at all. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

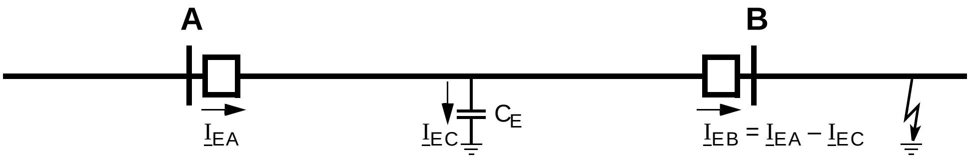


Figure 6-79 Possible current distribution during external earth fault

On three terminal lines (teed feeders) it should further be noted that the earth fault current is not equally distributed on the line ends during an external fault. The most unfavourable case is shown in Figure 6-80. In this case, the earth current flowing in from A is distributed equally on the line ends B and C. The setting value **3IoMin Teleprot** (address **3105**), which is decisive for the echo or the blocking signal, must therefore be set smaller than one half of the setting value for the earth current stage used for teleprotection. In addition, the above comments regarding the capacitive earth current which is left out in Figure 6-80 apply. If the earth current distribution is different from the distribution assumed here, the conditions are more favourable as one of the two earth currents $\underline{I}_{EB}$ or $\underline{I}_{EC}$ must then be larger than in the situation described previously.

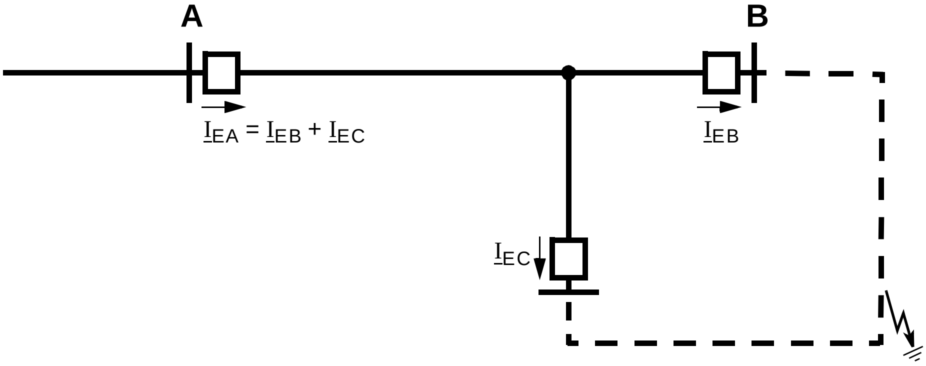


Figure 6-80 Possible unfavourable current distribution on a three terminal line during an external earth fault.

Time Settings

The send signal prolongation **Send Prolong.** (address **3203**) must ensure that the transmitted signal reliably reaches the opposite line end, even if tripping is very fast at the sending line end and/or the signal transmission time (channel delay) is relatively long. In the case of the permissive schemes ***Dir.Comp.Pickup*** and ***UNBLOCKING*** this signal prolongation only comes into effect if the device has already issued a trip command. This ensures the release of the other line end even if the fault is cleared very rapidly by a different protection function or other stage. In the case of the blocking scheme ***BLOCKING*** the transmit signal is always prolonged by this time. In this case it corresponds to a transient blocking following a reverse fault. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

The release of the directional tripping can be delayed by means of the permissive signal delay **Release Delay** (address **3208**). This is only required for the blocking scheme ***BLOCKING*** to allow sufficient transmission time for the blocking signal during external faults. This delay *only* has an effect on the receive circuit of the teleprotection; conversely tripping by the comparison protection is *not* delayed by the set time delay of the directional stage.

Transient Blocking

The setting parameters **TrBlk Wait Time** and **TrBlk BlockTime** are for the transient blocking with the comparison protection. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

The time **TrBlk Wait Time** (address **3209**) is a waiting time prior to transient blocking. In the case of the permissive schemes, only once the directional stage of the earth fault protection has recognized a fault in the reverse direction, within this period of time after fault detection, will the transient blocking be activated. In the case of the blocking scheme, the waiting time prevents transient blocking in the event that the blocking signal reception from the opposite line end is very fast. With the setting ∞ there is no transient blocking.

The transient blocking time **`TrBlk BlockTime`** (address **3210**) must definitely be set longer than the duration of severe transients resulting from the inception or clearance of external faults. The transmit signal is delayed by this time in the case of the permissive protection schemes ***`Dir.Comp.Pickup`*** and ***`UNBLOCKING`*** if the protection had initially detected a reverse fault. In the case of the blocking scheme ***`BLOCKING`*** the received (blocking) signal is prolonged by this time.

The preset value should be sufficient in most cases.

Echo Function

In the case of line ends with weak infeed, or not sufficient earth fault current, the echo function is sensible for the permissive scheme so that the infeeding line end can be released. The echo function may be activated under address **2501** **`FCT Weak Infeed`** (***`ECHO only`***) or deactivated (***`OFF`***). With this “switch” it is also possible to activate the weak infeed tripping (***`ECHO and TRIP`***, refer also to Section 6.7).

The comments above regarding the setting of the current stage **`3IoMin Teleprot`** (address **3105**) must be noted as well as the margin heading “Earth Fault Protection Prerequisites”.

The echo delay time **`Trip/Echo DELAY`** (address **2502**) must be set long enough to ensure that no unwanted echo signals are generated due to differences in the pick-up times of the earth fault protection fault detection at the two line ends during external faults (through-fault current). Typical setting is approx. 40 ms (presetting). This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

The echo impulse duration **`Trip EXTENSION`** (address **2503**) may be matched to the configuration data of the signal transmission equipment. It must be set long enough to ensure that the received signal is reliably detected taking into consideration possible differences in the operating times of the protection and transmission equipment at the two line ends. In most cases approx. 50 ms (presetting) is sufficient. This setting can only be changed with DIGSI® 4 under “**Additional Settings**”.

The echo function settings are common to all weak infeed measures and summarized in tabular form in Section 6.7.

6.6.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
3201	FCT Telep. E/F	ON OFF	ON	Teleprotection for Earth Fault O/C
3202	Line Config.	Two Terminals Three Terminals	Two Terminals	Line Configuration
3203A	Send Prolong.	0.00..30.00 sec; Ø	0.05 sec	Time for send signal prolongation
3207A	Delay for alarm	0.00..30.00 sec; Ø	10.00 sec	Unblocking: Time Delay for Alarm
3208	Release Delay	0.000..30.000 sec; Ø	0.000 sec	Time Delay for release after pickup
3209A	TrBlk Wait Time	0.00..30.00 sec; Ø; ∞	0.04 sec	Transient Block.: Duration external flt.
3210A	TrBlk BlockTime	0.00..30.00 sec; Ø	0.05 sec	Transient Block.: Blk.T. after ext. flt.

6.6.4 Information Overview

F.No.	Alarm	Comments
1311	>EF Teleprot.ON	>E/F Teleprotection ON
1312	>EF TeleprotOFF	>E/F Teleprotection OFF
1313	>EF TeleprotBLK	>E/F Teleprotection BLOCK
1318	>EF Rec.Ch1	>E/F Carrier RECEPTION, Channel 1
1319	>EF Rec.Ch2	>E/F Carrier RECEPTION, Channel 2
1320	>EF UB ub 1	>E/F Unblocking: UNBLOCK, Channel 1
1321	>EF UB bl 1	>E/F Unblocking: BLOCK, Channel 1
1322	>EF UB ub 2	>E/F Unblocking: UNBLOCK, Channel 2
1323	>EF UB bl 2	>E/F Unblocking: BLOCK, Channel 2
1324	>EF BlkEcho	>E/F BLOCK Echo Signal
1380	EF TeleON/offBI	E/F Teleprot. ON/OFF via BI
1381	EF Telep. OFF	E/F Teleprotection is switched OFF
1384	EF Tele SEND	E/F Telep. Carrier SEND signal
1386	EF TeleTransBlk	E/F Telep. Transient Blocking
1387	EF TeleUB Fail1	E/F Telep. Unblocking: FAILURE Channel 1
1388	EF TeleUB Fail2	E/F Telep. Unblocking: FAILURE Channel 2
1389	EF Tele BL STOP	E/F Telep. Blocking: carrier STOP signal
1390	EF Tele BL Jump	E/F Tele.Blocking: Send signal with jump

6.7 Weak-Infeed Tripping

6.7.1 Method of Operation

In cases, where there is no or only weak infeed present at one line end, the distance protection does not pick up there during a short-circuit on the line.

If there is no or only a very small zero sequence current at one line end during an earth fault, the earth fault protection can also not function.

By coordinating the weak infeed function with the teleprotection in conjunction with distance protection (refer to Section 6.4) and/or the teleprotection in conjunction with earth fault protection (refer to Section 6.6), fast tripping can also be achieved at both line ends in the above cases.

At the strong infeed line end, the distance protection can always trip instantaneously for faults inside zone Z1. With permissive teleprotection schemes, fast tripping for faults on 100 % of the line length is achieved by activation of the echo function (refer to Sub-section 6.4.1.11). This provides the permissive release of the trip signal at the strong infeed line end.

The permissive teleprotection scheme in conjunction with the earth fault protection can also achieve release of the trip signal at the strong infeed line end by means of the echo function (refer to Sub-section 6.6.1.5).

In many cases tripping of the circuit breaker at the weak infeeding line end is also desired. For this purpose the device 7SA6 has a dedicated protection function with dedicated trip command.

In Figure 6-81 the logic diagram of the weak-infeed tripping is shown. It may be activated in address **`2501 FCT Weak Infeed`** (Weak Infeed MODE) (***`ECHO and TRIP`***) or deactivated (***`OFF`***). If this “switch” is set to ***`ECHO only`***, the tripping is also disabled; however the echo function to release the infeeding line end is activated (refer also to Sub-section 6.4.1.11 and 6.6.1.5). The tripping function can be blocked at any time via the binary input “`>BLOCK Weak Inf`”.

The logic for the detection of a weak-infeed condition is built up per phase in conjunction with the distance protection and additionally once for the earth fault protection. This allows single-pole tripping in conjunction with the distance protection assuming the device version has the single-pole tripping option.

In the event of a fault, it may be assumed that only a small voltage appears at the line end with the weak-infeed condition, as the small fault current only produces a small voltage drop in the short-circuit loop. In the event of zero-infeed, the loop voltage is approximately zero. The weak-infeed tripping is therefore dependent on the measured undervoltage which is also used for the selection of the faulty phase.

If a signal is received from the opposite line end without fault detection by the local protection, this indicates that there is a fault on the protected feeder. In the case of three terminal lines, a receive signal from neither of the two opposite ends may be present.

After a security margin time of 40 ms following the start of the receive signal, the weak-infeed tripping is released if the remaining conditions are satisfied: undervoltage, circuit breaker closed and no fault detection.

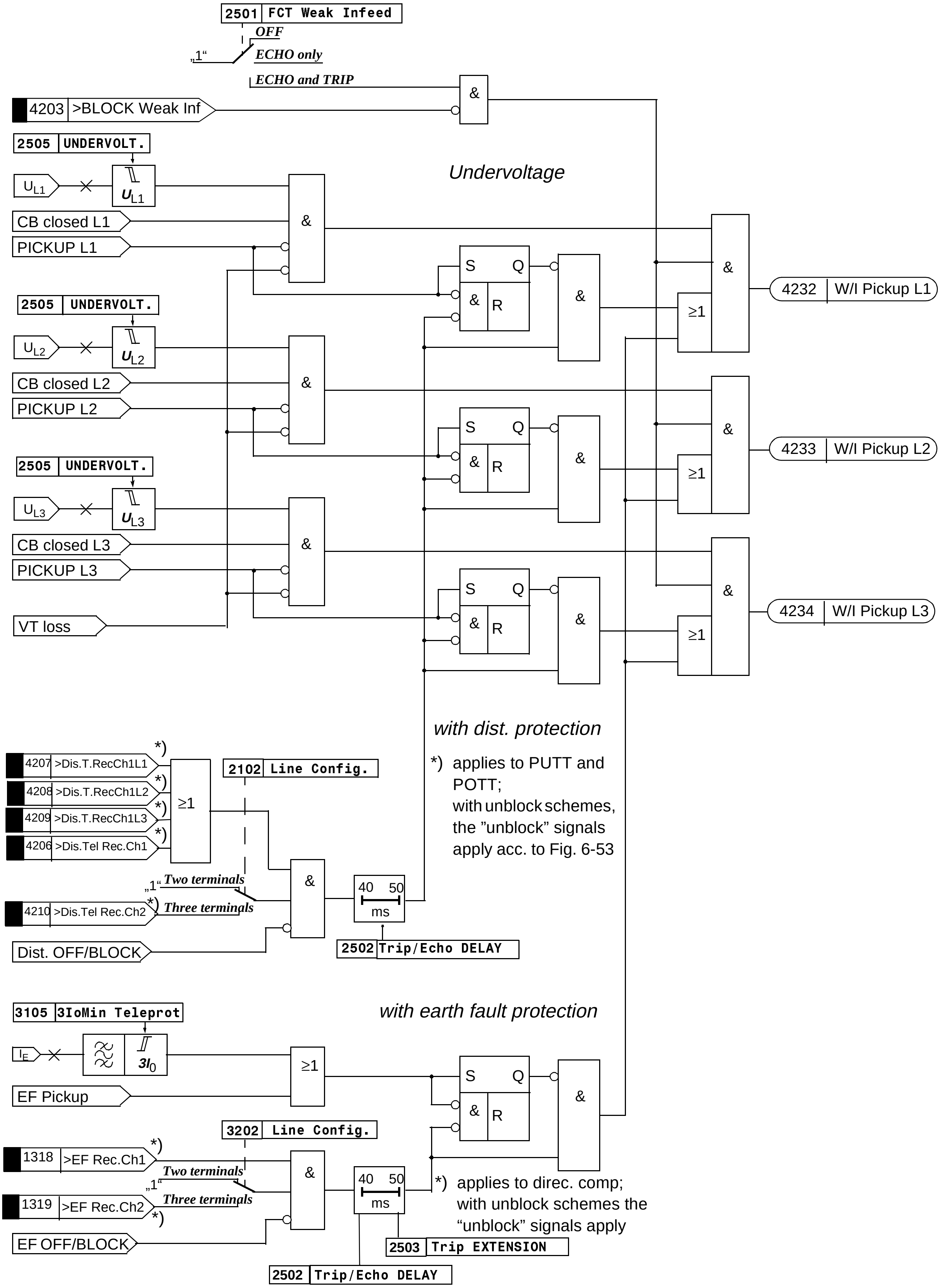


Figure 6-81 Logic diagram of the weak infeed tripping

To avoid a faulty pick up of the weak infeed function following tripping of the line and reset of the fault detection, the function cannot pick up any more once a fault detection in the affected phase was present (RS flip-flop in Figure 6-81).

In the case of the earth fault protection, the release signal is routed via the phase segregated logic modules. Single-phase tripping is therefore also possible if, besides the distance protection, the earth fault protection also issues a release condition.

6.7.2 Applying the Function Parameter Settings

It is a prerequisite for the operation of the weak infeed function that it was enabled during the configuration of the device (Section 5.1) under address **0125 Weak Infeed** = ***Enabled***.

With the parameter **FCT Weak Infeed** (address **2501**) it is determined whether the device shall trip during a weak infeed condition or not. With the setting ***ECHO and TRIP*** both the echo function and the weak infeed tripping function are activated. With the setting ***ECHO only*** the echo function for provision of the release signal at the infeeding line end is activated. There is however no tripping at the line end with missing or weak infeed condition. As the weak-infeed measures are dependent on the signal reception from the opposite line end, they only make sense if the protection is coordinated with teleprotection (refer to Section 6.4 and/or 6.6).

The receive signal is a functional component of the trip condition. Accordingly, the weak infeed tripping function must **not** be used **with the blocking schemes**. It is only permissible with the permissive schemes and the comparison schemes with release signals. In all other cases it must be switched off in address **2501** ***OFF***. In such cases it is better to disable this function from the onset by selecting the setting in address **0125** to ***Disabled***, during the device configuration. The associated parameters are then not accessible.

The undervoltage setting value **UNDERVOLTAGE** (address **2505**) must in any event be set below the minimum expected operational phase–earth voltage. The lower limit for this setting is given by the maximum expected voltage drop at the relay location on the weak-infeed side during a short-circuit on the protected feeder for which the distance protection may no longer pick up.

The remaining settings apply to the echo function and are described in the corresponding sections (6.4.2 and/or 6.6.2).

6.7.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
2501	FCT Weak Infeed	OFF Echo only Echo and Trip	Echo only	Weak Infeed function is
2502A	Trip/Echo DELAY	0.00..30.00 sec; Ø	0.04 sec	Trip / Echo Delay after carrier receipt
2503A	Trip EXTENSION	0.00..30.00 sec; Ø	0.05 sec	Trip Extension / Echo Impulse time
2505	UNDERVOLTAGE	2..70 V	25 V	Undervoltage (ph-e)

6.7.4 Information Overview

F.No.	Alarm	Comments
4203	>BLOCK Weak Inf	>BLOCK Weak Infeed Trip function
4221	WeakInf. OFF	Weak Infeed Trip fct. is switched OFF
4222	Weak Inf. BLOCK	Weak Infeed Trip function is BLOCKED
4223	Weak Inf ACTIVE	Weak Infeed Trip function is ACTIVE
4231	WeakInf. PICKUP	Weak Infeed Trip function PICKED UP
4232	W/I Pickup L1	Weak Infeed Trip function PICKUP L1
4233	W/I Pickup L2	Weak Infeed Trip function PICKUP L2
4234	W/I Pickup L3	Weak Infeed Trip function PICKUP L3
4241	WeakInfeed TRIP	Weak Infeed General TRIP command
4242	Weak TRIP 1p.L1	Weak Infeed TRIP command - Only L1
4243	Weak TRIP 1p.L2	Weak Infeed TRIP command - Only L2
4244	Weak TRIP 1p.L3	Weak Infeed TRIP command - Only L3
4245	Weak TRIP L123	Weak Infeed TRIP command L123
4246	ECHO SIGNAL	ECHO Send SIGNAL

6.8 External Direct and Remote Tripping

6.8.1 Method of Operation

External Trip of the Local Circuit Breaker

Any signal from an external protection or monitoring device can be coupled into the signal processing of the 7SA6 by means of a binary input. This signal may be delayed, alarmed and routed to one or several output relays. In Figure 6-82 the logic diagram is shown. If the device and circuit breaker are capable of single-phase operation, it is also possible to trip single phase. The tripping logic of the device in this case ensures that the conditions for single-phase tripping are satisfied (e.g. single-phase tripping enabled, automatic reclosure ready).

The external tripping can be switched on and off with a setting parameter and may be blocked via binary input.

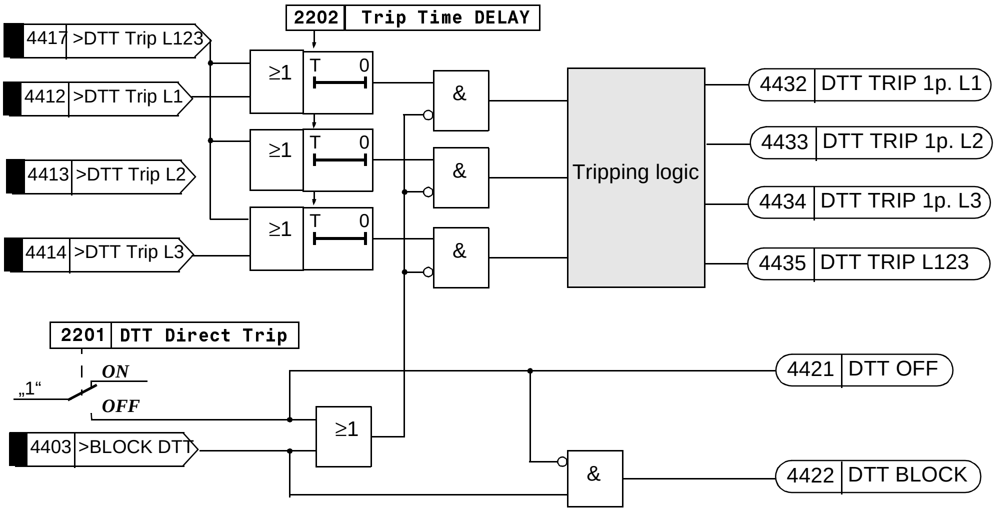


Figure 6-82 Logic diagram of the local external tripping

Remote Trip of the Circuit Breaker at the Opposite Line End

For remote tripping at the opposite line end, one separate communication channel is required for each required transmission direction. For this purpose, fibre-optic communication channels could for example be used or communication cables with voice frequency modulated HF channels, power line carrier or microwave radio channels.

If the trip command of the distance protection is to be transmitted, it is best to use the integrated teleprotection function for the transmission of the signal as this already incorporates the optional extension of the transmitted signal, as described in Subsection 6.4.1.3. Any of the commands can of course be used to trigger the transmitter to initiate the send signal.

On the receiver side, the local external trip function is used. The receive signal is routed to a binary input which is assigned to the logical binary input function “`>DTT Trip L123`”. If single pole tripping is required, the following binary inputs may alternatively be used “`>DTT Trip L1`”, “`>DTT Trip L2`” and “`>DTT Trip L3`”. Figure 6-82 therefore also applies in this case.

6.8.2 Applying the Function Parameter Settings

A prerequisite for the application of the direct and remote tripping functions is that during the configuration of the scope of functions in the device (Section 5.1) the setting in address **0122 DTT Direct Trip** = ***Enabled*** was applied. In address **2201 DTT Direct Trip** ***ON*** or ***OFF***, it is furthermore possible to switch the function on or off.

It is possible to set a trip delay for both the local external trip and the receive side of the remote trip in address **2202 Trip Time DELAY**. This can be used as a security time margin, especially in the case of local trip.

Once a trip command has been issued, it is maintained for at least as long as the set minimum trip command duration **TMin TRIP CMD**, which was set for the device in general in address 240A (Sub-section 6.1.1). Reliable operation of the circuit breaker is therefore ensured, even if the initiating signal pulse is very short.

6.8.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
2201	FCT Direct Trip	ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	0.00..30.00 sec; Ø; ∞	0.01 sec	Trip Time Delay

6.8.4 Information Overview

F.No.	Alarm	Comments
4403	>BLOCK DTT	>BLOCK Direct Transfer Trip function
4412	>DTT Trip L1	>Direct Transfer Trip INPUT Phase L1
4413	>DTT Trip L2	>Direct Transfer Trip INPUT Phase L2
4414	>DTT Trip L3	>Direct Transfer Trip INPUT Phase L3
4417	>DTT Trip L123	>Direct Transfer Trip INPUT 3ph L123
4421	DTT OFF	Direct Transfer Trip is switched OFF
4422	DTT BLOCK	Direct Transfer Trip is BLOCKED
4432	DTT TRIP 1p. L1	DTT TRIP command - Only L1
4433	DTT TRIP 1p. L2	DTT TRIP command - Only L2
4434	DTT TRIP 1p. L3	DTT TRIP command - Only L3
4435	DTT TRIP L123	DTT TRIP command L123

6.9 Overcurrent Protection

General

Overcurrent protection is integrated in the 7SA6 device. This function may optionally be used either as back-up time delayed overcurrent protection or as emergency overcurrent protection.

Whereas the distance protection can only function correctly if the measured voltage signals are available to the device, the emergency overcurrent protection only requires the currents. The emergency overcurrent function is automatically activated when the measured voltage signal is lost, e.g. due to a short circuit or interruption of the voltage transformer secondary circuits (emergency operation). The emergency operation therefore replaces the distance protection as short circuit protection if loss of the measured voltage signal is recognized by one of the following conditions:

- Pick-up of the internal measured voltage monitoring („Fuse–Failure–Monitor“, refer to Sub-section 6.19.1.3) or
- if the signal “`>Failure: Feeder VT (MCB tripped)`” is received via binary input, indicating that the measured voltage signal is lost.

If one of these conditions arise, the distance protection is immediately blocked and the emergency operation is activated.

If the overcurrent protection is configured as back-up overcurrent protection it functions independently of the other protective and monitoring functions, therefore also independent of the distance protection. The back-up overcurrent protection could for instance be used as the only short-circuit protection if the voltage transformers are not yet available when the feeder is initially commissioned.

For the overcurrent protection there are in total four stages for the phase currents and four stages for the earth currents as follows:

- two overcurrent stages with a definite time characteristic (O/C with DT),
- one overcurrent stage with inverse time characteristic (IDMT),
- one further overcurrent stage which is preferably used as a stub protection, but which can be applied as an additional normal definite time delayed stage.

These four stages are independent of each other and are freely combinable. Blocking by external criteria via binary input is possible as well as rapid (non delayed) tripping (e.g. by an external automatic reclose device). During energization of the protected feeder onto a dead fault it is also possible to release any stage, or also several, for non-delayed tripping. If not all the stages are required, each individual stage may be deactivated by setting the pick-up threshold to ∞.

6.9.1 Method of Operation

Measured Values

The phase currents are fed to the device via the input transformers of the measuring input. The residual current $3 \cdot I_0$ is either measured directly or calculated from the phase currents, depending on the ordered device version and usage of the fourth current input I_4 of the device.

If I_4 is connected in the current transformer star-point connection circuit the residual (earth) current is directly available as a measured quantity.

If the device is supplied with the high sensitivity current input for I_4 (ordered version), this current I_4 — under consideration of the factor **`I4/Iph CT`** (address **`221`**, refer to Sub-section 6.1.1) of the power system data 1 — is used. As the linear range of this measuring input is severely restricted in the high range (above approx. 1.6 A), this current is only evaluated up to an amplitude of approx. 1 A. In the event of larger currents, the device automatically switches over to the evaluation of the zero sequence current calculated from the phase currents. Naturally, all three phase currents obtained from a set of three star connected current transformers must be available and connected to the device. The processing of the earth current is then also possible if very small as well as large earth fault currents may occur.

If the fourth current input I_4 is used e.g. for a power transformer star-point current or for the earth current of a parallel line, the device derives the earth current from the phase currents. Naturally in this case also all three phase currents derived from a set of three star connected current transformers must be available and connected to the device.

Definite Time High Set Overcurrent Stage I>>

Each phase current is numerically filtered and then compared with the set value **`Iph>>`**, the earth current with **`3I0>>`**. After expiry of the associated time delays **`T Iph>>`** respectively **`T 3I0>>`** a trip command is issued. The reset threshold is approx. 5 % below the pick up threshold, but at least 1,5 % of rated current below the pick-up threshold.

Figure 6-83 shows the logic diagram of the I>>–stages. They may be blocked via the binary input “`>BLOCK O/C I>>`”. The binary input “`>O/C InstTRIP`” and the function module “Switch on to fault” are common to all stages and further described below. They may, however, separately affect the phase and/or earth current stages. This is accomplished with the following setting parameters:

- **`I>> Telep/BI`** (address **`2614`**), which determines whether a non-delayed trip of this stage is possible (***`Yes`***) via the binary input “`>O/C InstTRIP`” or not (***`No`***)
- **`I>> SOTF`** (address **`2615`**), which determines whether non-delayed tripping of this stage is possible (***`Yes`***) or not (***`No`***) following switching of the feeder on to a dead fault.

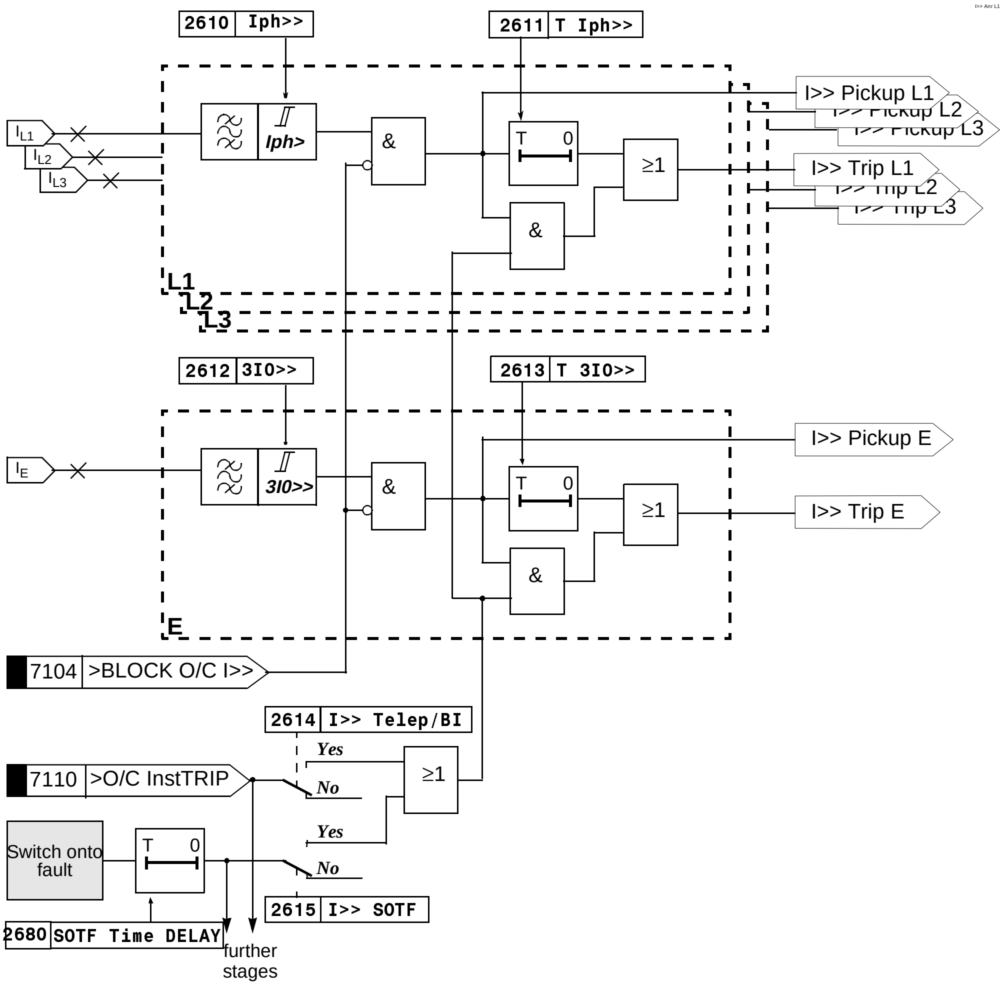


Figure 6-83 Logic diagram of the I>>–stage

Definite Time Overcurrent Stage I>

The logic of the overcurrent stage **I>** is the same as that of the **I>>**–stage. All references to **Iph>>** must simply be replaced by `Iph>` and **3I0>>** by `3I0>`. In all other respects Figure 6-83 applies.

Inverse Time Overcurrent Stage I_p

The logic of the inverse overcurrent stage also in principal functions the same as the remaining stages. The time delay in this case however results from the nature of the set characteristic (parameter `IEC Curve`), the magnitude of the current and the time multiplier (Figure 6-84). A pre-selection of the available characteristics was already done during the configuration of the protection functions. Furthermore, an additional constant time delay `T Ip Add` (address 2646) may be selected, which are added to the current dependant time derived from the IDMT characteristic. The available characteristics are shown in the technical data, Section 10.5, Figure 10-1 to 10-3.

Figure 6-84 shows the logic diagram. The setting parameter addresses of the IEC characteristics are shown by way of an example. In the setting information (Subsection 6.9.2) the different setting addresses are elaborated upon.

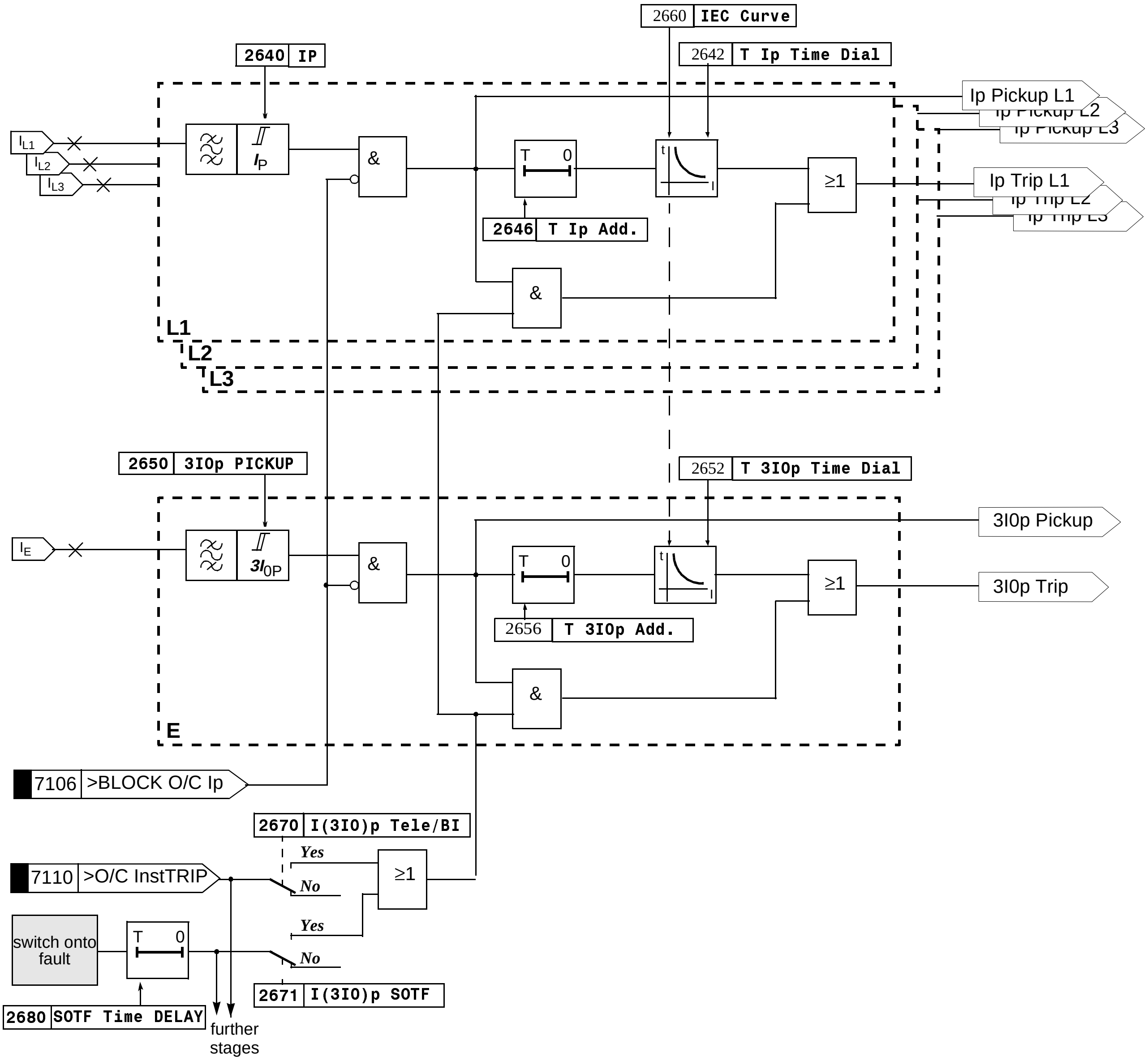


Figure 6-84 Logic diagram of the I_p–stage (inverse time overcurrent protection IDMT) — illustration for IEC–curves

Stub Protection

A further overcurrent stage is the stub protection. It can however also be used as a normal additional definite time overcurrent stage, as it functions independent of the other stages.

A stub fault is a short-circuit located between the current transformer set and the line isolator. It is of particular importance with the $1^1/_2$–circuit breaker arrangement (Figure 6-85).

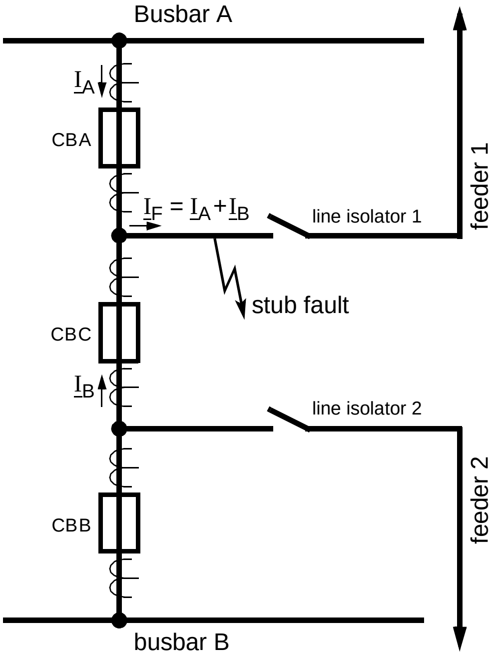


Figure 6-85 Stub fault at an $1^1/_2$–circuit breaker arrangement

If a fault current $\underline{I}_A$ and/or $\underline{I}_B$ flows while the line isolator 1 is open, this implies that a fault in the stub range between the current transformers $\underline{I}_A$, $\underline{I}_B$, and the line isolator exists. The circuit breakers CBA and CBC which carry fault current may be tripped without delay.The two sets of current transformers are connected in parallel such that the current sum $\underline{I}_F = \underline{I}_A + \underline{I}_B$ represents the current flowing towards the line isolator.

The stub protection is an overcurrent protection which is only in service when the state of the line isolator indicates the open condition via a binary input “`>I-STUB ENABLE`”. The binary input must therefore be operated via an auxiliary contact of the isolator. In the case of a closed line isolator, the stub protection is out of service. Figure 6-86 shows the logic diagram.

If the stub protection stage is to be used as a normal definite time overcurrent stage, the binary input “`>BLOCK I-STUB`”, should be left without allocation or routing (matrix). The enable input “`>I-STUB ENABLE`”, however, has to be constantly activated (either via a binary input or via integrated logic (CFC) functions which can be configured by the user.

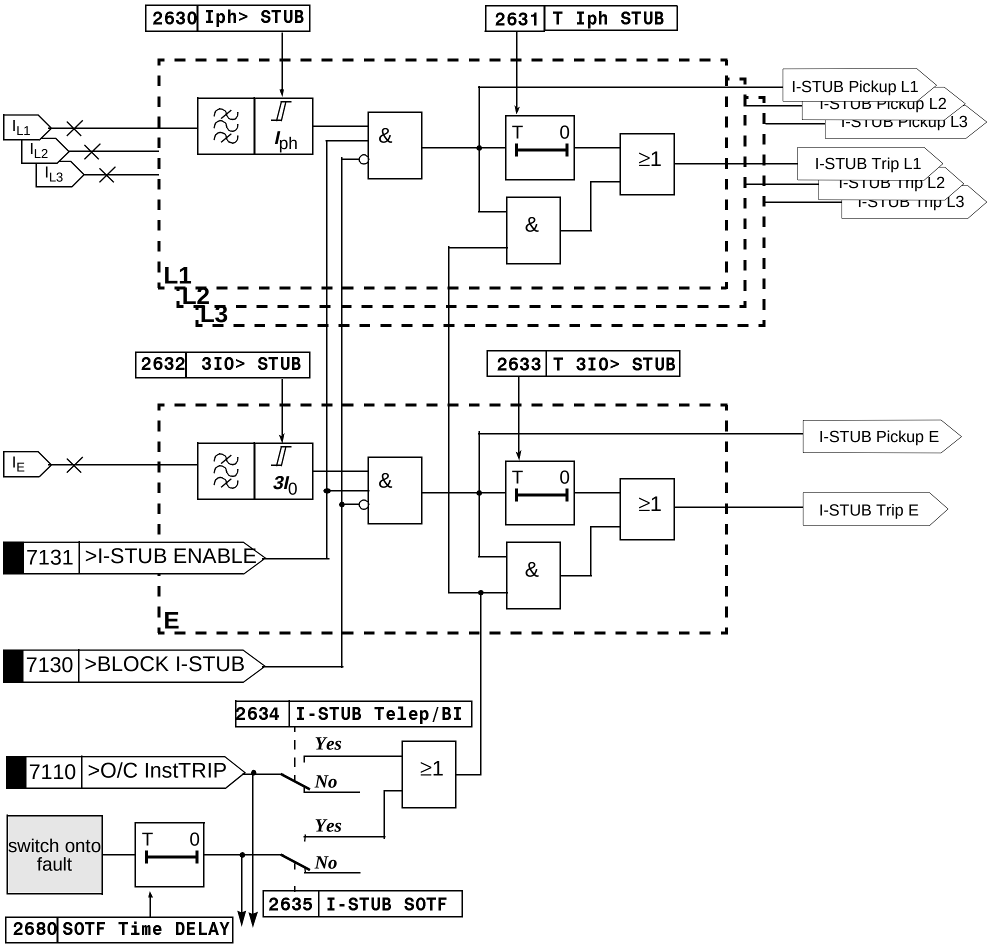


Figure 6-86 Logic diagram of the stub protection

Switching onto a Dead Fault

To achieve fast tripping following manual closure of the circuit breaker onto a dead fault, the switch onto fault signal can be routed to the overcurrent protection. The overcurrent protection can then trip three-pole without delay or with a reduced delay. It can be determined via setting parameter for which stage(s) the rapid tripping following closure on to a dead fault applies. (Refer also to the logic diagrams in Figure 6-83, 6-84 and 6-86, and Sub-section 6.1.3, margin “Circuit Breaker Status”).

Fault Detection and Trip Logic

The fault detection signals of the individual phases (and earth) and the individual stages are combined in such a manner that both the phase information as well as the stage information of the picked up stages can be output. (Table 6-10).

In the case of the trip signals, the stage which resulted in the trip command is also indicated. If the device has the option to trip single-pole, and this option has been activated, the pole which has been tripped is also indicated during single-pole tripping (refer also to Sub-section 6.20.4 Overall Tripping Logic of the Device).

Table 6-10 Fault detection annunciations of the overcurrent protection

Internal event	Figure	Output alarm	FNo
I>> Pickup L1 I> Pickup L1 Ip Pickup L1 I-STUB Pickup L1	6-83 6-84 6-86	`O/C Pickup L1`	7162
I>> Pickup L2 I> Pickup L2 Ip Pickup L2 I-STUB Pickup L2	6-83 6-84 6-86	`O/C Pickup L2`	7163
I>> Pickup L3 I> Pickup L3 Ip Pickup L3 I-STUB Pickup L3	6-83 6-84 6-86	`O/C Pickup L3`	7164
I>> Pickup E I> Pickup E Ip Pickup E I-STUB Pickup E	6-83 6-84 6-86	`O/C Pickup E`	7165
I>> Pickup L1 I>> Pickup L2 I>> Pickup L3 I>> Pickup E	6-83 6-83 6-83 6-83	`O/C PICKUP I>>`	7191
I> Pickup L1 I> Pickup L2 I> Pickup L3 I> Pickup E		`O/C PICKUP I>`	7192
Ip Pickup L1 Ip Pickup L2 Ip Pickup L3 Ip Pickup E	6-84 6-84 6-84 6-84	`O/C PICKUP Ip`	7193
I-STUB Pickup L1 I-STUB Pickup L2 I-STUB Pickup L3 I-STUB Pickup E	6-86 6-86 6-86 6-86	`I-STUB PICKUP`	7201
(all pick-ups)		`O/C PICKUP`	7161

6.9.2 Applying the Function Parameter Settings

General

During the configuration of the device scope of functions (refer to Section 5.1, address **126**) it was determined which characteristics are to be available. Only those parameters that apply to the available characteristics, according to the selected configuration and the version of the device, are accessible in the procedures described below.

According to the desired operating mode of the overcurrent protection the address **2601** is set: **Operating Mode** = ***ON*** means that the overcurrent protection operates independent on the other protection functions, in other words, as back-up overcurrent protection. If the overcurrent protection should only operate as emergency protection during loss of VT–supply, the setting ***Only by VT loss*** must be applied. Finally, the overcurrent protection can also be switched ***OFF***.

If not all the stages are required, the time delay of those stages that are not used can be deactivated by setting the pickup value to ∞. But if you set an associated time delay to ∞ this does not suppress the pick-up annunciations, but merely prevents the time delay from expiring.

The stub protection remains in service even if the overcurrent mode of operation setting is ***Only by VT loss***.

One or more stages can be set as fast tripping stages when switching on to a dead fault. This will be determined when setting the individual stages (see below). To avoid a spurious pick-up due to transient overcurrents, the delay **T SOTF** (address 2680) can be set. Typically the presetting of ***0*** is correct. On long cables, where large inrush currents may arise, or on transformers, a short time delay setting may be reasonable. The time delay depends on the severity and duration of the transient overcurrents as well as on which stages were selected for the fast switch onto fault clearance.

High Set Overcurrent Stages Iph>>, 3I0>>

The I>>–stages **Iph>>** (address **2610**) and **3I0>>** (address **2612**) along with the I>–stages or the I_p–stages result in a dual stage characteristic. Of course, it is also possible to combine all three stages. If a particular stage is not required, its pickup value is set to ∞. The I>>–stages always operate with a defined time delay.

If the I>>–stages are used as a fast tripping stage prior to automatic reclosure, the current setting corresponds to that of the I>– or I_p–stages (see below). In this case only the difference in the trip delay times is of interest. The times **T Iph>>** (address **2611**) and **T 3I0>>** (address **2613**) can be set to ***0*** or a very small value as rapid clearance of the fault current prior to an automatic reclosure has preference above the selective fault clearance. Prior to the final trip, these stages must be blocked to achieve selective final clearance of the fault.

On very long lines with a small source impedance or in front of large reactances (e.g. transformers, series reactors), the I>>–stages can also be used for current grading. In this case they must be set such that they definitely do not pick up for a fault at the end of the line. The time delays can then be set to ***0*** or a very small value.

When using a personal computer and DIGSI® 4 to apply the settings, these can be optionally entered as primary or secondary values. When applying the setting parameters as secondary values, the primary currents must be converted to the secondary side of the current transformer.

Calculation example:

110 kV overhead line 150 mm^2 as used in the example in Subsubsection 6.2.4.2:

s (length) = 60 km
R_1/s = 0,19 Ω/km
X_1/s = 0,42 Ω/km

Short circuit power at the beginning of the line:
S_k' = 2,5 GVA

current transformers 600 A/5 A

The line impedance Z_L and source impedance Z_S are calculated with these values as follows:

Z_1/s = $\sqrt{0.19^2 + 0.42^2}$ Ω/km = 0.46 Ω/km
Z_L = 0.46 Ω/km · 60 km = 27.66 Ω

$$Z_S = \frac{110^2\ kV^2}{2500\ MVA} = 4.84\ \Omega$$

The three phase short circuit current at the end of the line is $I_{F\ end}$:

$$I_{F\ end} = \frac{1.1 \cdot U_N}{\sqrt{3} \cdot (Z_S + Z_L)} = \frac{1.1 \cdot 110\ kV}{\sqrt{3} \cdot (4.84\ \Omega + 27.66\ \Omega)} = 2150\ A$$

With a safety margin of 10 % the resultant primary setting value is:

Set value I>> = 1.1 · 2150 A = 2365 A

or the secondary setting value:

$$\text{Setting value I>>} = 1.1 \cdot \frac{2150\ A}{600\ A} \cdot 5\ A = 19.7\ A$$

i.e. if the fault current is greater than 2365 A (primary) or 19.7 A (secondary) the fault is definitely on the protected feeder. This fault may be cleared immediately by the overcurrent protection.

Comment: The calculation was carried out with scalar quantities which is sufficient for overhead lines. If there is a large difference in the angle of the source and line impedance, the calculation must be done with complex values.

An analogous calculation can be done for earth faults, whereby the maximum earth fault current that flows during an earth fault at the end of the line is decisive.

The set time delays are pure additional delays, which do not include the operating time (measuring time).

The parameter **I>> Telep/BI** (address **2614**) determines whether the delay times **T Iph>>** (address **2611**) and **T 3I0>>** (address **2613**) may be bypassed via the binary input "**>O/C InstTRIP**" (F.No. **7110**) or via the automatic reclose ready state. The binary input (if assigned) is common to all stages of the overcurrent protection. With the parameter **I>> Telep/BI** = ***Yes*** it is determined that the I>>–stages trip without delay following pick up if there is an operating signal present at the binary input; if the setting is **I>> Telep/BI** = ***No*** the set delay times always come into effect.

If the I>>-stage is to trip when switching the line on to a fault with or without a short delay, **SOTF Time DELAY** (address **2680**, see above and refer to Sub-section "General"), the parameter **I>> SOTF** (address **2615**) must be set to ***Yes.*** For this fast switch on to a fault protection any other stage may also be selected.

Definite Time Overcurrent Stages Iph>, 3I0>

For the setting of the current pick-up threshold **Iph>** (address **2620**), the maximum operating current that can occur is decisive. Pick-up due to overload must be excluded as the device operates as short-circuit protection with correspondingly short tripping times and not as overload protection. The setting is therefore: on overhead lines approximately 10 %, on transformers and motors approximately 20 % above the maximum expected (over-)load current.

When using a personal computer and DIGSI® 4 to apply the settings, these can be optionally entered as primary or secondary values. When applying the setting parameters as secondary values, the primary currents must be converted to the secondary side of the current transformer.

Calculation example:

110 kV overhead line 150 mm^2 as in the example in Sub-section 6.2.4.2:

maximum transmittable power
P_{max} = 120 MVA corresponds to
I_{max} = 630 A

current transformers 600 A/5 A

security margin 1.1

When applying settings with primary values, the following setting results:

Set value I> = 1.1 · 630 A = 693 A

When applying settings with secondary values, the following setting results:

$$\textit{Setting value I>} = 1.1 \cdot \frac{630\ A}{600\ A} \cdot 5\ A = 5.8\ A$$

The earth current stage **3I0>** (address **2622**), must still be able to detect the smallest earth fault current that may be present. For very small earth currents the earth fault protection is most suited (refer to Section 6.5).

The time delay **T Iph>** (address **2621**) which has to be set is derived from the grading plan of the system. If implemented as emergency overcurrent protection, shorter tripping time delays (one grading time margin longer than the fast tripping stage) are advisable, as this function is only activated when the *local* measured voltage fails.

The time **T 3I0>** (address **2623**) can usually be set with a smaller time delay according to a separate earth fault grading plan.

The set times of the definite time stages are pure additional time delays which do not include the operating (measuring) time of the protection. If only the phase currents of a particular stage should be monitored, the pickup value of the earth current stage is set to ∞.

The setting parameter **I> Telep/BI** (address **2624**) determines if it is possible to use the binary input "**>O/C InstTRIP**" to bypass the trip delay times **T Iph>** (address **2621**) and **T 3I0>** (address **2623**). The binary input (if assigned) is common to all stages of the overcurrent protection. With **I> Telep/BI** = ***Yes*** it is therefore determined that the I>–stages trip without time delay following pick-up, if an operate signal is present at the binary input; if the setting is **I> Telep/BI** = ***No*** the set trip time delays always come into force.

If the I>-stage is to trip when switching the line on to a fault with or without a short delay, **SOTF Time DELAY** (address **2680**, see above and refer to Sub-section "General"), the parameter **I> SOTF** (address **2625**) is set to **Yes.** We recommend, however, not to choose the sensitive stage for the switch on to fault function as energizing of the line onto a fault usually causes a large fault current. It is important to avoid that the selected stage picks up in a transient way when energizing the line.

Inverse Time Overcurrent Stages IP, 3I0P with IEC–curves

In the case of the inverse time overcurrent stages, various characteristics can be selected, depending on the version of the device and the configuration (Section 5.1, address **0126**). For the IEC–curves (address **0126 Back-Up O/C** = ***TOC IEC***) the following are available in address **2660 IEC Curve**:

Inverse (*normal inverse*, Type A according to IEC 60255–3),
Very inverse (*very inverse*, Type B according to IEC 60255–3),
Extremely inverse (*extremely inverse*, Type C according to IEC 60255–3), and
LongTimeInverse (*longtime*, Type B according to IEC 60255–3).

The curves and equations that the curves are based on, are shown in the technical data (Section 10.5, Figure 10-1).

For the setting of the current thresholds **Ip>** (address **2640**) and **3I0p PICKUP** (address **2650**) the same considerations as for the overcurrent stages of the definite time protection (see above) apply. In this case it must be noted that a safety margin between the pick-up threshold and the set value has already been incorporated. Pick-up only occurs at a current which is approximately 10 % above the set value.

The above example shows that the maximum expected operating current may directly be applied as setting here:

primary: Set value Ip> = 630 A,

secondary: Set value Ip> = 5.25 A, i.e. (630 A / 600 A) · 5 A.

The time multiplier setting **T Ip Time Dial** (address **2642**) is derived from the grading plan applicable to the network. If implemented as emergency overcurrent protection, shorter tripping times are advisable (one grading time margin above the fast tripping stage), as this function is only activated in the case of the loss of the *local* measured voltage.

The time multiplier setting **T 3I0p TimeDial** (address **2652**) can usually be set smaller according to a separate earth fault grading plan.

In addition to the current dependant time delay an additional constant time length delay can be set if required. The setting **T Ip Add** (address **2646** for phase currents) and **T 3I0p Add** (address **2656** for earth currents) are in addition to the time delays resulting from the set curves.

The setting parameter **I(3I0)p Tele/BI** (address **2670**) determines if it is possible to use the binary input "**>O/C InstTRIP**" (F.No. **7110**) to bypass the trip delays **T Ip Time Dial** (address **2642**) including the additional time **T Ip Add** (address **2646**) and **T 3I0p TimeDial** (address **2652**) including the additional time **T 3I0p Add** (address **2656**). The binary input (if it is assigned) is common to all stages of the overcurrent protection. With the setting **I(3I0)p Tele/BI** = ***Yes*** it is therefore determined that the I_P–stage trips without delay following pick-up if an operate signal is present at the binary input; with the setting **I(3I0)p Tele/BI** = ***No*** the set time delays always come into effect.

If the Ip-stage is to trip when switching the line on to a fault without or with a short delay, **SOTF Time DELAY** (address **2680**, see above and refer to Sub-section "General"), the parameter **I(3I0)p SOTF** (address **2671**) is set to **Yes.** We recommend, however, not to choose the sensitive stage for the switch on to fault function as energizing of the line on to a fault should cause a large fault current. It is important to avoid that the selected stage picks up in a transient way during line energization.

Inverse Time Overcurrent Stages IP, 3I0P with ANSI–curves

In the case of the inverse time overcurrent stages, various characteristics can be selected, depending on the version of the device and the configuration (Section 5.1, address **0126**). For the ANSI–curves (address **0126 Back-Up O/C** = ***TOC ANSI***) the following are available in address **2661 ANSI Curve**:

Inverse,
Short inverse,
Long inverse,
Moderately inv.,
Very inverse,
Extremely inv., and
Definite inv.

The curves and equations that the curves are based on, are shown in the technical data (Section 10.5, Figure 10-2 to 10-3).

For the setting of the current thresholds **Ip>** (address **2640**) and **3I0p PICKUP** (address **2650**) the same considerations as for the overcurrent stages of the definite time protection (see above) apply. In this case it must be noted that a safety margin between the pick-up threshold and the set value has already been incorporated. Pick-up only occurs at a current which is approximately 10 % above the set value.

The above example shows that the maximum expected operating current may directly be applied as setting here.

primary: Set value Ip> = 630 A,

secondary: Set value Ip> = 5.25 A, i.e. (630 A / 600 A) · 5 A.

The time multiplier setting **Time Dial TD Ip** (address **2643**) is derived from the grading coordination plan applicable to the network. If implemented as emergency overcurrent protection, shorter tripping times are advisable (one grading time margin above the fast tripping stage), as this function is only activated in the case of the loss of the *local* measured voltage.

The time multiplier setting **TimeDial TD3I0p** (address **2653**) can usually be set smaller according to a separate earth fault grading plan.

In addition to the current dependant time delay an additional constant time length delay can be set if required. The setting **T Ip Add** (address **2646** for phase currents) and **T 3I0p Add** (address **2656** for earth currents) are in addition to the time delays resulting from the set curves.

The setting parameter **I(3I0)p Tele/BI** (address **2670**) determines if it is possible to use the binary input "**>O/C InstTRIP**" (F.No. **7110**) to bypass the trip delays **Time Dial TD Ip** (address **2643**) including the additional time **T Ip Add** (address **2646**) and **TimeDial TD3I0p** (address **2653**) including the additional time **T 3I0p Add** (address **2656**). The binary input (if it is assigned) is common to all stages of the overcurrent protection. With the setting **I(3I0)p Tele/BI** = ***Yes*** it is therefore determined that the I_P–stage trips without delay following pick-up if an operate signal is present at the binary input; with the setting **I(3I0)p Tele/BI** = ***No*** the set time delays always come into effect.

If the Ip-stage is to retrip when switching the line on to a fault with or without a short delay, **SOTF Time DELAY** (address **2680**, see above and refer to Sub-section "General"), the parameter **I> SOTF** (address **2625**) is set to **Yes.** We recommend, however, not to choose the sensitive stage for the switch on to a fault function as energizing of the line on to a fault should cause a large fault current. It is important to avoid that the selected stage picks up in a transient way during line energization.

Stub Protection

When using the I STUB protection the pick-up thresholds **`Iph> STUB`** (address **2630**) and **`3I0> STUB`** (address **2632**) are usually not critical, as this protection function is only activated when the line isolator is open which implies that every measured current should represents a fault current. With a $1^1/_2$–circuit breaker arrangement similar to Figure 6-85 it is possible that large short circuit currents flow from busbar A to busbar B or to feeder 2 via the current transformers. These currents could cause different transformation errors in the two current transformer sets $\underline{I}_A$ and $\underline{I}_B$, especially in the saturation range. The protection should therefore not be set unnecessarily sensitive. If the minimum short circuit currents on the busbars are known, the pick-up threshold **`Iph> STUB`** is set somewhat (approx. 10 %) below the minimum two phase short circuit current, **`3I0> STUB`** is set below the minimum single-phase current.

The time settings **`T Iph STUB`** (address **2631**) and **`T 3I0 STUB`** (address **2633**) are set to 0 for this application, to ensure rapid clearance of a stub fault when the line isolator is open.

If this stage is applied differently, similar considerations as for the other overcurrent stages apply.

If the **`I-Stub`**-stage is to trip when switching the line on to a fault with or without a short delay, **`SOTF Time DELAY`** (address **2680**, see above and refer to Sub-section “General”), the parameter **`I-STUB SOTF`** (address **2635**) is set to **`YES`**. If using the stub protection, then set to **`NO`** as the effect of this protection function only depends on the position of the isolator.

6.9.3 Settings

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
2601	Operating Mode	ON Only Active with Loss of VT sec. circuit OFF	Only Active with Loss of VT sec. circuit	Operating mode
2680	SOTF Time DELAY	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
2610	Iph>>	0.10..25.00 A; ∞	2.00 A	Iph>> Pickup
2611	T Iph>>	0.00..30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	0.05..25.00 A; ∞	0.50 A	3I0>> Pickup
2613	T 3I0>>	0.00..30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI	NO YES	YES	Instantaneous trip via Teleprot./BI
2615	I>> SOTF	NO YES	NO	Instantaneous trip after SwitchOnToFault
2620	Iph>	0.10..25.00 A; ∞	1.50 A	Iph> Pickup
2621	T Iph>	0.00..30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	0.05..25.00 A; ∞	0.20 A	3I0> Pickup
2623	T 3I0>	0.00..30.00 sec; ∞	2.00 sec	T 3I0> Time delay

Addr.	Setting Title	Setting Options	Default Setting	Comments
2624	I> Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI
2625	I> SOTF	NO YES	NO	Instantaneous trip after Switch-OnToFault
2640	Ip>	0.10..4.00 A; ∞	∞ A	Ip> Pickup
2642	T Ip Time Dial	0.05..3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip	0.50..15.00; ∞	5.00	Time Dial TD Ip
2646	T Ip Add	0.00..30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	0.05..4.00 A; ∞	∞ A	3I0p Pickup
2652	T 3I0p TimeDial	0.05..3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p	0.50..15.00; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add	0.00..30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve	Normal Inverse Very Inverse Extremely Inverse Long time inverse	Normal Inverse	IEC Curve
2661	ANSI Curve	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI
2671	I(3I0)p SOTF	NO YES	NO	Instantaneous trip after Switch-OnToFault
2630	Iph> STUB	0.10..25.00 A; ∞	1.50 A	Iph> STUB Pickup
2631	T Iph STUB	0.00..30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	0.05..25.00 A; ∞	0.20 A	3I0> STUB Pickup
2633	T 3I0 STUB	0.00..30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI	NO YES	NO	Instantaneous trip via Teleprot./ BI
2635	I-STUB SOTF	NO YES	NO	Instantaneous trip after Switch-OnToFault

6.9.4 Information Overview

F.No.	Alarm	Comments
7104	>BLOCK O/C I>>	>BLOCK Backup OverCurrent I>>
7105	>BLOCK O/C I>	>BLOCK Backup OverCurrent I>

F.No.	Alarm	Comments
7106	>BLOCK O/C Ip	>BLOCK Backup OverCurrent Ip
7110	>O/C InstTRIP	>Backup OverCurrent InstantaneousTrip
7130	>BLOCK I-STUB	>BLOCK I-STUB
7131	>I-STUB ENABLE	>Enable I-STUB-Bus function
7151	O/C OFF	Backup O/C is switched OFF
7152	O/C BLOCK	Backup O/C is BLOCKED
7153	O/C ACTIVE	Backup O/C is ACTIVE
7161	O/C PICKUP	Backup O/C PICKED UP
7162	O/C Pickup L1	Backup O/C PICKUP L1
7163	O/C Pickup L2	Backup O/C PICKUP L2
7164	O/C Pickup L3	Backup O/C PICKUP L3
7165	O/C Pickup E	Backup O/C PICKUP EARTH
7171	O/C PU only E	Backup O/C Pickup - Only EARTH
7172	O/C PU 1p. L1	Backup O/C Pickup - Only L1
7173	O/C Pickup L1E	Backup O/C Pickup L1E
7174	O/C PU 1p. L2	Backup O/C Pickup - Only L2
7175	O/C Pickup L2E	Backup O/C Pickup L2E
7176	O/C Pickup L12	Backup O/C Pickup L12
7177	O/C Pickup L12E	Backup O/C Pickup L12E
7178	O/C PU 1p. L3	Backup O/C Pickup - Only L3
7179	O/C Pickup L3E	Backup O/C Pickup L3E
7180	O/C Pickup L31	Backup O/C Pickup L31
7181	O/C Pickup L31E	Backup O/C Pickup L31E
7182	O/C Pickup L23	Backup O/C Pickup L23
7183	O/C Pickup L23E	Backup O/C Pickup L23E
7184	O/C Pickup L123	Backup O/C Pickup L123
7185	O/C PickupL123E	Backup O/C Pickup L123E
7191	O/C PICKUP I>>	Backup O/C Pickup I>>
7192	O/C PICKUP I>	Backup O/C Pickup I>
7193	O/C PICKUP Ip	Backup O/C Pickup Ip
7201	I-STUB PICKUP	O/C I-STUB Pickup
7211	O/C TRIP	Backup O/C General TRIP command
7212	O/C TRIP 1p.L1	Backup O/C TRIP - Only L1
7213	O/C TRIP 1p.L2	Backup O/C TRIP - Only L2
7214	O/C TRIP 1p.L3	Backup O/C TRIP - Only L3
7215	O/C TRIP L123	Backup O/C TRIP Phases L123

F.No.	Alarm	Comments
7221	O/C TRIP I>>	Backup O/C TRIP I>>
7222	O/C TRIP I>	Backup O/C TRIP I>
7223	O/C TRIP Ip	Backup O/C TRIP Ip
7235	I-STUB TRIP	O/C I-STUB TRIP
2054	Emer. mode	Emergency mode

6.10 High-Current Switch-On-To-Fault Protection

6.10.1 Method of Operation

General

The high-current switch-on-to-fault protection is intended to trip immediately and instantaneously following energization of a feeder onto a fault with large fault current magnitude. It is primarily used as fast protection in the event of energizing the feeder while the earth switch is closed, but can also be used every time the feeder is energized — in other words also following automatic reclosure — (selectable).

The energization of the feeder is reported to the protection by the circuit breaker state recognition function. This is described in detail in Section 6.20.

Pick-up

The high-current pick-up function measures each phase current and compares it with the set value `I>>>` (address **2404**). The currents are numerically filtered so that only the fundamental frequency is evaluated. If the measured current is more than twice the set value the protection automatically reverts to the unfiltered measured values, thereby allowing extremely fast tripping. DC current components in the fault current and in the CT secondary circuit following the switching off of large currents practically have no influence on the high-current pick-up operation.

Figure 6-87 shows the logic diagram. The high-current switch-on-to-fault function can be phase segregated or three-phase.

Following manual closure of the circuit breaker it always functions three-phase via the release signal “`SOTF-O/C Release L123`”, which is derived from the central information control in the device, assuming that the manual closure can be recognized there (refer to Section 6.20).

If further criteria were determined during the configuration of the recognition of line energization (address **1134** **`Line Closure`**, refer to Section 6.1.3) the release signal “`SOTF-O/C Release Lx`” may be issued phase segregated. This only applies to devices that can trip single-pole, and is then important in conjunction with single-pole automatic reclosure.

Tripping is always three-pole. The phase selectivity only applies to the pick-up in that the overcurrent criterion is coupled with the circuit breaker pole that has been closed.

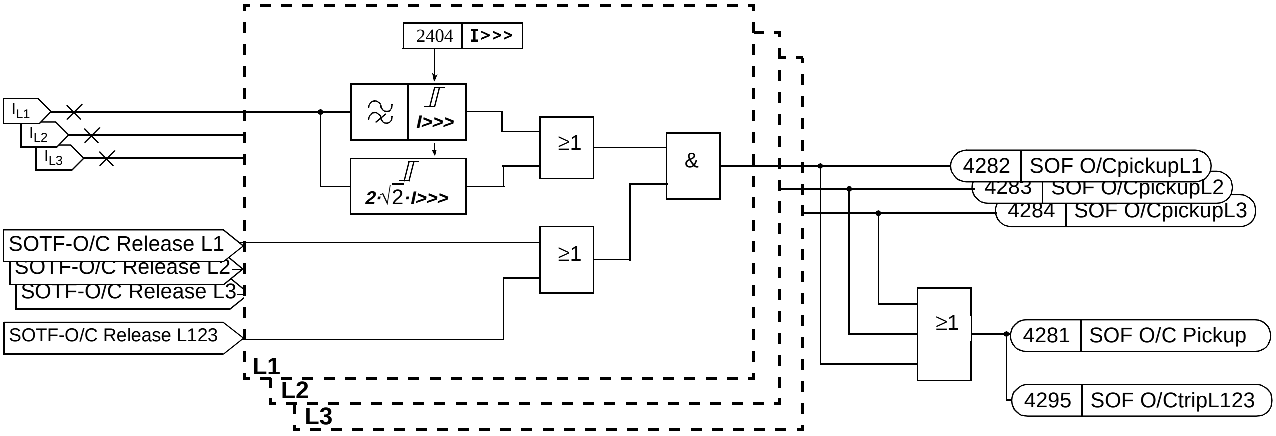


Figure 6-87 Logic diagram of the high current switch on to fault protection

6.10.2 Applying the Function Parameter Settings

A prerequisite for the operation of the switch-on-to-fault protection is that in address **`0124 SOTF Overcurr.`** = ***`Enabled`*** was set during the configuration of the device scope of functions (Section 5.1). It is furthermore possible to switch the function, in address **`2401`**, **`SOTF Overcurr.`** ***`ON`*** or ***`OFF`***.

The magnitude of the current which causes pick-up of the switch on to fault function is set as **`I>>>`** in address **`2404`**. The setting value should be selected large enough to ensure that the protection under no circumstances picks up due to an overload condition or due to a current increase resulting from e.g. an automatic reclosure dead time on a parallel feeder. It is recommended to set at least 2.5 times the rated current of the feeder.

6.10.3 Settings

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5.

Addr.	Setting Title	Function	Setting Options	Default Setting
2401	FCT SOTF-O/C	Instantaneous HighSpeed SOTF Overcurrent	ON OFF	ON
2404	I>>>	Instantaneous HighSpeed SOTF Overcurrent	1.00..25.00 A	2.50 A

6.10.4 Information Overview

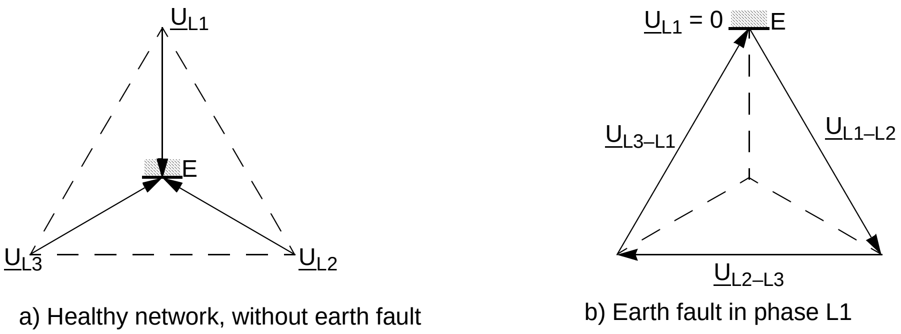
FNr.	Meldung	Erläuterung
4253	>BLOCK SOTF-O/C	>BLOCK Instantaneous SOTF Overcurrent
4271	SOTF-O/C OFF	SOTF-O/C is switched OFF
4272	SOTF-O/C BLOCK	SOTF-O/C is BLOCKED
4273	SOTF-O/C ACTIVE	SOTF-O/C is ACTIVE
4281	SOTF-O/C PICKUP	SOTF-O/C PICKED UP
4282	SOF O/CpickupL1	SOTF-O/C Pickup L1
4283	SOF O/CpickupL2	SOTF-O/C Pickup L2
4284	SOF O/CpickupL3	SOTF-O/C Pickup L3
4295	SOF O/CtripL123	SOTF-O/C TRIP command L123

6.11 Earth Fault Detection in Non-earthed Systems

6.11.1 Method of Operation

General

In systems whose starpoint is either non-earthed or earthed through an arc suppression coil (Petersen coil), single phase earth faults will not be detected by the short circuit protection, since no significant earth fault current flows. Furthermore, since network operation is not immediately affected by an earth fault (the voltage triangle is maintained, Figure 6-88) rapid disconnection is not normally desired. It is more important that the earth fault be recognized, indicated and, when possible, localized also. After network reconfiguration it can then be cleared. But 7SA6 enables the user to trip on directional earth fault in non-earthed systems.



a) Healthy network, without earth fault

b) Earth fault in phase L1

Figure 6-88 Earth fault in non-earthed neutral network

Dependent upon the chosen model, a 7SA6 relay can be fitted with optional earth fault detection module, which includes the following functions:

- Detection of an earth fault (pick-up) by monitoring the displacement voltage,
- Determination of the faulted phase by measuring the phase to earth voltages,
- Determination of the direction of the earth fault (residual) current by high accuracy real and reactive component measurement.

Pickup

The pickup is achieved when the settable threshold for the displacement voltage $3 \cdot U_0$ is exceeded. To ensure measurement of stable values, all earth fault detection functions are delayed until 1 second (settable) after inception of voltage displacement. Further, each alteration of the earth fault conditions (e.g. altered direction) is recognized only after this delay. Generally the pickup is only indicated if a fault was detected for sure by the phase determination function (see next margin heading).

Determination of the Earth-faulted Phase

After recognition of displaced voltage conditions the first objective of the device is selective detection of the earth-faulted phase. For this purpose the individual phase-to-earth voltages are measured. The affected phase is the one in which the voltage is below the settable threshold **`Uph-e min`** when simultaneously the other two voltages exceed an equally settable maximum threshold **`Uph-e max`**.

Sensitive Earth Fault Directional Determination

The direction of the earth fault can be determined from the direction of the earth fault current in relation to the displacement voltage. The only restriction is that the active or reactive current components must be available with sufficient magnitude at the point of measurement.

In networks with isolated starpoint, the earth fault current flows as capacitive current from the healthy lines via the measuring point to the point of fault. This capacitive current determines the direction.

In networks with arc suppression coils, the Petersen coil superimposes a corresponding inductive current on the capacitive earth fault current when an earth fault occurs, so that the capacitive current at the point of fault is compensated. Dependent upon the point of measurement in the network the resultant measured current can however be inductive or capacitive and the reactive current is therefore not suitable for the determination of direction. In this case, only the ohmic (active) residual current which results from the losses of the Petersen coil can be used for directional determination. This earth fault ohmic current is only a few percent of the capacitive earth fault current.

In 7SA6 the earth fault direction is determined from a highly accurate calculation of active and reactive power using the definitions:

$$P_E = \frac{1}{T} \cdot \int_{t}^{t+T} u_E(t) \cdot i_E(t) \cdot dt \qquad \text{and} \qquad Q_E = \frac{1}{T} \cdot \int_{t}^{t+T} u_E\left(t - \frac{\pi}{2}\right) \cdot i_E(t) \cdot dt$$

where T equals period of integration.

The use of an efficient calculation algorithm and simultaneous numerical filtering allows the directional determination to be achieved with high accuracy and sharply defined threshold limits (see Figure 6-89) and insensitivity to harmonic influences — particularly the third and fifth harmonics which are often large in earth fault currents. The directional decision results from the signs of active and reactive power.

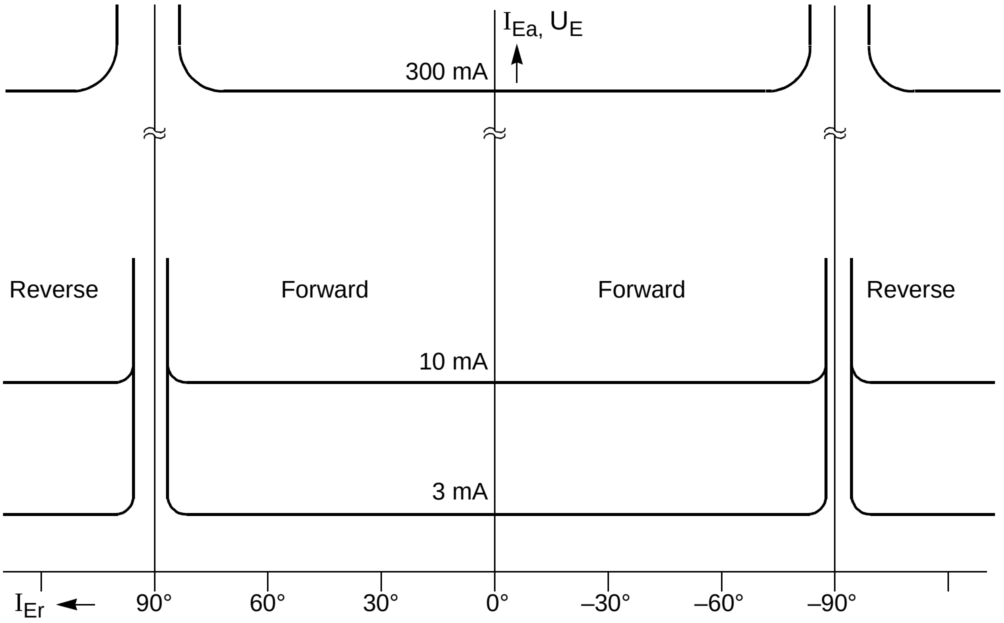


Figure 6-89 Directional earth fault measurement characteristic in a resonant-earthed system

Since the active and reactive component of the current – not the power – determine the earth fault directional decision, these current components are calculated from the power components. Thus for determination of the direction of the earth fault, active and reactive components of the earth fault current as well as the direction of the active and reactive power are evaluated.

In networks with **isolated** starpoint the following criteria apply:

- earth fault forwards, when $P_{Er} > 0$ and $I_{Er} >$ set value,
- earth fault backwards, when $P_{Er} < 0$ and $I_{Er} >$ set value.

In **resonant-earthed** networks (**with arc suppression coil**)
the following criteria apply:

- earth fault forwards, when $P_{Ea} > 0$ and $I_{Ea} >$ set value,
- earth fault backwards, when $P_{Ea} < 0$ and IEa > set value.

In the latter case it must be noted that, dependent upon the location of the protective relay, a considerable reactive component may be superimposed which, in the most unfavourable cases, can attain 50 times the active component. Even the extremely high accuracy of the calculation algorithm is then inadequate if the current transformers do not exactly convert the primary values.

The measurement input circuit of the relay version with earth fault detection is particularly designed for this purpose and permits an extremely high sensitivity for the directional determination of the wattmetric residual current. In order to utilize this sensitivity it is recommended that core balance current transformers be used for earth fault detection in compensated networks. As even the core balance transformers have an angle error, the protection system allows the setting of correction parameters which, dependent upon the current amplitude, will correct the error angle.

Earth Fault Location

In radial networks, location of the faulted line is relatively simple. Since all circuits on a busbar (Figure 6-90) carry a capacitive partial current, the measuring point on the faulted line in an isolated network sees almost the full prospective earth fault current of the network; in compensated networks the wattmetric residual current from the Petersen coil flows through the measuring point. For the faulted line or cable, a definite “forward” decision will result, whilst in the remaining circuits a “reverse” indication will be given unless the earth current is so small that no measurement can be taken. In any case the faulted cable can be clearly determined.

I

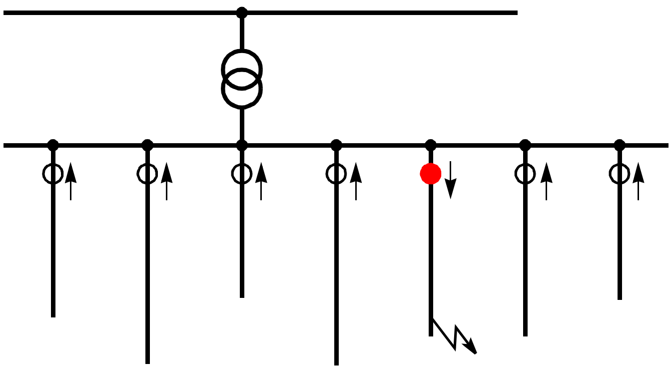


Figure 6-90 Faulted line location in radial network

In meshed or ring networks the measuring points at the ends of the faulted cable also see a maximum of earth fault (capacitive or ohmic) current. Only in this cable will the direction “forwards” be indicated on both line ends (Figure 6-91). The remaining directional indications in the network can aid location of the earth fault. But under certain circumstances one or more indications may not be given due to insufficient earth current. Further advice can be found in the leaflet “Earth-fault detection in isolated neutral or arc-suppression coil earthed high voltage systems”.

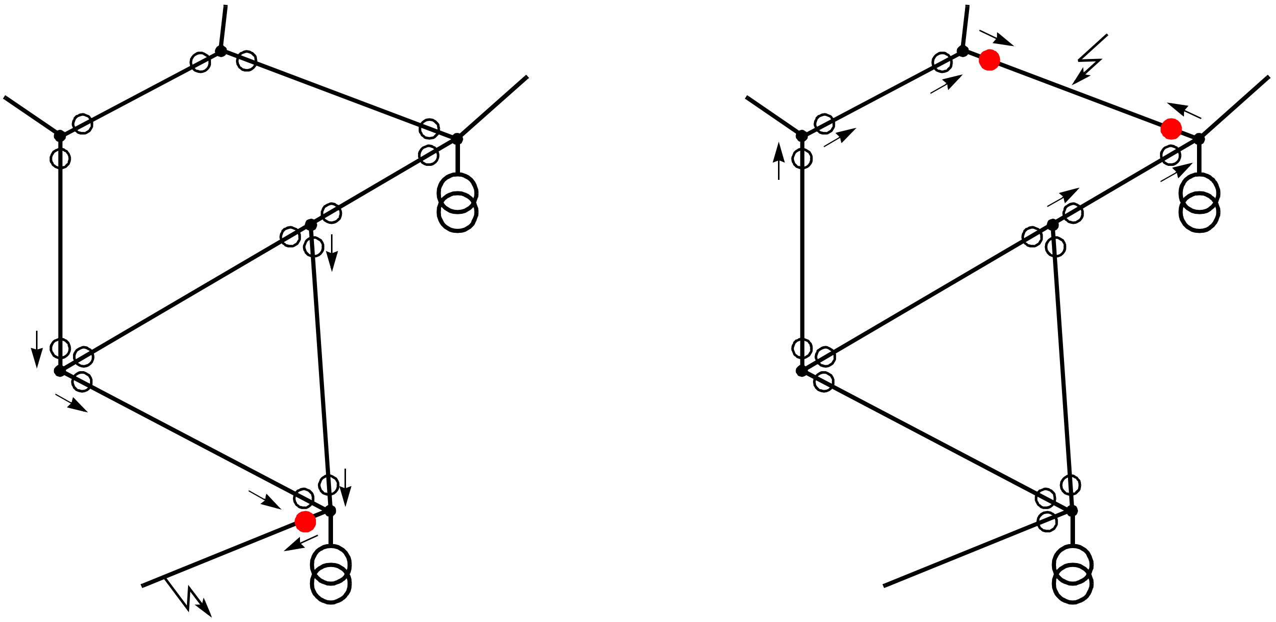


Figure 6-91 Faulted line location in meshed networks using directional indications

6.11.2 Applying the Function Parameter Settings

This section applies only to relay models with earth fault detection module and only when these are used in networks with isolated or compensated starpoint. In other cases, this section can be passed over.

Earth fault detection is only possible if address **Sens. Earth Flt** (Section 5.1) was set to ***enabled*** during the configuration (Section 5.1). If the device is equipped with earth fault detector but supposed to operate in an earthed network, address 0130 **Sens. Earth Flt** must be set to ***disabled***!

In address 3001 **Sens. Earth Flt** the options can be set for the earth fault detection function: ***ON***, ***OFF*** and ***Alarm only.*** In the latter case (presetting) the device announces detected earth faults, identifies the faulty phases and the earth fault direction according to the other settings.

If the earth fault detection is switched ***ON,*** it also issues a trip command. In this case no earth fault protocol is generated, but a trip log that registers all information about the earth fault and the earth fault tripping. The tripping can be delayed via address 3007 **T 3U0>**.

Voltage Settings

The displacement voltage is the pickup threshold of the earth fault detection and is set in address 3002 **3U0>**.

If the displacement voltage U_{en} of the voltage transformer set is directly connected to the fourth voltage measuring input U_4 of the device and if this was predefined during the configuration, the device will use this voltage, multiplied by the factor **Uph / Udelta** (address 0211). For the usual transformation of the voltage transformer with e–n–winding

$$\frac{U_{Nprim}}{\sqrt{3}} \Big/ \frac{U_{Nsec}}{\sqrt{3}} \Big/ \frac{U_{Nsec}}{3}$$

the factor is set to 1,73 ($\sqrt{3}$) (see also Subsection 6.1.1, margin heading "Voltage Transformer Connection"). In case of a complete displacement of a healthy voltage triangle the displacement voltage has a value that is $\sqrt{3}$ times the phase-to-phase voltage.

If no displacement voltage is connected to the device, the device calculates the monitored voltage from the total of the voltages:

$$3 \cdot U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|.$$

In case of a complete displacement of a healthy voltage triangle the displacement voltage also has a value that is $\sqrt{3}$ times the phase-to-phase voltage.

Since, in case of earth faults in isolated or resonant-earthed systems, the complete displacement voltage emerges, the setting value is uncritical; it should approx. be between 40 % to 50 % of the displacement voltage: for U_N = 100 V therefore between 70 V to 90 V.

The earth fault is only recognized and announced if the displacement voltage has been "present" for the time set in **T Sens.E/F** (address 3006). This stabilizing period is also enabled if earth fault conditions change (e.g. change of direction).

If tripping is also required for earth faults (address 3001, **Sens. Earth Flt** = ***ON***), a delay time can be set in address 3007 **T 3U0>.**

For phase determination **Uph-e min** (address 3003) is the criterion for the earth-faulted phase, when simultaneously the other two phase voltages have exceeded **Uph-e max** (address 3004). Accordingly, **Uph-e min** must be set lower than the minimum operational phase-earth voltage. This setting is, however, also not critical, 40 V (factory setting) should always be adequate. **Uph-e max** must lie above the maximum operational phase-earth voltage, but below the minimum operational phase-phase voltage, therefore, for example, 75 V at U_N = 100 V. The identification of the faulty phase is a further precondition for annunciation of an earth fault.

Directional Determination

For determination of the direction of the earth fault, in principle, the threshold current **3I0>** (address 3005) should be set as high as possible to prevent faulty operation due to asymmetrical currents in the network and the current transformers (particularly in Holmgreen connection). Dependent upon the treatment of the network star point, the magnitude of the capacitive earth fault current (for isolated networks) or the wattmetric residual current (for compensated networks) is decisive.

In **isolated** networks an earth fault in a cable will allow the total capacitive earth fault currents of the entire electrically connected network, with the exception of the faulted cable itself, to flow through the measuring point. It is normal to use half the value of this earth fault current as the threshold value.

Example: A 25 kV bus-bar feeds seven cable circuits. Each circuit has a current transformer set 300 A/1 A. The earth fault current is 2.5 A/km. The cables might be as follows:

Cable 1	3	km	7.5	A
Cable 2	5	km	12.5	A
Cable 3	2.6	km	6.5	A
Cable 4	5	km	12.5	A
Cable 5	3.4	km	8.5	A
Cable 6	3.4	km	8.5	A
Cable 7	2.6	km	6.5	A
Total	25.0	km	62.5	A

With an earth fault in cable 2, 62.5 A – 12.5 A = 50 A earth fault current will flow through the measuring point, since 12.5 A flows directly from cable 2 into the fault. Since that cable is amongst the longest, this is the most unfavourable case (smallest earth fault current flows through the measuring point). On the secondary side, flows:

50 A/300 = 0.167 A.

The relay should be set at approximately half this value, **3I0>** = ***0.080*** A.

In **resonant-earthed** networks directional determination is made more difficult since a much larger reactive current (capacitive or inductive) is superimposed on the critical wattmetric (active) current. The total earth current available to the relay can therefore, dependent upon the network configuration and location of the compensation coil, assume very different values in magnitude and phase angle. The relay, however, must evaluate only the active component of the earth fault current, that is, $I_E \cdot \cos \varphi$. This demands extremely high accuracy, particularly with regard to phase angle measurement of all the instrument transformers. Also, the relay should not be set unnecessarily sensitive. When used in compensated networks therefore, reliable directional determination is only expected when core balance or window-type transformers are used. Here also, use the rule of thumb: setting at half the expected measured current, whereby only the residual wattmetric current is applicable. This residual wattmetric current is provided principally by the losses in the Petersen coil.

Example: The same network, as in the previous example, is considered to be compensated by a Petersen coil. The coil is matched to the total network. The compensation current is thus 62.5 A. The losses should be 4 %. For earth fault directional determination, core balance current transformers 60 A/1 A are fitted.

Since the residual wattmetric current is derived principally from the coil losses, it is, independent of earth fault location, approximately the same:

4 % of 62.5 A = 2.5 A.

This active current is superimposed by a reactive current which can amount to up to 62.5 A for earth faults near the Petersen coil! On the secondary side we have

2.5 A/60 = 0.041 A.

As setting value **3I0>** = ***0.020*** A is selected.

If the earth fault protection is also to trip (Address 3001 **Sens. Earth Flt** = ***On***), set in address 3008 **TRIP Direction**, if for earth faults the signal is tripped ***forward*** (normally in line direction), ***reverse*** (normally in direction of busbar) or ***non-directional.*** This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Phase Angle Compensation

The high reactive current component in resonant-earthed networks and the unavoidable air gap of the core balance type current transformers require a phase angle compensation of the current transformer. This is possible with addresses 3010 to 3013. For the actual connected burden the maximum angle phase displacement **CT**

Err. F1 (address 3011) of the c.t. with its associated current **CT Err. I1** (address 3010) as well as a further c.t. operating point **CT Err. F2**/**CT Err. I2** (address 3013 and 3012), above which the angle displacement remains practically constant (see Figure 6-92), are set. The relay then approximates, with adequate accuracy, the characteristic of the transformer. In isolated networks this angle error compensation is not necessary.

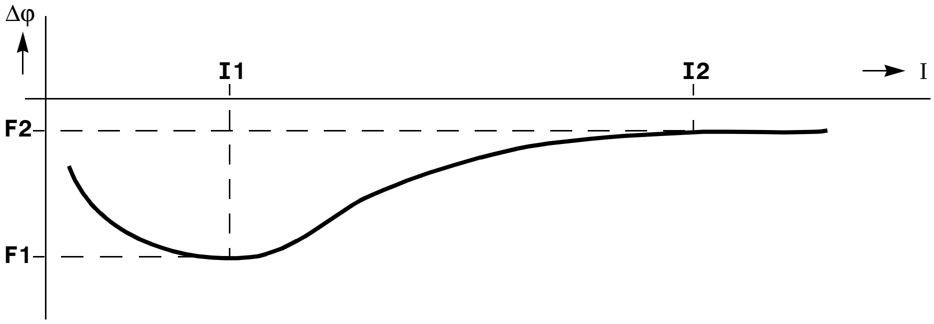


Figure 6-92 Settings for the phase angle correction

6.11.3 Settings

Note: The indicated secondary current values refer to current input I_4. They are independent from the nominal value of the device.

Addr.	Setting Title	Setting Options	Default Setting	Comments
3001	Sens. Earth Flt	Alarm Only ON OFF	Alarm Only	Sensitive Earth Flt.(comp/ isol. starp.)
3002	3U0>	1..150 V	50 V	3U0> pickup
3003	Uph-e min	10..100 V	40 V	Uph-e min of faulted phase
3004	Uph-e max	10..100 V	75 V	Uph-e max of healthy phases
3005	3I0>	0.003..1.000 A	0.050 A	3I0> Release directional element
3006	T Sens.E/F	0.00..320.00 sec; Ø	1.00 sec	Time delay for sens. E/F detection
3007	T 3U0>	0.00..320.00 sec; Ø	0.00 sec	Time delay for sens. E/F trip
3008A	TRIP Direction	Forward Reverse Non-Directional	Forward	Direction for sens. E/F trip
3010	CT Err. I1	0.003..1.600 A	0.050 A	Current I1 for CT Angle Error
3011	CT Err. F1	0.0..5.0 °; Ø	0.0 °	CT Angle Error at I1
3012	CT Err. I2	0.003..1.600 A	1.000 A	Current I2 for CT Angle Error
3013	CT Err. F2	0.0..5.0 °; Ø	0.0 °	CT Angle Error at I2

6.11.4 Information Overview

F.No.	Alarm	Comments
1251	>SensEF on	>Switch on sensitive E/F detection
1252	>SensEF off	>Switch off sensitive E/F detection
1253	>SensEF block	>Block sensitive E/F detection
1260	SensEF on/offBI	Sensitve E/F detection ON/OFF via BI
1261	SensEF OFF	Sensitve E/F detection is switched OFF
1262	SensEF BLOCK	Sensitve E/F detection is BLOCKED
1263	SensEF ACTIVE	Sensitve E/F detection is ACTIVE
1271	SensEF Pickup	Sensitve E/F detection picked up
1272	SensEF Phase L1	Sensitve E/F detection Phase L1
1273	SensEF Phase L2	Sensitve E/F detection Phase L2
1274	SensEF Phase L3	Sensitve E/F detection Phase L3
1276	SensEF Forward	Sensitve E/F detection Forward
1277	SensEF Reverse	Sensitve E/F detection Reverse
1278	SensEF undefDir	Sensitve E/F detection Undef. Direction
1281	SensEF TRIP	Sensitve E/F detection TRIP command
1219	3I0senA=	Active 3I0sen (sensitive Ie) =
1220	3I0senR=	Reactive 3I0sen (sensitive Ie) =
1291	SensEF 3U0>	Sensitve E/F detection 3U0> pickup

6.12 Automatic Reclosure Function

Experience shows that about 85 % of the arc faults on overhead lines are extinguished automatically after being tripped by the protection. The line can therefore be reclosed. Reclosure is performed by an automatic reclosure function (AR). An example of the normal time sequence of a double-shot reclosure is shown in Figure 6-93.

If the circuit-breaker poles can be operated individually, a single-pole auto-reclosure is usually initiated in the case of single-phase faults and a three-pole auto-reclosure in the case of multi-phase faults in the network with earthed system star point. If the fault is still present after reclosure (arc not extinguished or metallic short-circuit), the protection issues a final trip. Several reclosure attempts are made in some networks.

Automatic reclosure is only permitted on overhead lines because the possibility of automatic extinguishing of a fault only exists there. It must not be used in any other case. If the protected object consists of a mixture of overhead lines and other equipment (e.g. overhead line in block with a transformer or overhead line/cable), it must be ensured that reclosure can only be performed in the event of a fault on the overhead line.

In the version with single-pole tripping, 7SA6 allows phase-segregated, single-pole tripping. A single and three-pole, single and multiple shot automatic reclosure function is integrated, depending on the ordered version.

7SA6 can also operate with an external automatic reclosure device. In this case the signal exchange between 7SA6 and the external reclosure device must take place via the binary inputs and outputs.

It is also possible to have the integrated automatic reclosure circuit initiated by an external protection (e.g. alternate protection). The use of two 7SA6 with automatic reclosure function or the use of one 7SA6 with an automatic reclosure function and a second protection with its own automatic reclosure function are equally possible.

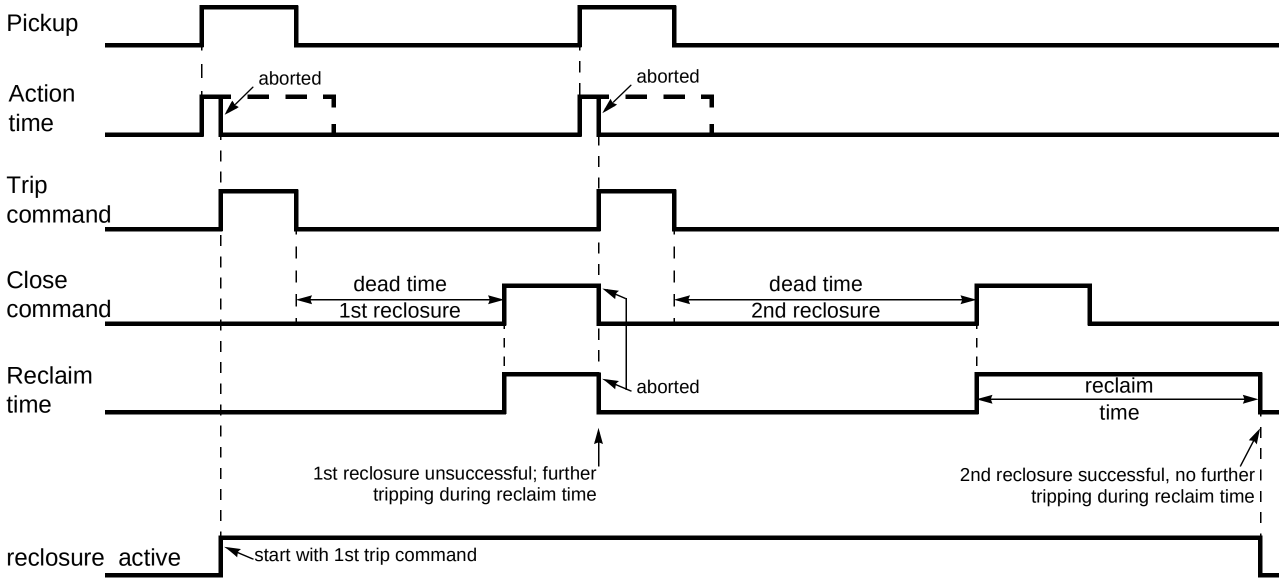


Fig. 6-93 Timing diagram of a double-shot reclosure with action time (2nd reclosure successful)

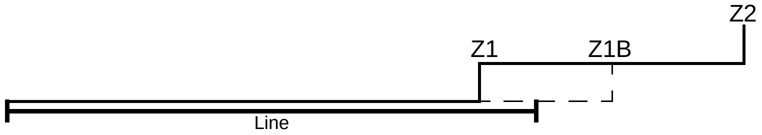
6.12.1 Method of Operation

The integrated automatic reclosure circuit allows up to 8 reclosure attempts.
The first four interrupt cycles may operate with different parameters (action and dead times, single/three-pole). The parameters of the fourth cycle also apply for the fifth cycle and onwards.

Selectivity before Reclosure

In order for the automatic reclosure to be successful, all faults on the entire overhead line must be cleared at all line ends simultaneously — as fast as possible. In the distance protection, for example, the overreaching zone Z1B may be released before the first reclosure (zone extension). This implies that faults up to the zone reach limit of Z1B are tripped without delay for the first cycle (figure 6-94). A limited unselectivity in favour of fast simultaneous tripping is accepted here because a reclosure will be performed in any case. The normal stages of the distance protection (Z1, Z2, etc.) and the normal grading of the other short-circuit functions are independent of the automatic reclosure function.

Reach for 1st tripping before reclosure (overreach zone Z1B enabled)



Reach after 1st reclosure (overreach zone Z1B disabled)

Figure 6-94 Reach control, before the first reclosure, in the distance protection

If the distance protection is operated with one of the signal transmission methods described in section 6.4 the signal transmission logic controls the overreaching zone, i.e. it determines whether an undelayed trip (or delayed with T1B) is permitted in the event of faults in the overreaching zone (i.e. up to the reach limit of zone Z1B) at both line ends simultaneously. Whether the automatic reclosure function is ready for reclosure or not is irrelevant because the teleprotection function ensures the selectivity over 100 % of the line length **and** fast, simultaneous tripping. Similar considerations apply for the earth fault direction comparison protection (section 6.6).

If, however, the signal transmission is switched off or the transmission path is disturbed, the internal automatic reclosure function can determine whether the overreaching zone (Z1B in the distance protection) is released for fast tripping. If no reclosure is expected (e.g. circuit-breaker not ready) the normal grading of the distance protection (i.e. fast tripping only for faults in zone Z1) must apply to retain selectivity.

Fast tripping before reclosure is also possible with multiple reclosures. Appropriate links between the output signals (e.g. 2nd reclosure ready: “`AR 2.CycZoneRel`“) and the inputs for enabling/releasing undelayed tripping of the protection functions can be established via the binary inputs and outputs or the integrated user-definable logic functions (CFC).

Mixed Lines Overhead Line/ Cable

On mixed lines with cables and overhead lines, it is possible to use the distance zone signals for distinguishing between cable and overhead line faults to a certain extent. The automatic reclosure can then be blocked by appropriate signals generated by means of the user-programmable logic functions (CFC) if there is a fault in the cable section.

Start

Starting the automatic reclosure function means storing the first trip signal during a network fault that was generated by a protection function intended to initiate automatic reclosure. In the case of multiple reclosure, starting therefore only takes place once with the first trip command. Storing this signal is the prerequisite for all subsequent actions of the automatic reclosure function.

The significance of starting becomes apparent when the first trip command does not appear before the expiry of an action time (see below under “Action Times”).

The automatic reclosure is not started if the circuit-breaker was not ready for at least one TRIP–CLOSE–TRIP–cycle at the instant of the first trip command. This can be achieved by setting parameters. See also subtitle “Interrogation of Circuit-Breaker Ready” (page 6-171).

Each short-circuit protection function can be parameterized as to whether it should operate with the automatic reclose function or not i.e. whether it should start the reclose function or not. The same applies to the trip commands coupled in via binary input and/or the trip commands generated by the teleprotection via transfer trip or intertrip signals.

Those protection and monitoring functions in the device which do not respond to short-circuits or similar conditions do not initiate the automatic reclosure function because a reclosure will be of no use here. Examples for this in the 7SA6 are the overload protection and overvoltage protection.

Action Times

It is often desirable to suppress the readiness for reclosure if the short-circuit condition was sustained for a certain time, e.g. because it is assumed that the arc has burned in to such an extent that there is no longer any chance of automatic arc extinction during the reclose dead time. Also for the sake of selectivity (see above), faults that are usually cleared after a time delay should not lead to reclosure. It is therefore recommended to use action times in conjunction with the distance protection.

The automatic reclosure function of the 7SA6 can be operated with or without action times (configuration parameter **`AR control mode`**, address **`0134`**, see section 5.1). No starting signal is necessary from the protection functions or external protection devices that operate without action time. Starting takes place as soon as the first trip command appears.

When operation with action time, an action time is available for each reclose cycle. The action times are always started by the general pickup signal (with logic *OR* combination of all internal and external protection functions which can start the automatic reclosure function). If no trip command is present before the action time expires, the corresponding reclose cycle is not carried out.

For each automatic reclose cycle it may be set via parameter whether it may start the recloser (the programmed first cycle does not necessarily have to be the first cycle that is executed - depending on the parameterization, the second, third or any other cycle may be the first one that is carried out). Following the first general start, only the action times of those cycles that are set such that they may start off the recloser are considered as the other cycles are not allowed to be the first cycle under any circumstances. By means of the action times and the permission to start the recloser (permission to be the first cycle that is executed) it is possible to determine which reclose cycles are executed depending on the time used by the protection function to trip.

Example 1: 3 cycles are set. At least the first cycle is configured to start the recloser (allowed to be the first cycle that is carried out). The action times are set as follows:
1.AR: T-ACTION = 0.2 s;
2.AR: T-ACTION = 0.8 s;
3.AR: T-ACTION = 1.2 s;
Since reclosure is ready before the fault occurs, the first trip following a fault is fast, i.e. before the expiry of any action time. The automatic reclosure function is therefore started (the first cycle is initiated). After an unsuccessful reclosure attempt the 2nd cycle would usually be initiated; but in this case the time-overcurrent protection trips according to its set grading time after 1 s. Since the action time for the second cycle was exceeded in this case, it is not initiated. The 3rd cycle according to its parameters is therefore now initiated. If the trip command only appeared more than 1.2 s after the 1st reclosure, there would have been no further reclosure.

Example 2: 3 cycles are set. Starting is only allowed for the first. The action times are set as in example 1.
The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, this cycle cannot start the automatic reclosure function. As the 2nd and 3rd cycles are not permitted to start the reclose function they will also not be initiated. Therefore no reclosure takes place as no starting took place.

Example 3: 3 cycles are set. At least the first two cycles are set such that they can start the recloser. The action times are set as in example 1.
The first protection trip takes place 0.5 s after starting. Since the action time for the 1st cycle has already expired at this time, this cycle cannot start the automatic reclosure circuit. However the 2nd cycle, which is also able to start the recloser, is activated immediately. This 2nd cycle therefore starts the automatic reclosure circuit, the 1st cycle is practically skipped.

Operating Modes of the Automatic Reclosure Function

The dead times — in other words, the time from fault clearance (reset of the trip command or indication by auxiliary contacts) upto the initiation of the automatic reclose command — may vary, depending on the automatic reclosure function operating mode selected when setting the scope of functions (section 5.1) and on the resulting signals generated by the protective functions selected to initiate reclosing.

In the ***Target on TRIP*** operating mode single-pole or single/three-pole reclose cycles are possible if the device and the circuit-breaker are suitable. In this case different dead times after single-pole tripping on the one hand and after three-pole tripping on the other hand are possible (for every reclose cycle). The protective function that issues the trip command determines the type of trip: single-pole or three-pole. Selection of the dead time depends on this.

In the ***with PICKUP*** operating mode, different dead times can be set for every reclose cycle after single-, two- and three-phase faults. Selection of the dead time in this case depends on the type of fault determined by the initiating protection function at the instant that the trip commands reset. This operating mode allows the dead times to be dependent on the type of fault in the case of three-pole reclose cycles.

Reclose Block

Different conditions lead to blocking of the automatic reclosure. No reclosure is for example possible if it is blocked via a binary input. If the automatic reclosure has not yet been started, it cannot be started at all. If a reclose cycle is already in progress, dynamic blocking takes place (see below).

Each individual cycle may also be blocked via binary input. In this case the cycle concerned is declared as invalid and will be skipped in the sequence of permissible cycles. If blocking takes place while the cycle concerned is already running, this leads to aborting of the reclosure, i.e. no reclosure takes place even if other valid cycles have been parameterized.

Internal blocking signals, with a limited duration, arise during the course of the reclose cycles:

The reclaim time **`T-RECLAIM`** is initiated along with every automatic reclosure command. If the reclosure is successful, all the functions of the automatic reclosure return to the quiescent state at the end of the reclaim time; a fault after expiry of the reclaim time is treated as a new fault in the network. Re-tripping by a protection function during the reclaim time initiates the next reclose cycle in the case of multiple reclosure; if no further reclosure is permitted, the last reclosure cycle is declared as unsuccessful if re-tripping within the reclaim time takes place. The automatic reclosure is blocked dynamically.

The dynamic blocking condition locks out the reclosure for the duration of the dynamic blocking time (0.5 s). This occurs for example after a final trip or if other conditions block the automatic reclosure function after starting has taken place. Restarting is locked out for this time. When this time expires, the automatic reclosure function returns to its quiescent state and is ready for a new fault in the power system.

If the circuit-breaker is closed manually (with the circuit breaker control discrepancy switch via a binary input, refer also to Subsection 6.20.1), the automatic reclosure is blocked for a Manual–Close–blocking time **`T-BLOCK MC`**. If a trip command is issued during this time, it can be assumed that a metallic short-circuit is the cause (e.g. closed earth switch). Every trip command within this time is therefore a final trip. With the user definable logic functions (CFC) further control functions may also be treated like a Manual–Close command.

Interrogation of Circuit-Breaker Ready

A precondition for automatic reclosure following clearance of a short-circuit is that the circuit breaker is ready for at least one TRIP–CLOSE–TRIP–cycle when the automatic reclosure is started (i.e. at the time of the first trip command). The circuit breaker ready state is signalled to the device via the binary input “`>CB1 Ready`” (FNo. **2730**). If no such signal is available, the circuit-breaker interrogation (at the time of the first trip) can be suppressed (presetting) as automatic reclosure would otherwise not be possible at all.

In the event of a single-shot reclosure this interrogation is usually sufficient. Since, for example, the air pressure or the spring tension for operation of the circuit-breaker drops during the trip operation, no further interrogation should take place.

It is of advantage, particularly in the case of multiple reclosure, to interrogate the readiness of the circuit-breaker not only at the time of the first trip command but also before every reclosure. The reclosure is blocked as long as the CB does not signal it is ready for another CLOSE–TRIP–cycle.

The recovery time of the circuit-breaker can be monitored by the 7SA6. This monitoring time **`CB TIME OUT`** starts as soon as the CB indicates the not ready state. The dead time may be extended if the ready state is not indicated when it expires. However, if the circuit-breaker not ready state lasts longer than the monitoring time, reclosure is blocked dynamically (refer also above to subtitle “Reclose Block”, page 6-170).

Processing the Circuit Breaker Auxiliary Contacts

If the circuit-breaker auxiliary contacts are connected to the device, a plausibility check of the circuit-breaker response is also carried out.

In the case of single-pole tripping this applies to each individual breaker poles. A precondition for this is that the auxiliary contacts must be connected to the appropriate binary inputs ("`>CB1 Pole L1`", F.No. 366, "`>CB1 Pole L2`", F.No. 367 and "`>CB1 Pole L3`", F.No. 368) for each pole.

If in stead of the individual pole auxiliary contacts, the series connection of the normally open and normally closed contacts are used (the normal state applies when the CB is open), the CB is assumed to have all three poles open when the series connection of the normally closed contacts is closed (binary input "`>CB1 3p Open`", F.No. 411). It has all three poles closed when the series connection of the normally open contacts is closed (binary input "`>CB1 3p Closed`", F.No. 410). If neither of these conditions are present, it is assumed that the circuit breaker has one pole open (even if this condition also theoretically applies to the two-pole open state).

The device continuously checks the switching state of the circuit-breaker: As long as the auxiliary contacts indicate that the CB is not closed (three-pole), the automatic reclosure function cannot be started. This guarantees that a close command can only be issued if the CB was previously tripped (out of the closed state).

The valid dead time starts when the trip command resets or when the auxiliary contacts indicate that the CB (pole) has opened.

If the CB opens with *three*-pole reclose cycles after a *single* pole trip command, this is considered as a three-pole trip. If three-pole reclose cycles are allowed, the dead time for three-pole tripping is activated with the operating mode: control by trip command (see above under title "Operating Modes of the Automatic Reclosure Function", page 6-170); with the mode: control by starting, the type of fault indicated by the protection function(s) issuing the start is still valid. If three-pole reclose cycles are not allowed, reclosure is blocked dynamically. The trip command is final.

The latter also applies if the CB trips two poles following a single-pole trip command. The device can only detect this if the auxiliary contacts of each pole are connected individually. The device immediately initiates three-pole coupling thus resulting in a three-pole trip command.

If the CB auxiliary contacts indicate that at least one further pole has opened during the dead time following a single-pole trip, a three-pole reclose cycle is initiated with the dead time for three-pole reclosure if this is allowed. If the auxiliary contacts are connected for each pole individually, the device can detect the two-pole open state of a CB. In this case the device immediately issues a three-pole trip command provided that the forced three-pole coupling is activated (see section 6.12.2 and refer to "Forced Three-pole Trip", page 6-186).

Sequence of a Three-pole Reclose Cycle

If the automatic reclosure function is ready, the short-circuit protection trips three pole for all faults inside the stage valid for reclosure. The automatic reclosure function is then started. When the trip command resets or the circuit-breaker opens (auxiliary contact criterion) an (adjustable) dead time starts. At the end of this dead time the circuit-breaker receives a close command. At the same time the (adjustable) reclaim time is started. If **`AR control mode`** was set under address **0134** ***`with Pickup`*** during configuration of the protective functions, different dead times can be parameterized depending on the type of fault recognised by the protection.

If the fault is cleared (successful reclosure), the reclaim time runs out and all functions return to their quiescent state. The system fault has ended.

If the fault is not cleared (unsuccessful reclosure), the short-circuit protection issues a final trip with the protection stage that is selected to operate without reclosure. Any fault during the reclaim time leads to a final trip.

After unsuccessful reclosure (final tripping), the automatic reclosure is blocked dynamically (see also page 6-170, "Reclose Block").

The sequence described above applies to a single reclosure cycle. In the 7SA6 multiple reclosure (up to 8 cycles) is also possible (see below).

Sequence of a Single-pole Reclose Cycle

Single-pole reclose cycles are only possible with the appropriate device version and if this was selected during the configuration of the protection functions (address **0110**, see also section 5.1). Of course, the circuit-breaker must also be suitable for single-pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips single pole for all single-phase faults inside the stage valid for reclosure. It can also be selected (address **1156A Trip2phFlt**, see also section 6.1.3), by setting, that single-pole tripping takes place for two-phase faults without earth. Single-pole tripping is of course only possible with short-circuit protection functions that can determine the faulty phase.

If only single-pole reclosure is selected then the short-circuit protection issues a final three-pole trip with the stage that is valid without reclosure. Every three-pole trip is final. The automatic reclosure is blocked dynamically (see also above under subtitle “Reclose Block”, page 6-170).

The automatic reclosure function is started following a single-pole trip. The (adjustable) dead time for the single-pole reclose cycles starts with reset of the trip command or opening of the circuit-breaker pole (auxiliary contact criterion). The circuit-breaker receives a close command after the dead time. At the same time the (adjustable) reclaim time is started. If the reclosure is blocked during the dead time following a single-pole trip, optional immediate three-pole tripping can take place (Forced Three-pole Trip, page 6-186).

If the fault has been cleared (successful reclosure), the reclaim time runs out and all functions return to their quiescent state. The system fault has ended.

If the fault is not cleared (unsuccessful reclosure), the short-circuit protection issues a final trip with the protection stage that is valid without reclosure. Any fault during the reclaim time also leads to a final trip.

After unsuccessful reclosure (final tripping) the automatic reclosure function is blocked dynamically (see also page 6-170, “Reclose Block”)

The sequence described above applies to single reclose cycles. In the 7SA6 multiple reclosure (up to 8 cycles) is also possible (see below).

Sequence of a Single and Three-pole Reclose Cycle

This operating mode is only possible with the appropriate device version and if this was selected during configuration of the protection functions (address **0110**, see also section 5.1). Of course, the circuit-breaker must also be suitable for single-pole tripping.

If the automatic reclosure function is ready, the short-circuit protection trips single-pole for single-phase faults and three-pole for multi-phase faults. Under **Power System Data 2 (P.System Data 2)** (address **1156**, see also Section 6.1.3) it can also be selected that single-pole tripping takes place for two-phase faults without earth. Single-pole tripping is of course only possible with short-circuit protection functions that can determine the faulty phase. The valid protection stage valid for reclosure ready state applies for all fault types.

The automatic reclosure function is started at the instant of a trip. Depending on the type of fault the (adjustable) dead time for the single-pole reclose cycle or the (separately adjustable) dead time for the three-pole reclose cycle starts following the reset of the trip command or opening of the circuit-breaker (pole). After expiry of the dead time the circuit-breaker receives a close command. At the same time the (adjustable) reclaim time is started. If the reclosure is blocked during the dead time following a single-pole trip, optional immediate three-pole tripping can take place (Forced Three-pole Trip, page 6-186).

If the fault is cleared (successful reclosure), the reclaim time expires and all functions return to their quiescent state. The system disturbance has ended.

If the fault is not cleared (unsuccessful reclosure), the short-circuit protection initiates a final three-pole trip with the protection stage that is valid when reclosure is not ready. All faults during the reclaim time also lead to the issue of a final three-pole trip.

After unsuccessful reclosure (final tripping) the automatic reclosure function is blocked dynamically (see also page 6-170, “Reclose Block”).

The sequence above applies for single reclosure cycles. In the 7SA6 multiple reclosure (up to 8 cycles) is also possible (see below).

Multiple Reclosure

If a short-circuit still exists after a reclosure attempt, further reclosure attempts can be made. Up to 8 reclosure attempts are possible with the automatic reclosure function integrated in the 7SA6.

The first four reclosure cycles are independent on each other. Each one has separate action and dead times, can operate single or three pole and can be blocked separately via binary inputs. The parameters and intervention possibilities of the fourth cycle also apply to the fifth cycle and onwards.

The sequence is the same in principle as in the different reclosure programs described above. However, if the first reclosure attempt was unsuccessful, the reclosure function is not blocked, but instead the next reclose cycle is started. The appropriate dead time starts with the reset of the trip command or opening of the circuit-breaker (pole) (auxiliary contact criterion). The circuit-breaker receives a new close command after expiry of the dead time. At the same time the reclaim time is started.

Until the set number of permissible reclose cycles is reached, the reclaim time is reset with each new trip command after reclosure and started again with the next close command.

If one of the cycles is successful, i.e. the fault no longer exists after reclosure, the reclaim time expires and all functions return to their quiescent state. The system fault has ended.

If none of the cycles is successful, a final three-pole trip is issued by the valid protection stage selected to operate during the recloser not ready state following the final permissible reclosure. The automatic reclosure is blocked dynamically (see also “Reclose Block”, page 6-170).

Handling of Sequential Faults

When single-pole or single- and three-pole reclose cycles are executed in the network, particular attention must be paid to sequential faults.

Sequential faults are faults which occur during the dead time after clearance of the first fault.

There are various ways of handling sequential faults in the 7SA6 depending on the requirements of the network:

Detection of an sequential fault can be selected to occur either with a *trip command* of a protection function during the dead time or with every further *fault detection*.

It is possible to select the desired **response** of the internal automatic recloser following the detection of an sequential fault.

a) `EV. FLT. MODE` ***blocks AR***:
The reclosure is blocked as soon as an sequential fault is detected. Tripping as a result of the sequential fault is three-pole. This applies irrespective of whether three-pole cycles are permitted or not. There are no further reclosure attempts; the automatic reclosure function is blocked dynamically (see also above under subtitle “Reclose Block”, page 6-170).

b) `EV. FLT. MODE` ***starts 3p AR***:
As soon as an sequential fault is detected the recloser switches over to a three-pole cycle. All trip commands are now three-pole. The separately settable dead time for sequential faults starts with the clearance of the sequential fault; after the dead time the circuit-breaker receives a close command. The further sequence is the same as for single and three-pole cycles.

The complete dead time in this case consists of the portion of the single-pole dead time up to clearance of the sequential fault plus the dead time for the sequential fault. This makes sense because the duration of the three-pole dead time is essential for the stability of the network.

If reclosure is blocked due to an sequential fault without the protection issuing a three-pole trip command (e.g. for sequential fault detection with fault detection), the device can send a three-pole trip command so that the circuit-breaker does not remain open with one pole (Forced Three-pole Trip, see page 6-186).

Dead Line Check (DLC)

If the voltage of a disconnected phase does not disappear following a trip, reclosure can be prevented. A prerequisite for this function is that the voltage transformers are connected on the line side of the circuit breaker. To select this function the dead line check must be activated. The automatic reclosure function then checks the disconnected line for no-voltage: The line must have been without voltage for at least an adequate measuring time during the dead time. If this was not the case the reclosure is blocked dynamically.

This no-voltage check on the line is of advantage if a small generator (e.g. wind generator) is connected along the line.

Reduced Dead Time (RDT)

If automatic reclosure is performed in connection with time-graded protection, non-selective tripping before reclosure is often unavoidable in order to achieve fast, simultaneous tripping at all line ends. The 7SA6 has a “reduced dead time (RDT)” procedure which reduces the effect of the short-circuit on healthy line sections to a minimum. The three phase voltages are measured for the reduced dead time. The voltage transformers must be located on the line side of the circuit breaker.

In the event of a fault close to on of the line ends, the surrounding lines can initially be tripped because for example a distance protection detects the fault in its overreaching zone Z1B (figure 6-95, relay location III). If the network is meshed and there is at least one other infeed on the busbar B, the voltage there returns immediately after clearance of the fault. For single-pole tripping it is sufficient if there is an earthed transformer with delta winding connected at busbar B which ensures symmetry of the voltages and thus induces a return voltage in the open phase. This allows a distinction between the faulty line and the unfaulted line to be made as follows:

Since line B−C is only tripped singled-ended at C, it receives a return voltage from the end B which is not tripped so that at C the open phase(s) also has (have) voltage. If the device detects this at position III, reclosure can take place immediately or in a shorter time (to ensure sufficient voltage measuring time). The healthy line B−C is then back in operation.

Line A–B is tripped at both ends. There is therefore no voltage here, this identifies the line at both ends as the faulted one. The normal dead time comes into service here.

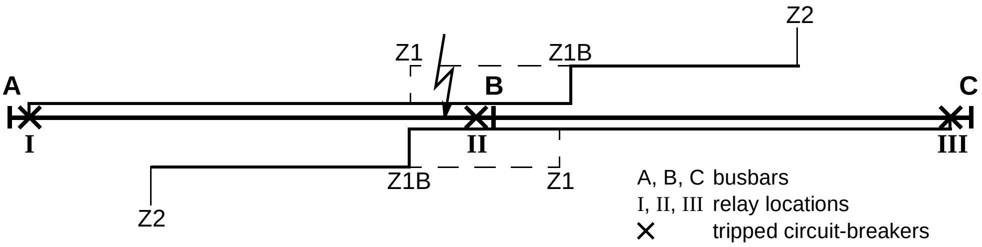


Figure 6-95 Example of a reduced dead time (RDT)

Adaptive Dead Time (ADT)

In all the previous alternatives it was assumed that defined and equal dead times were set at both line ends, if necessary for different fault types and/or reclose cycles.

It is also possible to set the dead times (if necessary different for various fault types and/or reclose cycles) at one line end only and to configure the adaptive dead time (ADT) at the other end (or ends). This can be done on condition that the voltage transformers are located on the line side of the circuit breaker or that means for the transfer of a close command exist.

Figure 6-96 shows an example. It is assumed that the device I is operating with defined dead times whereas the adaptive dead time is configured at position II. It is important that the line is at least fed from busbar A, i.e. the side with the defined dead times.

With the adaptive dead time the automatic reclosure function at line end II decides independently if and when reclosure is sensible and is therefore allowed and when it is not. The criterion is the voltage on the line at end II, which is fed from end I following reclosure there. Reclosure therefore takes place at end II as soon as it is apparent that voltage has been re-applied to the line from end I.

In the illustrated case, the lines are tripped at positions I, II and III. At I reclosure takes place after the dead time parameterized there. At III a reduced dead time can take place (see above) if there is also an infeed on busbar B.

If the fault has been cleared (successful reclosure), line A–B is re-energised from busbar A through position I. Device II detects this voltage and also reclosed after a short delay (to ensure a sufficient voltage measuring time). The system fault has ended.

If the fault has not been cleared after reclosure at I, a switch on to fault occurs at I, no healthy voltage appear at II. The device there detects this and does not reclose.

In the case of multiple reclosure the sequence may be repeated several times following an unsuccessful reclosure until one of the reclosures attempts is successful or a final trip takes place.

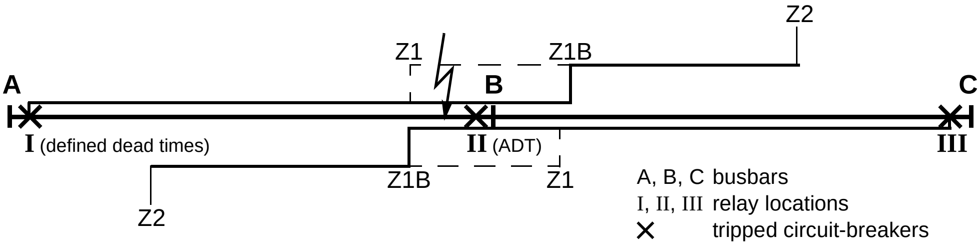


Figure 6-96 Example of adaptive dead time (ADT)

As is shown by the example, the adaptive dead time has the following advantages:

- The circuit-breaker at position II is not reclosed at all if the fault persists and is therefor not unnecessarily stressed.
- With non-selective tripping by overreach at position III no further trip and reclose cycles occur here because the short-circuit path via busbar B and position II remains interrupted even in the event of several reclosure attempts.
- At position I overreach is allowed in the case of multiple reclosures and even in the event of final tripping because the line remains open at position II and therefore no actual overreach can occur at I.

The adaptive dead time also includes the reduced dead time because the criteria are the same. There is no need to set the reduced dead time as well.

Close Command–transfer (Remote–CLOSE)

With close command transmission the dead times are only set at one line end. The other (or the others in case of lines with more than two ends) is (are) set to “adaptive dead time”. These ends respond to the received close command from the transmitting end.

The transmission of the close command by the transmitting line end is delayed until it is sure that the local reclosure was successful. This means that following reclosure one further possible local fault detection is waited for. This delay prevents unnecessary closing at the remote end on the one hand but also increases the time until reclosure takes place there. This is not critical for a single-pole interruption or in radial or meshed networks because no stability problems are expected under these conditions.

The close command may be transferred by means of any signal transmission method.

Connecting an External Reclosure Device

If the 7SA6 has to work with an external reclosure device, the binary inputs and outputs provided for this purpose must be taken into consideration. The following inputs and outputs are recommended:

<u>Binary inputs:</u>

`383 >Enable ARzones`	With this binary input the external reclosure device controls stages of the individual short-circuit protection functions which are active before reclosure (e.g. overreaching zone in the distance protection). The input can be omitted if no overreaching stage is required (e.g. distance protection with comparison mode, see also above under subtitle “Selectivity before Reclosure”).
`382 >Only 1ph AR`	The external reclosure device is only programmed for 1-pole; the stages of the individual protection functions that are activated before reclosure via F.No. 383 only do so in

	the case of single-phase faults; in the event of multiple phase faults these stages do not operate. This input is not required if no overreaching stage is used (e.g. differential protection or comparison mode with distance protection, see also above under subtitle “Selectivity before Reclosure”).
`381 >1p Trip Perm`	The external reclosure device allows 1-pole tripping (logic inversion of 3-pole coupling). If this input is not assigned or not routed (matrix), the protection functions trip 3-pole for all faults. If the external reclosure device cannot supply this signal but supplies a “3-pole coupling” signal instead, this must be taken into account in the routing of the binary inputs (see section 5.2): The signal must be inverted in this case (**L**–active = active without voltage).

Binary outputs:

`501 Relay PICKUP`	Start of protection device, general (if required by external recloser device).
`515 Relay TRIP 3ph.`	trip protective device 3-pole,
`512 Relay TRIP 1pL1`	trip protective device 1-pole phase L1.
`515 Relay TRIP 3ph.`	trip protective device 3-pole,
`513 Relay TRIP 1pL2`	trip protective device 1-pole phase L2.
`515 Relay TRIP 3ph.`	trip protective device 3-pole,
`514 Relay TRIP 1pL3`	trip protective device 1-pole phase L3.

In order to obtain a phase-segregated trip indication, the respective single-pole trip commands must be combined with the three-pole trip command on one output.

Figure 6-97 for example shows the interconnection between a 7SA6 and an external reclosure device with a mode selector switch.

Depending on what the external recloser device requires, the three single-pole outputs (F.No `512`, `513`, `514`) may also be combined to one “single-pole tripping” output; the F.No `515` provides the “three-pole tripping” signal to the external device.

If only three-pole reclosure takes place, general starting (F.No `501`, if required by the external reclosure device) and the trip signals (F.No `511`) from 7SA6 (see figure 6-98) usually suffice.

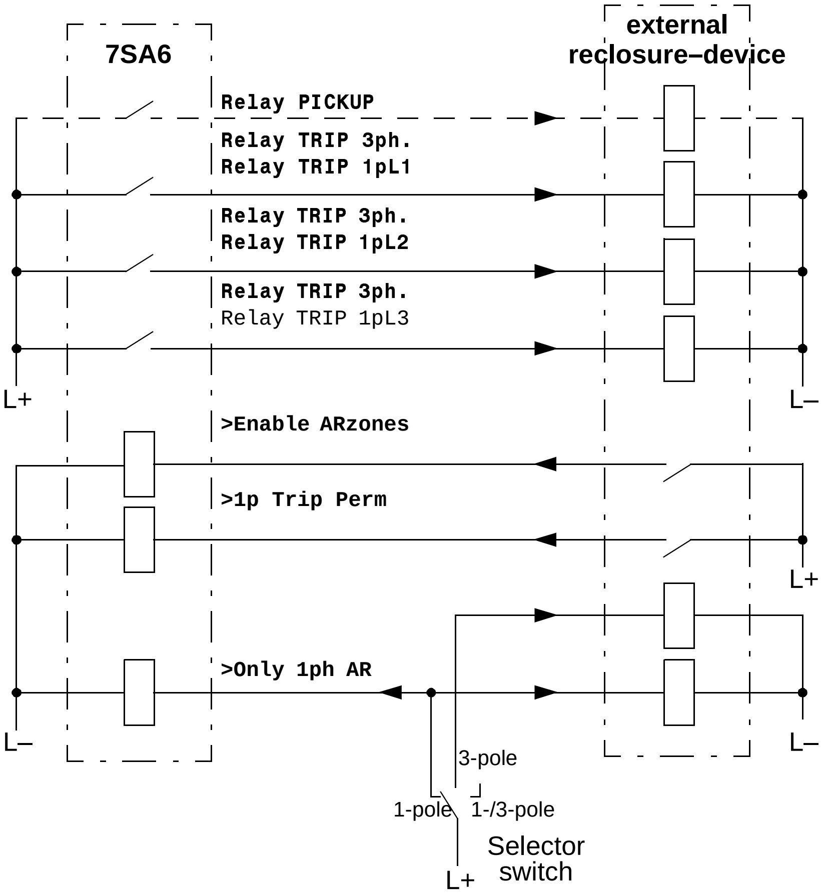


Figure 6-97 Connection example with external reclosure device for 1-/3-pole reclosure with mode selector switch

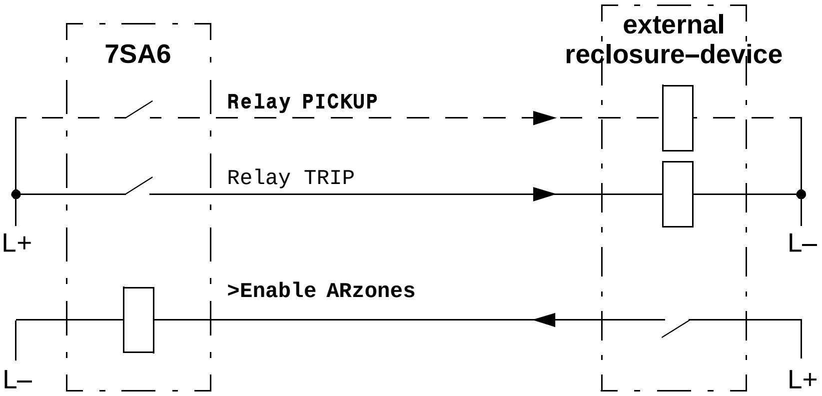


Figure 6-98 Connection example with external reclosure device for 3-pole reclosure

Control of the Internal Automatic Reclosure by an External Protection Device

If the 7SA6 is equipped with the internal automatic reclosure function, it may also be controlled by an external protection device. This is of use for example on line ends with redundant protection or additional back-up protection when the second protection is used for the same line end and has to work with the automatic reclosure function integrated in the 7SA6.

The binary inputs and outputs provided for this functionality must be considered in this case. It must be decided whether the internal automatic reclosure function is to be controlled by the fault detection (pickup) or by the trip command of the external protection (see also above under “Operating Modes of the Automatic Reclosure Function”, page 6-170).

If the automatic reclosure is controlled by the trip command, the following inputs and outputs are recommended:

The automatic reclosure function is started via the binary inputs:

`2711 >AR Start`	general fault detection signal for automatic reclosure (only required for action time),
`2712 >Trip L1 AR`	trip command L1 for automatic reclosure,
`2713 >Trip L2 AR`	trip command L2 for automatic reclosure,
`2714 >Trip L3 AR`	trip command L3 for automatic reclosure,

The general fault detection determines the starting of the action times. It is also necessary if the automatic reclosure is to detect evolving faults by fault detection. In other cases this input information is superfluous.

The trip commands decide whether the dead time for single-pole or three-pole reclose cycles is activated or whether the reclosure is blocked in the event of a three-pole trip (depending on the set dead times).

Figure 6-99 for example shows the interconnection between the internal automatic reclosure function in the 7SA6 and an external protection device.

To achieve three-pole coupling of the external protection and to release, if necessary, its accelerated stages before reclosure the following output signals are suitable:

`2864 AR 1p Trip Perm`	internal automatic reclosure function ready for 1-pole reclose cycle, i.e. allows 1-pole tripping (logic inversion of the 3-pole coupling).
`2889 AR 1.CycZoneRel`	internal automatic reclosure function ready for the first reclose cycle, i.e. releases the stage of the external protection device for reclosure, the corresponding outputs can be used for other cycles. This output can be omitted if the external protection does not require an overreaching stage (e.g. differential protection or comparison mode with distance protection).
`2820 AR Program1pole`	internal automatic reclosure function is programmed for one pole, i.e. only recloses after single-pole tripping. This output can be omitted if no overreaching stage is required (e.g. differential protection or comparison mode with distance protection).

Instead of the three phase-segregated trip commands, the single-pole and three-pole tripping may also be signalled to the internal automatic reclosure function — provided that the external protection device is capable of this —, i.e. assign the following binary inputs of the 7SA6:

`2711 >AR Start`	general fault detection for the internal automatic reclosure function (only required for action time),
`2715 >Trip 1pole AR`	trip command 1-pole for the internal automatic reclosure function,

`2716 >Trip 3pole AR`	trip command 3-pole for the internal automatic reclosure function,

If *only* three-pole reclose cycles are to be executed, it is sufficient to assign the binary input “`>Trip 3pole AR`” (F.No `2716`) for the trip signal. Figure 6-100 shows an example. The overreaching stages of the external protection are again enabled by “`AR 1.CycZoneRel`” (F.No `2889`) and if applicable by further cycles.

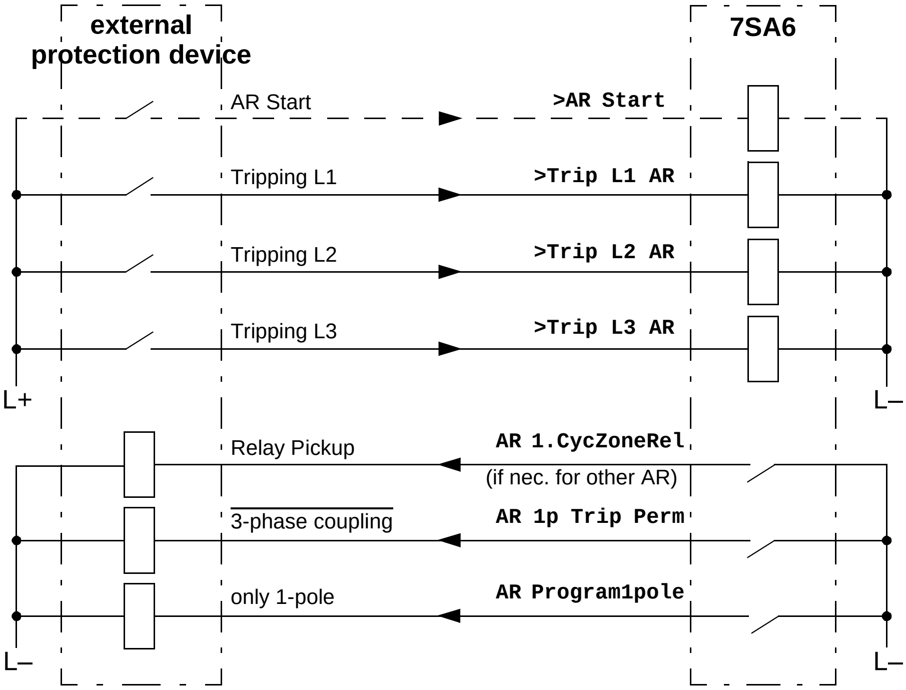


Figure 6-99 Connection example with external protection device for 1-/3-pole reclosure; AR control mode = ***with PICKUP***

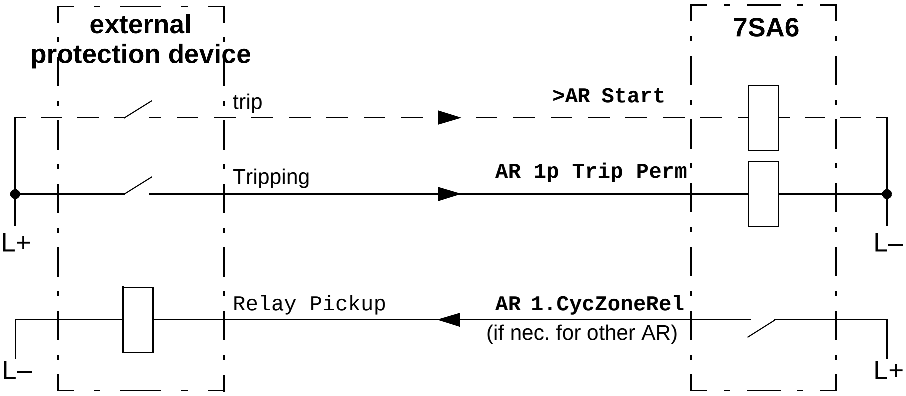
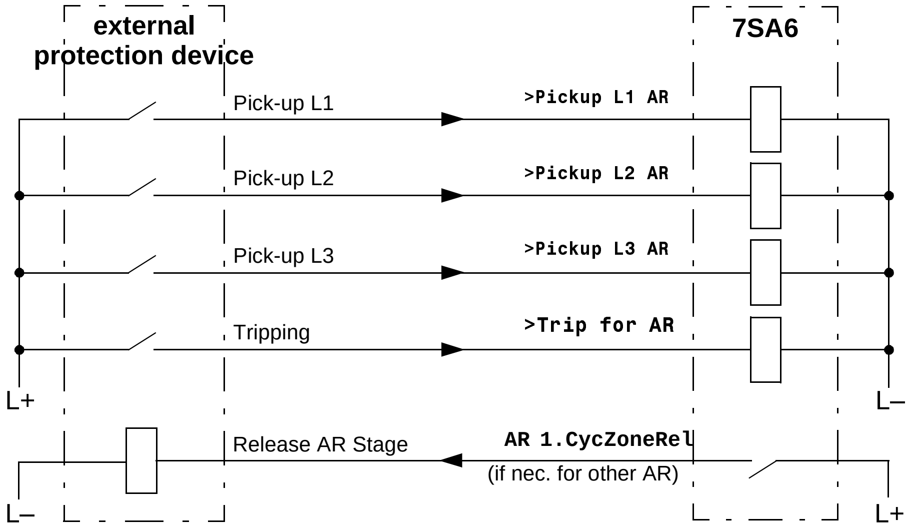
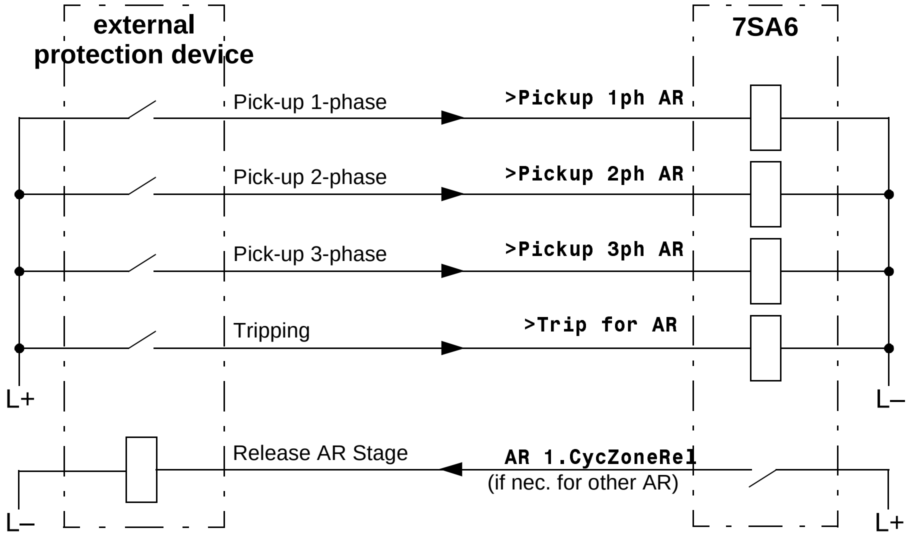


Figure 6-100 Connection example with external protection device for 3-pole reclosure; AR control mode = ***with TRIP***

If, on the other hand, the internal automatic reclosure function is controlled by the pickup (only possible with three-pole tripping: **`110 Trip mode = 3pole only`**), the phase-segregated fault detection (pickup) signals must be connected from the external protection. The general trip command then suffices for tripping (F.No 2746). Figure 6-101 shows connection examples.



Starting signal for each phase



Starting signal 1-phase, 2-phase and 3-phase

Figure 6-101 Connection example with external protection device for fault detection dependent dead time — dead time control by start signals of the protection device;
AR control mode = ***with PICKUP***

2 Protection Devices with 2 Automatic Reclosure Functions

If redundant protection is provided for a line and each protection operates with its own automatic reclosure function, a certain signal exchange between the two combinations is necessary. The connection example in figure 6-102 shows the necessary cross-connections.

If phase segregated auxiliary contacts of the circuit-breaker are connected, a three-pole coupling by the 7SA6 is guaranteed when more than one CB pole is tripped. This requires setting of the forced three pole coupling (see section 6.12.2 under subtitle

“Forced Three-pole Trip”, page 6-186). An external automatic three-pole coupling is therefore not necessary when the above conditions are satisfied. This rules out two-pole tripping under all circumstances.

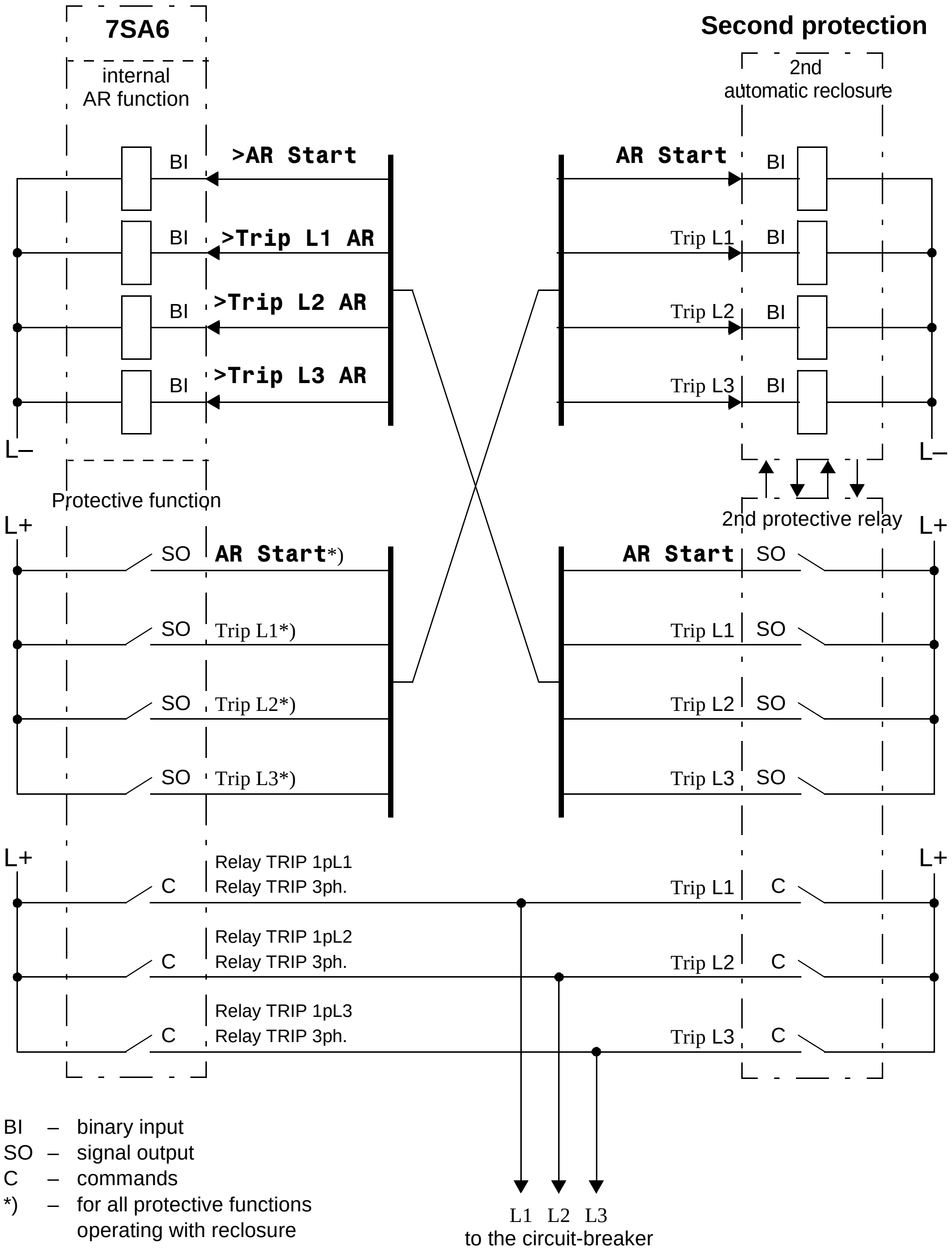


Figure 6-102 Connection example for 2 protection devices with 2 automatic reclosure functions

6.12.2 Setting the function parameters

General

If no reclosure is required on the feeder to which the distance protection 7SA6 is applied (e.g. for cables, transformers, motors or similar), the automatic reclosure function must be removed during configuration of the device (see Section 5.1, address `0133`). The automatic reclosure function is then completely disabled, i.e. the automatic reclosure is not processed in the 7SA6. No signals regarding the reclosure function are generated and the binary inputs for the automatic reclosure function are ignored. All parameters for setting the automatic reclosure function are inaccessible and of no significance. Tripping is always three-pole for all faults.

If, on the other hand, the internal automatic reclosure function is to be used, the type of reclosure must be selected during the configuration of the functions (see Section 5.1) in address **0133 Auto Reclose** and the **AR control mode** in address **0134**.

Up to 8 reclosure attempts are allowed with the integrated automatic reclosure function in the 7SA6. Whereas the settings in the addresses **3401** to **3441** are common to all reclosure cycles, the individual settings of the cycles are made from address **3450** onwards. It is therefore possible to set different individual parameters for the first four reclose cycles. The parameters of the fourth cycle also apply to the fifth cycle and onwards.

Under address **3401 AUTO RECLOSE** the automatic reclosure function can be switched ***On*** or ***Off***.

A prerequisite for automatic reclosure taking place after a trip due to a short-circuit is that the circuit-breaker is ready for at least one TRIP–CLOSE–TRIP–cycle at the time the automatic reclosure is started (i.e. at the time of the first trip command). The readiness of the circuit-breaker is signalled to the device through the binary input "`>CB1 Ready`" (F.No 371). If no such signal is available, leave the setting under address **3402 CB? 1.TRIP** = ***No*** because no automatic reclosure would be possible at all otherwise. If circuit-breaker readiness can be interrogated, the setting **CB? 1.TRIP** = ***Yes*** should be applied.

Furthermore the circuit-breaker ready state can also be interrogated prior to every reclosure. This is set when setting the individual reclose cycles (see below).

To check if the circuit-breaker is ready again during the dead times, it is possible to set a circuit-breaker–ready–monitor time under address **3409 CB TIME OUT**. This time is set slightly longer than the recovery time of the circuit-breaker after a TRIP–CLOSE–TRIP–cycle. If the circuit-breaker is not ready again by the time this timer expires, no reclosure takes place, the automatic reclosure function is blocked dynamically.

Waiting for the circuit-breaker to be ready can lead to an increase of the dead times. Interrogation of a synchro–check (if used) can also delay reclosure. To avoid uncontrolled prolongation it is possible to set a maximum prolongation of the dead time in this case under address **3411A T-DEAD EXT.**. This prolongation is unlimited if the setting ∞ is applied. This setting can only be changed with DIGSI® 4 under "**Additional Settings**". Remember that longer dead times are only permissible after three-pole tripping when no stability problems arise or when a synchro–check takes place before reclosure.

The reclaim time **T-RECLAIM** (address **3403**) is the time after which the system fault is considered to be over after a successful reclosure. Re-tripping of a protection function within this time initiates the next reclose cycle in the event of multiple reclosure; if no further reclosure is permitted, the last reclosure is treated as unsuccessful. The reclaim time must therefore be longer than the longest response time of a protective function which can start the automatic reclosure function.

A few seconds are generally sufficient. In regions with frequent storms and thunderstorms a shorter reclaim time is advisable to reduce the risk of a final trip due to repeated lightning strikes or cable flashovers.

A long reclaim time must be selected in conjunction with multiple reclosure (see above) if the circuit-breaker can not be monitored (e.g. due to missing auxiliary contacts and CB–ready–information). Then the reclaim time must be longer than the recovery time of the circuit-breaker.

The blocking duration following Manual–Close–detection **T-BLOCK MC** (address **3404**) must guarantee safe switching on and off of the circuit-breaker (0.5 s to 1 s). If a fault is detected by a protection function within this time after detected closing of the circuit-breaker, no reclosure takes place and a final three-pole trip is issued. If this is not desired, address **3404** is set to ***0***.

The options for the treatment of evolving faults are described in Section 6.12.1 under the Sub-section “Handling of Sequential Faults” (page 6-174). The treatment of evolving faults is not necessary on line ends where the adaptive dead time is applied (address **0133** **Auto Reclose** = ***Adaptive Dead Time (ADT)***, Section 5.1). The addresses **3406** and **3407** are then of no consequence and therefore not accessible.

The detection of an evolving fault can be defined under address **3406** **EV. FLT. RECOG.** ***with PICKUP*** means that, during a dead time, every fault detection (*pickup*) by a protection function will be interpreted as an evolving fault. With **EV. FLT. RECOG.** ***with TRIP*** a fault during a dead time is only interpreted as an evolving fault if it has led to a *trip command* by a protection function. This may also include trip commands which are coupled in from external via a binary input or which have been transmitted from an opposite end of the protected object. If an external protection device operates with the automatic reclosure, evolving fault detection with pickup requires the connection of a start signal from the external device to the 7SA6; otherwise an evolving fault can only be detected with the external trip command even if ***with PICKUP*** was set here.

The reaction in response to evolving faults can be selected under address **3407**. **EV. FLT. MODE** ***blocks AR*** means that no reclosure takes place after detection of an evolving fault. This is always useful when only single-pole reclosure is to take place or when stability problems are expected due to the subsequent three-pole dead time. If a three-pole reclose cycle is to be initiated by tripping of the evolving fault, set **EV. FLT. MODE** = ***starts 3p AR***. In this case a separately adjustable three-pole dead time is started with the three-pole trip command due to the evolving fault. This is only useful if three-pole reclosure is also permitted.

Address **3408** **T-Start MONITOR** monitors the reaction of the circuit-breaker after a trip command. If the CB has not opened during this time (from the beginning of the trip command), the automatic reclosure is blocked dynamically. The criterion for circuit breaker opening is the position of the circuit-breaker auxiliary contact or the disappearance of the trip command. If a circuit-breaker failure protection (internal or external) is used on the feeder, this time should be shorter than the delay time of the circuit-breaker failure protection so that no reclosure takes place if the circuit-breaker fails.

If the reclosure command is transmitted to the opposite end, this transmission can be delayed by the time setting in address **3410** **T RemoteClose**. This transmission is only possible if the device operates with adaptive dead time at the remote end (address **0133** **Auto Reclose** = ***Adaptive Dead Time (ADT)*** at remote end). This parameter is otherwise irrelevant. On the one hand, this delay serves to prevent the remote end device from reclosing unnecessarily when local reclosure is unsuccessful. On the other hand it should be noted that the line is not available for energy transport until the remote end has also closed. This delay must therefore be added to the dead time for consideration of the network stability.

Configuration of the Automatic Reclosure Function

This configuration concerns the interaction between the protection and supplementary functions of the device and the automatic reclosure function. The selection of functions of the device which are to start the automatic reclosure circuit and which are not to, is made here.

In the 7SA6 this concerns:
Address **3420 AR w/ DIST.**, i.e. with distance protection,
Address **3421 AR w/ SOTF-O/C**, i.e. with high–current fast tripping,
Address **3422 AR w/ W/I**, i.e. with weak-infeed trip function,
Address **3423 AR w/ EF-O/C**, i.e. with transfer trip and remote trip,
Address **3424 AR w/ DTT**, i.e. with externally coupled trip command,
Address **3425 AR w/ BackUpO/C**, i.e. with time-overcurrent protection.
For the functions which are to start the automatic reclosure, the corresponding address is set to ***Yes***, for the others to ***No***. The other functions (overvoltage protection, overload protection) cannot start the automatic reclosure because reclosure is of no use here.

Forced Three-pole Trip

If reclosure is blocked during the dead time of a single-pole cycle without a three-pole trip command having been given, the line remains interrupted single-pole. With address **3430 AR TRIP 3pole** it is possible to determine that the tripping logic of the device issues a three-pole trip command in this case (pole discrepancy prevention for the CB poles). Set this address to ***Yes*** if the CB can be tripped single-pole and has no pole discrepancy protection itself. Nevertheless, the device pre-empts the pole discrepancy protection of the CB poles because the forced three-pole trip of the device is immediately activated as soon as the reclosure is blocked following a single-pole trip or if the CB auxiliary contacts indicate a non plausible switching state (see also section 6.12.1 under subtitle “Processing the Circuit Breaker Auxiliary Contacts”). The forced three-pole trip is also activated when only three-pole cycles are allowed but a single-pole trip is signalled externally via a binary input.

The forced three pole trip is unnecessary if only a common three-pole control of the CB is possible.

Dead Line Check/ Reduced Dead Time

Under address **3431** the dead line check or the reduced dead time function can be activated. Either the one or the other can be used as the two options are contradictory. The voltage transformers must be connected to the line side of the circuit breaker if either of these modes is to be used. If this is not the case or if neither of the two functions is used, set **DLC or RDT** = ***WITHOUT***. If the adaptive dead time is used (see below), the parameters mentioned here are omitted because the adaptive dead time implies the properties of the reduced dead time.

DLC or RDT = ***DLC*** means that the dead line check of the line voltage is used. This only enables reclosure after it becomes apparent that the line has been dead. In this case, the setting **U-dead<** under address **3441** determines the limit voltage, phase–earth,below which the line is considered to be definitely dead (disconnected). The setting is applied in Volts secondary. This value can be entered as a primary value when parametrizing with a PC and DIGSI® 4. Address **3438 T U-stable** determines the measuring time available for determining the no-voltage condition. Address **3440** is irrelevant here.

DLC or RDT = ***RDT*** means that the reduced dead time is used. This is described in detail in section 6.12.1 under subtitle “Reduced Dead Time (RDT)”, page 6-175. In this case the setting under address **3440 U-live>** determines the limit voltage, phase–

earth,above which the line is considered to be fault-free. It must be set smaller than the smallest expected operating voltage. The setting is applied in Volts secondary. This value can be entered as a primary value when parametrizing with a PC and DIGSI® 4. Address **3438 T U-stable** determines the measuring time available for determining this voltage. It should be longer than any transient oscillations resulting from line energisation. Address **3441** is irrelevant here.

Adaptive Dead Time (ADT)

When operating with adaptive dead time, it must initially be ensured that *one* end per line operates with defined dead times and has an infeed. The other (or the others in multi-branch lines) may operate with adaptive dead time. It is essential that the voltage transformers are located on the line side of the circuit breaker. Details about this function can be found in section 6.12.1 under subtitle “Adaptive Dead Time (ADT)” on page 6-176.

For the line end with defined dead times the number of desired reclose cycles must be set during the configuration of the protective functions (section 5.1) under address **0133 Auto Reclose**. For the devices operating with adaptive dead time **Auto Reclose** = ***Adaptive Dead Time (ADT)*** must be set during the configuration of the protective functions (section 5.1) under address **0133**. Only the parameters described below are interrogated in the latter case. No settings are then made for the individual reclosure cycles. The adaptive dead time implies functionality of reduced dead time.

The adaptive dead time may be controlled by return voltage or by the **remote–CLOSE**–command. Both is possible at the same time. In the first case reclosure takes place as soon as the return voltage, after reclosure at the remote end, is detected. For this purpose the device must be connected to voltage transformers located on the line side of the circuit breaker. In the case of **remoteCLOSE**, the device waits until the **remoteCLOSE** command is received before issuing the reclose command.

The action time **T-ACTION ADT** (address **3433**) is the time after a pick-up by a protection function which is able to activate the automatic reclosure within which the trip command must occur. If the command does not appear until after the action time has expired, there is no reclosure. Depending on the configuration of the protection functions (see section 5.1) the action time may also be omitted; this particularly applies when an initiating protection function has no fault detection signal (only trip signal).

The dead times are determined by the reclosure command of the device at the line end with the defined dead times. In cases where this reclosure command does not appear, e.g. because the reclosure was in the mean time blocked there, the readiness of the local device must return to the quiescent state at some time. This takes place after the maximum wait time **T-MAX ADT** (address **3434**). This must be long enough to include the last reclosure of the remote end. In the case of single-shot reclosure, the sum total of maximum dead time plus reclaim time of the other device is sufficient. In the case of multiple reclosure the worst case is that all reclosures of the other end except the last one are unsuccessful. The time of all these cycles must be taken into account. To save having to make exact calculations, it is possible to use the sum of all dead times and all protection operating times plus one reclaim time.

Under address **3435 ADT 1p allowed** it can be determined whether single-pole tripping is allowed (on condition that single-pole tripping is possible). If ***No***, the protection trips three-pole for all fault types. If ***Yes*** the tripping capability of the initiating protection functions is decisive.

Under address **3436 ADT CB? CLOSE** it can be determine whether circuit-breaker ready is interrogated before reclosure after an adaptive dead time. If set to ***Yes*** the dead time may be extended if at the end of the dead time the circuit-breaker is not ready for a CLOSE–TRIP–cycle. The maximum extension is by the circuit-breaker–monitoring time; which was set for all reclosure cycles under address **3409** (see above). Details about the circuit-breaker–monitoring can be found in the function description, section 6.12.1, under subtitle “Interrogation of Circuit-Breaker Ready”, page 6-171.

If there is a risk of stability problems in the network during a three-pole interruption, the setting in address **3437** **ADT SynRequest** should be ***Yes***. In this case the voltage of the line and busbar are checked after a three pole trip and before reclosure to determine if sufficient synchronism exists. This assumes that the device has a voltage and synchronism check capability or that an external device is available for this purpose. If only single-pole reclosure cycles are executed or no stability problems are expected during three-pole dead times (e.g. due to close meshing of the network or in radial networks), set address **3437** to ***No***.

Addresses **3438** and **3440** are only significant if the *voltage-controlled* adaptive dead time is used. Set under address **3440** **U-live>** the limit voltage phase–earth above which the line is considered to be fault-free. The setting must be smaller than the lowest expected operating voltage. The setting is applied in Volts secondary. This value can be entered as a primary value when parametrizing with a PC and DIGSI® 4. Address **3438** **T U-stable** determines the measuring time used to determine that the line is fault free with this return voltage. It should be longer than any transient oscillations resulting from line energization.

1st Reclosure Cycle

If working on a line with adaptive dead time, no further parameters are needed for the individual reclose cycles here. All the following parameters assigned to the individual cycles are then superfluous and inaccessible.

Address **3450** **1.AR: START** is only available if the automatic reclosure is configured with action time in the operating mode, i. e. if address **0134** **AR control mode** = ***Pickup w/ Tact*** or ***Trip w/ Tact*** was set when configuring the protection functions (the first setting only applies to three-pole tripping). It determines whether automatic reclosure should be started at all with the first cycle. This address is included mainly for the sake of uniformity of the parameters for all the reclosure cycles and must be set to ***Yes*** for the first cycle. If several cycles are used it is possible to control (in control mode ***with PICKUP***) the effect of the individual cycles with this parameter and various action times. Notes and examples can be found in section 6.12.1 under subtitle “Action Times” (page 6-169).

The action time **1.AR: T-ACTION** (address) is the time after pickup (fault detection) by any protective function which can start the automatic reclosure function within which the trip command must appear. If the command does not appear until after the action time has expired, there is no reclosure. Depending on the configuration of the protective functions (see section 5.1) the action time may also be omitted; this applies especially when an initiating protective function has no fault detection signal.

Depending on the configured operating mode of the automatic reclosure (see section 5.1 under address **0134 AR control mode**) only addresses **3456** and **3457** (if control mode ***with TRIP***) or the addresses **3453** to **3455** (if operating mode ***with PICKUP***) are available.

In the control mode ***with TRIP*** it is possible to set different dead times for single-pole and three-pole reclose cycles. Whether single-pole or three-pole tripping takes place depends solely on the initiating protection functions. Single-pole tripping is only possible of course if the device and the corresponding protection function are also capable of single-pole tripping.

Address **3456** **1.AR Tdead1Trip** is the dead time after 1-pole tripping,
Address **3457** **1.AR Tdead3Trip** is the dead time after 3-pole tripping.

If only single-pole reclose cycle are to be allowed, the dead time for three-pole tripping must be set to ∞. If only three-pole reclose cycle are to be allowed, the dead time for single-pole tripping must be set to ∞; the protection then trips three-pole for all fault types.

The dead time after single-pole tripping (if set) **1.AR Tdead1Trip** (address **3456**) should be long enough for the short-circuit arc to be extinguished and the surrounding air to be de-ionized so that the reclosure promises to be successful. The longer the line is, the longer this time should be due to the recharging of the conductor capacitances. The typical values are 0.9 s to 1.5 s.

For three-pole tripping (address **3457 1.AR Tdead3Trip**) the stability of the network is the main concern. Since the disconnected line cannot transfer any synchronizing forces, only a short dead time is often permitted. The usual values are 0.3 s to 0.6 s. If the device is operating with a synchronism check (refer also to section 6.13), a longer time may be tolerated under certain circumstances. Longer three-pole dead times are also possible in radial networks.

In the control mode ***with PICKUP*** it is possible to make the dead times dependent on the type of fault detected by the initiating protection function(s):

address **3453 1.AR Tdead 1Flt** is the dead time after 1-phase starting,
address **3454 1.AR Tdead 2Flt** is the dead time after 2-phase starting,
address **3455 1.AR Tdead 3Flt** is the dead time after 3-phase starting.

If the dead time is to be the same for all types of faults, set all three parameters the same. Note that these settings only cause different dead times for different *starting (fault detection)* conditions. The *tripping* can only be three-pole.

With the setting ***starts 3p AR*** applied in address **3407 EV. FLT. MODE** when setting the response to evolving faults (see above under “General”, page 6-184), it is possible to apply a separate dead time **1.AR: Tdead EV.** (address **3458**) for the three-pole dead time after clearance of the evolving fault. Stability aspects are also decisive here. Normally the setting constraints are similar to address **3457 1.AR Tdead3Trip**.

Under address **3459 1.AR: CB? CLOSE** it can be determined whether circuit-breaker ready must be interrogated before this first reclosure. With the setting ***Yes***, the dead time may be extended if the circuit-breaker is not ready for a CLOSE–TRIP–cycle when the dead time expires. At most the dead time can be extended by the **CB TIME OUT**; this was set for all reclosure cycles together under address **3409** (see above). Details about the circuit-breaker monitoring can be found in the function description, section 6.12.1, under subtitle “Interrogation of Circuit-Breaker Ready”, page 6-171.

If there is a danger of stability problems in the network during a three-pole dead time, you should set address **3460 1.AR SynRequest** to ***Yes***. In this case a check is made before every reclosure following three-pole tripping whether the voltages of the feeder and busbar are sufficiently synchronized. This on condition that either the internal synchronism and voltage check function is available or that an external device is available for synchronism check. If only single-pole reclose cycles are executed or no stability problems are expected during three-pole dead times (e.g. due to closely meshed networks or in radial networks), set address **3460** to ***No***.

2nd to 4th Reclosure Cycle

If several cycles were selected during the configuration of the scope of functions (section 5.1), it is possible to set individual reclosure parameters for the 2nd to 4th cycles. The options are the same as for the 1st cycle. Again only some of the parameters shown below will be available depending on the selections made during configuration of the scope of protection function (section 5.1).

For the 2nd cycle:
Address **3461** **2.AR: START**; determines if starting in 2nd cycle is allowed at all
Address **3462** **2.AR: T-ACTION**; action time for the 2nd cycle
Address **3464** **2.AR Tdead 1Flt**; dead time after 1-phase starting
Address **3465** **2.AR Tdead 2Flt**; dead time after 2-phase starting
Address **3466** **2.AR Tdead 3Flt**; dead time after 3-phase starting
Address **3467** **2.AR Tdead1Trip**; dead time after 1-pole tripping
Address **3468** **2.AR Tdead3Trip**; dead time after 3-pole tripping
Address **3469** **2.AR: Tdead EV.**; dead time in case of sequential fault
Address **3470** **2.AR: CB? CLOSE**; check CB ready before reclosure
Address **3471** **2.AR SynRequest**; sync. check after 3-pole tripping

For the 3rd cycle:
Address **3472** **3.AR: START**; determines if starting in 3rd cycle is allowed at all
Address **3473** **3.AR: T-ACTION**; action time for the 3rd cycle
Address **3475** **3.AR Tdead 1Flt**; dead time after 1-phase starting
Address **3476** **3.AR Tdead 2Flt**; dead time after 2-phase starting
Address **3477** **3.AR Tdead 3Flt**; dead time after 3-phase starting
Address **3478** **3.AR Tdead1Trip**; dead time after 1-pole tripping
Address **3479** **3.AR Tdead3Trip**; dead time after 3-pole tripping
Address **3480** **3.AR: Tdead EV.**; dead time in case of sequential fault
Address **3481** **3.AR: CB? CLOSE**; check CB ready before reclosure
Address **3482** **3.AR SynRequest**; sync. check after 3-pole tripping

For the 4th cycle:
Address **3483** **4.AR: START**; determines if starting in 4th cycle is allowed at all
Address **3484** **4.AR: T-ACTION**; action time for the 4th cycle
Address **3486** **4.AR Tdead 1Flt**; dead time after 1-phase starting
Address **3487** **4.AR Tdead 2Flt**; dead time after 2-phase starting
Address **3488** **4.AR Tdead 3Flt**; dead time after 3-phase starting
Address **3489** **4.AR Tdead1Trip**; dead time after 1-pole tripping
Address **3490** **4.AR Tdead3Trip**; dead time after 3-pole tripping
Address **3491** **4.AR: Tdead EV.**; dead time in case of sequential fault
Address **3492** **4.AR: CB? CLOSE**; check CB ready before reclosure
Address **3493** **4.AR SynRequest**; sync. check after 3-pole tripping

5th to 8th reclosure cycles

If more than 4 cycles have been selected during the configuration of the scope of functions (section 5.1), the cycles following the fourth cycle operate with the same settings as the fourth cycle.

6.12.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
3401	AUTO RECLOSE	OFF ON	ON	Auto-Reclose function
3402	CB? 1.TRIP	YES NO	NO	CB ready interrogation at 1st trip
3403	T-RECLAIM	0.50..300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	0.50..300.00 sec; Ø	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	with Pickup with Trip	with Trip	Evolving fault recognition
3407	EV. FLT. MODE	blocks AR starts 3pole AR-cycle is ignored	starts 3pole AR-cycle	Evolving fault (during the dead time)
3408	T-Start MONITOR	0.01..300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	0.01..300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	0.00..300.00 sec; Ø; ∞	∞ sec	Send delay for remote close command
3411A	T-DEAD EXT.	0.50..300.00 sec; ∞	∞ sec	Maximum dead time extension
3430	AR TRIP 3pole	YES NO	YES	3pole TRIP by AR
3433	T-ACTION ADT	0.01..300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	0.50..3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3437	ADT SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3438	T U-stable	0.10..30.00 sec	0.10 sec	Supervision time for dead/ live voltage
3440	U-live>	30..90 V	48 V	Voltage threshold for live line or bus
3441	U-dead<	2..70 V	30 V	Voltage threshold for dead line or bus
3450	1.AR: START	YES NO	YES	Start of AR allowed in this cycle
3451	1.AR: T-ACTION	0.01..300.00 sec; ∞	0.20 sec	Action time
3453	1.AR Tdead 1Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3454	1.AR Tdead 2Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3455	1.AR Tdead 3Flt	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults

Addr.	Setting Title	Setting Options	Default Setting	Comments
3456	1.AR Tdead1Trip	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1pole trip
3457	1.AR Tdead3Trip	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3458	1.AR: Tdead EV.	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3459	1.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3460	1.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3461	2.AR: START	YES NO	NO	AR start allowed in this cycle
3462	2.AR: T-ACTION	0.01..300.00 sec; ∞	0.20 sec	Action time
3464	2.AR Tdead 1Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3465	2.AR Tdead 2Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3466	2.AR Tdead 3Flt	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3467	2.AR Tdead1Trip	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3468	2.AR Tdead3Trip	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3469	2.AR: Tdead EV.	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3470	2.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3471	2.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3472	3.AR: START	YES NO	NO	AR start allowed in this cycle
3473	3.AR: T-ACTION	0.01..300.00 sec; ∞	0.20 sec	Action time
3475	3.AR Tdead 1Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3476	3.AR Tdead 2Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3477	3.AR Tdead 3Flt	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3478	3.AR Tdead1Trip	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3479	3.AR Tdead3Trip	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3480	3.AR: Tdead EV.	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3481	3.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3482	3.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3483	4.AR: START	YES NO	NO	AR start allowed in this cycle
3484	4.AR: T-ACTION	0.01..300.00 sec; ∞	0.20 sec	Action time
3486	4.AR Tdead 1Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3487	4.AR Tdead 2Flt	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3488	4.AR Tdead 3Flt	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3489	4.AR Tdead1Trip	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip

Addr.	Setting Title	Setting Options	Default Setting	Comments
3490	4.AR Tdead3Trip	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3491	4.AR: Tdead EV.	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3492	4.AR: CB? CLOSE	YES NO	NO	CB ready interrogation before reclosing
3493	4.AR SynRequest	YES NO	NO	Request for synchro-check after 3pole AR
3430	AR TRIP 3pole	YES NO	YES	3pole TRIP by AR
3431	DLC or RDT	Without Reduced Dead Time (RDT) Dead Line Check (DLC)	Without	Dead Line Check or Reduced Dead Time
3438	T U-stable	0.10..30.00 sec	0.10 sec	Supervision time for dead/ live voltage
3440	U-live>	30..90 V	48 V	Voltage threshold for live line or bus
3441	U-dead<	2..70 V	30 V	Voltage threshold for dead line or bus
3420	AR w/ DIST.	YES NO	YES	AR with distance protection
3421	AR w/ SOTF-O/C	YES NO	YES	AR with switch-onto-fault over-current
3422	AR w/ W/I	YES NO	YES	AR with weak infeed tripping
3423	AR w/ EF-O/C	YES NO	YES	AR with earth fault overcurrent prot.
3424	AR w/ DTT	YES NO	YES	AR with direct transfer trip
3425	AR w/ BackUpO/C	YES NO	YES	AR with back-up overcurrent

6.12.4 Information Overview

The most important information about automatic reclosure is briefly explained insofar as it was not mentioned in the following lists or described in detail in the preceding text.

“`>BLK 1.AR-cycle`” (F.No. 2742) to “`>BLK 4.-n. AR`” (F.No. 2745)
The corresponding reclose cycle is blocked. If the blocking state already exists when the automatic reclosure function is initiated, the blocked cycle is not executed and may be skipped (if other cycles are permitted). The same applies if the automatic reclosure function is started (running) but not busy with (inside) the cycle being blocked. If the block signal of a cycle appears while this cycle is being executed (busy) the automatic reclosure function is blocked dynamically; no further automatic reclosures cycles are then executed.

“`AR 1.CycZoneRel`” (F.No. 2889) to “`AR 4.CycZoneRel`” (F.No. 2892)
The automatic reclosure function is ready for the corresponding reclosure cycle. This

information indicates which cycle will be run next. For example, external protection functions can use this information to release accelerated or overreaching trip stages prior to the corresponding reclose cycle.

“`AR is blocked`” (F.No. 2783)
The automatic reclosure is blocked (e.g. circuit-breaker not ready). This information indicates to the operational information system that in the event of an upcoming system fault there will be a final trip, i.e. without reclosure. If the automatic reclosure is already started, this information does not appear.

“`AR not ready`” (F.No. 2784)
The automatic reclosure is not ready for reclosure at the moment. In addition to the “`AR is blocked`” (F.No. 2783) mentioned above there are also obstructions during the course of the reclose cycles such as “action time expired” or “last reclaim time running”. This information is particularly helpful during testing because no protection test cycle with reclosure may be initiated during this state.

“`AR in progress`” (F.No. 2801)
This information appears following starting of the automatic reclosure function, i.e. with the first trip command that can start the automatic reclosure function. If this reclosure was successful (or any in the case of more than one), this information resets with the expiry of the last reclaim time. If no reclosure was successful or if reclosure was blocked, it ends with the last — the final — trip command.

“`AR Sync.Request`” (F.No. 2865)
Request for sync check measurement to an external device. This information appears at the end of a dead time after a three-pole trip if a synchro–check request was set for the corresponding cycle. Reclosure only takes place when the synchro–check device has granted release “`>Sync.release`” (F.No. 2731).

“`>Sync.release`” (F.No. 2731)
Release of reclosure by an external synchro–check device if this was requested by the output information “`AR Sync.Request`” (F.No. 2865).

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F.No.	Alarm	Comments
2701	>AR on	>AR: Switch on auto-reclose function
2702	>AR off	>AR: Switch off auto-reclose function
2703	>AR block	>AR: Block auto-reclose function
2711	>AR Start	>External start of internal Auto reclose
2712	>Trip L1 AR	>AR: External trip L1 for AR start
2713	>Trip L2 AR	>AR: External trip L2 for AR start
2714	>Trip L3 AR	>AR: External trip L3 for AR start
2715	>Trip 1pole AR	>AR: External 1pole trip for AR start
2716	>Trip 3pole AR	>AR: External 3pole trip for AR start
2727	>AR RemoteClose	>AR: Remote Close signal
2731	>Sync.release	>AR: Sync. release from ext. sync.-check
2737	>BLOCK 1pole AR	>AR: Block 1pole AR-cycle
2738	>BLOCK 3pole AR	>AR: Block 3pole AR-cycle
2739	>BLK 1phase AR	>AR: Block 1phase-fault AR-cycle

F.No.	Alarm	Comments
2740	>BLK 2phase AR	>AR: Block 2phase-fault AR-cycle
2741	>BLK 3phase AR	>AR: Block 3phase-fault AR-cycle
2742	>BLK 1.AR-cycle	>AR: Block 1st AR-cycle
2743	>BLK 2.AR-cycle	>AR: Block 2nd AR-cycle
2744	>BLK 3.AR-cycle	>AR: Block 3rd AR-cycle
2745	>BLK 4.-n. AR	>AR: Block 4th and higher AR-cycles
2746	>Trip for AR	>AR: External Trip for AR start
2747	>Pickup L1 AR	>AR: External pickup L1 for AR start
2748	>Pickup L2 AR	>AR: External pickup L2 for AR start
2749	>Pickup L3 AR	>AR: External pickup L3 for AR start
2750	>Pickup 1ph AR	>AR: External pickup 1phase for AR start
2751	>Pickup 2ph AR	>AR: External pickup 2phase for AR start
2752	>Pickup 3ph AR	>AR: External pickup 3phase for AR start
2781	AR off	AR: Auto-reclose is switched off
2782	AR on	AR: Auto-reclose is switched on
2783	AR is blocked	AR: Auto-reclose is blocked
2784	AR not ready	AR: Auto-reclose is not ready
2787	CB not ready	AR: Circuit breaker not ready
2788	AR T-CBreadyExp	AR: CB ready monitoring window expired
2796	AR on/off BI	AR: Auto-reclose ON/OFF via BI
2801	AR in progress	AR in progress
2809	AR T-Start Exp	AR: Start-signal monitoring time expired
2810	AR TdeadMax Exp	AR: Maximum dead time expired
2818	AR evolving Flt	AR: Evolving fault recognition
2820	AR Program1pole	AR is set to operate after 1p trip only
2821	AR Td. evol.Flt	AR dead time after evolving fault
2839	AR Tdead 1pTrip	AR dead time after 1pole trip running
2840	AR Tdead 3pTrip	AR dead time after 3pole trip running
2841	AR Tdead 1pFlt	AR dead time after 1phase fault running
2842	AR Tdead 2pFlt	AR dead time after 2phase fault running
2843	AR Tdead 3pFlt	AR dead time after 3phase fault running
2844	AR 1stCyc. run.	AR 1st cycle running
2845	AR 2ndCyc. run.	AR 2nd cycle running
2846	AR 3rdCyc. run.	AR 3rd cycle running
2847	AR 4thCyc. run.	AR 4th or higher cycle running
2848	AR ADT run.	AR cycle is running in ADT mode

F.No.	Alarm	Comments
2851	AR CLOSE Cmd.	AR: Close command
2852	AR Close1.Cyc1p	AR: Close command after 1pole, 1st cycle
2853	AR Close1.Cyc3p	AR: Close command after 3pole, 1st cycle
2854	AR Close 2.Cyc	AR: Close command 2nd cycle (and higher)
2861	AR T-Recl. run.	AR: Reclaim time is running
2862	AR successful	AR successful
2864	AR 1p Trip Perm	AR: 1pole trip permitted by internal AR
2865	AR Sync.Request	AR: Synchro-check request
2871	AR TRIP 3pole	AR: TRIP command 3pole
2889	AR 1.CycZoneRel	AR 1st cycle zone extension release
2890	AR 2.CycZoneRel	AR 2nd cycle zone extension release
2891	AR 3.CycZoneRel	AR 3rd cycle zone extension release
2892	AR 4.CycZoneRel	AR 4th cycle zone extension release
2893	AR Zone Release	AR zone extension (general)
2894	AR Remote Close	AR Remote close signal send

6.13 Synchronism and Voltage Check (Dead-line / Dead-bus check)

6.13.1 Method of Operation

General

The synchronism and voltage check function ensures, when switching a line onto a bus-bar, that the stability of the network is not endangered. The function can be programmed to perform the synchronism and voltage check for automatic reclosure only, for manual closure only, or for both cases. Different close permission (release) criteria can also be programmed for automatic and manual closure.

The synchronism and voltage check function uses the feeder voltage — designated with U_{line} — and the bus-bar voltage — designated with U_{bus} — for comparison purposes. The latter may be any convenient phase-to-earth or phase-to-phase voltage derived from the bus-bar voltage transformers.

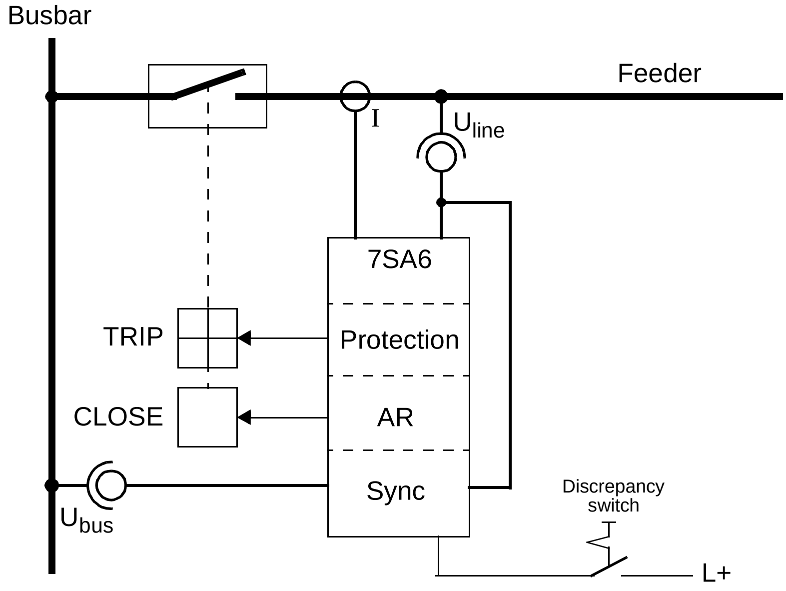

Figure 6-103 Synchronism check on closing

If a power transformer is situated between the feeder voltage transformers and the bus-bar voltage transformers (Figure 6-104), its vector group can be compensated for by the 7SA6 relay, so that no external matching transformers are necessary.

The synchronism check function in the 7SA6 usually operates in conjunction with the integrated automatic reclose and manual close functions of the relay. It is however also possible to co-ordinate with an external automatic reclosure relay. In this case, the information exchange between the devices must be performed through binary inputs and outputs. If further control functions are to operate with synchronism or voltage check, these must be combined with the manual close function, either through the binary inputs and outputs, or by means of the integrated user definable logic functions (CFC).

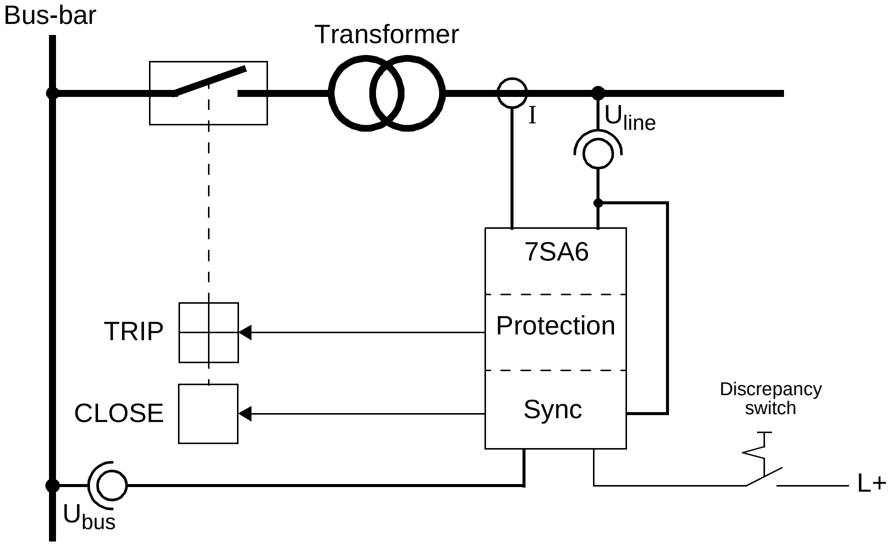

Figure 6-104 Synchronism check across a transformer

Furthermore, switching is possible with synchronous or asynchronous system conditions. Synchronous switching means that the closing command is given as soon as the critical values (voltage magnitude difference **`Max. Volt. Diff`**, angle difference **`Max. Angle Diff`**, and frequency difference **`Max. Freq. Diff`**) lie within the set tolerances. For switching with asynchronous system conditions, the device calculates the correct timing of the closing command from the angle difference **`Max. Angle Diff`** and the frequency difference **`Max. Freq. Diff`** such that the voltages on the bus-bar and the feeder circuit have exactly the same phase relationship at the instant that the circuit breaker primary contacts close. For this purpose the circuit breaker closing time must be programmed into the relay. Different frequency limit thresholds apply to switching under synchronous and asynchronous conditions. If closing shall be permitted exclusively under synchronous system conditions, the frequency difference limit for this condition can be set. If closing is permitted under synchronous as well as under asynchronous system conditions, a frequency difference below 0.01 Hz is treated as a synchronous condition, a higher frequency difference value can then be set for closing under asynchronous system conditions.

The synchronism check function only operates when it is requested to do so. This request can come from the internal automatic reclosure function, from the manual closing command or from an external automatic reclose relay via binary input.

The synchronism check function gives permission for passage of the closing command. Optionally, a closing command my be issued by the synchronism check function. This can directly control the closing coil of the circuit breaker, or be connected in series with the automatic reclose command.

The time window during which synchronism check is permitted is limited by an adjustable synchronous monitoring time. Within this period, the programmed conditions must have been met otherwise closing permission will not be given. A new synchronism check sequence requires a new request.

The device outputs messages if, after a request to check synchronism, the conditions for release are not fulfilled, i.e. if the absolute voltage difference **`Max. Volt. Diff`**, the absolute frequency difference **`Max. Freq. Diff`**, or the absolute phase angle difference **`Max. Freq. Diff`** lie outside the permissible limit values. A precondition for these messages is that voltages within the operating range of the relay are available.

Operating modes

The closing check procedure can be selected from the following operating modes:

- **SYNC-CHECK** = Release at synchronism, that is, when the critical values **Max. Volt. Diff**, **Max. Freq. Diff** and **Max. Angle Diff** lie within the set limits.
- **Usync> U-line<** = Release for energized bus-bar (U_{bus}>) and de-energized line (U_{line}<).
- **Usync< U-line>** = Release for de-energized bus-bar (U_{bus}<) and energized line (U_{line}>).
- **Usync< U-line<** = Release for de-energized bus-bar (U_{bus}<) and de-energized line (U_{line}<).
- **OVERRIDE** = Release without any check.

Each of these conditions can be switched to be effective or not effective; combinations are also possible (e.g. release when **Usync> U-line<** *or* **Usync< U-line>** are satisfied). Combination of **OVERRIDE** with other parameters is, of course, not meaningful.

The release conditions can be set individually for automatic and for manual closing, e.g. you can permit manual closing at synchronism *or* dead line, whilst, before an automatic reclosure, at one line end *only* dead line and, at the other, *only* synchronism will be permitted.

Dead-line or dead-bus closing

For release of the closing command to energize a voltage free line from a live bus-bar, the following conditions are checked:

- Does the feeder voltage U_{line} lie below the set value **Dead Volt. Thr.**?
- Does the bus-bar voltage U_{bus} lie above the set value **Live Volt. Thr.**, but below the maximum operating voltage **Umax**?
- Does the bus-bar voltage frequency f_{bus} lie within the permissible operating range f_N ± 3 Hz?

When the conditions are satisfied, the closing command is released.

Corresponding conditions apply when switching a live line onto a dead bus-bar or a dead line onto a dead bus-bar.

Closing at synchronous system conditions

To release a closing command at synchronous system conditions, the following conditions are checked:

- Does the bus-bar voltage U_{bus} lie above the set value **Live Volt. Thr.**, but below the maximum operating voltage **Umax**?
- Does the feeder voltage U_{line} lie above the set value **Live Volt. Thr.**, but below the maximum operating voltage **Umax**?
- Does the voltage magnitude difference $\left| |U_{line}| - |U_{bus}| \right|$ lie within the permissible tolerance **Max. Volt. Diff**?
- Do both the frequencies f_{bus} and f_{line} lie within the permissible operating range f_N ± 3 Hz?
- Does the frequency difference $|f_{line} - f_{bus}|$ lie within the permissible tolerance **Max. Freq. Diff**?

- Does the angle difference $|\varphi_{line} - \varphi_{bus}|$ lie within the permissible tolerance **Max. Angle Diff**?

A check that the synchronous system conditions are maintained for the minimum duration **T SYNC-STAB** is carried out. When the conditions are satisfied for this duration within the synchronous supervision time **T-SYN. DURATION**, the closing command is released.

Closing at Asynchronous System Conditions

For release of a closing command with asynchronous system conditions, the following conditions are checked:

- Does the bus-bar voltage U_{bus} lie above the set value **Live Volt. Thr.**, but below the maximum operating voltage **Umax**?
- Does the feeder voltage U_{line} lie above the set value **Live Volt. Thr.**, but below the maximum operating voltage **Umax**?
- Does the voltage magnitude difference $\left| |U_{line}| - |U_{bus}| \right|$ lie within the permissible tolerance **Max. Volt. Diff**?
- Do both the frequencies f_{bus} and f_{line} lie within the permissible operating range f_N ± 3 Hz?
- Does the frequency difference $|f_{line} - f_{bus}|$ lie within the permissible tolerance **Max. Freq. Diff**?

When the conditions are satisfied, the device calculates the time upto the next instant of voltage phase synchronism, from the rate-of-change of angle and the frequency difference. The closing command is then released at the instant when the remaining time upto the next instant of synchronism equals the closing time of the breaker.

6.13.2 Applying the Function Parameter Settings

Preconditions

When setting the general power system data (Power system data 1, refer to Section 6.1.1) a number of parameters regarding the measured quantities and the operating mode of the synchronism check function must be applied. This concerns the following parameters:

203	**Unom PRIMARY**	rated primary voltage of the feeder voltage transformers (phase-to-phase) in kV;
204	**Unom SECONDARY**	rated secondary voltage of the feeder voltage transformers (phase-to-phase) in V;
210	**U4 transformer**	connection of the additional voltage transformer input U_4 of the device; must be ***Ubus–trnsf*** and connected to any voltage of the bus-bar;
212	**Usync connect.**	type of voltage which is connected to the device from the bus-bar voltage transformer;
214A	φ **Usync-Uline**	phase angle displacement between the voltage of the bus-bar and that of the feeder in case a power transformer is installed inbetween;
215	**U-line / Usync**	the ratio of the secondary feeder voltage to the secondary bus-bar voltage under nominal voltage conditions;

230 Rated Frequency the operating range of the synchronism check is: rated frequency ± 3 Hz;

and, if switching at asynchronous system conditions is allowed,

239 **T-CB close** the closing time of the circuit breaker.

Warning!

Incorrect synchronization is possible if the closing time of the circuit breaker is not set correctly under the general power system data (Power system data 1, see Sub-section 6.1.1, address **239**).

General

The synchronism and voltage check function can only operate if it was configured as ***enabled*** during setting of the scope of functions (see Section 5.1, address **0135**).

Different close permission (release) conditions can be set for automatic reclosure on the one hand and for manual closure on the other hand.

The general limit values for closure are set under addresses **3501** to **3508**. Additionally, addresses **3510** to **3519** are relevant for automatic reclosure, addresses **3530** to **3539** are relevant for manual closure.

The complete synchronism and voltage check function is switched ***Off*** or ***On*** under address **3501 FCT Synchronism**. The close command is not released when the function is switched off.

The voltage below which the line or bus-bar is safely regarded as being dead, is set under address **3502 Dead Volt. Thr.** (for dead-line or dead-bus check). Setting is applied in volts secondary. When operating the device from a personal computer using DIGSI® 4, setting may be in secondary or primary values. Depending on the connection of the bus-bar voltage (phase–phase or phase–earth) the phase–phase or the phase–earth voltage is decisive.

The voltage above which the feeder or bus-bar is regarded as being definitely live, is set under address **3503 Live Volt. Thr.** (for live-line or live-bus check and for the lower voltage limit of synchronism check). It must be set below the minimum expected operating voltage under normal conditions. Setting is in volts secondary. When operating the device from a personal computer using DIGSI® 4, setting may be in secondary or primary values. Depending on the connection of the bus-bar voltage (phase–phase or phase–earth) the phase–phase or the phase–earth voltage is decisive.

The maximum permissible voltage for the operating range of the synchronism and voltage check function is set under address **3504 Umax**. Setting is in volts secondary. When operating the device from a personal computer using DIGSI® 4, setting may be in secondary or primary values. Depending on the connection of the bus-bar voltage (phase–phase or phase–earth) the phase–phase or the phase–earth voltage is decisive.

Address **3507 T-SYN. DURATION** determines the period of time, starting from the measurement request, within which the synchronism check conditions must be fulfilled. When the conditions are not fulfilled within this time, closing is blocked. When set to ∞ the conditions will always be checked until they are fulfilled.

If the conditions for synchronous operation must be checked to be maintained for a certain duration, this minimum duration can be set under address **3508 T SYNC-STAB**.

Synchronism Check Conditions before Automatic Reclosure

Addresses **3510** to **3519** are relevant to the check conditions before automatic reclosure of the circuit breaker. When setting the parameters for the internal automatic reclosing function (Section 6.12.2) it was decided with which automatic reclosing cycle synchronism and voltage check should be carried out.

Address **3510 Op.mode with AR** determines whether closing under asynchronous system conditions is allowed. Set this parameter to ***with T-CB close***, if asynchronous closing shall be allowed; the relay will then consider the circuit breaker closing time before determining the correct instant for the closing command. Remember that closing under asynchronous system conditions is allowed only if the circuit breaker closing time is set correctly (see above under Preconditions)! If you wish to permit automatic reclosure only under synchronous system conditions, set this address to
w/o T-CB close.

The permissible magnitude difference of the voltages is set under address **3511 Max. Volt. Diff**. Setting is in volts secondary. When operating the device from a personal computer using DIGSI® 4, setting may be in secondary or primary values. Depending on the connection of the bus-bar voltage (phase–phase or phase–earth) the phase–phase or the phase–earth voltage is decisive.

The permissible frequency difference between the voltages is set under address **3512 Max. Freq. Diff**, the permissible phase angle difference under address **3513 Max. Angle Diff**.

The further release conditions for automatic reclosing are set under addresses **3515A** to **3519**:

3515A SYNC-CHECK = synchronism check: the bus-bar (Ubus) and the feeder (Uline) must both be live (**Live Volt. Thr.**, address **3503**); the conditions for synchronism **Max. Volt. Diff** (address **3511**), **Max. Freq. Diff** (address **3512**), and **Max. Angle Diff** (address **3513**) are checked before automatic reclosure;

3516 Usync> U-line< = dead-line check: the bus-bar (Ubus) must be live (**Live Volt. Thr.**, refer to address **3503**), the feeder (Uline) must be dead (**Dead Volt. Thr.**, refer to address **3502**);

3517 Usync< U-line> = dead-bus check: the bus-bar (Ubus) must be dead (**Dead Volt. Thr.**, refer to address **3502**), the feeder (Uline) must be live (**Live Volt. Thr.**, refer to address **3503**);

3518 Usync< U-line< = dead-bus and dead-line check: the bus-bar (Ubus) and the feeder (Uline) must both be dead (**Dead Volt. Thr.**, refer to address **3502**);

3519 OVERRIDE = automatic reclosure is released without any check.

The five possible release conditions are independent of each other and can be combined.

Synchronism Check Conditions before Manual Closing

The release conditions for manual closing are set under addresses **3530** to **3539**. When setting the general protection data (Power System Data 2, Section 6.1.3) it was decided whether synchronism and voltage check should be carried out before manual closing. With the following setting in address **1151 SYN.MAN.CL** = ***w/o Sync-***

check, no checks are performed before manual closing. The following parameters are then irrelevant.

Address **3530 Op.mode with MC** determines whether closing under asynchronous system conditions is allowed. Set this parameter to **with T-CB close**, if asynchronous closing shall be allowed; the relay will then consider the circuit breaker closing time before determining the correct instant for the close command. Remember that closing under asynchronous system conditions is allowed only if the circuit breaker closing time is set correctly (see above under “Preconditions”)! If you wish to only permit manual closing under synchronous system conditions, set this address to **w/o T-CB close**.

The permissible magnitude difference of the voltages is set under address **3531 MC maxVolt.Diff**. Setting is in volts secondary. When operating the device from a personal computer using DIGSI® 4, setting may be in secondary or primary values. Depending on the connection of the bus-bar voltage (phase–phase or phase–earth) the phase–phase or the phase–earth voltage is decisive.

The permissible frequency difference between the voltages is set under address **3532 MC maxFreq.Diff**, the permissible phase angle difference under address **3533 MC maxAngleDiff**.

The release conditions for manual closing are set under addresses **3535A** to **3539**:

3535A MC SYNCHR = synchronism check: the bus-bar (Ubus) and the feeder (Uline) must both be live (**Live Volt. Thr.**, address **3503**); the conditions for synchronism **MC maxVolt.Diff** (address **3531**), **MC maxFreq.Diff** (address **3532**), and **MC maxAngleDiff** (address **3533**) are checked before manual closure;

3536 MC Usyn> Uline< = dead-line check: the bus-bar (Ubus) must be live (**Live Volt. Thr.**, refer to address **3503**), the feeder (Uline) must be dead (**Dead Volt. Thr.**, refer to address **3502**);

3537 **MC Usyn< Uline>** = dead-bus check: the bus-bar (Ubus) must be dead (**Dead Volt. Thr.**, refer to address **3502**), the feeder (Uline) must be live (**Live Volt. Thr.**, refer to address **3503**);

3538 MC Usyn< Uline< = dead-bus and dead-line check: the bus-bar (Ubus) and the feeder (Uline) must both be dead (**Dead Volt. Thr.**, refer to address **3502**);

3539 MC O/RIDE = manual closing is released without any check.

The five possible release conditions are independent of each other and can be combined.

6.13.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
3501	FCT Synchronism	ON OFF	ON	Synchronism and Voltage Check function
3502	Dead Volt. Thr.	1..60 V	5 V	Voltage threshold dead line / bus (ph-e)
3503	Live Volt. Thr.	20..125 V	90 V	Voltage threshold live line / bus (ph-e)
3504	Umax	20..140 V	110 V	Maximum permissible voltage
3507	T-SYN. DURATION	0.01..600.00 sec; ∞	1.00 sec	Maximum duration of synchronism-check
3508	T SYNC-STAB	0.00..30.00 sec; Ø	0.00 sec	Synchronous condition stability timer
3510	Op.mode with AR	with consideration of CB closing time without consideration of CB closing time	without consideration of CB closing time	Operating mode with AR
3511	Max. Volt. Diff	1.0..40.0 V	2.0 V	Maximum voltage difference
3512	Max. Freq. Diff	0.03..2.00 Hz	0.10 Hz	Maximum frequency difference
3513	Max. Angle Diff	2..60 °	10 °	Maximum angle difference
3515A	SYNC-CHECK	YES NO	YES	Live bus / live line and Sync before AR
3516	Usync> U-line<	YES NO	NO	Live bus / dead line check before AR
3517	Usync< U-line>	YES NO	NO	Dead bus / live line check before AR
3518	Usync< U-line<	YES NO	NO	Dead bus / dead line check before AR
3519	OVERRIDE	YES NO	NO	Override of any check before AR
3530	Op.mode with MC	with consideration of CB closing time without consideration of CB closing time	without consideration of CB closing time	Operating mode with Man.Cl
3531	MC maxVolt.Diff	1.0..40.0 V	2.0 V	Maximum voltage difference
3532	MC maxFreq.Diff	0.03..2.00 Hz	0.10 Hz	Maximum frequency difference
3533	MC maxAngleDiff	2..60 °	10 °	Maximum angle difference
3535A	MC SYNCHR	YES NO	YES	Live bus / live line and Sync before MC
3536	MC Usyn> Uline<	YES NO	NO	Live bus / dead line check before Man.Cl
3537	MC Usyn< Uline>	YES NO	NO	Dead bus / live line check before Man.Cl

Addr.	Setting Title	Setting Options	Default Setting	Comments
3538	MC Usyn< Uline<	YES NO	NO	Dead bus / dead line check before Man.Cl
3539	MC O/RIDE	YES NO	NO	Override of any check before Man.Cl

6.13.4 Information Overview

Important information available as output by the device is explained, in so far as it can not be interpreted in the following list and was not described in the foregoing text.

“**>Sync.Start**” (F.No. 2906)
Request to execute a check synchronism measurement from an external automatic reclosure device. After this request, the conditions for automatic reclosure are checked.

“**Sync. release**” (F.No. 2951)
Release signal to an external automatic reclosure device.

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F.No.	Alarm	Comments
2901	>Sync. on	>Switch on synchro-check function
2902	>Sync. off	>Switch off synchro-check function
2903	>BLOCK Sync.	>BLOCK synchro-check function
2906	>Sync. Start	>Start synchro-check
2907	>Sync. synch	>Sync-Prog. Live bus / live line / Sync
2908	> Usyn< U-line>	>Sync-Prog. Dead bus / live line
2909	> Usyn> U-line<	>Sync-Prog. Live bus / dead line
2910	> Usyn< U-line<	>Sync-Prog. Dead bus / dead line
2911	>Sync. o/ride	>Sync-Prog. Override (bypass)
2930	Sync. on/off BI	Synchro-check ON/OFF via BI
2931	Sync. OFF	Synchro-check is switched OFF
2932	Sync. BLOCK	Synchro-check is BLOCKED
2934	Sync. faulty	Synchro-check function faulty
2935	Sync.Tsup.Exp	Synchro-check supervision time expired
2941	Sync. running	Synchronization is running
2942	Sync.Override	Synchro-check override/bypass
2943	Synchronism	Synchronism detected
2944	Usyn< U-line>	Sync. dead bus / live line detected
2945	Usyn> U-line<	Sync. live bus / dead line detected
2946	Usyn< U-line<	Sync. dead bus / dead line detected
2947	Sync. Udiff>	Sync. Voltage diff. greater than limit

F.No.	Alarm	Comments
2948	Sync. fdiff>	Sync. Freq. diff. greater than limit
2949	Sync. φ-diff>	Sync. Angle diff. greater than limit
2951	Sync. release	Synchronism release (to ext. AR)
2961	Sync.CloseCmd	Close command from synchro-check
2970	Sync. f-bus>>	Sync. Bus frequency > (fn + 3Hz)
2971	Sync. f-bus<<	Sync. Bus frequency < (fn - 3Hz)
2972	Sync. f-line>>	Sync. Line frequency > (fn + 3Hz)
2973	Sync. f-line<<	Sync. Line frequency < (fn - 3Hz)
2974	Sync. U-syn>>	Sync. Bus voltage > Umax (P.3504)
2975	Sync. U-syn<<	Sync. Bus voltage < U> (P.3503)
2976	Sync. U-line>>	Sync. Line voltage > Umax (P.3504)
2977	Sync. U-line<<	Sync. Line voltage < U> (P.3503)

6.14 Voltage Protection

General

The overvoltage protection avoids stress of electrical equipment by extremely high voltages and the resultant insulation problems.

Abnormally high voltages often occur in weak-loaded, long distance transmission lines, in islanded systems when generator voltage regulation fails, or after full load shutdown of a generator and external generators (not connected to the system). Even if compensation reactors are used to avoid line overvoltages by compensation of the line capacitance and thus reduction of the overvoltage, the overvoltage will endanger the insulation if the reactors fail (e.g. due to fault clearance). The line must be deenergized within very short time.

The undervoltage protection can be applied, for example, for disconnection or load shedding tasks in a system. Furthermore, this protection scheme can detect menacing stability problems. With induction machines undervoltages have an effect on the stability and permissible torque thresholds.

The overvoltage protection in the 7SA6 detects the phase voltages $U_{L1–E}$, $U_{L2–E}$ and $U_{L3–E}$, the phase-to-phase voltages $U_{L1–L2}$, $U_{L2–L3}$ and $U_{L3–L1}$, as well as the displacement voltage $3U_0$. Instead of the displacement voltage any other voltage that is connected to the fourth voltage input U_4 of the device can be detected. Furthermore the device calculates the positive sequence system voltage and the negative sequence system voltage so that the symmetrical components are also monitored.

The phase voltages $U_{L1–E}$, $U_{L2–E}$ and $U_{L3–E}$, the phase-to-phase voltages $U_{L1–L2}$, $U_{L2–L3}$ and $U_{L3–L1}$, as well as the positive sequence system can also be used for the undervoltage protection.

These voltage protection functions can be combined according to the user’s requirements. They can be switched on or off separately, or used for alarm purposes. In the latter case the respective trip commands do not appear. Each voltage protection function is dual-stage, i. e. it is provided with two threshold settings each with the appropriate times delay.

6.14.1 Method of Operation

6.14.1.1 Overvoltage Protection

Overvoltage Phase–Earth

Figure 6-105 depicts the logic diagram of the phase voltage stages. The fundamental frequency is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely eliminated. Two threshold stages **`Uph-e>`** and **`Uph-e>>`** are compared with the voltages. If a phase voltage exceeds these thresholds it is indicated phase-segregated. Furthermore, a general pick-up indication “`Uph–e> Pickup`” and “`Uph–e>> Pickup`” is given. The drop-off to pick-up ratio can be set (**`Uph-e>(>) RESET`**).

Every stage starts a time delay which is common to all phases. The expiry of the respective time delay **`T Uph-e>`** or **`T Uph-e>>`** is indicated and issues the trip command
“`Uph–e>(>) TRIP`”.

The overvoltage protection phase–earth can be blocked via a binary input “`>Uph–e>(>) BLK`”.

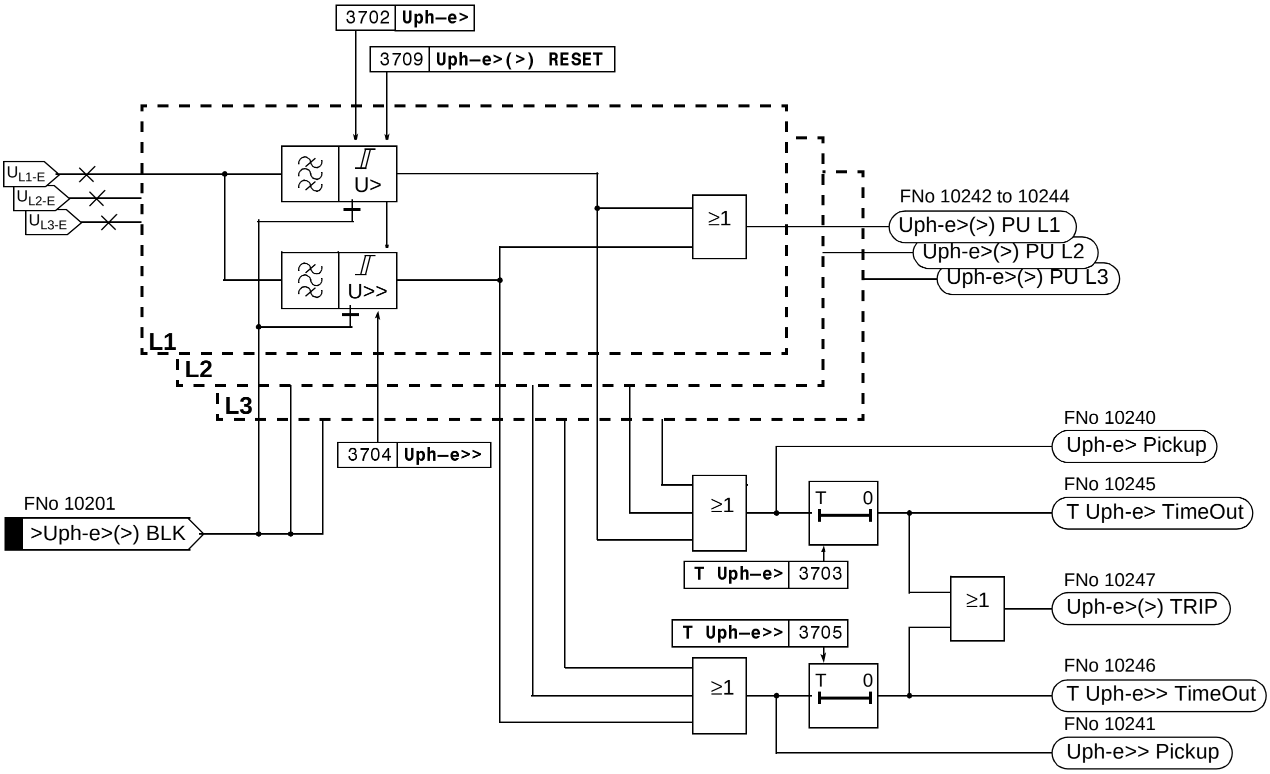


Figure 6-105 Logic diagram of the overvoltage protection for phase voltages

Overvoltage Phase–Phase

The phase–phase overvoltage protection operates just like the phase–earth protection except that it detects phase–to–phase voltages. Accordingly, phase–to–phase voltages which have exceeded one of the stage thresholds **Uph-ph>** or **Uph-ph>>** are also indicated. Otherwise, Figure 6-105 also applies in principle.

The phase–phase overvoltage protection can also be blocked via a binary input “>Uph-ph>(>) BLK”.

Overvoltage Positive Sequence System U_1

The device calculates the positive sequence system voltage according to its defining equation:

$$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$$

with $\underline{a} = e^{j120°}$.

The resulting single–phase AC voltage is fed to the two threshold stages **U1>** and **U1>>** (see Figure 6-106). Combined with the associated time delays these stages form a two-stage overvoltage protection for the positive sequence system. Here too, the drop-off to pick-up ratio can be set.

The overvoltage protection for the positive sequence system can also be blocked via a binary input “>U1>(>) BLK”.

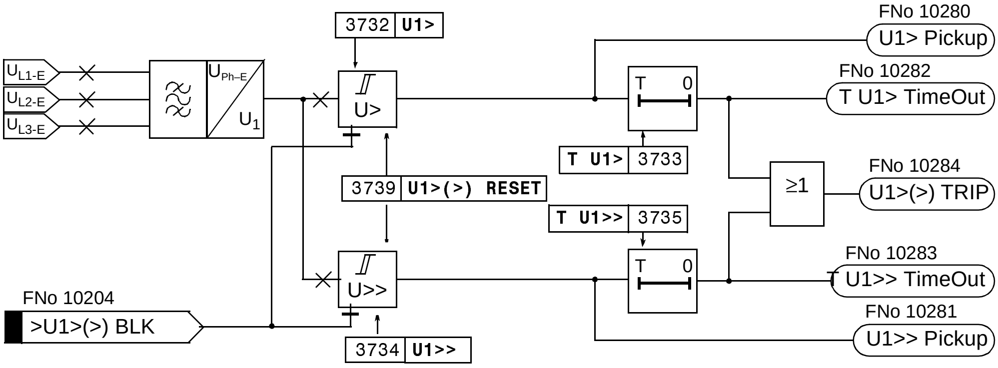


Figure 6-106 Logic diagram of the overvoltage protection for the positive sequence voltage system

Overvoltage Negative Sequence System U_2

The device calculates the negative sequence system voltages according to its defining equation:

$$\underline{U}_2 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3})$$

with $\underline{a} = e^{j120°}$.

The resulting single–phase AC voltage is fed to the two threshold stages **U2>** and **U2>>**. The logic is designed just like in the positive sequence system (Figure 6-106). Combined with the associated time delays **T U2>** and **T U2>>** these stages form a two-stage overvoltage protection for the negative sequence system. Here too, the drop-off to pick-up ratio can be set. The overvoltage protection for the negative sequence system can also be blocked via a binary input “`>U2>(>) BLK`”. The stages of the negative sequence voltage protection are automatically blocked as soon as an asymmetrical voltage failure was detected (“Fuse–Failure–Monitor”, also see Section 6.19.1.3, margin heading “Fuse Failure Monitor (Non-Symmetrical Voltages)”) or when the trip of the mcb for voltage transformers has been signalled via the binary input “`>FAIL:Feeder VT`” (internal indication “internal blocking”).

The stages of the negative sequence voltage protection are automatically blocked (with the internal automatic reclosure function) during single-pole automatic reclose dead time, to avoid pick-up with the false negative sequence values arising during this state. If the device cooperates with an external automatic reclosure function, or if a single-pole tripping can be triggered by a different protection system (working in parallel), the overvoltage protection for the negative sequence system must be blocked via a binary input during single-pole tripping.

Overvoltage Zero Sequence System $3 \cdot U_0$

Figure 6-107 depicts the logic diagram of the zero sequence voltage stage. The fundamental frequency is numerically filtered from the measuring voltage so that the harmonics or transient voltage peaks remain largely harmless.

The triple zero sequence voltage 3 U_0 is fed to the two threshold stages **3U0>** and **3U0>>**. Combined with the associated time delays **T 3U0>** and **T 3U0>>** these stages form a two-stage overvoltage protection for the zero sequence system. Here too, the drop-off to pick-up ratio can be set (**3U0>(>) RESET**).

The overvoltage protection for the zero voltage system can also be blocked via a binary input “`>3U0>(>) BLK`”. The stages of the zero sequence voltage protection are automatically blocked as soon as a asymmetrical voltage failure is detected (“Fuse–Failure–Monitor”, also see Section 6.19.1.3, margin heading “Fuse Failure Monitor (Non-Symmetrical Voltages)”) or if the trip of the mcb for voltage transformers has been signalled via the binary input “`>FAIL:Feeder VT`” (internal signal “internal blocking”).

The stages of the zero sequence voltage protection are automatically blocked (with the internal automatic reclosure function) during single-pole automatic reclose dead time to avoid pick-up with the false zero sequence values arising during this state. If the device operates with an external automatic reclosure function or if single-pole tripping can be triggered by a different protection system (operating in parallel), the overvoltage protection for the zero sequence system must be blocked via a binary input during single-pole tripping.

According to Figure 6-107 the device calculates the voltage to be monitored:

$$3\cdot\underline{U}_0 = \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}.$$

This applies if no suitable voltage is connected to the fourth measuring input U_4.

However, if the displacement voltage U_{en} of the voltage transformer set is directly connected to the fourth measuring input U_4 of the device and this information was entered during configuration the device will automatically use this voltage and calculate the triple zero sequence voltage.

$$3\cdot U_0 = \mathbf{Uph\ /\ Udelta}\cdot U_4.$$

As the voltage transformation of the voltage transformer set is usually

$$\frac{U_{Nprim}}{\sqrt{3}} \Big/ \frac{U_{Nsek}}{\sqrt{3}} \Big/ \frac{U_{Nsek}}{3}$$

the factor is **`Uph / Udelta`** = $3/\sqrt{3} = \sqrt{3} \approx$ ***1.73***. For more details see Power System Data 1 in Section 6.1.1, margin heading “Voltage Transformer Connection”, address `0211`.

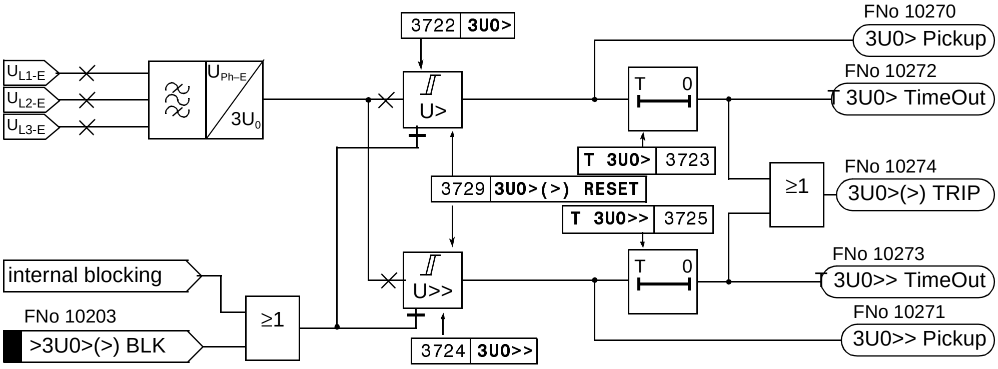


Figure 6-107 Logic diagram of the overvoltage protection for zero sequence voltage

Freely Selectable Single–phase Voltage

As the zero sequence voltage stages operate separately and independent from the other protective overvoltage functions they can be used for any other single–phase voltage. Therefore the fourth voltage input U_4 of the device must be assigned accordingly. (also see Section 6.1.1 in “Voltage Transformer Connection”).

The same features apply as for the use of the zero sequence voltage protection, i.e. blocking via a binary input “`>3U0>(>) BLK`”, when the asymmetrical “Fuse–Failure–Monitor” picks up during trip of the mcb for the voltage transformers, and during the single-pole dead time before automatic reclosure.

6.14.1.2 Undervoltage Protection

Undervoltage Phase–Earth

Figure 6-108 depicts the logic diagram of the phase voltage stages. The fundamental frequency is numerically filtered from each of the three measuring voltages so that harmonics or transient voltage peaks are largely harmless. Two threshold stages **`Uph-e<`** and **`Uph-e<<`** are compared with the voltages. If phase voltage falls below a threshold it is indicated phase-segregated. Furthermore, a general pick-up indication "`Uph-e< Pickup`" or "`Uph-e<< Pickup`" is given. The drop-off to pick-up ratio is 1.05.

Each stage starts a time delay common to all phases. Expiry of the respective time delay
`T Uph-e<` or **`T Uph-e<<`** is signalled and results in the trip command "`Uph-e<(<) TRIP`".

Depending on the configuration of the substations the voltage transformers are located on the busbar side or on the outgoing feeder side. This results in a different behaviour of the undervoltage protection when the line is deenergized. While the voltage remains present or reappears at the busbar side after a trip command and opening of the circuit breaker, it is switched on at the outgoing side. For the undervoltage protection this results in a pick-up state being present if the voltage transformers are on the outgoing side. If this pick-up must be reset, the current can be used as an additional criterion (current supervision **`CURR.SUP.`**) to achieve this result. Undervoltage will then only be detected if, together with the undervoltage condition, the minimum current **`PoleOpenCurrent`** (address `1130`) of the corresponding phase is also exceeded. This condition is communicated by the central function control of the device.

The undervoltage protection phase–earth can be blocked via the binary input "`>Uph-e<(<) BLK`". The stages of the undervoltage protection are then automatically blocked if a voltage failure is detected ("Fuse–Failure–Monitor", also see Section 6.19.1.3) or if the trip of the mcb of the voltage transformers is indicated (internal blocking) via the binary input "`>FAIL:Feeder VT`".

Also during a single-pole automatic reclose dead time (using the internal autoreclosure function) the stages of the undervoltage protection are automatically blocked in the pole open state. If necessary, the current criterion will be considered, so that they do not respond to the undervoltage of the disconnected phase when voltage transformers are located on the outgoing side.

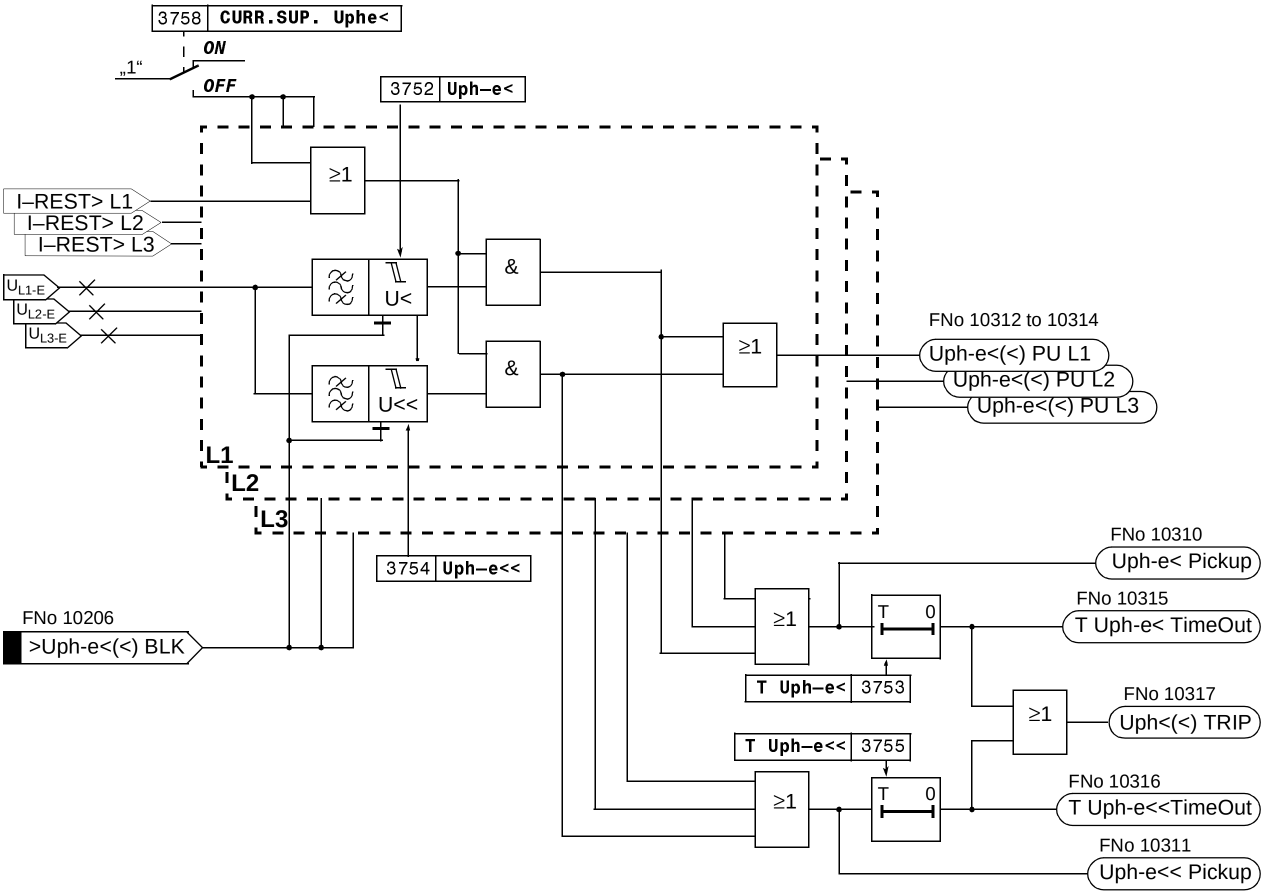


Figure 6-108 Logic diagram of the undervoltage protection for phase voltages

Undervoltage Phase–Phase

Basically, the phase–phase undervoltage protection operates like the phase–earth protection except that it detects phase–to–phase voltages. Accordingly, both phases are indicated during pick-up of an undervoltage stage if one of the stage thresholds **Uph-ph<** or **Uph-ph<<** was undershot. Beyond this, Figure 6-108 applies in principle.

It is sufficient for the current criterion that current flow is detected in one of the involved phases.

The undervoltage protection phase–phase can also be blocked via a binary input “>Uphph<(<) BLK”. There is an automatic blocking if the measuring voltage failure was detected or voltage mcb tripping was indicated (internal blocking of the phases affected by the voltage failure).

During single-pole dead time for automatic reclosure (using the internal automatic reclosure function) the stages of the undervoltage protection are automatically blocked in the disconnected phase so that it does not respond to the undervoltage of the disconnected phase provided that the voltage transformers are located on the outgoing side.

Undervoltage Positive Sequence System U_1

The device calculates the positive sequence system according to its defining equation

$\underline{U}_1 = {}^1/_3 \cdot (\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3})$

with $\underline{a} = e^{j120°}$.

The resulting single–phase AC voltage is fed to the two threshold stages **U1<** and **U1<<** (see Figure 6-109). Combined with the associated time delays **T U1<** and **T U1<<** these stages form a two-stage undervoltage protection for the positive sequence system.

Current can be used as an additional criterion for the undervoltage protection of the positive sequence system (current supervision **CURR.SUP.**). An undervoltage is only detected if the current flow is detected in at least one phase together with the undervoltage criterion.

The undervoltage protection for the positive sequence system can be blocked via the binary input “`>U1<(<) BLK`”. The stages of the undervoltage protection are automatically blocked if voltage failure is detected (“Fuse–Failure–Monitor”, also see Section 6.19.1.3) or, if the trip of the mcb for the voltage transformer is indicated via the binary input “`>FAIL:Feeder VT`” (internal blocking).

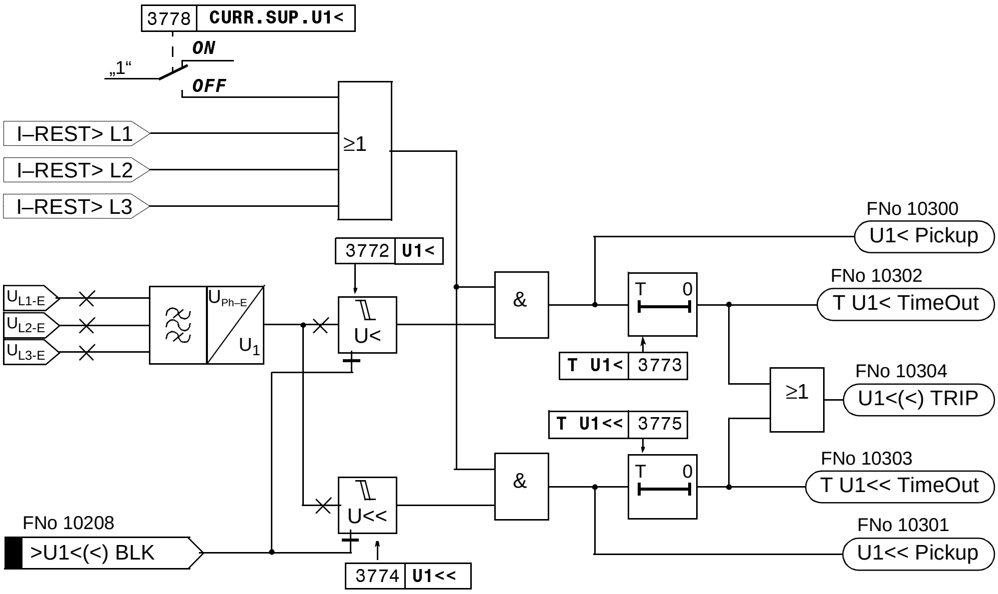


Figure 6-109 Logic diagram of the undervoltage protection for positive sequence voltage system

During single-pole dead time for automatic reclosure (using the internal automatic reclosure function) the stages of the undervoltage protection are automatically blocked in the positive sequence system so that they do not respond to the reduced voltage cause by the disconnected phase in case the voltage transformers are located on the outgoing side.

6.14.2 Applying the Function Parameter Settings

The voltage protection can only operate if it has been set to ***Enabled*** during the configuration of the device scope (see Section 5.1, address `0137`).

The overvoltage and undervoltage stages can detect phase–to–earth voltages, phase–to–phase voltages or the symmetrical positive sequence system of the voltages; the symmetrical negative sequence system can also be used for overvoltage. Any combination is possible. Detection procedures that are not required are switched ***Off***.

Overvoltage Phase–Earth

The phase voltage protection stages can be switched ***On*** or ***Off*** in address 3701 **Uph-e>(>)**. In addition to that you can also set ***Alarm Only***; i.e. these stages operate and transmit signals. Without generating a trip command.

The settings of the voltage and time values depend on what they are used for. If steady-state overvoltages are to be detected on long unloaded lines, the **Uph-e>** stage (address 3702) is set to at least 5 % above the maximum stationary phase–to–earth voltage that is to be expected in operation. Additionally, a high drop-off to pick-up ratio is required (address 3709 **Uph-e>(>) RESET** = ***0.98*** = presetting). This setting can only be changed with DIGSI® 4 under "**Additional Settings**". The delay time **T Uph-e>** (address 3703) should be a few seconds so that overvoltages with short duration may not result in tripping.

The **Uph-e>>** stage (address 3704) is provided for high overvoltages with short duration. Here, an adequately high pick-up value is set, e.g. the 1.5–fold of the nominal phase–earth voltage. 0.1 s to 0.2 s are sufficient for the time delay **T Uph-e>>** (address 3705).

Overvoltage Phase–Phase

Basically, the same considerations apply as for the phase voltage stages. These stages may be used instead of the phase voltage stages or be used addionally. The address 3711 **Uph-ph>(>)** is set to ***On***, ***Off*** or ***Alarm Only***.

As phase–to–phase voltages will be detected, phase–to–phase values are used for the settings **Uph-ph>** (address 3712) and **Uph-ph>>** (address 3714).

The same aspects as mentioned above apply to the time delays **T Uph-ph>** (address 3713) and **T Uph-ph>>** (address 3715) as well as to the drop-off to pick-up ratios (address 3719 **Uphph>(>) RESET**). This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Positive Sequence System Overvoltage U_1

The positive sequence voltage stages can be used instead of or in addition to previously mentioned overvoltage stages. The address 3731 **U1>(>)** is set to ***On***, ***Off*** or ***Alarm Only***, accordingly.

These stages are particularly suited to the detection of steady-state overvoltages on long, weak-loaded transmission lines (Ferranti effect). Here too, the **U1>** stage (address 3732) with a longer delay time is used for the detection of steady-state overvoltages, the **U1>>** stage (address 3734) with the short delay time **T U1>>** (address 3735) is used for high overvoltages that may jeopardize insulation.

Note that the positive sequence system is established according to its defining equation $U_1 = {}^1/_3 \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase–to–earth voltage.

The drop-off to pick-up ratio (address 3739 **U1>(>) RESET**) is set as high as possible with regard to the detection of even small steady-state overvoltages. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Negative Sequence System Overvoltage U_2

The negative sequence system voltage stages detect asymmetrical voltages. If such voltages shall cause tripping, set the address 3741 **U2>(>)** to ***On***. If these states shall be signalled only, set the address **U2>(>)** to ***Alarm Only***, in any other cases to ***Off***.

This protective function also has in two stages, one being **U2>** (address 3742) with a greater time delay **T U2>** (address 3743) for stationary asymmetrical voltages and the other being **U2>>** (address 3744) with a short delay time **T U2>>** (address 3745) for high asymmetrical voltages.

Note that the negative sequence system is established according to its defining equation $U_2 = {}^{\mathbf{1}}/_{\mathbf{3}} \cdot |\underline{U}_{L1} + \underline{a}^2 \cdot \underline{U}_{L2} + \underline{a} \cdot \underline{U}_{L3}|$. For symmetrical voltages and two exchanged phases this is equivalent to the phase–to–earth voltage value.

The drop-off to pick-up ratio **U2>(>) RESET**) can be set in address 3749. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Zero Sequence System Overvoltage

The zero sequence voltage stage can be switched ***On*** or ***Off*** in address **3721**. In addition, this stage can also be selected to ***Alarm Only*** i.e. these stages operate and issue alarms only. This protection function can be used for any other single-phase voltage which is connected to the fourth voltage measurement input U_4. (Also refer to Section 6.1.1 and see margin heading "Voltage Transformer Connection").

The settings of the voltage threshold and the timer values depend on the type of application. Here no general guidelines can be established. Generally, with a sensitive setting of **3U0>** (address **3722**), i.e. close to operational values that are to be expected, not only the time delay **T 3U0** (address **3724**) must be greater, but also the reset ratio **3U0 Reset Ratio** (address **3723**) must also be as large as possible. Usually the presetting is sufficient. This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

Similar considerations apply if this voltage stage is used for a different voltage at the measuring input U_4.

When setting the voltage values please observe the following:

- If the U_{en}-voltage of the set of voltage transformers is connected to U_4 and if this was already set in the power system data 1 (refer also to Section 6.1.1 under margin heading "Voltage Transformer Connection", **U4 transformer =** ***Udelta transf.***), the device multiplies this voltage by the matching ratio **Uph / Udelta** (address **0211**), usually with 1.73. Therefore the voltage measured is $\sqrt{3} \cdot U_{en} = 3 . U_0$. When the voltage triangle is fully displaced, the voltage will be √3-times the phase-to-phase voltage.
- If any other voltage is connected to U_4, which is *not* used for voltage protection, and if this was already set in the power system data 1 (refer also to Section 6.1.1, "Voltage Transformer Connection", e. g. **U4 transformer =** ***Not connected*** or **U4 transformer =** ***Usync transf.***), the device calculates the zero sequence voltage according to its definition: $3 \cdot U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. When the voltage triangle is fully displaced, the voltage will be √3-times the phase-to-phase voltage.
- If any other voltage is connected to U_4, which is used for voltage protection, and if this was already set in the power system data 1 (refer also to Section 6.1.1, "Voltage Transformer Connection", i. e. **U4 transformer =** ***Ux transformer***), this voltage will be used for the voltage stages without any further factors. This "zero sequence voltage protection" then is, in reality, a single-phase voltage protection for any kind of voltage at U_4.

Undervoltage Phase–Earth

The phase undervoltage stages can be switched ***On*** or ***Off*** in address 3751 **Uph-e<(<)**. In addition to this, you can set ***Alarm Only***, i.e. these stages operate and send alarms but do not generate any trip commands.

This undervoltage protection function has two stages. The **Uph-e<** stage (address 3752) operates with the longer set time value **T Uph-e<** (address 3753) for a slight undervoltages. However, it must not be set above the admissible undervoltage. In case of severe voltage drops the **Uph-e<<** stage (address 3754) with a time delay **T Uph-e<<** (address 3755) is active.

The setting of voltage and time values depends on the intended use, that is why general setting recommendations cannot be given. With regard to load shedding, for example, the values mostly depend on a priority grading schedule. If stability problems occur, admissible undervoltages and their duration must be considered. With induction machines the undervoltages influence the admissible torque thresholds.

If the voltage transformers are located on the line side, the measuring voltages will be missing if the line is disconnected. To avoid that the undervoltage stages in these cases are or remain picked up, the current criterion **CURR.SUP. Uphe<** (address 3758) is switched ***On***. With busbar side voltage transformers it can be switched ***Off***. However, with a dead busbar the undervoltage protection picks up and expires, if it is not blocked by other criteria or binary inputs.

Undervoltage Phase–Phase

Basically, the same considerations apply as for the phase undervoltage stages. These stages may replace the phase voltage stages or be used additionally. Address 3761 **Uph-ph<(<)** is set to ***On***, ***Off*** or ***Alarm Only***.

As phase–to–phase voltages are monitored, the phase–to–phase values are used for the settings **Uph-ph<** (address 3762) and **Uph-ph<<** (address 3764).

The corresponding times delay are **T Uph-ph<** (address 3763) und **T Uphph<<** (address 3765).

If the voltage transformers are located on the line side, the measuring voltages will missing if the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.Uphph<** (address 3768) is switched ***On***. With busbar side voltage transformers it can be switched ***Off***. However, with a dead busbar the undervoltage protection picks up and expires, if it is not blocked by other criteria via binary inputs.

Positive Sequence System Undervoltage U_1

The positive sequence undervoltage stages can be used instead of or in addition to previously mentioned undervoltage stages. The address 3771 **U1<(<)** is set to ***On***, ***Off*** or ***Alarm Only***, accordingly.

Basically, the same considerations apply as for the other undervoltage stages. Especially in case of stability problems, the positive sequence system is advantageous, since the positive sequence system is relevant for the limit of the stable energy transmission in most applications.

To achieve the two-stage condition, the **U1<**–stage (address 3772) is combined with a greater time delay **T U1<** (address 3773). The **U1<<**–stage (address 3774) with a shorter time delay **T U1<<** (address 3775).

Note that the positive sequence system is established according to its defining equation $U_1 = {}^{1}/_{3} \cdot |\underline{U}_{L1} + \underline{a} \cdot \underline{U}_{L2} + \underline{a}^2 \cdot \underline{U}_{L3}|$. For symmetrical voltages this is equivalent to a phase–earth voltage.

If the voltage transformers are located or line side, the measuring voltages will be missing when the line is disconnected. To avoid that the undervoltage levels in these cases are or remain picked up, the current criterion **CURR.SUP.U1<** (address 3768) is switched ***On***. With busbar side voltage transformers it can be switched ***Off***. However, with a dead busbar the undervoltage protection picks up and expires, if it is not blocked by other criteria via binary inputs.

6.14.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
3701	Uph-e>(>)	OFF Alarm Only ON	OFF	Operating mode Uph-e overvoltage prot.
3702	Uph-e>	1.0..170.0 V	85.0 V	Uph-e> Pickup
3703	T Uph-e>	0.00..30.00 sec; Ø	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	1.0..170.0 V	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	0.00..30.00 sec; Ø	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	0.50..0.98	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	OFF Alarm Only ON	OFF	Operating mode Uph-ph overvoltage prot.
3712	Uph-ph>	2.0..220.0 V	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	0.00..30.00 sec; Ø	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	2.0..220.0 V	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	0.00..30.00 sec; Ø	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	0.50..0.98	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	OFF Alarm Only ON	OFF	Operating mode 3U0 (or Ux) overvoltage
3722	3U0>	1.0..220.0 V	30.0 V	3U0> Pickup (or Ux>)
3723	T 3U0>	0.00..30.00 sec; Ø	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	1.0..220.0 V	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	0.00..30.00 sec; Ø	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3729A	3U0>(>) RESET	0.50..0.98	0.95	3U0>(>) Reset ratio (or Ux)
3731	U1>(>)	OFF Alarm Only ON	OFF	Operating mode U1 overvoltage prot.
3732	U1>	2.0..220.0 V	150.0 V	U1> Pickup
3733	T U1>	0.00..30.00 sec; Ø	2.00 sec	T U1> Time Delay
3734	U1>>	2.0..220.0 V	175.0 V	U1>> Pickup
3735	T U1>>	0.00..30.00 sec; Ø	1.00 sec	T U1>> Time Delay
3739A	U1>(>) RESET	0.50..0.98	0.98	U1>(>) Reset ratio
3741	U2>(>)	OFF Alarm Only ON	OFF	Operating mode U2 overvoltage prot.
3742	U2>	2.0..220.0 V	30.0 V	U2> Pickup
3743	T U2>	0.00..30.00 sec; Ø	2.00 sec	T U2> Time Delay
3744	U2>>	2.0..220.0 V	50.0 V	U2>> Pickup

Addr.	Setting Title	Setting Options	Default Setting	Comments
3745	T U2>>	0.00..30.00 sec; Ø	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	0.50..0.98	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	OFF Alarm Only ON	OFF	Operating mode Uph-e undervoltage prot.
3752	Uph-e<	1.0..100.0 V	30.0 V	Uph-e< Pickup
3753	T Uph-e<	0.00..30.00 sec; Ø	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	1.0..100.0 V	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	0.00..30.00 sec; Ø	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	ON OFF	ON	Current supervision (Uph-e)
3761	Uph-ph<(<)	OFF Alarm Only ON	OFF	Operating mode Uph-ph undervoltage prot.
3762	Uph-ph<	1.0..175.0 V	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	0.00..30.00 sec; Ø	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	1.0..175.0 V	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	0.00..30.00 sec; Ø	1.00 sec	T Uph-ph<< Time Delay
3768	CURR.SUP.Uphph<	ON OFF	ON	Current supervision (Uph-ph)
3771	U1<(<)	OFF Alarm Only ON	OFF	Operating mode U1 undervoltage prot.
3772	U1<	1.0..100.0 V	30.0 V	U1< Pickup
3773	T U1<	0.00..30.00 sec; Ø	2.00 sec	T U1< Time Delay
3774	U1<<	1.0..100.0 V	10.0 V	U1<< Pickup
3775	T U1<<	0.00..30.00 sec; Ø	1.00 sec	T U1<< Time Delay
3778	CURR.SUP.U1<	ON OFF	ON	Current supervision (U1)

6.14.4 Information Overview

F.No.	Alarm	Comments
10201	>Uph-e>(>) BLK	>BLOCK Uph-e>(>) Overvolt. (phase-earth)
10202	>Uph-ph>(>) BLK	>BLOCK Uph-ph>(>) Overvolt (phase-phase)
10203	>3U0>(>) BLK	>BLOCK 3U0>(>) Overvolt. (zero sequence)
10204	>U1>(>) BLK	>BLOCK U1>(>) Overvolt. (positive seq.)
10205	>U2>(>) BLK	>BLOCK U2>(>) Overvolt. (negative seq.)
10206	>Uph-e<(<) BLK	>BLOCK Uph-e<(<) Undervolt (phase-earth)
10207	>Uphph<(<) BLK	>BLOCK Uphph<(<) Undervolt (phase-phase)

F.No.	Alarm	Comments
10208	>U1<(<) BLK	>BLOCK U1<(<) Undervolt (positive seq.)
10215	Uph-e>(>) OFF	Uph-e>(>) Overvolt. is switched OFF
10216	Uph-e>(>) BLK	Uph-e>(>) Overvolt. is BLOCKED
10217	Uph-ph>(>) OFF	Uph-ph>(>) Overvolt. is switched OFF
10218	Uph-ph>(>) BLK	Uph-ph>(>) Overvolt. is BLOCKED
10219	3U0>(>) OFF	3U0>(>) Overvolt. is switched OFF
10220	3U0>(>) BLK	3U0>(>) Overvolt. is BLOCKED
10221	U1>(>) OFF	U1>(>) Overvolt. is switched OFF
10222	U1>(>) BLK	U1>(>) Overvolt. is BLOCKED
10223	U2>(>) OFF	U2>(>) Overvolt. is switched OFF
10224	U2>(>) BLK	U2>(>) Overvolt. is BLOCKED
10225	Uph-e<(<) OFF	Uph-e<(<) Undervolt. is switched OFF
10226	Uph-e<(<) BLK	Uph-e<(<) Undervolt. is BLOCKED
10227	Uph-ph<(<) OFF	Uph-ph<(<) Undervolt. is switched OFF
10228	Uph-ph<(<) BLK	Uphph<(<) Undervolt. is BLOCKED
10229	U1<(<) OFF	U1<(<) Undervolt. is switched OFF
10230	U1<(<) BLK	U1<(<) Undervolt. is BLOCKED
10231	U</> ACTIVE	Over-/Under-Voltage protection is ACTIVE
10240	Uph-e> Pickup	Uph-e> Pickup
10241	Uph-e>> Pickup	Uph-e>> Pickup
10242	Uph-e>(>) PU L1	Uph-e>(>) Pickup L1
10243	Uph-e>(>) PU L2	Uph-e>(>) Pickup L2
10244	Uph-e>(>) PU L3	Uph-e>(>) Pickup L3
10245	Uph-e> TimeOut	Uph-e> TimeOut
10246	Uph-e>> TimeOut	Uph-e>> TimeOut
10247	Uph-e>(>) TRIP	Uph-e>(>) TRIP command
10255	Uphph> Pickup	Uph-ph> Pickup
10256	Uphph>> Pickup	Uph-ph>> Pickup
10257	Uphph>(>)PU L12	Uph-ph>(>) Pickup L1-L2
10258	Uphph>(>)PU L23	Uph-ph>(>) Pickup L2-L3
10259	Uphph>(>)PU L31	Uph-ph>(>) Pickup L3-L1
10260	Uphph> TimeOut	Uph-ph> TimeOut
10261	Uphph>> TimeOut	Uph-ph>> TimeOut
10262	Uphph>(>) TRIP	Uph-ph>(>) TRIP command
10270	3U0> Pickup	3U0> Pickup
10271	3U0>> Pickup	3U0>> Pickup

F.No.	Alarm	Comments
10272	3U0> TimeOut	3U0> TimeOut
10273	3U0>> TimeOut	3U0>> TimeOut
10274	3U0>(>) TRIP	3U0>(>) TRIP command
10280	U1> Pickup	U1> Pickup
10281	U1>> Pickup	U1>> Pickup
10282	U1> TimeOut	U1> TimeOut
10283	U1>> TimeOut	U1>> TimeOut
10284	U1>(>) TRIP	U1>(>) TRIP command
10290	U2> Pickup	U2> Pickup
10291	U2>> Pickup	U2>> Pickup
10292	U2> TimeOut	U2> TimeOut
10293	U2>> TimeOut	U2>> TimeOut
10294	U2>(>) TRIP	U2>(>) TRIP command
10300	U1< Pickup	U1< Pickup
10301	U1<< Pickup	U1<< Pickup
10302	U1< TimeOut	U1< TimeOut
10303	U1<< TimeOut	U1<< TimeOut
10304	U1<(<) TRIP	U1<(<) TRIP command
10310	Uph-e< Pickup	Uph-e< Pickup
10311	Uph-e<< Pickup	Uph-e<< Pickup
10312	Uph-e<(<) PU L1	Uph-e<(<) Pickup L1
10313	Uph-e<(<) PU L2	Uph-e<(<) Pickup L2
10314	Uph-e<(<) PU L3	Uph-e<(<) Pickup L3
10315	Uph-e< TimeOut	Uph-e< TimeOut
10316	Uph-e<< TimeOut	Uph-e<< TimeOut
10317	Uph-e<(<) TRIP	Uph-e<(<) TRIP command
10325	Uph-ph< Pickup	Uph-ph< Pickup
10326	Uph-ph<< Pickup	Uph-ph<< Pickup
10327	Uphph<(<)PU L12	Uphph<(<) Pickup L1-L2
10328	Uphph<(<)PU L23	Uphph<(<) Pickup L2-L3
10329	Uphph<(<)PU L31	Uphph<(<) Pickup L3-L1
10330	Uphph< TimeOut	Uphph< TimeOut
10331	Uphph<< TimeOut	Uphph<< TimeOut
10332	Uphph<(<) TRIP	Uphph<(<) TRIP command

6.15 Fault Location

Measurement of the distance to fault in the event of a short circuit is an important supplement to the protection functions. The availability of the line for transmission of energy in the system can be increased by a more rapid determination of the fault location and repair of any resultant damage.

6.15.1 Method of Operation

Starting Conditions

The fault location function in the distance protection 7SA6 is a function which is independent of the distance measurement. It has a separate measured value memory and dedicated filter algorithms. The short-circuit protection merely has to provide a start command to allow the selection of the valid measuring loop and the best suited time interval for the storage of the measured signals.

The fault location function can be triggered by the trip command of the short-circuit protection, or also by each fault detection. In the latter case, a fault location calculation is also possible if a different protection device clears the fault. In the case of a fault outside of the protected feeder, the fault location output cannot always be correct, because the measured values may be distorted by for instance an intermediate infeed.

Determination of the Fault Location

The measured value pairs of fault currents and fault voltages (in intervals of $^1/_{20}$ AC cycle) are stored in a circular buffer and frozen shortly after the trip command is issued before any distortion of the measured values occurs due to the opening of the circuit breaker even with very fast circuit breakers. Filtering of the measured values and the number of impedance calculations are automatically adapted to the number of stabilized measured value pairs in the determined data window. If a sufficient data window with stabilized values could not be determined, the alarm "`Flt.Loc.invalid`" is issued.

The evaluation of the measured values in the short-circuit loops is carried out after the short-circuit has been cleared. Short-circuit loops are those, which caused the trip. In the event of tripping by the earth fault protection, the three phase–earth loops are evaluated.

With the memorized and filtered measured values, at least three pairs of results for R and X are determined according to the line equation. With the pairs of results, the average values and standard deviations are calculated. After elimination of "deviants" which are recognized by their large deviation from the standard deviation, a new average is calculated. This average for X is the fault reactance which is proportional to the distance to fault. If several loops were evaluated, the loop with the smallest reactance is valid. In this manner, the fault on the protected feeder is in any event determined during multiple faults or in the event of tripping by only the earth fault protection.

Output of the Fault Location

The fault location function issues the following results:

- the short-circuit loop which was used to determine the fault reactance,
- the reactance X per phase in Ω primary and Ω secondary,
- the resistance R per phase in Ω primary and Ω secondary,
- the distance to fault d in kilometres or miles of the line proportional to the reactance, converted based on the set line reactance per unit line length,

- the distance to fault d in % of the line length, calculated based on the set reactance per unit length and the set line length.

The fault location indicated in per cent can, at the same time, be output as BCD-code (Binary Coded Decimal). This, however, must have been preset in address `0138` during the configuration of the protection functions (Section 5.1, “Special Cases”, page 5-3. A further prerequisite is that the required number of binary outputs is allocated for this purpose (see Section 5.2). 10 output relays are needed. They are classified in the following:

- 4 outputs for the units ($1 \cdot 2^0 + 1 \cdot 2^1 + 1 \cdot 2^2 + 1 \cdot 2^3$),
- 4 outputs for the tens ($10 \cdot 2^0 + 10 \cdot 2^1 + 10 \cdot 2^2 + 10 \cdot 2^3$),
- 1 output for the hundreds ($100 \cdot 2^0$),
- 1 output for the ready-state annunciation “`BCD dist. VALID`”.

Once a fault was located, the corresponding binary outputs pick up. Then the output “`BCD dist. VALID`” signalizes that the data are then valid. The duration can be selected. In the event of a new fault the data of the former fault are terminated automatically.

The output range extends from 0 % to 195 %. Output “197” means that a negative fault was detected. Output “199" describes an overflow, i. e. the calculated value is higher than the maximum possible value of 195 %.

The fault location indicated in per cent can also be output as analog value (0 mA to 20 mA). It is a prerequisite that the device is provided with (an) analog output(s) (according to the ordering code) and that an analog output was allocated to the fault location in address `0152` or `0153` during the configuration of the protection functions (Section 5.1, in “Special Cases”, page 5-3. For more information about the analog output settings please refer to Subsection 6.18.

Note: The distance can only be applicable in the form of kilometres, miles or percent if the relevant line section is homogeneous. If the line is composed of line sections with different reactance per unit length characteristic, e.g. overhead line–cable sections, the reactance calculated by the fault location function can be subjected to a separate computation to derive the distance to fault.

Correction of Measured Values on Parallel Lines

In the case of earth faults on double circuit lines, the measured values obtained for calculation of the impedance are influenced by the mutual coupling of the earth impedance of the two parallel lines. This causes measuring errors in the result of the impedance computation unless special measures are taken. The device is therefore provided with a parallel line compensation function. This function takes the earth current of the parallel line into consideration when solving the line equation, thereby compensating for the coupling influence as was the case with the derivation of the distance by the distance protection (refer to Sub-section 6.2.3 under “Measured Value Correction for Parallel Lines” and Figure 6-27). The earth current of the parallel line must, of course, be connected to the device and the current input I_4 must be configured accordingly during the setting of the Power System Data (Sub-section 6.1.1 under “Current Transformer Connection”).

The parallel line compensation only applies to faults on the protected feeder. For external faults, including those on the parallel line, compensation is impossible.

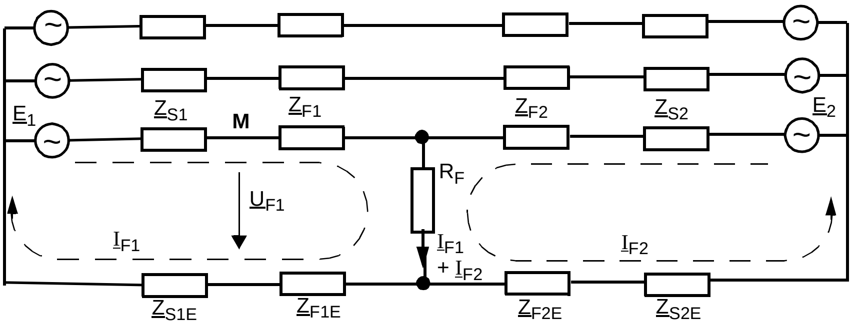
Correction of Measured Values for Load Current on Double-end Fed Lines

When faults occur on loaded lines fed from both ends (Figure 6-110), the fault voltage $\underline{U}_{F1}$ is influenced not only by the source voltage $\underline{E}_1$ but also by the source voltage $\underline{E}_2$, when both voltages are applied to the common earth resistance R_F. If not corrected, this will result in inaccuracies in the calculated impedance, since the current component $\underline{I}_{F2}$ cannot be seen at the measuring point M. For long heavily loaded lines, this can give a significant error in the X–component of the fault impedance (the determining factor for the distance-to-fault calculation).

A load compensation feature is provided for the fault location calculation which corrects this measurement inaccuracy. Correction for the R–component of the fault impedance is not possible; but the resultant inaccuracy is not critical, since only the X–component is critical for the distance to fault indication.

Load compensation is effective for single–phase faults. For single–phase to earth faults, positive and zero phase sequence components of the symmetrical components are used in the compensation.

Load compensation can be switched on or off for the fault locator (address 3806, **Load Compensat.**). Off-switching is useful, for example, during relay testing, in order to avoid influences caused by the test quantities.



Legend:

M	Measuring location	$\underline{Z}_{S1}$, $\underline{Z}_{S2}$	Source impedances
$\underline{E}_1$, $\underline{E}_2$	Source voltages (EMF)	$\underline{Z}_{S1E}$, $\underline{Z}_{S2E}$	Earth source impedances
$\underline{U}_{F1}$	Fault voltage at the measuring location	$\underline{Z}_{F1}$, $\underline{Z}_{F2}$	Fault impedances
$\underline{I}_{F1}$, $\underline{I}_{F2}$	Part fault currents	$\underline{Z}_{F1E}$, $\underline{Z}_{F2E}$	Earth fault impedances
$\underline{I}_{F1}$ + $\underline{I}_{F2}$	Total fault current	R_F	Common fault resistance

Figure 6-110 Fault currents and voltages on double–end fed lines

6.15.2 Applying the Function Parameter Settings

The fault location function is only in service if it was selected to ***Enabled*** during the configuration of the device functions (Section 5.1, address 0138).

If the fault location calculation is to be started by the trip command of the protection, address 3802 **START** = ***TRIP*** is set. In this case a fault location is only output if the device has also issued a trip. The fault location calculation can however also be started with each fault detection of the device (address 3802 **START** = ***PICKUP***). In this case the fault location is also calculated if for example a different protection device cleared the fault. For a fault outside the protected line, the fault location information is not always correct, as the measured values can be distorted by e.g. intermediate infeeds.

To calculate the distance to fault in kilometres or miles, the device requires the reactance per unit length data in Ω/km or Ω/mile. For correct indication of the fault location in % of line length, the correct line length should also be entered. These setting parameters were already applied with the plant data (Section 6.1.3 under "General Line Data").

A prerequisite for the correct indication of the fault location furthermore is that the other parameters that influence the calculation of the distance to fault have also been set correctly. These are the addresses (refer also to Sub-section 6.1.3)

1116 RE/RL(Z1),
1117 XE/XL(Z1)

or

1120 K0(Z1),
1121 PHI(K0(Z1)).

If the parallel line compensation is used, the address **3805** must be set to **Paral.Line Comp** = ***Yes***; the presetting is ***No***. Further prerequisites are that

- the earth current of the parallel line has been connected to the fourth current input I_4 with the correct polarity and
- the parameter for the fourth current input **I4 transformer** has been set to ***In paral. line*** (address **0220**) in the "power system data 1" (refer also to Sub-section 6.1.1 under "Current Transformer Connection") and
- the current transformer ratio **I4/Iph CT** (address **0221**) in the "power system data 1" has been set correctly (refer also to Sub-section 6.1.1 under "Current Transformer Connection") and
- the mutual impedances **RM/RL ParalLine** and **XM/XL ParalLine** (addresses **1126** and **1127**) have been set correctly in the general protection data ("power system data 2", refer to Sub-section 6.1.3).

If load compensation is applied to single-phase faults in double-fed lines of an earthed system, set ***Yes*** in address 3806 **Load Compensat.**. In case high fault resistances are expected for single-phase faults, e.g. at overhead lines without overhead earth wire or unfavourable footing of the towers, this will improve the accuracy of the distance calculation.

If the fault location is required to be output as BCD-code, set the maximum time period the data should be available at the outputs using address 3811 **Tmax OUTPUT BCD**. If a new fault occurs, the data are terminated immediately. Allocate the corresponding output relays as "stored" if a longer time period is desired for the output. Once a fault occurred the data will be latched until the memory is reset or a new fault is registered.

6.15.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
3802	START	Pickup TRIP	Pickup	Start fault locator with
3805	Paral.Line Comp	NO YES	NO	Mutual coupling parall.line compensation
3806	Load Compensat.	NO YES	NO	Load Compensation
3811	Tmax OUTPUT BCD	0.10..30.00 sec	0.30 sec	Maximum output time via BCD

6.15.4 Information Overview

F.No.	Alarm	Comments
1114	Rpri =	Flt Locator: primary RESISTANCE
1115	Xpri =	Flt Locator: primary REACTANCE
1117	Rsec =	Flt Locator: secondary RESISTANCE
1118	Xsec =	Flt Locator: secondary REACTANCE
1119	dist =	Flt Locator: Distance to fault
1120	d[%] =	Flt Locator: Distance [%] to fault
1122	dist =	Flt Locator: Distance to fault
1123	FL Loop L1E	Fault Locator Loop L1E
1124	FL Loop L2E	Fault Locator Loop L2E
1125	FL Loop L3E	Fault Locator Loop L3E
1126	FL Loop L1L2	Fault Locator Loop L1L2
1127	FL Loop L2L3	Fault Locator Loop L2L3
1128	FL Loop L3L1	Fault Locator Loop L3L1
1132	Flt.Loc.invalid	Fault location invalid
1133	Flt.Loc.ErrorK0	Fault locator setting error K0,angle(K0)
1143	BCD d[1%]	BCD Fault location [1%]
1144	BCD d[2%]	BCD Fault location [2%]
1145	BCD d[4%]	BCD Fault location [4%]
1146	BCD d[8%]	BCD Fault location [8%]
1147	BCD d[10%]	BCD Fault location [10%]
1148	BCD d[20%]	BCD Fault location [20%]
1149	BCD d[40%]	BCD Fault location [40%]
1150	BCD d[80%]	BCD Fault location [80%]
1151	BCD d[100%]	BCD Fault location [100%]

F.No.	Alarm	Comments
1152	BCD dist. VALID	BCD Fault location valid

6.16 Circuit Breaker Failure Protection

6.16.1 Method of Operation

General

The circuit breaker failure protection provides rapid back-up fault clearance, in the event that the circuit breaker fails to respond to a trip command from a feeder protection.

Whenever e.g. a short-circuit protection relay of a feeder issues a trip command to the circuit breaker, this is repeated to the breaker failure protection (Figure 6-111). A timer T–BF in the breaker failure protection is started. The timer runs as long as a trip command is present and current continues to flow through the breaker poles.

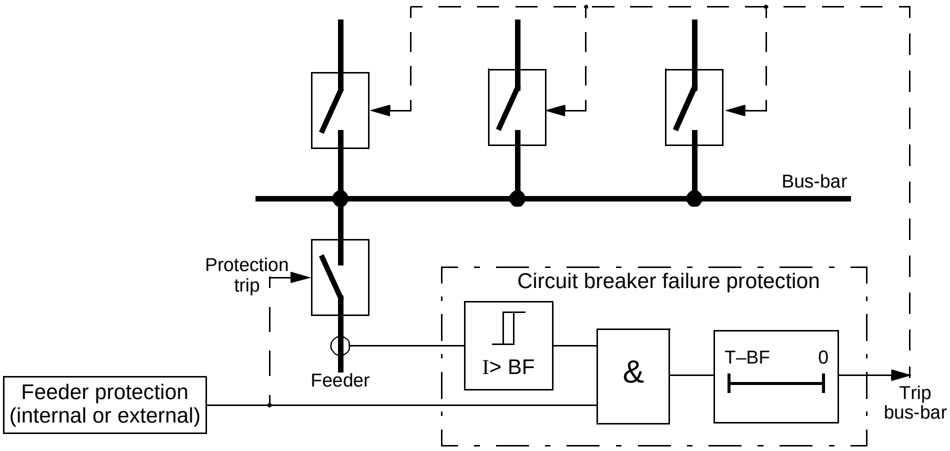


Figure 6-111 Simplified function diagram of circuit breaker failure protection with current flow monitoring

Normally, the breaker will open and interrupt the fault current. The current monitoring stage quickly resets (typical 10 ms) and stops the timer T–BF.

If the trip command is not carried out (breaker failure case), current continues to flow and the timer runs to its set limit. The breaker failure protection then issues a command to trip the back-up breakers and interrupt the fault current.

The reset time of the feeder protection is not relevant because the breaker failure protection itself recognizes the interruption of the current.

For protection functions where the tripping criteria is not dependent on current (e.g. Buchholz protection), current flow is not a reliable criterion for proper operation of the breaker. In such cases, the circuit breaker position can be derived from the auxiliary contacts of the breaker. Therefore, instead of monitoring the current, the condition of the auxiliary contacts is monitored (see Figure 6-112). For this purpose, the outputs from the auxiliary contacts must be fed to binary inputs on the relay (refer also Section 6.20.2).

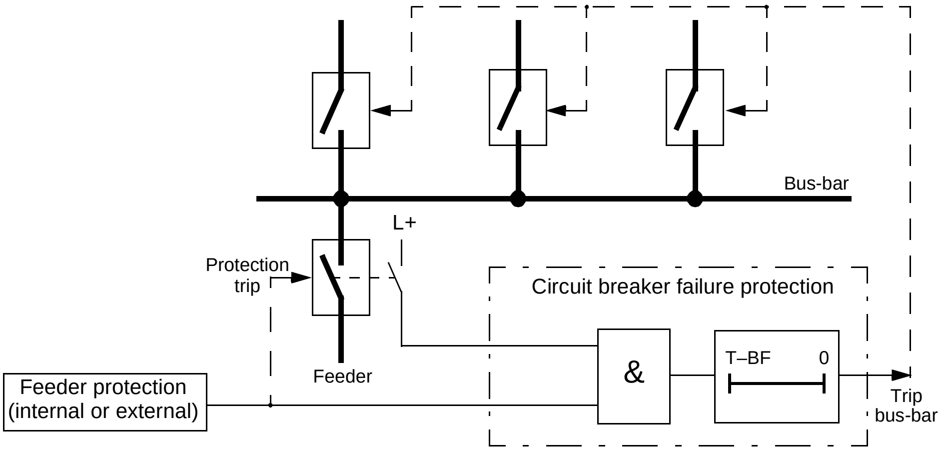


Figure 6-112 Simplified function diagram of circuit breaker failure protection controlled by circuit breaker auxiliary contact

Current Flow Monitoring

Each of the phase currents and an additional plausibility current (see below) are filtered by numerical filter algorithms so that only the fundamental frequency is used for further evaluation.

Special features recognise the instant of current interruption. With sinusoidal currents, current interruption is detected after approx.10 ms. With d.c. transient current components present in the fault current and/or in the current transformer secondary circuit after interruption (e.g. current transformers with linearized core) or if the current transformers are saturated by the d.c. component in the fault current, it can take one a.c. cycle before the disappearance of the primary current is reliably detected.

The currents are monitored and compared with the set threshold. Besides the three phase currents, two further current detectors are provided in order to allow a plausibility check (see Figure 6-113).

The earth current (residual current $I_E = 3 \cdot I_0$) is preferably used as plausibility current. If the residual current from the star-point of the current transformer set is connected to the device this is used for $3 \cdot I_0$. If the residual current is not available the device calculates it with the formula

$$3 \cdot \underline{I}_0 = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}.$$

Additionally, three times the negative sequence current $3 \cdot I_2$ is used for plausibility check. This is calculated by the 7SA6 according to the equation:

$$3 \cdot \underline{I}_2 = \underline{I}_{L1} + \underline{a}^2 \cdot \underline{I}_{L2} + \underline{a} \cdot \underline{I}_{L3}$$

where

$$\underline{a} = e^{j120°}.$$

These plausibility currents do not have any direct influence on the basic functionality of the breaker failure protection but they allow a plausibility check in that at least two current thresholds must have been exceeded before any of the breaker failure delay times can be started, thus providing high security against false operation.

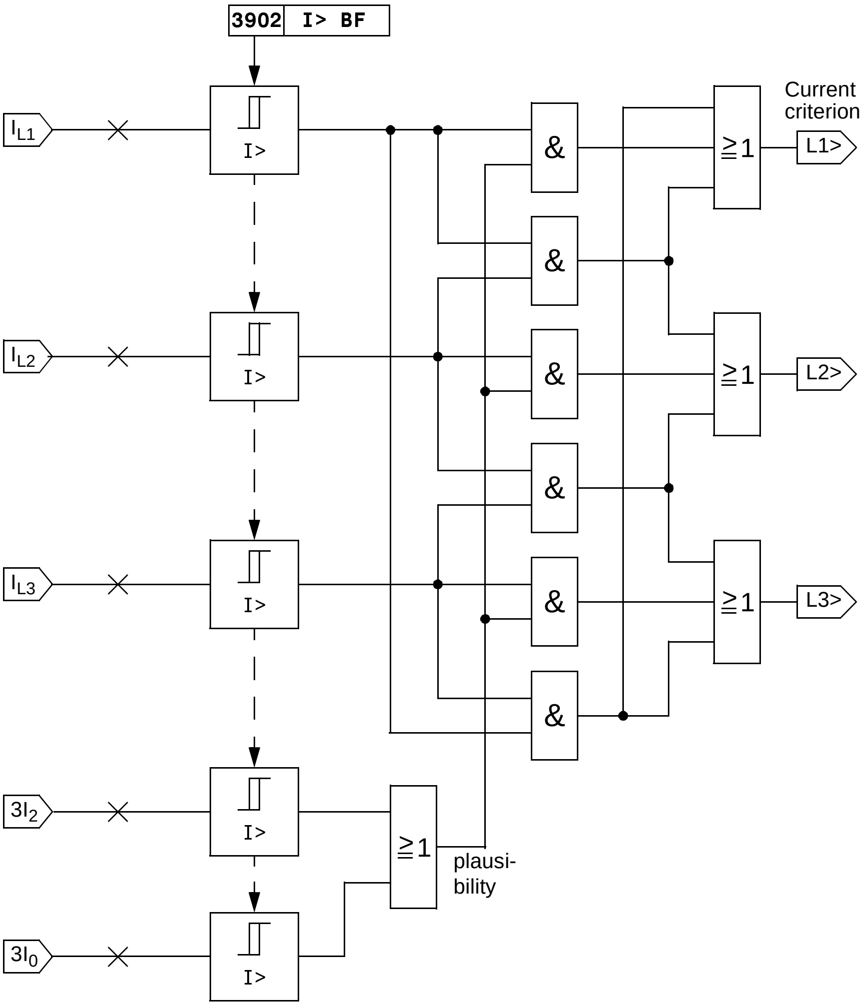


Figure 6-113 Current flow monitoring with the plausibility currents $3 \cdot I_0$ and $3 \cdot I_2$

Processing of the Circuit Breaker Auxiliary Contacts

The position of the circuit breaker is derived from the central function control of the device (refer also to Section 6.20.2). Evaluation of the breaker auxiliary contacts is carried out in the breaker failure protection function only when the current flow monitoring has not picked up. Once the current flow criterion has picked up during the trip signal from the feeder protection, the circuit breaker is assumed to be open as soon as the current disappears, even if the associated auxiliary contact does not (yet) indicate that the circuit breaker has opened (Figure 6-114). This gives preference to the more reliable current criterion and avoids overfunctioning due to a defect e.g. in the auxiliary contact mechanism or circuit. This interlock feature is provided for each individual phase as well as for three-pole trip.

It is possible to disable the auxiliary contact criterion. If you set the parameter switch **Chk BRK CONTACT** (Figure 6-116 above) to ***No***, the breaker failure protection can only be started when current flow is detected. The position of the auxiliary contacts is then not evaluated even if the auxiliary contacts are connected to the device.

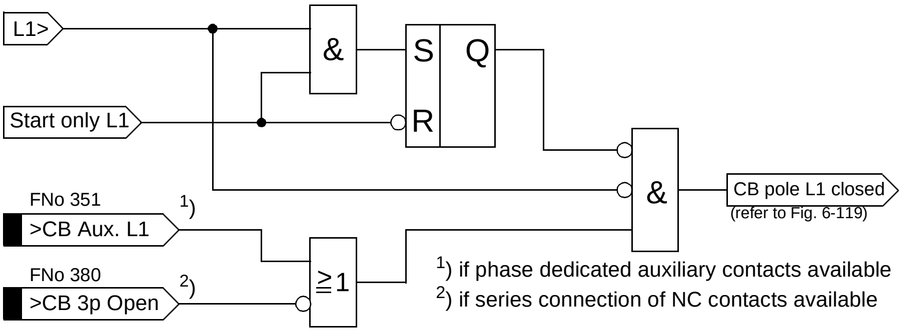


Figure 6-114 Interlock of the auxiliary contact criterion — example for phase L1

On the other hand, current flow is not a reliable criterion for proper operation of the circuit breaker for faults which do not cause detectable current flow (e.g. Buchholz protection). Information regarding the position of the circuit breaker auxiliary contacts is required in these cases to check the correct response of the circuit breaker. For this purpose, the binary input “`>BF Start w/o I`” is provided (Figure 6-116 left). This input initiates the breaker failure protection even if no current flow is detected.

Common Phase Initiation

Common phase initiation is used, for example, for lines without automatic reclosure, for lines with only three-pole automatic reclosure, for transformer feeders, or if the busbar protection trips. This is the only available initiation mode if the actual 7SA6 model is able to trip three-pole only.

If the breaker failure protection is intended to be initiated by further external protection devices, it is recommended, for security reasons, to connect two starting criteria to the 7SA6 device: the trip command to the input “`>BF Start 3pole`” and an additional release signal (e.g. fault detection, pickup) to the input “`>BF release`”. For Buchholz protection it is recommended that the trip command is connected to the 7SA6 by two separate wire pairs in order to achieve dual-channel initiation of the breaker failure protection.

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input “`>BF release`” must then not be assigned to any physical input of the device during configuration.

The scheme functionality is shown in Figure 6-116. When the trip signal appears from any internal or external feeder protection and at least one current flow criterion (according to Figure 6-113) is present, the breaker failure protection is initiated and the corresponding delay time(s) is (are) started.

If the current criterion is not fulfilled for any of the phases the position of the circuit breaker auxiliary contact(s) is interrogated provided that this is available. If the circuit breaker poles have individual auxiliary contacts, the series connection of the three normally closed (NC) auxiliary contacts is used. The circuit breaker has operated correctly after a three-pole trip command only when none of the phases carries current or when all three NC auxiliary contacts have closed.

Figure 6-115 illustrates how the internal signal “CB pole L1 closed” is created (see Figure 6-116 left) if at least one circuit breaker pole is closed.

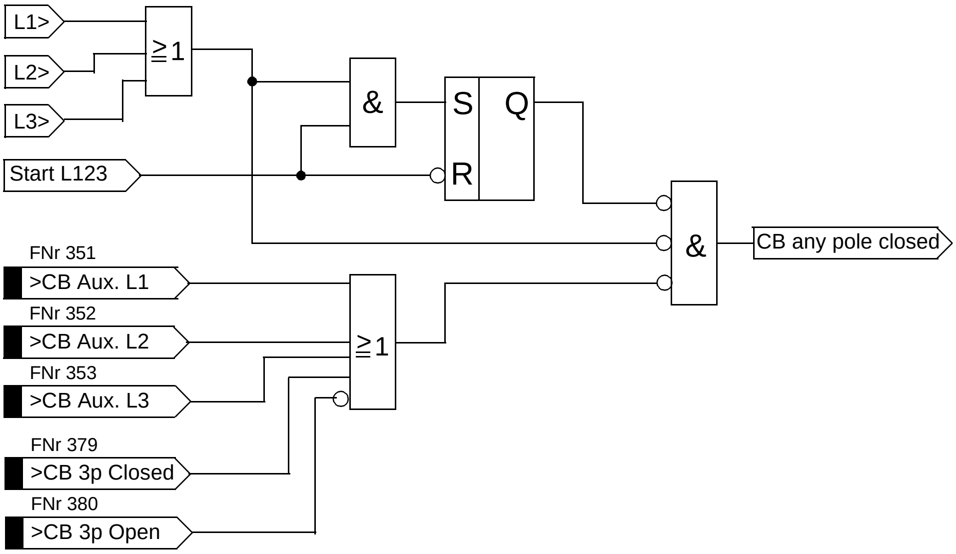


Figure 6-115 Creation process of signal “CB any pole closed”

If an internal protection function or an external protection device trips without current flow, the internal input “Start internal w/o I” or the external input “`>BF Start w/o I`” is used to initiate the breaker failure protection. In these cases the breaker auxiliary contact position is the only criterion for the response of the circuit breaker.

Initiation can be blocked via the binary input “`>BLOCK BkrFail`” (e.g. during testing of the feeder protection relay). Additionally, an internal blocking option is provided.

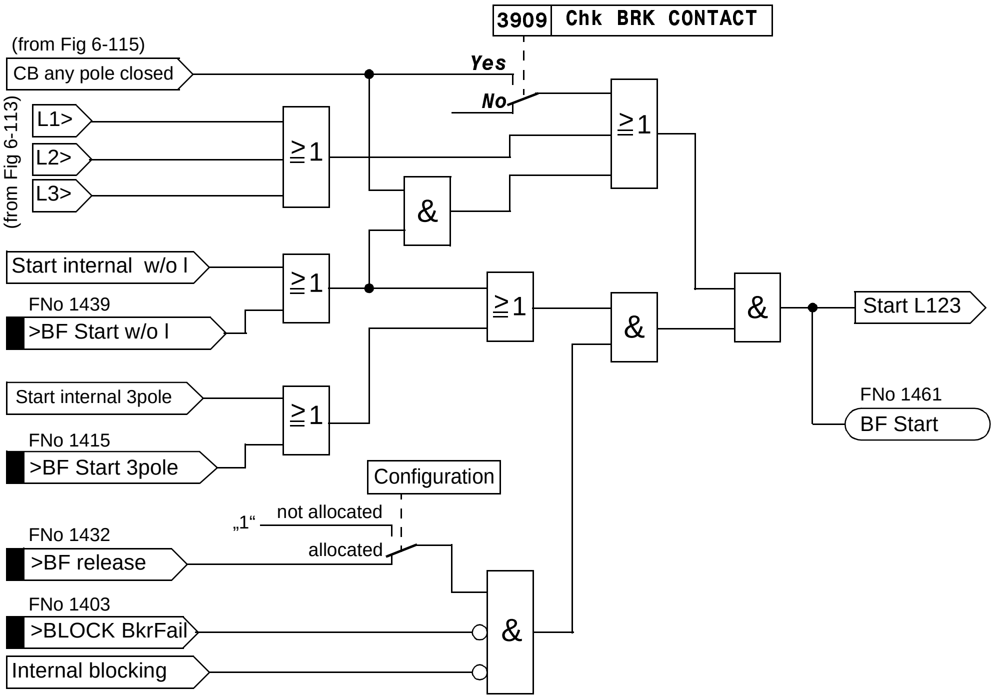


Figure 6-116 Breaker failure protection with common phase initiation

Phase Segregated Initiation

Phase segregated initiation of the breaker failure protection is necessary if the circuit breaker poles can be operated individually, e.g. if single-pole automatic reclosure is used. This is possible if the device is able to trip single-pole.

If initiation of the breaker failure protection must also be possible by further external protection devices, it is recommended, for security reasons, to connect an additional release signal (e.g. fault detection, pickup) at the input “`>BF release`”, besides the trip commands at the inputs “`>BF Start L1`”, “`>BF Start L2`”, and “`>BF Start L3`”. Figure 6-117 shows the connections of this dual-channel initiation.

Nevertheless, it is possible to initiate the breaker failure protection in single-channel mode should a separate release criterion not be available. The binary input “`>BF release`” must then not be assigned to any physical input of the device during configuration.

If the external protection device does not provide a general fault detection signal, a general trip signal can be used instead. Alternatively, the parallel connection of a separate set of trip contacts can produce such a release signal as shown in Figure 6-118.

The starting condition logic for the delay times is shown in Figure 6-119. In principle, it is designed similar to that for the common phase initiation, but, individually for each of the three phases. Thus, current flow and initiation conditions are processed for each phase. In case of single-pole interruption before an automatic reclose cycle, current disappearance is reliably monitored for the tripped breaker pole only.

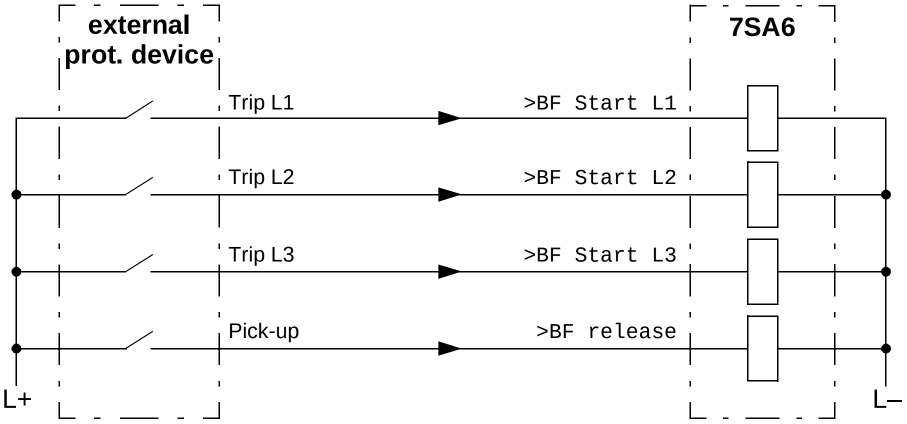


Figure 6-117 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a fault detection signal

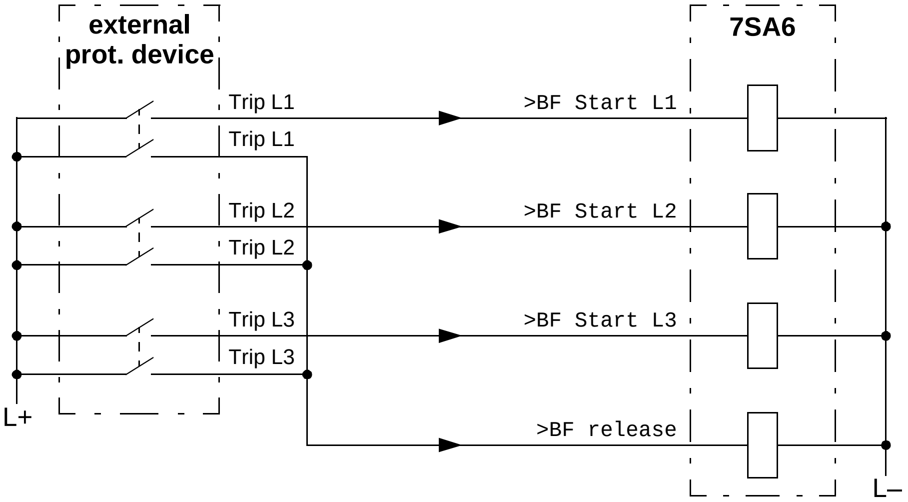


Figure 6-118 Breaker failure protection with phase segregated initiation — example for initiation by an external protection device with release by a separate set of trip contacts

Initiation of a single-phase, e.g. “Start L1 only” is valid when the starting input (= trip command of any feeder protection) appears for only this phase and current flow is detected in at least this phase. If current flow is not detected, the auxiliary contact position can be interrogated according to Figure 6-114, dependent on the setting (**`Chk BRK CONTACT`** = ***`Yes`***).

The auxiliary contact criterion is also processed for each individual breaker pole. If however the breaker auxiliary contacts are not available for each individual breaker pole, then a single-pole trip command is assumed to be executed only once the series connection of the normally open (NO) auxiliary contacts is interrupted. This information is provided to the breaker fail protection by the central function control of the device (refer to Section 6.20.2).

The three-phase starting signal “Start L123” is generated if trip signals appear in more than one pole (regardless from which protection function). Phase segregated initiation is then blocked. The input “`>BF Start w/o I`” (e.g. from Buchholz protection) operates in three-phase mode as well. The function is the same as with common phase initiation.

The additional release-signal “`>BF release`” (if assigned to a binary input) affects all starting conditions. Initiation can be blocked via the binary input “`>BLOCK BrkFail`” (e.g. during test of the feeder protection relay). Additionally, an internal blocking option is provided.

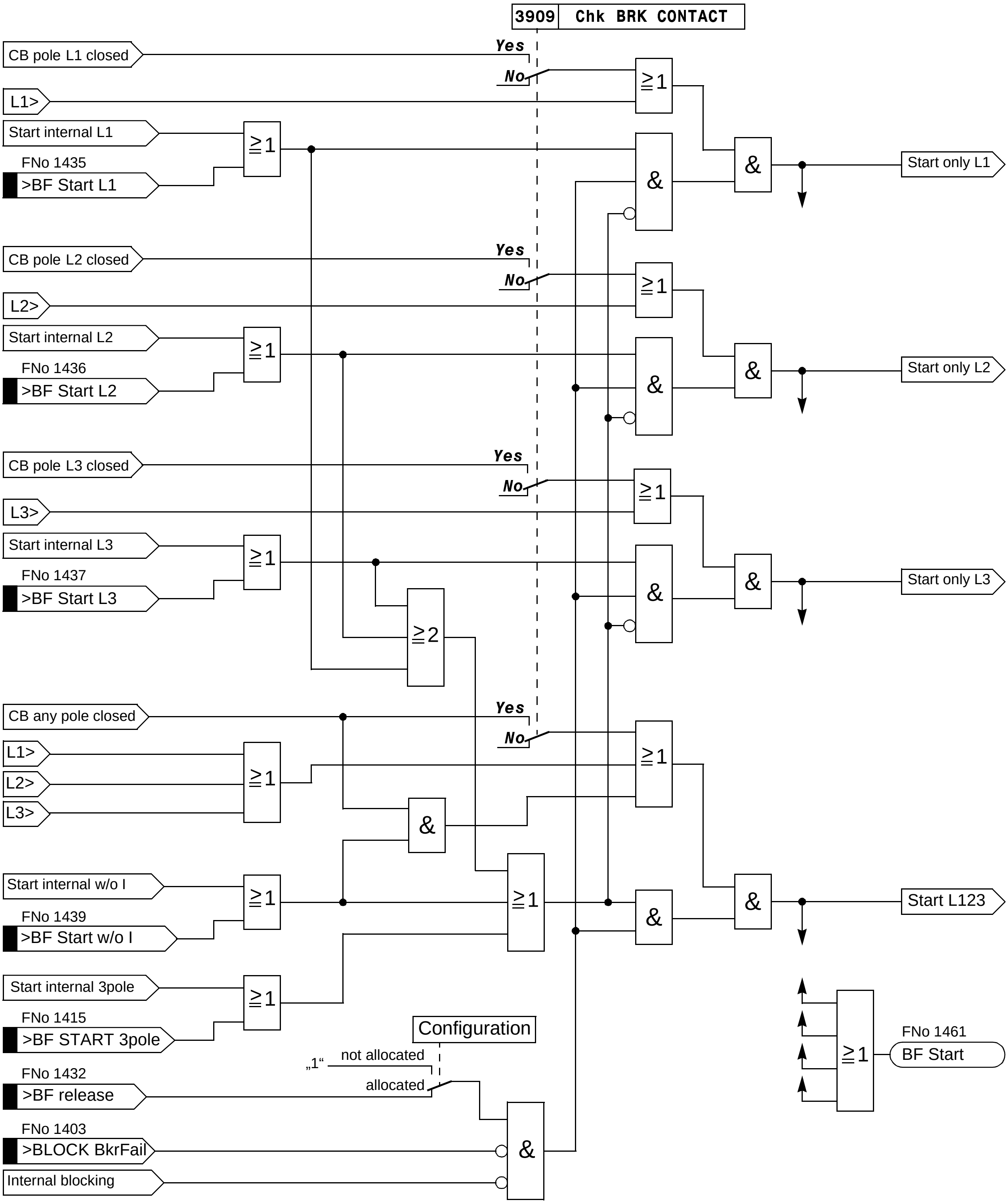


Figure 6-119 Initiation conditions with phase segregated initiation

Delay Timers

When the initiate conditions are fulfilled, the associated timers are started. The circuit breaker pole(s) must open before the associated time has elapsed.

Different delay timers are provided for operation after common phase initiation and phase segregated initiation. A third time stage can be used for two-stage breaker failure protection.

With single-stage breaker failure protection, the trip command is routed to the adjacent circuit breakers should the local feeder breaker fail (refer to Figure 6-111 or 6-112). The adjacent circuit breakers are all those which must trip in order to interrupt the fault current, i.e. the breakers which feed the bus-bar or the bus-bar section to which the feeder under consideration is connected. The possible initiation conditions for the breaker failure protection are those discussed above. Depending on the application of the feeder protection, common phase or phase segregated initiation conditions may occur. Tripping by the breaker failure protection is always three-pole.

The simplest solution is to start the delay timer **T2** (Figure 6-120). The phase-segregated initiation signals are omitted if the feeder protection always trips three-pole or if the circuit breaker is not capable of single-pole tripping.

If different delay times are required after a single-pole trip and three-pole trip by the feeder protection it is possible to use the timer stages **T1-1pole** and **T1-3pole** according to Figure 6-121.

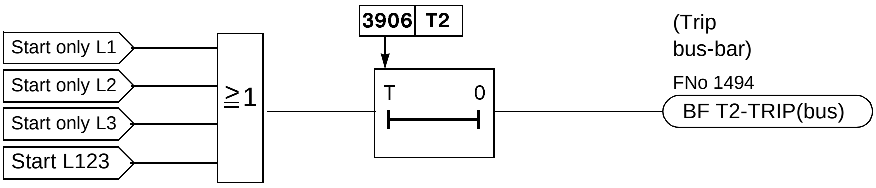


Figure 6-120 Single-stage breaker failure protection with common phase initiation

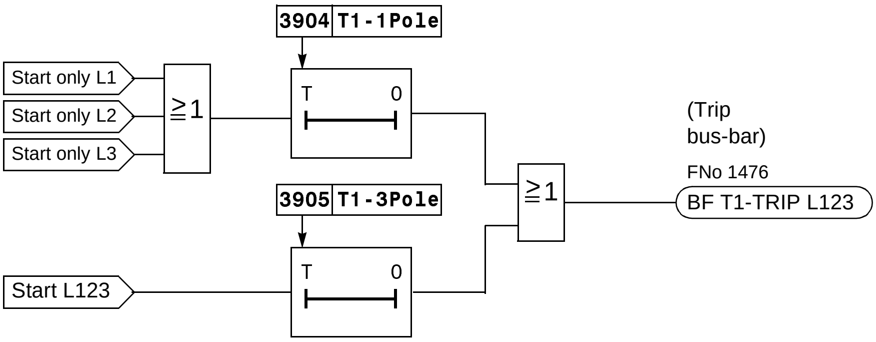


Figure 6-121 Single-stage breaker failure protection with different delay timers

With two-stage breaker failure protection, the trip command of the feeder protection is usually repeated, after a first time stage, to the feeder circuit breaker, often via a second trip coil or set of trip coils, if the breaker has not responded to the original trip command. A second time stage monitors the response to this repeated trip command and trips the breakers of the relevant bus-bar section, if the fault has not yet been cleared after this second time.

For the first time stage, different time delays can be selected for a single-pole trip and three-pole trip by the feeder protection. Additionally, you can select (parameter **1p-RETRIP (T1)**) whether this repeated trip should be single-pole or three-pole.

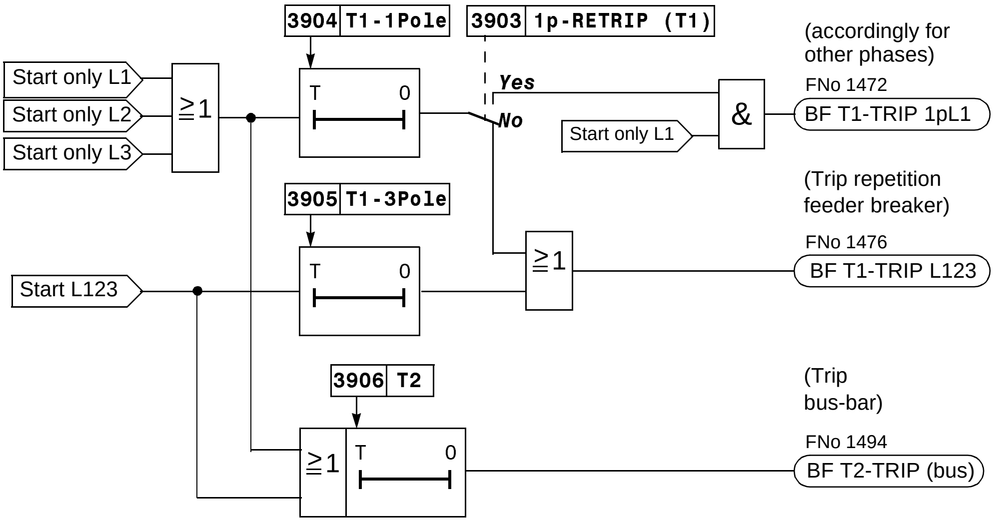


Figure 6-122 Two-stage breaker failure protection with phase segregated initiation — one phase

Circuit Breaker not Operational

There may be cases when it is immediately apparent that the circuit breaker associated with a feeder protection relay cannot clear a fault, e.g. when the tripping voltage or the tripping energy is not available.

In such a case it is not necessary to wait for the response of the feeder circuit breaker. If provision has been made for the detection of such a condition (e.g. control voltage monitor or air pressure monitor), the monitor alarm signal can be fed to the binary input “`>CB faulty`” of the 7SA6. On occurrence of this alarm and a trip command by the feeder protection, a separate timer **`T3-BkrDefective`**, which is normally set to 0, is started (Figure 6-123). Thus, the adjacent circuit breakers (bus-bar) are tripped immediately in case the feeder circuit breaker is not operational.

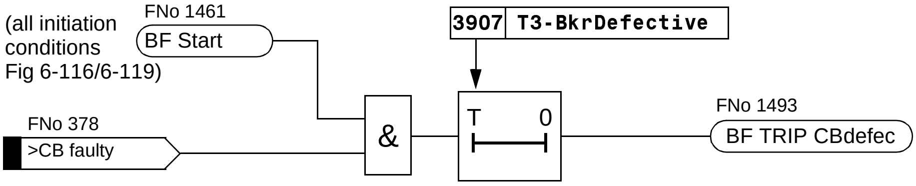


Figure 6-123 Circuit breaker not operational

Transfer Trip to the Remote End Circuit Breaker

The 7SA6 has the facility to give an additional intertrip signal to the circuit breaker at the remote line end in the event that the local feeder circuit breaker fails. For this, a suitable protection signal transmission link is required (e.g. via communication cable, power line carrier transmission, radio transmission, or optical fibre transmission).

To realise this intertrip, the desired command — usually the trip command which is intended to trip the adjacent breakers — is assigned to a binary output of the device. The contact of this output triggers the transmission device.

End Fault Protection

An end fault is defined here as a short–circuit which has occurred at the end of a line or protected object, between the circuit breaker and the current transformer set.

This situation is shown in Figure 6-124. The fault is located — as seen from the current transformers (= measurement location) — on the bus-bar side, thus, it will not be regarded by the feeder protection relay as a feeder fault. It can only be detected by either a reverse stage of the feeder protection or by a bus-bar protection. Nevertheless, a trip command given to the feeder circuit breaker cannot clear the fault since the opposite end(s) continue(s) to feed the fault. Thus, the fault current does not stop flowing even though the feeder circuit breaker has properly responded to the trip command.

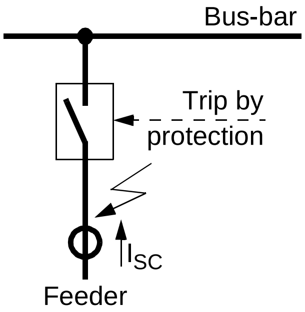


Figure 6-124 End fault between circuit breaker and current transformers

The end fault protection has the task to recognize this situation and to transmit a trip signal to the remote end(s) of the protected object to clear the fault. For this purpose, the output command "`BF EndFlt TRIP`" is available to trigger a signal transmission device (e.g. power line carrier, radio wave, or optical fibre) — if applicable, together with other commands that need to be transferred.

The end fault is recognized when the current continues flowing although the circuit breaker auxiliary contacts indicate that the breaker is open. In the 7SA6, an additional criterion is the presence of any breaker failure protection initiate signal. The scheme functionality is shown in Figure 6-125. If the breaker failure protection is initiated and current flow is recognized (current criteria "L∗>" according Figure 6-113), but no circuit breaker pole is closed (auxiliary contact criterion "CB any pole closed"), then a timer **`T-EndFault`** is started, after which an intertrip signal is transmitted to the opposite end(s) of the protected object.

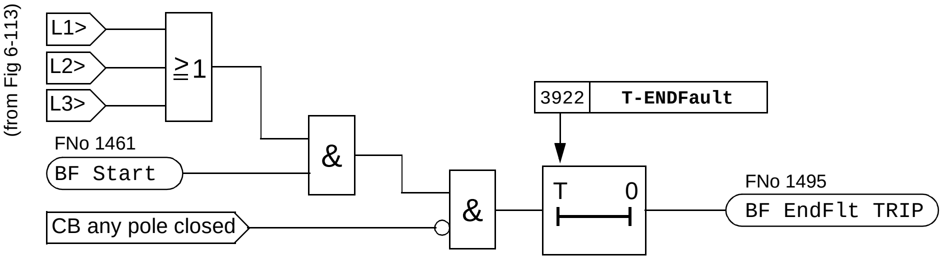


Figure 6-125 Function block diagram of end fault protection

Circuit Breaker Pole Discrepancy Supervision

The pole discrepancy supervision has the task to detect discrepancies in the position of the three circuit breaker poles. Under steady-state conditions, either all three poles of the breaker must be closed, or all three poles must be open. Discrepancy is permitted only for a short time interval during a single-pole automatic reclose cycle.

The scheme functionality is shown in Figure 6-126. The signals which are processed here are the same as those used for the breaker failure protection. The pole discrepancy condition is established when at least one pole is closed (“CB any pole closed”) and at the same time not all poles are closed (“CB any pole open”).

Additionally, the current criteria (from Figure 6-113) are processed. Pole discrepancy can only be detected when current is not flowing through all three poles (<3), i.e. through only one or two poles. When current is flowing through all three poles, all three poles must be closed even if the breaker auxiliary contacts indicate a different status.

If pole discrepancy is detected, this is annunciated by a fault detection signal. This signal identifies the pole which was open before the trip command of the pole discrepancy supervision occurred.

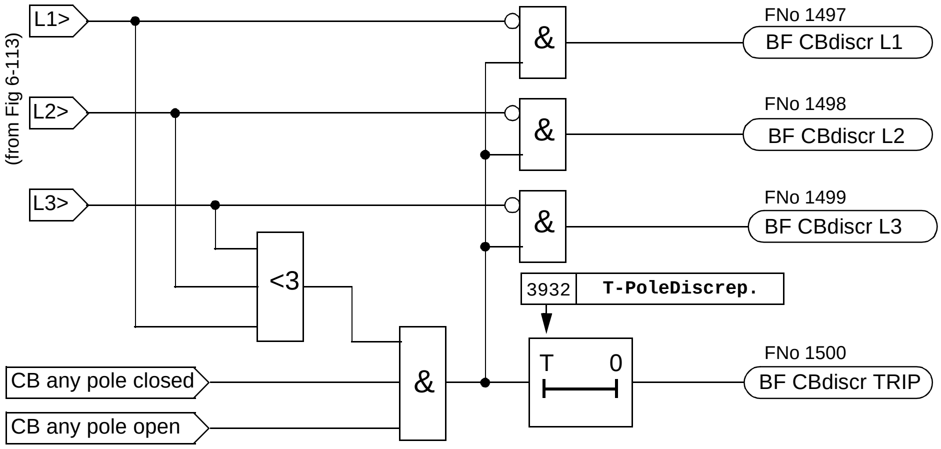


Figure 6-126 Function block diagram of pole discrepancy supervision

6.16.2 Applying the Function Parameter Settings

General

The breaker failure protection and its ancillary functions (end fault protection, pole discrepancy supervision) can only operate if they were configured as ***`enabled`*** during setting of the scope of functions (see Section 5.1, address **`0139`**).

Breaker Failure Protection

The complete breaker failure protection including its ancillary functions is switched ***Off*** or ***On*** under address **`3901 FCT BreakerFail`**.

The current threshold **`I> BF`** (address **`3902`**) should be selected such that the protection will operate with the smallest expected short-circuit current. To ensure this, the value should be 10 % less than the minimum anticipated fault current. On the other hand, the value should not be set lower than necessary.

Normally, the breaker failure protection evaluates the current flow criterion as well as the position of the breaker auxiliary contact(s). If the auxiliary contact(s) status is not available in the device, this criterion cannot be processed. In this case, set address **3909 Chk BRK CONTACT** to ***No***.

The breaker failure protection in the 7SA6 can be operated single-stage or two-stage:

Two-stage Breaker Failure Protection

With two-stage operation, the trip command is repeated after a time delay T1 to the local feeder breaker, normally to a different set of trip coils of this breaker. A choice can be made whether this trip repetition shall be single-pole or three-pole if the initial feeder protection trip was single-pole (provided single-pole trip is possible). This choice is made in address **3903 1p-RETRIP (T1)**. Set this parameter to ***Yes*** if you wish single-pole trip for the first stage, otherwise to ***No***.

If the breaker does not respond to this first stage trip, the adjacent circuit breakers must be tripped provided the fault has not yet been cleared. The adjacent breakers are those of the other feeders on the bus-bar or bus-bar section and — if signal transmission is possible — the breaker at the remote end(s) of the protected object.

In the 7SA6, after a further delay time **T2** (address **3906**), the adjacent circuit breakers (i.e. the breakers of the bus-bar zone and — if signal transmission is possible — the breaker at the remote end) are tripped provided the fault has not yet been cleared. An example of the time sequence is illustrated in Figure 6-127.

Separate delay times can be set:

- for single- or three-pole trip repetition to the local feeder circuit breaker after **1**-pole trip of the feeder protection under address **3904 T1-1pole**,
- for three-pole trip repetition to the local feeder circuit breaker after **3**-pole trip of the feeder protection under address **3905 T1-3pole**,
- for trip of the adjacent circuit breakers (bus-bar zone and remote end if applicable) under address **3906 T2**.

The delay times are set dependant on the maximum operating time of the feeder circuit breaker and the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 6-127. For sinusoidal currents one can assume that the reset time of the current detectors is less than 12 ms but if current transformer saturation is expected then 25 ms should be assumed.

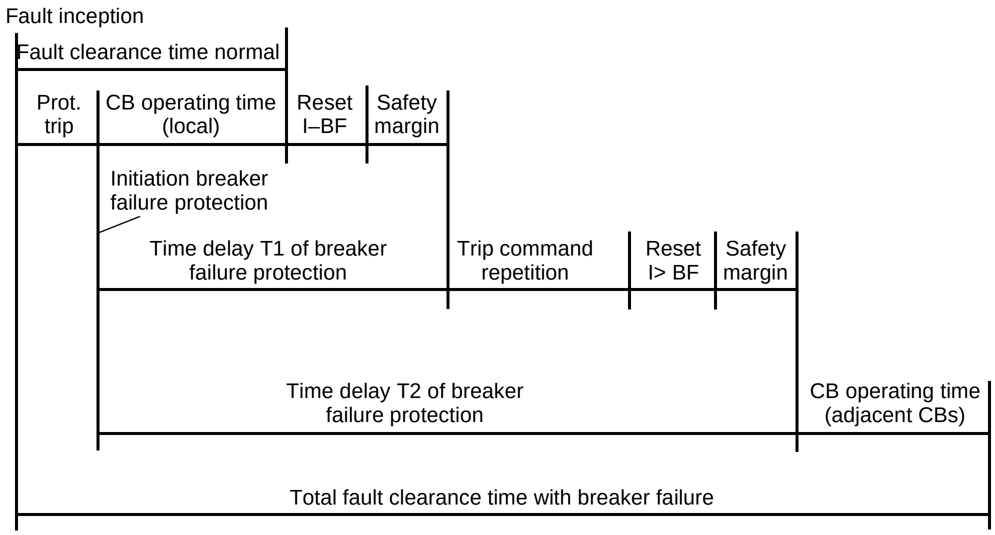


Figure 6-127 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using two-stage breaker failure protection

Single-stage Breaker Failure Protection

With single-stage operation, the adjacent circuit breakers (i.e. the breakers of the bus-bar zone and — if transmission of the signal is possible — the breaker at the remote end) are tripped after a delay time **T2** (address **3906**) following initiation, should the fault not have been cleared within this time.

The timers **`T1-1pole`** (address **3904**) and **`T1-3pole`** (address **3905**) are then set to ∞ since they are not needed.

But you may use the T1-timers for single-stage protection if you wish to utilize the facility of setting different delay times after single-pole trip and three-pole trip of the feeder protection. In this case, set the desired times under addresses **3904 `T1-1pole`** and **3905 `T1-3pole`** but set address **3903 `1p-RETRIP (T1)`** to ***No*** to avoid a single-pole trip to the bus-bar. And set **T2** (address **3906**) to ∞ or equal to **`T1-3pole`**. Be sure that the correct trip commands are assigned to the desired trip relay(s).

The delay times are determined from the maximum operating time of the feeder circuit breaker, the reset time of the current detectors of the breaker failure protection, plus a safety margin which allows for any tolerance of the delay timers. The time sequence is illustrated in Figure 6-128. For sinusoidal currents one can assume that the reset time of the current detectors is less than 12 ms but if current transformer saturation is expected then 25 ms should be assumed.

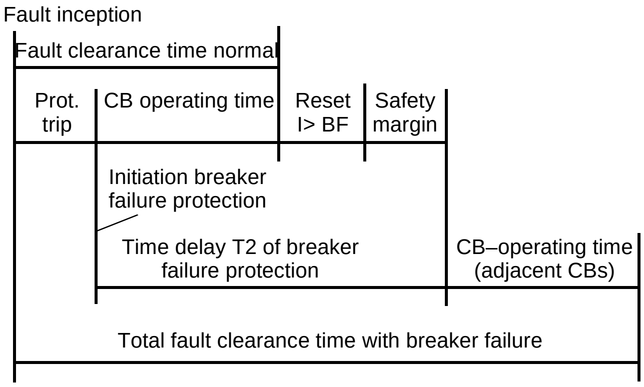


Figure 6-128 Time sequence example for normal clearance of a fault, and with circuit breaker failure, using single-stage breaker failure protection

Circuit Breaker not Operational

If the circuit breaker associated with the feeder is not operational (e.g. control voltage failure or air pressure failure), it is apparent that the local breaker cannot clear the fault. Time delay before tripping the adjacent breakers is not necessary in this case. If the relay is informed about this disturbance (via the binary input “`>CB faulty`”, the adjacent circuit breakers (bus-bar and remote end if applicable) are tripped after the time **`T3-BkrDefective`** (address **3907**) which is usually set to ***`0`***.

Address **3908** **`Trip BkrDefect.`** determines to which output the trip command is routed in the event that the breaker is not operational when a feeder protection trip occurs. Select that output which is used to trip the adjacent breakers (bus-bar trip).

End Fault Protection

The end fault protection can be switched ***`On`*** or ***`Off`*** separately under address **3921** **`End Flt. stage`**. An end fault is a short-circuit between the circuit breaker and the current transformer set of the feeder. The end fault protection presumes that the device is informed about the circuit breaker position via breaker auxiliary contacts connected to binary inputs.

If, during an end fault, the circuit breaker is tripped by a reverse fault stage of the feeder protection or by the bus-bar protection (the fault is a bus-bar fault as determined from the location of the current transformers), the fault current will continue to flow, because the fault is fed from the remote end of the feeder circuit.

The time **`T-EndFault`** (address **3922**) is started when, during the fault detection condition of the feeder protection, the circuit breaker auxiliary contacts indicate open poles and, at the same time, current flow is detected (address **3902**). The trip command of the end fault protection is intended for the transmission of an intertrip signal to the remote end circuit breaker.

Thus, the delay time must be set such that it can bridge out short transient apparent end fault conditions which may occur during switching of the breaker.

Pole Discrepancy Supervision

The pole discrepancy supervision can be switched ***`On`*** or ***`Off`*** separately under address **3931** **`PoleDiscrepancy`**. It is only useful if the breaker poles can be operated individually. It avoids that only one or two poles of the local breaker are open continuously. It has to be provided that either the auxiliary contacts of each pole or the series connection and the parallel connection of the auxiliary contacts are connected to the device’s binary inputs. If these conditions are not fulfilled, switch the pole discrepancy supervision ***`Off`***.

The delay time **`T-PoleDiscrep.`** (address **3932**) determines how long a breaker pole discrepancy condition of the feeder circuit breaker, i.e. only one or two poles open, may be present before the pole discrepancy supervision issues a three-pole trip command. This time must clearly be longer than the duration of a single-pole automatic reclose cycle. The time should be less than the permissible duration of an unbalanced load condition which is caused by the unsymmetrical position of the circuit breaker poles. Conventional values are 2 s to 5 s.

6.16.3 Settings

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
3901	FCT BreakerFail	ON OFF	ON	Breaker Failure Protection is
3902	I> BF	0.05..20.00 A	0.10 A	Pick-up threshold I>
3903	1p-RETRIP (T1)	NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole	0.00..30.00 sec; Ø; ∞	0.00 sec	T1, Delay after 1pole start (local trip)
3905	T1-3pole	0.00..30.00 sec; Ø; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2	0.00..30.00 sec; Ø; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective	0.00..30.00 sec; Ø; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.	NO trips with T1-trip-signal trips with T2-trip-signal trips with T1 and T2-trip-signal	NO	Trip output selection with defective bkr
3909	Chk BRK CONTACT	NO YES	YES	Check Breaker contacts
3921	End Flt. stage	ON OFF	OFF	End fault stage is
3922	T-EndFault	0.00..30.00 sec; Ø; ∞	2.00 sec	Trip delay of end fault stage
3931	PoleDiscrepancy	ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.	0.00..30.00 sec; Ø; ∞	2.00 sec	Trip delay with pole discrepancy

6.16.4 Information Overview

F.No.	Alarm	Comments
1401	>BF on	>BF: Switch on breaker fail protection
1402	>BF off	>BF: Switch off breaker fail protection
1403	>BLOCK BkrFail	>BLOCK Breaker failure
1432	>BF release	>BF: External release
1439	>BF Start w/o I	>BF: External start 3pole (w/o current)
1415	>BF Start 3pole	>BF: External start 3pole
1435	>BF Start L1	>BF: External start L1
1436	>BF Start L2	>BF: External start L2
1437	>BF Start L3	>BF: External start L3
1440	BkrFailON/offBI	Breaker failure prot. ON/OFF via BI
1451	BkrFail OFF	Breaker failure is switched OFF
1452	BkrFail BLOCK	Breaker failure is BLOCKED
1453	BkrFail ACTIVE	Breaker failure is ACTIVE
1461	BF Start	Breaker failure protection started
1493	BF TRIP CBdefec	BF Trip in case of defective CB
1472	BF T1-TRIP 1pL1	BF Trip T1 (local trip) - only phase L1
1473	BF T1-TRIP 1pL2	BF Trip T1 (local trip) - only phase L2
1474	BF T1-TRIP 1pL3	BF Trip T1 (local trip) - only phase L3
1476	BF T1-TRIP L123	BF Trip T1 (local trip) - 3pole
1494	BF T2-TRIP(bus)	BF Trip T2 (busbar trip)
1495	BF EndFlt TRIP	BF Trip End fault stage
1496	BF CBdiscrSTART	BF Pole discrepancy pickup
1497	BF CBdiscr L1	BF Pole discrepancy pickup L1
1498	BF CBdiscr L2	BF Pole discrepancy pickup L2
1499	BF CBdiscr L3	BF Pole discrepancy pickup L3
1500	BF CBdiscr TRIP	BF Pole discrepancy Trip

6.17 Thermal Overload Protection

6.17.1 Method of Operation

The thermal overload protection prevents damage to the protected object caused by thermal overloading, particularly in case of transformers, rotating machines, power reactors and cables. It is in general not necessary for overhead lines, since no meaningful overtemperature can be calculated because of the great variations in the environmental conditions (temperature, wind). In this case, however, a current-dependent alarm stage can signal an imminent overload.

The unit computes the overtemperature according to a thermal single-body model as per the following thermal differential equation

$$\frac{d\Theta}{dt} + \frac{1}{\tau_{th}} \cdot \Theta = \frac{1}{\tau_{th}} \cdot \left(\frac{I}{k \cdot I_N}\right)^2$$

with Θ – instantaneous overtemperature referred to the final temperature rise for the maximum permissible line current $k \cdot I_N$

τ_{th} – thermal time constant for heating

k – k-factor which states the maximum permissible continuous current referred to the rated current of the current transformers

I – currently measured r.m.s. current

I_N – rated current of current transformers

The solution of this equation under steady-state conditions is an e-function whose asymptote shows the final overtemperature Θ_{end}. When the overtemperature reaches the first settable temperature threshold Θ_{alarm}, which is below the final overtemperature, a warning alarm is given in order to allow a timely load reduction. When the second temperature threshold, i.e. the final overtemperature or tripping temperature, is reached, the protected object is disconnected from the network. The overload protection can, however, also be set on ***`Alarm Only`***. In this case only an alarm is output when the final overtemperature is reached.

The overtemperature is calculated separately for each phase with a thermal replica from the square of the associated phase current. This guarantees a true r.m.s. value measurement and also includes the influence of harmonic content. A choice can be made whether the maximum calculated overtemperature of the three phases, the average overtemperature, or the overtemperature calculated from the phase with maximum current should be decisive for evaluation of the thresholds.

The maximum permissible continuous thermal overload current I_{max} is described as a multiple of the rated current I_N:

$$I_{max} = k \cdot I_N$$

In addition to the k-factor, the time constant τ_{th} as well as the alarm temperature Θ_{alarm} must be entered in the protection.

Apart from the thermal alarm stage, the overload protection also includes a current overload alarm stage I_{alarm}, which can output an early warning that an overload current is present, even if the overtemperature has not yet reached the alarm or trip overtemperature values.

The overload protection can be blocked via a binary input. In doing so, the thermal images are also reset to zero.

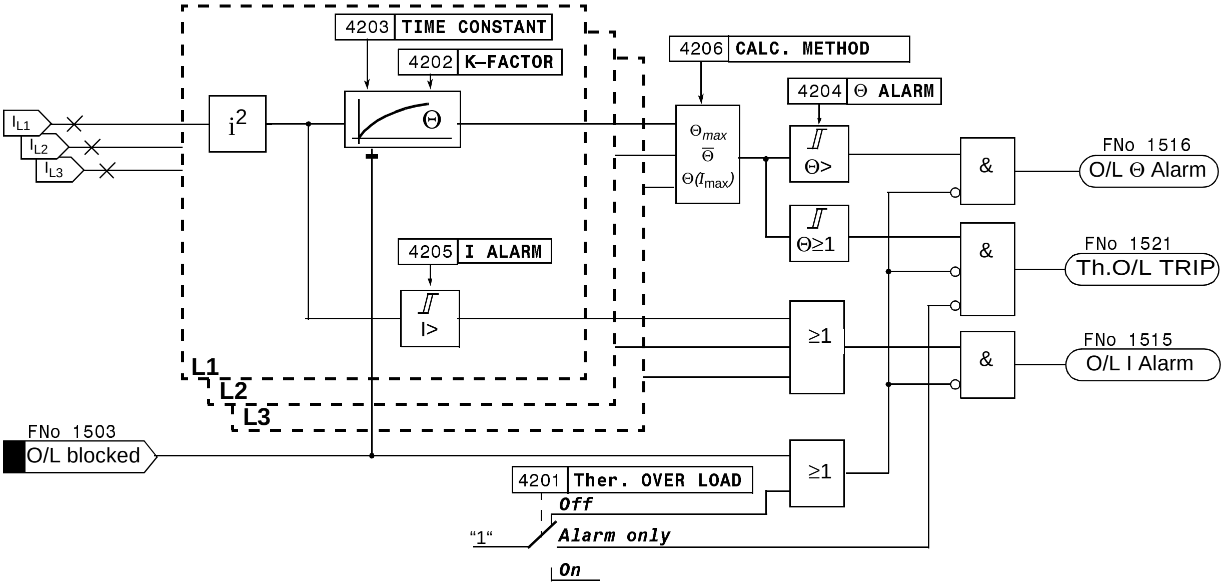


Figure 6-129 Logic diagram of the thermal overload protection

6.17.2 Applying the Function Parameter Settings

General Information

A precondition for the use of the thermal overload protection is that **`Overload`** = ***`Enabled`*** was configured under address 0142 (Section 5.1). It can be switched ***`On`*** or ***`Off`*** under address 4201 **`Ther. OVERLOAD`**. Furthermore ***`Alarm Only`*** can be set. With that latter setting the protection function is active but only outputs an alarm when the tripping temperature is reached, i.e. the output function "`Th.O/L TRIP`" is not active.

k–factor

The rated current of the device is taken as the base current for detecting an overload. The setting factor k is set under address 4202 **`K-FACTOR`**. It is determined by the relation between the permissible thermal continuous current and this rated current:

$$k = \frac{I_{max}}{I_N}$$

The permissible continuous current is at the same time the current at which the e-function of the overtemperature has its asymptote. It is not necessary to determine the tripping temperature since it results automatically from the final rise temperature at $k \cdot I_N$. Manufacturers of electrical machines usually state the permissible continuous current. If no data are available, k is set to 1.1 times the rated current of the protected object. For cables, the permissible continuous current depends on the cross section, the insulation material, the design and the way they are laid, and can be derived from the relevant tables.

Please note that the overload capability of electrical equipment relates to its primary current. This has to be considered if the primary current differs from the rated current of the current transformers.

Example:

Belted cable 10 kV 150 mm^2
Permissible continuous current I_{max} = 322 A

Current transformer 400 A/5 A

$$k = \frac{322\ A}{400\ A} = 0.805$$

Setting value **K-FACTOR** = ***0.80***

Time Constant τ

The thermal time constant τ_{th} is set under the address 4203 **TIME CONSTANT**. This is also provided by the manufacturer. Please note that the time constant must be set in minutes. Quite often other values for determining the time constant are stated which can be converted into the time constant as follows:

- 1–s current

$$\frac{\tau_{th}}{min} = \frac{1}{60} \cdot \left(\frac{perm.\ 1\text{-}s\ current}{perm.\ contin.\ current}\right)^2$$

- permissible current for application time other than 1 s, e.g. for 0.5 s

$$\frac{\tau_{th}}{min} = \frac{0.5}{60} \cdot \left(\frac{perm.\ 0.5\text{–}s\ current}{perm.\ contin.\ current}\right)^2$$

- t_6–time; this is the time in seconds for which a current of 6 times the rated current of the protected object may flow

$$\frac{\tau_{th}}{min} = 0.6 \cdot t_6$$

Example:

Cable as above with
permissible 1–s current 13.5 kA

$$\frac{\tau_{th}}{min} = \frac{1}{60} \cdot \left(\frac{13500\ A}{322\ A}\right)^2 = \frac{1}{60} \cdot 42^2 = 29,4$$

Setting value **TIME CONSTANT** = ***29.4*** min

Alarm Stages

By setting a thermal alarm stage Θ **ALARM** (address 4204) an alarm can be output before the tripping temperature is reached, so that a trip can be avoided by early load reduction or by switching over. The percentage is referred to the tripping temperature.

The current overload alarm setpoint **I ALARM** (address 4205) is stated as a factor of the rated device current and should be set equal to or slightly below the permissible continuous current $k \cdot I_N$. It can also be used instead of the thermal alarm stage. In this case the thermal alarm stage is set to 100 % and thus practically ineffective.

Calculating the Overtemperature

The thermal replica is calculated individually for each phase. Address 4406 **CALC. METHOD** decides whether the highest of the three calculated temperatures (Θ ***max***) or their arithmetic average (***Average*** Θ) or the temperature calculated from the phase with maximum current (Θ ***@ Imax***) should be decisive for the thermal alarm and tripping stage.

Since an overload usually occurs in a balanced way, this setting is of minor importance. If unbalanced overloads are to be expected, however, these options lead to different results.

Averaging should only be used if a rapid thermal equilibrium is possible in the protected object, e.g. with belted cables. If the three phases are, however, more or less thermally isolated (e.g. single conductor cables or overhead lines), one of the maximum settings should be chosen at any rate.

6.17.3 Settings

Note: The indicated secondary current for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
4201	Ther. OVERLOAD	OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR	0.10..4.00	1.10	K-Factor
4203	TIME CONSTANT	1.0..999.9 min	100.0 min	Time constant
4204	Θ ALARM	50..100 %	90 %	Thermal Alarm Stage
4205	I ALARM	0.10..4.00 A	1.00 A	Current Overload Alarm setpoint
4206	CALC. METHOD	Theta Max Average Theta Theta from Imax	Theta Max	Method of Acquiring Temperature

6.17.4 Information Overview

F.No.	Alarm	Comments
1503	>BLK ThOverload	>BLOCK Thermal Overload Protection
1511	Th.Overload OFF	Thermal Overload Protection OFF
1512	Th.Overload BLK	Thermal Overload Protection BLOCKED
1513	Th.O/L ACTIVE	Thermal Overload Protection ACTIVE
1515	Th.O/L I Alarm	Th. Overload: Current Alarm (I alarm)
1516	Th.O/L Θ Alarm	Th. Overload Alarm: Near Thermal Trip
1517	Th.O/L Pickup	Th. Overload Pickup before trip
1521	Th.O/L TRIP	Th. Overload TRIP command

6.18 Analog Outputs

6.18.1 Method of Operation

Depending on the ordering version the 7SA6 relay up to four analog outputs are available. During the configuration of the functional scope (see Figure 5.1) it was determined which values may be transmitted via these interfaces. Up to four outputs can be selected out of the following list:

- Measured value I_{L2} (current of phase L2) in per cent of the operational nominal current
- Measured value U_{L2-L3} (phase-to-phase voltage L2-L3) in per cent of the operational nominal voltage
- Measured value |P| (value of active power) in per cent of the operational nominal power $\sqrt{3} \cdot U_N \cdot I_N$
- Measured value |Q| (value of reactive power) in per cent of the operational nominal apparent power $\sqrt{3} \cdot U_N \cdot I_N$
- Fault distance d in per cent of line length on the basis of the configured reactance per unit length and the line length (Address 1110 to 1113, see also Subsection 6.1.3)
- Fault distance d in kilometres or miles, depending on the configured length unit (Address 0236, see also Subsection 6.1.1), on the basis of the configured reactance per unit length (Address 1110 or 1112, see also Subsection 6.1.3)
- Fault current I_{max}, i. e. the maximum of 3 phase currents during clearance of the last fault, primary in Ampere, on the basis of the configured primary and secondary nominal current (Address 0205 and 0206, see also Subsection 6.1.1)

The operational nominal values are the nominal values configured according to Address 1103 and 1104 (see also Subsection 6.1.3).

The analog values are output as current source. The nominal range of the analog outputs is 0 mA to 20 mA, the operating range may reach up to 22.5 mA. The conversion factor and the valid range can be set.

6.18.2 Applying the Function Parameter Settings

Measure Values

Once the measured values are selected (Section 5.1, Addresses 0150 to 0153), set the conversion factor and the valid range for the available outputs, as follows:

for analog output 1 at mounting location “B” (Port B1):
Address 5001 **`20 mA (B1)`** = value in % to be indicated at 20 mA
Address 5006 **`MIN VALUE (B1)`** the minimum value permitted

for analog output 2 at mounting location “B” (Port B2):
Address 5011 **`20 mA (B2)`** = value in % to be indicated at 20 mA
Address 5016 **`MIN VALUE (B2)`** the minimum value permitted

for analog output 1 at mounting location “D” (Port D1):
Address 5021 **20 mA (D1)** = value in % to be indicated at 20 mA
Address 5026 **MIN VALUE (D1)** the minimum value permitted

for analog output 2 at mounting location “D” (Port D2):
Address 5031 **20 mA (D2)** = value in % to be indicated at 20 mA
Address 5036 **MIN VALUE (D2)** the minimum value permitted

The maximum value is 22.0 mA. If it is exceeded (value outside of the maximum permissible range), then a value of 22.5 mA is output.

Example:

The phase current I_{L2} is output as analog output 1 at mounting location “B”. The operational nominal current should correspond to 10 mA output, which means that 20 mA correspond to a rate of 200 %. Values below 4 mA are not valid.

Settings:
Address 5001 **20 mA (B1)** = ***200*** %,
Address 5006 **MIN VALUE (B1)** = ***4*** mA.

Fault Location

For the fault location the conversion factor, i. e. the value to be output, is also set to 20 mA. Dependening on whether the fault location should be output in per cent of the line length or in length unit, set the following:

For analog output 1 at mounting location “B” (Port B1):
Address 5001 **20 mA (B1)** = value in % to be indicated at 20 mA
or
Address 5003 or 5004 **20 mA (B1)** = value in kilometres or miles that is to be indicated at 20 mA.

For analog output 2 at mounting location “B” (Port B2):
Address 5011 **20 mA (B2)** = value in % to be indicated at 20 mA
or
Address 5013 or 5014 **20 mA (B2)** = value in kilometres or miles that is required to be indicated at 20 mA.

For analog output 1 at mounting location “D” (Port D1):
Address 5021 **20 mA (D1)** = value in % to be indicated at 20 mA
or
Address 5023 or 5024 **20 mA (D1)** = value in kilometres or miles that is required to be indicated at 20 mA.

For analog output 2 at mounting location “D” (Port D2):
Address 5031 **20 mA (D2)** = the value in % that is required to be indicated at 20 mA
or
Address 5033 or 5034 **20 mA (D2)** = value in kilometres or miles to be indicated at 20 mA.

Set in Addresses 5007 **NEG VALUE (B1)**, 5017 **NEG VALUE (B2)**, 5027 **NEG VALUE (D1)** or 5037 **NEG VALUE (D2)** which output value is to be indicated in case the fault location is negative (fault in reverse direction). In addresses 5008 **OVERFLOW (B1)**, 5018 **OVERFLOW (B2)**, 5028 **OVERFLOW (D1)** or 5038 **OVERFLOW (D2)** the value of the numerical overflow (fault outside the maximum permissible range) is set.

The values for the negative fault location and the overflow must be set as large as possible since the linear transmission range of the fault location values ends 0.5 mA below the smallest of these values.

Set in Addresses 5009 **Tmax OUTPUT(B1)**, 5019 **Tmax OUTPUT(B2)**, 5029 **Tmax OUTPUT(D1)** or 5039 **Tmax OUTPUT(D2)** for how long the valid fault location is to be delayed. If a new fault occurs, the fault location is updated. Having set the value to ∞ the transmission of the last fault location will not be interrupted until a further one is calculated.

Example:

The fault location must be output in kilometers at mounting location “B” via the analog output 2. At a value of 20 mA the device must indicate 50 km. For a fault in reverse direction a value of 19.84 mA should be indicated, in the event of overflow a value of 22.5 mA. The value must be output for a time period of 5 s provided that no fault occurs in the meantime.

Settings:
Address 5013 **20 mA (B2) =** ***50*** km,
Address 5017 **NEG VALUE (B2)** = ***19.84*** mA,
Address 5018 **OVERFLOW (B2)** = ***22.50*** mA,
Address 5019 **Tmax OUTPUT(B2)** = ***5.00*** s.

In this case the fault location values can be output up to 19.84 mA – 0.5 mA = 19.34 mA. Theoretically, this corresponds to a value of 48.35 km.

Maximum Fault Current

Set the conversion factor and the maximum output time for the maximum fault current:

For Analog output 1 at mounting location “B” (Port B1):
Address 5002 **20 mA (B1) =** value in Amps to be indicated at 20 mA
Address 5009 **Tmax OUTPUT(B1)** = maximum output time of the value.

For Analog output 2 at mounting location “B” (Port B2):
Address 5012 **20 mA (B2) =** value in Amps to be indicated at 20 mA
Address 5019 **Tmax OUTPUT(B2)** = maximum output time of the value;

for Analog output 1 at mounting location “D” (Port D1):
Address 5022 **20 mA (D1) =** value in Amps to be indicated at 20 mA
Address 5029 **Tmax OUTPUT(D1)** = maximum output time of the value;

for Analog output 2 at mounting location “D” (Port D2):
Address 5032 **20 mA (D2) =** value in Amps to be indicated at 20 mA
Address 5039 **Tmax OUTPUT(D2)** = maximum output time of the value;

If the maximum output time value is set to ∞, the transmission of the last fault current will not be interrupted until a further one is calculated.

The maximum value is 22.0 mA. In case there is an overflow (value is outside of the maximal permissible threshold), then 22.5 mA is output.

Example:

The fault current must be output in mounting location “D” via analog output 2. 20 mA corresponds to a value of 20000 A. The value must be output for a time period of 5 s provided that no fault occurs in the meantime.

Settings:
Address 5032 **`20 mA (D2) =`** ***`20000`*** A,
Address 5039 **`Tmax OUTPUT(D2)`** = ***`5.00`*** s.

6.18.3 Settings

Addr.	Setting Title	Setting Options	Default Setting	Comments
5001	20 mA (B1) =	10.0..1000.0 %	200.0 %	20 mA (B1) correspond to
5002	20 mA (B1) =	10..100000 A	20000 A	20 mA (B1) correspond to
5003	20 mA (B1) =	1.0..1000.0 km	50.0 km	20 mA (B1) correspond to
5004	20 mA (B1) =	1.0..1000.0 Miles	50.0 Miles	20 mA (B1) correspond to
5006	MIN VALUE (B1)	0.0..5.0 mA; Ø	4.0 mA	Output value (B1) valid from
5007	NEG VALUE (B1)	19.00..22.50 mA	19.84 mA	Output value (B1) for negative values
5008	OVERFLOW (B1)	19.00..22.50 mA	22.50 mA	Output value (B1) for overflow
5009	Tmax OUTPUT(B1)	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (B1)
5011	20 mA (B2) =	10.0..1000.0 %	200.0 %	20 mA (B2) correspond to
5012	20 mA (B2) =	10..100000 A	20000 A	20 mA (B2) correspond to
5013	20 mA (B2) =	1.0..1000.0 km	50.0 km	20 mA (B2) correspond to
5014	20 mA (B2) =	1.0..1000.0 Miles	50.0 Miles	20 mA (B2) correspond to
5016	MIN VALUE (B2)	0.0..5.0 mA; Ø	4.0 mA	Output value (B2) valid from
5017	NEG VALUE (B2)	19.00..22.50 mA	19.84 mA	Output value (B2) for negative values
5018	OVERFLOW (B2)	19.00..22.50 mA	22.50 mA	Output value (B2) for overflow
5019	Tmax OUTPUT(B2)	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (B2)
5021	20 mA (D1) =	10.0..1000.0 %	200.0 %	20 mA (D1) correspond to
5022	20 mA (D1) =	10..100000 A	20000 A	20 mA (D1) correspond to
5023	20 mA (D1) =	1.0..1000.0 km	50.0 km	20 mA (D1) correspond to
5024	20 mA (D1) =	1.0..1000.0 Miles	50.0 Miles	20 mA (D1) correspond to
5026	MIN VALUE (D1)	0.0..5.0 mA; Ø	4.0 mA	Output value (D1) valid from
5027	NEG VALUE (D1)	19.00..22.50 mA	19.84 mA	Output value (D1) for negative values
5028	OVERFLOW (D1)	19.00..22.50 mA	22.50 mA	Output value (D1) for overflow
5029	Tmax OUTPUT(D1)	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (D1)
5031	20 mA (D2) =	10.0..1000.0 %	200.0 %	20 mA (D2) correspond to
5032	20 mA (D2) =	10..100000 A	20000 A	20 mA (D2) correspond to
5033	20 mA (D2) =	1.0..1000.0 km	50.0 km	20 mA (D2) correspond to
5034	20 mA (D2) =	1.0..1000.0 Miles	50.0 Miles	20 mA (D2) correspond to
5036	MIN VALUE (D2)	0.0..5.0 mA; Ø	4.0 mA	Output value (D2) valid from

Addr.	Setting Title	Setting Options	Default Setting	Comments
5037	NEG VALUE (D2)	19.00..22.50 mA	19.84 mA	Output value (D2) for negative values
5038	OVERFLOW (D2)	19.00..22.50 mA	22.50 mA	Output value (D2) for overflow
5039	Tmax OUTPUT(D2)	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (D2)

6.19 Monitoring Functions

The device incorporates extensive monitoring functions of both the device hardware and software; the measured values are also continually checked to ensure their plausibility; the current and voltage transformer secondary circuits are thereby substantially covered by the monitoring function. Furthermore it is possible to implement a trip circuit supervision function by means of the available binary inputs.

6.19.1 Method of Operation

6.19.1.1 Hardware Monitoring

The device is monitored from the measuring inputs up to the command relays. Monitoring circuits and the processor check the hardware for faults and inadmissible states.

Auxiliary and Reference Voltages

The 5 V processor voltage is monitored by the hardware, as the processor would no longer function once the voltage is below the minimum value threshold. The device is taken out of service. On recovery of the voltage the processor system is restarted.

If the auxiliary supply fails or is switched off, the device is taken out of service; this state is alarmed by a normally closed contact (can be changed to a normally open contact via jumper, refer to subsection 8.1.3) Short dips in the auxiliary supply voltage do not affect the serviceability of the device (refer to Sub-section 10.1.2 in the technical data).

The processor monitors the offset and reference voltage of the ADC (analogue-to-digital converter). In the case of inadmissible deviations, the protection is blocked; permanent faults are alarmed.

Buffer Battery

The charging state of the internal battery buffer, which ensures the correct function of the internal clock and the storage of counters and alarms in the event of auxiliary supply failure is cyclically checked. If the voltage drops below the minimum permissible level, the alarm “`Fail Battery`” is issued.

Memory Modules

The working memory (RAM) is tested during booting of the system. If a fault is detected, the booting sequence is terminated and a LED blinks. During operation the memory is checked by means of its checksum.

A checksum of the program memory (EPROM) is cyclically generated and compared with the stored program checksum.

A checksum for the parameter memory (EEPROM) is cyclically generated and compared with the checksum which is computed after each change of the stored parameters.

If a fault is detected, the processor system is restarted.

Sampling Frequency

The sampling frequency and the synchronism of the internal buffer modules is continuously monitored. If deviations occur which cannot be removed by re-synchronization, the processor system is rebooted.

Measured Value Acquisition — Currents

Four measuring inputs are available in the current circuits. If the three phase currents and the earth current from the current transformer star-point or from a separate earth current transformer on the protected circuit are connected to the device, the sum of the four digitized currents must equal 0. Faults in the current circuits are detected if

$$I_F = |\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E| \quad > \quad \Sigma\mathtt{\mathbf{I\ THRESHOLD}} \cdot I_N + \Sigma\mathtt{\mathbf{I\ FACTOR}} \cdot I_{max}$$

whereby k_I (parameter **`I4/Iph CT`**) takes the eventual ratio difference of a separate I_E–current transformer into consideration (e.g. core balance CT). Σ**`I THRESHOLD`** and Σ**`I FACTOR`** are setting parameters. The amount Σ**`I FACTOR`** · I_{max} takes the permissible current proportional ratio errors of the input transducers into account which are particularly prevalent during large fault currents (Figure 6-130). The reset ratio is approx. 97 %.

This failure is alarmed by “`Failure Σ I`”.

Note:

The current sum monitoring is only effective if the fourth current measuring input (I_4) is connected to measure the earth current of the protected line.

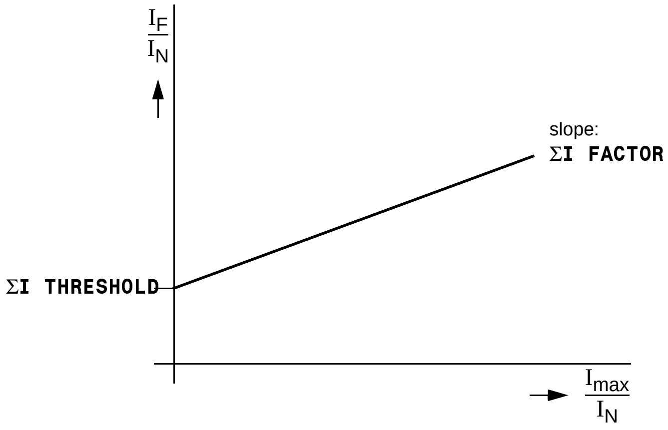


Figure 6-130 current sum monitoring

Measured Value Acquisition — Voltages

Four measuring inputs are available in the voltage circuits: three for phase–earth voltages as well as one input for the displacement voltage (e-n voltage of an open delta connection) or a busbar voltage. If the displacement voltage is connected to the device, the sum of the three digitized phase voltages must equal three times the zero sequence voltage. Errors in the voltage transformer circuits are detected when

$$U_F = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \cdot \underline{U}_{EN}| \quad > \quad 25\ V.$$

The factor k_U allows for a difference of the transformation ratio between the displacement voltage input and the phase voltage inputs (parameter **`Uph / Udelta`**). The reset ratio is approx. 97 %.

This fault is alarmed by “`Fail Σ U Ph-E`”.

Note:

The voltage sum monitoring is only effective if the measuring input U_4 is connected to a displacement voltage which was generated externally.

6.19.1.2 Software–Monitoring

Watchdog

For the continuous monitoring of the program execution, a time monitoring is incorporated in the hardware (hardware watchdog). The watchdog expires and resets the processor system causing a complete reboot if the processor fails or when a program loses synchronism.

A further software–watchdog ensures that errors in the program execution are detected. This watchdog also initiates a reset of the processor.

If a fault is not removed by the restart of the processor system, a new restart is attempted. Following three failed restarts within 30 s the protection takes itself out of service and the red LED “ERROR” is illuminated. The device ready relay resets and alarms the device failure state with its normally closed contact.

6.19.1.3 Monitoring of the External Instrument Transformer Circuits

Interruptions or short circuits in the secondary circuits of the current and voltage transformers, as well as incorrect terminations (important during commissioning) are largely recognized by the device and alarmed. To this end, the measured values are cyclically checked in the background as long as no fault detection is present.

Current Symmetry

During normal system operation, a certain degree of current symmetry can be assumed. This symmetry is checked in the device by means of a magnitude monitoring. The smallest phase current is compared with the largest. Non-symmetry is detected when

$|I_{min}| / |I_{max}| <$ **`BAL. FACTOR I`**

as long as $I_{max} / I_N >$ **`BALANCE I LIMIT`** $/ I_N$

I_{max} is the largest and I_{min} is the smallest of the three phase currents. The symmetry factor **`BAL. FACTOR I`** is a measure of the phase conductor non-symmetry, the threshold value **`BALANCE I LIMIT`** represents the lower limit of the operating range of this monitoring function (refer to Figure 6-131). Both parameters can be set. The reset ratio is approx. 97 %.

This failure is alarmed by “`Fail I balance`”.

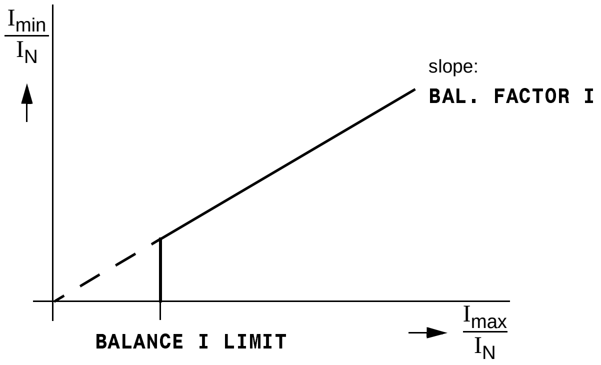


Figure 6-131 Current symmetry monitoring

Broken Conductor

A broken conductor of the protected line or in the current transformer secondary circuit can be detected, if the minimum current **BALANCE I LIMIT** flows via the feeder. If a current symmetry failure is detected and the minimum current is below the threshold **PoleOpenCurrent** (address 1130, refer to subsection 6.1.3), an interruption of this conductor may be assumed. After approximately 5 s the device issues the alarm “`Fail Conductor`”.

Voltage Symmetry

During normal system operation, a certain degree of voltage symmetry can be assumed. The symmetry is monitored in the device with a magnitude comparison. The smallest phase voltage is compared to the largest. Non-symmetry is detected when

$|U_{min}| / |U_{max}|$ < **BAL. FACTOR U**

as long as $|U_{max}|$ > **BALANCE U-LIMIT**

U_{max} is the largest and U_{min} is the smallest of the three voltages. The symmetry factor **BAL. FACTOR U** provides a measure of the voltage unsymmetry, the threshold value **BALANCE U-LIMIT** defines the lower limit of the operating range for this monitoring function (refer to Figure 6-132). Both parameters can be set. The reset ratio is approx. 97 %.

This failure is alarmed by “`Fail U balance`”.

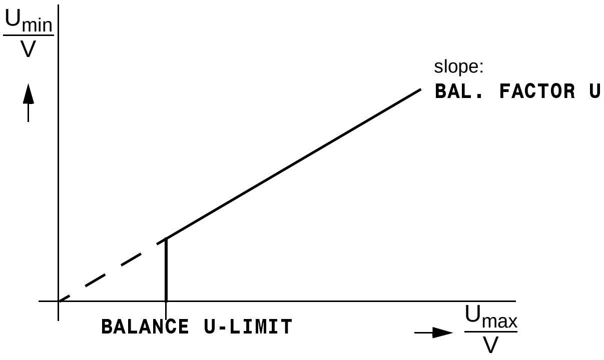


Figure 6-132 Voltage symmetry monitoring

Voltage Phase Rotation

The verification of the faulted phases and the phase preference, direction measurement and polarization with quadrature voltages usually demand clockwise rotation of the measured values. The phase rotation of the measured voltages is checked by monitoring of the voltage phase sequence.

$\underline{U}_{L1}$ before $\underline{U}_{L2}$ before $\underline{U}_{L3}$

This check takes place if each measured voltage has a minimum magnitude of

$|\underline{U}_{L1}|, |\underline{U}_{L2}|, |\underline{U}_{L3}| > 40\ V/\sqrt{3}$

In the event of negative phase rotation, the alarm “`Fail Ph. Seq.`” is issued.

If the system has a negative phase rotation, this must have been set during the configuration of the power system data (Sub-section 6.1.1). In such event, the phase rotation monitoring applies to the corresponding opposite phase sequence.

Fuse Failure Monitor (Non-Symmetrical Voltages)

In the event of measured voltage failure due to a short circuit or broken conductor in the voltage transformer secondary circuit certain measuring loops may mistakenly see a voltage of zero, which due to the load current may result in an unwanted pick-up or even trip.

If a VT miniature circuit breaker (mcb) with correspondingly adjusted auxiliary contacts is not available, but instead e.g. fuses are used, the fuse failure monitor may be activated. Naturally, it is also possible to use voltage transformer mcb and fuse failure monitor at the same time.

The non-symmetrical measured voltage failure is characterized by its voltage unsymmetry with simultaneous current symmetry. In Figure 6-133 the logic diagram of the fuse failure monitor during unsymmetrical failure of the measured voltage is shown.

If there is substantial voltage unsymmetry of the measured values, without unsymmetry of the currents being registered at the same time, this indicates the presence of a non-symmetrical failure in the voltage transformer secondary circuit.

The unsymmetry of the voltage is detected by the fact that either the zero sequence voltage or the negative sequence voltage exceed a settable value **`FFM U>(min)`**. The current is assumed to be sufficiently symmetrical, if both the zero sequence as well as the negative sequence current are below the settable threshold **`FFM I< (max)`**.

As soon as this state is recognized, the distance protection and all other functions that operate on the basis of undervoltage (e.g. also weak infeed tripping, undervoltage protection) are blocked. The immediate blocking demands current flow in at least one of the phases. The distance protection may be switched over to definite time overcurrent emergency operation if the overcurrent protection was configured accordingly (refer to Section 6.9).

The fast blocking may not occur as long as one phase is without voltage due to a single-pole dead time condition before auto-reclosure, as the non-symmetry of the measured values arising in this state is due to the switching state of the line and not due to a failure in the secondary circuits. Accordingly, the fast blocking is disabled when the line is tripped single-pole (internal information “1pole open” in the logic diagram).

If a zero sequence or negative sequence current is detected within approximately 10 s after recognition of this criterion, the protection assumes a short-circuit and removes the blocking by the fuse failure monitor for the duration of the fault. If on the other hand the voltage failure criterion is present for longer than approx. 10 s, the blocking is permanently activated (latching of the voltage criterion after 10 s). Only once the voltage criterion is removed by correction of the secondary circuit failure, will the blocking automatically reset, thereby releasing the blocked protection functions again.

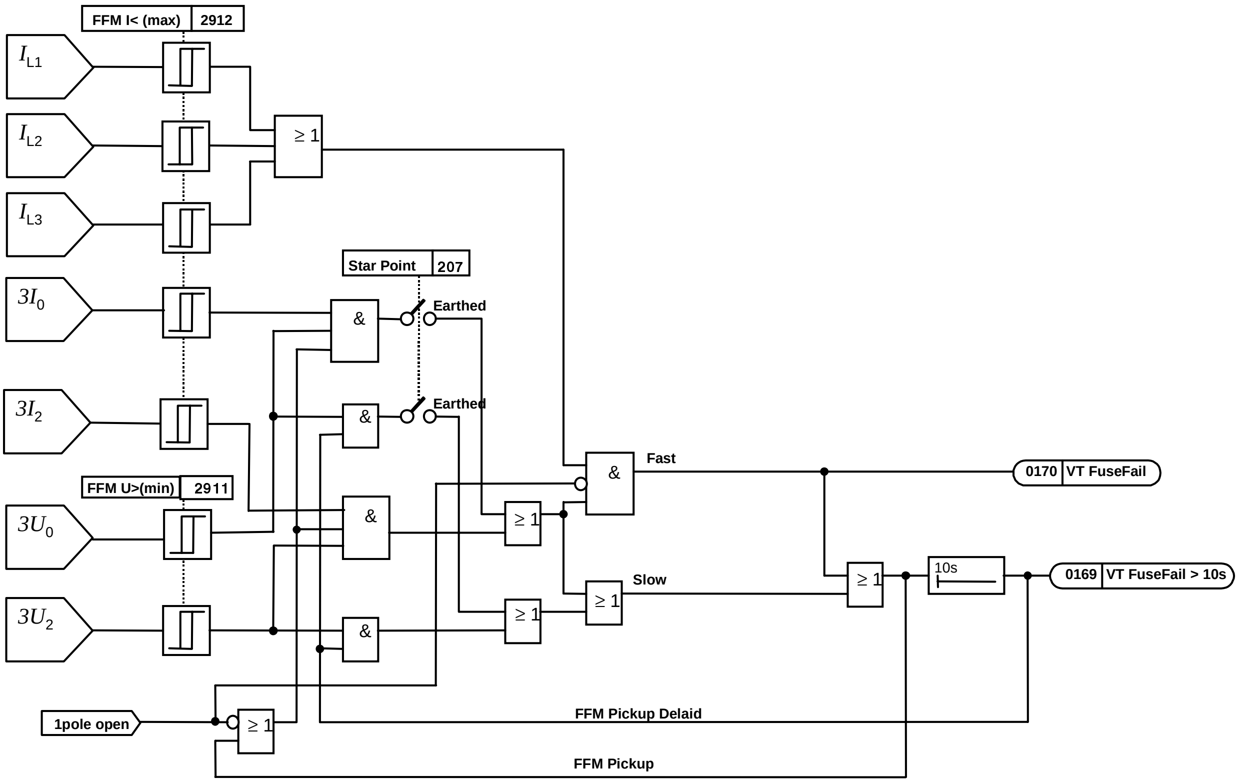


Figure 6-133 Logic diagram of the fuse failure monitor with zero and negative sequence system

Fuse Failure Monitor (Three-Phase)

A three-phase failure of the secondary measured voltage can be distinguished from an actual system fault by the fact that the currents have no significant change in the event of a failure in the secondary measured voltage. For this reason, the sampled current values are routed to a buffer, so that the difference between the present and stored current values can be analysed to recognize the magnitude of the current differential (current differential criterion). A three-pole voltage failure is detected if

- all three phase–earth voltages are smaller than the threshold **`FFM U<max (3ph)`**,
- the current differential in all three phases is smaller than the threshold **`FFM Idelta (3p)`**, and
- all three phase current amplitudes are greater than the minimum current **`Iph>`** for impedance measurement by the distance protection.

If no stored current values are present (yet), the current magnitude criterion is resorted to. A three-pole system voltage failure is detected in this case if

- all three phase–earth voltages are smaller than the threshold **`FFM U<max (3ph)`**,
- all three phase current amplitudes are smaller than the minimum current **`Iph>`** for impedance measurement by the distance protection, and
- all three phase current amplitudes are greater than a fixed set noise threshold (40 mA).

If such a voltage failure is recognized, the distance protection and all other functions that operate on the basis of undervoltage (e.g. also weak infeed tripping, undervoltage protection) are blocked until the voltage failure is removed; thereafter the blocking is automatically removed. Definite time overcurrent emergency operation is possible during the voltage failure if the overcurrent protection was configured accordingly (refer to Section 6.9).

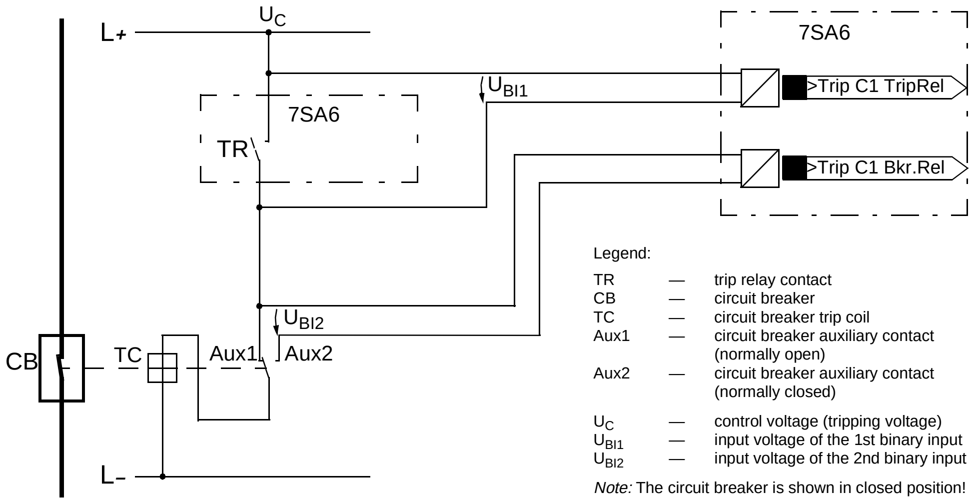
6.19.1.4 Trip Circuit Supervision

The distance protection 7SA6 incorporates an integrated trip circuit supervision function. Depending on the number of binary inputs with isolated control inputs that are still available, a choice can be made between monitoring with one or with two binary inputs. If the allocation of the required binary inputs does not match the selected monitoring mode, a corresponding alarm is issued (“`TripC. ProgFAIL`” along with the number of the faulty monitoring circuit). If two binary inputs are used, disturbances of the trip circuit can be detected during all switching states. With only one binary input, faults in the circuit breaker can not be detected. If single-pole tripping is possible, a separate trip circuit supervision can be implemented for each circuit breaker pole provided the required binary inputs are available.

Supervision Using Two Binary Inputs

If two binary inputs are used, these are connected as shown in Figure 6-134. The one binary input is connected in parallel to the corresponding trip relay contact of the protection while the other is connected in parallel to the circuit breaker auxiliary contacts.

A prerequisite for use of the trip circuit supervision function is that the control voltage of the circuit breaker is greater than the sum of the minimum voltage drops across the two binary inputs ($U_C > 2 \cdot U_{BImin}$). As at least 19 V is necessary per binary input, the monitoring can only be used if the trip control voltage is greater than 38 V.



Note: The circuit breaker is shown in closed position!

Figure 6-134 Trip circuit supervision operating principle with two binary inputs

The monitoring with two binary inputs not only detects interruptions of the trip circuit and failure of the control voltage, but also monitors the reaction of the circuit breaker by means of the switching state of the circuit breaker auxiliary contacts.

Depending on the switching state of the trip relay and circuit breaker, the binary inputs are initiated (logic state “H” in Table 6-11) or short circuited (logic state “L”).

The state where both binary inputs are not energized ("L") is only present during a short transition phase (trip relay contact is closed, but the circuit breaker has not yet opened) if the trip circuit is healthy.

A continuous occurrence of this state is only possible during interruption or short circuit of the trip circuit as well as during failure of the battery supply voltage, or faults in the mechanism of the circuit breaker.

Table 6-11 Condition table of the binary inputs depending on the trip relay state and CB state

No.	Trip relay	Circuit breaker	Auxiliary contact 1	Auxiliary contact 2	BI 1	BI 2
1	open	CLOSED	closed	open	H	L
2	open	OPEN	open	closed	H	H
3	closed	CLOSED	closed	open	L	L
4	closed	OPEN	open	closed	L	H

The two binary inputs are periodically interrogated to determine their state. An interrogation takes place every 500 ms. Only once n = 3 sequential state interrogations detect a failure, will the failure alarm be generated (refer to Figure 6-135). Due to this measurement repetition the delay of the failure alarm is determined. A failure alarm due to transient transition phases is thereby avoided. After removal of the failure in the trip circuit, the alarm automatically resets after the same time.

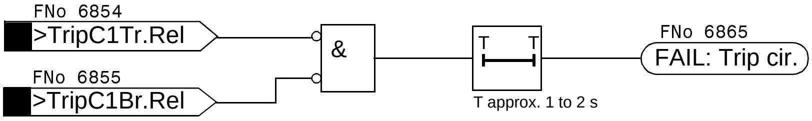


Figure 6-135 Logic diagram of the trip circuit supervision with two binary inputs

Supervision Using One Binary Input

The binary input is connected in parallel to the corresponding trip relay of the protection according to Figure 6-136. The circuit breaker auxiliary contact is bridged by means of a high-ohmic shunt resistor R.

The control voltage of the circuit breaker should be at least twice the minimum voltage drop across the binary input ($U_C > 2 \cdot U_{BImin}$). As at least 19 V are required for the binary input, the supervision function can be used if the trip control voltage is greater than approximately 38 V.

An calculation example for the substitute resistance of R is shown in subsection 8.1.2, margin "Trip Circuit Supervision".

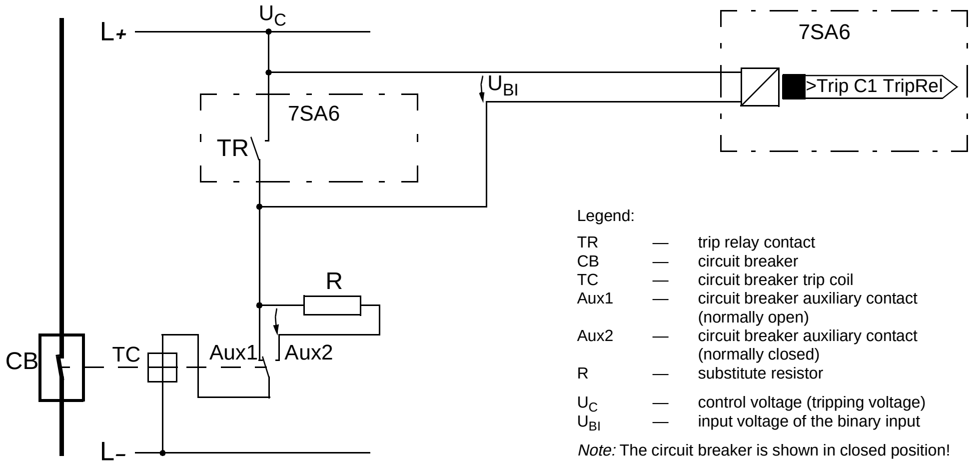


Figure 6-136 Operating principle of the trip circuit supervision with one binary input

During normal operation there is an input signal on the binary input when the trip relay contact is open and the trip circuit is healthy (logic state “H”), because the monitoring circuit is closed via the auxiliary contact (while circuit breaker is closed) or via the substitute resistance R. The binary input is only short circuited and thereby not picked up (logic state “L”) while the trip relay is closed.

If the binary input is continuously not picked up, this indicates an interruption of the trip circuit or loss of the (tripping) control supply voltage.

As the trip circuit supervision is not in service during a system fault, the closed trip relay contact does not cause an incorrect alarm. If however other trip relay contacts from different devices are connected in parallel in the trip circuit, the failure alarm must be delayed by **`Alarm Delay`** (refer also to Figure 6-137). After clearance of the failure in the trip circuit, the failure alarm automatically resets with the same time delay.

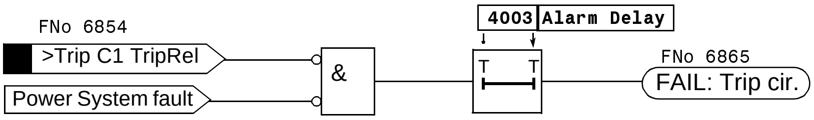


Figure 6-137 Logic diagram of the trip circuit supervision with one binary input

6.19.1.5 Response to Failures

Depending on the nature of the detected failure, an alarm is issued, the processor system is rebooted or the device is taken out of service. Following three unsuccessful restart attempts, the device is also taken out of service. The device healthy relay (live) also resets and alarms the failure state of the relay with its normally closed contact. In addition the red LED “ERROR” on the front plate of the device is illuminated if the internal auxiliary supply is available, and the green LED “RUN” is extinguished. If the internal auxiliary supply also fails all LEDs are extinguished. In Table 6-12 a summary of the monitoring functions and the response of the device to detected failures is shown. In addition these monitoring alarms are allocated to four different general alarm categories:

- **`Error with a summary alarm`** (F.No. 140, i.e. general device failure)
- **`Alarm summary event`** (F.No. 160, i.e. general supervision alarm)
- **`Failure: general current supervision`** (F.No. 161)
- **`Failure: general voltage supervision`** (F.No. 164)

Table 6-12 Summary of the device response to detected failures

Monitoring	Possible causes	Alarm (function no.)	Failure response General alarms	Output
Auxiliary voltage failure	external (aux. supply) internal (converter)	all LEDs dark or “**`Error 5 V`**” (144)	device out of service or general alarm: 140	D.OK²) resets
Measured value acquisition	internal (converter or reference voltage)	LED „ERROR” “**`Error A/D-conv.`**” (181)	protection out of service general alarm: 140	D.OK²) resets
Buffer battery	internal (buffer battery)	**`“Fail Battery” (177)`**	alarm: 177	as allocated
Hardware–watchdog	internal (processor fail)	LED “ERROR”	protection out of service	D.OK²) resets
Software–watchdog	internal (program execution)	LED “ERROR”	reboot attempt ¹)	D.OK²) resets
Working memory	internal (RAM)	LED flashes	reboot attempt ¹) abortion of the boot process device out of service	D.OK²) resets
Program memory	internal (EPROM)	LED “ERROR”	reboot attempt ¹)	D.OK²) resets
Parameter memory	internal (EEPROM or RAM)	LED “ERROR”	reboot attempt ¹)	D.OK²) resets
Sampling frequency	internal (clock)	LED “ERROR”	reboot attempt ¹)	D.OK²) resets
1 A/5 A–setting	jumper settings 1 A/5 A incorrect	“**`Error1A/5Awrong`**” “**`Error A/D-conv.`**” LED “ERROR” (192, 181)	general alarm: 140 protection out of service	D.OK²) resets
Calibration data	internal (EEPROM or RAM)	“**`Alarm NO calibr`**” (193)	general alarm: 160 default values used	as allocated
Earth current transformer sensitive/normal	I/O–module does not correspond to the ordering code of the device	“**`Error neutralCT`**” “**`Error A/D-conv.`**” LED “ERROR” (194, 181)	general alarm: 140 protection out of service	D.OK²) resets
Modules	module does not correspond to the ordering code of the device	“**`Error Board 1...7`**” and if applicable “**`Error A/D-conv.`**” (183 ... 189, 181)	general alarms: 160, 140 protection out if service	D.OK²) resets
Current sum	internal (measured value acquisition)	**`“Failure ΣI`**” (162)	general alarms: 161, 160	as allocated
Current symmetry	external (primary plant or current transformers)	“**`Fail I balance`**”(163)	general alarms: 161, 160	as allocated
Broken conductor	external (primary plant or current transformers)	“**`Fail Conductor`**” (195)		as allocated

¹) Following three unsuccessful reboot attempts, the device is taken out of service

²) D.OK = “Device Okay” = Live contact relay

Table 6-12 Summary of the device response to detected failures

Monitoring	Possible causes	Alarm (function no.)	Failure response General alarms	Output
Voltage sum	internal (measured value acquisition)	“**Fail ΣU Ph-E**” (165)	general alarms: 164, 160	as allocated
Voltage symmetry	external (primary plant or voltage transformers)	“**Fail U balance**” (167)	general alarms: 164, 160	as allocated
Voltage phase rotation	Extrem (primary plant or connection)	“**Fail Ph. Seq.**” (171)	general alarm: 160	as allocated
Voltage failure, three-phase, Fuse failure monitor	external (primary plant or connection)	“**Fuse–Failure**” (169, 170)	general alarm: 160 distance protection blocked	as allocated
Voltage failure, single-/two-phase, Fuse failure monitor	external (voltage transformers)	“**Fuse–Failure**” (169, 170)	general alarm: 160 distance protection blocked	as allocated
Trip circuit supervision	external (trip circuit or control voltage failure)	“**FAIL: Trip cir.**” (6865)	general alarm: –	as allocated

[1]) Following three unsuccessful reboot attempts, the device is taken out of service

[2]) D.OK = “Device Okay” = Live contact relay

6.19.2 Applying the Function Parameter Settings

The sensitivity of the measured value monitoring can be changed. In the factory, presettings based on experience have already been applied, which should be sufficient for most applications. If particularly high operational asymmetries of the currents and/or voltages are expected, or if one or more monitoring functions pick up sporadically during normal operation, the sensitivity setting(s) should be reduced.

In address **2901 MEASURE. SUPERV** the measured value monitoring can be switched ***ON*** or ***OFF***.

Symmetry Monitoring

Address **2902 BALANCE U-LIMIT** determines the voltage threshold (phase–phase), above which the voltage symmetry monitoring is in service (refer to Figure 6-132). Address **2903 BAL. FACTOR U** is the corresponding symmetry factor, i.e. the slope of the symmetry characteristic (Figure 6-132).

Address **2904 BALANCE I LIMIT** determines the current threshold above which the current symmetry monitoring is in service (refer also to Figure 6-131). Address **2905 BAL. FACTOR I** is the corresponding symmetry factor, i.e. the slope of the symmetry characteristic (Figure 6-131).

Summation Monitoring

Address **2906 ΣI THRESHOLD** determines the current threshold above which the current summation monitoring (refer to Figure 6-130) picks up (absolute value, only referred to I_N). The relative component (referred to the maximum conductor current) for the pick-up of the current summation monitoring (Figure 6-130) is set in address **2907 ΣI FACTOR**.

Note:

The current summation monitoring is only in service if the earth current of the protected feeder is connected to the fourth current measuring input (I_4) for earth currents.

Fuse Failure Monitor (Non-Symmetrical Voltages)

The settings of the fuse failure monitor for non-symmetrical measured voltage failure (single- or two-phase) must be selected such that on the one hand reliable pick-up of the monitoring is ensured in the case of loss of a single-phase voltage (address **2911** **`FFM U>(min)`**), while on the other hand a pick-up due to earth faults in an earthed system is avoided. In accordance with this requirement, address **2912** **`FFM I<(max)`** must be set sufficiently sensitive (below the smallest fault current due to earth faults). In address **2910** **`FUSE FAIL MON.`**, the fuse failure monitor can be switched ***`OFF`*** e.g. during non symmetrical testing.

Fuse Failure Monitor (Three-Phase)

In address **2913** **`FFM U<max (3ph)`** the minimum voltage threshold is set. If the measured voltage drops below this threshold and a simultaneous current jump which exceeds the limits according to address **2914** **`FFM Idelta (3p)`** is not detected while all three phase currents are greater than the minimum current required for the impedance measurement by the distance protection according to address **1202** **`Iph>`**, a three phase measured voltage failure is recognized.

Voltage Transformer Secondary m.c.b.

If a miniature circuit breaker for voltage transformers (VT mcb) is installed in the secondary circuit of the voltage transformers, the status is sent, via binary input, to the device informing it about the position of the VT mcb. If a short-circuit in the secondary side initiates the tripping of the VT mcb, the distance protection function has to be blocked immediately. Otherwise a trip by the distance protection due to the lack of measured voltage while load current is possible. The blocking must be faster than the first stage of the distance protection.This requires an extremely short reaction time for VT mcb (≤ 4 ms for 50 Hz, ≤ 3 ms for 60 Hz nominal frequency). If this cannot be ensured, the reaction time is to be set under address **2921** **`T mcb`**.

Note that the fast trip of Zone 1 is delayed by the setting in **2921**. Unless absolutely necessary the setting should be zero. Alternatively the internal Fuse Failure Monitor can be used (see above).

Trip Circuit Supervision

The number of circuits to be monitored was set during the configuration in address **0140** **`TripCirc.Superv`** (Section 5.1). If the trip circuit supervision is not used at all, the setting ***`Disabled`*** must be applied there.

The trip circuit supervision can be switched ***`ON`*** or ***`OFF`*** in address **4001** **`FCT TripSuperv.`**. The number of binary inputs that shall be used in each of the monitored circuits is set in address **4002** **`No. of BI.`** If the marshalling of the binary inputs required for this function does not correspond to the previously selected type of monitoring, a corresponding alarm is issued (“`TripC ProgFAIL`” with the number of the faulty monitoring circuit).

The trip circuit failure alarm is delayed by a fixed period of approximately 1 s to 2 s in the case of monitoring with two binary inputs. The alarm delay in the event of monitoring with one binary input can be set in address **4003** **`Alarm Delay`**. If 7SA6 is the only device connected in the trip circuit, a delay of 1 s to 2 s is sufficient as the trip circuit supervision is not active during a detected system fault. If, however, trip contacts from other devices are connected in parallel in the trip circuit, the fail alarm must be delayed such that the longest trip command duration can be reliably bridged.

6.19.3 Settings

Measurement Supervision

Note: The indicated secondary current values for setting ranges and default settings refer to I_N = 1 A. For the nominal current 5 A the current values are to be multiplied by 5. The values of impedance are divided by 5.

Addr.	Setting Title	Setting Options	Default Setting	Comments
2901	MEASURE. SUPERV	ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT	10..100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U	0.58..0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	0.10..1.00 A	0.50 A	Current Balance Monitor
2905A	BAL. FACTOR I	0.10..0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	0.05..2.00 A	0.10 A	Summated Current Monitoring Threshold
2907A	ΣI FACTOR	0.00..0.95; Ø	0.10	Summated Current Monitoring Factor
2910	FUSE FAIL MON.	ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)	10..100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	0.10..1.00 A	0.10 A	Maximum Current Threshold I<
2913A	FFM U<max (3ph)	2..100 V	5 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	0.05..1.00 A	0.10 A	Delta Current Threshold (3phase)
2921	T mcb	0..30 ms; Ø	0 ms	T mcb

Trip Circuit Supervision

Addr.	Setting Title	Function	Setting Options	Default Setting
4001	FCT TripSuperv.	Trip Circuit Supervision	ON OFF	OFF
4002	No. of BI	Trip Circuit Supervision	1..2	2
4003	Alarm Delay	Trip Circuit Supervision	1..30 sec	2 sec

6.19.4 Information Overview

Hardware and Software Supervision

FNo.	Alarm	Comments
68	Clock SyncError	Clock Synchronization Error
69	DayLightSavTime	Daylight Saving Time
110	Event Lost	Event lost
113	Flag Lost	Flag Lost
125	Chatter ON	Chatter ON
140	Error Sum Alarm	Error with a summary alarm
144	Error 5V	Error 5V
160	Alarm Sum Event	Alarm Summary Event
177	Fail Battery	Failure: Battery empty
181	Error A/D-conv.	Error: A/D converter
182	Alarm Clock	Alarm: Real Time Clock
190	Error Board 0	Error Board 0
183	Error Board 1	Error Board 1
184	Error Board 2	Error Board 2
185	Error Board 3	Error Board 3
186	Error Board 4	Error Board 4
187	Error Board 5	Error Board 5
188	Error Board 6	Error Board 6
189	Error Board 7	Error Board 7
192	Error1A/5Awrong	Error:1A/5Ajumper different from setting
193	Alarm NO calibr	Alarm: NO calibration data available
194	Error neutralCT	Error: Neutral CT different from MLFB
	HWTestMod	Hardware Test Mode

General Current Supervision

F.No.	Alarm	Comments
161	Fail I Superv.	Failure: General Current Supervision
162	Failure Σ I	Failure: Current Summation
163	Fail I balance	Failure: Current Balance
164	Fail U Superv.	Failure: general Voltage Supervision
165	Fail Σ U Ph-E	Failure: Voltage summation Phase-Earth

F.No.	Alarm	Comments
167	Fail U balance	Failure: Voltage Balance
169	VT FuseFail>10s	VT Fuse Failure (alarm >10s)
170	VT FuseFail	VT Fuse Failure (alarm instantaneous)
171	Fail Ph. Seq.	Failure: Phase Sequence
195	Fail Conductor	Failure: Broken Conductor
196	Fuse Fail M.OFF	Fuse Fail Monitor is switched OFF
197	MeasSup OFF	Measurement Supervision is switched OFF

Trip Command Supervision

F.No.	Alarm	Comments
6854	>TripC1 TripRel	>Trip circuit superv. 1: Trip Relay
6855	>TripC1 Bkr.Rel	>Trip circuit superv. 1: Breaker Relay
6856	>TripC2 TripRel	>Trip circuit superv. 2: Trip Relay
6857	>TripC2 Bkr.Rel	>Trip circuit superv. 2: Breaker Relay
6858	>TripC3 TripRel	>Trip circuit superv. 3: Trip Relay
6859	>TripC3 Bkr.Rel	>Trip circuit superv. 3: Breaker Relay
6861	TripC OFF	Trip circuit supervision OFF
6865	FAIL: Trip cir.	Failure Trip Circuit
6866	TripC1 ProgFAIL	TripC1 blocked: Binary input is not set
6867	TripC2 ProgFAIL	TripC2 blocked: Binary input is not set
6868	TripC3 ProgFAIL	TripC3 blocked: Binary input is not set

6.20 Function Control

The function control is the control centre of the device. It coordinates the execution of the protection and supplementary functions, processes their decisions and the information that emanates from the plant. In particular the following

- switch-in recognition,
- processing of the circuit breaker position,
- fault detection logic,
- tripping logic.

6.20.1 Detection of Line Energization

During energization of the protected object, several measures may be required or desirable. Following a manual close onto a short-circuit, immediate trip of the circuit breaker is usually required. In the distance protection for example, this is implemented by activation of the overreaching zone Z1B for a short period following manual closure. The high-current switch-on-to-fault protection in particular is intended to trip immediately following energization of a feeder on to a fault (refer to Sub-section 6.10.1). In addition at least one stage of each short-circuit protection function can be selected to trip without time delay following manual closure as described in the corresponding sections. In this regard refer also to Sub-section 6.1.3 under the margin heading “Circuit Breaker Status”.

The manual close command must be routed to the device via a binary input. In order to be independent of the duration that the switch is closed, the command is set to a defined length in the device (adjustable with the address **1150** **`SI Time Man.Cl`**). Fig. 6-138 shows the logic diagram.

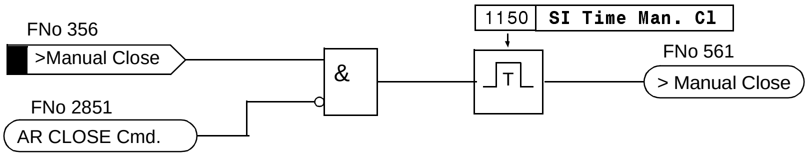


Figure 6-138 Logic diagram of the manual closure handling

If the device has an integrated automatic reclosure, the integrated manual closure logic of the 7SA6 automatically distinguishes between an external control command via the binary input and an automatic reclosure by the internal auto-reclosure function so that the binary input “`>Manual Close`” can be connected directly to the control circuit of the close coil of the circuit breaker.

If, however, external close commands which should not activate the manual close function are possible (e.g. external reclosure device), the binary input “`>Manual Close`” must be triggered by a separate contact of the control switch (Figure 6-140).

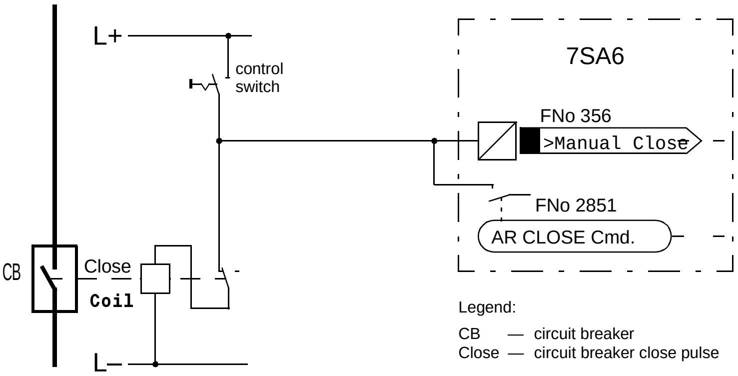


Figure 6-139 Manual closure with internal automatic reclosure

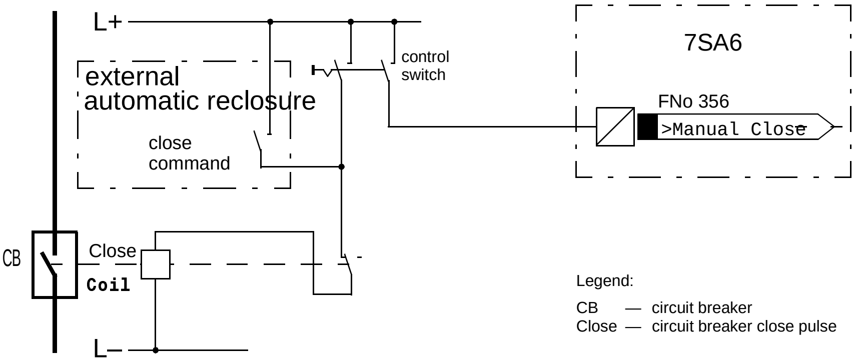


Figure 6-140 Manual closure with external automatic reclosure

6.20.2 Processing of the Circuit Breaker Position

Information regarding the circuit breaker position is required by various protection and supplementary functions to ensure their optimal functionality. This is for example of assistance for

- the echo function in comparison schemes with distance protection (refer to Subsection 6.4.1.11)
- the echo function in the earth fault directional comparison pick-up (refer to Subsection 6.6.1.5)
- weak infeed tripping (refer to Subsection 6.7.1)
- the high-current instantaneous tripping (6.10.1)
- the plausibility check before automatic reclosure (refer to Subsection 6.12.1)
- the circuit breaker failure protection (refer to Subsection 6.16.1)
- verification of the reset condition for the trip command (refer to Subsection 6.20.4)
- the circuit breaker test by means of the trip-close test cycle (refer also to Subsection 6.20.5)

A circuit breaker position logic is incorporated in the device (Figure 6-141). Depending on the type of auxiliary contact(s) provided by the circuit breaker and the method in which these are connected to the device, there are several alternatives of implementing this logic.

In most cases it is sufficient to furnish the status of the circuit breaker with its auxiliary contacts via a binary input to the device. This always applies if the circuit breaker is only switched three-pole. Then the NO auxiliary contact of the circuit breaker is connected to a binary input which must be configured to the input function “`>CB 3p Closed`” (FNo. `379`). The other inputs are then not used and the logic is restricted in principle to simply passing of this input information on.

If the circuit breaker poles can be switched individually, and only the series-connected NC contacts is available, the relevant binary input (BI) is again allocated to the function “`>CB 3p Open`” (FNo. `380`). The remaining inputs are again not used in this case.

If the circuit breaker poles can be switched individually, and the individual auxiliary contacts are available, an individual binary input should be used for each auxiliary contact if this is possible and if the device can and should trip single-pole. With this configuration, the device can process the maximum amount of information. Three binary inputs are used for this purpose:

– “`>CB Aux. L1`” (FNo. `351`), for the auxiliary contact of pole `L1`,

– “`>CB Aux. L2`” (FNo. `352`), for the auxiliary contact of pole `L2`,

– “`>CB Aux. L3`” (FNo. `353`), for the auxiliary contact of pole `L3`,

The inputs FNo. `379` and FNo. `380` are not used in this case.

If the circuit breaker can be switched individually, two binary inputs are sufficient if both the series-connected NO contacts and the series-connected NC contacts of the auxiliary contacts of the three poles are available. In this case, series circuit of the NO contacts is routed to the input function “`>CB 3p Closed`” (FNo. `379`) and the series connection of the NC contacts is routed to the input function “`>CB 3p Open`” (FNo. `380`).

Please note that Figure 6-141 shows the complete logic for all connection alternatives. For each particular application, only a portion of the inputs is used as described above.

The 8 output signals of the circuit breaker position logic can be processed by the individual protection and supplementary functions. The output signals are blocked if the signals provided by the circuit breaker are not plausible e.g. the circuit breaker can not be open and closed simultaneously. Furthermore, the detection of current flow has priority to the circuit breaker open detection via auxiliary contacts.

Special binary inputs are available for the auto-reclosure function and for the circuit breaker check; they are to be handled in the same way and additionally allocated if necessary. These inputs have an analogueous meaning to the inputs described above and are identified with “`LS1` ...” for easy distinction:

– “`>CB1 3p Closed`” (FNo. `410`) for the series connection of the NO auxiliary contacts of the CB

– “`>CB1 3p Open`” (FNo. `411`) for the series connection of the NC auxiliary contacts of the CB

– “`>CB1 Pole L1`” (FNo. `366`) for the auxiliary contact of pole L1

– “`>CB1 Pole L2`” (FNo. `367`) for the auxiliary contact of pole L2

– “`>CB1 Pole L3`” (FNo. `368`) for the auxiliary contact of pole L3

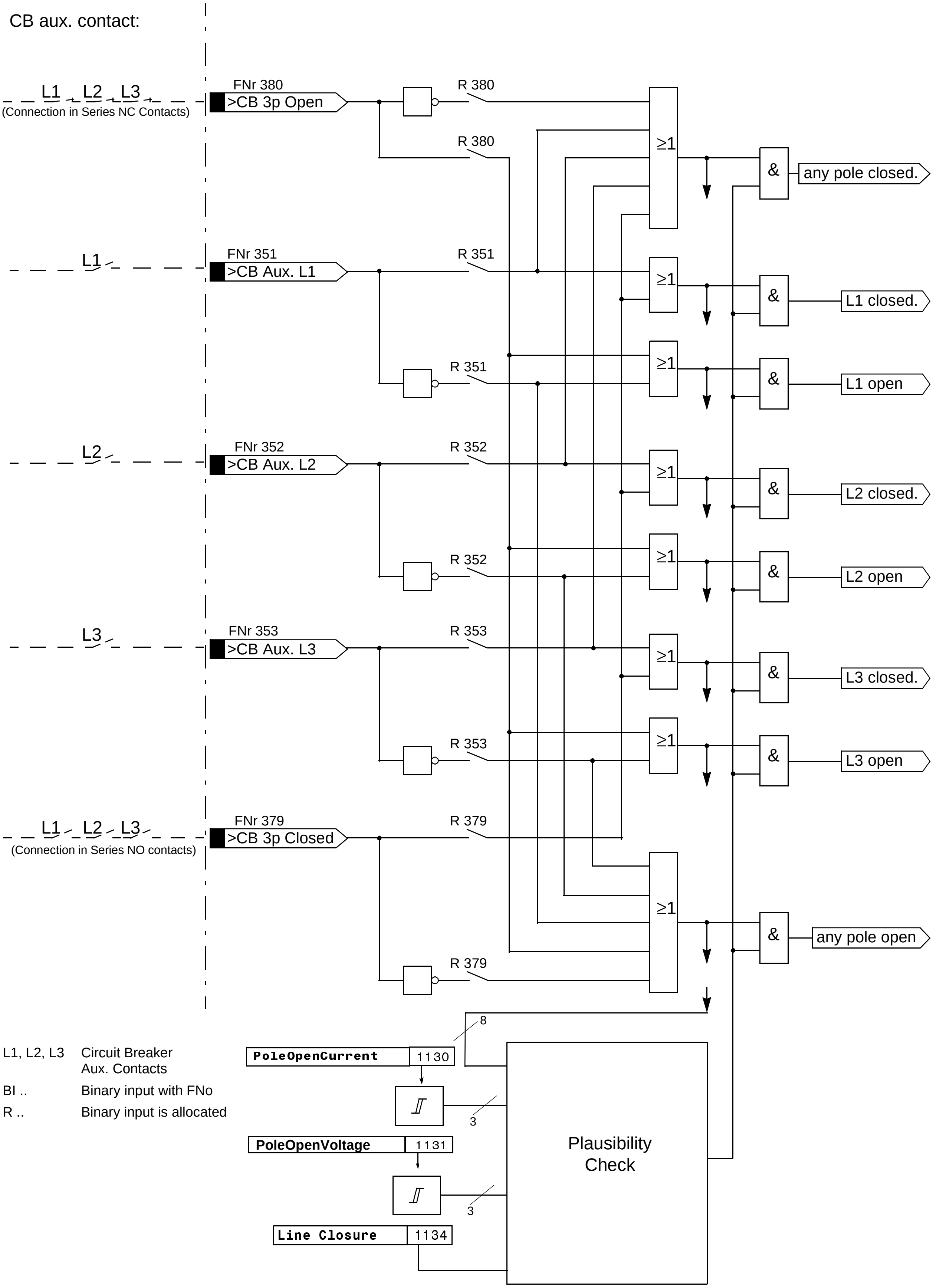


Figure 6-141 Circuit breaker position logic

6.20.3 Overall Fault Detection Logic of the Device

Phase Segregated Fault Detection

The fault detection logic combines the fault detection (pick-up) signals of all protection functions. In the case of those protection functions that allow for phase segregated pick-up, the pick-up is output per phase. If a protection function detects an earth fault, this is also output as a common device alarm. The following alarms are therefore available “`Relay PICKUP L1`”, “`Relay PICKUP L2`”, “`Relay PICKUP L3`” and “`Relay PICKUP E`”.

The annunciations above can be allocated to LEDs or output relays. For the local display of fault event messages (trip log) and for the transmission of event messages to a personal computer or a centralized control system, several protection functions provide the possibility to display the faulted phase information in a single message, e.g. “`Dis.Pickup L12E`” for the distance protection fault detection in L1–L2–E only one such messages appears. It represents the complete definition of the fault detection.

General Fault Detection

All fault detection signals are combined with a logic *OR* function and cause a general fault detection of the device. It is designated with “`Relay PICKUP`”. If no protection function is picked-up anymore, the “`Relay PICKUP`” will reset (message “Going”).

The general fault detection is a prerequisite for a number of internal and external consequential functions. The following belong to the internal functions which are controlled by the general fault detection:

- Initiation of a fault event report (trip log): from the pick-up to the reset of the general fault detection the fault messages are stored in the trip log.
- Initialisation of the fault recording: the storage of analogue and binary traces can additionally be made dependant on the appearance of a trip command.
- Generation of spontaneous messages. Certain fault messages may appear in the display of the device as so called spontaneous messages (see “Spontaneous Messages” below). This display may additionally be made dependant on the appearance of a trip command.
- Start action time of automatic reclosure (if available and used)

External functions may be controlled via an output contact. The following are examples:

- Automatic reclose devices,
- Channel boost in conjunction with signal transmission by PLC,
- Initiation of further supplementary devices etc.

Spontaneous Messages

Spontaneous messages are fault messages which appear in the display automatically following a general fault detection of the device or trip command. In the 7SA6 these are:

- “`Relay PICKUP`”: protection function which picked up most recently;
- ”`Relay TRIP`”: protection function which tripped (only device with graphic display);
- “`PU Time`”: the duration from pickup to reset of the general fault detection of the device; the time is indicated in ms;
- “`TRIP Time`”: the duration from pickup to the of the first trip command of the device; the time is indicated in ms;

- “`dist =`”:	the distance to fault in kilometres or miles derived by the distance to fault location function.

6.20.4 Overall Tripping Logic of the Device

Three-Pole Tripping

In general, the device trips three-pole in the event of a fault. Depending on the version ordered, (13th position of the ordering code = “4” to “7”) single-pole tripping is also possible (see below). If, in general, single-pole tripping is not possible or desired, the output function “`Relay TRIP 3ph.`” is used for the trip command output to the circuit breaker. In these cases the following sections regarding single-pole tripping are not of interest.

Single-Pole Tripping

Single-pole tripping only makes sense on overhead lines, on which automatic reclosure shall be carried out and where the circuit breakers at both ends of the line are capable of single-pole tripping. In such cases, the faulted phase may be tripped single-pole and subsequently reclosed; in the case of two-phase and three-phase faults with or without earth, three-pole tripping is usually carried out.

Device prerequisites for phase segregated tripping are:

- that phase segregated tripping is provided by the device (according to the ordering code);
- that phase segregated tripping is provided by the protection function which trips (accordingly not e.g. earth fault protection, high-current switch-on-to-fault protection, overvoltage protection, overload protection);
- that the binary input “`>1p Trip Perm`” is configured and activated or the internal automatic reclosure function is ready for reclosure after single-pole tripping.

In all other cases tripping is always three-pole. The binary input “`>1p Trip Perm`” is derived from an external automatic reclose device and is equivalent to the logic inversion of a three-pole coupling signal. This signal is present as long as the external reclosure is ready for single-pole automatic reclosure.

With the 7SA6, it is also possible to trip three-pole when only one phase is subjected to the trip conditions, but more than one phase indicates a fault detection. With distance protection this is the case when two faults at different locations occur simultaneously but only one of them is within the range of the fast tripping zone (`Z1` or `Z1B`). This is selected with the setting parameter **`3pole coupling`**, which is set to ***`with Pickup`*** (every multiple-phase *fault detection* causes three-pole trip) or ***`with Trip`*** (in the event of multiple-phase *trip* commands the tripping is three-pole).

The tripping logic combines the trip signals from all protection functions. The trip commands of those protection functions that allow single-pole tripping are phase segregated. The corresponding alarms are “`Relay TRIP L1`”, “`Relay TRIP L2`” and “`Relay TRIP L3`”.

These alarms can be allocated to LEDs or output relays. In the event of three-pole tripping all three alarms pick up.

For the local display of fault event messages and for the transmission of event messages to a personal computer or a centralized control system, the device also provides a summarized image of the trip signals, e.g. “`Dis.Trip 1pL1`”, “`Dis.Trip 1pL2`”, “`Dis.Trip 1pL3`” for single-pole tripping as well as “`Dis.Trip 3p`” for three-pole tripping. Only one of these alarms appears at a time. These alarms are also intended for the trip command output to the circuit breaker.

Single-Pole Tripping with Two-Phase Faults

Single-pole tripping for two-phase faults is a special feature. If a phase-phase fault without earth occurs in an earthed system, this fault can be cleared by single-pole trip and automatic reclosure in one of the faulted phases, as the short-circuit path is interrupted in this manner. The phase selected for tripping must be the same at both line ends (and should be the same for the entire system).

By means of the setting parameter **`Trip2phFlt`** it is possible to select whether this tripping is ***`1pole leading Ph`***, i.e. single-pole tripping of the leading phase or ***`1pol.lagging Ph`***, i.e. single-pole tripping of the lagging phase. The standard setting is ***`3pole`*** tripping for two-phase faults (presetting).

Table 6-13 shows a summary of the conditions under which single-pole or three-pole tripping results.

Table 6-13 Single and three pole tripping depending on the type of fault

Fault type from protection functions)				Parameter 1156 `Trip2phFlt`	Trip output signals			
					`RelayTrip 1pL1`	`RelayTrip 1pL2`	`RelayTrip 1pL3`	`Relay TRIP 3ph.`
L1				(irrelevant)	X			
	L2			(irrelevant)		X		
		L3		(irrelevant)			X	
L1			E	(irrelevant)	X			
	L2		E	(irrelevant)		X		
		L3	E	(irrelevant)			X	
L1	L2			***`3pole`***				X
L1	L2			***`1pole leading.Ph`***	X			
L1	L2			***`1pole lagging.Ph`***		X		
	L2	L3		***`3pole`***				X
	L2	L3		***`1pole leading.Ph`***		X		
	L2	L3		***`1pole lagging.Ph`***			X	
L1		L3		***`3pole`***				X
L1		L3		***`1pole leading.Ph`***			X	
L1		L3		***`1pole lagging.Ph`***	X			
L1	L2		E	(irrelevant)				X
	L2	L3	E	(irrelevant)				X
L1		L3	E	(irrelevant)				X
L1	L2	L3		(irrelevant)				X
L1	L2	L3	E	(irrelevant)				X
			E	(irrelevant)				X

General Trip

All trip signals from the protection functions are combined with an *OR* function and cause the alarm “`Relay TRIP`”. This can be allocated to LED or output relay.

Reset of the Trip Command

Once a trip command is initiated, it is phase segregatedly latched (in the event of three-pole tripping for each of the three poles) (refer to Figure 6-142). At the same time a minimum trip command duration **`TMin TRIP CMD`** is started. This ensures that the trip command is output for a sufficiently long time to the circuit breaker even if the tripping protection function resets very rapidly. Only after the last protection function has reset (no function is picked up any more) *AND* the minimum trip command duration has expired, the trip commands can reset.

A further condition for the reset of the trip command is that the circuit breaker has opened, in the event of single-pole tripping the relevant circuit-breaker pole. In the function control of the device this is checked by means of the circuit-breaker position feedback (Subsection 6.20.2) and the current flow.

The residual current **PoleOpenCurrent** that is certainly undershot when the circuit breaker pole is open is set in address 1130A. Address 1135 **Reset Trip CMD** determines under which conditions a trip command is reset. If ***CurrentOpenPole*** is set, the trip command is reset as soon as the current disappears. It is important that the value set in address 1130A **PoleOpenCurrent** (see above) is undershot. If ***Current AND CB*** is set, the circuit-breaker auxiliary contact must send a message that the circuit breaker is open. It is a prerequisite for this setting that the position of the auxiliary contacts is allocated via a binary input.

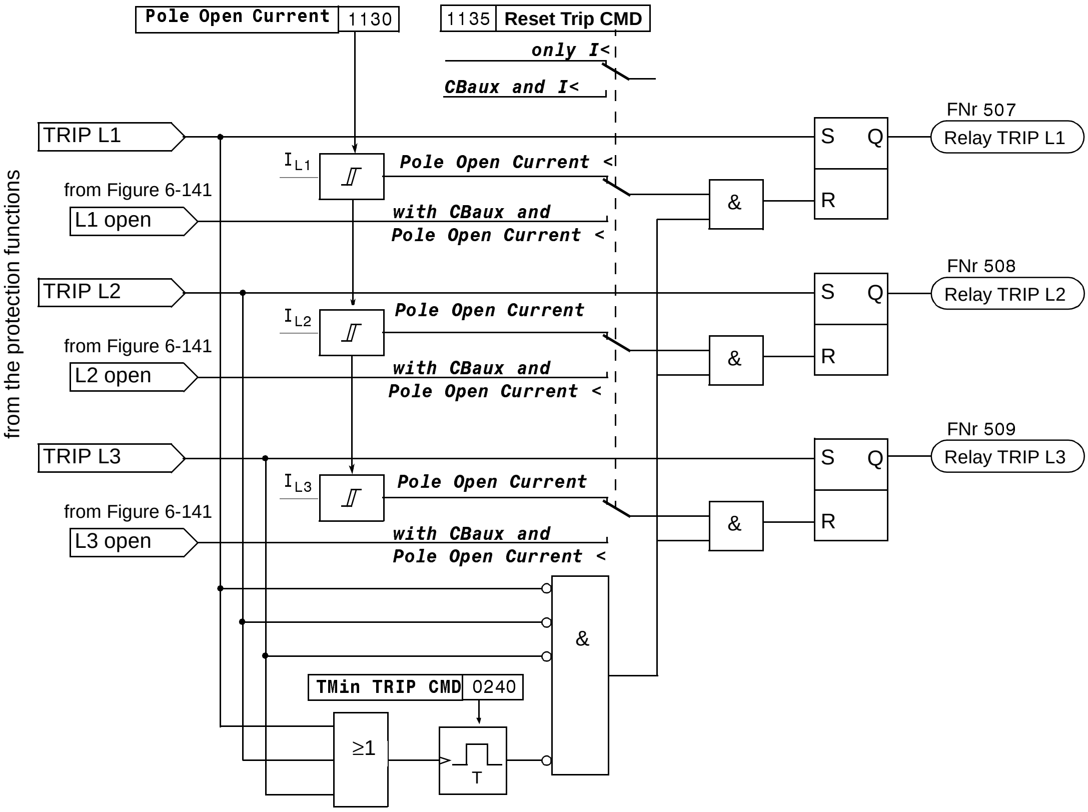


Figure 6-142 Latching and reset of the trip command

Trip Seal-in (Reclosure Lock-out)

When tripping the circuit-breaker with a protection function reclosure must often be locked until the cause for the protection function operation is found. 7SA6 therefore provides the integrated reclosure lock-out function.

The lock-out state (“`LOCKOUT`”) is realized by a RS flipflop which is protected against auxiliary voltage failure (see Figure 6-143). The RS flipflop will be set via a binary input “`>Lockout SET`” (FNo 385). With the output alarm “`LOCKOUT`” (FNo 530), if interconnected correspondingly, a reclosure of the circuit-breaker (e.g. for automatic reclosure, manual close signal, synchronization, closing via control) can be blocked.

Only once the cause for the protection operation is known, should the lock-out be reset by a manual reset via binary input “`>Lockout RESET`” (FNo `386`).

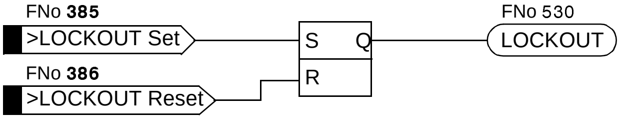


Figure 6-143 Trip circuit seal-in (reclosure lock-out)

The conditions which cause reclosure lock-out and the control commands which have to be locked can be set individually. The two inputs and the output can be wired via the correspondingly allocated binary inputs and outputs or be linked via user-defined logic functions (CFC).

If, for example, each trip by the protection function should be sealed, then combine the tripping command “`Relay TRIP`” (FNo `511`) with the binary input “`>Lockout SET`”. If automatic reclosure is applied, only the final trip of the protection function should establish closing lock-out. Then combine the output alarm “`Definitive TRIP`” (FNo `536`) with the lock-out input “`>Lockout SET`”, so that the lock-out function is not established when an automatic reclosure is still expected to come.

In the most simple case the output alarm “`LOCKOUT`” (FNo 530) can be allocated to the output which trips the circuit-breaker without creating further links. Then the tripping command is sealed until the lock-out is reset via the binary reset input. Naturally it has to be ensured in advance that the close coil at the circuit breaker — as is usually done — is locked as long as a tripping command is maintained.

The output alarm “`LOCKOUT`” can also be applied to interlock certain closing commands (externally or via CFC), e.g. by combining the output alarm with the binary input “`>Close Cmd. Blk`” (FNo `357`) or by connecting the inverted alarm with the bay interlocking of the feeder.

The reset input “`>Lockout RESET`” (FNo `386`) resets the interlocking state. This input is initiated by an external device which is protected against unauthorized or unintentional operation. The lock-out state can also be reset by internal sources, e.g. a function key, operation of the device or using DIGSI® 4 on a PC.

For each case please make sure the corresponding logical combinations, security measures, etc. are taken into account for the routing of the binary inputs and outputs (Section 5.2) and are also considered for the setting of user-defined logic functions (Section 5.3), if necessary.

Breaker Tripping Alarm Suppression

While on feeder without automatic reclosure every trip command by a protection function is final, it is desirable, when using automatic reclosure, to prevent the operation detector of the circuit-breaker (intermediate contact on the breaker) from sending an alarm if the trip of the breaker is not final (Figure 6-144).

For this purpose, the signal from the circuit-breaker is routed via a correspondingly allocated output contact of the 7SA6 (output alarm “`CB Alarm Supp`”, FNo `563`). In the idle state and when the device is turned off, this contact shall be closed. Therefore an output contact with a normally closed contact (NC contact) has to be allocated. Which contact is to be allocated is dependent on the device version. Refer to General Diagrams in Appendix A, Subsection A.2.

Prior to the command, with the internal automatic reclosure in the ready state, the contact in open so that no signal from the circuit-breaker is forwarded. This is only the case if the device is equipped with internal automatic reclosure and if this was taken into consideration when configuring the protection functions (Section 5.1, address `0133`).

Also when closing the breaker via the binary input “`>Manual Close`” (FNo `356`) or via the integrated automatic reclosure the contact is interrupted so that no breaker alarm can be sent.

Further optional closing commands which are not sent via the device cannot be taken into consideration. Closing commands for control can be linked to the alarm suppression via the user-defined logic functions (CFC).

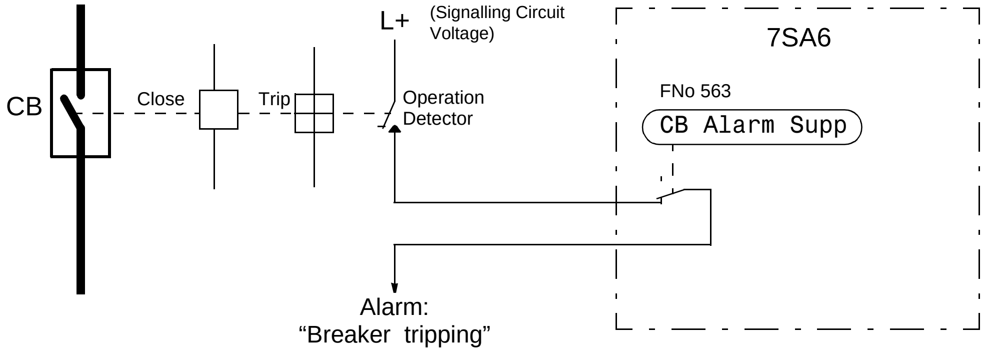


Figure 6-144 Breaker tripping alarm suppression

If the device issues a final trip command, the contact remains closed. This is the case, during the reclaim time of the automatic reclosure cycle, when the automatic reclosure is blocked or switched off or, due to other reasons is not ready for automatic reclosure (e.g. tripping only occurred after the action time expired).

Figure 6-145 shows time diagrams for manual trip and close as well as for protection tripping with an unsuccessful automatic reclosure.

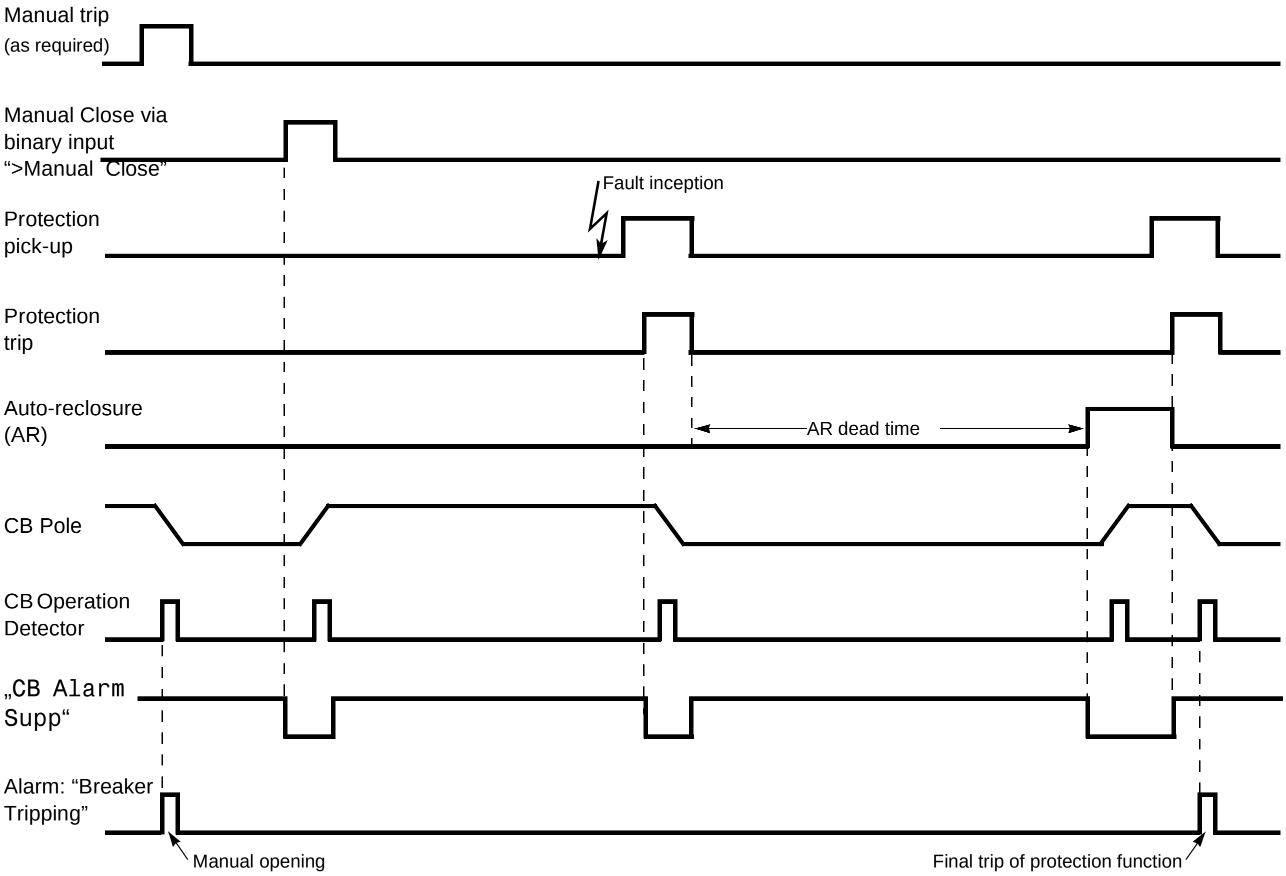


Figure 6-145 Breaker tripping alarm suppression — sequence examples

Trip Dependent Messages

The latching of fault messages, allocated to the device LEDs and the storage of spontaneous messages after tripping may be made dependant on whether the device has issued a trip command. This information is then not output if during a system disturbance one or more protection functions have picked up, but no tripping by the 7SA6 resulted because the fault was cleared by a different device (e.g. on another line). In this manner, these messages are restricted to faults occurring on the protected feeder (“no trip – no flag”).

Figure 6-146 shows the logic diagram of this function.

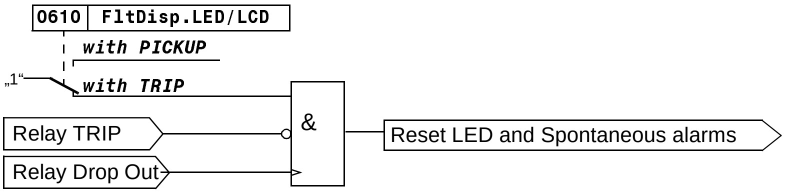


Figure 6-146 Logic diagram of the trip dependent messages

Switching Statistics

The number of trips initiated by the device 7SA6 are counted. If the device is capable of single-pole tripping, a separate counter for each circuit breaker pole is provided.

Following each trip command the device registers the value of each phase current that was switched off in each pole. This information is then provided in the trip log and accumulated in a register. The maximum current that was switched off is also stored.

If the device is equipped with the integrated automatic reclosure, the automatic close commands are also counted, separately for reclosure after single-pole tripping, after three-pole tripping as well as separately for the first reclosure cycle and other reclosure cycles.

The counter and register contents are protected against loss of auxiliary voltage. They may be set to zero or any other initial value. Further information can be obtained in Subsection 7.1.2.

6.20.5 Circuit Breaker Trip Test

The distance protection 7SA6 allows for convenient testing of the trip circuits and the circuit breaker.

The test programs as shown in Table 6-14 are available. The single-pole tests are naturally only available if the device at hand allows for single-pole tripping. The listed output alarms must be allocated to the corresponding command relays, used for the operation of the circuit breaker trip and close coils, during marshalling as stated in Sub-section 5.2.4.

The test is initiated via the keypad and display on the front of the device or from a PC with DIGSI® 4. The procedure is described in Section 7.3. Figure 6-147 shows the sequence of a trip/close test cycle. The timer setting values are according to Sub-section 6.1.1 for “Trip/Close Command Duration” and “Circuit Breaker Test”.

If the auxiliary contacts of the circuit breaker or the individual circuit breaker poles indicate the position of the circuit breaker via the binary inputs, the test cycle can only be started when the circuit breaker is closed.

The information regarding the position of the circuit breaker is not automatically derived from the position logic according to Sub-section 6.20.2 (Figure 6-141). For the circuit breaker test function there are separate binary inputs for the switching status feedback of the circuit breaker position. These must be taken into consideration when allocating the binary inputs as mentioned in Section 6.20.2 (Page 6-270).

The alarms of the device show the respective state of the test sequence.

Table 6-14 Circuit breaker test programs

Seq. No.	Test cycles	CB	Output alarm
1	1 pole TRIP/CLOSE cycle pole L1	CB 1	`CB1-TESTtrip L1` (7325)
2	1pole TRIP/CLOSE cycle pole L2		`CB1-TESTtrip L2` (7326)
3	1pole TRIP/CLOSE cycle pole L3		`CB1-TESTtrip L3` (7327)
4	3pole TRIP/CLOSE cycle		`CB1-TESTtrip123` (7328)
	applicable close command		`CB1-TEST close` (7329)

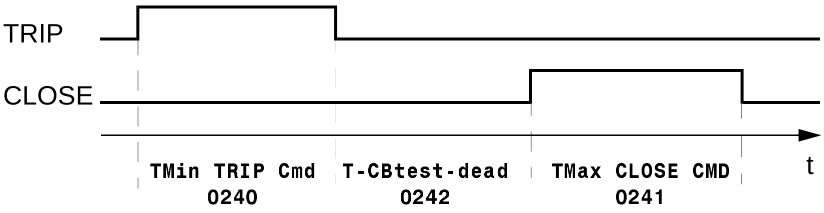


Figure 6-147 Trip/Close test cycle

6.20.6 Applying the Function Parameter Settings

The configuration concerning the tripping logic of the device as a whole and circuit-breaker test function was already set in accordance with the general data in Subsection 6.1.3 and 6.1.1.

Furthermore, the setting in address **0610 FltDisp.LED/LCD**, determines whether the fault messages which are allocated to the local LEDs as well as the spontaneous messages that are displayed via the LCD on the front of the device following a fault, are stored following each fault detection of a protection function (***with PICKUP***), or if storage only takes place if a trip command is issued (***with TRIP*** = “No trip no flag”-feature).

6.20.7 Settings

Fault display

Addr.	Setting Title	Setting Options	Default Setting	Comments
610	FltDisp.LED/LCD	Display Targets on every Pickup Display Targets on TRIP only	Display Targets on every Pickup	Fault Display on LED / LCD
615	Spont. FltDisp.	NO YES	NO	Spontaneous display of flt.annunciations

6.20.8 Information Overview

Circuit-breaker test

F.No.	Alarm	Comments
7325	CB1-TESTtrip L1	CB1-TEST TRIP command - Only L1
7326	CB1-TESTtrip L2	CB1-TEST TRIP command - Only L2
7327	CB1-TESTtrip L3	CB1-TEST TRIP command - Only L3
7328	CB1-TESTtrip123	CB1-TEST TRIP command L123
7329	CB1-TEST close	CB1-TEST CLOSE command
7345	CB-TEST running	CB-TEST is in progress
7346	CB-TSTstop FLT.	CB-TEST canceled due to Power Sys. Fault
7347	CB-TSTstop OPEN	CB-TEST canceled due to CB already OPEN
7348	CB-TSTstop NOTr	CB-TEST canceled due to CB was NOT READY
7349	CB-TSTstop CLOS	CB-TEST canceled due to CB stayed CLOSED
7350	CB-TST .OK.	CB-TEST was succesful
	CB1tst L1	CB1-TEST trip/close - Only L1
	CB1tst L2	CB1-TEST trip/close - Only L2
	CB1tst L3	CB1-TEST trip/close - Only L3
	CB1tst 123	CB1-TEST trip/close Phases L123

6.21 Supplementary Functions

The auxiliary functions of the 7SA6 relay include:

- processing of messages,
- processing of operational measured values,
- storage of fault record data.

6.21.1 Processing of Messages

For the detailed fault analysis, the information regarding the reaction of the protection device and the measured values following a system fault are of interest. For this purpose, the device provides information processing which operates in a threefold manner:

Indicators (LEDs) and Binary Outputs (Output Relays)

Important events and states are indicated with optical indicators (LED) on the front plate. The device furthermore has output relays for remote indication. Most of the signals and indications can be marshalled, i.e. routing can be changed from the presetting with delivery. In Chapter 5 and Appendix A the state of the delivered relay (presetting) and marshalling facilities are extensively discussed.

The output relays and the LEDs may be operated in a latched or unlatched mode (each may be individually set).

The latched state is saved against loss of auxiliary supply. It is reset:

- locally by operation of the key LED reset on the front of the device,
- from remote via a binary input,
- via one of the serial interfaces,
- automatically on detection of a new fault.

Condition messages should not be latched. Also, they cannot be reset until the criterion to be reported has reset. This applies to e.g. messages from monitoring functions, or similar.

A green LED indicates that the device is in service (“RUN”); it can not be reset. It extinguishes if the self-monitoring of the microprocessor recognizes a fault or if the auxiliary supply fails.

In the event that the auxiliary supply is available while there is an internal device failure, the red LED (“ERROR”) is illuminated and the device is blocked.

Information via Integrated Display (LCD) or a Personal Computer

Events and states can be obtained from the LCD on the front plate of the device. A personal computer can be connected to the front interface or the service interface for retrieval of the information.

In the quiescent state, i.e. as long as no system fault is present, the LCD can display selectable operational information (overview of the operational measured values). In the event of a system fault, information regarding the fault, the so-called spontaneous messages, are displayed instead. The quiescent state information is displayed again once the fault messages have been acknowledged. The acknowledgement is identical to the resetting of the LEDs (see above).

The device in addition has several event buffers for operational messages, switching statistics, etc., which are saved against loss of auxiliary supply by means of a battery buffer. These messages can be displayed on the LCD at any time by selection via the keypad or transferred to a personal computer via the serial service or PC interface. The retrieval of events/alarms during operation is extensively described in Subsection 7.1.1.

Following a system fault, it is possible to for example retrieve important information regarding its progress, such as pick-up and trip. The start of the fault is time stamped with the absolute time of the internal system clock. The progress of the disturbance is output with a relative time referred to the instant of fault detection, so that the duration of the fault until tripping and up to reset of the trip command can be ascertained. The resolution of the time information is 1 ms.

With a PC and the protection data processing program DIGSI® 4 it is also possible to retrieve and display the events with the convenience of visualisation on a monitor and a menu-guided dialogue. The data may be printed or stored for evaluation at a later time and place.

The protection device stores the messages of the last eight system faults; in the event of a ninth fault, the oldest is erased.

A system fault starts with the recognition of the fault by the fault detection of any protection function and ends with the reset of the fault detection of the last protection function or after the expiry of the auto-reclose reclaim time, so that several unsuccessful auto-reclose cycles are also stored cohesively. Accordingly a system fault may contain several individual fault events (from fault detection up to reset of fault detection).

Information to a Control Centre

If the device has a serial system interface, stored information may additionally be transferred via this interface to a centralised control and storage device. Several communication protocols are available for the transfer of this information.

6.21.2 Operational Measurement

Display of Measured Values

A range of measured values and values derived from these are available continuously for local display or data transfer (refer to Table 6-15).

A precondition for the correct display of primary and percentage values is the complete and correct entry of the instrument transformer and plant rated values, as well as the transformation ratios of the current and voltage transformers in the earth connections according to Sub-section 6.1.1.

Depending on the ordering code and the manner of connection to the device, only a portion of the listed operational measured values in Table 6-15 may be available. Of the current values I_{EE}, I_Y und I_P only the one which is connected to the current measuring input I_4 can apply. The phase-earth voltages can be measured if the voltage inputs phase-earth are connected. The displacement voltage $3U_0$ is the e–n voltage U_{en}, usually multiplied by $\sqrt{3}$ (setting address 0211, **Uph / Udelta**) — if U_{en} is connected — or derived from the phase–earth voltages $3U_0 = |\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}|$. The three phase–earth voltage inputs must be connected for this.

For the thermal overload protection the calculated overtemperatures are indicated in relation to the trip overtemperature.

If the device is provided with the synchronism and voltage check, the characteristic values (voltages, frequencies, differences) can be read out.

If the device is provided with the earth fault detection function for non-earthed systems, the components of the earth current (active and reactive component) are indicated, as well.

Table 6-15 Operational measured values

Measured values		**primary**	**secondary**	**% in relation to**
I_{L1}, I_{L2}, I_{L3}	phase currents	A	A	rated operational current 1)
$3I_0$	earth currents	A	A	rated operational current 1)
I_1, I_2	pos. and neg. seq. currents	A	A	rated operational current 1)
$3I0_{sen}$	sensitive earth current	A	mA	rated operational current 1) 3)
I_Y, I_P	transformer star point current or earth current in the parallel line	A	A	rated operational current 1) 3)
U_{L1-L2}, U_{L2-L3}, U_{L3-L1}	line voltages	kV	V	rated operational voltage 2)
U_{L1-E}, U_{L2-E}, U_{L3-E}	phase-earth voltages	kV	V	rated operational voltage / $\sqrt{3}$ 2)
$3U_0$	displacement voltage	kV	V	rated operational voltage $\cdot\sqrt{3}$ 2) 4)
U_X	voltage at the measuring input U_4	kV	V	rated operational voltage / $\sqrt{3}$ 2)
U_1, U_2	pos. and neg. seq. voltages	kV	V	rated operational voltage / $\sqrt{3}$ 2)
R_{L1-E}, R_{L2-E}, R_{L3-E} R_{L1-L2}, R_{L1-L2}, R_{L3-L1}	operational resistances of all conductor loops	Ω	Ω	—
X_{L1-E}, X_{L2-E}, X_{L3-E} X_{L1-L2}, X_{L2-L3}, X_{L3-L1}	operational reactances of all conductor loops	Ω	Ω	—
S, P, Q	apparent, real, and reactive power	MVA, MW, MVAR	—	$\sqrt{3}\cdot U_N\cdot I_N$ rated operational values 1) 2)
cos φ	power factor	(abs)	(abs)	—
f	frequency	Hz	Hz	rated frequency
$\Theta_{L1}/\Theta_{trip}$, $\Theta_{L2}/\Theta_{trip}$, $\Theta_{L3}/\Theta_{trip}$	thermal value of each line related to trip value	—	—	overtemperature
Θ/Θ_{trip}	thermal value, related to trip value, calculated acc. to the configured method	—	—	overtemperature
U_{line}, U_{sync}, U_{diff}	line voltage, busbar voltage and voltage magnitude difference (for synchro-check)	kV	—	—
f_{line}, f_{sync}, f_{diff}	line voltage, busbar voltage and frequency difference (for synchronism check)	Hz	—	—

1) acc. to address `1104` (refer to Sub-section 6.1.3) 2) acc. to address `1103` (refer to Sub-section 6.1.3)

3) with consideration of the factor `0221 I4/Iph CT` (refer to Sub-section 6.1.1)

Table 6-15 Operational measured values

Measured values		primary	secondary	% in relation to
φ_{diff}	magnitude of the phase angle difference between line and busbar (for sychronism check)	°	—	—
I_{EEa}, I_{EEr}	active and reactive component of earth fault current	A	mA	—

[1]) acc. to address `1104` (refer to Sub-section 6.1.3) [2]) acc. to address `1103` (refer to Sub-section 6.1.3)

[3]) with consideration of the factor `0221 I4/Iph CT` (refer to Sub-section 6.1.1)

The computation of the operational measured values is also executed during an existent system fault in intervals of approx. 0.5 s.

Min/Max Values and Average Values

Minimum, maximum and long-term average values are calculated by the 7SA6. Time and date of the last update of the values can also be read out. At any time the min/max values can be reset via binary inputs, via DIGSI® 4 or via the integrated control panel. Additionally, the reset can be carried out cyclically, beginning with a preset point of time.

The time period of the average value window and the number of updates can be set for the long-term average values. The corresponding min/max values can be reset via binary inputs, via DIGSI® 4 or via the integrated control panel.

For an overview of the minimum, maximum and average values as well as their meaning please refer to Subsection 6.21.6, “Average Calculation” and “Min/Max Values”

Limit Value / Set Point Monitoring

Use to detect about operating conditions. If a preset limit value / set point is exceeded, an alarm is generated. This alarm can also be allocated to output relays and LEDs. In contrast to the actual protection functions the monitoring function operates in the background; therefore it may not pick up if measured values are changed spontaneously in the event of a fault and if protection functions are picked up. Since an alarm is only output in case the limit value / set point is exceeded more than once, the monitoring process cannot pick up directly before a trip.

Set points can be set for the following measured and metered values:

- IL1dmd>: exceeding a preset maximum average value in phase L1.
- IL2dmd>: exceeding a preset maximum average value in phase L2.
- IL3dmd>: exceeding a preset maximum average value in phase L3.
- I1dmd>: exceeding a preset maximum average value of the positive sequence system currents.
- |Pdmd|>: exceeding a preset maximum average value of the active power magnitude.
- |Qdmd|>: exceeding a preset maximum average value of the reactive power magnitude.
- Sdmd>: exceeding a preset maximum average value of the apparent power.
- |cosφ|<: untershooting a preset magnitude of the power factor

6.21.3 Data Storage for Fault Recording

The distance protection 7SA6 has a fault recording memory. The instantaneous values of the measured signals

i_{L1}, i_{L2}, i_{L3}, i_E or i_{EE}, and u_{L1}, u_{L2}, u_{L3}, u_{en}

(voltages according to type of connection) are sampled at an interval of 1 ms (at 50 Hz) respectively 0.83 ms (at 60 Hz), and stored in a circular shift register (20 samples per cycle). In the event of a fault the data is memorized for a selectable period of time, not exceeding 5 s per fault. In a total period of approx. 15 s up to 8 fault recordings can be memorized. The recording memory is automatically updated in the event of a new system fault, thereby not requiring an acknowledgment. In addition to storage of the fault recording by the protection fault detection, a recording may also be initiated via binary input, the integrated keypad and display, or via the serial PC or service interface.

The data can be retrieved via the serial interfaces by means of a personal computer and evaluated with the protection data processing program DIGSI® 4 and the graphic analysis software DIGRA 4. The latter graphically represents the data recorded during the system fault and calculates additional information such as the impedance or RMS values from the measured values. A selection may be made as to whether the currents and voltages are represented as primary or secondary values. Binary signal traces (marks) of particular events e.g. “fault detection”, “tripping” are also represented.

If the device has a serial system interface, the fault recording data can be passed on to a central device via this interface. The evaluation of the data is done by applicable programs in the central device. Currents and voltages are referred to their maximum values, scaled to their rated values and prepared for graphic representation. In addition, internal events are recorded as binary traces (marks), e.g. “fault detection”, “tripping”.

In the event of transfer to a central device, the request for data transfer can be executed automatically and can be selected to take place after each fault detection by the protection, or only after a trip.

6.21.4 Applying the Function Parameter Settings

Minimum, Maximum and Average Values

In addresses 8311 to 8314 you can determine the time intervals for the calculation of minimum, maximum and average values.

The tracking of minimum and maximum values can be reset automatically at a predefinied point in time. To select this feature, address 8311 **MinMax cycRESET** is set to ***Yes***. The point in time when reset is to take place (the minute of the day in which reset will take place) is set in address 8312 **MiMa RESET TIME**. The reset cycle (in days) is entered at address 8313 **MiMa RESETCYCLE**, and the date for starting the cyclical process in days after completion of the configuration procedure is entered in address 8314 **MinMaxRES.START**.

The time interval for measured value averaging is set at address 8301 **DMD Interval**. The first number specifies the averaging time window in minutes while the second number determines the number of updates within the time window. A setting of ***15 Min., 3 Subs***, for example, means that time averaging occurs for all measured values that arrive within 15 minutes, and that output is updated three times during the 15 minute window, or every 15/3 = 5 minutes.

Determine in address 8302 **DMD Sync.Time** whether the selected time period for the averaging is to begin on the hour (***On The Hour***) or if it is to be synchronized with a different point in time (***15 After Hour***, ***30 After Hour*** or ***45 After Hour***).

If the settings for averaging are changed, then the measured values stored in the buffer are deleted, and new results for the average calculation are only available after the set time period has passed.

Limit Values

The settings are entered under **Measurement (Measurement)** in the sub-menu **SET POINTS (MV)** by overwriting the existing values.

Data Storage for Fault Recording

The configuration of the fault recording memory is done in the sub-menu **Fault recording** of the menu **PARAMETER**. A distinction is made between the reference instant (relative time = 0) and the storage criterion (trigger) of the fault recording (address **402A WAVEFORMTRIGGER**). This setting can only be changed with DIGSI® 4 under "**Additional Settings**". Normally the reference instant is the occurrence of device fault detection, i.e. the fault detection of any protection function is allocated with the time stamp 0. The fault detection can also be the storage criterion (***Save w. Pickup***) or the device trip command (***Save w. TRIP***) can be the storage criterion. The device trip command can also be used as reference time (***Start w. TRIP***); in this case it is also the storage criterion.

A fault event starts with the fault detection of any protection function and ends with the reset of the last fault detection. Usually this is also the extent of a fault recording (address **403A WAVEFORM DATA** = ***Fault event***). If automatic reclosure is implemented, the entire system disturbance — possibly with several reclose attempts — up to the ultimate fault clearance can be stored (address **403A WAVEFORM DATA** = ***Power System fault***). This facilitates the representation of the entire system fault history, but also consumes storage capacity during the auto-reclosure dead time(s). This setting can only be changed with DIGSI® 4 under "**Additional Settings**".

The actual storage time encompasses the pre-fault time **PRE. TRIG. TIME** (address **411**) ahead of the reference instant, the normal recording time and the post-fault time **POST REC. TIME** (address **412**) after the storage criterion has reset. The maximum permissible storage period per fault recording **MAX. LENGTH** is set in address **410**.

The fault recording can also be triggered via a binary input, via the keypad on the front of the device or with a PC via the operation or service interface. The storage is then dynamically triggered. The length of the fault recording is set in address **415 BinIn CAPT.TIME** (maximum length however is **MAX. LENGTH**, address **410)**. The pre- and post-fault times are additive. If the time for the binary input is set to ∞, the duration of the storage is as long as the binary input is initiated (static), the maximum length however still is **MAX. LENGTH** (address **410**).

6.21.5 Settings

Average Calculation

Addr.	Setting Title	Setting Options	Default Setting	Comments
2801	DMD Interval	15 Min per., 1 Sub 15 Min per., 3 Subs 15 Min per., 15 Subs 30 Min per., 1 Sub. 60 Min per., 1 Sub.	60 Min per., 1 Sub.	Demand Calculation Intervals
2802	DMD Sync.Time	On the Hour 15 Min. after Hour 30 Min. after Hour 45 Min. after Hour	On the Hour	Demand Synchronization Time

Min/Max Values

Addr.	Setting Title	Setting Options	Default Setting	Comments
2811	MinMax cycRESET	NO YES	YES	Automatic Cyclic Reset Function
2812	MiMa RESET TIME	0..1439 min; Ø	0 min	MinMax Reset Timer
2813	MiMa RESETCYCLE	1..365 day(s)	7 day(s)	MinMax Reset Cycle Period
2814	MinMaxRES.START	1..365 Days	1 Days	MinMax Start Reset Cycle in

Waveform Capture

Addr.	Setting Title	Setting Options	Default Setting	Comments
402A	WAVEFORMTRIGGER	Save with Pickup Save with TRIP Start with TRIP	Save with Pickup	Waveform Capture
403A	WAVEFORM DATA	Fault event Power System fault	Fault event	Scope of Waveform Data
410	MAX. LENGTH	0.30..5.00 sec	1.00 sec	Max. length of a Waveform Capture Record
411	PRE. TRIG. TIME	0.05..0.50 sec	0.10 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	0.05..0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	0.10..5.00 sec; ∞	0.50 sec	Capture Time via Binary Input

6.21.6 Information Overview

Average Calculation

F.No.	Alarm	Comments
963	IL1dmd=	I L1 demand
964	IL2dmd=	I L2 demand
965	IL3dmd=	I L3 demand
833	I1dmd =	I1 (positive sequence) Demand
834	Pdmd =	Active Power Demand
1052	Pdmd Forw=	Active Power Demand Forward
1053	Pdmd Rev =	Active Power Demand Reverse
835	Qdmd =	Reactive Power Demand
1054	Qdmd Forw=	Reactive Power Demand Forward
1055	Qdmd Rev =	Reactive Power Demand Reverse
836	Sdmd =	Apparent Power Demand

Min/Max Values

F.No.	Alarm	Comments
395	>I MinMax Reset	>I MIN/MAX Buffer Reset
396	>I1 MiMaReset	>I1 MIN/MAX Buffer Reset
397	>U MiMaReset	>U MIN/MAX Buffer Reset
398	>UphphMiMaRes	>Uphph MIN/MAX Buffer Reset
399	>U1 MiMa Reset	>U1 MIN/MAX Buffer Reset
400	>P MiMa Reset	>P MIN/MAX Buffer Reset
401	>S MiMa Reset	>S MIN/MAX Buffer Reset
402	>Q MiMa Reset	>Q MIN/MAX Buffer Reset
403	>Idmd MiMaReset	>Idmd MIN/MAX Buffer Reset
404	>Pdmd MiMaReset	>Pdmd MIN/MAX Buffer Reset
405	>Qdmd MiMaReset	>Qdmd MIN/MAX Buffer Reset
406	>Sdmd MiMaReset	>Sdmd MIN/MAX Buffer Reset
407	>Frq MiMa Reset	>Frq. MIN/MAX Buffer Reset
408	>PF MiMaReset	>Power Factor MIN/MAX Buffer Reset
837	IL1d Min	I L1 Demand Minimum
838	IL1d Max	I L1 Demand Maximum
839	IL2d Min	I L2 Demand Minimum
840	IL2d Max	I L2 Demand Maximum

F.No.	Alarm	Comments
841	IL3d Min	I L3 Demand Minimum
842	IL3d Max	I L3 Demand Maximum
843	I1dmdMin	I1 (positive sequence) Demand Minimum
844	I1dmdMax	I1 (positive sequence) Demand Maximum
845	PdMin=	Active Power Demand Minimum
846	PdMax=	Active Power Demand Maximum
847	QdMin=	Reactive Power Demand Minimum
848	QdMax=	Reactive Power Demand Maximum
849	SdMin=	Apparent Power Demand Minimum
850	SdMax=	Apparent Power Demand Maximum
851	IL1Min=	I L1 Minimum
852	IL1Max=	I L1 Maximum
853	IL2Min=	I L2 Mimimum
854	IL2Max=	I L2 Maximum
855	IL3Min=	I L3 Minimum
856	IL3Max=	I L3 Maximum
857	I1 Min=	Positive Sequence Minimum
858	I1 Max=	Positive Sequence Maximum
859	UL1EMin=	U L1E Minimum
860	UL1EMax=	U L1E Maximum
861	UL2EMin=	U L2E Minimum
862	UL2EMax=	U L2E Maximum
863	UL3EMin=	U L3E Minimum
864	UL3EMax=	U L3E Maximum
865	UL12Min=	U L12 Minimum
867	UL12Max=	U L12 Maximum
868	UL23Min=	U L23 Minimum
869	UL23Max=	U L23 Maximum
870	UL31Min=	U L31 Minimum
871	UL31Min=	U L31 Maximum
10102	3U0min =	3U0min =
10103	3U0max =	3U0max =
874	U1 Min =	U1 (positive sequence) Voltage Minimum
875	U1 Max =	U1 (positive sequence) Voltage Maximum
1040	Pmin Forw=	Active Power Minimum Forward
1041	Pmax Forw=	Active Power Maximum Forward

F.No.	Alarm	Comments
841	IL3d Min	I L3 Demand Minimum
842	IL3d Max	I L3 Demand Maximum
843	I1dmdMin	I1 (positive sequence) Demand Minimum
844	I1dmdMax	I1 (positive sequence) Demand Maximum
845	PdMin=	Active Power Demand Minimum
846	PdMax=	Active Power Demand Maximum
847	QdMin=	Reactive Power Demand Minimum
848	QdMax=	Reactive Power Demand Maximum
849	SdMin=	Apparent Power Demand Minimum
850	SdMax=	Apparent Power Demand Maximum
851	IL1Min=	I L1 Minimum
852	IL1Max=	I L1 Maximum
853	IL2Min=	I L2 Mimimum
854	IL2Max=	I L2 Maximum
855	IL3Min=	I L3 Minimum
856	IL3Max=	I L3 Maximum
857	I1 Min=	Positive Sequence Minimum
858	I1 Max=	Positive Sequence Maximum
859	UL1EMin=	U L1E Minimum
860	UL1EMax=	U L1E Maximum
861	UL2EMin=	U L2E Minimum
862	UL2EMax=	U L2E Maximum
863	UL3EMin=	U L3E Minimum
864	UL3EMax=	U L3E Maximum
865	UL12Min=	U L12 Minimum
867	UL12Max=	U L12 Maximum
868	UL23Min=	U L23 Minimum
869	UL23Max=	U L23 Maximum
870	UL31Min=	U L31 Minimum
871	UL31Min=	U L31 Maximum
10102	3U0min =	3U0min =
10103	3U0max =	3U0max =
874	U1 Min =	U1 (positive sequence) Voltage Minimum
875	U1 Max =	U1 (positive sequence) Voltage Maximum
1040	Pmin Forw=	Active Power Minimum Forward
1041	Pmax Forw=	Active Power Maximum Forward

F.No.	Alarm	Comments
1042	Pmin Rev =	Active Power Minimum Reverse
1043	Pmax Rev =	Active Power Maximum Reverse
1044	Qmin Forw=	Reactive Power Minimum Forward
1045	Qmax Forw=	Reactive Power Maximum Forward
1046	Qmin Rev =	Reactive Power Minimum Reverse
1047	Qmax Rev =	Reactive Power Maximum Reverse
880	SMin=	Apparent Power Minimum
881	SMax=	Apparent Power Maximum
882	fMin=	Frequency Minimum
883	fMax=	Frequency Maximum
1048	PFminForw=	Power Factor Minimum Forward
1049	PFmaxForw=	Power Factor Maximum Forward
1050	PFmin Rev=	Power Factor Minimum Reverse
1051	PFmax Rev=	Power Factor Maximum Reverse

Limit Values

F.No.	Alarm	Comments
	IL1dmd>	Upper setting limit for IL1dmd
	IL2dmd>	Upper setting limit for IL2dmd
	IL3dmd>	Upper setting limit for IL3dmd
	I1dmd>	Upper setting limit for I1dmd
	|Pdmd|>	Upper setting limit for Pdmd
	|Qdmd|>	Upper setting limit for Qdmd
	Sdmd>	Upper setting limit for Sdmd
273	SP. IL1 dmd>	Set Point Phase L1 dmd>
274	SP. IL2 dmd>	Set Point Phase L2 dmd>
275	SP. IL3 dmd>	Set Point Phase L3 dmd>
276	SP. I1dmd>	Set Point positive sequence I1dmd>
277	SP. |Pdmd|>	Set Point |Pdmd|>
278	SP. |Qdmd|>	Set Point |Qdmd|>
279	SP. |Sdmd|>	Set Point |Sdmd|>
	PF<	Lower setting limit for Power Factor
285	cosφ alarm	Power factor alarm

Waveform Capture

F.No.	Alarm	Comments
4	>Trig.Wave.Cap.	>Trigger Waveform Capture
203	Wave. deleted	Waveform data deleted
	FltRecSta	Fault Recording Start

6.22 Processing of Commands

General

In addition to the protective functions described so far, a control command process is integrated in the SIPROTEC® 7SA6 to coordinate the operation of circuit breakers and other equipment in the power system. Control commands can originate from four command sources:

– Local operation using the keypad on the local user interface of the device

– Local or remote operation using DIGSI® 4

– Remote operation via system interface IEC (e.g. SICAM)

– Automatic functions (e.g. using a binary input)

The number of switchgear devices that can be controlled is basically limited by the number of available and required binary inputs and outputs. For the output of control commands it has be ensured that all the required binary inputs and outputs are configured and provided with the correct properties (see also Subsection 5.2.4 under “Binary outputs for switchgear”).

If specific interlocking conditions are needed for the execution of commands, the user can program the device with bay interlocking by means of the user-defined logic functions (CFC) (see Section 5.3).

6.22.1 Types of commands

Two types of commands can be issued with this device:

– Control commands

– Internal / pseudo commands

Control Commands

These commands operate binary outputs and change the power system status:

– Commands for the operation of circuit breakers (asynchronous; the synchro-check can be implemented via CFC by applying the synchronism check and closing control function) as well as commands for the control of isolators and earth switches,

– Step commands, e.g. for raising and lowering transformer taps

– Tap change commands with configurable time settings (Petersen coils)

Internal / Pseudo Commands

These commands do not directly operate binary outputs. They serve to initiate internal functions, simulate or acknowledge changes of state.

– Manual entry execution to change the feedback indication of plant such as the status and switching condition, for example in the case of the physical connection to the auxiliary contacts is not available. A manual entry execution is captured and can be diplayed accordingly.

– Additionally, tagging commands can be issued to establish internal settings, such as switching authority (remote / local), parameter set changeover, data transmission inhibit and metering counter reset or initialization.

– Acknowledgment and resetting commands for setting and resetting internal buffers.

- Status information commands for setting / deactivating the “information status” for the information value of an object:
  - Controlling activation of binary input status
  - Blocking binary outputs

6.22.2 Steps in the Command Sequence

Safety mechanisms in the command sequence ensure that a command can only be released after a thorough check of preset criteria has been successfully concluded. Additionally, user-defined interlocking conditions can be configured separately for each device. The actual execution of the command is also monitored afterwards. The entire sequence of a command is described briefly in the following:

Check Sequence

- Command entry (e.g. using the keypad on the local user interface of the device)
  - Check password → access rights
  - Check switching mode (interlocking activated/deactivated) → selection of deactivated interlocking status
- User configurable interlocking checks that can be selected for each command
  - Switching authority (local, remote)
  - Switching direction control (target state = present state)
  - Zone controlled/bay interlocking (logic using CFC)
  - System interlocking (centrally via SICAM)
  - Double operation (interlocking against parallel switching operation)
  - Protection blocking (blocking of switching operations by protective functions)
- Fixed commands
  - Timeout monitoring (time between command initiation and the beginning of the execution can be controlled).
  - Configuration in process (if setting modification is in process, commands are rejected or delayed)
  - Equipment not present at output (if controllable equipment is not assigned to a binary output, then the command is denied)
  - Output block (if an output block has been programmed for the circuit breaker, and is active at the moment the command is processed, then the command is denied)
  - Component hardware malfunction
  - Command in progress (only one command can be processed at a time for each circuit breaker or switch)
  - 1- out of -n-check (for schemes with multiple assignments, such as common ground, it is checked whether a command has already been initiated for the affected output relay).

Monitoring the Command Execution

- – Interruption of a command because of a cancel command
- – Running time monitor (feedback message monitoring time)

6.22.3 Interlocking

Interlocking is executed by the user-defined logic (CFC). The interlocking checks of a SICAM/SIPROTEC®-system are classified into:

- System interlocking checked by a central control system (for a busbar)
- Zone controlled/bay interlocking checked in the bay device (for the feeder)

System interlocking relies on the system data base in the central control system. Zone controlled/bay interlocking relies on the status of the circuit breaker and other switches that are connected to the relay.

The extent of the interlocking checks is determined by the configuration and interlocking logic of the relay.

Switchgear which is subject to system interlocking in the central control system is marked with a parameter (in the routing matrix)

For all commands the user can select the operation mode with interlocking (normal mode) or without interlocking (test mode):

- – for local commands by reprogramming the settings with password check,
- – for automatic commands via command processing with CFC,

6.22.3.1 Interlocked/Non-Interlocked Switching

The command checks that can be selected for the SIPROTEC®-relays are also referred to as “standard interlocking”. These checks can be activated (interlocked) or deactivated (non interlocked) via DIGSI® 4.

Deactivated interlock switching means the configured interlocking conditions are not checked in the relay.

Interlocked switching means that all configured interlocking conditions are checked in the command check. If a condition could not be fulfilled, the command will be rejected by a message with a minus added to it (e.g. “**CO-**”), immediately followed by an operation response information. Table 6-16 shows some types of commands and messages. For the device the messages designated with *) are displayed in the event logs, for DIGSI® 4 they appear in spontaneous messages.

Table 6-16 types of command and messages

Type of command	Abbrev.	Message
Control issued	CO	CO+/–
Manual tagging (positive / negative)	MT	MT+/–
Input blocking	IB	IB+/– *)
Output blocking	OB	OB+/– *)
Control abortion	CA	CA+/–

The “plus” appearing in the message is a confirmation of the command execution: the command execution was as expected, in other words positive. The “minus” is a negative confirmation, the command was rejected. Figure 6-148 shows the messages relating to command execution and operation response information for a successful operation of the circuit breaker.

The check of interlocking can be programmed separately for all switching devices and tags that were set with a tagging command. Other internal commands such as manual entry or abort are not checked, i.e. carried out independent of the interlocking.

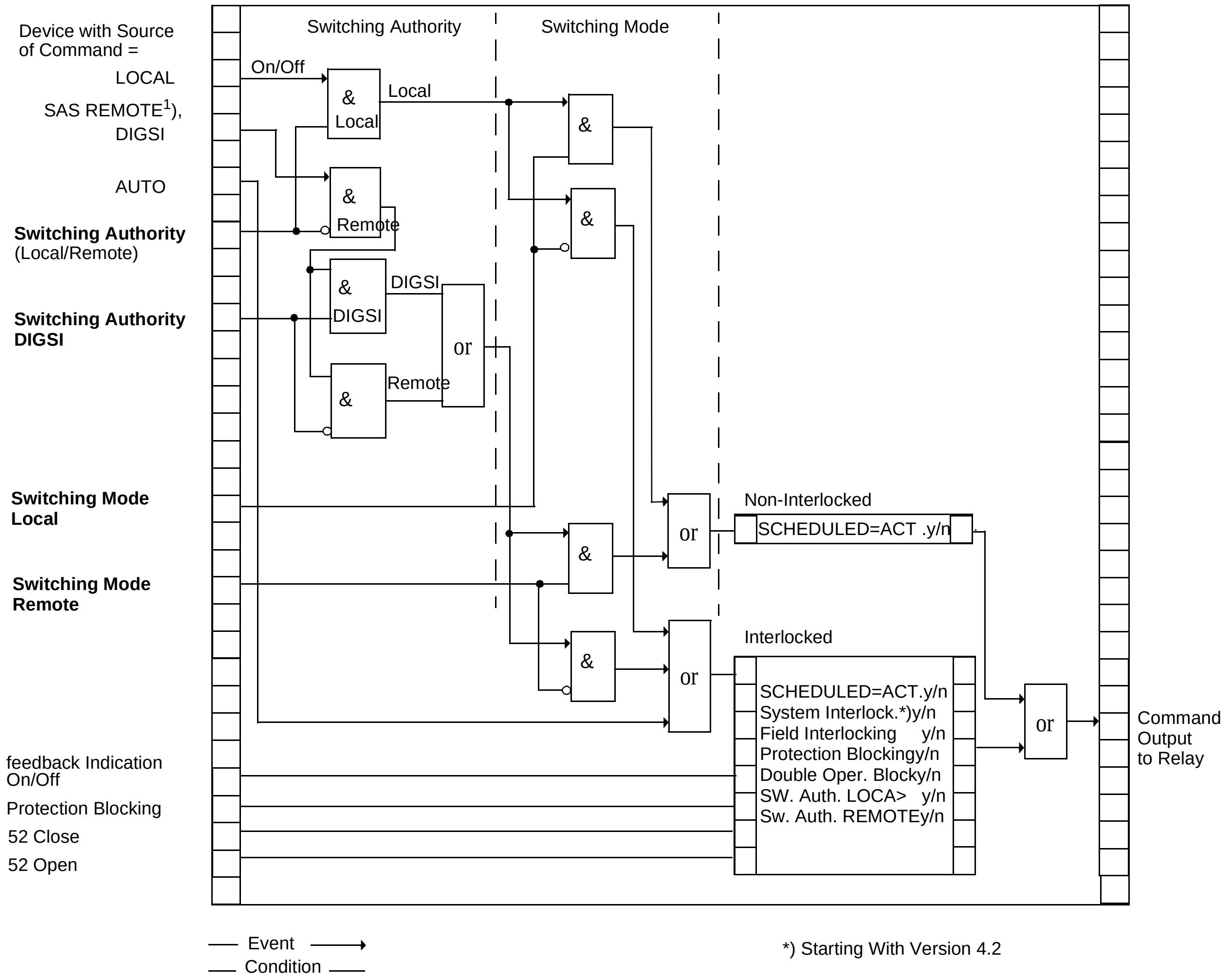
```
EVENT LOG
--------------------
19.06.99 11:52:05,625
Q0          CO+ close

19.06.99 11:52:06,134
Q0          FB+ close
```

Figure 6-148 Example of a message when closing the circuit breaker Q0

Standard Interlocking

The standard interlocking includes the checks for each device which were set during the configuration of inputs and outputs, see Section 5.2.5 under “Binary Outputs for Switching Devices”.

An overview for processing the interlocking conditions in the relay is shown by Figure 6-149.



[1]) Source REMOTE also includes SAS.

LOCAL .. Command via substation controller.

REMOTE Command via telecontrol system to substation controller and from substation controller to device.

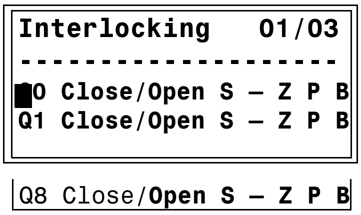
Figure 6-149 Standard Interlocking Arrangements

The display shows the configured interlocking reasons. The are marked by letters explained in the following table 6-17.

Table 6-17 Interlocking commands

Interlocking commands	Abbrev.	Message
Control authorization	L	L
System interlock	S	S
Zone controlled	Z	Z
Target state = present state (check switch position)	P	P
Block by protection	B	B

Figure 6-150 shows all interlocking conditions (which usually appear in the display of the device) for three switchgear items with the relevant abbreviations explained in table 6-17. All parametrized interlocking conditions are indicated (see Figure 6-150).



```
Interlocking   01/03
--------------------
█0 Close/Open S – Z P B
Q1 Close/Open S – Z P B

Q8 Close/Open S – Z P B
```

Figure 6-150 Example of configured interlocking conditions

Control Logic using CFC

For zone controlled/field interlocking, control logic can be programmed, using the CFC. Via specific release conditions the information “released” or “bay interlocked” are available.

6.22.4 Recording and acknowledgement of commands

During the processing of the commands, independent of the further message routing and processing, command and process feedback information are sent to the message processing centre. These messages contain message cause indication. The messages are entered in the event list.

Acknowledgement of commands to the device front

All messages which relate to commands that were issued from the device front “Command Issued = Local” are transformed into a corresponding response and shown in the display of the device.

Acknowledgement of commands to local/remote/Digsi

The messages which relate to commands with the origin “Command Issued = Local/ Remote/DIGSI” must be send independent of the routing (configuration on the serial digital interface) to the initiating point.

The acknowledgement of commands is therefore not executed by a response indication as it is done with the local command but by ordinary command and feedback information recording.

Monitoring of feedback information

The processing of commands monitors the command execution and timing of feedback information for all commands. At the same time the command is sent, the monitoring time is started (monitoring of the command execution). This time controls whether the device achieves the required final result within the monitoring time. The monitoring time is stopped as soon as the feedback information arrives. If no feedback information arrives, a response “Timeout command monitoring time” appears and the process is terminated.

Commands and information feedback are also recorded in the event list. Normally the execution of a command is terminated as soon as the feedback information (FB+) of the relevant switchgear arrives or, in case of commands without process feedback information, the command output resets.

The “plus” appearing in a feedback information confirms that the command was successful, the command was as expected, in other words positive. The “minus” is a negative confirmation and means that the command was not fulfilled as expected.

Command Output and Switching Relays

The command types needed for tripping and closing of the switchgear or for raising and lowering of transformer taps are described in Section 5.2 and Subsection 5.2.1.

Control During Operation

7

This chapter describes interaction possibilities with the SIPROTEC® 7SA6 device during operation. The information that can be obtained and the procedure for retrieving the data are discussed. Methods of influencing the device functions during operation and controlling the system using the device are covered.

Detailed knowledge about the device functions is not required at this point. However, the configuration of the device covered in Chapter 5 — especially configuration of the input and output functions — is assumed to have already taken place.

Please note that the examples shown are general and may differ in wording or details from the device at hand. Also, depending on the model variant, some of the functions discussed below may not be available.

7.1 Read-out of Information

General

The device provides a great deal of information that can be obtained on-site or from data transfer:

- Messages,
- Operating measurement and metered values,
- Waveform data in oscillographic fault records.

This information is individually discussed below. Methods for viewing, retrieving, acknowledging, and storing this information on a PC are also explained.

7.1.1 Messages

7.1.1.1 Output of Messages

Messages provide operating information about the power system, the device, and the measurements. Other messages give an overview of important events such a network fault and the operation of device functions. The information provided is useful in checking overall operation of the device during testing and commissioning.

Password entry is not required to read messages.

The messages generated in the device can be presented in various ways:

- Display using light-emitting diodes (LEDs) on the front of the device,
- Operation of output relays connected to external signalling equipment,
- Display in the LCD on the front of the device,
- Display on the screen of a PC running the DIGSI® 4 program, connected to the operating or service interface of the device,
- Transfer to a master station using one of the serial system interfaces (if available).

Light-Emitting Diodes

The green light-emitting diode with the label “RUN” lights continuously during normal operation.

The red LED with the label “ERROR” indicates that the processor system has recognized an internal problem. If this LED lights up, then the device is not operational. Chapter 9 discusses steps to take if a failure occurs in the device.

The other LEDs on the front of the device display the messages in accordance with the configuration, as discussed in Chapter 5. The description of each LED illumination should then be indicated on the label strips.

If the messages for the LEDs are latched, then the memory can be reset with the LED key **LED**. This key simultaneously serves as a functional check for all of the LEDs except the “RUN” and “ERROR” LEDs. While the key is pressed, all of these LEDs must light.

LEDs that display a condition should light for as long as the condition is maintained. The LED action is therefore generally not latched. Of course, these LEDs are also included in the function check with the LED key **LED**.

Binary Outputs

Indications can be configured to output relays for external indication (e.g. annunciator, sequence-of-events recorder, RTU, etc), and operate like LEDs. See also Chapter 5 for details.

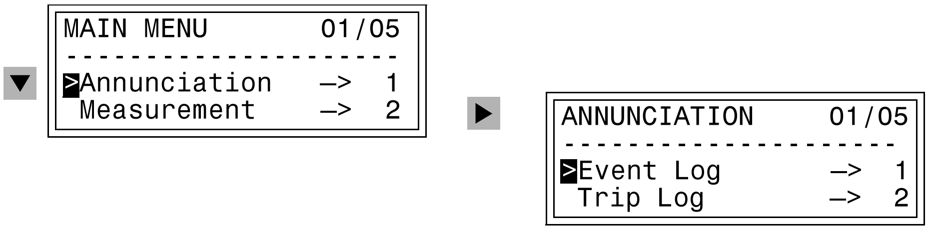
Front Panel

To retrieve messages using the front panel:

First press the **MENU** key MENU. The **MAIN MENU** appears. The first menu item ***Annunciation*** is marked.

All menus and message lists begin with a title. The number in the upper right corner of the display indicates presently selected menu entry or message, and, behind the slash, the total number of menu entries or messages (see Figure 7-1, each first line).

Press the ▶ key to go to the **ANNUNCIATION** sub-menu, as shown in Figure 7-1. In this menu the messages can be reached by entering the associated selection number, or by selecting the desired entry using the ▼ and ▲ keys and moving further with the ▶ key. This procedure is described in more detail below.



```
MAIN MENU        01/05
---------------------
>Annunciation   –>  1
 Measurement    –>  2
```

```
ANNUNCIATION     01/05
--------------------
>Event Log       –>  1
 Trip Log        –>  2
```

Figure 7-1 Selection of messages on the operator control panel

PC–Interfaces

A personal computer running the DIGSI® 4 program can be connected to the operating interface on the front of the device to retrieve the messages. A PC can also be connected to the service interface on the back of the device. This connection typically applies when the PC is hard-wired with several devices, using a data bus (station computer) or modem.

Details about the operation of DIGSI® 4 are contained in the “DIGSI® 4 Device Operation” handbook, order no. E50417-H1176-C097.

If the DIGSI® 4 **Online** directory is opened with a double-click, the operating functions for the device appear in the navigation window (Figure 7-2). By double clicking on **Annunciation**, the tree structure expands and shows the individual message groups. The groups are described in detail below.

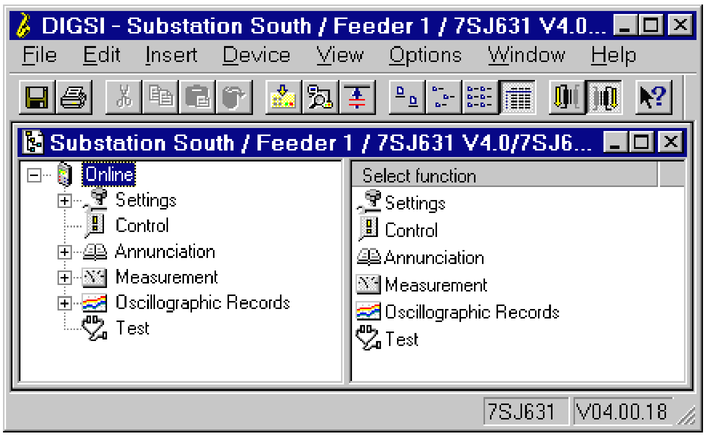


Figure 7-2 Function selection screen in DIGSI® 4 - example

System (SCADA) Interface

The system interface (if available) is generally hardwired and transfers all device information to a master station via data cable or optical fibre cable.

Division of Messages

The messages are categorized as follows:

- Event Log: these are operating messages that can occur during the operation of the device. They include information about the status of device functions, measurement data, system data, and similar information.
- Trip Log: these are fault messages from the last eight network faults that were processed by the device.
- Sensitive Earth Fault Log: Earth fault messages, if the device has sensitive earth fault detection. For networks with non-earthed star-point or star-point earthed by a Peterson coil.
- Switching statistics; these values include a counter for the trip commands initiated by the device, accumulated currents interrupted by the individual poles of the circuit breaker.
- Erasing and setting the messages named above.

A complete list of all message and output functions that can be generated by the device, with the associated information number (FNo), can be found in Appendix B. The lists also indicate where each message can be sent. The lists are based on a SIPROTEC® 4 device with the maximum complement of functions. If functions are not present in the specific version of the device, or if they are set as “***`Disabled`***” in device configuration, then the associated messages cannot appear.

7.1.1.2 Event Log (Operating Messages)

Operating messages contain information that the device generates during operation and about the operation. Up to 200 operating messages are stored in chronological order in the device. New messages are added at the end of the list. If the memory has been exceeded, then the oldest message is overwritten for each new message.

Exceeding or undershooting of thresholds, that can be changed by the user himself (see Section 7.1.3.3), is also displayed in the event log.

Faults in the power system are indicated with “`Network Fault`” and the present fault number. The fault messages (**`Trip Log`**) contain details about the history of faults. This topic is discussed in Sub-section 7.1.1.3.

Earth faults are indicated with „`Earth Fault`“ and numbered consecutively (only devices provided with the earth fault detection function). Detailed information on earth faults messages can be found in Subsection 7.1.1.4., **`Earth Fault Messages`**.

All predefined operating messages are listed and explained in a table in the Appendix. In a specific case, of course, only the appropriate messages appear in the display. The appendix also shows whether the message is only issued as “ON” (to indicate an event), or as “ON” and “OFF” (to designate the beginning and end of a condition).

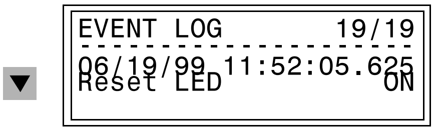
From the DeviceFront

With the device ready for operation, first press the MENU key. The **`MAIN MENU`** appears. The first menu item (*Annunciation*) is marked.

Press the ▶ key to enter the **ANNUNCIATION** menu (see Figure 7-1).

Here, select the menu item ***`Event Log`*** (already marked). The **EVENT LOG** table appears.

If no messages are present, then the text “`list is empty`” appears. Otherwise important events and changes in conditions are listed in chronological order (see Figure 7-3 as an example). Upon entering the menu, the newest (last) message is displayed at first. The applicable date and time are noted in the display line directly above the message. If the memory for the operating messages is not full, then the end of the entries is indicated by “`END`”.



```
EVENT LOG        19/19
----------------------
06/19/99 11:52:05.625
Reset LED           ON
```

Figure 7-3 Example of an operating message in the operating field of the device

The ▼ and ▲ keys can be used to move up and down in the Event Log.

Press the MENU key to return to the **`MAIN MENU`**.

From PC with DIGSI® 4

Click on **`Annunciation`**. The options appear in the data window (Figure 7-4).

Double click on the desired message group in the data window, in this case **`Event Log`**. A date and time appear in the data window as shown in Figure 7-4.

Double click on the date and time and the contents of the message group are displayed in another window.

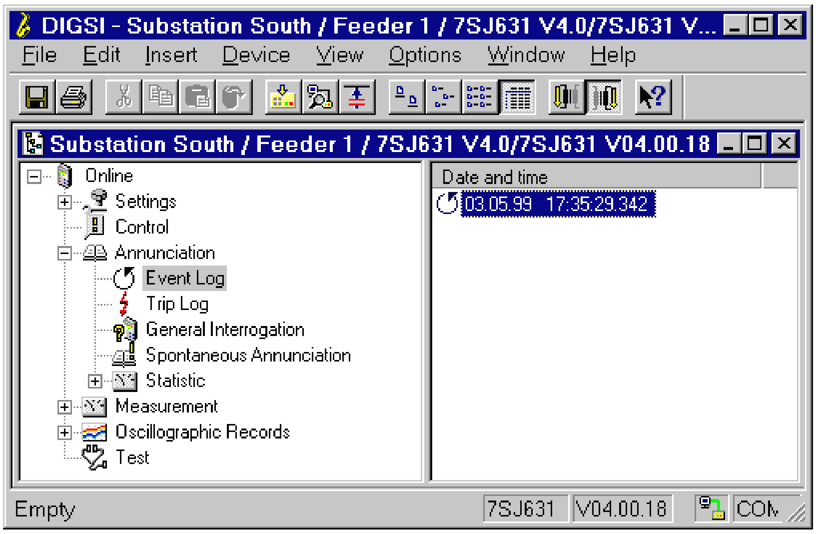
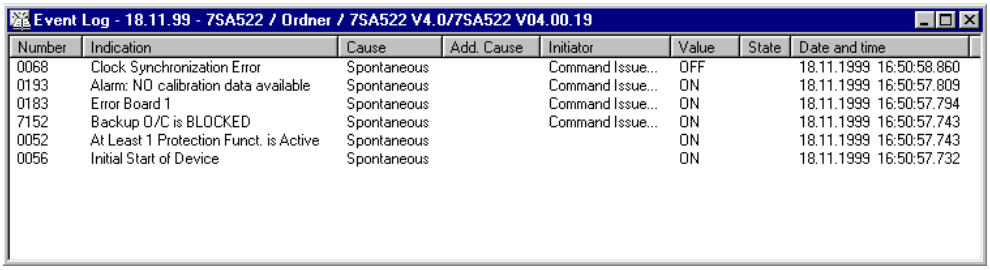


Figure 7-4 Selection of operational messages in DIGSI® 4



Event Log - 18.11.99 - 7SA522 / Ordner / 7SA522 V4.0/7SA522 V04.00.19

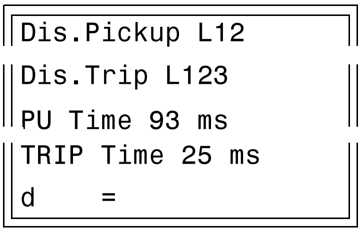
Number	Indication	Cause	Add. Cause	Initiator	Value	State	Date and time
0068	Clock Synchronization Error	Spontaneous		Command Issue...	OFF		18.11.1999 16:50:58.860
0193	Alarm: NO calibration data available	Spontaneous		Command Issue...	ON		18.11.1999 16:50:57.809
0183	Error Board 1	Spontaneous		Command Issue...	ON		18.11.1999 16:50:57.794
7152	Backup O/C is BLOCKED	Spontaneous		Command Issue...	ON		18.11.1999 16:50:57.743
0052	At Least 1 Protection Funct. is Active	Spontaneous			ON		18.11.1999 16:50:57.743
0056	Initial Start of Device	Spontaneous			ON		18.11.1999 16:50:57.732

Figure 7-5 Example of operational messages in DIGSI® 4

7.1.1.3 Trip Log (Fault Messages)

Spontaneous Messages

The spontaneous messages appear automatically in the display, after a general pick-up of the device. The most important data about a fault can be viewed on the device front in the sequence shown in Figure 7-6.



```
Dis.Pickup L12
Dis.Trip L123
PU Time 93 ms
TRIP Time 25 ms
d    =
```

Protection function that picked up, e.g. distance protection, with phase information;

Protection function that is tripped, e.g. 3pole distance protection (only devices with graphic display);

Elapsed time from pick-up until reset;

Elapsed time from pick-up until the first trip command of a protection function;

Fault distance d in km or miles

Figure 7-6 Display of spontaneous messages in the device display - example

The spontaneous messages can be acknowledged by pressing the LED key. After acknowledgment, the default display is shown.

Options for Fault Location

Especially for the fault location there are, except for the display options in the device display and in DIGSI® 4, further display options. Their availability depends on the device version, the configuration (Section 5.1) and the routing (Section 5.2):

- If the device is provided with an BCD output for fault location, the corresponding binary outputs are allocated and transmitted to a suited display panel with BCD decoder, the fault location is indicated in per cent (the line length) and can be read out immediately after the fault ocurred. The numbers have the following significance:

0 to 195	the calculated fault location in % (line length). If the number exceeds the 100 % rate, the fault is located outside the protected line in forward direction;
197	a negative fault location was calculated (the fault is not located in the protected line, but in reverse direction);
199	overflow (the calculated value is higher than the maximum value (195 %) that can be transmitted).

- If the device is provided with at least one analog output (0...20 mA) and the fault location is output via the latter and then transmitted to a suited display panel, the fault distance can be read out immediately after a fault ocurred.

For each case please take into consideration that the calculated fault distance only refers to faults in protected lines, in homogeneous lines. In different cases the result may be falsified considerably, e.g. from intermediate infeed.

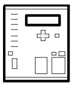
Retrieved messages

The messages for the last eight network faults can be retrieved. The definition of a network fault is such that the time period from fault detection up to final clearing of the system fault is considered to be one network fault. If auto-reclosure occurs, then the network fault ends after the last reclosing shot, which means after a successful or final-unsuccessful reclosing. Therefore, the entire clearing process, including the reclosing attempt (or all reclosing attempts), occupies only one trip log buffer. Within a network fault, several fault events can occur (from the first pick-up of a protective function to the last drop-out of a protective function). Without auto-reclosing, every fault event is a network fault.

Altogether up to 600 indications can be stored. Oldest data are erased for newest data when the buffer is full.

All available indications are displayed and explained in the Appendix. In a specific case, of course, only the applicable messages appear on the display.

From the DeviceFront



With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears. The first menu item (***`Annunciation`***) is marked.

Press the ▶ key to enter the **`ANNUNCIATION`** sub-menu (see Figure 7-1).

Using the ▼ key, select the sub-menu item ***Trip Log*** and move to the Trip Log sub-menu using the ▶ key. The **`TRIP LOG`** selection appears.

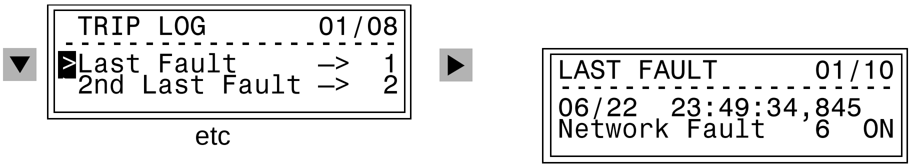
In this sub-menu, the indications for the last 8 network faults can be selected, again using the ▼ and ▶ keys. See the example in Figure 7-7.

If no messages are present for a fault, then entrance is denied and “`List Empty`” is displayed.

The messages within a fault record are listed in chronological order and numbered, from the oldest to the newest.

The inception of a fault is identified with the date and time in hours, minutes, and seconds (resolution to ms). See the example in Figure 7-7.

The individual messages that are associated with the fault are tagged with a relative time. At least one complete individual message always appears in the display.



```
TRIP LOG          01/08
-----------------------
>Last Fault      –>  1
 2nd Last Fault  –>  2
```

```
LAST FAULT      01/10
---------------------
06/22  23:49:34,845
Network Fault   6  ON
```

Figure 7-7 Example of fault messages in the front display

Use the ▼ and ▲ keys to move up and down in the fault messages.

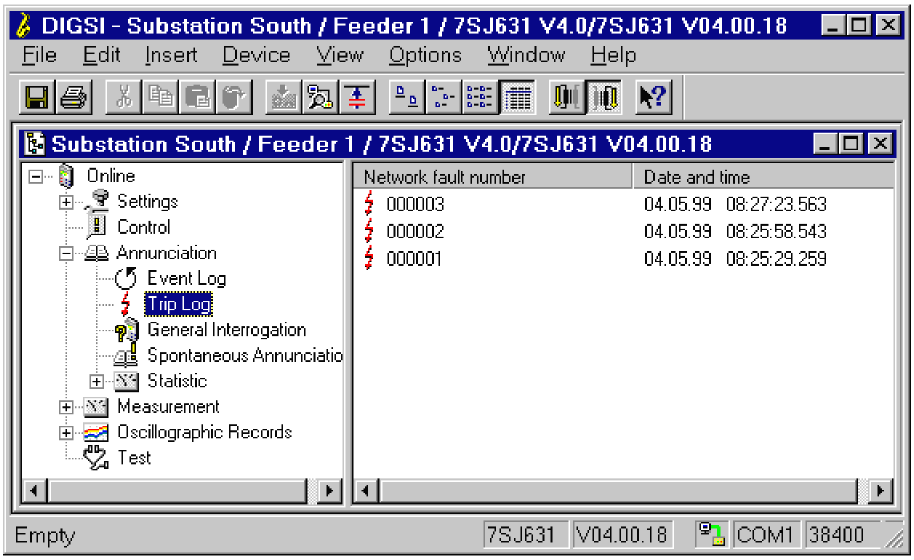
Use the ◀ key to move back into the **`TRIP LOG`** level; or press the MENU key to go back to the **`MAIN MENU`**.

From PC with DIGSI® 4

Click on **`Annunciation`**. The options appear in the data window (see Figure 7-2).

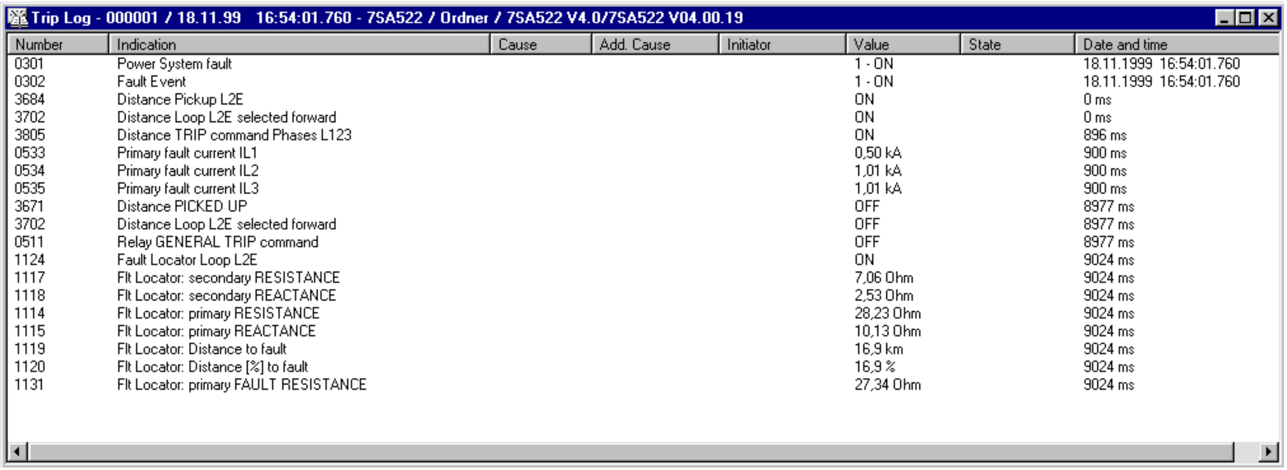
Double click on the desired message group in the data window, in this case the **`Trip Log`**. A list appears in the data window, as shown in Figure 7-8.

By double clicking on an entry in the list view, the associated contents of the network fault is displayed in another window. The entries are chronologically listed with the newest message appearing first.



Network fault number	Date and time
000003	04.05.99 08:27:23.563
000002	04.05.99 08:25:58.543
000001	04.05.99 08:25:29.259

Figure 7-8 Selection of fault messages in DIGSI® 4



Trip Log - 000001 / 18.11.99 16:54:01.760 - 7SA522 / Ordner / 7SA522 V4.0/7SA522 V04.00.19

Number	Indication	Cause	Add. Cause	Initiator	Value	State	Date and time
0301	Power System fault				1 - ON		18.11.1999 16:54:01.760
0302	Fault Event				1 - ON		18.11.1999 16:54:01.760
3684	Distance Pickup L2E				ON		0 ms
3702	Distance Loop L2E selected forward				ON		0 ms
3805	Distance TRIP command Phases L123				ON		896 ms
0533	Primary fault current IL1				0,50 kA		900 ms
0534	Primary fault current IL2				1,01 kA		900 ms
0535	Primary fault current IL3				1,01 kA		900 ms
3671	Distance PICKED UP				OFF		8977 ms
3702	Distance Loop L2E selected forward				OFF		8977 ms
0511	Relay GENERAL TRIP command				OFF		8977 ms
1124	Fault Locator Loop L2E				ON		9024 ms
1117	Flt Locator: secondary RESISTANCE				7,06 Ohm		9024 ms
1118	Flt Locator: secondary REACTANCE				2,53 Ohm		9024 ms
1114	Flt Locator: primary RESISTANCE				28,23 Ohm		9024 ms
1115	Flt Locator: primary REACTANCE				10,13 Ohm		9024 ms
1119	Flt Locator: Distance to fault				16,9 km		9024 ms
1120	Flt Locator: Distance [%] to fault				16,9 %		9024 ms
1131	Flt Locator: primary FAULT RESISTANCE				27,34 Ohm		9024 ms

Figure 7-9 Example of fault messages in DIGSI® 4

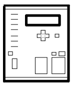
7.1.1.4 Earth Fault Messages

Devices with sensitive earth fault detection provide special earth fault logs. The earth faults are registered if the earth fault detection function is set to “OFF” (Address `3001` = ***`Alarm Only`***) and an earth fault was already in queue so that the trip delay (**`T Sens.E/F`**) could expire.

Up to 200 earth fault messages can be stored for the last 8 earth faults.

All available indications are displayed and explained in Appendix B. In a specific case, of course, only the applicable messages appear on the display.

From the DeviceFront



With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears. The first menu item (***`Annunciation`***) is marked.

Press the ▶ key to enter the **`ANNUNCIATION`** sub-menu (see Figure 7-1).

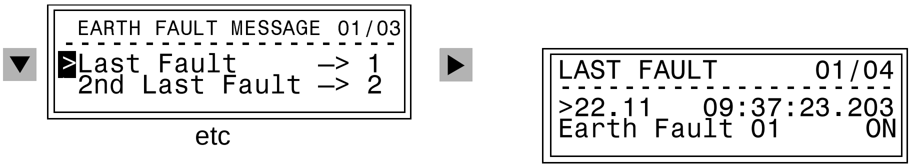
Using the ▼ key, select the sub-menu item ***`Earth Fault Messages`*** and move to the earth fault logs using the ▶ key. The **`EARTH FAULT MESSAGES`** selection appears.

In this sub-menu, the indications for the last 3 network faults can be selected, again using the ▼ and ▶ keys. See the example in Figure 7-10.

If no messages are present for a fault, then entrance is denied and “`List Empty`” is displayed.

The messages within an earth fault log are listed in chronological order and numbered consecutively, from the oldest to the newest ones.

The inception of an earth fault is identified with the date (without indication of the year) and time in hours, minutes, and seconds (resolution = 1 ms). See the example in Figure 7-10.



```
EARTH FAULT MESSAGE 01/03
-------------------------
>Last Fault      –> 1
 2nd Last Fault  –> 2
```

```
LAST FAULT        01/04
-----------------------
>22.11    09:37:23.203
Earth Fault 01      ON
```

Figure 7-10 Example of earth fault messages in the front display

Use the ▼ and ▲ keys to move up and down in the fault messages.

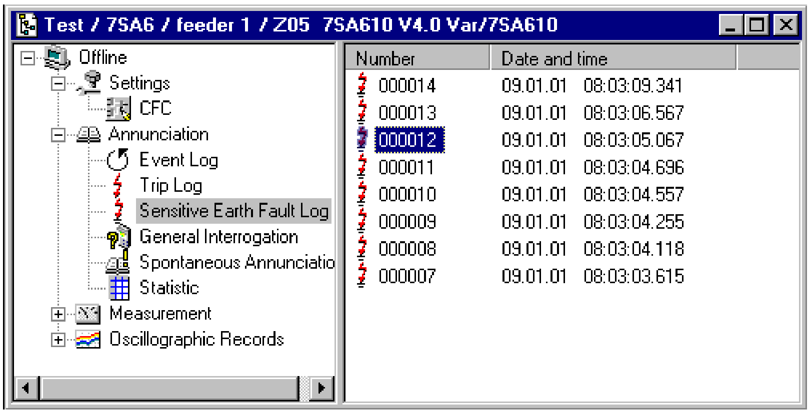
Use the ◀ key to move back into the **EARTH FAULT MESSAGES** level; or press the MENU key to go back to the **MAIN MENU**.

From PC with DIGSI® 4

Click on **Annunciation**. The options appear in the data window (see Figure 7-2).

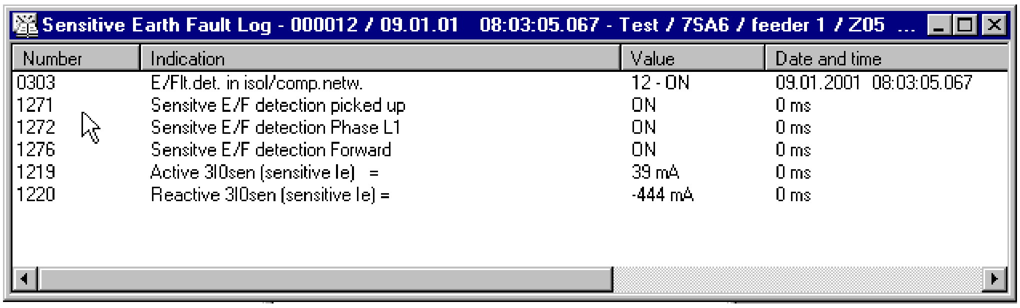
Double click on the desired message group in the data window, in this case the **EARTH FAULT MESSAGES**. A list of the earth fault logs appears in the data window, as shown in Figure 7-11.

By double clicking on an entry in the list view, the associated contents of the network fault is displayed in another window. The entries are chronologically listed with the newest message appearing first.


Test / 7SA6 / feeder 1 / Z05 7SA610 V4.0 Var/7SA610

Number	Date and time
000014	09.01.01 08:03:09.341
000013	09.01.01 08:03:06.567
000012	09.01.01 08:03:05.067
000011	09.01.01 08:03:04.696
000010	09.01.01 08:03:04.557
000009	09.01.01 08:03:04.255
000008	09.01.01 08:03:04.118
000007	09.01.01 08:03:03.615

Figure 7-11 DIGSI® 4 Selection of Earth Fault Log with a Fault Indicated in the Data Window


Sensitive Earth Fault Log - 000012 / 09.01.01 08:03:05.067 - Test / 7SA6 / feeder 1 / Z05 ...

Number	Indication	Value	Date and time
0303	E/Flt.det. in isol/comp.netw.	12 - ON	09.01.2001 08:03:05.067
1271	Sensitve E/F detection picked up	ON	0 ms
1272	Sensitve E/F detection Phase L1	ON	0 ms
1276	Sensitve E/F detection Forward	ON	0 ms
1219	Active 3I0sen (sensitive Ie) =	39 mA	0 ms
1220	Reactive 3I0sen (sensitive Ie) =	-444 mA	0 ms

Figure 7-12 DIGSI® 4 Example of Indications for Earth Fault, Earth Fault Log

7.1.1.5 Saving and Erasing the Messages

Normally, erasing the messages is not necessary because the oldest messages are automatically erased when new events are entered, if the memory is full at the time. However, erasure of the stored messages may be useful, for instance, after revision of the plant, so that in the future the memory only contains information about actual events. Erasing the memory takes place separately for each of the message groups.

Note:

When the Trip Log (fault messages) is erased, then the fault records are erased, too, and all corresponding counters are set to zero. If, however, a fault record is erased (cf. Sub-section 7.1.4), the fault messages are unaffected.

From the DeviceFront

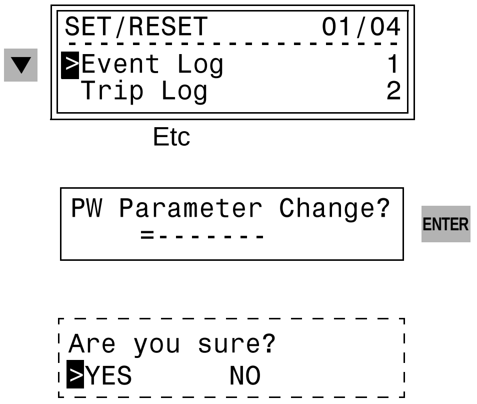
If erasure is desired, first press the MENU key. The `MAIN MENU` appears. The first menu item *`Annunciation`* is marked.

Press the ▶ key to enter the **`ANNUNCIATION`** menu (see Figure 7-1).

Using the ▼ key, select the item ***`Set/Reset`***, and switch to the sub-menu using the ▶ key.

Here, select the message group to be erased using the ▼ key, and then press the ENTER key. See Figure 7-13 as an example.

Password No. 5 (for setting changes) is required at this point. After entering the password and confirming with the ENTER key, the safety question “**`Are you sure?`**” appears. The response “**`YES`**” is the default (Figure 7-13). Confirm with the ENTER key, if the message group should really be erased. If the message group should not be erased, press the ▶ key so that the response “**`NO`**” is highlighted, and confirm this answer with the ENTER key. Before confirming with the ENTER key, the responses can be toggled between “**`YES`**” and “**`NO`**” using the ◀ and ▶ keys. Alternatively, the ESC key can be pressed to cancel the erasure procedure.



```
SET/RESET        01/04
- - - - - - - - - - - -
>Event Log           1
 Trip Log            2
```

Etc

Select the associated message group or press the associated number key to select the messages to be erased.

```
PW Parameter Change?
   =-------
```

Enter Password No. 5 (for setting change) and confirm with ENTER

```
Are you sure?
>YES      NO
```

Confirm “YES” with the ENTER key and complete the erasing of the selected messages, or switch to “NO” with the ▶ key and cancel the erasure with the ENTER key.

Figure 7-13 Erasing messages from the front panel

From PC with DIGSI® 4

Operating the device from the PC via DIGSI® 4 enables the user to save the above described messages on your hard disc before clearing them from the device. Proceed as if reading out the messages. However, instead of opening the information list by making a double-click on the event group, select the option **`File`** → **`Save`** in the menu of the DIGSI window. Then DIGSI® 4 automatically creates a directory for the event group. For more details also refer to the instruction manual of DIGSI® 4, ordering no. E50417-H1176-C097, Section 9.4.

If all event groups required are stored in the PC, they can be deleted from the device - as described before - via the front panel.

Naturally all messages stored via DIGSI® 4 can be deleted from your hard disc like any other object.

7.1.1.6 General Interrogation

From PC with DIGSI® 4

The present condition of a SIPROTEC® device can examined by using DIGSI® 4 to view the contents of the “General Interrogation” annunciation.

The messages are found by double-clicking on **`Annunciation`** (see Figure 7-2), double-clicking on **`General Interrogation`**, and double-clicking on the date and time that appear in the right window. All of the messages that are defined for a general interrogation are shown along with the actual values and states.

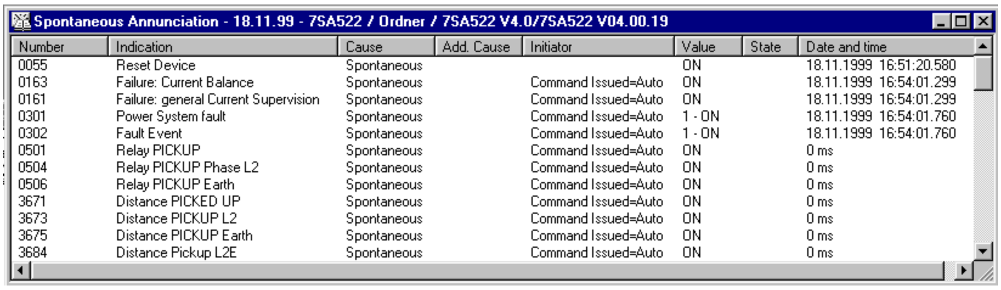
7.1.1.7 Spontaneous Messages

From PC with DIGSI® 4

The spontaneous messages that can be displayed via DIGSI® 4 are refreshed immediately.

Find the message groups by clicking on **`Annunciation`** (Figure 7-2).

Double click **Spontaneous Annunciation** in the data window. The date and time appear in the data window. By double clicking on them, the Spontaneous Annunciation window opens, as shown in the following figure. Each entering message appears immediately, without requiring that an update be initiated.



Spontaneous Annunciation - 18.11.99 - 7SA522 / Ordner / 7SA522 V4.0/7SA522 V04.00.19

Number	Indication	Cause	Add. Cause	Initiator	Value	State	Date and time
0055	Reset Device	Spontaneous			ON		18.11.1999 16:51:20.580
0163	Failure: Current Balance	Spontaneous		Command Issued=Auto	ON		18.11.1999 16:54:01.299
0161	Failure: general Current Supervision	Spontaneous		Command Issued=Auto	ON		18.11.1999 16:54:01.299
0301	Power System fault	Spontaneous		Command Issued=Auto	1 - ON		18.11.1999 16:54:01.760
0302	Fault Event	Spontaneous		Command Issued=Auto	1 - ON		18.11.1999 16:54:01.760
0501	Relay PICKUP	Spontaneous		Command Issued=Auto	ON		0 ms
0504	Relay PICKUP Phase L2	Spontaneous		Command Issued=Auto	ON		0 ms
0506	Relay PICKUP Earth	Spontaneous		Command Issued=Auto	ON		0 ms
3671	Distance PICKED UP	Spontaneous		Command Issued=Auto	ON		0 ms
3673	Distance PICKUP L2	Spontaneous		Command Issued=Auto	ON		0 ms
3675	Distance PICKUP Earth	Spontaneous		Command Issued=Auto	ON		0 ms
3684	Distance Pickup L2E	Spontaneous		Command Issued=Auto	ON		0 ms

Figure 7-14 Spontaneous annunciation window — example

7.1.2 Switching Statistics

The messages in switching statistics are counters for the accumulation of interrupted currents by each of the breaker poles, the number of trips issued by the device to the breaker. The interrupted currents are in primary terms.

Switching statistics can be viewed on the LCD of the device, or on a PC running DIGSI® 4 and connected to the operating or service interface.

A password is not required to read switching statistics; however, a password is required to change or delete the statistics.

7.1.2.1 Viewing the Switching Statistics

For each trip command initiated by a protective element of the device, the magnitude of interrupted current for each circuit breaker pole is determined and stored. The current magnitudes are added to previously interrupted currents, and the accumulated values are stored.

In devices with automatic reclosure the number of reclosure commands is counted, i. e. separately according to single-pole (if available) and three-pole automatic reclosure cycles as well as separately according to the first and all further automatic reclosures.

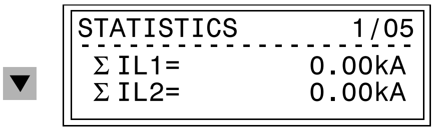
The memories are protected against auxiliary voltage failure.

From the Device Front

With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears. The first menu item ***`Annunciation`*** is marked.

Press the ▶ key to enter the **`ANNUNCIATION`** sub-menu (see Figure 7-2).

Use the ▼ key to select the item ***`Statistic`***, and switch to the list of statistics values using the ▶ key. The **`STATISTIC`** list appears. See Figure 7-15.



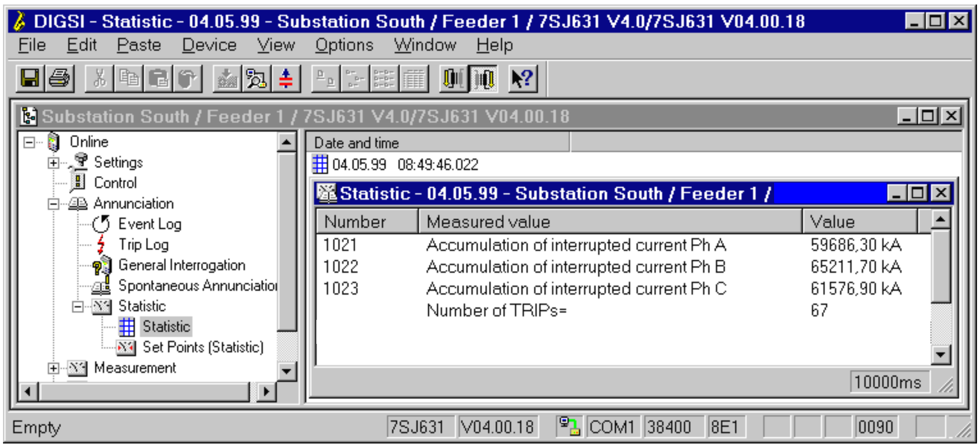
```
STATISTICS        1/05
----------------------
 ΣIL1=          0.00kA
 ΣIL2=          0.00kA
```

Etc.

Figure 7-15 Switching statistics viewed from the front display

From PC with DIGSI® 4

Under **`Annunciation`** (Figure 7-2), the switching statistics can be found by double clicking. Double click on **`Statistic`**. In the right part of the window the submenu **`Statistic`** appears. When double-clicking on it the content is displayed in another window. See Figure 7-16.



Date and time
04.05.99 08:49:46.022

Number	Measured value	Value
1021	Accumulation of interrupted current Ph A	59686,30 kA
1022	Accumulation of interrupted current Ph B	65211,70 kA
1023	Accumulation of interrupted current Ph C	61576,90 kA
	Number of TRIPs=	67

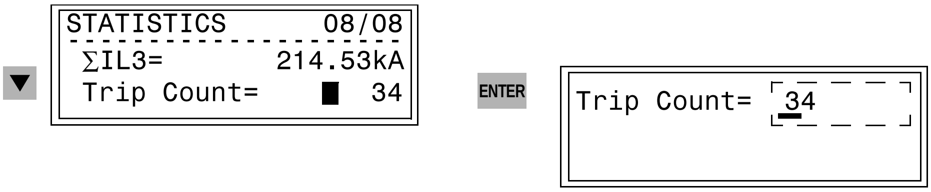
Figure 7-16 List of statistic values in DIGSI® 4 — example

7.1.2.2 Resetting and Setting the Switching Statistics

The memories and counters for switching statistics are secured against a loss of power supply voltage. The values can, however, be set to zero, or to any desired value within certain setting limits.

From the Device Front

In the **`STATISTIC`** (see previous sub-section) sub-menu (see previous sub-section), select the value to be set by using the ▼ key, and then press the ENTER key. See Figure 7-17 for an example of changing the trip counter. Enter the password (password N° 5 for individual settings). Having done this the cursor blinks and the value is highlighted in a box. The number can be overwritten using the number keys. If the new value is outside of the permissible range, either above or below, then the maximum or minimum limit value appears at the bottom edge of the screen. Confirm the change with the ENTER key.



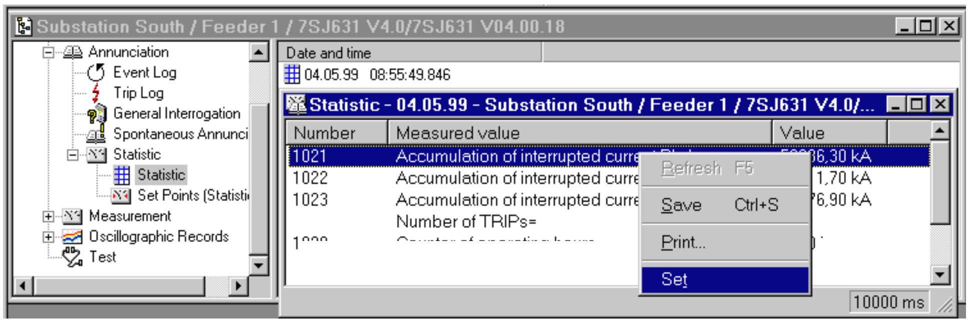
```
STATISTICS       08/08
 ΣIL3=        214.53kA
 Trip Count=   █   34
```

```
Trip Count= 34
```

Figure 7-17 Setting statistics values from the device front — example

From PC with DIGSI® 4

In the `Statistic` window (see previous sub-section), mark the value that is to be set. With the *right* mouse button, open a context menu and select `Set`. See Figure 7-18. After the password N° 5 for individual settings is entered, the previous value in the window can be overwritten.



Substation South / Feeder 1 / 7SJ631 V4.0/7SJ631 V04.00.18

Date and time
04.05.99 08:55:49.846

Statistic - 04.05.99 - Substation South / Feeder 1 / 7SJ631 V4.0/...

Number	Measured value	Value
1021	Accumulation of interrupted curre	6,30 kA
1022	Accumulation of interrupted curre	1,70 kA
1023	Accumulation of interrupted curre	6,90 kA
	Number of TRIPs=	

10000 ms

Figure 7-18 Setting statistic values in DIGSI® 4 — example

7.1.3 Measured Values

Operating measured values are determined in the background by the processor system. They can be called up at the front of the device, read out via the operating interface using a PC with DIGSI® 4, or transferred to a central master station via the system interface (if available).

No password entry is required to view the measured values. The values are updated every few seconds.

Most measured values can be displayed in primary quantities, secondary quantities, and percentages based on nominal values. A precondition for correct display is that the nominal values be correctly set in the power system data.

Secondary values are values measured at the device terminals or values calculated from the latter values.

7.1.3.1 Measured Values

Read-out of Measured Values

In the 7SA6 with maximum functionality the measured values as shown in Table 7-1 are available.

The displacement voltage $3U_0$ is either measured directly ($3U_0 = \sqrt{3} \cdot U_{en}$, if U_{en} is connected to the voltage input U_4) or calculated (from $3U_0 = U_{L1\text{-}E} + U_{L2\text{-}E} + U_{L3\text{-}E}$).

The power measurements P, Q are positive, if real power or inductive reactive power flows into the protected object. This is assuming that this direction has been parameterized as “forward”.

The sign of the power factor cos φ corresponds to the sign of the active power.

For the thermal overload protection the calculated temperature rise values are related to the tripping temperature rise.

If the device is provided with the synchronism and voltage check function, the characteristical values (voltages, frequences, differences) can be read out.

If the device is provided with earth fault detection in a non-earthed system, also the components of the earth fault current (active and reactive components) are indicated.

In addition to those measured values listed in the table, it is possible to retrieve user defined measurement, metering and set points, if these were generated during the configuration of the device according to Section 5.2 and/or 5.3 “Generating user definable functions with CFC”.

Table 7-1 Operational measured values

Measured values		**primary**	**secondary**	**% related to**
I_{L1}, I_{L2}, I_{L3}	phase currents	A	A	rated operational current 1)
$3I_0$	earth currents	A	A	rated operational current 1)
I_1, I_2	pos. and neg. seq. currents	A	A	rated operational current 1)
$3I0_{sen}$	sensitive earth current	A	mA	rated operational current 1) 3)
I_Y, I_P	transformer star point current or earth current in the parallel line	A	A	rated operational current 1) 3)
$U_{L1–L2}$, $U_{L2–L3}$, $U_{L3–L1}$	line voltages	kV	V	rated operational voltage 2)
$U_{L1–E}$, $U_{L2–E}$, $U_{L3–E}$	phase-earth voltages	kV	V	rated operational voltage $/\sqrt{3}$ 2)
$3U_0$	displacement voltage	kV	V	rated operational voltage $\cdot\sqrt{3}$ 2)4)
U_X	voltage at the measuring input U_4	kV	V	rated operational voltage $/\sqrt{3}$ 2)
U_1, U_2	pos. and neg. seq. voltages	kV	V	rated operational voltage $/\sqrt{3}$ 2)
$R_{L1–E}$, $R_{L2–E}$, $R_{L3–E}$ $R_{L1–L2}$, $R_{L1–L2}$, $R_{L3–L1}$	operational resistance of all phase loops	Ω	Ω	—
$X_{L1–E}$, $X_{L2–E}$, $X_{L3–E}$ $X_{L1–L2}$, $X_{L2–L3}$, $X_{L3–L1}$	operational reactance of all phase loops	Ω	Ω	—
S, P, Q	apparent, real, and reactive power	MVA, MW, MVAR	—	$\sqrt{3}\cdot U_N\cdot I_N$ rated operational values1) 2)
cos φ	power factor	(abs)	(abs)	—
f	frequency	Hz	Hz	rated frequency
$\Theta_{L1}/\Theta_{trip}$, $\Theta_{L2}/\Theta_{trip}$, $\Theta_{L3}/\Theta_{trip}$	thermal value of each phase related to trip value	—	—	temperature rise
Θ/Θ_{trip}	thermal value, related to trip value, calculated according to the configured method	—	—	temperature rise
U_{line}, U_{sync}, U_{diff}	line voltage, busbar voltage and voltage magnitude difference (for synchronism check)	kV	—	—
f_{line}, f_{sync}, f_{diff}	line voltage, busbar voltage and frequency difference (for synchronism check)	Hz	—	—
φ_{diff}	magnitude of the phase angle difference between line and busbar (for sychronism check)	°	—	—
3I0senA, 3I0senR	active and reactive components of earth fault current	A	mA	—

1) acc. to address 1104 (refer to Sub-section 6.1.3) 2) acc. to address1103 (refer to Sub-section 6.1.3)
3) with consideration of the factor 0221 **I4/Iph CT** (refer to Sub-section 6.1.1)
4) with consideration of the factor 0211 **Uph / Udelta** (refer to Sub-section 6.1.1)

If the device is provided with analog outputs allocated to certain measured values during the configuration according to Section 5.1, they can be read out in the display (e.g. analog instrument).

Except for the current measured values the user can also read out the minimum, maximum and long-term measured values. The interval range for the calculation of the average value was set in Subsection 6.21.4.

The following average values are available:

- I_{L1}dmd, I_{L2}dmd, I_{L3}dmd, I_1dmd: the measured values of the phase currents and symmetrical positive sequence system;
- Pdmd, Pdmd Forw, Pdmd Rev: the active power as a whole and separately according to Demand Forward and Demand Reverse;
- Qdmd, QdmdForw, QdmdRev: the reactive power as a whole and separately according to Demand Forward and Demand Reverse;
- Sdmd: the apparent power.

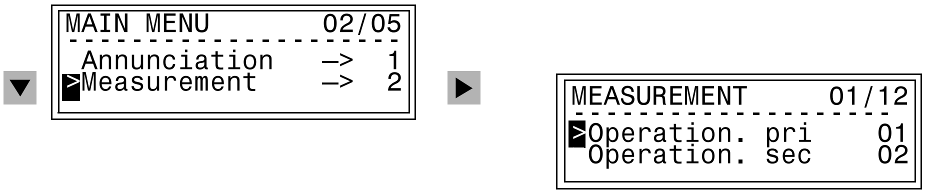
For the following values both the minimum and the maximum values are available:

- I_{L1}, I_{L2}, I_{L3}, I_1: phase currents and the symmetrical positive sequence system of the currents;
- I_{L1}d, I_{L2}d, I_{L3}d, I_1d: average values of the phase currents and the symmetrical positive sequence of the currents;
- $U_{L1–E}$, $U_{L2–E}$, $U_{L3–E}$, U_1: phase-earth voltages and symmetrical positive sequence system of the voltages;
- $U_{L1–L2}$, $U_{L2–L3}$, $U_{L3–L1}$, $3U_0$: phase-phase voltages and the triple zero voltage;
- PForw, PRev, QForw, QRev, S: active and reactive power separately according to Demand Forward and Demand Reverse as well as apparent power;
- Pd, Qd, Sd: average values of active, reactive and apparent power;
- cos φ Pos, cos φ Neg: power factor separately according Demand Forward and Demand Reverse;
- f: frequency.

From the DeviceFront

With a device ready for operation, first press the **MENU** key. The **`MAIN MENU`** appears.

Use the ▼ key to select the menu item ***`Measurement`***, and switch to the list of measured values using the ▶ key. The **`MEASUREMENT`** selection appears. See figure 7-19.



```
MAIN MENU         02/05
--------------------
 Annunciation   –>  1
>Measurement    –>  2
```

```
MEASUREMENT      01/12
------------------
>Operation. pri    01
 Operation. sec    02
```

Etc.

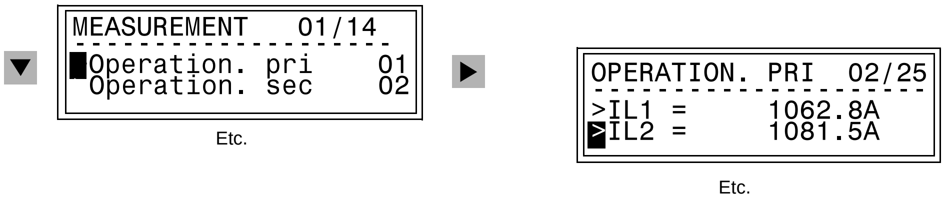
Figure 7-19 Selection of measured values on the front — example

The measured values are divided into the following groups:

01	**Operation. pri**	Operational measured values, primary.
02	**IEE,primary**	Measured values of earth fault, primary;
03	**Impedance Prim**	Operational impedance, primary;
04	**SynchrCheck,pri**	Measured values of synchronism check, primary;
11	**Operation. sec**	Operational measured values, secondary;
12	**IEE,secondary**	Measured values of earth fault, secondary;
13	**Impedance Sec**	Operational impedance, secondary ;
21	**Percent**	Operational measured values, in percent of operational nominal quantities;
31	**Demand**	Long-term average values, in primary values;
32	**Min/Max Demand**	Minimum and maximum average values with date and time indication of moment of occurrence, in primary values;
33	**U/I,Min/Max**	Minimum and maximum values of voltages and currents with date and time indication of moment of occurrence, in primary values;
34	**p,cosφ,Min/Max**	Minimum and maximum values of the actve, reactive and apparent power of the frequence and the power factor;
41	**Thermal Meter**	Thermal measured values of the overload protection, if available;
51	**User Defined**	Measured values that are defined by the user during initial setting of the device (see Section 5.2).
61	**Set Points**	See Subsubsection 7.1.3.2
71	**Set points (MV)**	See Subsubsection 7.1.3.3
81	**Reset**	See Subsubsection 7.1.3.4.

If a measured value is not available, then instead of the measured value, 3 dots appear. If the value is undefined (e.g., cos φ, when no current is flowing), then "**–––**" appears (3 horizontal bars). If a measured value overruns, then "★★★" (3 asterisks) is displayed.

Use the ▼ key to select the measured value group that has the values desired, and switch to the display of this group with the ▶ key. Figure 7-20 shows an example for the display of operating measured values.



```
MEASUREMENT   01/14
--------------------
█Operation. pri    01
 Operation. sec    02
```

```
OPERATION. PRI  02/25
---------------------
>IL1 =      1062.8A
>IL2 =      1081.5A
```

Figure 7-20 Viewing operating measured values on the front display

Move up and down in the table of measured value groups using the ▼ and ▲ keys.

Use the ◀ key to return to the **MEASUREMENT** sub-menu. Use the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4

The measured value groups are found under **Measurement** (Figure 7-2) with a double click, as shown in Figure 7-21, left.

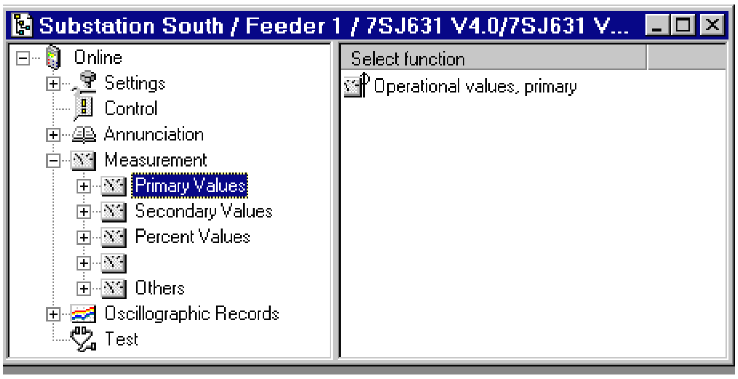


Figure 7-21 Measurement window in DIGSI® 4

The measured values are categorized into the following groups and subgroups (maximum scope):

- **Primary** with
  Operational values, primary;
  Sens. E/F values, primary;
  Operating impedances, primary;
  Synchro-check measured values, primary
- **Secondary** with
  Operational values, secondary,
  Sens. E/F values, primary;
  Operating impedances, secondary;
- **Percentage** with
  Operational values, percentage;
  referred to the rated operational values;
- **Min/Max/Demand** with
  Demand;
  Min/Max Demand;
  U/I,Min/Max;
  P, f, Power Factor, Min/Max;
- **Other** with
  Thermal Meter;
- ***User defined measured values;***
  User defined counter;
  Energy;
  Set point values of measured values,
  i.o.w. only such values that were generated in the configuration (according to 5.2) and/or with the user definable logic CFC (according to Section 5.3).

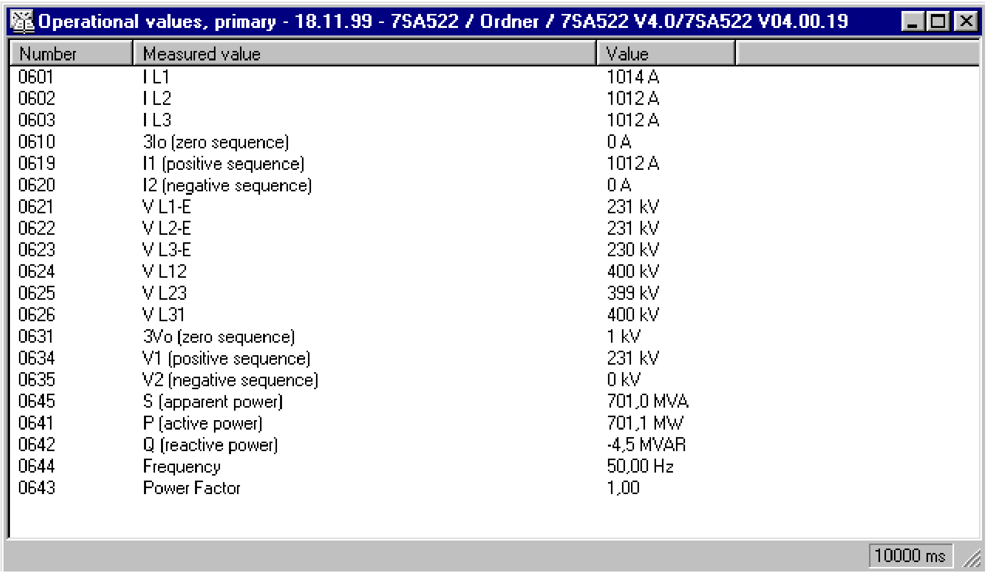
If a measured value is not available, then instead of the measured value, 3 dots appear. If the value is undefined (e.g., cos φ, when no current is flowing), then “**–––**”

appears (3 horizontal bars). If the measured value overruns, then “★★★” (3 asterisks) are viewed.

Double click on the desired measured value group, e.g. **`Primary`**. The next sub-group is displayed.

Double click on the desired sub-group, e.g. **`Operational values, primary`**.

By double clicking on an entry in the list in the right part of the window, detailed information on the measured value group is displayed in another window, as shown in Figure 7-22.



Operational values, primary - 18.11.99 - 7SA522 / Ordner / 7SA522 V4.0/7SA522 V04.00.19

Number	Measured value	Value
0601	I L1	1014 A
0602	I L2	1012 A
0603	I L3	1012 A
0610	3Io (zero sequence)	0 A
0619	I1 (positive sequence)	1012 A
0620	I2 (negative sequence)	0 A
0621	V L1-E	231 kV
0622	V L2-E	231 kV
0623	V L3-E	230 kV
0624	V L12	400 kV
0625	V L23	399 kV
0626	V L31	400 kV
0631	3Vo (zero sequence)	1 kV
0634	V1 (positive sequence)	231 kV
0635	V2 (negative sequence)	0 kV
0645	S (apparent power)	701,0 MVA
0641	P (active power)	701,1 MW
0642	Q (reactive power)	-4,5 MVAR
0644	Frequency	50,00 Hz
0643	Power Factor	1,00

Figure 7-22 Example of measured values shown in DIGSI® 4

7.1.3.2 Energy

Reading out Metered Values

In the maximum scope of device 7SA6 there are counters that summarize the active and reactive power (***Wp, Wq***) separately according to output and input of the active energy or capacitive and inductive reactive power (in direction to the protected object). It is a prerequisite that the direction is configured to ***forward*** (Address 0201, see Section 6.1).

From the Device Front

With the device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Use the ▼ key to select the menu item ***Measurement*** (See Figure 7-1), and switch to the list of measured values using the ▶ key. The **`MEASUREMENT`** selection appears.

There, select the menu item ***Energy*** with the ▼ key, and switch to the table of energy using the ▶ key.

Use the ▼ and ▲ keys to move up and down in the table of the energy.

Use the ◀ key to return to the **`MEASUREMENT`** submenu. Use the MENU key to return to the **`MAIN MENU`**.

From PC with DIGSI® 4

Make a double click on **`MEASUREMENT`** (Figure 7-2) to view the measurement groups.

Select **`Other`** with another double click.

In the next level double-click on ***`Energy`***.

By double-clicking on an item in the list in the right part of the window, another window is opened viewing the corresponding content of the counter group.

7.1.3.3 Setting Set Points

SIPROTEC® 7SA6 enables the user to set limit points (or: set points) for some important measured and metered values. If one of these set points is reached, exceeded or undershot, the device generates an event log. This annunciation - like all event logs - can be allocated to LEDs and/or output relays and then transmitted via interfaces.

Set points can be set for the following measured and metered values:

- IL1dmd>: exceeding a preset maximum average value in phase L1.
- IL2dmd>: exceeding a preset maximum average value in phase L2.
- IL3dmd>: exceeding a preset maximum average value in phase L3.
- I1dmd>: exceeding a preset maximum average value of the positive sequence system of the currents.
- |Pdmd|>: exceeding a preset maximum average value of the active power magnitude.
- |Qdmd|>: exceeding a preset maximum average value of the reactive power magnitude.
- Sdmd>: exceeding a preset maximum average value of the apparent power.
- |cosφ|<: untershooting a preset rate of the power factor

Further set points can be set if their measured and metered values have been configured via CFC (see Section 5.3).

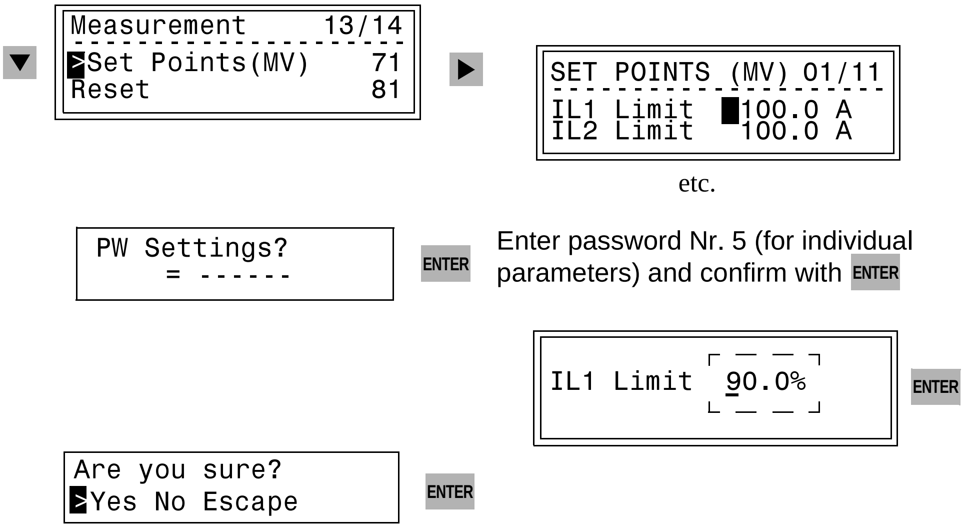
The exceeding or undershooting of set points is output as event log (see Subsubsection 7.1.1.2).

From the DeviceFront

With the device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Use the ▼ key to select the menu item ***`Measurement`*** and switch to the list of measured values using the ▶ key. The **`MEASUREMENT`** selection appears.

There, select the menu item ***`Set Points`*** with the ▼ key and switch to the list of set points using the ▶ key (see Figure 7-23).



```
Measurement     13/14
---------------------
>Set Points(MV)    71
Reset              81
```

```
SET POINTS (MV) 01/11
---------------------
IL1 Limit  █100.0 A
IL2 Limit   100.0 A
```

etc.

```
PW Settings?
   = ------
```

Enter password Nr. 5 (for individual parameters) and confirm with ENTER

```
IL1 Limit  90.0%
```

```
Are you sure?
>Yes No Escape
```

Figure 7-23 Setting of set-points on the device front — example

With the keys ▼ and ▲ the user can page up and down in the set point table.

To change a set point, it must be marked using the keys ▼ and ▲. Then press the ENTER key.

A prompt for the entry of password No. 5 (for individual settings) appears. After entry of the password and confirmation with ENTER, the current value appears in a frame with a flashing cursor. The current value must be overwritten with the desired new value using the numeric keys. If the permissible range for the setting value is exceeded to the top or the bottom, the maximum or minimum set point value appears at the bottom of the display when the value is entered.

Press the ENTER key. The new value now appears in the list of set points.

In the same way, further set points, if available, can be modified.

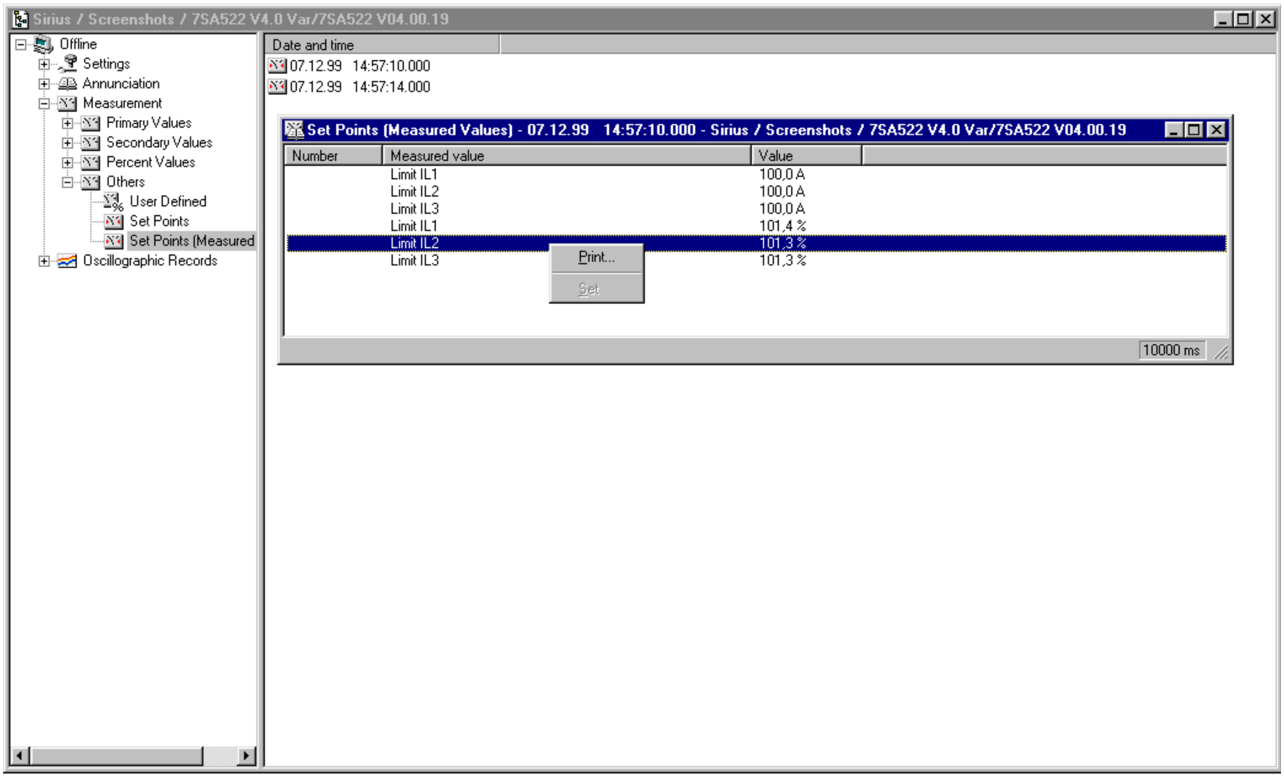
If this level is exited with the key ◀ or MENU the query “`Are you sure?`”, with the default answer “`Yes`” appears (Figure 7-23). Confirm with the key ENTER, to validate the the value. If the value must not be modified, press the ▶ key, so that the answer “**`No`**” is marked, and confirm with the ENTER key. If the value is to be modified once more, mark “**`Abort`**”, confirm with the ENTER key and enter the value again.

From PC with DIGSI® 4

Set points are only available in online–mode. The metered value groups are to be found under **`Measurement`** (Figure 7-2) by double-clicking on the latter. Select **`Other`** and then **`Set Points (Measured Values)`** (Figure 7-24).

By double clicking on an entry in the list in the right part of the window, the set points are loaded. Mark the number of the value which is to be changed. With a *right* mouse click, open the context menu and click on **`Set`**, as shown in Figure 7-24. A password inquiry (password No 5 for individual settings) occurs. Next, the dialog field **`Set Metered Value`** is opened. Enter the desired value in the entry field. Then click on **`OK`**.

The entered value is transferred to the device and the display within the window in Figure 7-24 is updated.



Date and time
07.12.99 14:57:10.000
07.12.99 14:57:14.000

Number	Measured value	Value
	Limit IL1	100,0 A
	Limit IL2	100,0 A
	Limit IL3	100,0 A
	Limit IL1	101,4 %
	Limit IL2	101,3 %
	Limit IL3	101,3 %

Figure 7-24 Set Points in DIGSI® 4

7.1.3.4 Resetting of Metered Values and Minimum/Maximum Values

Metered values of measured values and minimum/maximum value memories can be reset.

From the Device Front

With the device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Use the ▼ key to select the menu item ***`Measurement`*** and switch to the list of measured values using the ▶ key. The **`MEASUREMENT`** selection appears.

There, select the menu item ***`Reset`*** with the ▼ key, and switch to the list of limit values using the ▶ key (see Figure 7-25).

▼

```
RESET           13/14
---------------------
 ResMinMax         71
 Meter res         81
```

```
 PW Settings?
     = ------
```

ENTER Enter password Nr. 5 (for individual parameters) and confirm with ENTER

```
Are you sure?
>Yes No Escape
```

Confirm “YES” with the ENTER key and complete the resetting of the selected measured values, or switch to “`NO`” with the ▶ key and cancel the resetting with the ENTER key.

Figure 7-25 Setting of metered values and minimum/maximum values on front panel

With the keys ▼ and ▲ paging up and down in the table is possible.

To reset a memory, it must be marked by means of the keys ▼ and ▲ and subsequently the key ENTER must be pressed.

A prompt for the entry of password No. 5 (for individual parameters) appears. After entry of the password and confirmation with ENTER, the query “`Are you sure?`”, with the default answer “`Yes`” appears (Figure 7-25). Confirm with the key ENTER, if the corresponding measured values should really be reset. A message in the display will then show the answer “`Change ok`”. If you do not want to reset the measured values, press the ▶ key, so that the answer “`No`” is marked, and confirm with the ENTER key. Before confirming with the ENTER key, the responses can be toggled between “YES” and “`NO`” using the ◀ and ▶ keys. Alternatively, the ESC key can be pressed to cancel the resetting procedure.

Use the ◀ key to return to the **`MEASUREMENT`** submenu. Use the MENU key to return to the **`MAIN MENU`**.

From PC with DIGSI® 4

Resetting of metered values and minimum/maximum values is done for all categories at the same time.

To reset values back to zero, first click onto the required group (energy or minimum/ maximum values) in the **`MEASUREMENT`** submenu. Open the context menu with a *right* mouse click and select **`Reset.`**

After having entered the password N° 5 (changing parameters) the reset process is initiated.

Note:
When selecting **`Reset`**, all values are reset to **zero**. This procedure cannot be undone.

7.1.4 Fault Records

Waveform data is stored in the device and can be graphically represented on a personal computer using DIGSI® 4, together with the graphic program DIGRA® 4. The settings associated with fault recording — such as duration and pre- and post-trigger times — were set according to Chapter 6.

7.1.4.1 Viewing Fault Records

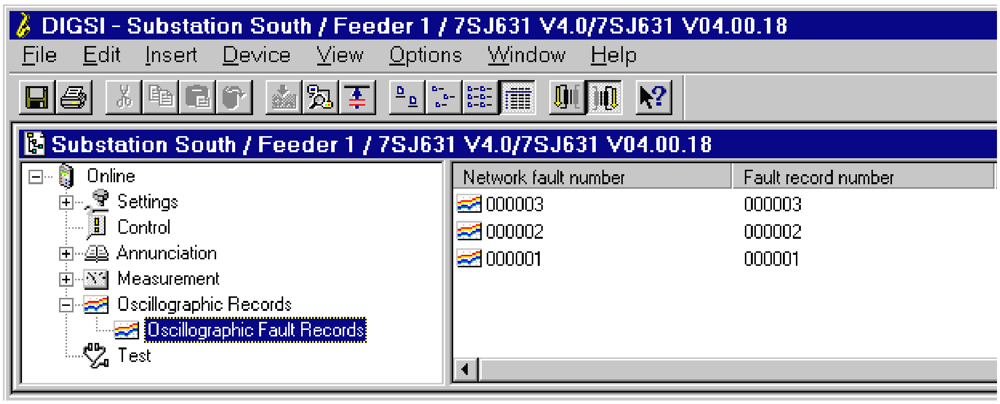
From PC with DIGSI® 4

To view the fault recording data on a screen, one of the programs SIGRA® 4 or Comtrade Viewer (included with SIMATIC Manager) is needed. Do the following:

Double click on **`Oscillographic Records`** (Figure 7-2) to view the folder ***`Oscillographic Fault Records`***. The folders listed in the right window show an overview of oscillographic records. The records are identified with a network fault number, a fault record number, and the date and time.

One single line fault can generate one oscillographic record or more than one. The oscillographic records are numbered.

By double clicking on an fault record in the list view in the right side of the window, one of the above programs is opened, and the selected waveform data are loaded. (See also DIGSI® 4, Operating Handbook, order no. E50417–H1176–C097, Sub-section 8.3.3).



Network fault number	Fault record number
000003	000003
000002	000002
000001	000001

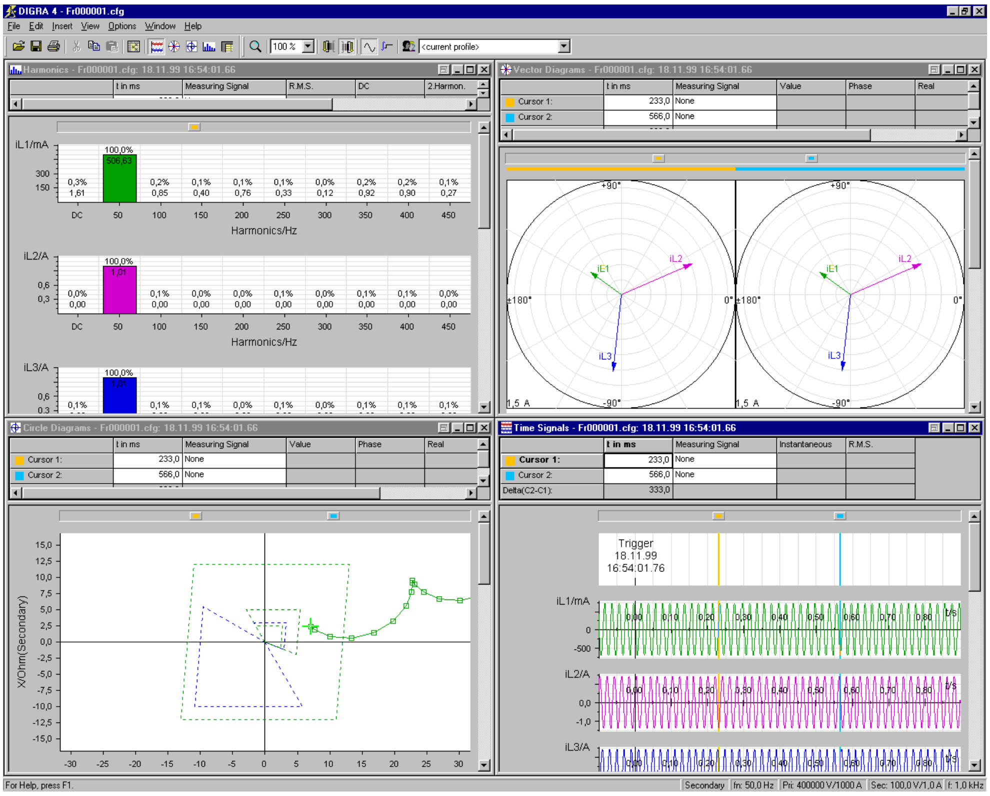
Figure 7-26 Retrieval of fault records in DIGSI® 4 – example

SIGRA® 4 provides support in the analysis of faults in a power system. The program graphically prepares the data recorded during a fault, and calculates additional measured quantities, such as impedances or rms values.

The quantities can be represented in these views:

- Time signals
- Vector diagrams
- Circle diagrams
- Harmonics

Selection takes place using the menu bar (**`View`**), or clicking in the symbol bar above the represented switching fields. Figure 7-27 shows all four views simultaneously.



	t in ms	Measuring Signal	Value	Phase	Real
Cursor 1:	233,0	None			
Cursor 2:	566,0	None			

	t in ms	Measuring Signal	Instantaneous	R.M.S.
Cursor 1:	233,0	None		
Cursor 2:	566,0	None		
Delta(C2-C1):	333,0			

Figure 7-27 SIGRA 4 — Diagrams in the four possible views

The recorded data read into the PC memory are first shown in full on the screen. Current, and possibly voltage, for each phase and the ground are represented separately. The date and time of the viewing process are also memorized.

Representation of primary or secondary quantities can be selected. The base values for currents and voltages are the nominal values of the transformers (CTs or VTs). An identical scale is used for all currents, relative to the largest occurring current value, and for all voltages, relative to the largest occurring voltage value.

Having selected the view **`Time Signals`** different binary information (e. g. general pickup, general tripping) can be recorded as event marks provided that they were configured as mark signals beforehand (see Chapter 5). They also have to be within the recorded time zone (refer to Figure 7-28).

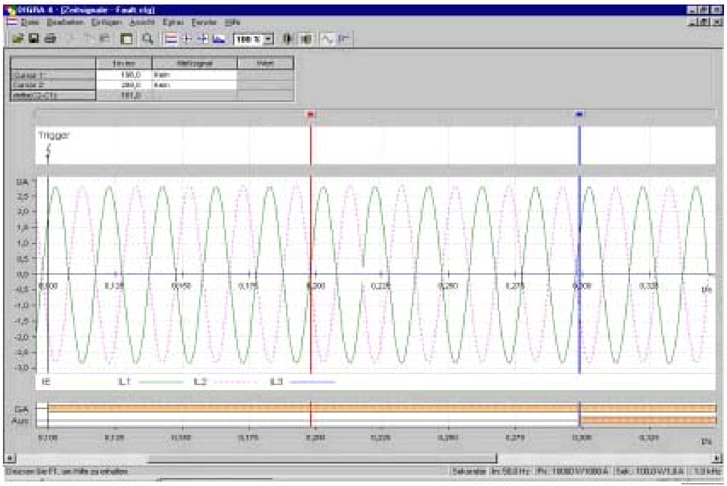


Figure 7-28 Example of a fault record viewing the time signal view

There are 2 cursors in the time axis, cursor 1 and cursor 2. Moving one cursor on the time axis it is possible to read out (in all views) the corresponding points of time from the table below the function bar. In the view **`Time Signals`** the cursors appear as vertical lines across the whole diagram, in view **`Circle Diagrams`** as reticle.

If the user wants to know a specific value of a signal sent at a certain point of time, a cursor must be assigned to this signal. Signal type, value and point of time are then shown in the table.

A zoom function enlarges or minimizes the whole diagram or a part of it. It also optimises the scale. The latter can be carried out either for both axes at the same time or only for a single one. Via the function **`Adapt`**, different diagrams can be adapted in their scale.

Select **`File`** → **`Print`** to print a whole fault record or selected diagrams. To save them you have to indicate the file name and the path.

Options

Using a black-and-white printer it would be sensible to change the layout of the fault record, e. g. to distinguish signals with different types of lines (broken line, dotted line etc.).

Define a layout that is accepted by the printer and save it in **`Options`** / **`Dialogue User Profile`** choosing the file name yourself. All defined signal assignments to the individual diagrams, letterings, types of lines etc. are then permanently available under this name and can be assigned to different fault records. Before starting the printing process first select the user profile.

Further details about the many possibilities that SIGRA® 4 offers can be found in the SIGRA handbook (Order No. E50417–H1176–C070).

7.1.4.2 Saving the Fault Records

Storage of Fault Recording Data

Oscillographic records that are received from the device are not automatically saved in the PC. The data can, however, be saved in files.

To store the fault records click on **`File`** → **`Save`**. This command is only activated if new record data that haven't been stored so far are available. Then DIGSI® 4 automatically generates a directory for the messages - if there is still none existing.

The event group is then stored in this directory. The following question “`Should the process data also be saved?`” is to be answered according to the user‘s requirements. For more details, see the DIGSI® 4 Operating Handbook, Order No. E50417-H1176-C097, Section 9.4.

The oscillographic records stored in the device do not need to be deleted, since the data are stored in a cyclic buffer. The oldest data are automatically overwritten by the newest data.

7.2 Control of Device Functions

You may change individual functions and messages in a 7SA6 while the device is in-service. Some examples are given above, including deleting stored information (Sub-section 7.1.1.5) and setting/resetting counters and set-points (Sub-sections 7.1.2.2 and 7.1.3.3). In this section, three other control capabilities are discussed. They are correcting the date and time, changing the settings group, and affecting information at the system interface during test operations.

7.2.1 Read and Set Date and Time

The 7SA6 device can be connected to an external clock source, binary input or use the internal RTC for time and date stamping.

Whether and by which synchronization source the internal clock should be set was already determined in Section 5.7, “Date and Time Stamping”. Once the device is not supplied with power, the internal time clock (RTC) continues working by taking its power from the integrated buffer battery. Right after the running up of the device it displays a plausible time. The time then is changed automatically by the synchronization source linked to the device or is altered manually. Before initiating a synchronization process which is going to stamp a valid time, different types of time indication in the device display are possible. The following paragraph gives you more details about this matter.

Time Status

Besides the display of date and time, the status of these readings is also provided. The text of the status display can have the appearances given in Table 7-2, under regular conditions of time control.

Table 7-2 Time Status

Status Text	No.	
`-- -- -- --`	1	synchronized
`-- -- -- ST`	2	
`-- -- ER --`	3	not synchronized
`-- -- ER ST`	4	
`-- NS ER --`	5	
`-- NS -- --`	6	

The text symbols, or “status bits”, for the time status have the following meanings:

NS	Not synchronized	Time was neither set manually nor synchronized after power-up. The synchronization via the system interface defines the transmitted time value as “invalid”, the cyclical synchronization continues however.
ER	Time error	At the moment, there is no cyclical synchronization within the tolerance times (time can jump)
ST	Daylight savings time	The latest synchronization signal received supplied a daylight savings time bit

A healthy condition is ensured if texts No 1 and No 2 of Table 7-2 appear in the display.

Representation of the Time

Various representations of the date and time stamp may be given in the **DATE/TIME** sub-menu and in all messages stamped with the date and time. The year number and the values of the status bits “time invalid” and “time malfunction” determine the representations. The possible representations and the associated causes are listed in Table 7-3.

Table 7-3 Representations of Date and Time:

Item	**Display (Example)**		**Year**	**Time Malfunction**	**Time Invalid**
	Date	**Time**			
1	**★★.★★.★★★★**	**15?07:15**	Year = 1990	irrelevant	
2	**04/19/1999**	**15?07:15**	1990<Year<2090	Yes	No
3	**04?19/1999**	**15?07:15**		Yes	Yes
4	**04/09/1998**	**15:07:15**		No	No
5	**★★?★★.★★★★**	**15?07:15**		No	Yes

(**?** appearing in the date and time field indicate that the clock synchronisation has been lost).

Item 1 appears if the internal clock RTC did not have a valid time upon start-up. The messages in the memory buffers are dated 01/01/1990.
Corrective action: Set the date and time manually (see margin header “Changing the Time” below).

Item 2 appears if the time was actually set, but not synchronized. This can happen:
– briefly upon device power-up,
– if synchronization is lost; that is, if the cyclical synchronization is interrupted for a time longer than the set tolerance time (**Error Time**).

Corrective action: If an external synchronizing source is being used, check the source and the connection.

Item 3 is displayed if the RTC had a valid value upon device start-up but the time was neither manually set nor synchronized since.
Corrective action: Set the date and time manually, or wait until the cyclical synchronization takes effect.

Item 4 displays the normal condition; that is, the time is synchronized cyclically according to the type of operation.

Item 5 is displayed if the transmitted time value from the synchronization via the system interface is marked as “invalid”.

Changing the Time

The time can be changed

- By setting the time manually, using the integrated control panel or DIGSI® 4;
- By adjusting the settings for time control.

The date and time can be manually set during operation, provided that the device allows this and password N° 5 (individual settings) was entered. A precondition is that the appropriate type of operation for time control must be selected (see Section 5.7).

When the source of time synchronisation is “internal” or “pulse via binary input” the date and time can be manually set during operation at any instant. The annunciations “time error ON” and “time error OFF” appear in the annunciation log to indicate time synchronization and loss of time synchronization, respectively.

In the other operating modes, manual adjustments are only accepted if the synchronization is momentarily lost. The messages “time error ON” and “time error OFF” are given when manually changing the year in the IRIG B mode.

Without healthy or external time synchronisation the free running date and time can also be relatively adjusted (+/– 23:59:59) using the entry field **Diff.–time**.

This input possibility is not to be confused with the parameter **Offset** (see Section 5.7), which affects the specific general offset to the received synchronization time of the radio clock receiver (e.g. local time vs. GMT time).

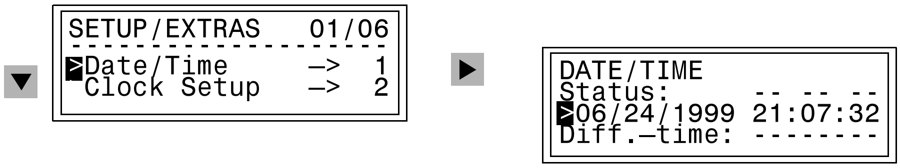
Setting Date and Time

Please take note that in a Distance Protection system with 7SA6 the internal clock continues working without supply voltage for a maximum time period of 24 hours. Once this time period has expired, date and time must be set again.

From the Device Front

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Select ***Settings***, and in the sub-menu **SETUP/EXTRAS**. To set the date and time manually, choose the selection ***Date/Time*** and move to the **DATE/TIME** display using the ▶ key. See Figure 7-29.



```
SETUP/EXTRAS   01/06
--------------------
>Date/Time     ->  1
 Clock Setup   ->  2
```

```
DATE/TIME
Status:        -- -- --
>06/24/1999 21:07:32
Diff.–time: --------
```

Figure 7-29 Manual date and time adjustment from the front panel

To change one of the previous settings (date, time, differential time), mark the item using the ▼ and ▲ keys, and then press the ENTER key.

Enter password N° 5 (for changing settings). Then the actual setting appears in a frame with a blinking cursor. Overwrite this setting with the desired new one using the number keys. Be careful to enter the format properly.

Confirm the change with the ENTER key.

To change the time offset or the tolerance time for a clock error signal, select ***Clock Setup*** under **SETUP/EXTRAS**, as shown in Figure 7-30. Under ***Offset***, the time offset can be changed. Under ***Error Time***, the time delay for the alarm and the source of the time synchronization can be changed. These adjustments are done in the same manner as setting the time, by overwriting the displayed values and confirming with the ENTER key.

To return to the **SETUP/EXTRAS** level, press the ◀ key, several times if necessary. To return to the **MAIN MENU**, press the MENU key.

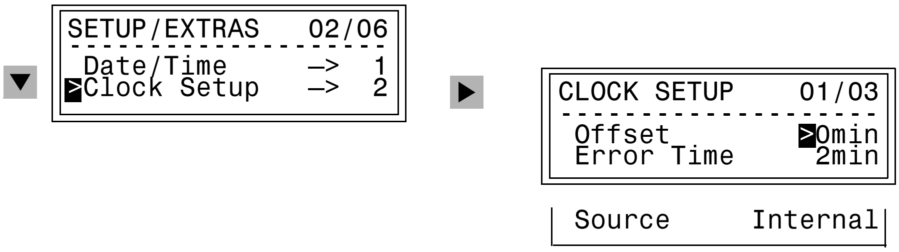


Figure 7-30 Date and time settings from the front panel

From PC with DIGSI$^{®}$ 4

To manually change the date and time of the device:

Click on **Device** in the menu bar as shown in Figure 7-31. Select the command **Set Clock**.

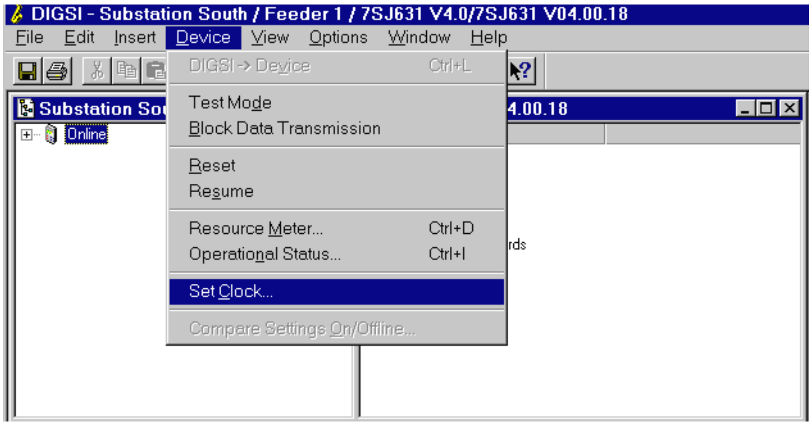
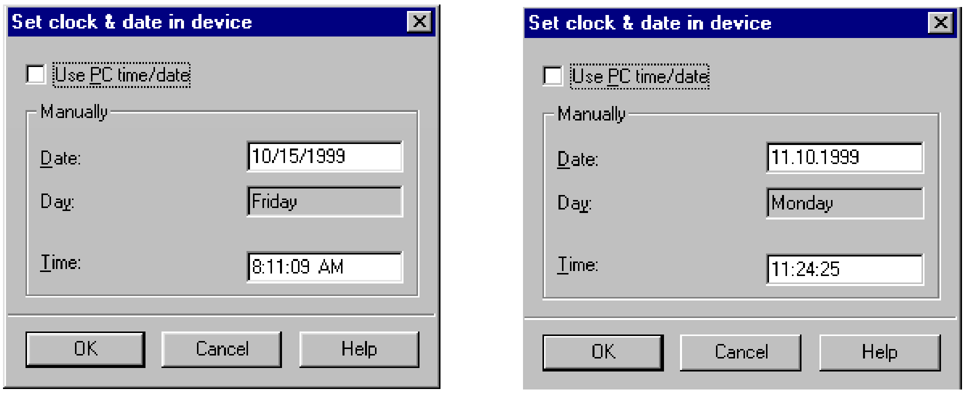


Figure 7-31 Selecting the command **Set Clock** in DIGSI$^{®}$ 4

A dialog field, **Set clock & date in device**, is opened. The displayed values are the present date and time. The day of the week is automatically derived from the date — and cannot be edited.

- Edit the input fields **Date** and **Time**. The format depends on your regional settings of the PC. See Figure 7-32.
  Date: mm/dd/yyyy or dd.mm.yyyy
  Time: hh.mm.ss

Click on **OK** to transfer the entered values into the device. The previous values are changed and the dialog field is closed.



Set clock & date in device

☐ Use PC time/date

Manually

Date: 10/15/1999

Day: Friday

Time: 8:11:09 AM

Set clock & date in device

☐ Use PC time/date

Manually

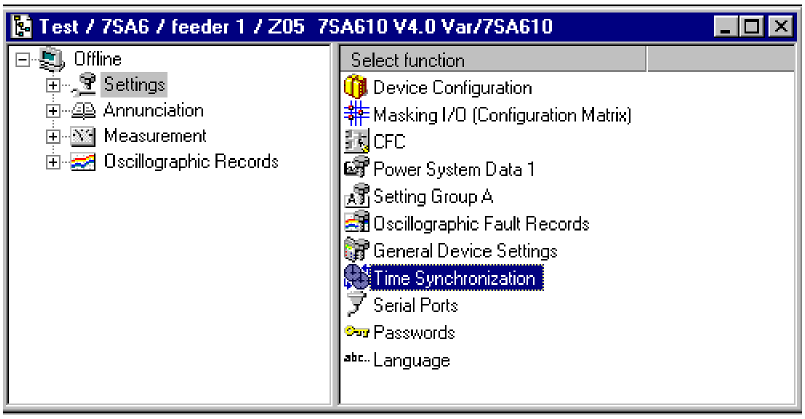
Date: 11.10.1999

Day: Monday

Time: 11:24:25

Figure 7-32 Dialog Field: **Set clock & date in device**

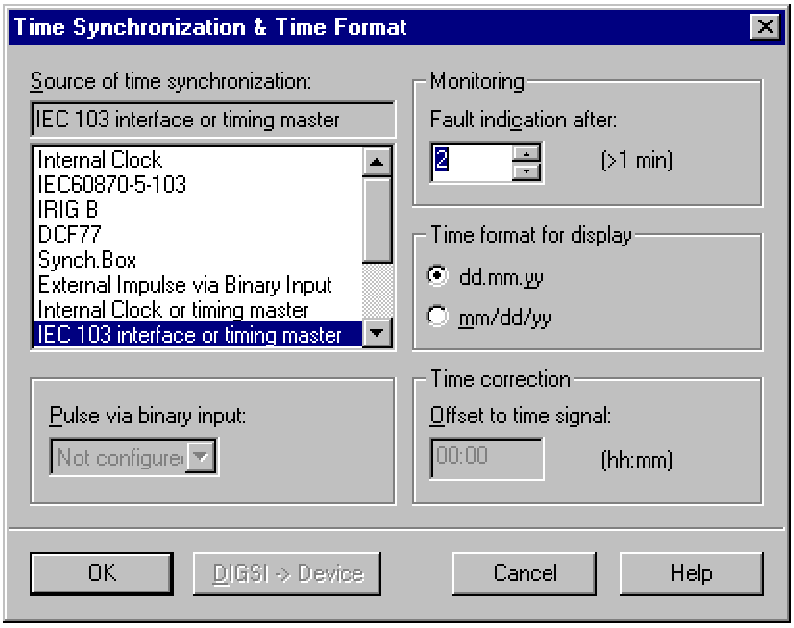
If the time offset or tolerance time is to be changed when the clock alarm failed, double-click onto **Settings** (Figure 7-33) to select the function.



Test / 7SA6 / feeder 1 / Z05 7SA610 V4.0 Var/7SA610

Figure 7-33 Dialog Field: **Settings** in DIGSI® 4 — example

Make a double click onto **Time Synchronization** and the window **Time Synchronization & Time Format** appears. There the user can change the alarm delay („Fault indication after“) and the time offset in the field “Offset to time signal”.



Time Synchronization & Time Format

Source of time synchronization: IEC 103 interface or timing master

- Internal Clock
- IEC60870-5-103
- IRIG B
- DCF77
- Synch.Box
- External Impulse via Binary Input
- Internal Clock or timing master
- IEC 103 interface or timing master

Monitoring

Fault indication after: 2 (>1 min)

Time format for display

● dd.mm.yy

○ mm/dd/yy

Pulse via binary input: Not configure

Time correction

Offset to time signal: 00:00 (hh:mm)

Figure 7-34 Dialogue Field: **Time Synchronization & Time Format**

7.2.2 Changeover of Setting Groups

Four different setting groups for the protective functions are available. The active group can be changed onsite while the 7SA6 is in-service by using the integrated operating field on the device or the operating interface on a PC running DIGSI® 4. Alternatively, you may decide that the active setting group be remotely controlled via binary inputs or the System (SCADA) interface.

Password No 5 (password for individual settings) is required to change setting groups.

The first setting group is called group A. The others are groups B, C, and D. If setting group changing is to be used, then settings for the groups to be employed must have been entered (see Section 6) and the switching process must be ***Enabled*** under Address 0103 **Grp Chge OPTION**.

From the Device Front

When the device is ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item ***Settings*** and switch to the settings with the ▶ key. The selection **SETTINGS** appears.

Using the ▼ key, select the item ***Change Group*** and move to the selection of groups with the ▶ key. The sub-menu **CHANGE GROUP** appears, as shown in Figure 7-35.

The first Address 0301 is marked. The address displays the setting group presently in effect (in Figure 7-35, the active group is ***Group A***).

Using the ▼ key, select Address 0302 and confirm with the ENTER key.

Enter the password No 5 for individual settings, and confirm.

Using the ▼ key, select one of the four groups A, B, C, or D, or give control to another source.

If ***Binary Input*** (activation using binary inputs) is selected, setting group switching is controlled by binary inputs, provided appropriate configuration has been done and the necessary physical connections are present (see Section 5.2).

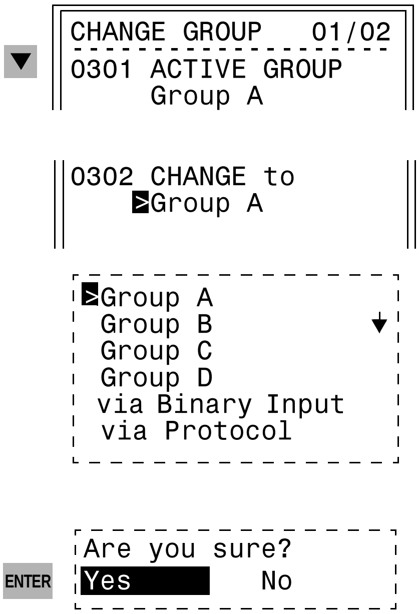
If ***via Protocol*** is chosen (enabled via VDEW-protocol or IEC 60870-5-103), setting group changes can be controlled via the system serial interface.

The currently-active setting group is displayed under Address 0301.

The setting group can be changed under Address 0302: by pressing the ENTER key, after entering the password, two possible alternatives are displayed in a new window each time:

Using the ▼ ▲ keys, select one of the alternatives and confirm with the ENTER key;

The next question (“***Are you sure?***”) is answered with **Yes** and the selected alternative is confirmed, or is answered with **No** using the ▶ key and the change is cancelled with the ENTER key.



▼

```
CHANGE GROUP    01/02
---------------------
0301 ACTIVE GROUP
     Group A
```

```
0302 CHANGE to
    >Group A
```

```
>Group A
 Group B            ↓
 Group C
 Group D
 via Binary Input
 via Protocol
```

ENTER

```
Are you sure?
Yes          No
```

Figure 7-35 Switching setting groups from the front panel

Control of the setting groups can always be regained by switching to one of the groups A through D provided that you know the required password.

The ◀ key can be used to return to the **SETTINGS** sub-menu; the MENU key can be pressed to returns to the **MAIN MENU**.

From PC with DIGSI® 4

By opening the **Online** directory with a double click in DIGSI® 4, the operating functions for the device appear in the left part of the window. See Figure 7-36.

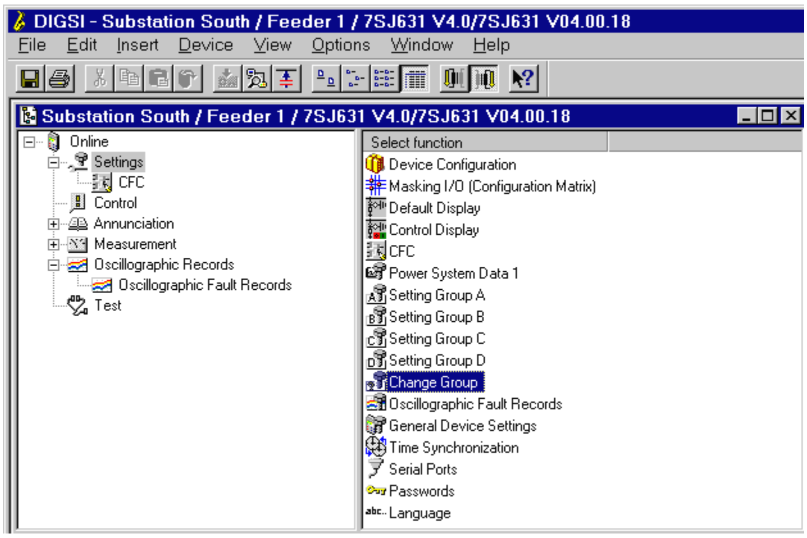
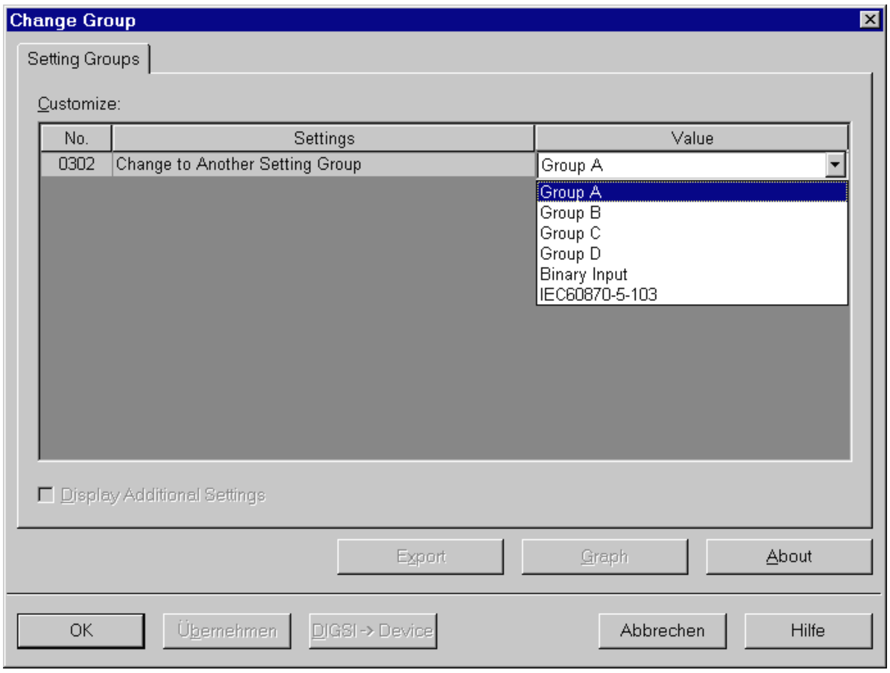


Figure 7-36 Function selection window in DIGSI® 4 – example

Double click on **Settings** to find **Change Group** `in the data window` (Figure 7-36 right).

Double click on **Change Group**. The **Change Group** window is opened, as shown in Figure 7-37.



No.	Settings	Value
0302	Change to Another Setting Group	Group A

Figure 7-37 Setting group switching in DIGSI® 4

The active setting group is displayed. To switch to another setting group, click on the field **Value** and select the desired option from the drop-down list. Before closing the window, transfer the change to the device. This is done by clicking on the button **Digsi → Device**. A request for Password No. 7 (password for setting groups) is given. Enter the correct password, and then click on **OK**.

7.2.3 Test Messages to the System (SCADA) Interface during Test Operation

Depending on the type of protocol, all messages and measured values transferred to the central control system can be identified with an added message “test operation”-bit while the device is being tested onsite (test mode). This identification prevents the messages from being incorrectly interpreted as resulting from an actual power system disturbance or event. As another option, all messages and measured values normally transferred via the SCADA interface can be blocked during the testing (block data transmission).

A password for test and diagnostics is required (password no. 4) to block the messages and measured values.

Data transmission block can be accomplished by controlling binary inputs, by using the operating panel on the device, or via DIGSI® 4.

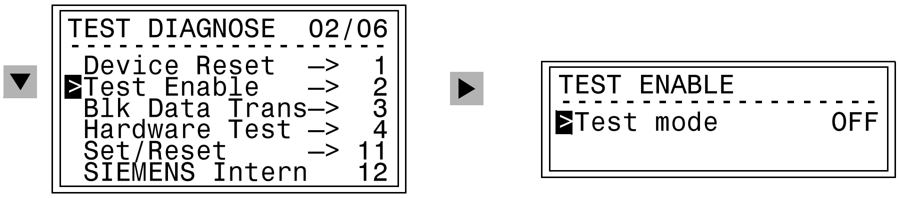
If binary inputs are used, then the appropriate inputs must be configured.

From the Device Front

With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, highlight the menu item ***`Test/Diagnose`***, and then press the ▶ key to enter sub-menu. **`TEST/DIAGNOSE`** will appear at the top of the menu.

At this point, highlight the menu item ***`Test Enable`*** using the ▼ key, and then press the ▶ key to enter sub-menu. **`TEST ENABLE`** will appear at the top of the menu. See Figure 7-38.



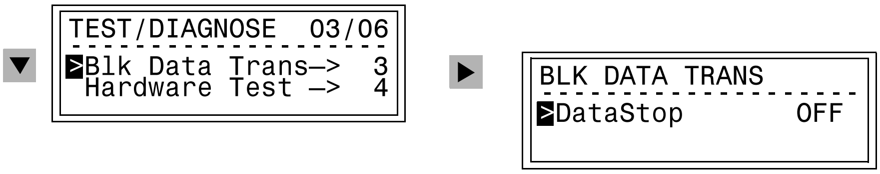
```
▼   TEST DIAGNOSE  02/06      ▶   TEST ENABLE
    --------------------          --------------------
     Device Reset   –>  1         ▶Test mode       OFF
    ▶Test Enable    –>  2
     Blk Data Trans–>   3
     Hardware Test  –>  4
     Set/Reset      –> 11
     SIEMENS Intern    12
```

Figure 7-38 Applying Test Mode from the Operator Control Panel

To start **`Test mode`**, press the ENTER key, enter the password N° 4 (for test and diagnostics) and confirm with the ENTER key. A new window appears with the options ***`ON`*** and ***`OFF`***. Use the ▼ and ▲ keys to select the desired mode, and press the ENTER key. The question “**`Are you sure?`**” is displayed. Highlight the desired response and press the ENTER key. If the mode is changed, the footer shows the message “`Control Executed`” for a short time.

Use the ◀ key to return to the **`TEST/DIAGNOSE`** level; press the MENU key to return to the **`MAIN MENU`**.

The procedure for changing the Block Data Transmission mode is the same. See Figure 7-39 (simplified).



```
▼   TEST/DIAGNOSE  03/06      ▶   BLK DATA TRANS
    --------------------          --------------------
    ▶Blk Data Trans–>  3          ▶DataStop        OFF
     Hardware Test –>  4
```

Figure 7-39 Applying a Block of Data Transmission from the Front Panel (simplified)

The settings for the test mode and the data transmission block are normally ***`OFF`***. Definitions:

- **`Test mode`** – With the ***`ON`*** setting, the “test mode”-bit is transferred for messages compatible with IEC 60 870–5–103.
- **`DataStop`** – With the ***`ON`*** setting, no messages or measured values are transferred (“transfer block”).

From PC with DIGSI® 4

Click on **`Device`** in the menu bar to reach the commands **`Block Data Transmission`** and **`Test Mode`**. See Figure 7-40.

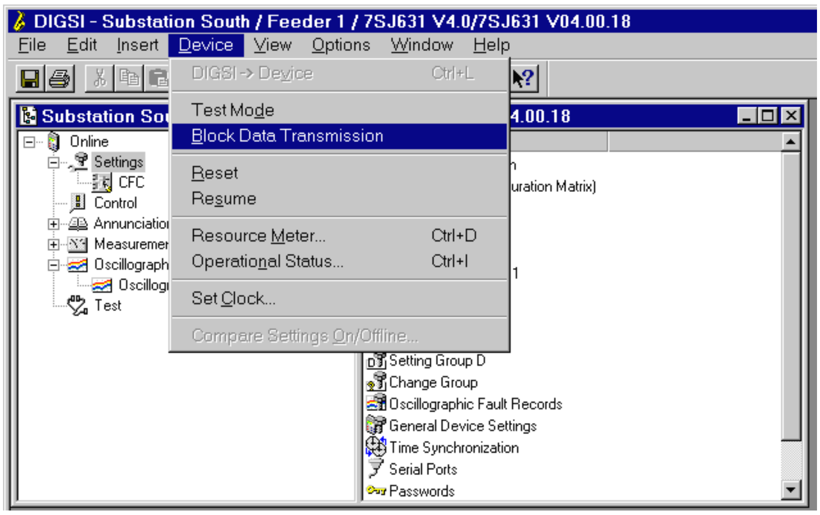


Figure 7-40 Example: Transfer Block Activated in DIGSI® 4

Click on **`Block Data Transmission`** to activate or deactivate the transfer block. After entry of Password No. 4 for test and diagnostics, and confirmation with **`OK`**, the setting change is complete.

Activation is indicated with a check mark in front of the command.

Follow the same procedure for the command **`Test Mode`**, if this option is desired.

Note:

Remember to change the settings for **Block Data Transmission** and **Test Mode** back to the desired, in-service settings (both typically ***`OFF`***) when the tests are complete.

7.3 Circuit Breaker Test Function

The circuit breaker and the trip circuits can be tested during normal operation by execution of a TRIP and CLOSE command via the device.

A prerequisite for this test is that the required test commands were allocated to the corresponding command relays during the configuration of the device. It is also possible to test the individual circuit breaker poles, provided that the device is capable of single-pole tripping, the circuit breaker is capable of single-pole tripping and that the wiring and routing has been done accordingly.

A maximum of 4 test programs is available (refer to Table 7-4). For the circuit breaker it may be possible to initiate single- and three-pole TRIP/CLOSE cycles. In the event of three-pole tripping, only item 4 is important.

Table 7-4 Circuit breaker test programs

Item	Test Program	Operational Messages
1	1-pole TRIP/CLOSE–cycle phase L1	`CB1–TEST TRIP command – Only L1`
2	1-pole TRIP/CLOSE–cycle phase L2	`CB1–TEST TRIP command – Only L2`
3	1-pole TRIP/CLOSE–cycle phase L3	`CB1–TEST TRIP command – Only L3`
4	3-pole TRIP/CLOSE–cycle	`CB1–TEST TRIP command L123`
	associated close command	`CB1–TEST CLOSE command`

In the event that circuit breaker auxiliary contacts are used to derive the switching state of the circuit breaker via binary inputs to the device, the test cycle can only be initiated when the circuit breaker is in closed position.

Note:

For CB Test and automatic re-closure the CB auxiliary contact status derived with the binary inputs > CB1 ... (FNo. 366 - 371, 410 and 411) is relevant for indicating the CB switching status. The other binary inputs > CB ... (FNo. 351 - 353, 379 and 380) apply to the recognition of line status (address 1134) and reset of trip command (address 1135) which is used by the other protection functions, e.g. echo function, switch-onto-fault overcurrent etc. . For applications with only one CB, both binary input functions e.g. 366 and 351 can be allocated to the same physical input.

A further prerequisite for the initiation of the test is that no protection function in the device has picked up, and that the circuit breaker is ready.

The device indicates the status of the test sequence with corresponding messages in the display or on the monitor of a PC. If the device refuses to run or terminates the test sequence, it is likely that one of the preconditions for the execution of the test cycle has not been satisfied. The reason for the refusal or termination is also shown in the front display or monitor of the PC.

`CB-TEST running`	Circuit breaker test in progress
`CB-TSTstop FLT.`	Circuit breaker test cannot be started as a system fault is present
`CB-TSTstop OPEN`	Circuit breaker test cannot be started as the circuit breaker is not closed
`CB-TSTstop NOTr`	Circuit breaker test cannot be started as the circuit breaker is not ready
`CB-TSTstop CLOS`	Circuit breaker test has been terminated as the CB is still closed (prior to CB test reclosure)
`CB-TST .OK.`	Circuit breaker test cycle has been completed successfully

The following diagram shows the test sequence in principal:

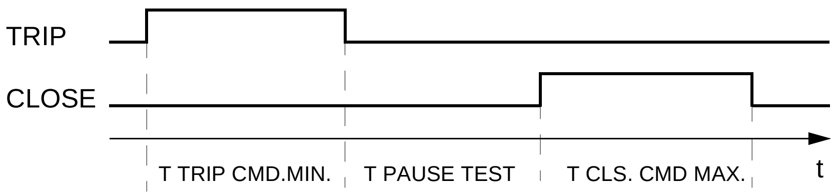


Figure 7-41 TRIP-CLOSE test cycle

The initiation of the test is done via the keypad and display on the front of the device or with a PC running DIGSI® 4. Entry of the password (password No. 4 for test and diagnostics) is required.

DANGER!

A successful initiation of a test cycle may cause closure of the circuit breaker if an external reclose device is available!

From the Device Front

With the device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

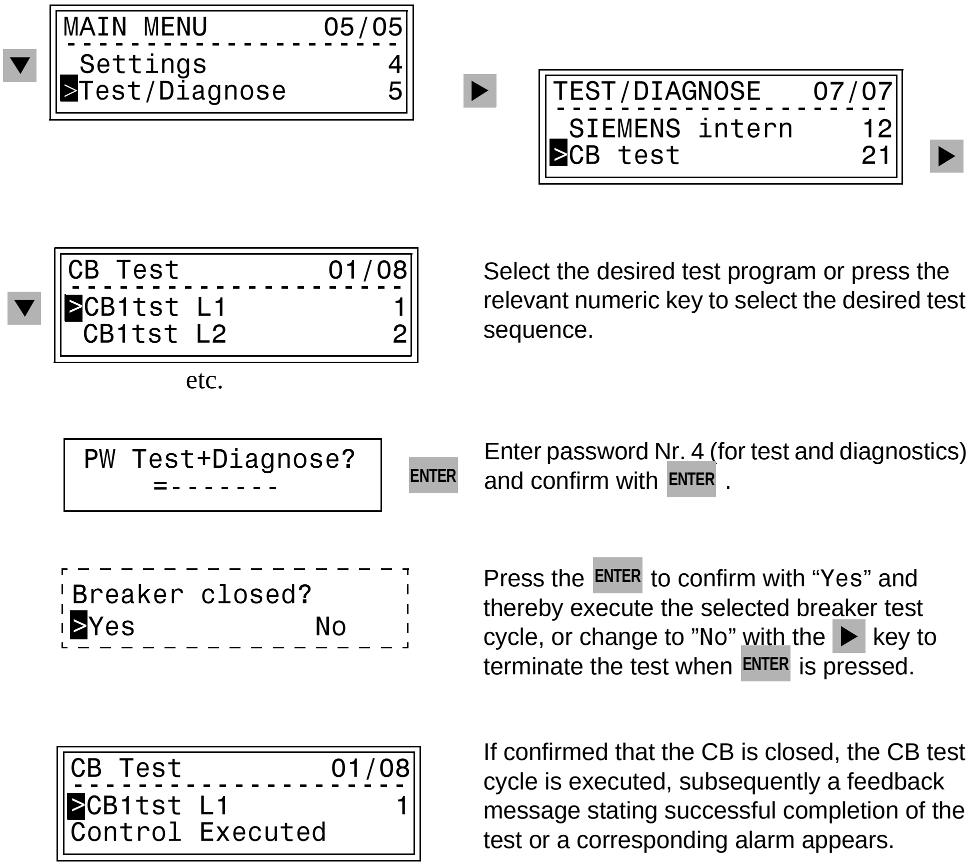
Select the ***`Test/Diagnose`*** option using the ▼ key and enter the sub-menu **`TEST/ DIAGNOSE`** with the ▶ key.

With the ▼ key, the ***`CB test`*** (21) is now marked and the test program is selected with the ▶ key.

A prompt for entry of password No. 4 (test and diagnostics) appears. After entry of the password and confirmation with ENTER, the query "`Breaker closed?`" appears, with the default response "Yes" (Figure 7-42). This must be confirmed by pressing the ENTER key if the circuit breaker is definitely closed.

If circuit breaker auxiliary contacts are connected and marshalled, the device rejects the test cycle when the auxiliary contacts indicate that the circuit breaker is not closed, even if the operator confirms the opposite. Only if no auxiliary contacts are marshalled, will the device rely on the confirmation by the operator.

If the test cycle should be cancelled, press the ▶ key in response to the above query, so that the answer “`No`” is marked. This must be confirmed with the ENTER key. Prior to the confirmation with the ENTER it is possible to toggle between “**`Yes`**” and “**`No`**” with the ◀ and ▶ keys. Alternatively, the test sequence may also be cancelled by pressing the ESC key.



```
MAIN MENU         05/05
---------------------
 Settings             4
>Test/Diagnose        5
```

```
TEST/DIAGNOSE   07/07
---------------------
 SIEMENS intern     12
>CB test            21
```

```
CB Test           01/08
---------------------
>CB1tst L1            1
 CB1tst L2            2
```

etc.

Select the desired test program or press the relevant numeric key to select the desired test sequence.

```
PW Test+Diagnose?
   =-------
```

Enter password Nr. 4 (for test and diagnostics) and confirm with ENTER .

```
Breaker closed?
>Yes           No
```

Press the ENTER to confirm with “`Yes`” and thereby execute the selected breaker test cycle, or change to ”`No`” with the ▶ key to terminate the test when ENTER is pressed.

```
CB Test           01/08
---------------------
>CB1tst L1            1
Control Executed
```

If confirmed that the CB is closed, the CB test cycle is executed, subsequently a feedback message stating successful completion of the test or a corresponding alarm appears.

Figure 7-42 Circuit breaker trip test cycle from the front of the device

From PC with DIGSI® 4

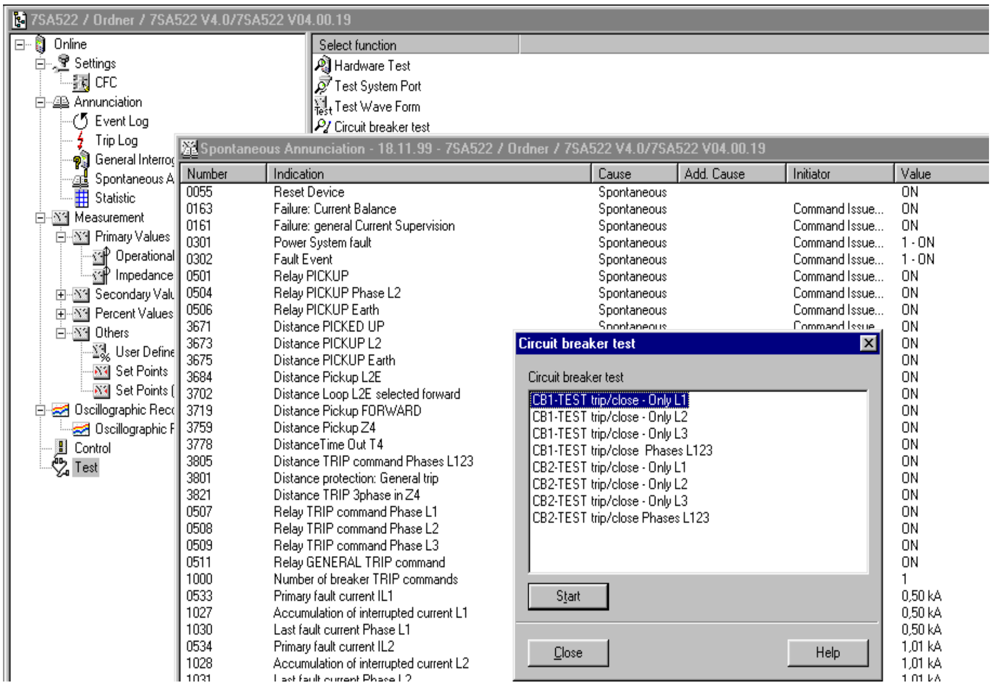
If the **`Online`** directory in DIGSI® 4 is opened with a double click, the operation functions of the device appear in the left hand side of the window.

By clicking on **`Test`**, a list of the available functions appears on the right hand side of the display (Figure 7-43).

By a double click on the **`Circuit breaker test`**, a dialogue window is opened in which the desired test sequence can be marked for selection.

Following a double click, a prompt for the entry of password No. 4 (for test and diagnosis) appears.

After entry of the password and confirmation with **`Ok`** the test sequence is executed. In the spontaneous event window, the execution of the test is displayed with the corresponding control responses and messages.



Spontaneous Annunciation - 18.11.99 - 7SA522 / Ordner / 7SA522 V4.0/7SA522 V04.00.19

Number	Indication	Cause	Add. Cause	Initiator	Value
0055	Reset Device	Spontaneous			ON
0163	Failure: Current Balance	Spontaneous		Command Issue...	ON
0161	Failure: general Current Supervision	Spontaneous		Command Issue...	ON
0301	Power System fault	Spontaneous		Command Issue...	1 - ON
0302	Fault Event	Spontaneous		Command Issue...	1 - ON
0501	Relay PICKUP	Spontaneous		Command Issue...	ON
0504	Relay PICKUP Phase L2	Spontaneous		Command Issue...	ON
0506	Relay PICKUP Earth	Spontaneous		Command Issue...	ON
3671	Distance PICKED UP	Spontaneous		Command Issue...	ON
3673	Distance PICKUP L2				ON
3675	Distance PICKUP Earth				ON
3684	Distance Pickup L2E				ON
3702	Distance Loop L2E selected forward				ON
3719	Distance Pickup FORWARD				ON
3759	Distance Pickup Z4				ON
3778	DistanceTime Out T4				ON
3805	Distance TRIP command Phases L123				ON
3801	Distance protection: General trip				ON
3821	Distance TRIP 3phase in Z4				ON
0507	Relay TRIP command Phase L1				ON
0508	Relay TRIP command Phase L2				ON
0509	Relay TRIP command Phase L3				ON
0511	Relay GENERAL TRIP command				ON
1000	Number of breaker TRIP commands				1
0533	Primary fault current IL1				0,50 kA
1027	Accumulation of interrupted current L1				0,50 kA
1030	Last fault current Phase L1				0,50 kA
0534	Primary fault current IL2				1,01 kA
1028	Accumulation of interrupted current L2				1,01 kA
1031	Last fault current Phase L2				1,01 kA

CB1-TEST trip/close - Only L1
CB1-TEST trip/close - Only L2
CB1-TEST trip/close - Only L3
CB1-TEST trip/close Phases L123
CB2-TEST trip/close - Only L1
CB2-TEST trip/close - Only L2
CB2-TEST trip/close - Only L3
CB2-TEST trip/close Phases L123

Figure 7-43 Circuit breaker trip test in DIGSI® 4

7.4 Control of Switchgear

A SIPROTEC® 4 device 7SA6 contains control functions that allow for opening and closing of power system switching devices (i.e. circuit breakers). Local control is possible utilizing different elements of the 7SA6. Breaker control from a remote location is also possible using the SCADA interface or DIGSI® 4. (Performing control functions with a PC running DIGSI® 4, connected to the front serial port, is considered a “remote” operation for breaker control purposes.) Some control actions from a 7SA6 include unsynchronized commands for circuit breakers, circuit switchers, ground switches, etc., and stepping commands for increasing or decreasing transformer LTC steps.

Safety mechanisms in the command path ensure a command can only take place if the check of previously defined safety criteria is concluded positively.

Note:

To be able to control switchgears, the corresponding binary inputs and outputs must have been allocated during configuration (see Section 5.2). Interlocking settings may also have been preset for the device by means of the user-defined logic functions (as described in 5.3).

If a power system switching device has auxiliary contacts that indicate the position of the device and these contacts are connected to the 7SA6 and configured as double-point indications then the switching device provides feedback indication that are monitored for plausibility of control actions. If a switching device does not indicate either the closed or open position, the display for the switching device indicates an invalid position in the 7SA6. All subsequent control operations to the equipment are interlocked.

Control from a 7SA6 to a power system equipment can originate from four sources:

- Local operation using the operator control panel,
- Operation with a PC, via the operating interface and DIGSI® 4
- Binary inputs,
- Remote operation using the system interface,

Switching priority for the four command sources is set using the Switching Authority.

For Interlocked Switching, all programmed interlocking conditions are checked before a control operation is performed. If one of the conditions is not met, then the command is rejected and an error message is recorded and displayed. Fixed, predefined, standard interlocking features are implemented in the 7SA6 and can be configured (activated) for the specific application. The following tests can be activated (on) or deactivated (off) for a switching device:

- Device Position (check SCHEDULED = ACTUAL comparison).
- Substation controller, to be implemented with Version 4.2,
- Zone controlled / Bay interlocking (e.g., logic via CFC),
- Blocking by protection (control operations blocked by protective functions),
- Double operation (blocking of multiple control operations),
- Switching authority (Local/Remote),

7.4.1 Display Equipment Position and Control

From the Device Front

Devices with graphic display:

Devices with graphic display enable the user to read out the current switchgear positions in the default and control display. With the latter switchgears can also be controlled. For this purpose use the three independent keys of different colours you can find below the graphic display.

The CTRL key is used to directly reach the control display.

Select the required switchgear using the navigation keys ▲, ▼, ◀, ▶. To quit the program during the selection process of switches or before tripping the command press ESC.

To define the switching direction press key I or key O.

The circuit breaker symbol in the control display blinks when it is in the required position. On the lower screen end you will be requested to confirm your decision.

Press the ENTER key. Then a safety query is carried out.

Confirm the safety query using the ENTER key or quit the procedure with ESC.

Having confirmed the query, the actual switching activities can be initiated.

If the process has not been confirmed within one minute or if it was interrupted, the blinking activitiy still indicating the required position goes back to the corresponding actual status.

Under normal conditions the control display shows the new actual status after a tripped switching command. At the lower screen end the message “`End of Command`” appears. For switching commands with feedback the message “`RM erreicht`“ appears shortly before the latter.

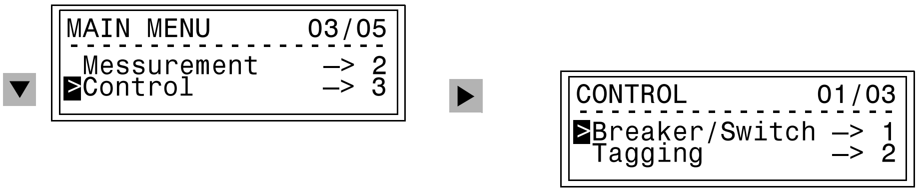
If the switching command is rejected because one interlocking condition could not be fulfilled, the display shows a message informing the user about the reason of the rejection (see Subsection 7.4.8). The message must be cancelled with ENTER to be able to continue the operation of the device.

All devices:

All devices provide the option to read out the circuit breaker positions and to control switching commands via the display menus.

With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`***, and go to editing the control functions with the ▶ key. The selection **`CONTROL`** appears (See Figure 7-44).



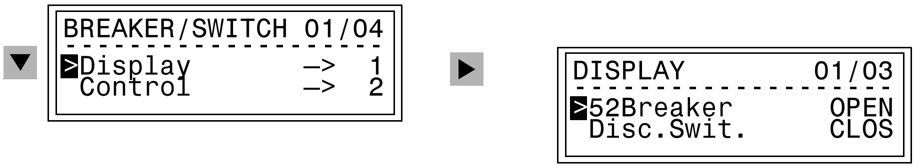
```
MAIN MENU       03/05
-------------------
 Messurement     -> 2
>Control         -> 3
```

```
CONTROL         01/03
-------------------
>Breaker/Switch -> 1
 Tagging         -> 2
```

Figure 7-44 Control Selections from the Front Panel

Select, by means of the ▼ key, the item ***Breaker/Switch***, and continue with the item by pressing the ▶ key. The selection **BREAKER/SWITCH** appears. See Figure 7-45.

Select ***Display*** (default) and press the ▶ key. The selection **DISPLAY** appears, in which the positions of all planned switching devices can be read out.



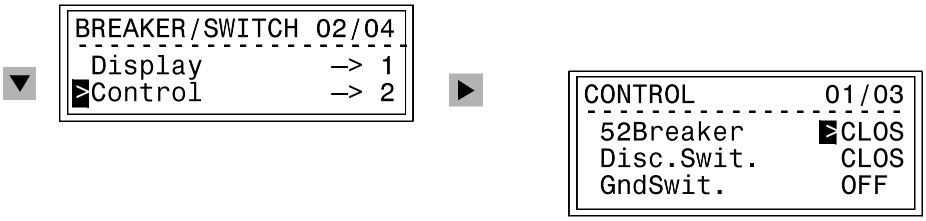
```
BREAKER/SWITCH 01/04
--------------------
>Display      ->  1
 Control      ->  2
```

```
DISPLAY        01/03
--------------------
>52Breaker      OPEN
 Disc.Swit.     CLOS
```

Figure 7-45 Display of Switch Positions in the HMI (example)

The ◀ key can be used to return to **BREAKER/SWITCH**.

To control a switching device, select the option ***Control*** in the **BREAKER/SWITCH** sub-menu and press the ▶ key to go to the table of operating resources that can be controlled. See Figure 7-46. All planned switching devices appear. The actual position of each switch is displayed first. Use the ▲ and ▼ keys to move to the desired switch.



```
BREAKER/SWITCH 02/04
--------------------
 Display      -> 1
>Control      -> 2
```

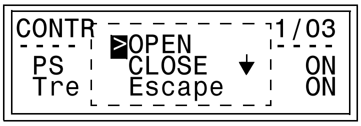
```
CONTROL        01/03
--------------------
 52Breaker     >CLOS
 Disc.Swit.     CLOS
 GndSwit.       OFF
```

Figure 7-46 Control of Switching Devices from the Operator Control Panel (example)

Select the switch to be controlled using the ▲ and ▼ keys and press the ENTER key.

Enter Password No. 1 (for interlocked switching) and acknowledge with the ENTER key. Note: if the switching mode is ***NON–INTERLOCKED (Test)*** (Sub-section 7.4.7), all switching operations are only possible with Password No. 2 (for non-interlocked switching).

A new window appears. Depending on the operating and command type of the selected switching device, various options are offered. Move between them using the▼ and ▲ keys.



```
CONTR          1/03
----  >OPEN    ----
 PS    CLOSE ↓   ON
 Tre   Escape    ON
```

Figure 7-47 Selection Window for Control Operations on the Front Panel (example)

To perform control, confirm with the ENTER key. A safety inquiry appears, “**Are you sure?**”. If the response is “**YES**”, the switching operation is initiated (provided the Local command is allowed). A message is displayed and recorded indicating the results of the control action. Acknowledge this by pressing the ENTER key once again.

The command is not executed if the switching operation is restricted. The operation may be restricted for reasons pertaining to, for example, switching authority (see Sub-section 7.4.6) or interlocking (see Sub-section 7.4.7). A message is displayed and recorded indicating the results of the control action. Acknowledge the message by pressing the ENTER key. Parameters to set control properties can be examined in the display. Refer to Sub-section 7.4.4.

The ◄ key can be used to return to **BREAKER/SWITCH**. Press the MENU key to return to the **MAIN MENU**.

From PC with DIGSI® 4

When the **Online** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window. Clicking on **Control** displays the associated function selection in the data window. See Figure 7-48.

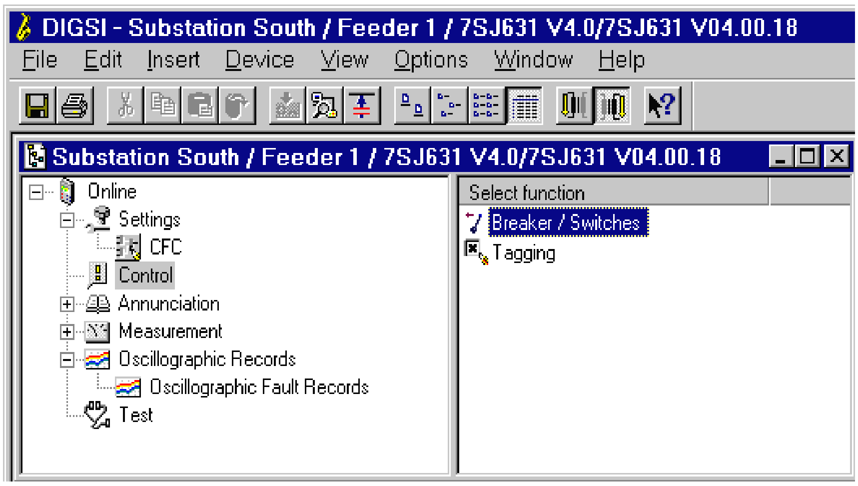
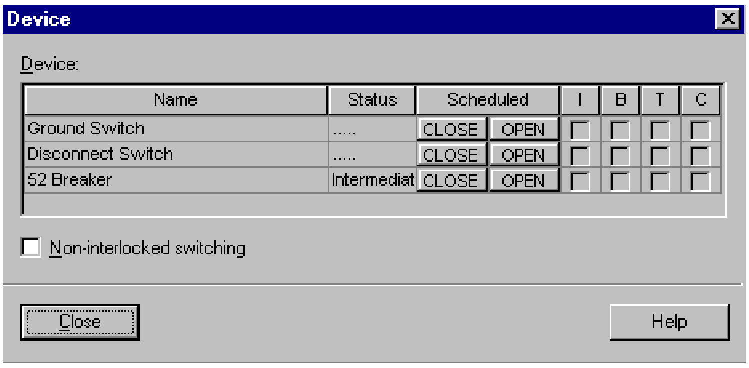


Figure 7-48 Window for Control of Operating Resources in DIGSI® 4 - (example)

By double clicking on **Breaker/Switches**, a dialog field is opened in which the present status of each switch is visible. See Figure 7-49. Control can be performed from this dialog box provided the switching authority is set to ***REMOTE***.

The switching authority is first transferred to DIGSI® 4 at the moment the control window shown in Figure 7-49 is opened. The configuration matrix discussed in Section 5.2 determines the control devices that have information displayed in this field.



Device:

Name	Status	Scheduled		I	B	T	C
Ground Switch	.....	CLOSE	OPEN	☐	☐	☐	☐
Disconnect Switch	.....	CLOSE	OPEN	☐	☐	☐	☐
52 Breaker	Intermediat	CLOSE	OPEN	☐	☐	☐	☐

☐ Non-interlocked switching

Figure 7-49 Dialog Box for Performing Control in DIGSI® 4 (example)

A description of the switching device is displayed in the left column of the dialog field. This represents the contents of the **`Long Text`** column within the configuration matrix.

The actual position of the switch is displayed in the **`Status`** column (***`OPEN`***, ***`CLOSE`***, ***`Intermediat`***). The switching possibilities are displayed in the **`Scheduled`** column.

Four control fields are shown in the right part of the dialog field. If a check mark is displayed in one of these fields, **`AB`** (Access Block = Block Input Acquisition), **`TB`** (Transmission Block = Serial Interface Blocked), **`TR`** (Manual Overwriting), and **`CB`** (Chatter Block), the associated block function is set or the feedback indications of the device have been simulated.

Normally, operating devices are switched in the ***`interlocked (Normal)`*** mode. The configured interlocking conditions are checked before a control command is carried out. As soon as a control command is entered in the **`Scheduled`** column, Password No. 1 for interlocked switching is requested for safety reasons. Further control possibilities remain possible until the control dialog field is closed, or the switching mode is changed.

If a control command is successfully executed, then the display of the actual condition of the affected switch is updated in the window.

Operating resources can be switched without interlocking condition checks; however, the correct Password No. 2 for non-interlocked switching must be entered. Mark the option ***`Unlock`*** by clicking on the field.

DANGER!

Only highly qualified personnel who have an exact knowledge of the power system conditions shall perform non-interlocked switching. Inappropriate switching operations can lead to death, serious personnel injury and property damage.

7.4.2 Manual Overwriting

When using the **Control with Feedback** feature, the device checks the feedback indications (i.e. 52-a and 52-b) before and after a control command is issued. If for some reason, the physical connection from a circuit breaker auxiliary contact to the binary inputs of the device is broken, inadvertently shorted, or disconnected, commands may be blocked. If this situation occurs, and the affected switching device is to be operated, the desired device position indication can be simulated through “manual overwriting” (Input Tagging). The entered device position indication in the 7SA6 can be used to simulate and check interlocking conditions.

To accomplish manual overwriting in the 7SA6 the binary inputs of the affected device must be decoupled first. This decoupling of the system is accomplished by setting the respective status. The decoupling is discussed in Sub-section 7.4.3.

From the Device Front

To enter the desired position indication for a switching device:

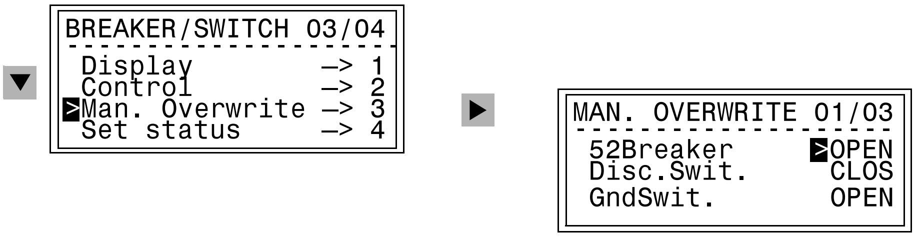
With a 7SA6 ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`*** and go to the control functions with the ▶ key. The selection **`CONTROL`** appears.

By pressing the ▶ key, the **`BREAKER/SWITCH`** sub-menu is entered (see Figure 7-50).

Select the item ***`Man. Overwrite`*** using the ▼ key, and move to the next selection using the ▶ key. **`MAN. OVERWRITE`** appears, as shown in Figure 7-50.

The actual position of each switching device is displayed. Move to the desired switch using the ▼ and ▲ keys.



```
BREAKER/SWITCH 03/04
--------------------
 Display        —> 1
 Control        —> 2
>Man. Overwrite —> 3
 Set status     —> 4
```

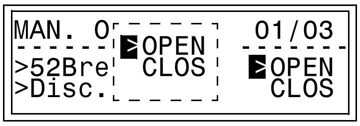
```
MAN. OVERWRITE 01/03
--------------------
 52Breaker     >OPEN
 Disc.Swit.     CLOS
 GndSwit.       OPEN
```

Figure 7-50 Manual Overwriting for Switching Devices from the Front Panel

Enter Password No. 2 (for unlocked switching) and acknowledge with the ENTER key.

By pressing the ENTER key, a selection window is opened for the marked switch, in which manual overwriting can be done with the options ***`OPEN`***/***`CLOSE`***. See Figure 7-51.

Make the selection using the ▲ and ▼ keys, and confirm with the ENTER key.



```
MAN. O┌─────┐ 01/03
------¦>OPEN ¦-------
>52Bre¦ CLOS ¦ >OPEN
>Disc.└─────┘   CLOS
```

Figure 7-51 Selection Window for Manual Overwriting of a Switch Position, Front Panel

A safety inquiry appears: “**`Are you sure?`**” Provided manual overwriting is allowed, a response of “**`YES`**” results in an appropriate message on the display. Acknowledge the message by pressing the ENTER key again.

Manual overwriting is cancelled if the process is restricted because, for example, “**`input ignored`**” is not set (see Sub-section 7.4.3). Manual overwriting is also canceled if the user aborts the procedure. The display provides an appropriate message if manual overwriting is canceled. Acknowledge the message by pressing the ENTER key.

Return to the **`BREAKER/SWITCH`** sub-menu using the ◀ key, or the **`MAIN MENU`** by pressing the MENU key.

From PC with DIGSI® 4

For safety reasons, manual overwriting can only be executed locally using the keypad on the front panel of the device. The feature is not available in DIGSI® 4.

7.4.3 Set Status

A feature of the 7SA6 that is especially useful during testing and commissioning of the device is the capability of temporarily removing the coupling between a switching device and the 7SA6, or between the SCADA and the 7SA6, without physically disconnecting the equipment. This type of separation is also necessary, for instance, if a switch position feedback message is not functioning properly (refer to Sub-section 7.4.2). The menu item **`SET STATUS`** is used to perform the decoupling.

The menu displays a list of all planned switching devices and associated status information identified by a letter. The letters have the following meanings:

- **T** Device is tagged (manually overwritten).
- **I** Input ignored, which means the acquisition of an input status is de-coupled from the process (from the switch-gear).
- **B** Blocked, which means data transmissions to the central device (or SCADASCADA) are blocked.
- **C** Chatter block active, which means, because of frequent message changes, the chatter block was set.
- **O** Output block active, which means the command output is de-coupled from the process (from the system).
- **–** None of the listed limitations is in effect.

Note:

Input ignored (**I**) only works for physical inputs! Do not set “input ignored” for indications created by CFC and allocated to the operating level “Manual Overwriting”. Different to physical inputs - they do not provoke decoupling from the system.

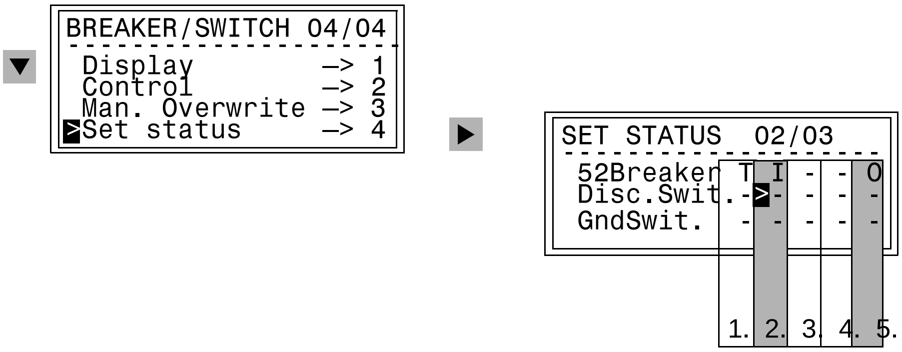
From the Device Front

With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`*** and go to editing the control functions with the ▶ key. The selection **`CONTROL`** appears.

Enter the **`BREAKER/SWITCH`** menu by pressing the ▶ key.

Select the item ***`Set Status`*** with the ▼ key and switch to the next option using the ▶ key. **`SET STATUS`** appears, as shown in Figure 7-52.



```
BREAKER/SWITCH 04/04
--------------------
 Display         -> 1
 Control         -> 2
 Man. Overwrite  -> 3
>Set status      -> 4
```

```
SET STATUS  02/03
-----------------
 52Breaker T I - - O
 Disc.Swit.->- - - -
 GndSwit.  - - - - -
```

Figure 7-52 Set Status at the Front Panel (example)

Move the cursor, using the ▶ and ◀ keys, to the second (Input Ignore) or fifth (Control Block) column of the switching device for which a status change is desired. Entries in this table can only be made in these two columns.

Press the ENTER key. Enter password N° 2 (for interlocked switching) and confirm with ENTER. A selection window is opened displaying all change options that are available.

The second column is reserved for setting Input Ignore (**I**); the fifth for setting the output block (O). The first, third, and fourth columns can only be read in this menu.

The example in Figure 7-52 shows the position for the circuit breaker (52) was tagged (**T**) after the input ignore (**I**) was set, which means the message input was de-coupled from the system. The output block is active (**O**), so the command output is also de-coupled from the system. For the disconnect switch and the ground switch, no limitations are set.

Select the desired change option using the ▼ and ▲ keys, and confirm with the ENTER key.

A safety inquiry appears: "`Are you sure?`" If the response is "**`YES`**", and provided the return routing is allowed, then the display gives an appropriate message.

To return to the **`BREAKER/SWITCH`** level, press the ◀ key as necessary. Press the MENU key to return to the **`MAIN MENU`**.

From PC Using DIGSI® 4

For safety reasons, status changes can only be executed locally using the keypad on the front panel of the device. Status changes are not possible in DIGSI® 4.

7.4.4 Interlocking

Operating equipment such as circuit breakers, circuit switchers and ground switches can be subject to interlocking conditions. These conditions can be viewed at the device under the menu item **`INTERLOCK`**; however, the conditions cannot be changed.

The Interlock display has an object table similar to the one described for Set Status. The table provides the set interlocking conditions, which prevent, or could prevent, a local control operation. Letters identify the interlocking conditions. The meanings of the letters are:

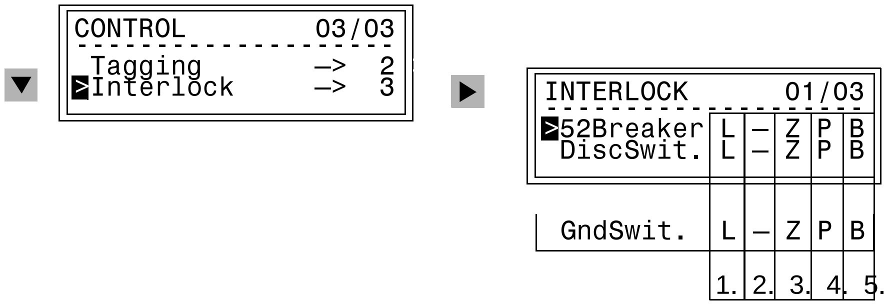
- **L** Local/Remote (Switching Authority),
- **S** Equipment is subject to System Interlocking (in Substation Controller). Commands entered locally are sent to the central computer or controller,
- **Z** Zone controlled (Field- or Bay-Interlocking),
- **P** Check switch position (test actual vs. scheduled),
- **B** Blocking by picked-up protection elements,
- **–** Non-Interlocked.

From PC with DIGSI® 4

With a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`*** and move to editing the control functions with the ▶ key. The selection **`CONTROL`** appears.

Select the item ***`Interlock`*** with the ▼ key and switch to the next selection using the ▶ key. The selection **`INTERLOCK`** appears. See Figure 7-53.



```
CONTROL         03/03
-------------------
 Tagging      ->  2
>Interlock    ->  3
```

```
INTERLOCK      01/03
--------------------
>52Breaker L – Z P B
 DiscSwit. L – Z P B

 GndSwit.  L – Z P B
           1. 2. 3. 4. 5.
```

Figure 7-53 Example of Interlocking Conditions for Switching Equipment, Front Panel

From PC with DIGSI® 4

Interlocking is set for each switching device during project planning (see Sub-section 5.2.4) using the matrix and the dialog box “Object Properties”. Readout of the actively set interlocking is always possible, across the entire path, without a password.

If the **`Online`** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window (Figure 7-36). Double clicking on **`Settings`** brings up the function selection in the right side of the window. By double clicking on **`Masking I/O`**, the matrix is opened. Mark the switching device (in the line for the operating message of the switching device). Using the *right* mouse key, the properties of the switching device can now be called up. The conditions for **`Interlock Switching`**, among other items, are recognizable in the dialog box that opens. Active test conditions are identified with a check mark.

7.4.5 Tagging

To identify unusual operating conditions in the power system, tagging can be done. The tagging can, for example, be entered as additional operating conditions in interlocking checks, which are set up with CFC. Tagging is configured in the same way as for operating devices.

From PC with DIGSI® 4

With a device ready for operation, first press the MENU key. The **MAIN MENU** appears.

Using the ▼ key, select the menu item ***Control*** and move to editing the control functions with the ▶ key. The selection **CONTROL** appears.

Select the item ***Tagging*** with the ▼ key and switch to the next selection using the ▶ key. The selection **TAGGING** appears. See Figure 7-54. The status of the tagging is displayed **Tagging** → **Display**, or changed using **Tagging** → **Set**.

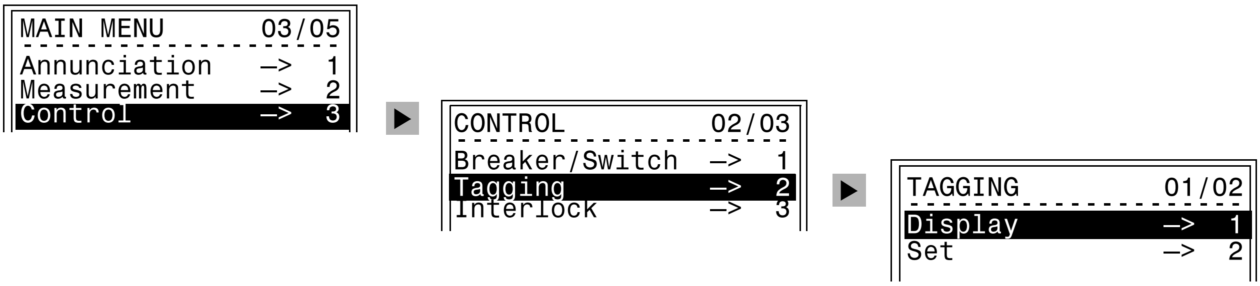


Figure 7-54 Tagging Equipment from the HMI

Note:

The Manual Overwrite function is always done using the HMI on the SIPROTEC® 4 devices.

7.4.6 Switching Authority

Switching authority determines the command sources that are permitted for control.

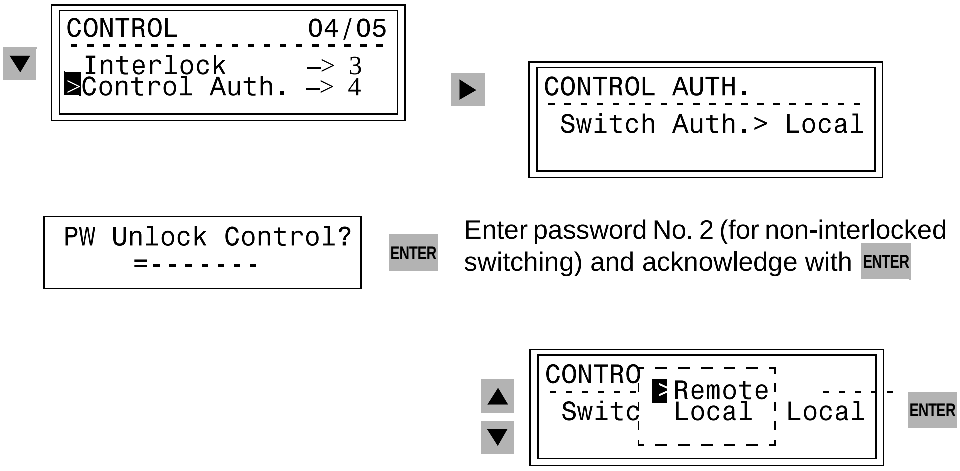
From the Device Front

In devices with graphic display the switching authority is determined by the upper key-operated switch. If the key-operated switch is in horizontal position (*local*), the local control is admitted via the device panel. If it is in vertical position (*remote*), the remote control is admitted.

Otherwise use the device control menu: with a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`*** and move to editing the control functions with the ▶ key. The selection **`CONTROL`** appears.

Here, select the menu item ***`Control Auth.`*** with the ▼ key and switch to the next selection using the ▶ key. The selection **`CONTROL AUTH.`** appears (see Figure 7-55).



```
CONTROL         04/05
---------------------
 Interlock     –> 3
▶Control Auth. –> 4
```

```
CONTROL AUTH.
--------------------
 Switch Auth.> Local
```

```
PW Unlock Control?
     =-------
```

Enter password No. 2 (for non-interlocked switching) and acknowledge with ENTER

```
CONTRO       -----
 Switc ▶Remote  Local
         Local
```

Figure 7-55 Setting Switching Authority with the Operator Control Panel

Pressing the ENTER key opens a selection window in which the options ***`LOCAL`*** / ***`REMOTE`*** are offered.

Choose the desired option using the ▼ and ▲ keys, and confirm with the ENTER key.

Acknowledge the subsequent message pressing the ENTER key.

Use the ◀ key to return to the **`SWITCH AUTH`** level; the MENU key to return to the **`MAIN MENU`**.

From PC with DIGSI® 4

For safety reasons, switching authority can only be changed locally using the keypad on the front panel of the device. Switching authority cannot be changed with DIGSI® 4.

To perform control with DIGSI® 4, switching authority at the device must be set to **`REMOTE`**, or the test conditions for remote control of switching authority must not be set to active. Switching authority is first transferred to DIGSI® 4 when the control window (see Figure 7-49) is opened.

7.4.7 Switching Mode

The switching mode can be changed during operation; so, for example, non-interlocked switching can be enabled during the commissioning of the installed equipment.

DANGER!

Only highly qualified personnel who have an exact knowledge of the power system conditions shall perform non-interlocked switching. Inappropriate switching operations can lead to death, serious personnel injury and property damage.

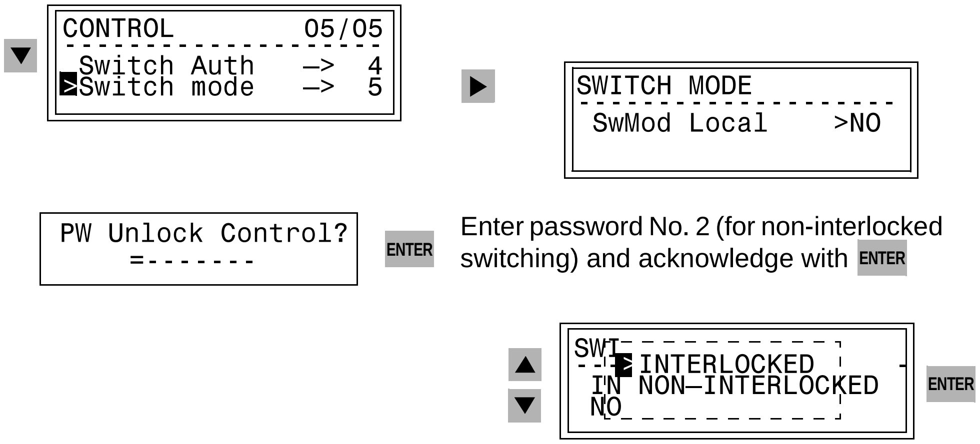
From the Device Front

Devices with graphic display the switching mode is determined by the lower key-operated switch. If the key-operated switch is in horizontal position (*test*), non-interlocked switching is admitted. If it is in vertical position (*normal*), only interlocked switching is admitted.

Otherwise use the device control menu: with a device ready for operation, first press the MENU key. The **`MAIN MENU`** appears.

Using the ▼ key, select the menu item ***`Control`*** and move to editing the control functions with the ▶ key. The selection **`CONTROL`** appears.

Here, select the menu item ***`Switch Mode`*** with the ▼ key and switch to the next selection using the ▶ key. The selection **`SWITCH MODE`** appears (see Figure 7-56).



Enter password No. 2 (for non-interlocked switching) and acknowledge with ENTER

Figure 7-56 Operating Menu for Switching Mode Using Front Panel

Pressing the ENTER key opens a selection window in which the options **`INTERLOCKED`**/**`NON-INTERLOCKED`** are offered.

Make the choice using the ▲ and ▼ keys, and confirm with the ENTER key.

Acknowledge the safety inquiry that follows by again pressing the ENTER key. Use the ◀ key to return to the **`CONTROL`** level. Press the MENU key to return to the **`MAIN MENU`**.

From PC with DIGSI® 4

When the **On-line** window in DIGSI® 4 is opened with a double click, the operating functions for the device appear in the left part of the window (Figure 7-36). Clicking on **Controls** brings up the function selection in the right side of the window (Figure 7-48). By double clicking on **Breaker/Switches**, a dialog field is opened in which, among other options, the option for interlocked and non-interlocked (Unlock) switching is offered.

To switch operating resources without a check of the associated interlocking conditions, mark the option ***Unlock*** by clicking in that field, see subsection 7.4.1.

To set the switching mode for interlocked switching, the aforementioned option field must not be marked. The marking is removed by clicking in the field again.

Further switching operations are possible until the dialog field ***Breaker/Switches*** is closed, or the switching mode is changed.

7.4.8 Control Messages

In the course of system control, the device generates several messages that document the process. For example, messages may be given to report the end of a command or provide the reason for a command denial. These messages and the associated causes are listed in Table 7-5, together with other messages for the control of device functions.

Table 7-5 Possible Control Messages

Message Text	Message Cause
System Error	Interruption by system error
Man.Overwrite OK	Return routing carried out
Man.Overwrite Fail	Return routing cannot be carried out
Control Abort OK	Command interruption carried out correctly
Control Abort Fail	Process cannot be interrupted because no command is issued, command runs in different switching direction, or interruption is not planned or set up.
Control Executed	Command was correctly executed and ended
Control Failed	Refusal because the command number or the origination source is not permitted
Interlocked	Refusal because the communication interface was blocked or the command object is blocked by a protective function.
Switchgr.Intlocked	Refusal because the command object is subject to field interlocking
Switch in Position	Refusal because the present switch position = command direction
Setting Error	Refusal because of a parameter fault, such as unknown command type
Not Authorized	Command from ON-SITE refused because command object is subject to switching authority, which is set to REMOTE
Control Expired	Refusal because command is too old (expiry monitor)
No Control Device	Information address is not planned as command output

Table 7-5 Possible Control Messages

Message Text	Message Cause
`Config. Error`	Refusal because no relay is assigned to this object, or the relay jumpered in the device does not exist
`Control Blocked`	Refusal because an output block is set
`System Overload?`	Refusal because a relay to be controlled is already active (e.g., by another command)
`SW: 1 to n error?`	Refusal because another relay is already controlled
`System Overload`	No more free timers available
`UpperSett. Limit`	For transformer LTC step commands, highest level already reached
`Lower Sett. Limit`	For transformer LTC step commands, lowest level already reached
`Executing Control`	New command refused because a command is already in processing
`Command Timeout`	Feedback indication missing
`BinaryInp. Ignored`	Recording block set
`Chatter Active`	Flutter block is active
`Setting active`	Refusal because parameter loading process is running
`Status Change OK`	Status `command executed`
`Status Change Fail`	Status command cannot be executed
`Change OK`	Marking executed
`Change Failed`	Marking cannot be executed
`Checking Interlock`	Command is sent to the central unit to check system interlocking
`Settings  are OK`	Parameter change was correctly accepted
`Time Limit Expired`	Parameter change was interrupted because time expired
`Terminated-Pickup`	Parameter change interrupted because a fault became active during parameterization
`Restore Parameters`	As a reaction to a fault recognized during parameterization, the last active parameter set is activated again
`Please Wait…`	Initiated process running and requires some time
`Checking Settings`	The changed parameters are tested before acceptance
`Swgr. Feedback OK`	Return message: destination reached
`Swgr. Feedback Fail`	Return message: destination not reached
`Change Rejected`	Parameter change was rejected (e.g., because time expired, or abnormal occurrence during parameterization)
`Control OK`	Positive conclusion message for commands
`Value Incorrect`	Plausibility error in command

7.4.9 Other Commands

The device is equipped with a serial interface for connection to the System (SCADA) interface. From there, the device can receive standardized commands (according to the supported protocol) and transmit them to the respective switching devices, or activate internal functions, e.g. block inputs/outputs or set tags (manual overwrite), or release processing of functions in the CFC. This command processing is determined during project planning and configuration of the matrix.

■

Installation and Commissioning

8

This section is primarily for personnel who are experienced in installing, testing, and commissioning protective and control systems, and are familiar with applicable safety rules, safety regulations, and the operation of the power system.

Installation of the 7SA6 is described in this section. Hardware modifications that might be needed in certain cases are explained. Connection verifications required before the device is put in service are also given. Commissioning tests are provided. Some of the tests require the protected object (line, transformer, etc.) to carry load.

8.1 Mounting and Connections

Warning!

The successful and safe operation of the device is dependent on proper handling, installation, and application by qualified personnel under observance of all warnings and hints contained in this manual.

In particular the general erection and safety regulations (e.g. IEC, DIN, VDE, EN or other national and international standards) regarding the correct use of hoisting gear must be observed. Non-observance can result in death, personal injury, or substantial property damage.

Requirements

Verification of the ratings of the 7SA6 according to Sub-section 3.2.1 as well as matching to ratings of the external equipment must have been completed.

8.1.1 Installation

Panel Flush Mounting

Depending on the version of the device, the housing width may be $^1/_3$, $^1/_2$ or $^1/_1$ of a 19 inch rack. For housing sizes $^1/_3$ and $^1/_2$ (Figure 8-1 and Figure 8-2) there are 4 covers and 4 holes for securing the device, for size $^1/_1$ (Figure 8-3) there are 6 covers and 6 securing holes.

- ☐ Remove the 4 covers located at the corners of the front cover, for size $^1/_1$ the 2 additional covers located centrally at the top and bottom, reveal the 4 respectively 6 slots in the mounting flange.
- ☐ Insert the device into the panel cut-out and fasten it with four or six screws. For the dimensions refer to Figure 10-7 to 10-9 in Section 10.20.
- ☐ Replace the four or six covers.
- ☐ Connect the ground on the rear plate of the device to the protective ground of the panel. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.
- ☐ Connect the plug terminals and/or the screwed terminals on the rear side of the device according to the wiring diagram for the panel.
  When using forked lugs or directly connecting wires to screwed terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
  A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.
  Section 2.1 has pertinent information regarding wire size, lugs, bending radii, etc.

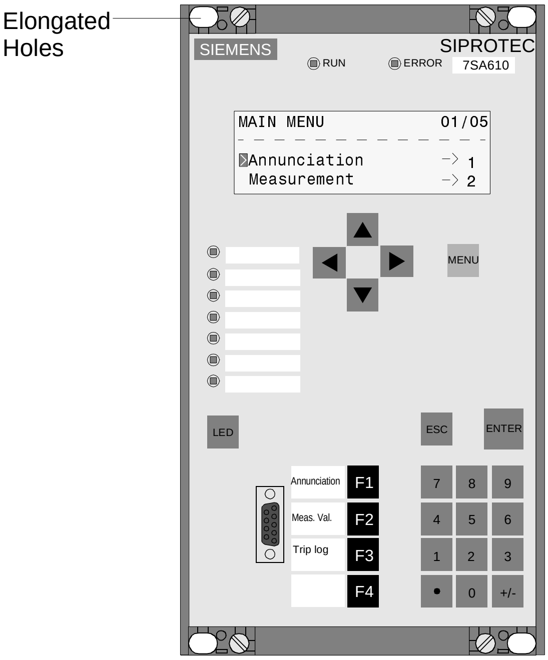


Figure 8-1 Panel mounting of a 7SA610 with a four-line display (housing width $^1/_3$) as an example

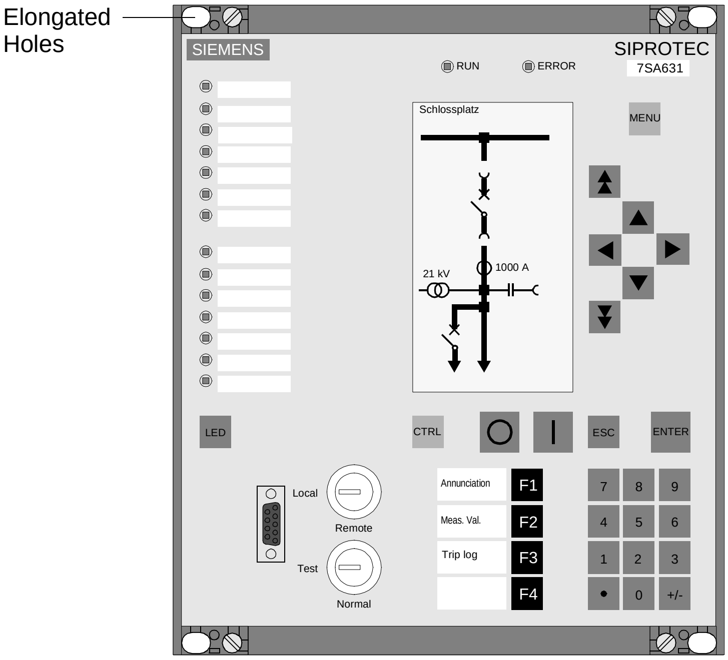


Figure 8-2 Panel mounting of a 7SA631 with graphic display (housing width $^1/_2$) as an example

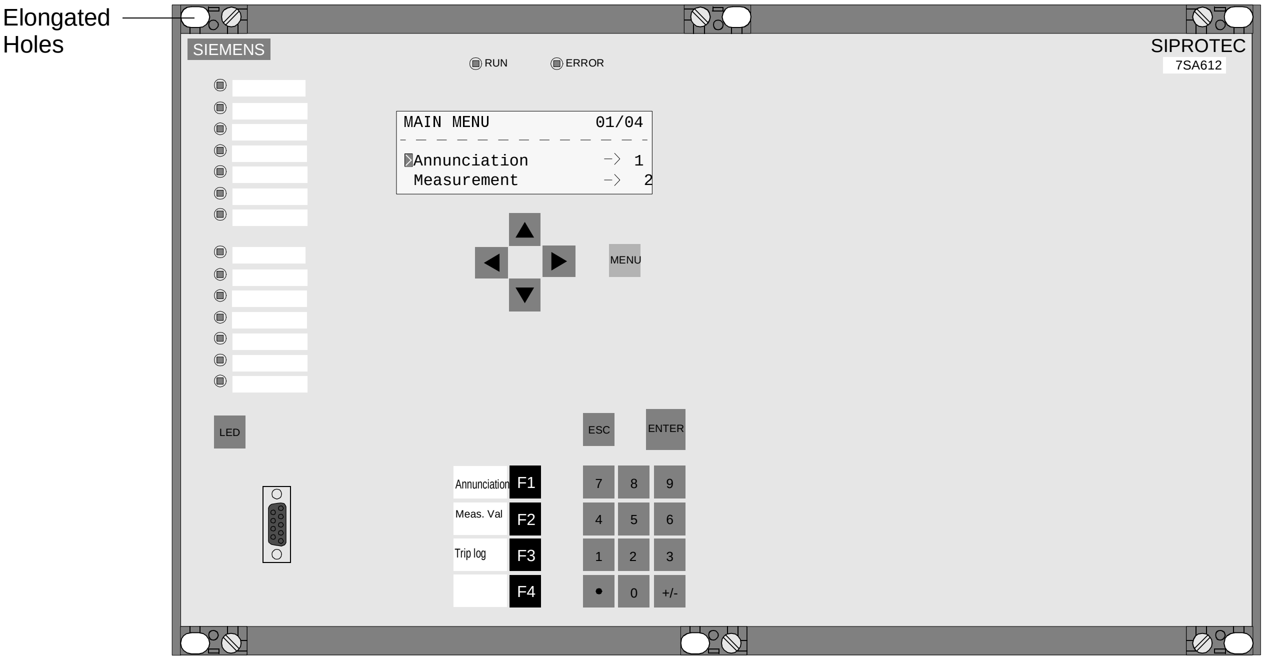


Figure 8-3 Panel mounting of a 7SA612 with a four-line display (housing width $^1/_1$) as an example

Rack Mounting and Cubicle Mounting

In housing sizes $^1/_3$ (Figure 8-4) and $^1/_2$ (Figure 8-5) there are 4 covers and 4 securing slots, with the housing size $^1/_1$ (Figure 8-6) there are 6 covers and 6 securing slots available.

To install the device in a frame or cubicle, two mounting brackets are required. The ordering codes are stated in Appendix A, Section .

- ❑ Loosely screw the two mounting brackets in the rack with four screws.
- ❑ Remove the 4 covers at the corners of the front cover, for size $^1/_1$ the 2 covers located centrally at the top and bottom also have to be removed. The 4 respectively. 6 slots in the mounting flange are revealed and can be accessed.
- ❑ Fasten the device to the mounting brackets with four or six screws.
- ❑ Replace the four or six covers.
- ❑ Tighten the mounting brackets to the rack using eight screws.
- ❑ Connect the ground on the rear plate of the device to the protective ground of the rack. Use at least one M4 screw for the device ground. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.

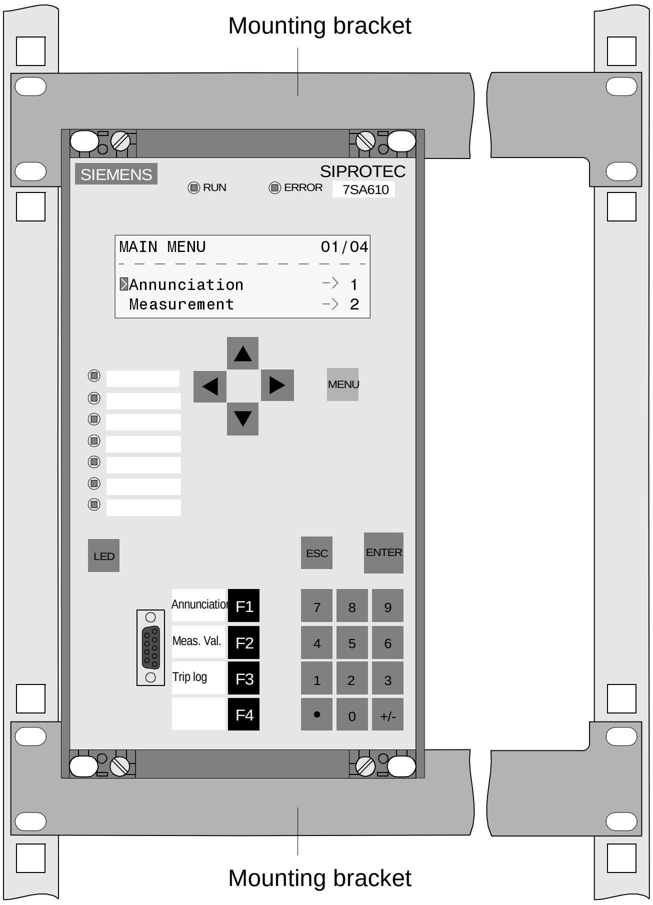


Figure 8-4 Installing a 7SA610 with a four-line display in a rack or cubicle (housing width $^1/_3$ of 19 inch rack) as an example

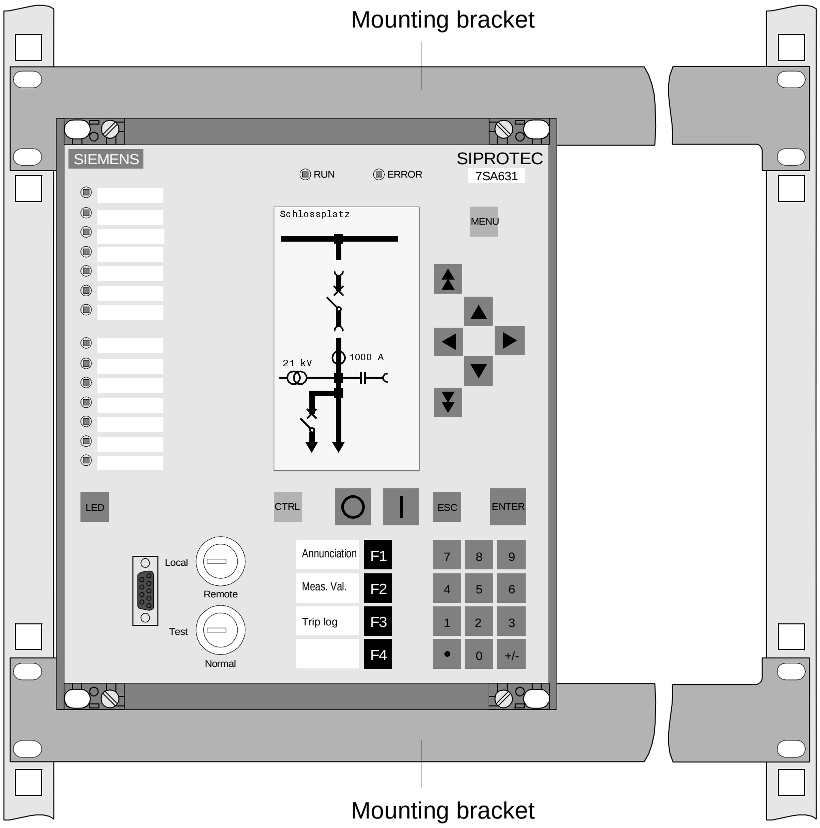


Figure 8-5 Installing a 7SA631 with graphic display in a rack or cubicle (housing width $^1/_2$ of 19 inch rack) as an example

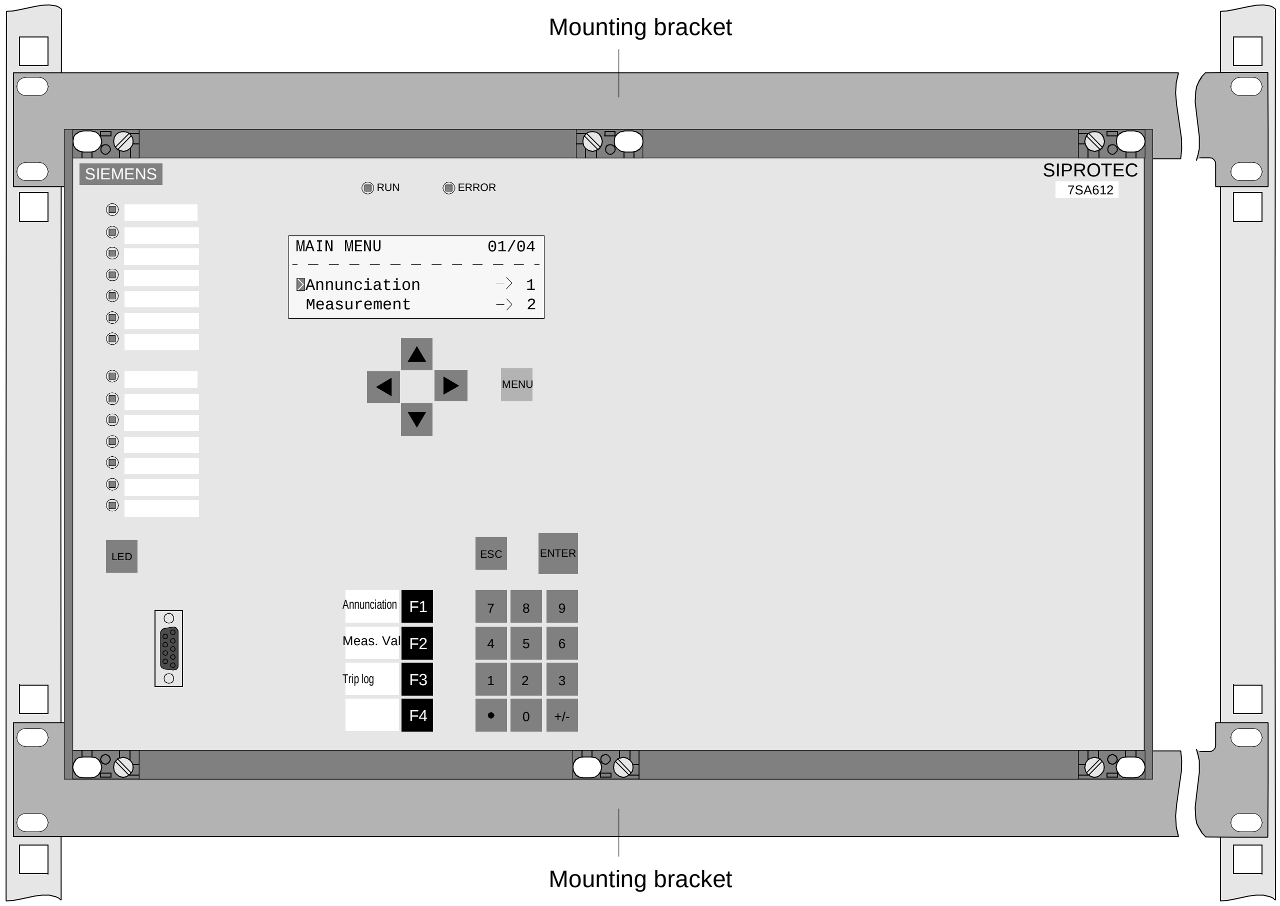


Figure 8-6 Installing a 7SA612 with a four-line display in a rack or cubicle (housing width $^1/_1$ of 19 inch rack) as an example

❑ Connect the plug terminals and/or the screwed terminals on the rear side of the device according to the wiring diagram for the rack.
When using forked lugs or directly connecting wires to screwed terminals, the screws must be tightened so that the heads are even with the terminal block before the lugs or wires are inserted.
A ring lug must be centred in the connection chamber so that the screw thread fits in the hole of the lug.
Section 2.1 has pertinent information regarding wire size, lugs, bending radii, etc.

Panel Surface Mounting

❑ Secure the device to the panel with four screws. For dimensions refer to Figure 10-10 to 10-12 in Section 10.20.

❑ Connect the ground of the device to the protective ground of the panel. The cross-sectional area of the ground wire must be greater than or equal to the cross-sectional area of any other control conductor connected to the device. Furthermore, the cross-section of the ground wire must be at least 2.5 mm^2.

❑ Connect solid, low-impedance operational grounding (cross-sectional area ≥ 2.5 mm^2) to the grounding surface on the side. Use at least one M4 screw for the device ground.

❑ Connections according to the circuit diagram via screw terminals, connections for optical fibres and electrical communication modules via the inclined housings. Section 2.2 has pertinent information regarding wire size, lugs, bending radii, etc.

Mounting with Detached Operator Panel

For mounting the device proceed as follows:

- Fasten device of housing size $^1/_2$ with 6 screws and device of housing size $^1/_1$ with 10 screws. For dimensions see Section 10.20 (Figure 10-13 and 10-14).
- Connect the ground on the rear plate of the device to the protective ground of the panel. Using at least one M4 screw. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. The cross-section of the ground wire must be at least 2.5 mm^2.
- Connections are realized via the plug terminals or screw terminals on the rear side of the device according to the circuit diagram.
  When using forked lugs for direct connections or screw terminal, the screws, before having inserted the lugs and wires, must be tightened in such a way that the screw heads are even with the terminal block.
  A ring lug must be centred in the connection chamber, in such a way that the screw thread fits in the hole of the lug. Section 2.3 has pertinent information regarding wire size, lugs, bending radii, etc.
- For mounting the detached operator panel please observe the following:
- The removal of the 4 covers located at the corners of the front cover reveal 4 elongated holes in the mounting bracket.
- Insert the operator panel into the panel cut-out and fasten with four screws. For dimensions refer to Figure 10-15 in Section 10.20.
- Mount the four covers.
- Connect the ground on the rear plate of the operator control element to the protective ground of the panel using at least one M4 screw. The cross-sectional area of the ground wire must be equal to the cross-sectional area of any other control conductor connected to the device. The cross-section of the ground wire must be at least 2.5 mm^2.

Caution!

Do never pull or plug the connector between the device and the detached operator panel while the device is alive!

- Connect the operator panel to the device. Furthermore, plug the 68-pin connector of the cable belonging to the operator panel into the corresponding connection at the rear side of the device (see Section 2.3, Figure 2-31 and 2-32).

8.1.2 Termination variants

Outline diagrams are shown in Appendix A, Section A.2. Connection examples for current and voltage transformer circuits are provided in Appendix A, Section A.3. It must be checked that the setting configuration of the **Power System Data 1 (P.System Data 1)** corresponds with the connections to the device.

Currents

The Figures A-20 to A-23 show examples of the current transformer connection options.

For the normal connection according to Figure A-20 address 0220 must be set to **I4 transformer** = ***In prot. line***, and furthermore address 0221 must be set to **I4/ Iph CT** = ***1.000***.

For the connection as shown in Figure A-21 the setting of address 0220 must also be **I4 transformer** = ***In prot. line***. The factor 0221 **I4/Iph CT** may deviate from 1. For notes on how to calculate the factor, refer to Subsection 6.1.1 under “Current Transformer Connection”.

In Figure A-22 an example of the connection of the earth current of a parallel line is shown (for parallel line compensation). In address 0220 **I4 transformer** the setting option ***In paral. line*** must be set. The factor 0221 **I4/Iph CT** may deviate from 1. For notes on how to calculate the factor, refer to Subsection 6.1.1.

In Figure A-23 an example of the connection of the earth current of a source transformer is shown. In address 0220 **I4 transformer** the setting option **IY starpoint** must be set. Notes regarding the factor 0221 **I4/Iph CT** may again be found in Subsection 6.1.1.

Voltages

The Figures A-24 to A-27 show examples of the voltage transformer connection options.

For the normal connection as shown in Figure A-24 the 4th voltage measuring input U_4 is not used. Correspondingly the address 0210 must be set to **U4 transformer** = ***Not connected***.The factor in address 0211 **Uph / Udelta** must however be set to ***1.73*** (this factor is used internally for the conversion of measurement and fault recording values).

Figure A-25 shows an example of the additional connection of an e–n winding of the set of voltage transformers. Address 0210 must in this case be set to **U4 transformer** =***Udelta transf..***The factor in address 0211 **Uph / Udelta** is dependent on the ratio of the e–n winding. Notes may be referred to in Subsection 6.1.1 under “Voltage Transformer Connection”.

Also Figure A-26 shows an example of a connection of the e–n winding of a set of voltage transformers, in this case, however of a central set of transformers at a busbar. For more information refer to the previous paragraph.

Figure A-27 shows an example of the connection of a different voltage, in this case the busbar voltage (e.g. for overvoltage protection). For overvoltage protection address 0210 must be set to **U4 transformer** = ***Ux transformer***. The factor address 0215 **U-line / Usync** is always equal to 1 unless the feederside VT and busbarside VT have a different transformation ratio. The factor in address 0211 **Uph / Udelta** must be ***1.73*** (this factor is used internally for the conversion of measurement and fault recording values).

Binary Inputs and Outputs

The configuration of the binary in and outputs, i.e. the individual adaptation to the plant conditions, is described in Section 5.2. The connections to the plant are dependent on this actual configuration. The presettings of the device are listed in Appendix A, Section A.4. Check also if the labelling corresponds to the allocated message functions.

Trip Circuit Supervision

It must be noted that two binary inputs or one binary input and one bypass resistor R must be connected in series. The pick-up threshold of the binary inputs must therefore be substantially below half the rated control DC voltage.

If *two* binary inputs are used for the trip circuit supervision, these binary inputs must be potential free i.o.w. not be commoned with each other or with another binary input.

If *one* binary input is used, a bypass resistor R must be employed (refer to Figure 8-7). This resistor R is connected in series with the second circuit breaker auxiliary contact (Aux2), to also allow the detection of a trip circuit failure when the circuit breaker auxiliary contact 1 (Aux1) is open, and the command relay contact has reset. The value of this resistor must be such that in the circuit breaker open condition (therefore Aux1 is open and Aux2 is closed) the circuit breaker trip coil (TC) is no longer picked up and binary input (BI1) is still picked up if the command relay contact is open.

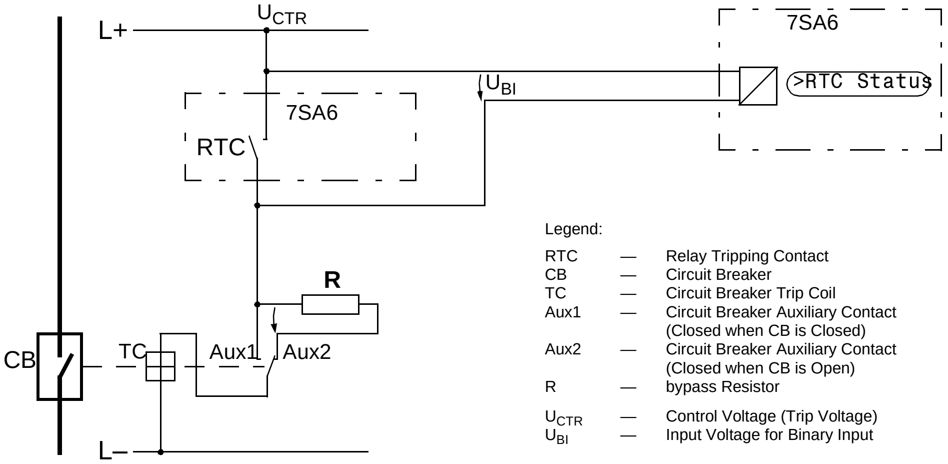


Figure 8-7 Trip circuit supervision with one binary input

This results in an upper limit for the resistance dimension, R_{max}, and a lower limit R_{min}, from which the optimal value of the arithmetic mean should be selected.

$$R = \frac{R_{max} + R_{min}}{2}$$

To ensure the minimum voltage for the control of the binary input, R_{max} is derived as:

$$R_{max} = \left(\frac{U_{CRT} - U_{BI\ min}}{I_{BI\ (High)}}\right) - R_{CBTC}$$

So the circuit breaker trip coil does not remain energized in the above case, R_{min} is derived as:

$$R_{min} = R_{TC} \cdot \left(\frac{U_{CTR} - U_{TC\ (LOW)}}{U_{TC\ (LOW)}}\right)$$

$I_{BI\ (HIGH)}$	Constant current with BI on (= 1,7 mA)
$U_{BI\ min}$	Minimum control voltage for BI =19 V for delivery setting for nominal voltage of 24/48/60 V; =73 V for delivery setting for nominal voltage of 110/125/220/250 V;
UCTR	Control voltage for trip circuit
R_{CBTC}	DC resistance of circuit breaker trip coil
$U_{CBTC\ (LOW)}$	Maximum voltage on the circuit breaker trip coil that does not lead to tripping

If the calculation results that $R_{max} < R_{min}$, then the calculation must be repeated, with the next lowest switching threshold $U_{BI\ min}$, and this threshold must be implemented in the relay using plug-in bridges (see Sub-section 8.1.3).

For the power consumption of the resistance:

$$P_R = I^2 \cdot R = \left(\frac{U_{CTR}}{R + R_{CBTC}}\right)^2 \cdot R$$

Example:

$I_{BI\ (HIGH)}$	1.8 mA (from SIPROTEC® 7SA6)
$U_{BI\ min}$	19 V for delivery setting for nominal voltage 24/48/60 V 73 V or delivery setting for nominal voltage 110/125/220/250 V
UCTR	110 V (from system / release circuit)
R_{CBTC}	500 Ω (from system / release circuit)
$U_{CBTC\ (LOW)}$	2 V (from system / release circuit)

$$R_{max} = 50.1\ k\Omega$$

$$R_{min} = 27\ k\Omega$$

$$R = \frac{R_{max} + R_{min}}{2} = 38.6\ k\Omega$$

$$R_{max} = \left(\frac{110\ V - 19\ V}{1.8\ mA}\right) - 500\Omega$$

$$R_{min} = 500\Omega \cdot \left(\frac{110\ V - 2\ V}{2V}\right)$$

The closest standard value of 39 kΩ is selected; the power is:

$$P_R = \left(\frac{110\ V}{39\ k\Omega + 0.5\ k\Omega}\right)^2 \cdot 39\ k\Omega$$

$$P_R \geq 0.3\ W$$

Pilot Wire Protection

If the transmission scheme **`Teleprot. Dist.`** = ***`Pilot wire comp`*** (address `0121`) is applied in the Distance Protection, the user has to make sure that the closed current loop is supplied with enough auxiliary voltage. The function itself is described in Subsection 6.4.1.8.

Please take note that both binary inputs are interconnected and connected in series with the resistor of the pilot wires. Therefore the loop voltage must not be too low or the pickup voltage of the binary inputs must not be too high. In general, the lowest threshold (19 V) must be selected for the auxiliary voltages of 60 V to 125 V, the threshold of 73 V is selected for voltages of 220 V to 250 V.

Due to the low current consumption of the binary inputs it may be necessary to additionally burden the pilot wire loop with an external shunt connected resistor so that the input to the binary inputs are not maintained by the charge on the pilot wire capacitance after interruption of the loop.

Pilot wires used as cable connections between stations must always be checked on their effect on high voltage. The pilot wires of the pilot cables must stand external strains.

The worst electrical fault that may occur to the connected pilot cables is generated in the pilot wire system by an earth fault. The short-circuit current induces a longitudinal voltage into the pilot wires lying parallel to the high voltage line. The induced voltage can be reduced by well-conductive cable jackets and by armouring (low reduction factor, for both high voltage cable and pilot cables).

The induced voltage can be calculated with the following formula:

$$U_i = 2\pi f \cdot M \cdot I_{F1} \cdot l \cdot r_1 \cdot r_2$$

with

U_i = induced longitudinal voltage in V,
f = nominal frequency in Hz,
M = mutual inductance between power line and pilot wires in mH/km,
I_{F1} = maximum earth fault current via power line in kA,
l = length; distance between energy line and pilot wires in km,
r_1 = reduction factor of power cable (r_1 = 1 for overhead lines),
r_2 = reduction factor of pilot wire cable.

The calculated induced voltage should neither exceed the 60 % rate of the test voltage of the pilot wires nor of the device connections (binary inputs and outputs). Since the latter were produced for a test voltage of 2 kV, only a maximum induced longitudinal voltage of 1.2 kV is allowed.

8.1.3 Hardware Modifications

8.1.3.1 General

Hardware modifications might be necessary or desired. For example, a change of the pick-up threshold for some of the binary inputs might be advantageous in certain applications. Terminating resistors might be required for the communication bus. In either case, hardware modifications are needed. The modifications are done with jumpers on the printed circuit boards inside the 7SA6. Follow the procedure described in Subsubsection 8.1.3.2 to 8.1.3.5, whenever hardware modifications are done.

Power Supply Voltage

There are different ranges for the power supply voltage of the various power supplies. Refer to the data for the 7SA6 ordering numbers in Section A.1 of the Appendix. The power supplies with the ratings DC 60/110/125 V and DC 110/125/220 V-, AC115 are interconvertible. Jumper settings determine the rating. The assignment of these jumpers to the supply voltages is described in Subsubsection 8.1.3.3, see “Processor Board C-CPU-2”. When the relay is delivered, these jumpers are set according to the name-plate sticker. Generally, they need not be altered.

Life Contact

The life contact of the device is a changeover contact from which either the NC contact or the NO contact can be connected to the device connections F3 and F4 (or corresponding terminals on housings for panel surface mounting) via a plug-in jumper (X40). The assignment of the plug-in jumper to the type of contact and the location of the jumper is described in Subsubsection 8.1.3.3, see “Processor Board C-CPU-2”.

Nominal Currents

The input transformers of the device are set to a nominal current of 1 A or 5 A with jumpers. The position of the jumpers are set according to the name-plate sticker. The assignment of the jumpers to the nominal rate and the arrangement of the jumpers is described in 8.1.3.3, see “Input/Output Board C–I/O–2” or “Input/Output Board C–I/O–11”. All jumpers must be set for the same nominal current, i.e. a jumper (X61 to X64) one jumper for each input transformer and additionally one jumperX 60.

Note:

If nominal current ratings are changed exceptionally, then the new ratings must be registered in address 0206 **`CT SECONDARY`** in the **`Power System Data 1 (P.System Data 1)`** (see Subsection 6.1.1).

Control Voltages for Binary Inputs

When the device is delivered from the factory, the binary inputs are set to operate with a voltage that corresponds to the rated DC voltage of the power supply. In general, to optimize the operation of the inputs, the pick-up voltage of the inputs should be set to most closely match the actual control voltage being used. Each binary input has a pick-up voltage that can be independently adjusted; therefore, each input can be set according to the function performed.

A jumper position is changed to adjust the pick-up voltage of a binary input. The physical arrangement of the binary input jumpers in relation to the pick-up voltages is described in 8.1.3.3.

Note:

If the 7SA6 performs trip circuit monitoring, two binary inputs, or one binary input and a resistor, are connected in series. The pick-up voltage of these inputs must be less than half of the nominal DC voltage of the trip circuit.

Type of Contact for Binary Outputs

Input and output boards can contain relays of which the contact can be set as normally closed or normally open contact. Therefore it is necessary to rearrange a jumper. Section 8.1.3.3 “Input/Output Board C-I/O-1” and “Input/Output Board B–I/O–2” describes to which type of relays in which boards this applies.

Replacing Interfaces

Only serial interfaces of devices for panel and cubicle mounting as well as of mounting devices with detached operator panel are replaceable. For more details on this matter refer to Subsubsection 8.1.3.4, “Replacing Interface Modules”.

Termination of Serial Interfaces

If the device is equipped with a serial RS485 port or Profibus, they must be terminated with resistors at the last device on the bus to ensure reliable data transmission. For this purpose, the printed circuit board of the central processor unit C-CPU-2 and the RS485 or Profibus interface module are provided with terminating resistors that can be connected to the system by means of jumpers. It is important to use only 1 of the 3 options. The position of the jumpers on the printed circuit board of the central processor unit C-CPU-2 is described in Subsubsection 8.1.3.3, see “Processor Board C-CPU-2” and the position of the jumpers on the interface modules in Subsubsection 8.1.3.4, see “Serial Interfaces with Bus Capability”. Both jumpers must always be plugged in the same way.

As delivered from the factory, the resistors are switched out.

8.1.3.2 Disassembly of the Device

If changes on jumper settings are required, e.g. control or removing and plugging of jumpers or replacing printed circuit boards, proceed as follows:

Caution!

Jumper-setting changes that affect nominal values of the device render the ordering number and the corresponding nominal values on the nameplate sticker invalid. If such changes are necessary, the changes should be clearly and fully noted on the device. Self adhesive stickers are available that can be used as replacement nameplates.

☐ Prepare area of work. Provide a grounded mat for protecting components subject to damage from electrostatic discharges (ESD). The following equipment is needed:

– screwdriver with a 5 to 6 mm wide tip,

– 1 Philips screwdriver,

– 4.5 mm socket or nut driver.

☐ Unfasten the screw-posts of the D-subminiature connector on the back panel at location “A” and “C”. This activity does not apply if the device is for surface mounting.

☐ If there are additional interfaces on location “B” and “D” next to the interfaces at location “A” to “C”, remove the screws located diagonally to the interfaces. This activity is not necessary if the device is for surface mounting.

☐ Remove the four or six caps on the front cover and loosen the screws that become accessible.

☐ Carefully take off the front cover. The front cover is connected to the CPU board with a short ribbon-cable. With device versions with a detached operator panel it is possible to remove the front cover of the device right after having unscrewed all screws.

Caution!

Electrostatic discharges through the connections of the components, wiring, plugs, and jumpers must be avoided. Wearing a grounded wrist strap is preferred. Otherwise, first touch a grounded metal part.

☐ Disconnect the ribbon cable between the front cover and the C-CPU-2 board (❶) at the front cover side. To disconnect the cable, push up the top latch of the plug connector and push down the bottom latch of the plug connector. Carefully draw out the plug connector.
This action does not apply to the device version with detached operator panel. However, on the central processor unit C-CPU-2 (❶) the 7-pole plug connector X16 behind the D-subminiture connector and the plug connector of the ribbon cable (connected to the 68pole plug connector on the rear side) must be removed.

☐ Disconnect the ribbon cables between the C-CPU-2 unit (❶) and the input/output printed circuit boards (depending on the version❷ to ❺).

☐ Remove the boards and set them on the grounded mat to protect them from ESD damage. A greater effort is required to withdraw the C-CPU-2 board, especially in versions of the device for surface-mounting, because of the communication connectors.

☐ Check the jumpers according to Figures 8-11 to 8-16 and the following information Change or remove the jumpers as necessary.

The order of the boards for housing size $^1/_3$ is shown in Figure 8-8, for housing size $^1/_2$ refer to Figure 8-9 and housing size $^1/_1$ in Figure 8-10.

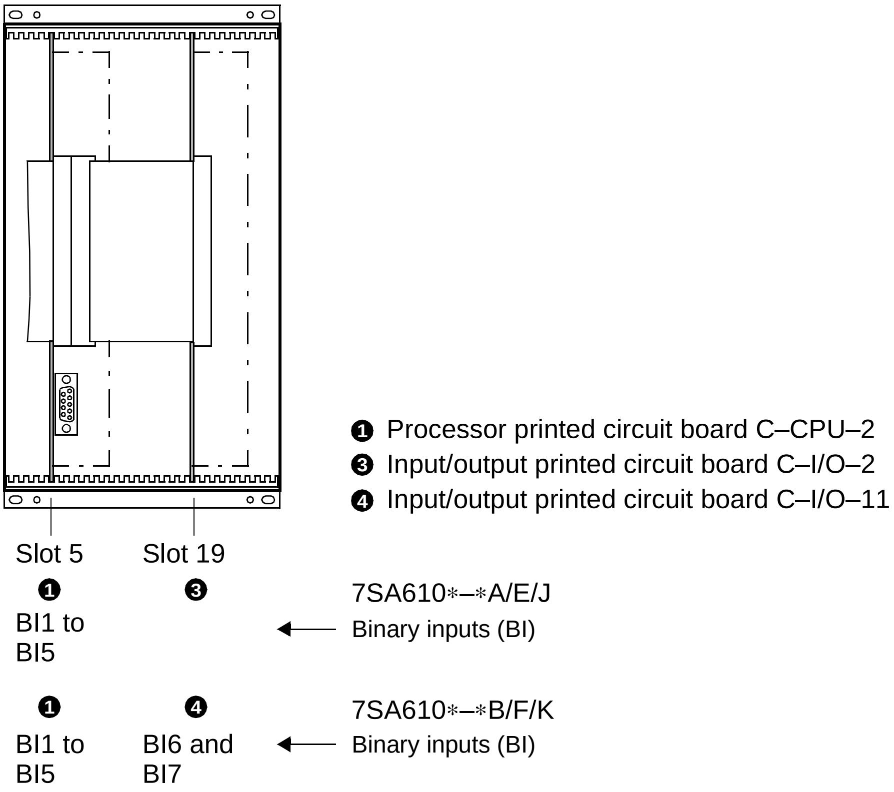


Figure 8-8 Front view of device of housing size $^{1}/_{3}$ after removal of the front cover (simplified and scaled down)

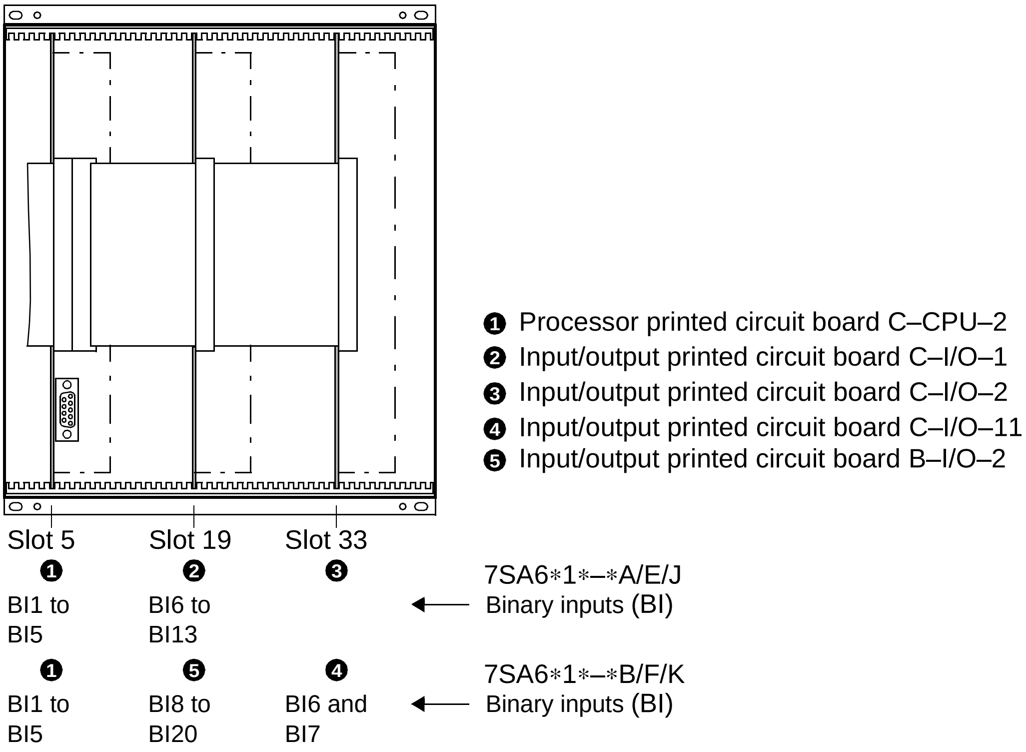
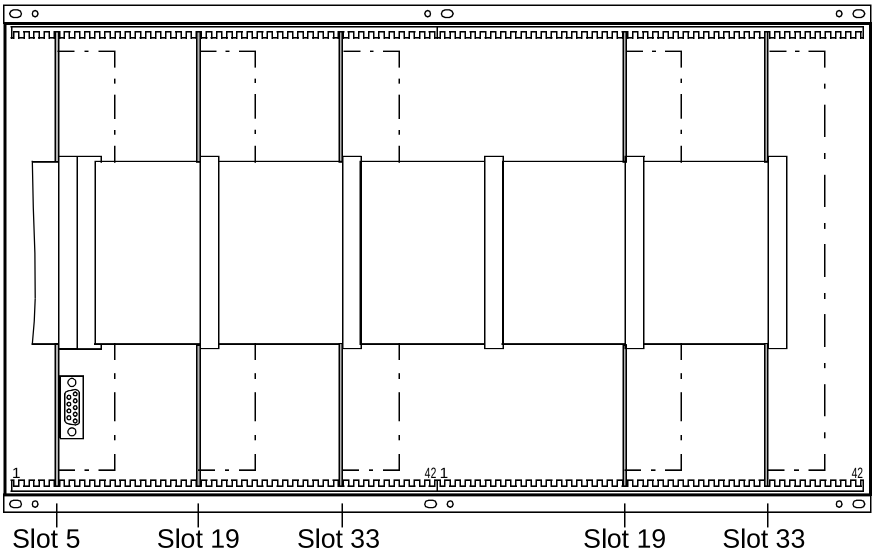


Figure 8-9 Front view of the device with housing size $^1/_2$ after removal of the front cover (simplified and scaled down)



❶ Processor p. c. b. C–CPU–2
❷ Input/output p. c. b. C–I/O–1
❸ Input/output p. c. b. C–I/O–2
❹ Input/output p. c. b. C–I/O–11
❺ Input/output p. c. b. B–I/O–2

❶		❷	❷	❸	7SA6∗2∗–∗A/E/J
BI1 to BI5		BI6 to BI13	BI14 to BI21		← Binary Inputs (BI)
❶	❷	❷	❷	❸	7SA6∗2∗–∗B/F/K
BI1 to BI5	BI22 to BI29	BI6 to BI13	BI14 to BI21		← Binary Inputs (BI)
❶		❺	❺	❹	7SA6∗2∗–∗C/G/L
BI1 to BI5		BI8 to BI20	BI21 to BI33	BI6 and BI7	← Binary Inputs (BI)

Figure 8-10 Front view of the device with housing size $^1/_2$ after removal of the front cover (simplified and scaled down).

8.1.3.3 Jumper Settings on Printed Circuit Boards

Processor Board C-CPU-2

The layout of the printed circuit board of the processor printed circuit board C-CPU-2 is illustrated in Figure 8-11.

The set nominal voltage of the integrated current supply is checked according to Table 8-1, the quiescent state of the life contact according to Table 8-2 and the selected operating voltage of the binary inputs BI1 to BI5 according to Table 8-4 and the integrated interface RS232 / RS485 according to Table 8-5 to 8-7.

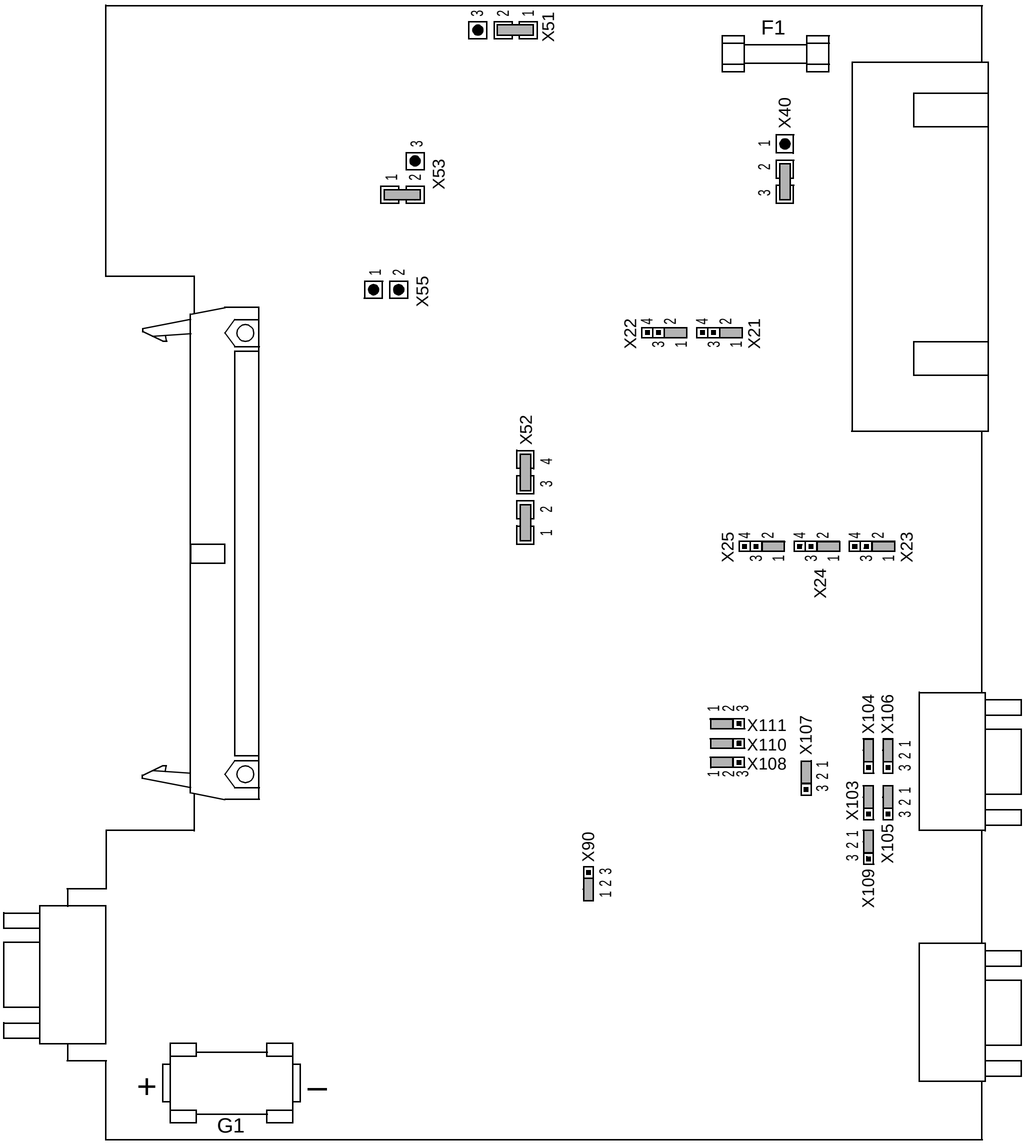


Figure 8-11 Processor printed circuit board C-CPU-2 with jumper settings required for the module configuration

Table 8-1 Jumper settings for the nominal voltage of the integrated **power supply** on the processor printed circuit board C-CPU-2

Jumper	Nominal Voltage		
	24 to 48 VDC	60 to 125 VDC	110 to 250 VDC, 115 VAC
X51	none	1–2	2–3
X52	none	1–2 and 3–4	2–3
X53	none	1–2	2–3
X55	none	none	1–2

Table 8-2 Jumper setting for the quiescent state of the **life contact** on the processor printed circuit board C-CPU-2

Jumper	Open in the quiescent state	Closed in the quiescent state	Presetting
X40	1–2	2–3	2–3

Table 8-3 Jumper settings of the **control voltages** of the binary inputs BI1 to BI5 on the processor printed circuit board C-CPU-2

Binary Inputs	Jumper	Threshold 17 V 1)	Threshold 73 V 2)
BI1	X21	1–2	2–3
BI2	X22	1–2	2–3
BI3	X23	1–2	2–3
BI4	X24	1–2	2–3
BI5	X25	1–2	2–3

1) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC
2) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115 VAC

By repositioning jumpers the interface RS485 can be modified into a RS232 interface.

The jumpers X105 to X110 must be plugged in the same way!

Table 8-4 Jumper settings of the integrated **interface RS232/RS485** on the processor printed circuit board C-CPU-2

Jumper	RS232	RS485
X103 and X104	1–2	1–2
X105 to X110	1–2	2–3

The jumpers are preset at the factory according to the configuration ordered.

Table 8-5 Jumper setting of **CTS (Clear-To-Send)** on the processor printed circuit board C-CPU-2

Jumper	/CTS of interface RS232	/CTS controlled by /RTS
X111	1–2	2–3

The jumper presetting is dependent on the order code of the device.

For RS232 (12th digit of order code = 0, 1):	setting 1–2
For RS485 (12th digit of order code = 2:	setting 2–3

If there are no external matching resistors in the system, the last devices on a RS485-bus must be configured via jumpers X103 and X104.

Table 8-6 Jumper setting of **matching resistors** of the interface RS485 on the processor printed circuit board C–CPU–2

Jumper	Matching resistor closed	Matching resistor open	Presetting
X103	2–3	1–2	1–2
X104	2–3	1–2	1–2

Note: Both jumpers must always be plugged in the same way!

Currently no function is assigned to the jumper X90. The presetting is 1-2.

The terminating resistors can also be connected externally (e.g. to the connection module). In this case, the terminating resistors located on the RS485 or the Profibus interface module or the resistors located directly on the processor circuit board C–CPU–2 must be disconnected.

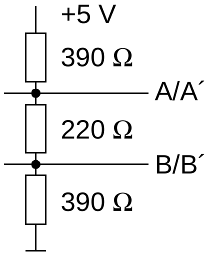


Figure 8-12 Termination of the RS 485 interface (external)

Input/Output Board C-I/O-1

The layout of the printed circuit board for the input/output board C-I/O–1 is illustrated in Figure 8-13.

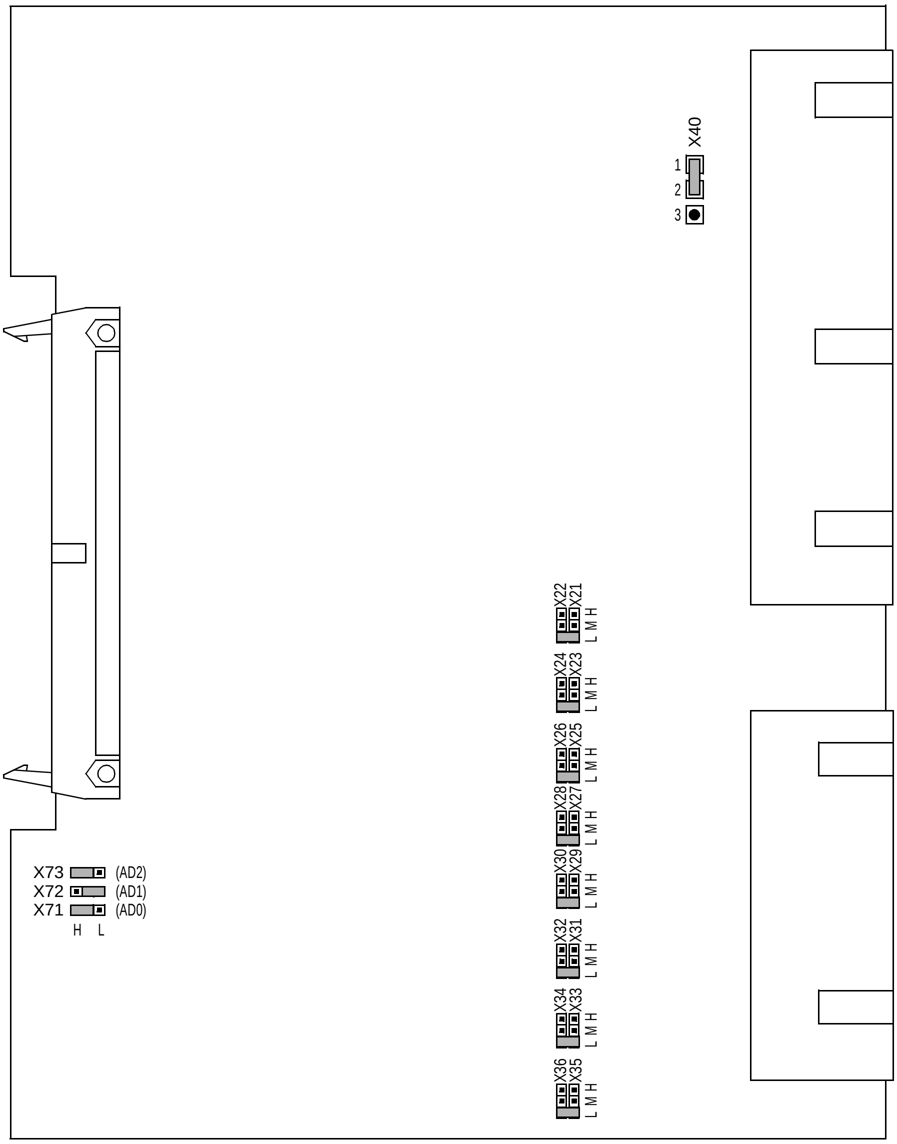


Figure 8-13 The input/output board C–I/O–1 with the jumpers necessary for the control of settings

For the input/output boards C–I/O–1 (Figure 8-13, Slot 19) of device version 7SA6***1-A**... (housing size $^1/_2$) it is possible to change the contact of the output relay for the binary output BO9 from **normally open** to **normally closed** (refer to General Diagrams in the Appendix A, Section A.2).

.

Table 8-7 Jumper setting for the contact type of relay for BO9

Module	for	Jumper	Quiescent state open (NO contact)	Quiescent state closed (NC contact)	Presetting
Slot 19	BO9	X40	1–2	2–3	1–2

With device versions 7SA6***2**–**A**... and 7SA6***2**–**B**... (housing size $^1/_1$) the contact of input/output boards C–I/O–1 (Figure 8-13, slot 19 left and right, as well as slot 33 left) the relays for the binary outputs BO9, BO17 and BO25 (depending on the version) can be changed from **normally closed** to **normally open** (refer to General Diagrams in the Appendix A under Section A.2).

Table 8-8 Jumper setting for the contact type of relay for BO9, BO17 and BO25

Module	for	Jumper	Quiescent state open (NO contact)	Quiescent state closed (NC contact)	Presetting
Slot 33 left	BO9	X40	1–2	2–3	1–2
Slot 19 right	BO17	X40	1–2	2–3	1–2
Slot 19 left	BO25	X40	1–2	2–3	1–2

Checking control voltages of binary inputs:

BI6 to BI13 (for housing size $^1/_2$) according to Table 8-9,
BI6 to BI29 (for housing size $^1/_1$, depending on version) according to Table 8-10.

Table 8-9 Jumper setting of **control voltages** of binary inputs BI6 to BI13 on the binary input/output boards C– I/O–1 for housing size $^1/_2$

Binary inputs	Jumper	Threshold 17 V[1]	Threshold 73 V[2]
Slot 19			
BI6	X21/X22	L	M
BI7	X23/X24	L	M
BI8	X25/X26	L	M
BI9	X27/X28	L	M
BI10	X29/X30	L	M
BI11	X31/X32	L	M
BI12	X33/X34	L	M
BI13	X35/X36	L	M

[1] Factory settings for devices with power supply voltages of 24 VDC to 125 VDC
[2] Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115 VAC

Table 8-10 Jumper setting of **control voltages** of binary inputs BI6 to BI29 on the binary input/output boards C– I/O–1 for housing size $^1/_1$

Binary input			Jumper	Threshold 17 V [1])	Threshold 73 V [2])
Slot 33 left	Slot 19 right	Slot 19 left			
BI6	BI14	BI22	X21/X22	L	M
BI7	BI15	BI23	X23/X24	L	M
BI8	BI16	BI24	X25/X26	L	M
BI9	BI17	BI25	X27/X28	L	M
BI10	BI18	BI26	X29/X30	L	M
BI11	BI19	BI27	X31/X32	L	M
BI12	BI20	BI28	X33/X34	L	M
BI13	BI21	BI29	X35/X36	L	M

[1]) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC

[2]) Factory settings for devices with power supply voltages of 110 VDC to 250 VDC and 115 VAC

The jumpers X71, X72 and X73 on the input/output board C–I/O–1 are for setting the bus address and must not be changed. Tables 8-11 and 8-12 list the jumper presettings.

Figures 8-8 to 8-10 show the mounting location of the printed circuit boards.

Table 8-11 Jumper setting of **printed circuit board addresses** of binary input/output boards C-I/O-1 for housing size $^1/_2$

Jumper	Mounting location
	Slot 19
X71	H
X72	L
X73	H

Table 8-12 Jumper setting of **printed circuit board addresses** of binary input/output boards C-I/O-1 for housing size $^1/_1$

Jumper	Mounting location		
	Slot 19 left	Slot 19 right	Slot 33 left
X71	H	L	H
X72	H	H	L
X73	H	H	H

Input/Output Board C–I/O–2

The layout of the printed circuit board for the input/output board C-I/O–2 is illustrated in Figure 8-14.

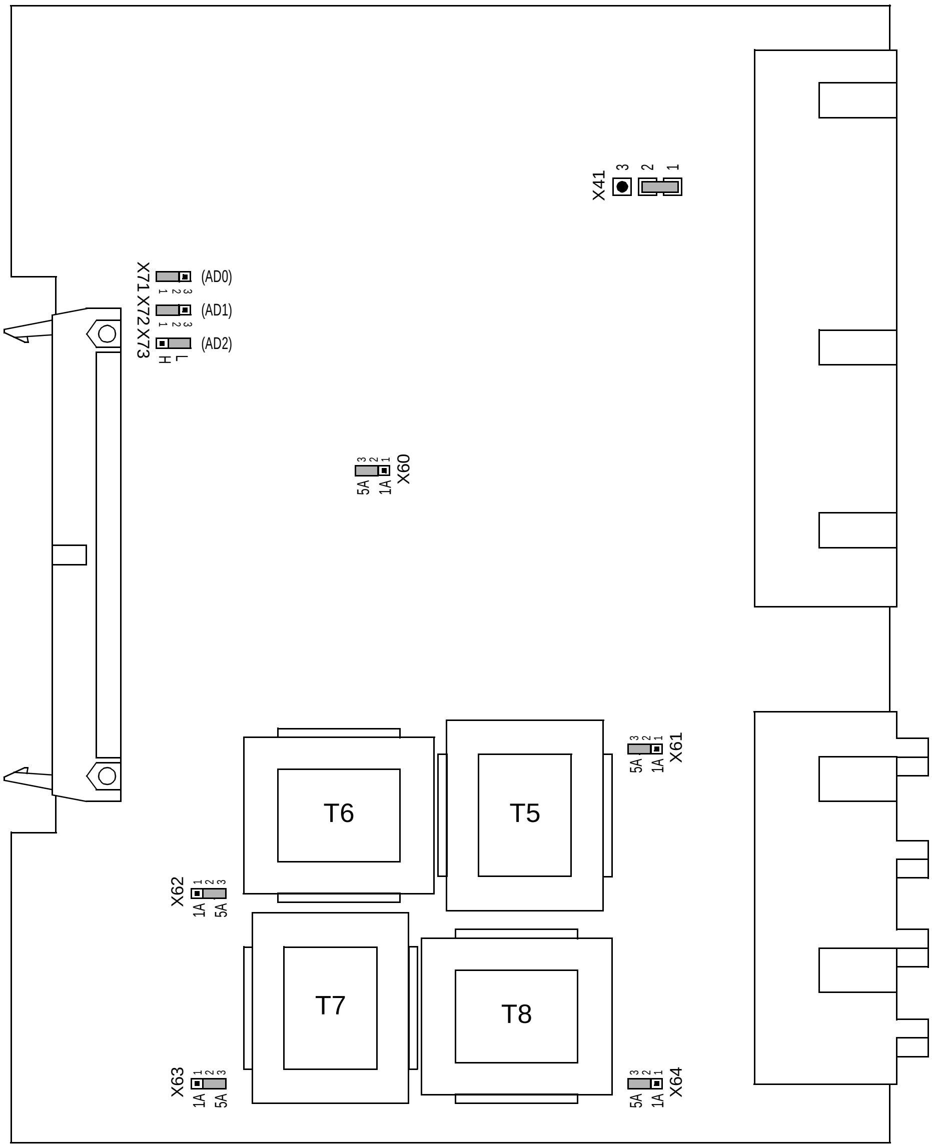


Figure 8-14 The input/output board C-I/O–2 with the jumpers necessary for the setting check

The contact of the relay for the binary output BO6 can be configured as NO or NC contact (see also General Diagrams in Appendix A, Section A.2).

Mounting location:

for housing size $^1/_3$ ❸ in Figure 8-8, slot 19,
for housing size $^1/_2$ ❸ in Figure 8-9, slot 33,
for housing size $^1/_1$ ❸ in Figure 8-10, slot 33 right.

Table 8-13 Jumper setting of relay contact for BO6.

Jumper	Quiescent state open (NO contact)	Quiescent state closed (NC contact)	Presetting
X41	1–2	2–3	1–2

The set nominal currents of the current input transformers are checked on the input/output board C–I/O–2. All jumpers must be set to the same nominal current, i.e. one jumper for each input transformer (X61 to X64) and one common jumper X60. **However:** There is no jumper X64 for the version with sensitive earth current input (input transformer T8).

The jumpers X71, X72 and X73 on the input/output board C–I/O–2 are for setting the bus address and must not be changed. Table 8-14 lists the jumper presettings.

Mounting location:

for housing size $^{1}/_{3}$ ❸ in Figure 8-8, slot 19,
for housing size $^{1}/_{2}$ ❸ in Figure 8-9, slot 33,
for housing size $^{1}/_{1}$ ❸ in Figure 8-10, slot 33 right.

Table 8-14 Jumper setting of **printed circuit board addresses** of binary input/output boards C-I/O-2

Jumper	Presetting
X71	1–2 (H)
X72	1–2 (H)
X73	2–3 (L)

Input/Output Board C–I/O–11

The layout of the printed circuit board for the input/output board C-I/O–11 is illustrated in Figure 8-15.

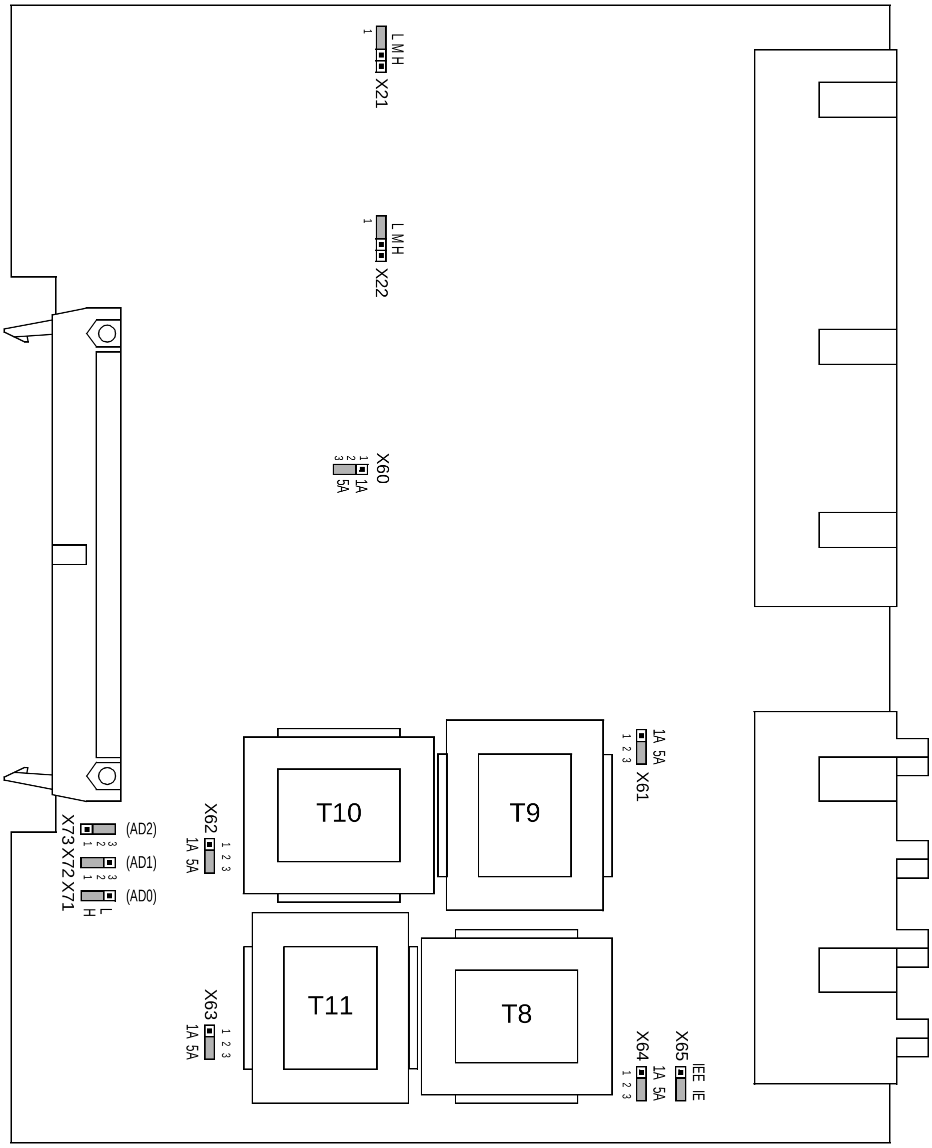


Figure 8-15 The input/output board C-I/O–11 with the jumpers necessary for the control of settings.

Table 8-15 Jumper setting of **control voltages** of the binary inputs BI6 and BI7 on the binary input/output boards C– I/O–11

Binary Inputs	Jumper	Threshold 17 V[1]	Threshold 73 V[2]
BI6	X21	L	M
BI7	X22	L	M

[1] Factory settings for devices with power supply voltages of 24 VDC to 125 VDC

[2] Factory settings for devices with power supply voltages of 110 VDC to 220 VDC and 115 VAC

The set nominal currents of the current input transformer are checked on the input/output board C–I/O–11. All jumpers must be set to the same nominal current, i.e. one jumper for each input transformer (X61 to X64) and one common jumper X60. **However:** there is no jumper X64 for the version with sensitive earth current input (input transformer T8).

For normal earth current inputs the jumper X65 is plugged in position “IE” and for sensitive earth current inputs in position “IEE”.

The jumpers X71, X72 and X73 on the input/output board C–I/O–11 are for setting the bus address and must not be changed. Table 8-16 lists the jumper presettings.

Mounting location:

for housing size $^1/_3$ ❹ in Figure 8-8, slot 19,
for housing size $^1/_2$ ❹ in Figure 8-9, slot 33,
for housing size $^1/_1$ ❹ in Figure 8-10, slot 33 right.

.

Table 8-16 Jumper setting of **printed circuit board addresses** of binary input/output boards C-I/O-11

Jumper	Presetting
X71	1–2 (H)
X72	1–2 (H)
X73	2–3 (L)

Input/Output Board B–I/O–2

The layout of the printed circuit board for the input/output board B–I/O–2 is illustrated in Figure 8-16.

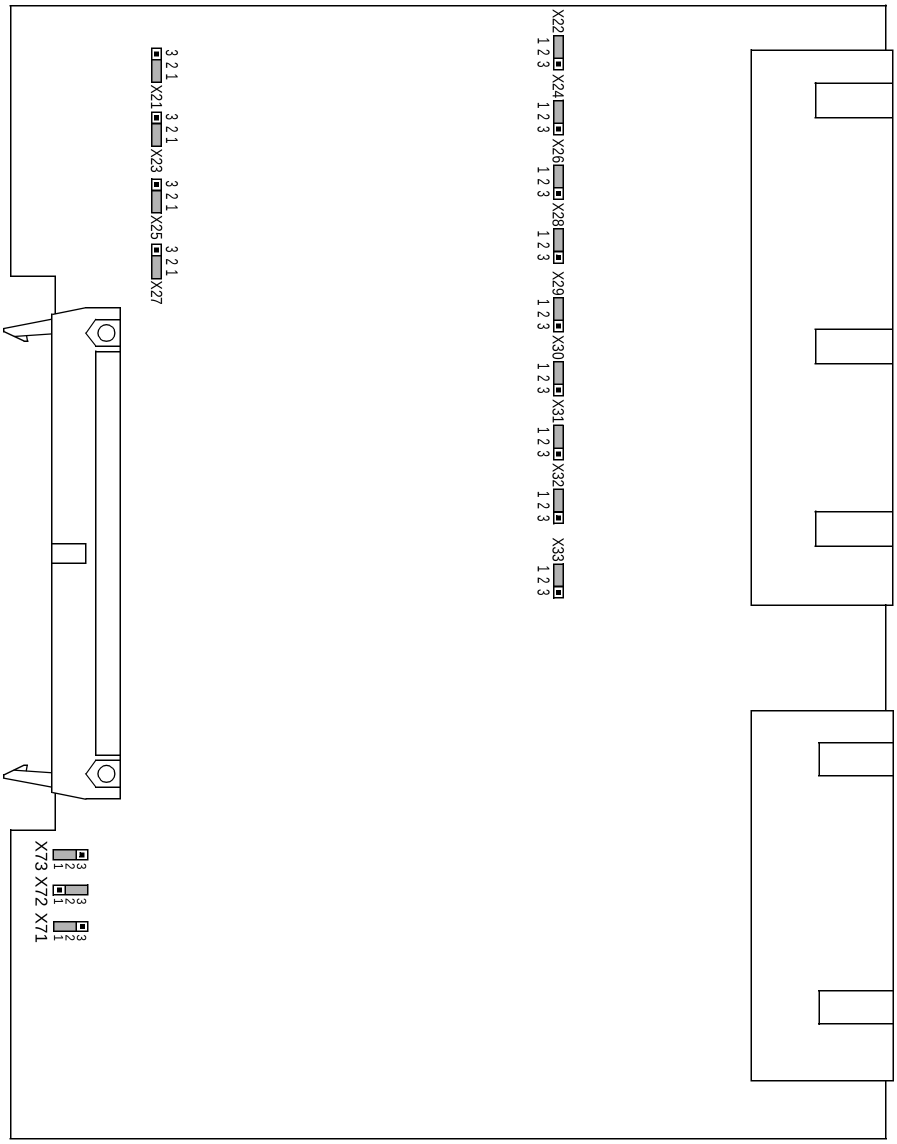


Figure 8-16 The input/output board B–I/O–2 with the jumpers necessary for the setting check

Check for control voltages of binary inputs:

BI8 to BI20 (for housing size $^1/_2$) according to Table 8-17.
BI8 to BI33 (for housing size $^1/_1$) according to Table 8-18.

Table 8-17 Jumper setting of **control voltages** of the binary inputs BI8 and BI20 on the binary input/output boards B–I/O–2 for version 7SA6***1**–**B**...

Binary inputs	Jumper	Threshold 17 V¹)	Threshold 73 V²)
Slot 19			
BI8	X21	1–2	2–3
BI9	X22	1–2	2–3
BI10	X23	1–2	2–3
BI11	X24	1–2	2–3
BI12	X25	1–2	2–3
BI13	X26	1–2	2–3
BI14	X27	1–2	2–3
BI15	X28	1–2	2–3
BI16	X29	1–2	2–3
BI17	X30	1–2	2–3
BI18	X31	1–2	2–3
BI19	X32	1–2	2–3
BI20	X33	1–2	2–3

¹) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC
²) Factory settings for devices with power supply voltages of 110 VDC to 220 VDC and 115 VAC

Table 8-18 Jumper setting of **control voltages** of the binary inputs BI8 and BI33 on the binary input/output boards B–I/O–2 for version 7SA6***2**–**C**...

Binary inputs		Jumper	Threshold 17 V¹)	Threshold 73 V²)
Slot 33 left	Slot 19 right			
BI8	BE21	X21	1–2	2–3
BI9	BE22	X22	1–2	2–3
BI10	BE23	X23	1–2	2–3
BI11	BE24	X24	1–2	2–3
BI12	BE25	X25	1–2	2–3
BI13	BE26	X26	1–2	2–3
BI14	BE27	X27	1–2	2–3
BI15	BE28	X28	1–2	2–3
BI16	BE29	X29	1–2	2–3
BI17	BE30	X30	1–2	2–3
BI18	BE31	X31	1–2	2–3
BI19	BE32	X32	1–2	2–3
BI20	BE33	X33	1–2	2–3

¹) Factory settings for devices with power supply voltages of 24 VDC to 125 VDC
²) Factory settings for devices with power supply voltages of 110 VDC to 220 VDC and 115 VAC

Jumpers X71, X72 and X73 on the input/output board C–I/O–2 are for setting the bus address and must not be changed. Table 8-19 and 8-20 lists the jumper presettings.

The mounting locations are shown in Figures 8-8 to 8-10.

Table 8-19 Jumper setting of **printed circuit board addresses** of the binary input/output boards B– I/O–2 for housing size $^1/_2$

Jumper	Mounting location
	Slot 19
X71	1–2
X72	2–3
X73	1–2

Tabelle 8-20 Jumper setting of **printed circuit board addresses** of the binary input/output boards B– I/O–2 for housing size $^1/_1$

Jumper	Mounting location	
	Slot 19 right	Slot 33 left
X71	1–2	2–3
X72	2–3	1–2
X73	1–2	1–2

8.1.3.4 Interface Modules

The interface modules are located on the processor printed circuit board C–CPU–2 (❶ in Figure 8-8 to 8-10). Figure 8-17 shows the printed circuit board and the modules.

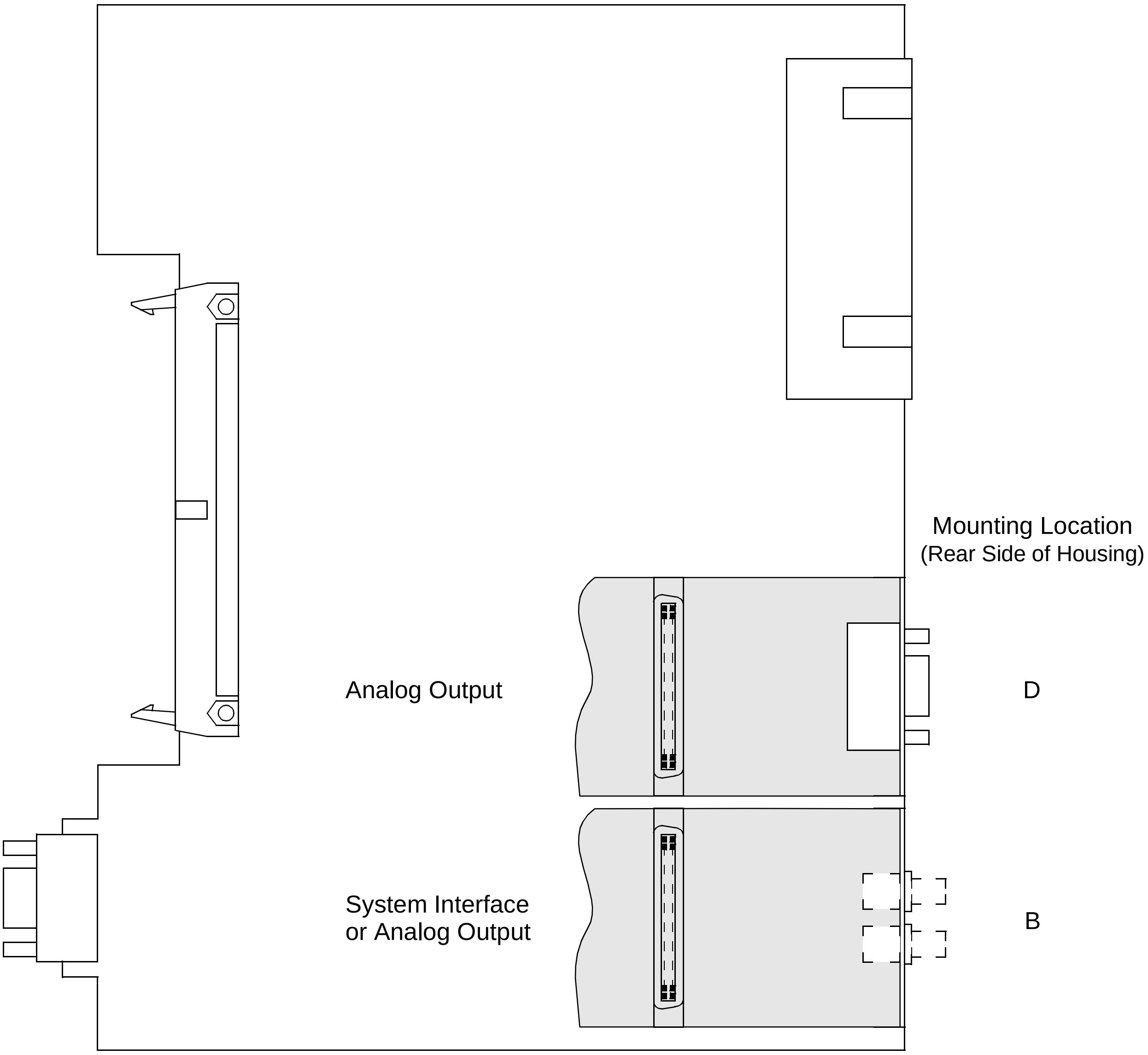


Figure 8-17 Processor printed circuit board C–CPU–2 with interface modules

Serial Interfaces with Bus Capability

Using interfaces with bus capability requires a termination of the last device at the bus, i. e. terminating resistors must be switched to the line. Talking about the 7SA6 this refers to the version with the RS485 interface or the Profibus interfaces.

The terminating resistors are located on the RS485 interface module or the Profibus interface module that is mounted to the processor input/output board C–CPU–2 (❶ in Figure 8-8 to 8-10) or located directly on the latter (see also Subsubsection 8.1.3.3, “Processor Board C-CPU-2”, and Table 8-6).

Figure 8-17 shows the printed circuit board of the C–CPU–2 and the order the modules are mounted.

The module for the RS485 interface is illustrated in Figure 8-18 for Profibus in Figure 8-19.

The jumpers are preset in such a way that the terminating resistors are disconnected. The two jumpers of a module must always be plugged in the same way.

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	2-3	1-2*)
X4	2-3	1-2*)

*) Factory Set

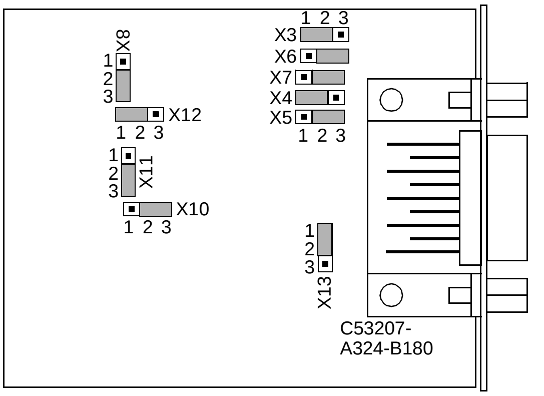


Figure 8-18 Location of the jumpers for the configuration of terminating resistors of the RS 485 interface

Jumper	Terminating Resistors	
	Connected	Disconnected
X3	1-2	2-3
X4	1-2	2-3

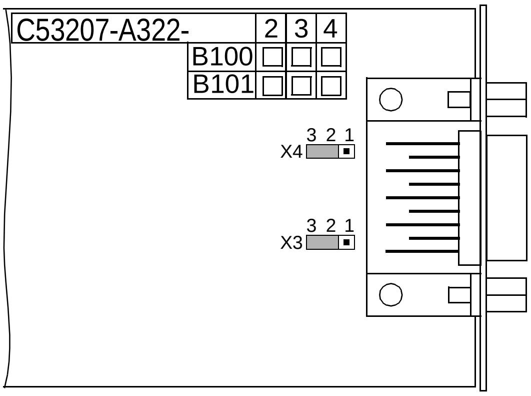


Figure 8-19 Location of the jumpers for the configuration of terminating resistors of the Profibus interface

The terminating resistors can also be connected externally (e.g. to the connection module) as illustrated in Figure 8-12. In this case, the terminating resistors located on the RS485 or the Profibus interface module or the resistors located directly on the processor circuit board C–CPU–2 must be disconnected.

The RS 485 interface can be modified to a RS232 interface by rearranging the jumpers.

The jumper settings for the alternative interfaces RS232 or RS485 (according to Figure 8-18) are listed in Table 8-21.

Table 8-21 Configuration for **RS232 or RS485** on the interface module according to Figure 8-18

Jumper	X5	X6	X7	X8	X10	X11	X12	X13
RS232	1–2	1–2	1–2	1–2	1–2	2–3	1–2	1–2
RS485	2–3	2–3	2–3	2–3	2–3	2–3	1–2	1–2

The jumpers X5 to X10 must be plugged in the same way!

Jumper presettings are in accordance with the ordered configuration.

Analog Output Module

The analog output module AN20 is provided with 2 isolated channels with a current range from 0 to 20 mA (unipolar, maximum 350 Ω).

The mounting location on the processor circuit board C–CPU–2 is “B” and/or “D”, dependent on the version (see Figure 8-17).

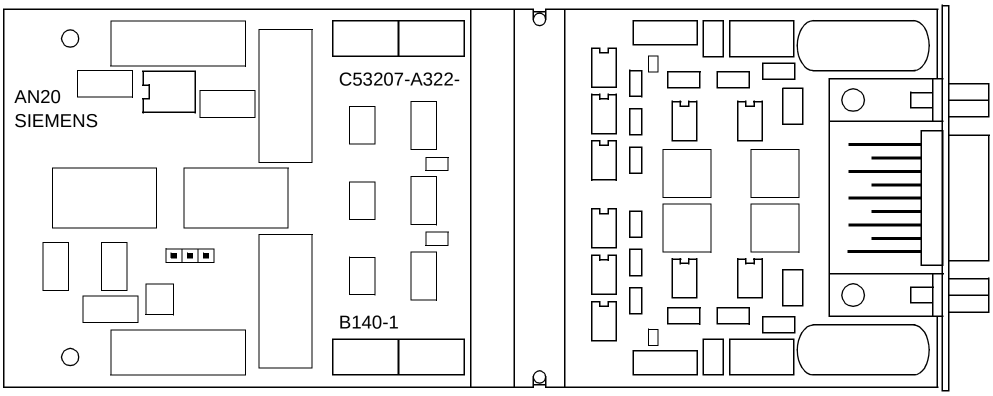


Figure 8-20 Interface module with the analog output AN20

Replacing Interface Modules

The interface modules can be replaced. Refer to Figure 8-17 for physical arrangement of the modules. The order numbers of the replacement module can be found in Appendix A, Section A.1.1.

Please note the following:

- Only interface modules of devices with panel flush mounting and cubicle mounting as well as of mounting devices with detached operator panel can be exchanged. Interface modules of devices in surface mounting housings with double-level terminals must be exchanged in our manufacturing centre.
- Use only interface modules that can be ordered in our facilities (see also Appendix A, Section A.1.1).

Table 8-22 Exchangeable interface modules

Interface	Mounting Location	Exchange Module
System Interface or Analog Output	B	RS232
		RS485
		LWL 820 nm
		Profibus FMS RS485
		Profibus FMS single-ended ring
		Profibus FMS double-ended ring
		AN20
Analog Output	D	AN20

8.1.3.5 Reassembly of Device

To reassemble the device, proceed as follows:

☐ Carefully insert the boards into the case. The installation locations of the boards are shown in Figure 8-8 to 8-10.
For the model of the device designed for surface mounting, use the metal lever to insert the processor circuit board C-CPU-2 board. The installation is easier with the lever.

☐ First plug the plug connectors of the ribbon cable into the input/output boards I/O and then onto the processor module C-CPU-2. Be careful to not bend any of the connecting pins! Do not use force!

☐ Insert the plug connector of the ribbon cable between the processor module C-CPU-2 and the front cover into the socket of the front cover.
For the version with detached operator panel the latter is to be ignored. Instead the plug connector of the ribbon cable connected to a 68pole plug connector on the rear side of the device must be plugged into the plug connector of the processor circuit board C-CPU-2. The 7-pole plug connector X16 connected to the ribbon cable must be plugged behind the D-subminiature female connector. Since the connection is protected against polarity reversal, no particular plug-in position must be observed.

☐ Press the latches of the plug connectors together.

☐ Replace the front cover and secure to the housing with the screws.

☐ Replace the covers.

☐ Re-fasten the interfaces on the rear of the device housing.
This activity is not necessary if the device is designed for surface mounting.

8.2 Checking the Connections

8.2.1 Data Connections

The following tables list the pin-assignments for the various serial interfaces of the device and the time synchronization interface.

PC Operating Interface at Front

When the recommended communication cable is used, correct connection between the SIPROTEC® device and the PC is automatically ensured. See the Appendix, Subsection for an ordering description of the cable.

System (SCADA) Interface

When a serial interface of the device is connected to a central substation control system, the data connection must be checked. A visual check of the transmit channel and the receive channel is important. Each connection is dedicated to one transmission direction. The data output of one device must be connected to the data input of the other device, and vice versa.

The data cable connections are designated in sympathy with DIN 66020 and ISO 2110 (see also Table 8-23):

- TxD data transmit
- RxD data receive
- $\overline{\text{RTS}}$ request to send
- $\overline{\text{CTS}}$ clear to send
- DGND signal/chassis ground

The cable shield is to be grounded at **both ends** so that potential differences cannot cause circulating currents to flow along the shield.

The physical arrangement of the connectors is illustrated in Sub-section 2.1.5, Figure 2-19.

Table 8-23 Installation of the D-subminiature ports

Pin No.	Operating interface	RS232	RS485	Profibus FMS Slave, RS485
1	Shield (with shield ends electrically connected)			
2	RxD	RxD	–	–
3	TxD	TxD	A/A' (RxD/TxD–N)	B/B' (RxD/TxD–P)
4	–	–	–	CNTR–A (TTL)
5	DGND	DGND	C/C' (DGND)	C/C' (DGND)
6	–	–	–	+5 V (max. load 100 mA)
7	$\overline{\text{RTS}}$	$\overline{\text{RTS}}$	–*)	–
8	$\overline{\text{CTS}}$	$\overline{\text{CTS}}$	B/B' (RxD/TxD–P)	A/A' (RxD/TxD–N)
9	–	–	–	–

*) Pin 7 also may carry the RS232 $\overline{\text{RTS}}$ signal to an RS485 interface. Pin 7 must therefore not be connected!

RS485 Termination

The RS485 interface is capable of half-duplex service with the signals A/A’ and B/B’ with a common relative potential C/C’ (DGND). Verify that only the last device on the bus has the terminating resistors connected, and that the other devices on the bus do not. The jumpers for the terminating resistors are on the interface module RS485 (Figure 8-18) or on the Profibus module (Figure 8-19).

If the bus is extended, make sure again that only the last device on the bus has the terminating resistors switched in, and that all other devices on the bus do not.

Analog Outputs

Both analog values are directed as current via a 9-pole D-subminiature female connector. The outputs are isolated.

Table 8-24 Pin-assignments for the D-subminiature female connector of the analog output

Pin-No.	Designation
1	Channel 1 positive
2	–
3	–
4	–
5	Channel 2 positive
6	Channel 1 negative
7	–
8	–
9	Channel 2 negative

Time Synchronization Interface

5 VDC, 12 VDC or 24 VDC time synchronization signals can be processed optionally if the connections are realized as indicated in Table 8-25.

Table 8-25 Pin-assignments for the D-subminiature port of the time synchronization interface

Pin-No.	Designation	Signal meaning
1	P24_TSIG	Input 24 V
2	P5_TSIG	Input 5 V
3	M_TSIG	Return Line
4	–*)	–*)
5	Screen	Shield potential
6	–	–
7	P12_TSIG	Input 12 V
8	P_TSYNC*)	Input 24 V*)
9	Screen	Shield potential

*) assigned, but not available

Optical Fibres

Signals transmitted over optical fibres are unaffected by interference. The fibres guarantee electrical isolation between the connections. Transmit and receive connections are identified with the symbols ——>● for transmit and ——>● for receive.

The character idle state for the optical fibre interface is “Light off.” If this setting is to be changed, use the operating program DIGSI® 4, as described in Section 5.6.

Warning!

Laser injection! Do not look directly into the fibre-optic elements!

8.2.2 Checking Power Plant Connections

Warning!

Some of the following test steps will be carried out in presence of hazardous voltages. They shall be performed only by qualified personnel which is thoroughly familiar with all safety regulations and precautionary measures and pay due attention to them.

Caution!

Operating the device on a battery charger without a connected battery can lead to unusually high voltages and consequently, the destruction of the device. For limit values see Sub-section 10.2.1 under Technical Data.

Before the device is energized for the first time, the device should be in the final operating environment for at least 2 hours to equalize the temperature and to minimize humidity and avoid condensation. Connection are checked with the device at its final location. The plant must first be switched off and grounded.

☐ Protective switches (e.g. test switches, fuses, or miniature circuit breakers) for the power supply and the measured voltages must be opened.

☐ Check the continuity of all current and voltage transformer connections against the system and connection diagrams:

- ☐ Are the current transformers grounded properly?
- ☐ Are the polarities of the current transformers the same?
- ☐ Is the phase relationship of the current transformers correct?
- ☐ Are the voltage transformers grounded properly?
- ☐ Are the polarities of the voltage transformers correct?
- ☐ Is the phase relationship of the voltage transformers correct?
- ☐ Is the polarity for current input I_4 correct (if used), also refer to Subsection 8.1.2, “Currents”?
- ☐ Is the polarity for voltage input U_4 correct (if used, e.g. with broken delta winding or busbar voltage), cf. also Subsection 8.1.2, “Voltages”?

- ☐ Check the functions of all test switches that may be installed for the purposes of secondary testing and isolation of the device. Of particular importance are test switches in current transformer circuits. Be sure these switches short-circuit the current transformers when they are in the test mode (open).
- ☐ The short-circuit feature of the current circuits of the device are to be checked. An ohmmeter or other test equipment for checking continuity is needed.
  - ☐ Remove the front panel of the device (see Figure 8-8 to 8-10).
  - ☐ Remove the ribbon cable connected to the I/O–2 board with the measured current and measured voltage inputs (on the front side it is the right printed circuit board, for housing size $^1/_3$, see Figure 8-8 [slot 19], for housing size $^1/_2$ see Figure 8-9 [slot 33], for housing size $^1/_1$ see Figure 8-10 [slot 33 right]. Furthermore, remove the printed circuit board so that there is no more contact anymore with the plug-in terminal.
  - ☐ At the terminals of the device, check continuity for each pair of terminals that receives current from the CTs.
  - ☐ Firmly re-insert the I/O–2 board. Carefully connect the ribbon cable. Do not bend any connector pins! Do not use force!
  - ☐ Check continuity for each of the current terminal-pairs again.
  - ☐ Attach the front panel and tighten the screws.
- ☐ Connect an ammeter in the supply circuit of the power supply. A range of about 2.5 A to 5 A for the meter is appropriate.
- ☐ Close the protective switches to apply voltage to the power supply. Check the polarity and magnitude of the voltage at the device terminals.
- ☐ The measured steady-state current should correspond to the quiescent power consumption of the device. Transient movement of the ammeter merely indicates the charging current of capacitors.
- ☐ Remove the voltage from the power supply by opening the protective switches.
- ☐ Disconnect the measuring equipment; restore the normal power supply connections.
- ☐ Apply voltage to the power supply.
- ☐ Close the protective switches for the voltage transformers.
- ☐ Verify that the voltage phase rotation at the device terminals is correct. Note that the device can be set for L1-L2-L3 rotation or L1-L3-L2 rotation under address `0235` **`PHASE SEQ.`** in **`P.System Data1`**. See also Sub-section 6.1.1.
- ☐ Open the protective switches for the voltage transformers and the power supply.
- ☐ Check the trip circuits to the power system circuit breakers.
- ☐ Check the close circuits to the power system circuit breakers.
- ☐ Verify that the control wiring to and from other devices is correct.
- ☐ Check the signalling connections.
- ☐ Check the analog outputs (if available and used).
- ☐ Close the protective switches to apply voltage to the power supply.

8.3 Commissioning

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non–observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this manual as well as with the applicable safety regulations.

Particular attention must be drawn to the following:

- The earthing screw of the device must be connected solidly to the protective earth conductor before any other electrical connection is made.
- Hazardous voltages can be present on all circuits and components connected to the supply voltage or to the measuring and test quantities.
- Hazardous voltages can be present in the device even after disconnection of the supply voltage (storage capacitors!).
- After disconnection of the auxiliary voltage wait at least 10 s before connecting the voltage again to then define the starting conditions.
- The limit values stated in the Technical Data (Chapter 10) must not be exceeded at all, not even during testing and commissioning.

When testing the device with secondary test equipment, make sure that no other measurement quantities are connected and that the trip and close commands to the circuit breakers and other primary switches are disconnected from the device unless expressly stated.

DANGER!

Current transformer secondary circuits must have been short-circuited before the current leads to the device are disconnected!

If test switches are installed that automatically short-circuit the current transformer secondary circuits, it is sufficient to place them into the “Test” position provided the short-circuit functions has been previously tested.

For the commissioning switching operations have to be carried out. A prerequisite for the prescribed tests is that these switching operations can be executed without danger. They are accordingly not meant for operational checks.

Warning!

Primary test may only be carried out by qualified personnel, who are familiar with the commissioning of protection systems, the operation of the plant and the safety rules and regulations (switching, earthing, etc.).

8.3.1 Testing mode and transmission blocking

If the device is connected to a substation control system or a server, the user is able to modify, in some protocols, information that is transmitted to the substation (see Section A.5 “Protocol Dependent Functions” in Appendix A).

In the **`testing mode`** all messages sent from a SIPROTEC®4–device to the substation are marked with an extra test bit so that the substation is able to identify them as messages announcing no real faults. Furthermore the **`transmission blocking`** function leads to a total blocking of the message transmission process via the system interface in the testing mode.

Refer to Subsection 7.2.3 to know how the testing mode and the transmission blocking can be enabled and disabled. Please note that it is necessary to be **`Online`** during the configuration of the device with DIGSI® 4 to be able to use the testing mode.

8.3.2 Checking the System (SCADA) Interface

Preliminary Remarks

Provided that the device is equipped with a system (SCADA) interface that is used for the communication with a substation, it is possible to test via the DIGSI® 4 operational function if messages are transmitted correctly. Do not apply this test function in the real operating mode of the device.

DANGER!

The transmission and reception of messages via the system (SCADA) interface by means of the testing mode is the real exchange of information between the SIPROTEC®4 device and the substation. Connected equipment such as circuit breakers or disconnectors can be operated as a result of these actions!

Note:

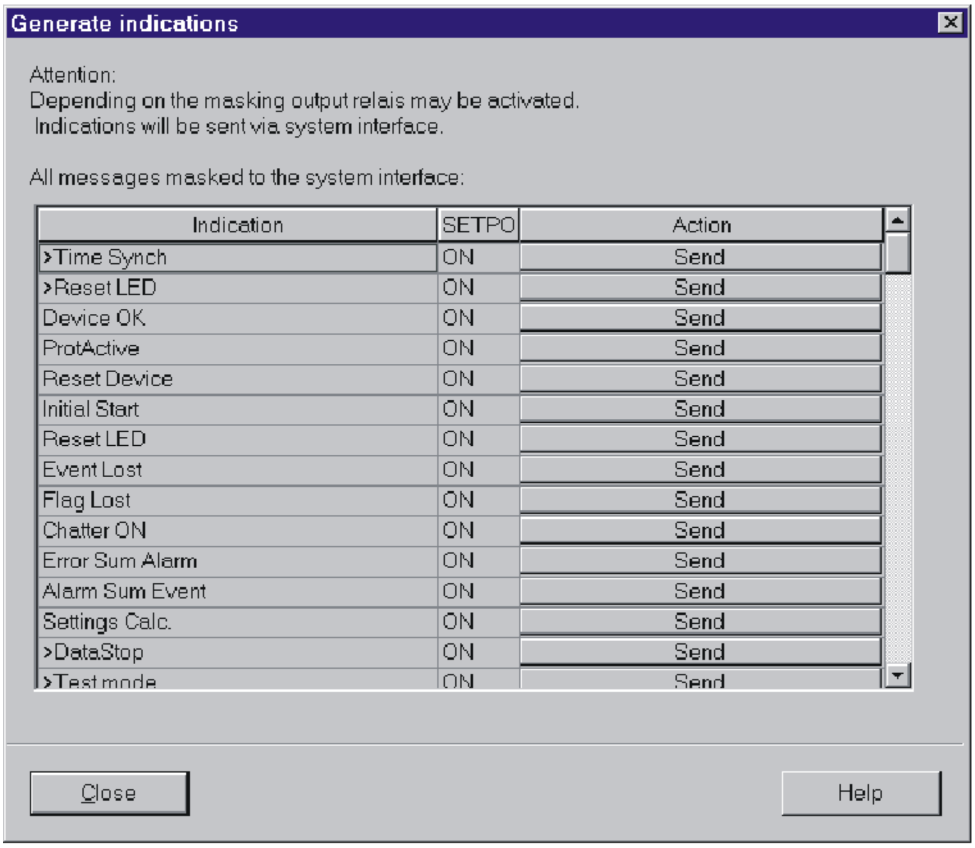
After termination of this test, the device will reboot. All annunciation buffers are erased. If required, these buffers should be extracted with DIGSI® 4 prior to the test.

The system interface test is carried out **`Online`** using DIGSI® 4:

- ❑ Double-click on the **`Online`** directory to open the required dialogue box.
- ❑ Click on **`Test`** and the functional options appear on the right side of the window.
- ❑ Double-click on **`Testing Messages for System Interface`** shown in the list view. The dialogue box **`Testing System Interface`** opens (refer to 8-21).

Structure of the Dialogue Box

In the column **`Indication`**, all message texts that were configured for the system interface in the matrix will then appear. In the column **`Status Scheduled`** the user has to define the value for the messages to be tested. Depending on the type of message different entering fields are available (e.g. message **`ON`** / message **`OFF`**). By double-clicking onto one of the fields the required value can be selected from the list.



Attention:
Depending on the masking output relais may be activated.
Indications will be sent via system interface.

All messages masked to the system interface:

Indication	SETPO	Action
>Time Synch	ON	Send
>Reset LED	ON	Send
Device OK	ON	Send
ProtActive	ON	Send
Reset Device	ON	Send
Initial Start	ON	Send
Reset LED	ON	Send
Event Lost	ON	Send
Flag Lost	ON	Send
Chatter ON	ON	Send
Error Sum Alarm	ON	Send
Alarm Sum Event	ON	Send
Settings Calc.	ON	Send
>DataStop	ON	Send
>Test mode	ON	Send

Figure 8-21 Dialog Box: Generate indications

Changing the Operating State

Clicking for the first time onto one of the field in column **`Action`** you will be asked for password n° 6 (for hardware test menus). Having entered the correct password messages can be issued. To do so, click on **`Send`**. The corresponding message is issued and can be read out either from the event log of the SIPROTEC$^{®}$4 - device or from the substation.

As long as the windows is open, further tests can be performed.

Test in Message Direction

For all information that is transmitted to the central station the following is tested in **`Status Scheduled:`**

- ☐ Make sure that each checking process is carried out carefully without causing any danger (see above and refer to **DANGER!**)
- ☐ Click on **`Send`** and check whether the transmitted information reaches the central station and shows the desired reaction.

Test in Command Direction

The information beginning with “>” is transmitted towards the device. This kind of information must be indicated by the central station. Check whether the reaction is correct.

Exiting the Test Mode

To end the System Interface Test, click on **`Close`**. The device is briefly out of service while the start-up routine is executed. The dialogue box closes.

8.3.3 Checking the Binary Inputs and Outputs

Preliminary Notes

The binary inputs, outputs, and LEDs of a SIPROTEC®4 device can be individually and precisely controlled using DIGSI® 4. This feature is used to verify control wiring from the device to plant equipment (operational checks), during commissioning. This test feature should **not** be used while the device is in service on a live system.

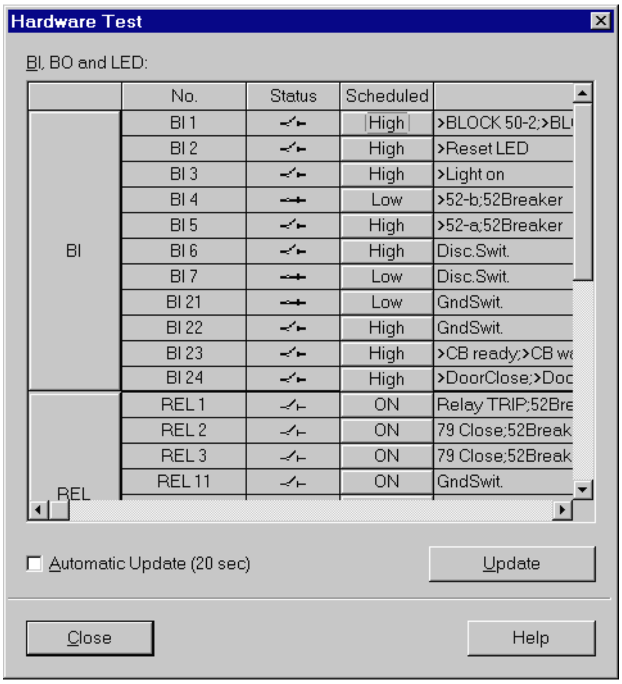
DANGER!

Changing the status of a binary input or output using the test feature of DIGSI® 4 results in an actual and immediate corresponding change in the SIPROTEC® device. Connected equipment such as circuit breakers or disconnectors will be operated as a result of these actions!

Note: After termination of the hardware test, the device will reboot. Thereby, all annunciation buffers are erased. If required, these buffers should be extracted with DIGSI® 4 prior to the test.

The hardware test can be done using DIGSI® 4 in the online operating mode:

- ❑ Open the **`Online`** directory by double-clicking; the operating functions for the device appear.
- ❑ Click on **`Test`**; the function selection appears in the right half of the screen.
- ❑ Double-click in the list view on **`Hardware Test`**. The dialogue box of the same name opens (see Figure 8-22).



BI, BO and LED:

	No.	Status	Scheduled	
BI	BI 1	─╱─	High	>BLOCK 50-2;>BL
	BI 2	─╱─	High	>Reset LED
	BI 3	─╱─	High	>Light on
	BI 4	───	Low	>52-b;52Breaker
	BI 5	─╱─	High	>52-a;52Breaker
	BI 6	─╱─	High	Disc.Swit.
	BI 7	───	Low	Disc.Swit.
	BI 21	───	Low	GndSwit.
	BI 22	─╱─	High	GndSwit.
	BI 23	─╱─	High	>CB ready;>CB w
	BI 24	─╱─	High	>DoorClose;>Do
REL	REL 1	─╱─	ON	Relay TRIP;52Bre
	REL 2	─╱─	ON	79 Close;52Break
	REL 3	─╱─	ON	79 Close;52Break
	REL 11	─╱─	ON	GndSwit.

☐ Automatic Update (20 sec)

Figure 8-22 Dialogue box for hardware test

Structure of the Test Dialogue Box

The dialogue box is horizontally divided into three groups: **`BI`** for binary inputs, **`REL`** for output relays, and **`LED`** for light-emitting diodes. Each of these groups is associated with an appropriately marked switching area. By double-clicking in an area, components within the associated group can be turned on or off.

In the **`Status`** column, the present (physical) state of the hardware component is displayed. The binary inputs and outputs are indicated by the symbol of an open or closed switch symbol, the LEDs by the symbol of a dark or illuminated LED symbol.

The possible intended condition of a hardware component is indicated with clear text under the **`Schedule`** column, which is next to the **`Status`** column. The intended condition offered for a component is always the opposite of the present state.

The right-most column indicates the commands or messages that are configured (masked) to the hardware components.

Changing the Hardware Conditions

To change the condition of a hardware component, click on the associated switching field in the **`Schedule`** column.

Password No. 6 for Hardware Test (if activated during configuration) will be requested before the first hardware modification is allowed. After entry of the correct password a condition change will be executed.

Further condition changes remain possible while the dialog box is open.

Note:

As soon as the first condition change of a hardware component is initiated under the Hardware Test, then all components in that group (BI, REL or LED) are separated from substation, or device-side, functionality. This means, for example, that external signals to binary inputs would be ignored by the device if their status conditions change and the test procedure had not been closed.

Local control is re-established when the dialog box is closed.

Test of the Binary Outputs

Each individual output relay can be energized allowing a check of the wiring between the output relay of the 7SA6 and the plant, without having to generate the message that is assigned to the relay. As soon as the first change of state for any one of the output relays is initiated, *all* output relays are separated from the internal device functions, and can only be operated by the hardware test function. This implies that a switching signal to an output relay from e.g. a protection function or control command cannot be executed.

- ❑ Ensured that the switching of the output relay can be executed without danger (see above under **DANGER**!).
- ❑ Each output relay must be tested via the corresponding **`Schedule`**–column in the dialog box.
- ❑ The test sequence must be terminated (refer to margin heading “Ending the Procedure”), to avoid the initiation of inadvertent switching operations by further tests.

Test of the Binary Inputs

To test the wiring between the plant and the binary inputs of the 7SA6 the condition in the plant which initiates the binary input must be generated and the response of the device checked.

To do this, the dialogue box **`Hardware Test`** must again be opened to view the physical state of the binary inputs. The password is not yet required.

- ❑ Each state in the plant which causes a binary input to pick up must be generated.

- ☐ The response of the device must be checked in the **`Ist`**–column of the dialogue box. To do this, the dialogue box must be updated. The options may be found below under the margin heading “Updating the Display”.

If however the effect of a binary input must be checked without carrying out any switching in the plant, it is possible to trigger individual binary inputs with the hardware test function. As soon as the first state change of any binary input is triggered and the password nr. 6 has been entered, *all* binary inputs are separated from the plant and can only be activated via the hardware test function.

- ☐ Terminate the test sequence (see above under the margin heading „Ending the Procedure“).

Test of the LED’s

The LED’s may be tested in a similar manner to the other input/output components. As soon as the first state change of any LED has been triggered, *all* LEDs are separated from the internal device functionality and can only be controlled via the hardware test frunction. This implies that no LED can be switched on anymore by e.g. a protection function or operation of the LED reset key.

Updating the Display

When the dialog box **`Hardware Test`** is opened, the present conditions of the hardware components at that moment are read in and displayed. An update occurs:

- for each harware component, if a command to change the condition is successfully performed,
- for all hardware components if the **`Update`** button is clicked,
- for all hardware components with cyclical updating if the **`Automatic Update (20sec)`** field is marked.

Ending the Procedure

To end the hardware test, click on **`Close`**. The dialog box closes. The device becomes unavailable for a brief start-up period immediately after this. Then all hardware components are returned to the operating conditions determined by the plant settings.

8.3.4 Checking Analog Outputs

7SA6 can be equipped with up to 2 analog outputs. In case analog outputs are available and used, their effect must be tested.

Since different measured values or results of the fault location are output, the check depends on the values used. They must be generated, e.g. with a secondary test equipment.

Please make sure that the corresponding values are output correctly at their destination.

8.3.5 Tests for the Circuit Breaker Failure Protection

If the device provides a breaker failure protection and if this is used, the integration of this protection function in the system must be tested under practical conditions.

Due to the variety of application options and the available system configurations, it is not possible to make a detailed description of the necessary tests. It is important to consider the local conditions and the protection and plant drawings.

It is advised to isolate the circuit breaker of the tested feeder at both sides, i.e. to keep the busbar isolator and the line isolator open, in order to ensure operation of the breaker without risk.

Caution!

Also for tests on the local circuit breaker of the feeder a trip command to the surrounding circuit breakers can be issued for the busbar. Therefore the tripping of the surrounding circuit breakers (busbar) must be deactivated, e. g. by switching off the corresponding control voltages.Nevertheless ensure that trip remains possible in case of a real primary fault if parts of the power plant are in service.

The trip command of the tested Distance Protection is made ineffective so that the local breaker can be tripped only by the breaker failure protection function of 7SA6.

Although the following lists do not claim to be complete it may also contain points which are to be ignored in the current application.

Circuit Breaker Auxiliary Contacts

If the circuit breaker auxiliary contacts are connected to the device, these provide an essential input to the functionality of the breaker failure protection. Make sure the correct assignment has been checked (Section 8.3.3).

External Start Conditions

If the breaker failure protection can also be started by external protection devices, the external start conditions should be checked. Single-pole or three-pole tripping is possible depending on the setting of the breaker failure protection. The pole discrepancy check of the device or the breaker may itself lead to three-pole tripping after single-pole tripping. Therefore check first how the parameters of the breaker failure protection are set. See Subsection 6.16.2, addresses `3901` onwards.

In order for the breaker failure protection to be started, a current must flow at least via the monitored phase. This may be a secondary injected current.

After every start, the message “`BF Start`” (FNo. `1461`) must appear in the spontaneous annunciation list or the trip log.

Only if phase segregated starting possible:

❑ single-pole starting by trip command of the external protection in phase L1:
binary input functions “`>BF Start L1`” and possibly “`>BF release`” (in spontaneous or fault messages). Trip command depending on configuration.

❑ single-pole starting by trip command of the external protection in phase L2:

binary input functions “`>BF Start L2`” and possibly “`>BF release`” (in spontaneous or fault messages). Trip command depending on configuration.

❑ single-pole starting by trip command of external protection in phase L3:
binary input functions “`>BF Start L3`” and possibly “`>BF release`” (in spontaneous or fault messages). Trip command depending on configuration.

❑ three-pole starting by trip command of the external protection via all three binary inputs L1, L2 and L3:
binary input functions “`>BF Start L1`”, “`>BF Start L2`” and “`>BF Start L3`” and possibly “`>BF release`” (in spontaneous or fault messages). Trip command three-pole.

For common phase starting:

❑ three-pole starting by trip command of the external protection:
binary input functions “`>BF Start 3pole`” and possibly “`>BF release`” (in spontaneous or fault messages. Trip command depending on configuration.

Switch off test current.

If BF start is possible without current flow

❑ BF start by trip command of the external protection without current flow:
binary input functions “`>BF Start w/o I`” and possibly “`>BF release`” (in spontaneous or fault messages). Trip command depending on configuration.

Busbar tripping

For testing the distribution of the trip commands in the substation in the case of breaker failures it is important to check that the trip commands to the surrounding circuit breakers is correct.

The surrounding circuit breakers are all those which need to trip when the feeder circuit breaker fails. These are therefore the circuit breakers of all feeders which feed the busbar or busbar section to which the feeder with the fault is connected.

A general detailed test guide cannot be specified because the layout of the surrounding circuit breakers largely depends on the switchgear topology.

In particular with multiple busbars the trip distribution logic for the surrounding circuit breakers must be checked. Here it should be checked for every busbar section that all circuit breakers which are connected to the same busbar section as the feeder circuit breaker under observation are tripped, and no other breakers.

Tripping of the Remote End

If the trip command of the circuit breaker failure protection must also trip the circuit breaker at the remote end of the feeder under observation, the transmission channel for this remote trip must also be checked. This is done together with transmission of other signals according to section 8.3.12.3.

Termination

All temporary measures taken for testing must be undone, e.g. especially switching states, interrupted trip commands, changes to setting values or individually switched off protection functions.

8.3.6 Current, Voltage, and Phase Rotation Checks

Load Current ≥ 10 % I_N

The connections of the current and voltage transformers are tested using primary quantities. Secondary load current of at least 10 % of the nominal current of the device is necessary. The line must be energized and remains energized during this measurement test.

With proper connections of the measuring circuits, none of the measured-values supervision elements in the device should pick up. If an element detects a problem, the relevant condition can be viewed in the operational annunciations (refer also to Sub-section 7.1.1.2).

If current summation errors occur, then check the matching factors. See Sub-section 6.1.1.

Messages from the symmetry monitoring could occur because there actually are asymmetrical conditions in the network. If these asymmetrical conditions are normal service conditions, the corresponding monitoring functions should be made less sensitive. See Section 6.19.2.

Quantities

Currents and voltages can be viewed as primary or secondary quantities in the front display or via the service interface with a personal computer, and compared with the actual measured values (refer to section 7.1.3.1).

If the measured values are not plausible, the connection must be checked and corrected after the line has been isolated and the current transformer circuits have been short-circuited. The measurements must then be repeated.

Phase Rotation

The phase rotation must correspond to the configured phase rotation, in general a clockwise phase rotation. If the system has an anti-clockwise phase rotation, this must have been considered when the power system data was set (address `0235` **`PHASE SEQ.`**, refer to Sub-section 6.1.1). If the phase rotation is incorrect, the alarm “`171 Fail Ph. Seq.`” (FNo `171`) is generated. The measured value phase allocation must be checked and corrected, if required, after the line has been isolated and current transformers have been short-circuited. The phase rotation check must then be repeated.

Voltage Transformer Miniature Circuit Breaker (VT mcb)

The VT mcb of the feeder must be opened. The measured voltages in the operational measured values (Sub-section 7.1.3.1) appear with a value close to zero (small measured voltages are of no consequence).

Check in the spontaneous messages (section 7.1.1.7) that the VT mcb trip was entered (message “`>FAIL:Feeder VT ON`” in the spontaneous messages). Beforehand it has to be assured that the position of the VT mcb is connected to the device via a binary input.

Close the VT mcb: The above messages appear under the spontaneous messages as “`OFF`”, i.e. “`>FAIL:Feeder VT OFF`”).

If one of the events does not appear, the connection and routing of these signals (Sub-section 5.2.5) must be checked.

If the „`ON`“–state and „`OFF`“–state are swapped, the contact type (H–active or L–active) must be checked and remedied (Sub-section 5.2.5).

If a busbar voltage is used (for voltage protection and synchronism check) and the assigned VT mcb is connected to the device, the following function must also be checked:

If the VT mcb is open the message “`>FAIL:Bus VT ON`” appears, if it is closed the message “`>FAIL:Bus VT OFF`” is displayed.

Switch off the protected power line.

8.3.7 Directional Checks with Load Current

Load Current ≥ 10 % I_N

The connections of the current and voltage transformers are checked using load current on the protected line. The secondary load current must be at least $0.10 \cdot I_N$. The load current should be in-phase or lagging the voltage (resistive or resistive-inductive load). The direction of the load current must be known. If there is a doubt, network loops should be opened or other action taken to guarantee the direction of the load current. The line remains energized during this directional test.

The direction can be derived directly from the operational measured values. Initially the correlation of the measured load direction with the actual direction of load flow is checked. In this case the normal situation is assumed whereby the forward direction (measuring direction) extends from the busbar towards the line (Figure 8-23).

P positive, if active power flows into the line,

P negative, if active power flows towards the busbar,

Q positive, if reactive power flows into the line,

Q negative, if reactive power flows toward the busbar.

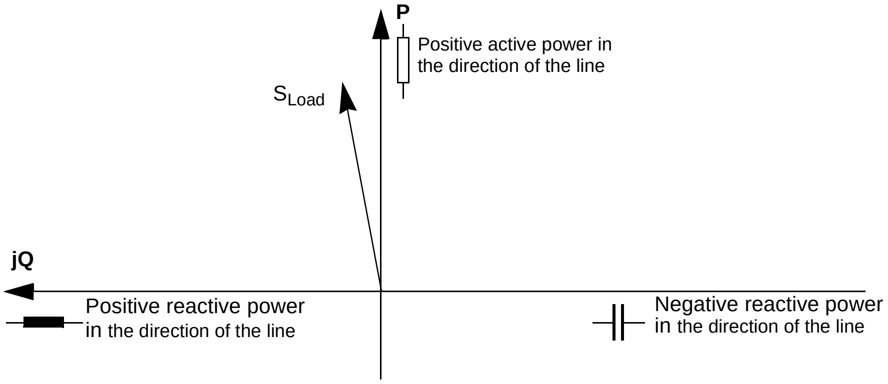


Figure 8-23 Complex (apparent) power

The power measurement provides an initial indication as to whether the measured values have the correct polarity. If both the active power as well as the reactive power have the wrong sign, the polarity in address `0201` **`CT Starpoint`** must be checked and rectified.

The power measurement on its own is however not able to recognize all types of incorrect connection. Accordingly, the impedances of all six measuring loops are evaluated. These can also be found as primary and secondary quantities in the operational measured values (Sub-section 7.1.3.1).

All six measured loops must have the *same* impedance components (R and X). Small variations may result due to the non-symmetry of the measured values. In addition the following applies for *all* impedances when the load is in the first quadrant:

R, X both positive, when power flows into the line,

R, X both negative, when power flows towards the busbar.

The general case is assumed here, whereby the forward direction (measuring direction) extends from the busbar towards the line. In the case of capacitive load, caused by e.g. underexcited generators or charging currents, the X-components may *all* have the opposite sign.

If significant differences in the values of the various loops are present, or if the individual signs are different, then individual phases in the current or voltage transformer circuits are swapped, not connected correctly, or the phase allocation is incorrect. After isolation of the line and short-circuiting of the current transformers the connections must be checked and corrected. The measurement must then be repeated.

Finally the power line is again isolated.

8.3.8 Polarity check for the voltage input U_4

Depending on the application of the voltage measuring input U_4, a polarity check may be necessary. If no measuring voltage is connected to this input, this subsection is irrelevant.

If the input U_4 is used for measuring a voltage for overvoltage protection (Power System Data 1 address 0210 **U4 transformer** = ***Ux transformer***), no polarity check is necessary because the polarity is irrelevant here. The voltage magnitude was checked according to Subsection 8.3.6.

If the input U_4 is used for measuring the displacement voltage Uen (power system data 1 address 0210 **U4 transformer** = ***Udelta transf.***), the polarity is checked together with the measured current test according to Subsection 8.3.10.

If the input U_4 is used for measuring a busbar voltage for synchronism check (power system data 1 address 0210 **U4 transformer** = ***Usync transf.***), the polarity must be checked as follows using the synchronism check function.

Only for Synchronism Check

The device must be equipped with the synchronism and voltage check (dead-line/ dead-bus check) function which must be configured to ***enabled*** under address 0135 (see section 5.1).

The voltage **Usync** connected to the busbar must be specified correctly under address 0212 **Usync connect.** (see Subsection 6.1.1).

If there is no transformer between the two measuring points, address 0214A φ **Usync-Uline** must be set to ***0°*** (see Subsection 6.1.1).

If the measurement is made across a transformer, this angle must correspond to the phase rotation through which the vector group of the transformer as seen from the feeder in the direction of the busbar rotates the voltage. An example is shown in Subsection 6.1.1.

If necessary different transformation ratios of the voltage transformers on the busbar and the feeder may have to be considered under address 0215 **U-line / Usync**.

The synchronism and voltage check must be switched ***on*** under address 3501 **FCT Synchronism**.

A further aid for checking in the connection are the messages 2947 “Sync. Udiff>” and 2949 “Sync. φ-diff>” in the spontaneous annunciations.

- ☐ Circuit breaker is open. The feeder is isolated (zero voltage). The VTmcbs of both voltage transformer circuits must be closed.
- ☐ The program **OVERRIDE** = ***yes*** (address 3519) must be set for the synchro-check; the other programs (addresses 3515A to 3518) are set to ***No***.
- ☐ A request for synchro-check is initiated via binary input (FNo. 2906 “>Sync. Start”). The synchro-check must give close release (message “Sync. release”, FNo. 2951). If not, check all relevant parameters again (synchro-check configured and switched on correctly, see sections 5.1, 6.1.1 and 6.13.2).
- ☐ Set address 3519 **OVERRIDE** to ***No***.
- ☐ Then the circuit breaker is closed while the line isolator is open (see Figure 8-24). Both voltage transformers therefore measure the same voltage.
- ☐ The program **SYNC-CHECK** = ***Yes*** (address 3515A) is set.
- ☐ A request for synchro-check measurement is initiated via binary input (FNo. 2906 “>Sync. Start”). The synchro-check must give close release (message “Sync. release”, FNo. 2951).

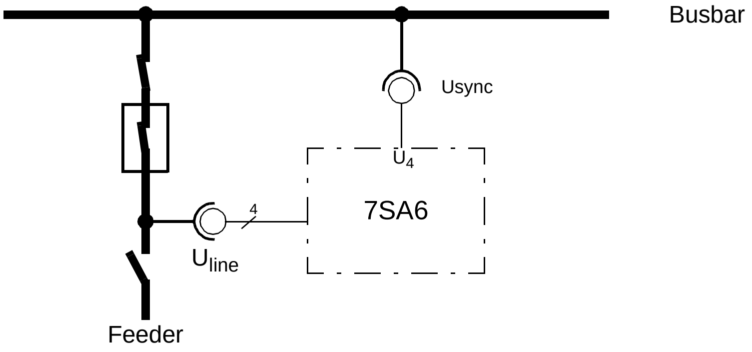


Figure 8-24 Measuring voltages for synchro-check

- ☐ If not, first check whether one of the aforenamed messages 2947 “Sync. Udiff>” or 2949 “Sync. φ-diff>” is available in the spontaneous messages.
  The message “Sync. Udiff>” indicates that the magnitude (ratio) adaptation is incorrect. Check address 0215 **U-line / Usync** and recalculate the adaptation factor.

  The message “Sync. φ-diff>” indicates that the phase relation of the busbar voltage does not match the setting under address 0212 **Usync connect.** (see Subsection 6.1.1). When measuring across a power transformer, address 0214A **φ Usync-Uline** must also be checked; this must adapt the vector group (see Subsection 6.1.1). If these are correct, there is probably a reverse polarity of the voltage transformer terminals **Usync**.

- ☐ For the synchro-check the program **Usync< U-line>** = ***Yes*** (address 3517) and **SYNC-CHECK** = ***Yes*** (address 3515A) is set.
- ☐ Open the VT mcb of the busbar voltage.
- ☐ A request for synchro-check measurement is initiated via binary input (FNo. 2906 “>Sync. Start”). There is no close release. If there is, the VT mcb for the busbar voltage is not allocated. Check whether this is the required state, alternatively check the binary input “>FAIL:Bus VT” if necessary (FNo. 0362).
- ☐ Close the VT mcb of the busbar voltage is to be closed again.
- ☐ Open the circuit breaker.
- ☐ The program **Usync> U-line<** = ***Yes*** (address 3516) and **Usync< U-line>** = ***No*** (address 3517) is set for the synchro-check.
- ☐ A request measurement for synchro-check is initiated via binary input (FNo. 2906 “>Sync. Start”. The synchronism check must release closing (message “Sync. release”, FNo. 2951).
  If not, check all voltage connections and the corresponding parameters again carefully as described in Subsection 6.1.1.
- ☐ Open the VT mcb of the feeder voltage.
- ☐ Via binary input (FNo. 2906 “>Sync. Start”) initiate the measuring request. No close release is given.
- ☐ Close the VT mcb of the busbar voltage again.

Addresses 3515A to 3519 must be restored as they were changed for the test. If the routing of the LEDs or signal relays was changed for the test, this must also be restored.

8.3.9 Earth Fault Check in a Non-earthed System

The earth fault check is only necessary if the device is connected to an isolated or resonant-grounded system and the earth fault detection is applied. The device must therefore be provided with the earth fault detection function according to its ordering code (position 16 in ordering code: 2 or 3 or 6 or 7). Furthermore, address 0130 **Sens. Earth Flt** = ***Enabled*** must have been preset during configuration to enable this function (according to Section 5.1). If none of this is the case, Subsection 8.3.9 is not relevant.

The primary check serves to find out the correct polarity of the transformer connections for the determination of the earth fault direction.

DANGER!

Primary measurements must only be carried out on disconnected and grounded equipment of the power system. Danger to life exists even on disconnected equipment because of capacitive coupling from other energized equipment of the power system!

Using the primary earth fault method a most reliable test result is guaranteed. Therefore please proceed as follows:

☐ Isolate the line and earth it on both ends. During the whole testing procedure the line must be open at the remote end.

☐ Make a test connection between a *single phase* and ground. On overhead lines it can be connected anywhere, however, it must be located behind the current transformers (looking from the busbar of the feeder to be checked). Cables are earthed on the remote end (sealing end).

☐ Remove the protective earthing of the line.

☐ Connect a circuit breaker to the line end that is to be checked.

☐ Check the direction indication (LED if allocated)

☐ The faulty phase (FNo `1272` for L1 or `1273` for L2 or `1274` for L3) and the direction of the line, i.e. “`SensEF Forward`” (FNo `1276`) must be displayed in the earth fault protocol (see also Section 7.1.1.4).

☐ The active and reactive components of the earth current are also displayed. The reactive current (“`3I0senR=`”, FNo `1220`) is the most relevant for isolated systems, for resonant-earthed systems it is the active current (“`3I0senA=`”, FNo `1219`). If the display shows the message “`SensEF Reverse`” (FNo `1277`), either the current or voltage transformer terminals are swopped in the neutral path. In case the message “`SensEF undefDir`” (FNo `1278`) appears the earth current may be too low.

☐ Deenergize and earth the line.

The check is then finished.

8.3.10 Polarity Check for the Current Measuring Input I_4

If the standard connection of the device is used whereby the current measuring input I_4 is connected in the star-point of the set of current transformers (refer also to the connection circuit diagram in the Appendix, Figure A-9), then the correct polarity of the earth current path in general will result automatically.

If however the current I_4 is derived from a separate summation CT (e.g. a core balance CT) or from a different point of measurement, e.g. transformer star-point current or earth current of a parallel line, an additional polarity check with this current is necessary.

If the device is provided with the sensitive current measuring input I_4 and it is connected to an isolated or resonant-grounded system, the polarity check for I_4 was already carried out with the earth fault check according to 8.3.9. Then this Subsection 8.3.10 can be ignored.

Otherwise the test is done with a disconnected trip circuit and primary load current. It must be noted that during all simulations that do not exactly correspond with situations that may occur in practice, the non-symmetry of measured values may cause the measured value monitoring to pick up. This must therefore be ignored during such tests.

DANGER!

Working on measurement transformers requires the highest precautions! Short-circuit the secondary side of the current transformers before any current connections to the device are opened!

I_4 Measured on the Protected Line

To generate a displacement voltage, the e–n winding of one phase in the voltage transformer set (e.g. L1) is bypassed (refer to Figure 8-25). If no connection on the e–n windings of the voltage transformer is available, the corresponding phase is open circuited on the secondary side. Via the current path only the current from the current transformer in the phase from which the voltage in the voltage path is missing, is connected; the other CTs are short-circuited. If the line carries load in the first quadrant, the protection is in principle subjected to the same conditions that exist during an earth fault in the direction of the line.

At least one stage of the earth fault protection must be set to be directional (address `31x0` of the earth fault protection). The pick-up threshold of this stage must be below the load current flowing on the line; if necessary the pick-up threshold must be reduced. The parameters that have been changed must be noted.

After switching the line on and off again, the direction indication must be checked: in the fault messages (refer also to Sub-section 7.1.1.3) the messages “`EF Pickup`” and “`EF forward`” must at least be present. If the directional pick up is not present, either the earth current connection or the displacement voltage connection is incorrect. If the wrong direction is indicated, either the direction of load flow is from the line toward the busbar or the earth current path has a swapped polarity. In the latter case, the connection must be rectified after the line has been isolated and the current transformers short-circuited.

In the event that the pick-up alarms were not even generated, the measured earth (residual) current may be too small.

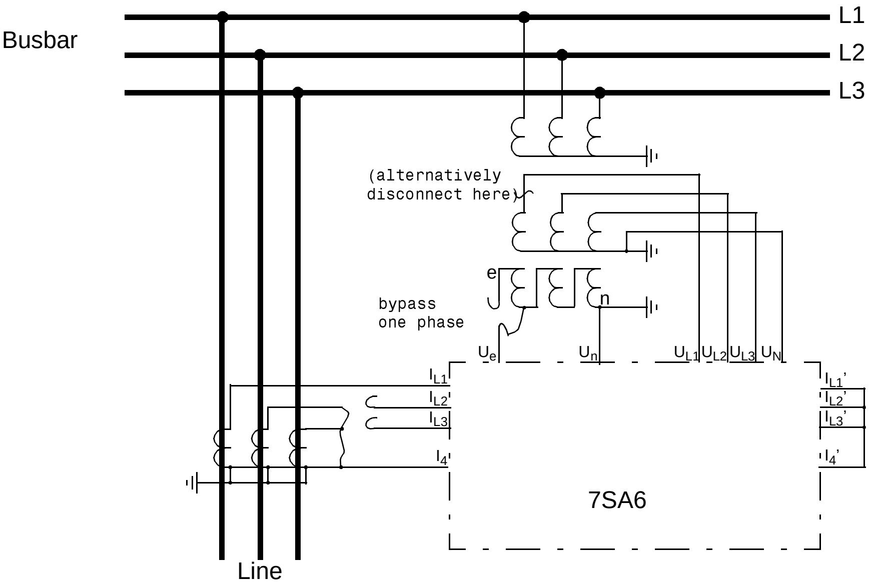


Figure 8-25 Polarity testing for I_4, example with current transformers configured in a Holmgreen-connection

Attention! If parameters were changed for this test, they must be returned to their original state after completion of the test!

I_4 Measured on a Parallel Line

If I_4 is the current measured on a parallel line, the above procedure is done with the set of current transformers on the parallel line (Figure 8-26). The same method as above is used here, except that a single phase current from the parallel feeder is measured. The parallel line must carry load while the protected line should carry load. The line remains switched on for the duration of the measurement.

If the polarity of the parallel line earth current measurement is correct, the impedance measured in the tested loop (in the example of Figure 8-26 this is L1–E) should be reduced by the influence of the parallel line. The impedances can be observed as primary or secondary quantities in the list of operational measured values (Section 7.1.3.1).

If, on the other hand, the measured impedance increases when compared to the value without parallel line compensation, the current measuring input I_4 has a swapped polarity. After isolation of both lines and short-circuiting of the current transformer secondary circuits, the connections must be checked and rectified. Subsequently the measurement must be repeated.

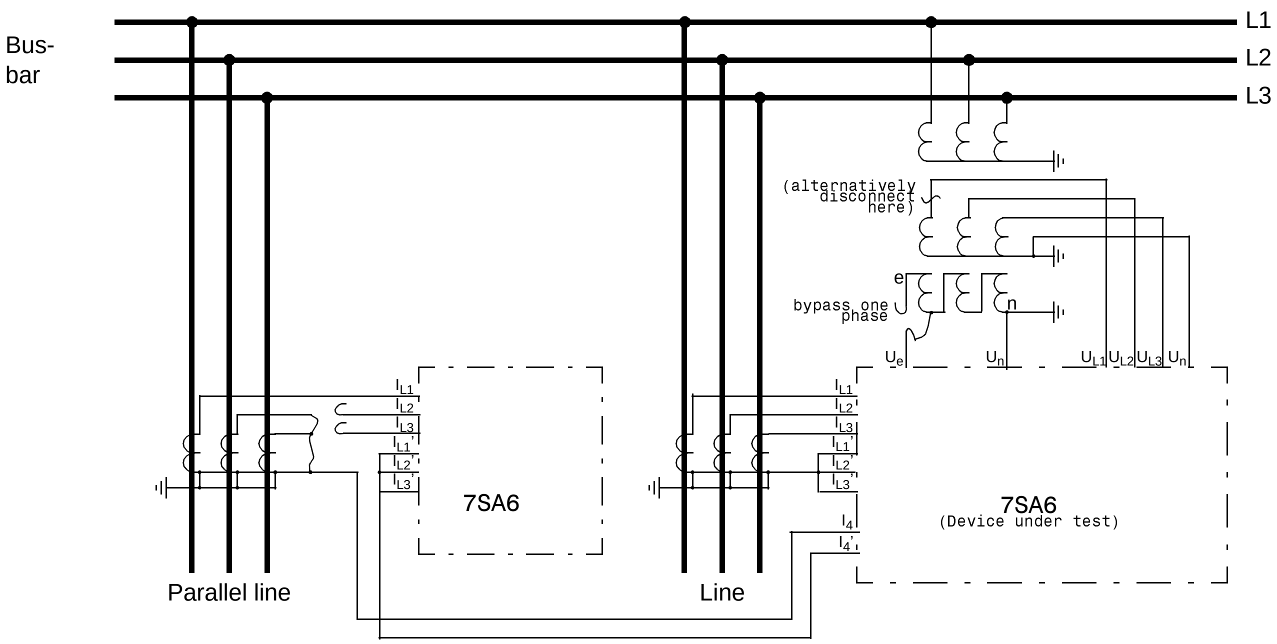


Figure 8-26 Polarity check of I_4, example with earth current of a parallel line

I_4 Measured in a Power Transformer Star-Point

If I_4 is the earth current measured in the star-point of a power transformer and intended for the earth fault protection direction determination (for earthed systems), then the polarity check can only be carried out with a zero sequence current flowing through the transformer. A test voltage source is required for this purpose (single-phase low voltage source).

Caution!

Zero sequence current should only be routed via a transformer if it has a delta winding, therefore e.g. Yd, Dy or Yy with a compensating winding. Otherwise inadmissible heating of the transformer may result.

DANGER!

Primary measurements must only be carried out on disconnected and grounded equipment of the power system. Danger to life exists even on disconnected equipment because of capacitive coupling from other energized equipment of the power system!

The configuration shown in Figure 8-27 corresponds to an earth current flowing through the line, in other words an earth fault in the forward direction.

At least one stage of the earth fault protection must be set to be directional (address 31x0 of the earth fault protection). The test current on the line must exceed the pick-up threshold setting of this/these stages; if required, the pick-up threshold setting must be reduced. The parameters that are changed, must be noted.

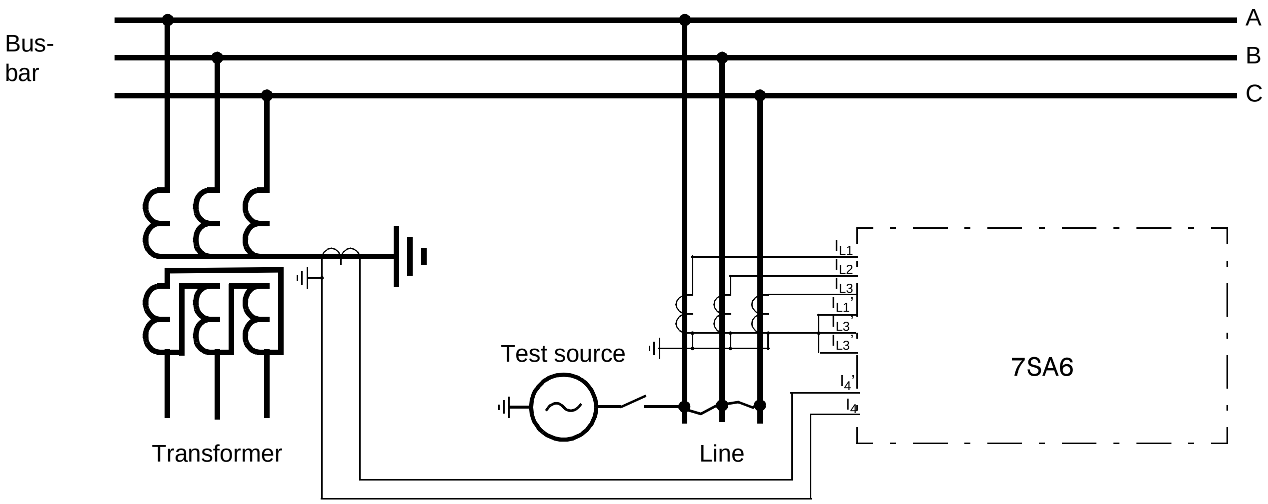


Figure 8-27 Polarity check of I_4, example with earth current from a power transformer star-point

After switching the test source on and off again, the direction indication must be checked: In the fault messages (refer also to Sub-section 7.1.1.3) at least the following alarms must be present “`EF Pickup`” and “`EF forward`”. If the directional pick-up alarm is missing, a connection error of the earth current connection I_4 is present. If the wrong direction is indicated, the earth current connection I_4 has a swapped polarity. The connection must be rectified after the test source has been switched off. The measurement must then be repeated.

If the pick-up alarm is missing altogether, this may be due to the fact that the test current is too small.

Attention! If parameters were changed for this test, they must be returned to their original state after completion of the test!

8.3.11 Measuring the operating time of the circuit breaker

Only for Synchronism Check

If the device is equipped with the function for synchronism and voltage check and it is applied, it is necessary — under asynchronous system conditions — that the operating time of the circuit breaker is measured and set correctly when closing. If the synchronism check function is not used or only for closing under synchronous system conditions, this subsection is irrelevant.

For measuring the operating time a setup as shown in figure 8-28 is recommended. The timer is set to 1 s and a graduation of 1 ms.

The circuit breaker is closed manually. At the same time the timer is started. After closing the poles of the circuit breaker, the voltage U_{Line} appears and the timer is stopped. The time displayed by the timer is the real circuit breaker closing time.

If the timer is not stopped due to an unfavourable closing moment, the attempt will be repeated.

It is particularly favourable to calculate the mean from several (3 to 5) successful switching attempts.

Set the calculated time under address 0239 as **`T-CB close`** (under power system data 2). Select the next lower adjustable value.

Note:

The operating time of the accelerated output relays for command tripping is taken into consideration by the device itself. The tripping command is to be allocated to a such relay. If this is not the case, then add 3 ms to the measured circuit-breaker operating time for achieving a greater reaction time of the “normal” output relay.

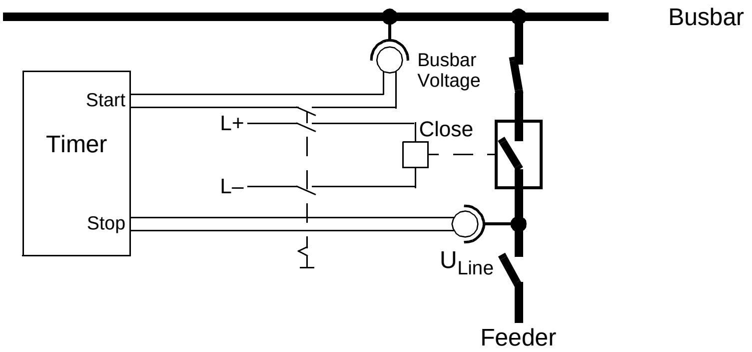


Figure 8-28 Measuring the circuit breaker closing time

8.3.12 Testing of the Teleprotection System

If the device is intended to operate with teleprotection, all devices used for the transmission of the signals must initially be commissioned according to the corresponding instructions.

8.3.12.1 Teleprotection with Distance Protection

For the functional check of the signal transmission, the earth fault protection should be disabled, to avoid signals from this protection influencing the tests: address 3101 **`FCT EarthFltO/C`** = ***`OFF`***.

Pilot Wire Comparison

The operating mode “pilot wire comparison” differs considerably from other teleprotection systems as far as the type of transmission (DC closed circuit-loop) is concerned. The examination is described in the following. If another teleprotection system is used, this part can be ignored.

Detailed information on the function of the pilot-wire comparison is available in Subsubsection 6.4.1.8.

For ***`Teleprotection for Distance prot. (Teleprot. Dist.)`*** set ***`Pilot Wire Comparison`*** in Address 0121 (Section 5.1). Furthermore, the **`FCT Telep.`**

Dis. must be set to ***Enabled*** in Address 2101. The protection relays at both line ends must be operating. First the quiescent current loop of the pilot wire comparison is not supplied with auxiliary voltage.

A fault is simulated outside of zone Z1, but within zone Z1B. Since stage Z1B is blocked, the Distance Protection is only tripped in a higher-leveled zone (usually with T2). This check must be carried out at both line ends.

The direct voltage for the quiescent current loop of the pilot wire comparison is switched to the line. The loop is then fed with quiescent current.

At one line end a fault is simulated outside of the first zone, but within the overreach zone Z1B. The command is tripped to T1B. This check must be carried out at both line ends.

Since the quiescent current loop is part of the nature of the pilot wire comparison, these tests also check if the transmission process is performed correctly. All further tests described in Subsubsection 8.3.12.1 can be passed over. However, please refer to the last margin heading “Important for All Schemes”!

Reverse Interlocking

The checking of the reverse interlocking is described below. If a different transmission scheme is applied, this part can be skipped.

For more detailed information about the reverse interlocking see Subsubsection 6.4.1.9.

For ***Teleprotection for Distance prot. (Teleprot. Dist.)*** set ***Reverse Interlocking*** in Address 0121 (Subsection 5.1). Furthermore the **FCT Telep. E/F** must be set to ***enabled*** in Address 2101. The Distance Protection of the infeed and switchgears of all outgoing feeders must operate. At the beginning no auxiliary voltage is fed to the line for the reverse interlocking.

The following paragraphs describe the testing in a blocked state, i.e. the pick-up signals of the outgoing devices are connected in parallel and block the tested device of the infeed. In case of release (the NC contacts of the outgoing devices are connected in series) the tests have to be reinterpreted respectively.

A fault is simulated within zone Z1 and overreaching zone Z1B. As a result of the missing blocking signal, the distance protection trips after time delay T1B (slightly delayed).

Now, the direct voltage for the reverse interlocking is switched in. The test is repeated as described above and ends up with the same result.

At each of the protection devices of the outgoing circuits, a pick-up is simulated. Meanwhile, another short-circuit is simulated as described before for the distance protection of the infeed. Now, the distance protection trips after time T1, which has a longer setting.

These tests also check the proper functioning of the transmission path. All other tests which are described in this Subsection 8.3.12.1 are no more necessary. However, please refer to the last margin heading “Important for All Schemes”!

Permissive Overreach Transfer, Unblocking

Prerequisite: ***Teleprotection for Distance prot. (Teleprot. Dist.)*** is set in address 0121 (Section 5.1) to one of the permissive overreach schemes with a release signal, ***Permissive Overreach*** or ***Directional Comparison Pickup*** or ***UNBLOCKING***; furthermore, the parameter in address 2101 must be set to **FCT Telep. E/F** ***ON***. Naturally, the corresponding send and receive signals must also be assigned to the corresponding binary output and input. For the echo function, the echo signal must be assigned separately to the transmit output!

The function of the permissive overreach transfer schemes is described in Subsubsections 6.4.1.4 to 6.4.1.6.

In the case of these release schemes, a simple check of the transmission paths from one line end is possible using the echo function. The echo function must be activated at both line ends, i.e. address 2501 **FCT Weak Infeed** = ***ECHO only***; with the setting ***ECHO and TRIP*** a trip may result at the line end opposite to the test location!

A short-circuit is simulated outside Z1, with the ***Permissive Overreach*** or ***UNBLOCKING*** inside Z1B, with the ***Directional Comparison Pickup*** somewhere in forward direction. This may be done with secondary injection test equipment. As the device at the opposite line end is not picked up, the echo function comes into effect there, and a trip command at the line end initiating the test, results.

If no trip command results, the transmission path must be checked again, in particular that the echo signals are assigned to the transmit outputs.

In case of a phase-segregated transmission the above-mentioned checks are carried out for each phase. The correct phase allocation must also be checked.

The tests must be executed at both line ends. For three terminal lines, it must be done at each line end, for each transmission path.

The functioning of the echo delay time and the derivation of the circuit breaker switching status should also be tested at this time (the functioning of the protection at the opposite line end is tested):

The circuit breaker of the feeder to which the protection belongs must be open, as is the circuit breaker at the opposite end of this line. As described above, a fault is again simulated. A receive signal impulse delayed by a little more than twice the signal transmission time, should appear via the echo from the opposite line end; the device should also issue a trip command.

The circuit breaker at the opposite line end should now be closed (with open isolators). After simulation of the same fault, a receive signal again appears and a trip command is again issued. However this time the receive signal is additionally delayed by the echo delay time of the device at the opposite line end (0,04 s presetting, address 2502 **Trip/Echo DELAY**).

If the echo delay response is opposite to the above description, the mode of operation of the corresponding binary inputs (H–active/L–active) at the opposite line end must be corrected (refer to Sub-section 5.2.4).

The circuit breaker is opened again.

The tests must also be carried out at both line ends, in the case of three terminal lines, at each end, for each transmission path. Please take note of the last margin heading “Important for All Schemes”!

Blocking Scheme

Prerequisites are: ***Teleprotection for Distance prot. (Teleprot. Dist.)*** in address 0121 (section 5.1) is set to the overreach transfer with a blocking signal i.e. ***Blocking***; furthermore, the setting in address 2101 must be set to **FCT Telep. E/F *ON***. Naturally, the corresponding send and receive signals must also be assigned to the corresponding binary output and input.

For more details about the function of the blocking scheme refer to Subsubsection 6.4.1.7. In the case of the blocking scheme, communication between the line ends is necessary.

On the transmitting end, a fault in the reverse direction is simulated, while at the receiving end a fault in Z1B but beyond Z1 is simulated. This may be achieved with secondary injection test equipment at each end. As long as the transmitting end is transmitting, the receiving end may not generate a trip signal, unless this results from a higher distance stage. After removal of the simulated fault at the transmitting end, the receiving end remains blocked for the additional duration of the transmit prolongation time of the transmitting end (**`Send Prolong.`**, address 2103). The transient blocking time of the receiving end (**`TrBlk BlockTime`**, address 2110) will additionally appear if a finite waiting time **`TrBlk Wait Time`** (address 2109) was set and if this time had been exceeded.

In case of a phase-segregated transmission the subsequent checks are carried out for each phase. The correct phase allocation is also to be checked.

The test must be carried out at both line ends, on a three terminal line at each line end for each transmission path. Please take note of the last margin heading “Important for All Schemes”!

Permissive Underreach Transfer

Prerequisite: ***`Teleprotection for Distance prot. (Teleprot. Dist.)`*** in address 0121 (Section 5.1) is set to the permissive underreach transfer trip mode, i.e. ***`PUTT`*** or ***`PUTT (Pickup)`***; furthermore the setting in address 2101 must be set to **`FCT Telep. E/F`** ***`ON`***. Naturally the corresponding transmit and receive signals must also be assigned to the corresponding binary output and input.

For more details about the function of the blocking scheme refer to Subsections 6.4.1.1 to 6.4.1.3. Communication between the line ends is necessary.

On the transmitting end, a fault in zone Z1 must be simulated. This can be achieved with secondary injection test equipment.

Subsequently, on the receiving end in case of permissive underreach transfer ***`PUTT`*** a fault is simulated inside Z1B, but for ***`PUTT (Pickup)`*** anywhere outside Z1. Tripping takes place immediately, (or in T1B), without signal transmission only in a higher distance stage. In case of direct transfer trip an immediate trip is always executed at the receiving end.

In case of a phase-segregated transmission the above-mentioned checks are carried out for each phase. The correct phase allocation is also to be checked.

The tests must be carried out at both line ends, on a three terminal line at each line end for each transmission path. Please take note of the last margin heading “Important for All Schemes”!

Important for All Schemes

If the earth fault protection was disabled for the signal transmission tests, it may be re-enabled now. If setting parameters were changed for the test (e.g. mode of the echo function or timers for unambiguous observation of sequences), these must now be reset to the prescribed values.

8.3.12.2 Teleprotection with Earth Fault Protection

This section is only relevant if the device is connected to a grounded system and earth fault protection is applied. The device must therefore be provided with the earth fault protection function according to its ordering code (position 16 in ordering code: 4 or 5 or 6 or 7). Address 0131 **`Earth Fault O/C`** must have been preset during configuration to enable one of the characteristics of this function (according to Section 5.1). Furthermore, the teleprotection must be used for the earth fault protection (address 0132 **`Teleprot. E/F`** configured to one of the optional methods). If none of this is the case, this Section 8.3.12.2 is not relevant.

If the signal transmission path for the earth fault protection is the same path that was already tested in conjunction with the distance protection according to Subsection 8.3.12.1, then this Subsection 8.3.12.2 is also of no consequence and may be omitted.

For the functional check of the earth fault protection signal transmission, the distance protection should be disabled, to avoid interference of the tests by signals from the distance protection: address 1201 **FCT Distance** = ***OFF***.

Directional Comparison Schemes

Prerequisites: ***Teleprotection for Earth fault overcurr. (Teleprot. E/F)*** in address 0132 (Section 5.1) must be set to one of the comparison schemes utilizing a release signal, i.e. ***Dir.Comp.Pickup*** or ***Unblocking***; in addition the setting in address 3201 must be set to **FCT Telep. E/F** ***ON***. Naturally, the corresponding send and receive signals must be assigned to the corresponding binary output and input. For the echo function, the echo signal must be assigned separately to the transmit output.

For more information about the directional comparison schemes see Subsubsection 6.6.1.1 and 6.6.1.2.

A simple check of the signal transmission path from one line end is possible via the echo function if these release techniques are used. The echo function must be activated at both line ends i.e. address 2501 must be set to **FCT Weak Infeed** = ***ECHO only***; with the setting ***ECHO and TRIP*** a trip may result at the line end opposite to the test location!

An earth fault is simulated in the direction of the line. This may be done with secondary injection test equipment. As the device at the opposite line end does not pick up, the echo function comes into effect there, and consequently a trip command is issued at the line end being tested.

If no trip command appears, the signal transmission path must be checked again, especially also the assignment of the echo signals to the transmit outputs.

This test must be carried out at both line ends, in the case of three terminal lines at each end for each signal transmission path.

The functioning of the echo delay time and monitoring of the circuit breaker switching status should also be tested at this time if this has not already been done under 8.3.12.1 (the operation of the protection at the opposite line end is checked):

The circuit breaker on the protected feeder must be opened, as must be the circuit breaker at the opposite line end. A fault is again simulated as before. A receive signal impulse delayed by somewhat more than twice the signal transmission time appears via the echo function at the opposite line end, and the device issues a trip command.

The circuit breaker at the opposite line end is now closed (while the isolators remain open). After simulation of the same fault, the receive and trip command appear again. In this case however, they are additionally delayed by the echo delay time of the device at the opposite line end (0,04 s presetting, address 2502 **Trip/Echo DELAY**).

If the response of the echo delay is opposite to the sequence described here, the operating mode of the corresponding binary input (H–active/L–active) at the opposite line end must be rectified (see Sub-section 5.2.4).

The circuit breaker is opened again.

This test must also be carried out at both line ends, in the case of three terminal lines at each line end and for each signal transmission path. Please take note of the last margin heading “Important for All Schemes”!

Blocking Scheme

Prerequisites: ***Teleprotection for Earth fault overcurr. (Teleprot. E/F)*** in address 0132 (Section 5.1) is set to a comparison scheme with a blocking signal, i.e. ***Blocking***; furthermore the setting in address 3201 must be **FCT Telep. E/F** ***ON***. Naturally the corresponding send and receive signals must also be assigned to the corresponding binary output and input.

For more information about the blocking scheme see Subsubsection 6.6.1.3. In the case of the blocking scheme, communication between the line ends is necessary.

An earth fault in the reverse direction is simulated at the transmitting line end. Subsequently, a fault at the receiving end in the direction of the line is simulated. This can be achieved with a set of secondary injection test equipment at each end of the line. As long as the transmitting end is transmitting, no trip signal must appear at the receiving line end, except is this is as a result of one of the back up stages with a longer delay time setting. After the simulated fault at the transmitting line end is switched off, the receiving line end remains blocked for the duration of the transmit prolongation time of the transmitting line end (**Send Prolong.**, address 3203). If applicable, the transient blocking time of the receiving line end (**TrBlk BlockTime**, address 3210) appears additionally if a finite delay time **TrBlk Wait Time** (address 3209) has been set and exceeded.

This test must be executed at both line ends, in the case of three terminal lines at each line end and for each transmission path. Please take note of the last margin heading “Important for All Schemes”!

Important for All Schemes

If the distance protection was switched off for the signal transmission tests, it may be switched on now. If setting parameters were changed for the test (e.g. mode of the echo function or timers for unambiguous observation of sequences), these must now be reset to the prescribed values.

8.3.12.3 Transfer Trip Signal Transmission for Breaker Failure Protection and/or Stub Protection

If the transfer trip command for breaker failure protection or stub protection is to be transmitted to the remote end, this transmission must also be checked.

To check the transmission the breaker failure protection function is initiated by a test current (secondary) with the circuit breaker in the open position. Make sure that the correct circuit breaker reaction takes place at the remote end.

Each transmission path must be checked on lines with more than two ends.

8.3.12.4 Signal Transmission for Intertripping and Direct Transfer Tripping

The 7SA6 provides the possibility to transmit a remote trip signal to the opposite line end if a signal transmission path is available for this purpose. This remote trip signal may be derived from both an internally generated trip signal (intertrip) as well as from any signal coming from an external protection or control device (direct transfer trip).

If an internal signal is used, the initiation of the transmitter must be checked. If the signal transmission path is the same and has already been checked in one of the previous subsections, it need not be checked again here. Otherwise the initiating event is simulated and the response of the circuit breaker at the opposite line end is verified.

In the case of the distance protection, the permissive underreach scheme may be used to trip the remote line end. The procedure is then the same as was the case for permissive underreach (Sub-section 8.3.12.1 under “Permissive Underreach Transfer”); however the received signal causes a direct trip.

For the remote transmission, the external command input is employed on the receiving line end; it is therefore a prerequisite that: in address `0122` the setting ***`DTT Direct Trip`*** is set to ***`Enabled`*** and that in address 2201 the setting ***`DTT Direct Trip`*** is set to ***`ON`***. If the signal transmission path is the same and has already been checked as part of the previous subsections, it need not be checked again here. A function check is sufficient, whereby the externally derived command is executed. For this purpose the external tripping event is simulated and the response of the circuit breaker at the opposite line end is verified.

8.3.13 Testing User-Defined Functions

7SA6 has a vast capability for allowing functions to be defined by the user, especially with the CFC logic. Any special function or logic added to the device must be checked.

Naturally, general test procedures cannot be given. Rather, the configuration of these user-defined functions and the necessary associated conditions must be known and verified. Of particular importance are possible interlocking conditions of the switchgear (circuit breakers, isolators, etc.). They must be considered and tested.

8.3.14 Trip and Close Test with the Circuit Breaker

The circuit breaker and tripping circuits can be conveniently tested by the device 7SA6.

The procedure is described in detail in Section 7.3.

If the check does not produce the expected results, the cause may be established from the text in the display of the device or the PC. If necessary, the connections of the circuit breaker auxiliary contacts must be checked:

It must be noted that the binary inputs used for the circuit breaker auxiliary contacts must be assigned separately for the CB-test. It is accordingly not sufficient that the auxiliary contacts are assigned to the binary inputs with FNo `351` to `353, 379 and 380` (depending on the options of the auxiliary contacts); in addition, the corresponding FNos `366` to `368` or `410` and/or `411` (according to the functions the auxiliary contacts provide) must be configured. In the CB-test only the latter ones are analysed. See also Subsection 6.20.2. Furthermore, the ready state of the circuit breaker for the CB-test must be indicated to the binary input with FNo `371`.

8.3.15 Switching Check for the Configured Operating Devices

Switching via Command

If the configured operating devices were not switched sufficiently in the hardware test already described (Subsection 8.3.3), all configured switching devices must be switched on and off from the device via the integrated control element. The feedback information of the circuit breaker position injected via binary inputs is read out at the device and compared with the actual breaker position. For devices with graphic display this is easy to do with the control display.

The switching procedure is described in Section 7.4.1. The switching authority must be set in correspondence with the source of commands used. The switching mode can be selected from interlocked and non-interlocked switching. Please take note that non-interlocked switching can be a safety hazard.

Switching from a Remote Control Centre

If the device is connected to a remote substation via a system (SCADA) interface, the corresponding switching tests may also be checked from the substation. Please also take into consideration that the switching authority is set in correspondence with the source of commands used.

8.3.16 Triggering Oscillographic Recordings

At the end of commissioning, an investigation of switching operations of the circuit breaker(s) or primary switching device(s), under load conditions, should be done to assure the stability of the protection during the dynamic processes. Oscillographic recordings obtain the maximum information about the behaviour of the 7SA6.

Requirements

Along with the capability of recording waveform data during system faults, the 7SA6 also has the capability of capturing the same data when commands are given to the device via the service program DIGSI® 4, the serial interfaces, or a binary input. For the latter, the binary input must be assigned to the function “`>Trig.Wave.Cap.`” (FNo 4). Triggering for the oscillographic recording then occurs when the input is energized. For example, an auxiliary contact of the circuit breaker or control switch may be used to control the binary input for triggering.

An oscillographic recording that is externally triggered (that is, without a protective element pick-up or device trip) is processed by the device as a normal fault recording with the exception that data are not given in the fault messages (trip log). The externally triggered record has a number for establishing a sequence.

Triggering with DIGSI$^{®}$ 4

To trigger oscillographic recording with DIGSI$^{®}$ 4, click on **`Test`** in the left part of the window. Double click the entry **`Test Wave Form`** in the list in the right part of the window to trigger the recording. See Figure 8-29.

A report is given in the bottom left region of the screen. In addition, message segments concerning the progress of the procedure are displayed.

The DIGRA$^{®}$ program or the Comtrade Viewer program is required to view and analyse the oscillographic data. Refer to Sub-section 7.1.4.

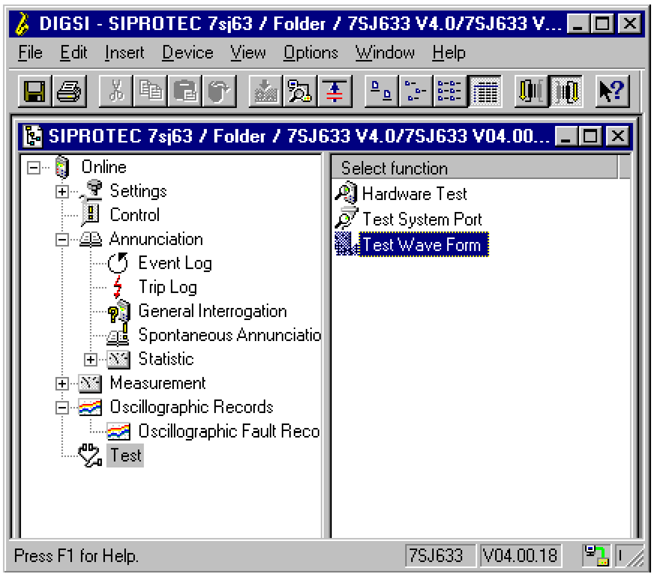


Figure 8-29 Triggering oscillographic recording with DIGSI$^{®}$ 4

8.4 Final Preparation of the Device

Tighten the used screws at the terminals; those ones not being used should be slightly fastened. Ensure all pin connectors are properly inserted.

Caution!

Do not use force! The tightening torques according to Chapter 2 must not be exceeded as the threads and terminal chambers may otherwise be damaged!

Verify that all service settings are correct. This is a crucial step because some setting changes might have been made during commissioning. The protective settings under device configuration, input/output configuration are especially important (Section 5.1) as well as the power system data, and activated Groups A through D (if applicable). All desired elements and functions must be set ***ON***. See Chapter 6. Keep a copy of all of the in-service settings on a PC.

Check the internal clock of the device. If necessary, set the clock or synchronize the clock if it is not automatically synchronized. For assistance, refer to Sub-section 7.2.1.

The Annunciation memory buffers should be cleared, particularly the Operational messages and fault messages. Future information will then only apply for actual system events and faults. To clear the buffers, press **`MAIN MENU`** → **`Annunciation`** → **`Set/Reset`**. Refer to Sub-section 7.1.1 if further assistance is needed. The numbers in the switching statistics should be reset to the values that were existing prior to the testing, or to values in accordance with the user’s practices. Set the statistics by pressing **`MAIN MENU`** → **`Annunciation`** → **`Statistic`**. Refer to Sub-section 7.1.2 if more information is needed.

Press the **ESC** key, several times if necessary, to return to the default display.

Clear the LEDs on the front panel by pressing the **LED** key. Any output relays that were picked up prior to clearing the LEDs are reset when the clearing action is performed. Future indications of the LEDs will then apply only for actual events or faults. Pressing the **LED** key also serves as a test for the LEDs because they should all light when the button is pushed. Any LEDs that are lit after the clearing attempt are displaying actual conditions.

The green “`RUN`” LED must be on. The red “`ERROR`” LED must not be lit.

Close the protective switches. If test switches are available, then these must be in the operating position.

The device is now ready for operation.

■

Routine Checks and Maintenance

9

General comments about the routine checks and maintenance activities to ensure the high reliability of the 7SA6 are given in this chapter. A procedure for replacing components such as the buffer battery is discussed. Troubleshooting advice is provided. A procedure for replacing the power supply fuse is described. Some comments concerning the return of a device to the factory are given.

9.1 General

Siemens numerical protective and control SIPROTEC® 4 devices are designed to require no special maintenance. All measurement and signal processing circuits are fully solid state. All input modules are also fully solid state. The output relays are hermetically sealed or provided with protective covers.

Since the device is almost completely self-monitored, from the measuring inputs to the output relays, hardware and software problems are automatically reported. The self-monitoring ensures the high availability of the device and generally allows for a corrective rather than preventive maintenance strategy. Therefore, maintenance checks in short intervals are not required.

Operation of the device is automatically blocked when a hardware failure is detected. The “live status” relay drops out to provide an alarm by its breaking contact. If a problem is detected in the external measuring circuits, the device normally only provides messages.

Recognized software failures result in the resetting and restarting of the processor system. If such a failure is not resolved by the restart, further restart attempts are initiated. If a problem is still present after three restart attempts, the device is automatically taken out of service. Then the “live status” contact drops out to provide an alarm and the red “ERROR” LED on the front panel illuminates.

The reaction of the device to failures and problems can be viewed in chronological sequence in the Operational messages. See Sub-section 7.1.1. The messages can be used to diagnose the problem.

When the device communicates with a master control system of the substation or other central control systems, the event and alarm messages are also sent over the serial interface.

9.2 Routine Checks

Routine checks of the characteristic curves or pick-up values of the protective elements are not necessary because they form part of the continuously supervised firmware programs. The normally scheduled interval for plant maintenance can be used for carrying out operational testing of the protective and control equipment. The maintenance serves mainly to check the serial or hardwired interfaces of the device, i.e. the coupling with the plant.

The steps listed below are recommended for routine checks. If a problem is detected during these checks, refer to Section 9.4.

☐ Verify that the green “RUN” LED is lit on the front panel and the red “ERROR” LED is not.

☐ Check that the states of the LEDs on the front panel give an accurate image of the conditions of the device and the plant. Investigate any problems or uncertainties.

☐ Press the **LED** key. All of the LEDs should temporarily light except for the “ERROR” LED. Only the LEDs indicating specific present conditions should remain lit.

☐ Read the measurement values and compare them to an independent source to check the measuring circuits of the 7SA6. Refer to Sub-section 7.1.3 for assistance in reading the measurement values.

☐ Review the messages given under the **Annunciation** sub-menu. Be sure there are no reports of unknown problems or abnormal occurrences related to the device, the measuring circuits, or the power system. All information should be plausible. See Sub-section 7.1.1.2 for help in reading the messages.

☐ Perform a reset (reboot) of the device. A complete check of the hardware is done. The device is effectively out of service during the reset, which lasts for about 10 to 15 seconds. To perform the reset from the operator control panel, press the **MENU** key and use the ▼ and ▶ keys to select the **Device Reset** under the **TEST/DIAGNOSE** sub-menu. Press the **ENTER** key, enter Password No. 4 for test and diagnostics, and answer with **Yes**. During the reset, the “ERROR” and “RUN” LEDs are lit, the other LEDs flash, and the display becomes blank. After a successful reset, the default display reappears and the LEDs return to indicate normal operation. The device is then back in-service. To perform the reset with DIGSI® 4, establish the **Online** mode, select **Device** in the menu bar, and then **Reset.** Enter password No 4 for test and diagnose; then **OK**.

Warning!

Changing of the states of the binary inputs, outputs, and LEDs must not be done with test features during normal operation. Any such change immediately affects the inputs and outputs of the device, and therefore the connected switching devices! This includes, for instance, non-interlocked primary switching!

☐ Other testing can be done with DIGSI® 4 on-line. In **Hardware Test** under **Test**, the conditions of all of the binary inputs, binary outputs, and LEDs can be monitored. Compare the indicated conditions with the actual conditions. Do not change the states of the device components because the station is immediately affected!

☐ The trip and close circuits for circuit breakers and other primary equipment can be verified with operator control actions. Other circuits can be checked as well. Refer to Section 7.3 for details about system control.

9.3 Maintenance

9.3.1 Replacing the Buffer Battery

The battery is used to retain the annunciation memories and fault recording data in the event of an interruption of the power supply. The battery also maintains the internal system clock with calendar after a loss of the power supply.

The battery is checked by the processor at regular intervals. If the capacity of the battery is found to be declining, an alarm is generated.

The battery should be changed when an alarm is given, or at the latest, after 10 years of service.

Recommended Battery:

Lithium Battery 3 V/1 Ah, Type CR 1/2 AA. For example:

– VARTA Order Number 6127 101 501

The way of replacing the battery depends on the device version. We distinguish between devices for panel flush mounting and cubicle flush mounting and panel surface mounting or mounting with detached operator panel.

9.3.1.1 Battery Change on Devices with Panel Flush Mounting and Cubicle Flush Mounting as well as Panel Surface Mounting

The battery is located near the front edge of the CPU printed circuit board. The front panel of the device must be removed to change the battery.

To replace the battery:

☐ Save the annunciations and fault records. These are the data under the Annunciation sub-menu (all items in this sub-menu). The records and data are lost when the battery is removed. The simplest and fastest method is to use the save feature in DIGSI® 4 when the program is on-line.

Note: All of the protective and control settings, including the input/output configuration and the CFC logic, are not affected by a power supply interruption. The settings are stored independently of the battery. The settings are not lost when the battery is removed, nor are the settings affected if the device operates without a battery.

☐ Have the replacement battery ready.

Caution!

Do not short the battery! Do not reverse the polarity of the battery! Do not lay the battery on the ground mat used to protect components from electrostatic discharges! Do not recharge the battery!

☐ Isolate the power supply by opening the protective switches for both terminals.

☐ Remove the covers on the front panel and loosen the screws that are securing the front panel.

Caution!

Electrostatic discharges through the connections of the components, wiring, and connectors must be avoided. Wearing a grounded wrist strap is preferred; otherwise, touch a grounded metal part before handling the internal components.

Warning!

Hazardous voltages may exist in the device, even after the power supply is disconnected and the boards are withdrawn from the case! Capacitors can still be charged!

☐ Carefully pull off the front panel and bend it aside. The front panel is connected to the internal CPU printed circuit board with a short ribbon-cable.

☐ Disconnect the ribbon-cable that links the front panel and the CPU board (❶), at the side of the front panel. To disconnect the cable, push up on the top latch of the plug connector and push down on the bottom latch of the plug connector. Carefully set aside the front panel.

☐ The battery is located on the bottom-front side of the CPU (❶) board. See Figure 9-1.

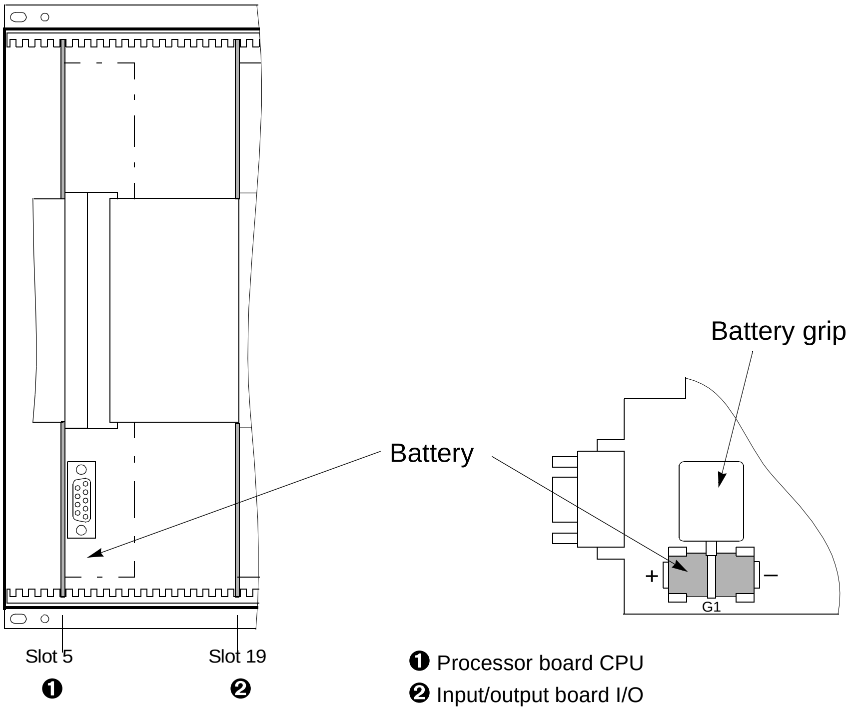


Figure 9-1 Front view without front panel – position of buffer battery (simplified and reduced)

☐ Remove the old battery from the snap-on connector using the plastic battery grip shown in Figure 9-1.

☐ Remove the battery grip from the old battery, and place the grip on the new battery.

☐ Observing the polarity and firmly insert the new battery into the snap-on connector shown in Figure 9-1.

☐ Connect the ribbon-cable between the CPU (❶) board and the front panel. Be especially careful not to bend any of the connector pins! Do not use any force! Be sure that the plug connectors latch.

☐ Carefully replace the front panel being mindful of the ribbon-cable. Fasten the panel to the case with the screws.

☐ Replace the covers.

☐ Close the protective switches to apply voltage to the power supply.

☐ After the device is operating, data saved in DIGSI® 4 can be loaded back into the device.

If the internal system clock is not automatically synchronized via a serial interface, then the clock should be set at this point. Refer to Sub-section 7.2.1 if assistance is needed to set the clock.

Warning!

The used battery contains Lithium. Do not throw the battery into the trash! It must be disposed off in line with the applicable regulations!

Do not reverse the polarity! Do not completely discharge! Do not throw the battery into a fire! Explosion hazard!

9.3.1.2 Battery Change on Devices with Mounting Housing with Detached Operator Panel

The battery is located at the front edge of the CPU printed circuit board. If a battery change is required, the battery must not be replaced by a new one.

The snap connection G2 in the front cover of the operator panel enables the user to fix the battery properly.

To replace the battery:

☐ Read out the device annunciations. Usually this is done with a PC via the operator interface using DIGSI® 4. The records and data are lost when the battery is removed. Therefore the information in the PC is saved.

Note: All protective and control settings, including the input/output configuration and the CFC logic. The settings are saved independently from the battery. No settings will get lost when the battery is removed. No settings will be affected if the device operates without a battery.

☐ Have the replacement battery ready.

Caution!

Do not short the battery! Do not reverse the polarity of the battery! Do not lay the battery on the ground mat used to protect components from electrostatic discharges! Do not recharge the battery!

☐ Remove the covers at the front panel of the operator control element.

☐ Loosen the screws that are securing the front panel.

☐ Plug the battery into the snap connection according to Figure 9-2.

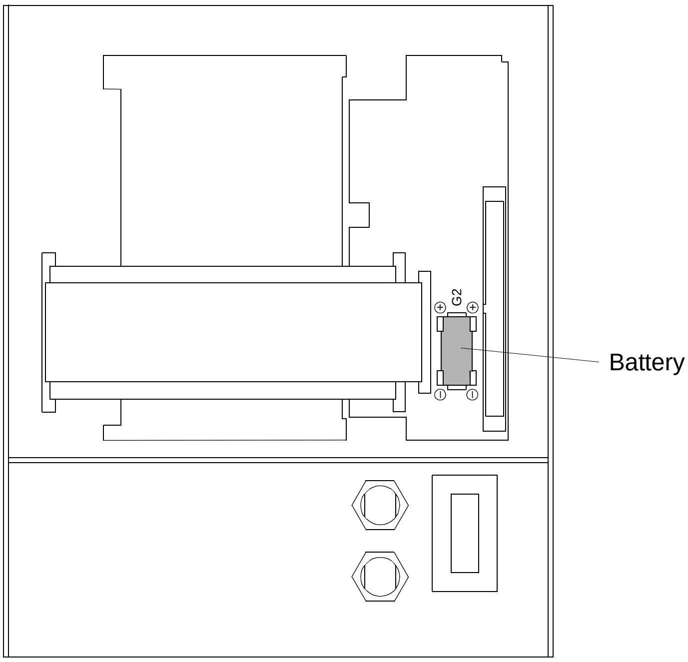


Figure 9-2 Rear side of front panel (housing size $^{1}/_{2}$) with separate operator control battery

Caution!

Electrostatic discharges through the connections of the components, wiring, and connectors must be avoided. Wearing a grounded wrist strap is preferred; otherwise, touch a grounded metal part before handling the internal components.

Warning!

Hazardous voltages may exist in the device, even after the power supply is disconnected and the boards are withdrawn from the case! Capacitors can still be charged!

☐ Fasten the panel to the case with the screws.

☐ Replace the covers.

☐ Switch the auxiliary voltage to the line. After restarting the device the annunciations and count values can be reloaded.

If the internal system clock is not automatically synchronized via a serial interface, then the clock should be set at this point. Refer to Subsection 7.2.1 if assistance is needed to set the clock.

Warning!

The used battery contains Lithium. Do not throw the battery into the trash! It must be disposed off in line with the applicable regulations!

Do not reverse the polarity! Do not completely discharge! Do not throw the battery into a fire! Explosion hazard!

9.4 Troubleshooting

If a device reports a problem or failure, the procedure below is recommended.

If none of the LEDs on the front panel are lit, then verify:

- ☐ Are the printed circuit boards put into the correct slots and properly covered by the front panel?
- ☐ Are the plug connectors of the flat cable plugged into the printed circuit boards and do the lockings snap properly?
- ☐ Is the auxiliary voltage high enough? Is the polarity at the corresponding connections correct?
- ☐ Are the voltage magnitude and polarity correct for the power supply. Connection drawings are shown in Section A.2 of Appendix A?
- ☐ Has the fuse in the power supply not blown? The location of the fuse is shown in Figure 9-7. If the fuse needs to be replaced, see Subsection 9.5.2.

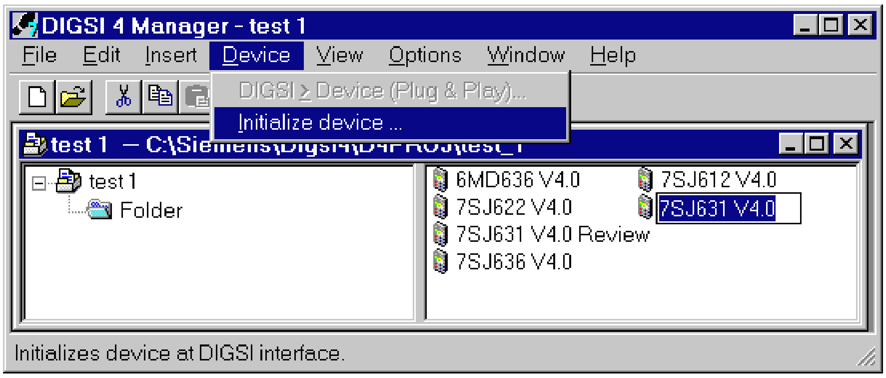
If the red “ERROR” LED is on and the green “RUN” LED is off, then the device has recognized an internal fault. Re-initializing the device can be attempted, see Section 9.2.

If you see the following display, the device has arrived “monitor”-mode. In this case you may initialize the device via DIGSI® 4:

```
MONITOR           01/05
---------------------
Equipment data ->    1
User interface ->    2
System I-face  ->    3
Reset          ->    4
Siemens insten ->    5
```

Figure 9-3 Monitor annunciation in device display

- ☐ Connect the operating interface of the SIPROTEC® 4 device with the operating interface of the SIPROTEC® 4 device and open the DIGSI® 4 software program.
- ☐ Select **`Initialize device`** in the menu **`Device`** (Figure 9-4).



Initializes device at DIGSI interface.

Figure 9-4 Initializing device via DIGSI® 4

☐ Enter password No 7. The display becomes blank. The annunciation in the device display first disappears. After a successful intitiation, the LEDs return to indicate normal operation and the default display reappears. The device settings are loaded into the device provided that they had been saved in the PC after commissioning. The device is then in-service.

Further Assistance

If these steps do not resolve the problem, please call your local Siemens representative or customer hot-line.

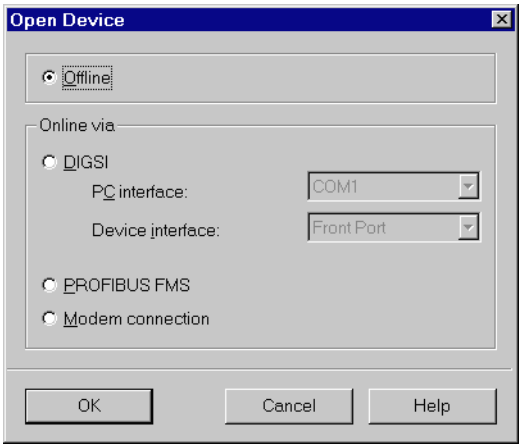
Our customer hot-line needs the following information to assist you:
– the complete order number (MLFB) of the device,
– the serial number of the device (BF...),
– the firmware version,
– the parameter set version.

This information is found in the device file of DIGSI® 4 as shown in Figure 9-6. Go to the **`Main Menu`** and select **`Parameters`** → **`Setup / Extras`** → **`MLFB/Version.`** The odering number and serial number. The ordering number and the serial number can also be read from the name-plate on the top of the device.

Furthermore these data can also be read out in the file created for the device in DIGSI® 4, as shown in Figure 9-6.

☐ Open the DIGSI® 4 application in the PC and select the device.

☐ Double click on this item. The **`Open Device`** dialogue box opens, as shown in Figure 9-5.



Open Device

● Offline

Online via

○ DIGSI

PC interface: COM1

Device interface: Front Port

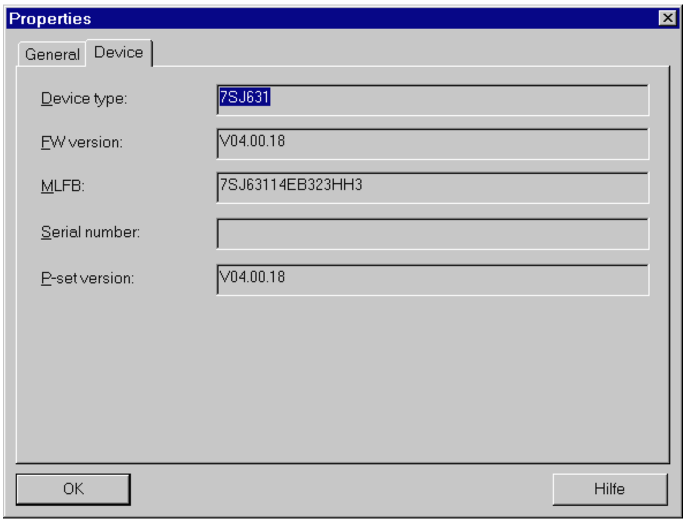
○ PROFIBUS FMS

○ Modem connection

Figure 9-5 DIGSI® 4, dialogue field **Open Device**

☐ Select the **`Offline`** mode and click **`OK`**; the initial DIGSI® 4 window opens.

☐ Select **`File`** → **`Properties`** from the menu bar. The desired information is shown.



Device type: 7SJ631

FW version: V04.00.18

MLFB: 7SJ63114EB323HH3

Serial number:

P-set version: V04.00.18

Figure 9-6 Retrieving the device data in the device properties

9.5 Corrective Action / Repairs

9.5.1 Software Procedures

A restart of the processor system, as described in Section 9.2, can be done as an attempt to solve a problem. Setting changes can be made to solve simple problems, such as sporadic alarms from elements of the measured value supervision. These attempts of solving problems can be done while the device is in service.

If a processor restart or setting change does not remedy the problem, then no further action should be done while the device is in service. Instead, replace the device with a tested spare.

9.5.2 Hardware Procedures

Hardware modifications or repair should be limited in scope to changes that are absolutely necessary. Some examples of hardware repair are changing the mini-fuse in the power supply and replacing a printed circuit board or module.

Hardware modifications or repair should only be done by experienced personnel. Do not insert or extract a printed circuit board unless the device is completely isolated. Soldering work must not be done on the printed circuit boards.

Disassembling the Device

The device must be disassembled if work is to be done on the printed circuit boards. The procedure below should be used.

☐ Prepare area of work. Provide a grounded mat for protecting components subject to damage from electrostatic discharges (ESD). The following equipment is needed:

- Screwdriver with a 5 to 6 mm or $^1/_4$ inch tip.
- 1 Phillips screwdriver.
- 4.5 mm socket or nut driver.

☐ Isolate the power supply by opening the protective switches (test switches, fuses, or miniature circuit breakers) for both terminals.

☐ Disconnect all communication cables from the device. Carefully remove optical fibres from the device. Apply protective caps to the fibber ends and the communication ports on the device.
These activities do not apply if the device is for surface mounting.

☐ Unfasten the screw-posts of the D-subminiature connector on the back panel at location “A.”
This activity does not apply if the device is for surface mounting.

☐ If the device has more communication interfaces at locations “B” and/or “C” on the rear, the screws located diagonally to the interfaces must be removed.
These activities are not necessary if the device is for surface mounting.

☐ Remove the corner covers on the front panel and loosen the screws that are holding the front panel to the device case.

☐ Carefully take off the front panel. The front panel is connected to the CPU board with a short ribbon-cable.
On devices with detached operator panel, the front panel can be taken off directly (without a ribbon cable).

Caution!

Electrostatic discharges through the connections of the components, wiring, and connectors must be avoided! Wearing a grounded wrist strap is preferred. Otherwise, first touch a grounded metal part.

Warning!

Hazardous voltages may exist in the device, even after the power supply is disconnected and the boards are withdrawn from the case! Capacitors can still be charged!

☐ At one end, disconnect the ribbon-cable that links the front panel and the CPU board (❶), at the side of the front panel. To disconnect the cable, push up on the top latch of the plug connector and push down on the bottom latch of the plug connector. Carefully set aside the front panel.
For the surface mounted device, the 7-pin connector X16 must be disconnected from the CPU board behind the D-subminiature port, and the ribbon-cable that runs to the 68-pin connector on the back must be detached.

☐ Disconnect the ribbon-cable between the CPU board and the I/O board.

☐ The boards can be removed and laid on the grounded mat to protect them from ESD damage.
A greater effort is required to remove the CPU board from the device designed for surface mounting, because of the type of connectors.

Replacing the Power Supply Fuse

The power supply fuse is located on the CPU board.

☐ Keep ready replacement fuse 5 x 20 mm. Verify the correct rating, correct characteristic (T) as well as the correct coding.
This data is printed on the module (see Figure 9-7). The type of fuse depends on the auxiliary supply voltage, e.g. for 24 to 48 VDC the fuse type “T4H250V” according to IEC 60127–2 is required (refer to Table 9-1).

☐ Remove the defective fuse. Figure 9-7 illustrates the fuse.

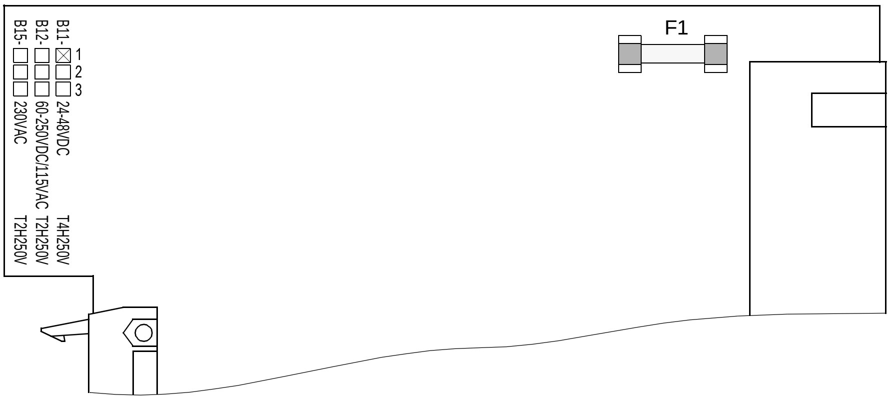


Figure 9-7 Power supply mini-fuse CPU board

Table 9-1 Assigning of the mini-fuse rating to the device auxiliary voltage rating

7SA6∗∗∗ Version	Rated Auxiliary Voltages	Fuse Type
–2∗∗∗∗–∗∗∗∗	24 V to 48 V—	T4H250V
–4∗∗∗∗–∗∗∗∗	60 V to 125 V—	T2H250V
–5∗∗∗∗–∗∗∗∗	110 V to 250 V—, 115 V~	T2H250V

☐ Install the new fuse into the holder.

☐ Carefully install the I/O board I/O-1 in the case. The insertion locations are indicated in Figures 8-9 and 8-10 in Sub-section 8.1.3.

Reassembling the Device

To reassemble the device:

☐ Connect the ribbon-cable between the I/O board and the CPU board. Be especially careful not to bend any of the connector pins! Do not use force! Make sure the connectors latch.

☐ Plug the plug-connector of the ribbon-cable between the CPU board and the front panel of the device onto the plug-connector of the cover. Be especially careful not to bend any of the connector pins! Do not use force! Make sure the connectors latch.
For the device versions with detached operator panel this activity can be skipped. Connect the ribbon-cable from the 68-pin connector at the back of the device to the plug-connector of the CPU board. The 7pin connector X16 must be plugged behind the D-subminiature port. The direction in which it is plugged is not relevant since the connection is protected against polarity reversal.

☐ Carefully replace the front panel being mindful of the ribbon-cables. Fasten the front panel to the case with the screws.

☐ Replace the covers.

The following steps are not applicable for the surface mount version:

☐ Align and fix the rear interfaces again.

☐ Attach all D-subminiature plugs to the matching D-subminiature sockets.

☐ Tighten all the optical fibre connectors. When connecting a FC-connector make sure that its lug is plugged properly into the slot of the socket and it does not come out when tightening the knurled nut. The knurled nut must not be tightened too strong.

Warning!

Do not look into the LEDs directly !

Close the protective switches to apply voltage to the power supply. If the green “RUN” LED does not light, there is a fault in the power supply. The device should be sent to the factory. See Section 9.6.

9.6 Return

Siemens strongly recommends that **no** further repairs on defective devices, boards, or components be done. Special electronic components are used for which procedures for preventing electrostatic discharges must be followed. Most importantly, special production techniques are necessary to avoid damaging the wave-soldered multilayer boards, the sensitive components, and the protective varnish.

If a problem cannot be solved by the procedures described in Section 9.5, then the complete device (including front cover) should be returned to the factory.

The original transport packaging material should be used for returning a device. If alternative packaging material is used, then the device and other contents must be provided with protection against shock and vibration according to IEC 60255–21–1 Class 2 and IEC 60255–21–2 Class 1.

Before returning a device, retrieve and save all of the configuration, function and control settings, and any important information. Note any changes that were made to the jumpers on the internal printed circuit boards after the device was first delivered.

Note:

Repaired devices are returned from the factory with all jumpers on the printed circuit boards set in the original positions according to the ordering number. All configuration, function and control parameters have the default setting.

■

Technical Data

10

This chapter provides the technical data of the SIPROTEC$^{®}$ 4 7SA6 device and its individual functions, including the limiting values that must not be exceeded under any circumstances. The electrical and functional data of fully equipped 7SA6 devices are followed by the mechanical data, with dimensional drawings.

10.1 General Device Data

10.1.1 Analog Inputs

	Nominal frequency f_N	50 Hz or 60 Hz(adjustable)
Current Inputs	Nominal current I_N	1 A or 5 A
	Power consumption per phase and earth path	
	– at I_N = 1 A	approx. 0.05 VA
	– at I_N = 5 A	approx. 0.3 VA
	– Sensitive earth fault detection at 1 A	approx. 0.05 VA
	Current overload capability per input	
	– thermal (rms)	500 A for 1 s 150 A for 10 s 20 A continuous
	– dynamic (pulse)	1250 A (half cycle)
	Current overload capability for sensitive earth current input	
	– thermal (rms)	300 A for 1 s 100 A for 10 s 15 A continuous
	– dynamic (pulse)	750 A (half cycle)
Voltage Inputs	Nominal voltage U_N	80 V to 125 V (adjustable)
	Power consumption per phase at 100 V	≤0.1 VA
	Overload capability per phase	
	– thermal (rms)	230 V continuous
Analog Output (for Measured Values and Fault Location)	Range	0 to 24 mA–
	– Connection for flush mounting housing	rear panel, mounting location „B“ or/and „D“ 9-pin D-subminiture female connector
	for surface mounting housing	on case bottom or/and on case top
	– max. load impedance	350 Ω

10.1.2 Power Supply

Direct Voltage Voltage supply via integrated DC/DC converter:

Nominal power supply direct voltage $U_{N\,DC}$	24/48 VDC	60/110/125 VDC	110/125/220/ 250 VDC
Permissible voltage ranges	19 to 58 VDC	48 to 150 VDC	88 to 300 VDC

Permissible AC ripple voltage, Peak to peak	≤15 % of nominal power supply
Power consumption	
– quiescient	approx. 5 W
– energized	with 7SA610*–*A/E/J approx. 8.6 W with 7SA610*–*B/F/K approx. 7.4 W with 7SA6*1*–*A/E/J approx. 11.8 W with 7SA6*1*–*B/F/K approx. 11.6 W with 7SA6*2*–*A/E/J approx. 15.0 W with 7SA6*2*–*B/K/F approx. 18.2 W with 7SA6*2*–*C/G/L approx. 15.8 W
Bridging time for failure/short-circuit of the power supply	≥50 ms at U_{NDC} = 48 V and U_{NDC} ≥ 110 V ≥20 ms at U_{NDC} = 24 V and U_{NDC} = 60 V

Alternating Voltage

Voltage supply via integrated AC/DC converter

Nominal power supply alternating voltage U_{NAC}	115 VAC
Permissible voltage ranges	92 to 132 VAC

Power consumption	
– quiescient	approx. 6.5 VA
– energized	with 7SA610*–*A/E/J approx. 13.6 VA with 7SA610*–*B/F/K approx. 12.4 VA with 7SA6*1*–*A/E/J approx. 16.8 VA with 7SA6*1*–*B/F/K approx. 16.6 VA with 7SA6*2*–*A/E/J approx. 20.0 VA with 7SA6*2*–*B/K/F approx. 23.2 VA with 7SA6*2*–*C/G/L approx. 20.8 VA
Bridging time for failure/short-circuit of the power supply	≥ 50 ms

10.1.3 Binary Inputs and Outputs

Binary Inputs

Quantity

- 7SA610*–*A/E/J	5 (allocatable)
- 7SA610*–*B/F/K	7 (allocatable)
- 7SA61/31*–*A/E/J	13(allocatable)
- 7SA61/31*–*B/F/K	20(allocatable)
- 7SA61/32*–*A/E/J	21(allocatable)
- 7SA61/32*–*B/F/K	29(allocatable)
- 7SA61/32*–*C/G/L	33(allocatable)
- 7SA641*–*A/J	13(allocatable)
- 7SA641*–*B/K	20(allocatable)
- 7SA642*–*A/J	21(allocatable)
- 7SA642*–*B/K	29(allocatable)
- 7SA642*–*C/L	33(allocatable)

	Nominal voltage	24 VDC to 250 VDC in 3 ranges, bipolar
	Switching thresholds – for nominal voltages 24/48 VDC 60/110/125 VDC	adjustable with jumpers $U_{pick-up}$ ≥ 19 VDC $U_{drop-off}$ ≤ 14 VDC
	– for nominal voltages 110/125/ 220/250 VDC	$U_{pick-up}$ ≥ 88 VDC $U_{drop-off}$ ≤ 66 VDC
	Current consumption, energized	approx. 1.8 mA independent of the control voltage
	Maximum permissible voltage	300 VDC
	Impulse filter on input	220 nF coupling capacity at 220 V with recovery time >60 ms
Binary Outputs	Alarm / command relay (see also General Diagrams in Appendix A, Section A.2)	
	Number and Information	acc. to the order variant (allocatable)

Order Variant	NO Contact (normal)	NO Contact (fast)	NO/NC (switch selectable)	Power Relay
7SA610*–*A/E/J	7	–	1	–
7SA610*–*B/F/K	5	–	–	–
7SA6*1*–*A/E/J	7	7	2	–
7SA6*1*–*B/F/K	8	–	–	4
7SA6*2*–*A/E/J	14	7	3	–
7SA6*2*–*B/F/K	21	7	4	–
7SA6*2*–*C/G/L	11	–	–	8
Switching capability MAKE BREAK	1000 W/VA 30 W ohmic 40 W for L/R ≤ 50 ms 25 W/VA			– – – –
Switching voltage	250 V			250 V
Permissible current per contact/ pulse current	5 A permanent 30 A ≤ 0.5 s			 30 A ≤ 0.5 s
Total permissible current on common paths	5 A permanent 30 A for 0.5 s			– –
Max. switching capability for 30 s for 28 V to 250 V for 24 V	– –			1000 W 500 W
Permissible relative closing time	–			1 %
Operating time, approx.	8 ms	5 ms	8 ms	–

Alarm relay		1 with NC contact or NO contact (switch selectable)
Switching capability	MAKE	30 W/VA
	BREAK	20 VA 30 W resistive 25 W for L/R ≤ 50 ms
Switching voltage		250 V
Permissible current		1 A permanent

10.1.4 Communications Interfaces

Operating Interface	– Connection	front panel, non-isolated, RS 232 9-pin DSUB socket for connection to a personal computer
	– Operation	with DIGSI® 4
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud; parity: 8E1
	– Maximum transmission distance	15 m (50 ft)
Rear Service/ Modem Interface	RS232/RS485/Optical	isolated interface for data transfer acc. ordered version
	Operation	with DIGSI® 4
	RS232	
	– Connection for flush mounted case	rear panel, mounting location “C” 9-pin DSUB socket
	for surface mounted case	at the terminal on the case bottom
		shielded data cable
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud
	– Maximum transmission distance	max. 15 m (50 ft)
	RS485	
	– Connection for flush mounted case	rear panel, mounting location “C” 9-pin DSUB socket
	for surface mounted case	on case bottom
		shielded data cable
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Baud; max. 115200 Baud factory setting: 38400 Baud
	– Maximum transmission distance	max. 1km

System (SCADA) Interface (optional)	RS232/RS485/Optical	floating interface for data transfer to a master terminal
	Profibus RS485/Profibus Optical	
	acc. to ordered version	
	RS232	
	– Connectionfor flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
	for surface mounted case	at the terminal on the case bottom
	– Test voltage	500 V; 50 Hz
	– Transmission speed	min. 4800 Bd, max. 38400 Bd factory setting: 19200 Bd
	– Maximum transmission distance	15 m (50 ft)
	RS485	
	– Connection for flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
	for surface mounted case	at the terminal on the case bottom
	– Test voltage	500 V, 50 Hz
	– Transmission speed	min. 4800 Bd, max. 38400 Bd factory setting: 19200 Bd
	– Maximum transmission distance	1000 m (3280 ft)
	– Bridging distance	max. 1 km
	Profibus RS485	
	– Connection for flush mounted case	rear panel, mounting location “B” 9-pin DSUB socket
	for surface mounted case	at the terminal on the case bottom
	– Test voltage	500 V; 50 Hz
	– Transmission speed	up to 12 MBd
	– Maximum transmission distance	1000 m at ≤ 93.75 kBd 500 m at ≤ 187.5 kBd 200 m at ≤ 1.5 MBd 100 m at ≤ 12 MBd
	Optical fibre	
	– Connector Type	ST–connector
	for flush mounted case	rear panel, mounting location “B”
	for surface mounted case	on the case bottom
	– Optical wavelength	λ = 820 nm
	– Laser class 1 acc. EN 60825–1/ –2	using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
	– Permissible optical signal attenuation	max. 8 dB, using glass fibre 62.5/125 µm
	– Maximum transmission distance	1.5 km (0.93 miles)
	– Character idle state	selectable; factory setting: “Light off”

Profibus LWL

– Connector Type	ST–connector single-ended ring / double-ended ring acc. to ordered version
for flush mounted case	rear panel, mounting location “B”
for surface mounted case	on the case bottom
– Transmission speed	up to 1.5 MBd
recommended:	> 500 kBd
– Optical wavelength	λ = 820 nm
– Laser class 1 acc. EN 60825–1/ –2	using glass fibre 50/125 µm or using glass fibre 62.5/125 µm
– Permissible optical signal attenuation	max. 8 dB, for glass fibre 62.5/125 µm
– Channel distance	max. 1.5 km (0.93 miles)

Time Synchronization Interface	– Signal type	DCF77/IRIG B-Signal
	– Connection for flush mounted case	rear panel, mounting location “A” 9-pin DSUB socket
	for surface mounted case	at the terminal on the case bottom
	– Nominal signal voltages	optional 5 V, 12 V or 24 V
	– Signal level and burden:	

	Nominal signal input voltage		
	5 V	12 V	24 V
U_{IHigh}	6.0 V	15.8 V	31 V
U_{ILow}	1.0 V for I_{ILow} = 0.25 mA	1.4 V for I_{ILow} = 0.25 mA	1.9 V for I_{ILow} = 0.25 mA
I_{IHigh}	4.5 mA to 9.4 mA	4.5 mA to 9.3 mA	4.5 mA to 8.7 mA
R_I	890 Ω for U_I = 4 V 640 Ω forU_I = 6 V	1930 Ω for U_I = 8.7 V 1700 Ω for U_I = 15.8 V	3780 Ω for U_I = 17 V 3560 Ω for U_I = 31 V

10.1.5 Electrical Tests

Specifications	Standards:	IEC 60255 (Product standards) ANSI/IEEE C37.90.0, C37.90.0.1, C37.90.0.2 DIN 57 435 Part 303 See also standards for individual functions
Insulation Tests	Standards:	IEC 60255–5 and 60870–2–1
	– High voltage test (routine test) all circuits except power supply,	2.5 kV (rms), 50 Hz

binary inputs, and
communications interfaces

– High voltage test (routine test) only power supply and binary inputs	3.5 kVDC
– High Voltage Test (routine test) only isolated communications interfaces	500 V (rms), 50 Hz
– Impulse voltage test (type test) all circuits except for communication interfaces, class III	5 kV (peak); 1.2/50 µs; 0,5 Ws; 3 positive and 3 negative surges in intervals of 5 s

EMC Tests; Interference Immunity (Type Tests)

Standards:	IEC 60255–6 and –22, (Product standards) EN 50082–2 (Generic standard) DIN 57435 Part 303	
– High frequency test IEC 60255–22–1, class III and VDE 0435 part 303, class III	2.5 kV (Peak); 1 MHz; $\tau = 15$ ms; 400 surges per s; test duration 2 s Ri = 200 Ω	
– Electrostatic discharge IEC 60255–22–2 class IV and IEC 61000–4–2, class IV	8 kV contact discharge; 15 kV air discharge, both polarities; 150 pF; R_i = 330 Ω	
– Irradiation with HF field, non-modulated IEC 60255–22–3 (report) class III	10 V/m; 27 MHz to 500 MHz	
– Irradiation with HF field, amplitude modulated; IEC 61000–4–3, class III	10 V/m; 80 MHz to 1000 MHz; 80 % AM; 1 kHz	
– Irradiation with HF field, pulse modulated IEC 61000–4–3/ENV 50204, class III	10 V/m; 900 MHz; repetition frequency 200 Hz; duty cycle of 50 %	
– Fast transient disturbance/burst IEC 60255–22–4 and IEC 61000–4–4, class IV	4 kV; 5/50 ns; 5 kHz; burst length = 15 ms; repetition rate 300 ms; both polarities; R_i = 50 Ω; test duration 1 min	
– High energy surge voltages (SURGE), IEC 61000–4–5 installation class 3	impulse: 1,2/50 µs	
power supply	common mode: diff. mode:	2 kV; 12 Ω; 9 µF 1 kV; 2 Ω; 18 µF
analog inputs, binary inputs and outputs	common mode: diff. mode:	2 kV; 42 Ω; 0.5 µF 1 kV; 42 Ω; 0.5 µF
– Line conducted HF, amplitude modulated; IEC 61000–4–6, class III	10 V; 150 kHz to 80 MHz; 80 % AM; 1 kHz	
– Power system frequency magnetic field; IEC 61000–4–8, class IV; IEC 60255–6	30 A/m continuous; 300 A/m for 3 s; 50 Hz 0.5 mT; 50 Hz	
– Oscillatory surge withstand capability ANSI/IEEE C37.90.1	2.5 to 3 kV (peak value); 1 MHz to 1,5MHz decaying wave; 50 surges per s; duration 2 s; R_i = 150 Ω to 200 Ω	
– Fast transient surge withstand capability, ANSI/IEEE C37.90.1	4 kV to 5 kV; 10/150 ns; 50 surges per s; both polarities; duration 2 s; R_i = 80 Ω	

	– Radiated electromagnetic interference ANSI/IEEE Std C37.90.2	35 V/m; 25 MHz to 1000 MHz amplitude and pulse modulated
	– Damped oscillations like IEC 60694, IEC 61000–4–12	2.5 kV (peak value), polarity alternating 100 kHz, 1 MHz, 10 MHz and 50 MHz, $R_i = 200\ \Omega$
EMC Tests; Interference Emission (Type Tests)	Standard:	EN 50081–* (Generic standard)
	– Conducted interference, only power supply voltage IEC–CISPR 22	150 kHz to 30 MHz limit class B
	– Radio interference field strength IEC–CISPR 22	30 MHz to 1000 MHz limit class B

10.1.6 Mechanical Stress Tests

Vibration and Shock During Operation	Standards:	IEC 60255–21 and IEC 60068–2
	– Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	sinusoidal 10 Hz to 60 Hz: ±0.075 mm amplitude 60 Hz to 150 Hz: 1 g acceleration frequency sweep rate 1 octave/min 20 cycles in 3 orthogonal axes.
	– Shock IEC 60255–21–2, class 1 IEC 60068–2–27	half-sine shaped acceleration 5 g, duration 11 ms, 3 shocks in each direction of 3 orthogonal axes
	– Seismic vibration IEC 60255–21–2, class 1 IEC 60068–3–3	sinusoidal 1 Hz to 8 Hz: ± 3.5 mm amplitude (horizontal axis) 1 Hz to 8 Hz: ± 1.5 mm amplitude (vertical axis) 8 Hz to 35 Hz: 1 g acceleration (horizontal axis) 8 Hz to 35 Hz: 0.5 g acceleration (vertical axis) Frequency sweep rate1 octave/min 1 cycle in 3 orthogonal axes
Vibration and Shock During Transport	Standards:	IEC 60255–21 and IEC 60068–2
	– Vibration IEC 60255–21–1, class 2 IEC 60068–2–6	sinusoidal 5 Hz to 8 Hz: ±7.5 mm amplitude 8 Hz to 150 Hz: 2 g acceleration Frequency sweep rate1 octave/min 20 cycles in 3 orthogonal axes
	– Shock IEC 60255–21–2, class 1 IEC 60068–2–27	half-sine shaped acceleration 15 g; duration 11 ms; 3 shocks in each direction of 3 orthogonal axes

	– Continuous shock IEC 60255–21–2, class 1 IEC 60068–2–29	half-sine shaped acceleration 10 g; duration 16 ms; 1000 shocks in each direction of 3 orthogonal axes

10.1.7 Climatic Stress Tests

Ambient Temperatures	Standards:	IEC 60255–6
	– recommended operating temperature	–5 °C to +55 °C (+23 °F to +131 °F) if max. half of the inputs and outputs are subjected to the max. permissible values
	– recommended operating temperature	–5 °C to +40 °C (+23 °F to +104 °F) if all inputs and outputs are subjected to the max. permissible values
	– limiting temporary (transient) operating temperature	–20 °C to +70 °C (–4 °F to 158 °F) Visibility of display may be impaired above +55 °C/130 °F in quiescent state, i.e. no pick-up and no indications
	– limiting temperature during storage	–25 °C to +55 °C (–13 °F to 131 °F)
	– limiting temperature during transport	–25 °C to +70 °C (–13 °F to 158 °F)
	Storage and transport of the device with factory packaging!	
Humidity	Permissible humidity	mean value p. year ≤75 % relative humidity on 56 days per year up to 93 % relative humidity; condensation not permissible!
	It is recommended that all devices are installed such that they are not exposed to direct sunlight, nor subject to large fluctuations in temperature that may cause condensation to occur.	

10.1.8 Service Conditions

The device is designed for use in an industrial environment or an electrical utility environment, for installation in standard relay rooms and compartments so that proper installation and electromagnetic compatibility (EMC) is ensured. In addition, the following are recommended:

- All contactors and relays that operate in the same cubicle, cabinet, or relay panel as the numerical protective device should, as a rule, be equipped with suitable surge suppression components.
- For substations with operating voltages of 100 kV and above, all external cables should be shielded with a conductive shield grounded at both ends. The shield must be capable of carrying the fault currents that could occur. For substations with lower operating voltages, no special measures are normally required.

- Do not withdraw or insert individual modules or boards while the protective device is energized. When handling the modules or the boards outside of the case, standards for components sensitive to electrostatic discharge (ESD) must be observed. The modules, boards, and device are not endangered when the device is completely assembled.

10.1.9 Construction

Housing		7XP20
Dimensions		see drawings, Section 10.20
Weight (mass) (max. complement) approx.		
– 7SA61	in flush mounting housing:	
	size $^1/_3$	4 kg
	size $^1/_2$	6 kg (13.2 pounds)
	size $^1/_1$	10 kg (22.0 pounds)
	in surface mounting housing:	
	size $^1/_3$	6 kg (13.2 pounds)
	size $^1/_2$	11 kg (24.3 pounds)
	size $^1/_1$	19 kg (41.9 pounds)
– 7SA63	in flush mounting housing:	
	size $^1/_2$	6 kg (13.2 pounds)
	size $^1/_1$	10 kg (22.0 pounds)
	in surface mounting housing,	
	size $^1/_2$	11 kg (24.3 pounds)
	size $^1/_3$	6 kg (13.2 pounds)
– 7SA64	in housing for detached operator panel:	
	size $^1/_2$	6 kg (13.2 pounds)
	size $^1/_1$	10 kg (22.0 pounds)
– detached operator panel		2.5 kg

Degree of protection acc. IEC 60529	
– for the device	
in surface mounted case	IP 51
in flush mounted case and with version with detached operator panel	
front	IP 51
rear	IP 50
– for human safety	IP 2x with closed protection cover

10.2 Distance Protection

Earth Impedance Matching	R_E/R_L	–0.33 to 7.00	(steps 0.01)
	X_E/X_L	–0.33 to 7.00	(steps 0.01)
		separate for first and higher zones	
	K_0	0.000 to 4.000	(steps 0.001)
	PHI (K_0)	–135.00° to +135.00°	(steps 0.01)
		separate for first and higher zones	
Mutual Impedance Matching (for Parallel Lines)	R_M/R_L	0.00 to 8.00	(steps 0.01)
	X_M/X_L	0.00 to 8.00	(steps 0.01)
	The matching factors for earth impedance and mutual impedance are valid also for fault location.		
Phase Preferences	For double earth fault In earthed systems	blocking of lagging phase–earth and phase–phase	
		blocking of leading phase–earth and phase–phase	
		release of all associated loops	
		release of only phase-to-earth loops	
		release of only phase-to-phase loop	
	For double earth fault in isolated or resonant-grounded systems		
		L3(L1) acyclic	
		L1(L3) acyclic	
		L2(L1) acyclic	
		L1(L2) acyclic	
		L3(L2) acyclic	
		L2(L3) acyclic	
		L3(L1) acyclic	
		L1(L3) acyclic	
		all associated loops	
Earth Fault Detection	Earth current $3I_0>$	0.05 A to 4.00 A *)	(steps 0.01 · A)
	Displacement voltage $3U_0>$	1 V to 100 V; ∞	(steps 1 V)
	Drop-off to pick-up ratios	approx. 0.95	
	Measuring tolerances for sinusoidal measured values	± 5 %	
	*) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Starting	<u>Overcurrent starting</u>		
	Overcurrent Iph >>	0.25 A to 10.00 A 1) (steps 0.01 A)	
	Drop-off to pick-up ratio	approx. 0.95	
	Measuring tolerances for sinusoidal measured values	± 5 %	

Voltage and angle-dependent current pickup (U/I/φ)

Characteristic	different steps with settable inclinations
Minimum current Iph>	0.10 A to 4.00 A 1) (steps 0.01 A)
Current in fault angle range Iφ>	0.10 A to 2.00 A 1) (steps 0.01 A)
Undervoltage phase–earth Uphe	20 V to 70 V (steps 1 V)
Undervoltage phase–phase Uphph (segregated for Iph> and Iφ> and Iph>>)	40 V to 130 V (steps 1 V)
Lower threshold angle φ>	30° to 60° (steps 1°)
Upper threshold angle φ<	90° to 120° (steps 1°)
Drop-off to pick-up ratio	
Iph>, Iφ>,	approx. 0.95
Uphe, Uphph	approx. 1.05
Measuring tolerances for sinusoidal measured values	
values of U, I	± 5 %
angles φ	± 3°

Impedance starting

Minimum current Iph>	0.10 A to 4.00 A 1) (steps 0.01 A)

The thresholds of the polygon set to the highest level are relevant taking into consideration the corresponding direction

Drop-off to pick-up ratio	approx. 1.05

*) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.

Distance Measurement

Characteristic	polygonal 5 independent and 1 controlled zone

Setting ranges polygon:

I_{Ph}> = min. current, phases	0.10 A to 4.00 A 1)	(steps 0.01 · A)
X = reactance reach	0.05 Ω to 250.00 Ω 2)	(steps 0.01 Ω)
R = resistance tolerance phase–phase	0.05 Ω to 250.00 Ω 2)	(steps 0.01 Ω)
RE = resistance tolerance phase–earth	0.05 Ω to 250.00 Ω 2)	(steps 0.01 Ω)
φ_{Line} = line angle	30° to 89°	(steps 1°)
α_{Pol} = tilt angle for 1st zone	0° to 30°	(steps 1°)

Direction determination for polygonal characteristic:

for all types of fault	with phase-true, memorizedor quadrature voltages

Each zone can be set to forward, reverse or non-directional

Load trapezoid:

R_{load}= minimum load resistance	0.10 Ω to 250.00 Ω 2); ∞	(steps 0.01 Ω)
φ_{load} = maximum load angle	20° to 60°	(steps 1°)

Drop-off to pick-up ratios	approx. 1.06
Measured value correction	mutual impedance matching for parallel lines (ordering option)

	Measuring tolerances with sinusoidal quantities and $U_K/U_N \geq 0.1$	$\left\|\frac{\Delta X}{X}\right\| \leq 5\ \%$ for $30° \leq \varphi_{sc} \leq 90°$ $\left\|\frac{\Delta R}{R}\right\| \leq 5\ \%$ for $0° \leq \varphi_{sc} \leq 60°$ $\left\|\frac{\Delta Z}{Z}\right\| \leq 5\ \%$ for $-30° \leq \varphi_{sc} - \varphi_{line} \leq 30°$

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.
[2]) Secondary values based on I_N = 1 A;
for I_N = 5 A the impedances must be devided by 5.

Times	Shortest trip time	approx. 17 ms (50 Hz) / 15 ms (60 Hz)
	Drop-off time	approx. 30 ms
	Stage timers	0.00 s to 30.00 s; ∞ (steps 0.01 s) for all zones; separate time setting possibilities for single-phase and multi-phase faults for the zones Z1, Z2, and Z1B
	Time expiry tolerances	1 % of set value or 10 ms
	The set times are pure delay times.	
Emergency Operation	In case of measured voltage failure, e.g. voltage secondary mcb trip	See Section 10.9

10.3 Power Swing Supplement

	Power swing detection	Rate of change of the impedance phasor and observation of the path curve
	Max. power swing frequency	approx. 7 Hz
	Power swing blocking programs	Block 1st zone only Block higher zones Block 1st and 2nd zone Block all zones
	Out-of-step trip	Trip following instable power swings (out-of-step)

10.4 Distance Protection Teleprotection Schemes

Mode	For two line ends	with one channel for each direction or with three channels for each direction (for phase segregated transmission)	
	For three line ends	with one channel for each direction and opposite line end	
Underreach Schemes	Method	Permissive Underreach Transfer Trip (PUTT) (with overreaching zone Z1B) PUTT (Pickup) Direct transfer trip	
	Send signal prolongation	0.00 s to 30.00 s	(steps 0.00 s)
Overreach schemes	Methods	Permissive Overreach Transfer Trip (POTT) (with overreaching zone Z1B) Dir. Comp. Pickup Unblocking (with overreaching zone Z1B) Blocking (with overreaching zone Z1B) Pilot wire comp. Rev. Interlock	
	Send signal prolongation	0.00 s to 30.00 s	(steps 0.01 s)
	Release signal prolongation	0.000 s to 30.000 s	(steps 0.001 s)
	Transient blocking time	0.00 s to 30.00 s	(steps 0.01 s)
	Waiting time for transient blocking	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Echo delay time	0.00 s to 30.00 s	(steps 0.01 s)
	Echo impulse duration	0.00 s to 30.00 s	(steps 0.01 s)
	Time expiry tolerances The set times are pure delay times.	1 % of set value or 10 ms	

10.5 Earth Fault Protection in Earthed Systems

Characteristics	Definite time stages	(definite)	$3I_0$>>>,$3I_0$>>,$3I_0$>	
	Inverse time stage	(IDMT)	$3I_{0P}$ one of the characteristics according to Figure 10-1 to 10-11 can be selected	
	Voltage-dependent stage	(U_0 inverse)	characteristic according to 10-8	

High Set Stage	Pickup value	$3I_0$>>>	0.50 A to 25.00 A 1)	(steps 0.01 A)
		$T_{3I0>>>}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \geq 0.5$	
	Pickup time Drop-off time		approx. 35 ms approx. 30 ms	
	Tolerances	current time	3 % of set value or 1% nominal current 1 % of set value or 10 ms	

The set times are pure delay times.

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

High Set Stage	Pickup value		$3I_0$>>0.20 A to 25.00 A 1)	(steps 0.01 A)
	Delay time	$T_{3I0>>}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \geq 0.5$	
	Pickup time Drop-off time		approx. 35 ms approx. 30 ms	
	Tolerances	current time	3 % of set value or 1% of nominal current 1 % of set value or 10 ms	

The set times are pure delay times.

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

High Set Stage	Pickup value	$3I_0$> or	0.05 A to 25.00 A 1) 0.003 A to 25.000 A 1)	(steps 0.01 A) (steps 0.001 A 1))
	Delay time	$T_{3I0>}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \geq 0.5$	
	Pickup time Drop-off time		approx. 35 ms approx. 30 ms	
	Tolerances	current time	3 % of set value or 1% of nominal current 1 % of set value or 10 ms	

The set times are pure delay times.

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

Overcurrent stage (inverse time acc. IEC)	Pickup value	$3I_{0P}$ or	0.05 A to 4.00 A 1) 0.003 A to 4.000 A 1)	(steps 0.01 A) (steps 0.001 A 1))
	Time factor	T_{3I0P}	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
	Additional time delay	$T_{3I0Pverz}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Characteristics		see Figure 10-1	
	Tolerances	current times	pickup at $1.05 \leq I/3I_{0P} \leq 1.15$ 5 % ± 15 ms for $2 \leq I/3I_{0P} \leq 20$ and $T_{3I0P}/s \geq 1$	

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

Overcurrent stage (inverse time acc. ANSI)	Pickup value	$3I_{0P}$ or	0.05 A to 4.00 A 1) 0.003 A to 4.000 A 1)	(steps 0.01 A) (steps 0.001 A 1))
	Time factor	D_{3I0P}	0.50 s to 15.00 s or ∞ (ineffective)	(steps 0.01 s)
	Additional time delay	$T_{3I0Pverz}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Characteristics		see Figures 10-2 and 10-3	
	Tolerances	current times	pickup at $1.05 \leq I/3I_{0P} \leq 1.15$ 5 % ± 15 ms for $2 \leq I/3I_{0P} \leq 20$ and $D_{3I0P}/s \geq 1$	

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

Overcurrent stage (logarithmic inverse)	Pickup value	$3I_{0P}$ or	0.05 A to 4.00 A 1) 0.003 A to 4.000 A 1)	(steps 0.01 A) (steps 0.001 A 1))
	Startstromfaktor	$3_{I0P\ FAKTOR}$	1.0 to 4.0	(steps 0.1)
	Time factor	T_{3I0P}	0.05 s to 15.00 s or ∞ (ineffective)	(steps 0.01 s)
	Maximal zeit	$T_{3I0P\ max}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Minimalzeit	$T_{3I0P\ min}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Additional time delay	$T_{3I0Pverz}$	0.00 s to 30.00 s	(steps 0.01 s)
		characteristics	see Figure 10-4	
	Tolerances			
		times	5 % ± 15 ms für $2 \leq I/3I_{0P} \leq 20$ und $T_{3I0P}/s \geq 1$	
		def. times	1 % of set value or 10 ms	

1) Secondary values based on I_N = 1 A; for I_N = 5 A the current values must be multiplied by 5.

Zero Sequence Voltage - U_0 inverse	Pickup values	$3I_{0P}$ $3U_0>$	0.05 A to 25.00 A 1) 1.0 V to 10.0 V	(steps 0.01 A) (steps 0.1 V)
	Voltage factor	$U_{0\ inv.min}$	0.1 V to 5 V	(steps 0.1 V)
		characteristics	see Figure 10-5	
	Additional delay times	Tforw Trev	0.00 s to 32.00 s 0.00 s to 32.00 s	(steps 0.01 s) (steps 0.01 s)

	characteristics	see Figure 10-5	
Tolerances	times	1 % of set value or 10 ms	
Drop-off to pick-up ratio	current voltage	approx. 0.95 for $I/I_N \geq 0.5$ approx. 0.95 for $3U_0 \geq 1$ V	

The set times are pure delay times.

1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A the current values must be multiplied by 5.

Inrush Stabilization

Second harmonic content for inrush blocking	10 % to 45 % referred to fundamental wave	(steps 1 %)
Inrush blocking is cancelled above	0.50 A to 25.00 A1)	(steps 0.01 A1))

Inrush stabilization may be switched effective or ineffective for each individual stage.

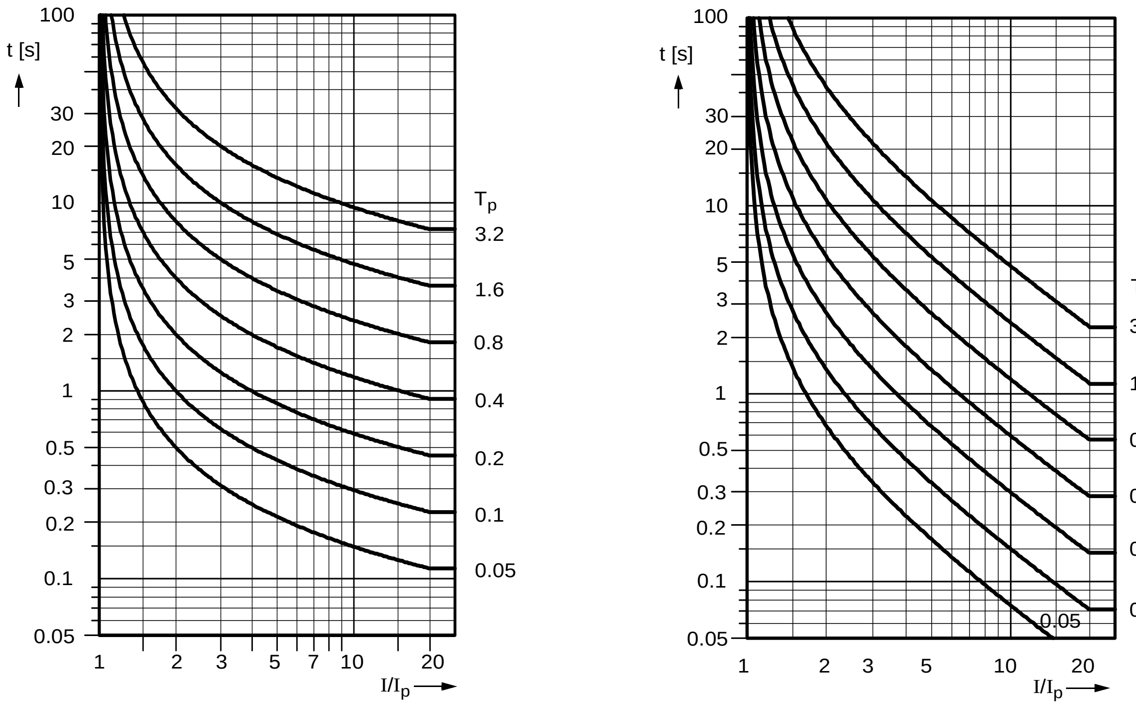
1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied with 5.

Direction Determination

Direction determination		with I_E (= $3I_0$) and $3U_0$ with I_E (= $3I_0$) and I_Y (transformer star-point current) with $3I_2$ and $3U_2$ (negative sequence quantities)	
Limit values			
Displacement voltage	$3U_0$>	0.5 V to 10.0 V	(steps 0.1 V)
Starpoint current of a power transformer I_Y>		0.05 A to 1.00 A1)	(steps 0.01 A)
Negative sequence current $3I_2$>		0.05 A to 1.00 A1)	(steps 0.01 A)
Negative sequence voltage $3U_2$>		0.5 V to 10.0 V	(steps 0.1 V)
“Forward” angle			
capacitive	Alpha	0° to 360°	(steps 1°)
inductive	Beta	0° to 360°	(steps 1°)
Tolerances	pick-up values	10 % of set value or 5% of nominal current or 0.5 V	
	“Forward” angle	5°	

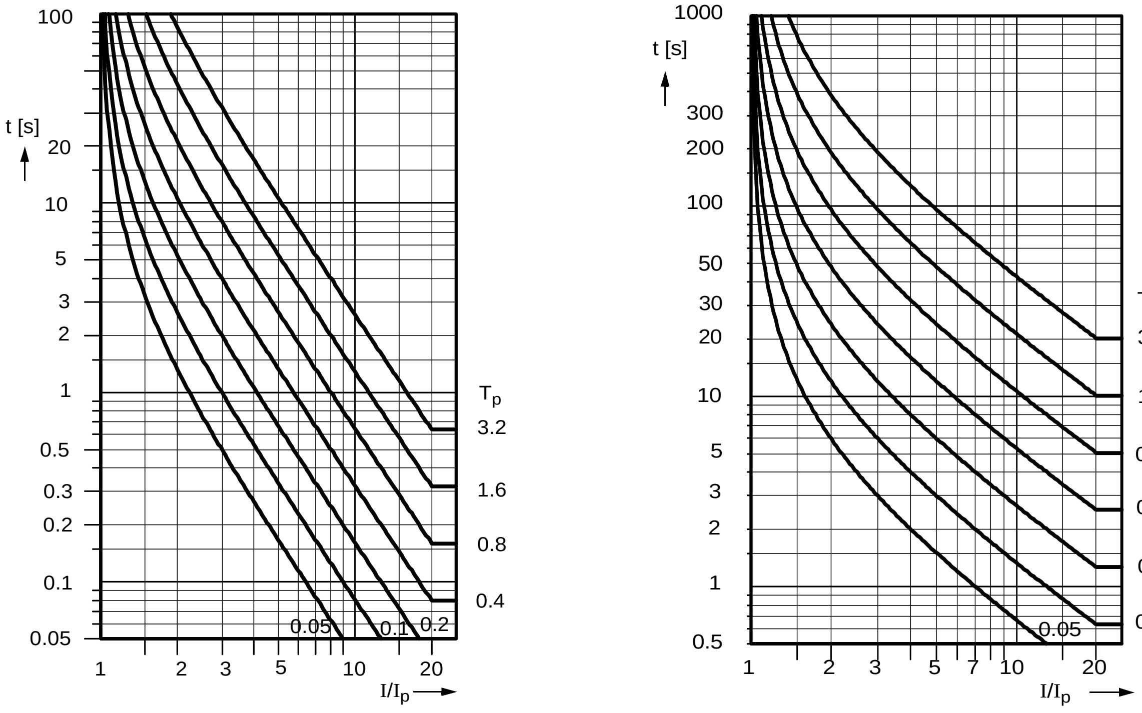
Re-orientation time after direction change approx. 30 ms

1) Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied by 5.



Normal inverse: $t = \frac{0.14}{(I/I_p)^{0.02} - 1} \cdot T_p$ [s]
(Type A)

Very inverse: $t = \frac{13.5}{(I/I_p)^{1} - 1} \cdot T_p$ [s]
(Type B)



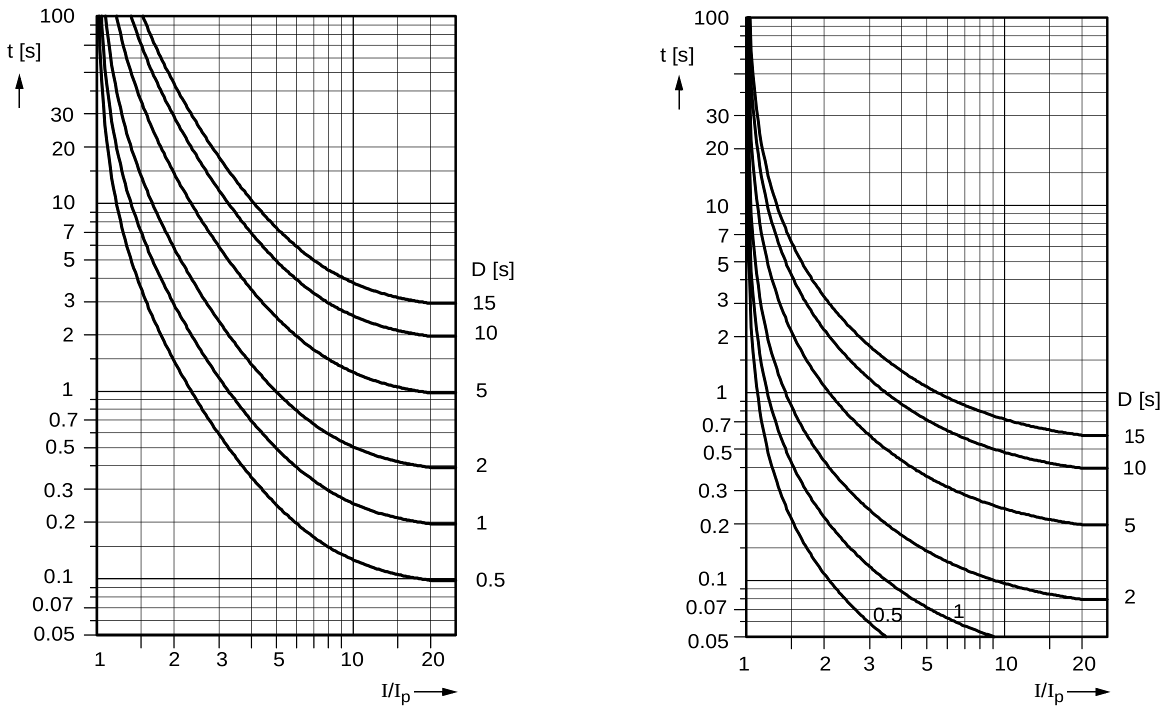
Extremely inverse: $t = \frac{80}{(I/I_p)^{2} - 1} \cdot T_p$ [s]
(Type C)

Longtime inverse: $t = \frac{120}{(I/I_p)^{1} - 1} \cdot T_p$ [s]

t	Trip time
T_p	Setting value time multiplier
I	Fault current
I_p	Setting value current

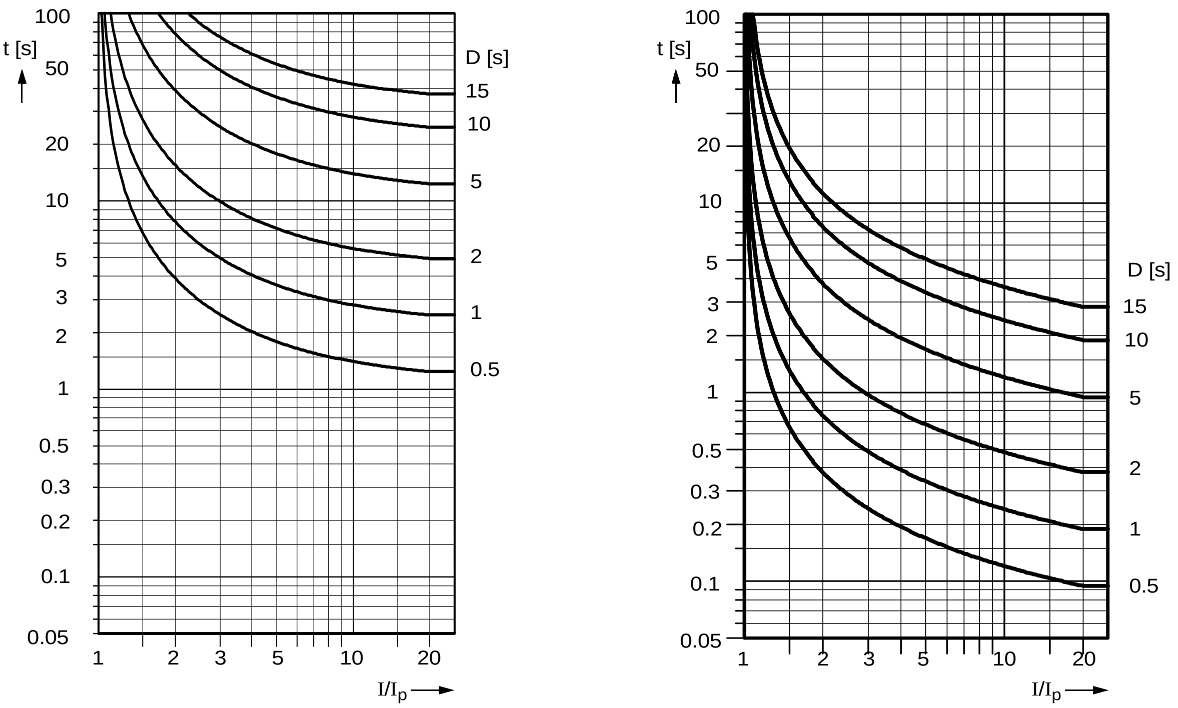
Note: For earth fault read $3I_{0p}$ instead of I_p and T_{3I0p} instead of T_p

Figure 10-1 Trip time characteristics of inverse time overcurrent protection, acc. IEC (phases and earth)



INVERSE
$$t = \left(\frac{8.9341}{(I/I_p)^{2.0938} - 1} + 0.17966 \right) \cdot D \quad [s]$$

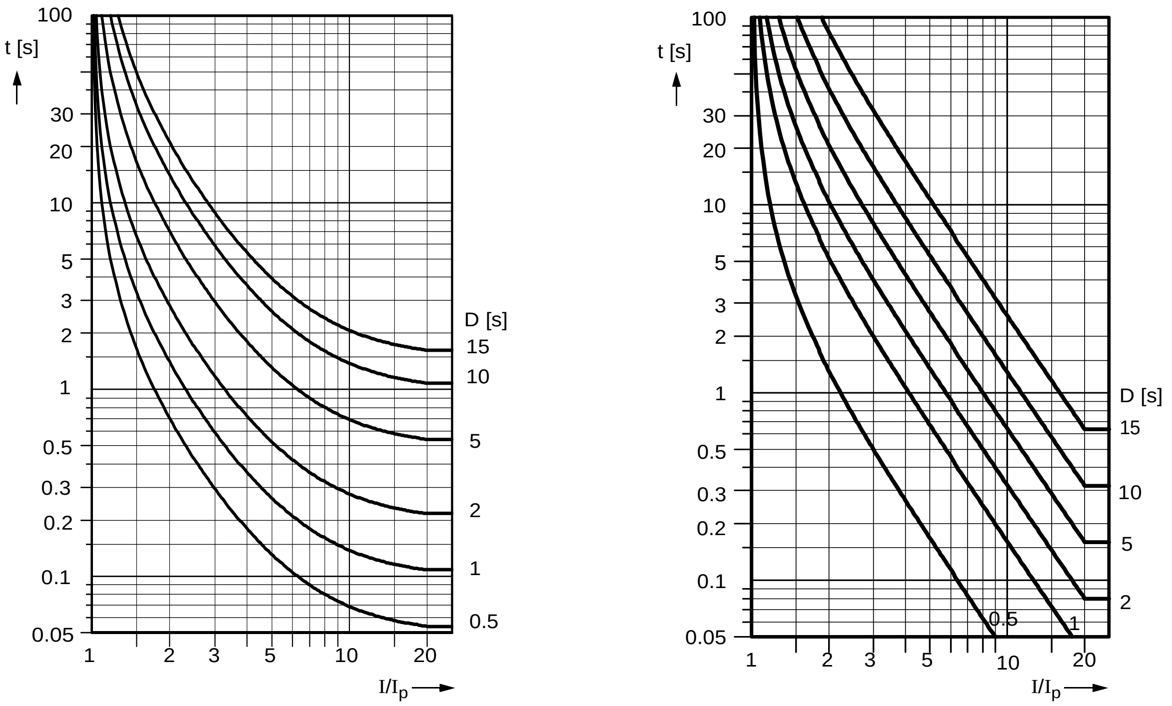
SHORT INVERSE
$$t = \left(\frac{0.2663}{(I/I_p)^{1.2969} - 1} + 0.03393 \right) \cdot D \quad [s]$$



LONG INVERSE
$$t = \left(\frac{5.6143}{(I/I_p) - 1} + 2.18592 \right) \cdot D \quad [s]$$

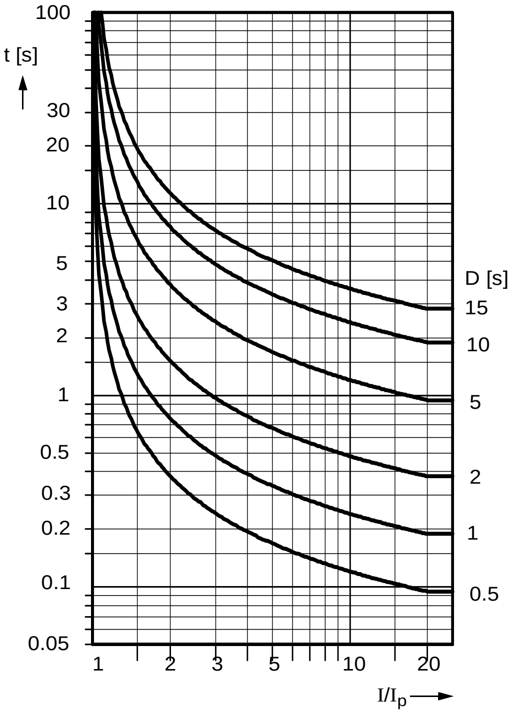
MODERATELY INVERSE
$$t = \left(\frac{0.0103}{(I/I_p)^{0.02} - 1} + 0.0228 \right) \cdot D \quad [s]$$

Figure 10-2 Trip time characteristics of inverse time overcurrent protection, acc. ANSI/IEEE, (phases and earth)



VERY INVERSE $t = \left(\frac{3{,}922}{(I/I_p)^2 - 1} + 0.0982\right) \cdot D \quad [s]$

EXTREMELY INVERSE $t = \left(\frac{5.64}{(I/I_p)^2 - 1} + 0.02434\right) \cdot D \quad [s]$

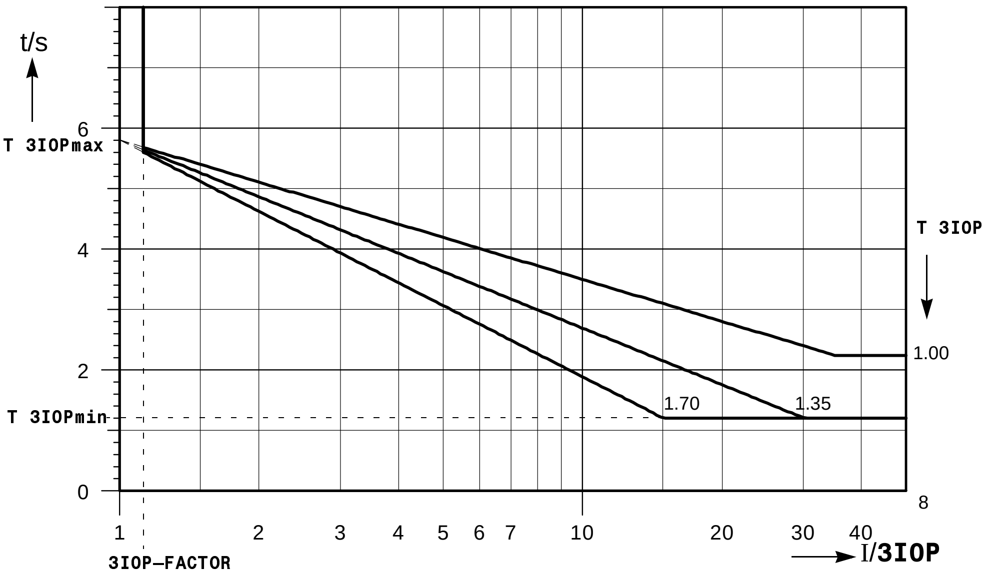


DEFINITE INVERSE $t = \left(\frac{0.4797}{(I/I_p)^{1.5625} - 1} + 0.21359\right) \cdot D \quad [s]$

t	Trip time
D	Setting value time multiplier
I	Fault current
I_p	Setting value current

Note: For earth fault read $3I_{0p}$ instead of I_p and D_{3I0p} instead of D_{Ip}

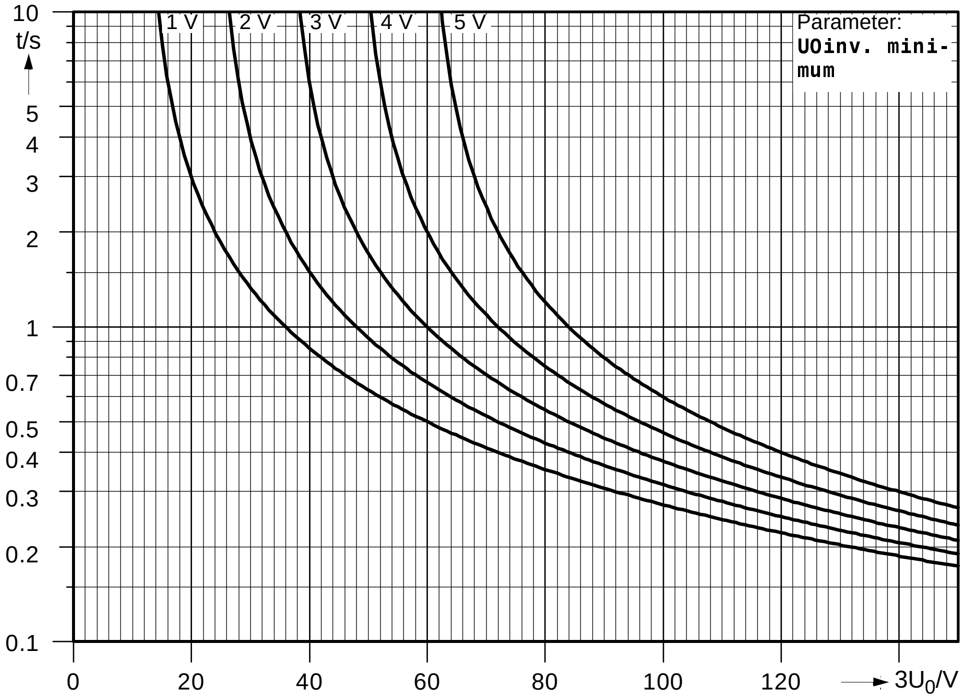
Figure 10-3 Trip time characteristics of inverse time overcurrent protection, acc. ANSI/IEEE (phases and earth)



Logarithmic inverse: $t = T_{3I0Pmax} - T_{3I0P} \cdot \ln(I/3I0P)$

Note: For currents I/**3I0P** ≥ 35 the tripping time is constant.

Figure 10-4 Trip time characteristics of inverse time overcurrent protection with logarithmic inverse characteristic



U_0 inverse: $t = \dfrac{2\text{ s}}{0{,}25\ U_0/V - U_{0min}/V}$ with U_{0min} = parameter **`U0inv. minimum`** (Adr. 3183)

Figure 10-5 Trip time characteristics of the zero sequence voltage protection $U_{0inv.}$

10.6 Earth Fault Protection Teleprotection Schemes

Mode	For two line ends	with one channel for each direction with three channels for each direction	
	For three line ends	with one channel for each direction and oposite line end	
Comparison Schemes	Schemes	directional comparison pickup scheme directional unblocking scheme directional blocking scheme	
	Application	2-terminal lines 3-terminal lines multi-terminal lines via CFC	
	Send signal prolongation	0.00 s to 30.00 s	(steps 0.01 s)
	Release signal prolongation	0.000 s to 30.000 s	(steps 0.001 s)
	Transient blocking time	0.00 s to 30.00 s	(steps 0.01 s)
	Waiting time for transient blocking	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Echo delay time	0.00 s to 30.00 s	(steps 0.01 s)
	Echo impulse duration	0.00 s to30.00 s	(steps 0.01 s)
	Time expiry tolerances	1 % of set value or 10 ms	
	The set times are pure delay times.		

10.7 Weak-Infeed Tripping

Operation method	Phase segregated undervoltage detection after reception of a carrier signal from the remote end			
Undervoltage Detection	Setting value	$U_{PhE}<$	2 V to 70 V	(steps 1 V)
	Drop-off to pick-up ratio		approx. 1.05	
	Pick-up tolerances		≤ 5 % of set value or 0.5 V	
Times	Release delay		0.00 s to 30.00 s	(steps 0.01 s)
	Release prolongation		0.00 s to 30.00 s	(steps 0.01 s)
	Time expiry tolerances		1 % of set value or 10 ms	

10.8 External Direct and Remote Tripping

External Trip of the Local Breaker	Operating time, total	approx. 11 ms	
	Trip time delay	0.00 s to 30.00 s, ∞ or ∞ (ineffective)	(steps 0.01 s)
	Time expiry tolerance	1 % of set value or 10 ms	
	The set time is a pure delay time.		

10.9 Overcurrent Protection

Operating Modes	As emergency overcurrent protection or back-up overcurrent protection:			
	Emergency overcurrent protection		operates on failure of the measured voltage, – on trip of a voltage secondary miniature circuit breaker (via binary input) – on detection of a fuse failure in the voltage secondary circuit	
	Back-up overcurrent protection		operates independent on any events	
Characteristics	Definite time stages	(definite)	I_{Ph}>>,$3I_0$>>, I_{Ph}>, $3I_0$>	
	Inverse time stage	(IDMT)	I_P, $3I_{0P}$ one of the characteristics according to Figure 10-1 to 10-3 (see Section 10.5) can be selected	
High Set Stages	Pickup values	I_{Ph}>> (phases)	0.10 A to 25.00 A[1]) or ∞ (ineffective)	(steps 0.01 A)
		$3I_0$>> (earth)	0.05 A to 25.00 A[1]) or ∞ (ineffective)	(steps 0.01 A)
	Time delays	$T_{IPh>}$ (phases)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{3I0>>}$ (earth)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \geq 0.5$	
	Pick-up time Drop-off time		approx. 25 ms approx. 30 ms	
	Tolerances	currents times	3 % of set value or 1% nominal current 1 % of set value or 10 ms	

The set times are pure delay times.

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Overcurrent stages	Pickup values	I_P (phases)	0.10 A to 25.00 A1) or ∞ (ineffective)	(steps 0.01 A)
		$3I_{0P}$ (earth)	0.05 A to 25.00 A1) or ∞ (ineffective)	(steps 0.01 A)
	Time delays	$T_{IPh>}$ (phases)	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{3I0>}$ (earth)	0.05 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \geq 0.5$	
	Pick-up time		ca. 25 ms	
	Drop-off time		ca. 30 ms	
	Tolerances	currents	3 % of set value or 1% nominal current	
		times	1 % of set value or 10 ms	

The set times are pure delay times.

1) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Overcurrent stages (inverse time acc. IEC)	Pickup values	I_P (phases)	0.10 A to 4.00 A1) or ∞ (ineffective)	(steps 0.01 A)
		$3I_{0P}$ (earth)	0.05 A to 4.00 A1) or ∞ (ineffective)	(steps 0.01 A)
	Time factors	T_{IP} (phases)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
		T_{3I0P} (earth)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
	Additional time delays	T_{IPadd} (phases.)	0.00 s to 30.00 s	(steps 0.01 s)
		$T_{3I0Padd}$ (earth)	0.00 s to 30.00 s	(steps 0.01 s)
	Characteristics	see Figure 10-1 (in Section 10.5)		
	Tolerances	currents		Pick-up at $1.05 \leq I/I_P \leq 1.15$; or $1.05 \leq I/3I_{0P} \leq 1.15$
		times	5 % ± 15 ms	for $2 \leq I/I_P \leq 20$ and $T_{IP}/s \geq 1$; or $2 \leq I/3I_{0P} \leq 20$ and $T_{3I0P}/s \geq 1$
		def. times	1 % of set value or 10 ms	

The set times are pure delay times with definite time protection.

1) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Overcurrent stages (inverse time acc. ANSI)	Pickup values	I_P (phases)	0.10 A to 4.00 A1) or ∞ (ineffective)	(steps 0.01 A)
		$3I_{0P}$ (earth)	0.05 A to 4.00 A1) or ∞ (ineffective)	(steps 0.01 A)

Time factors	D_{IP} (phases)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
	D_{3I0P} (earth)	0.05 s to 3.00 s or ∞ (ineffective)	(steps 0.01 s)
Additional time delays	T_{IPadd} (phases.)	0.00 s to 30.00 s	(steps 0.01 s)
	$T_{3I0Padd}$ (earth)	0.00 s to 30.00 s	(steps 0.01 s)
Characteristics	see Figure 10-1 (in Section 10.5)		
Tolerances	currents	Pick-up at or	$1.05 \le I/I_P \le 1.15$; $1.05 \le I/3I_{0P} \le 1.15$
	times	5 % ± 15 ms	for $2 \le I/I_P \le 20$ and $D_{IP}/s \ge 1$; or $2 \le I/3I_{0P} \le 20$ and $T_{3I0P}/s \ge 1$
	def. times	1 % of set value or 10 ms	

The set times are pure delay times with definite time protection.

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

Stub Protection	Pick-up values	I_{PhSTUB} (phases)	0.10 A to 25.00 A[1]) or ∞ (ineffective)	(steps 0.01 A)
		$3I_{0STUB}$> (earth)	0.05 A to 25.00 A[1])	(steps 0.01 A)
		$T_{3I0\,STUB}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Time delays	$T_{IPh>>>}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
		$T_{3I0>>>}$	0.00 s to 30.00 s or ∞ (ineffective)	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 0.95 for $I/I_N \ge 0.5$	
	Pick-up time Drop-off time		approx. 25 ms approx. 30 ms	
	Tolerances	currents	3 % of set value or 1% nominal current	
		times	1 % of set value or 10 ms	

The set times are pure delay times.

[1]) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.

10.10 High-Current Switch-On-To-Fault Protection

Pick-up	High current pick-up	I>>>	1.00 A to 25.00 A^{1})	(steps 0.01 A)
	Drop-off to pick-up ratio		approx. 0.90	
	Pick-up tolerance		≤ 3 % of set value or 1% of I_N	
Times	Shortest tripping time		approx. 13 ms	

10.11 Earth Fault Detection in a Non-Earthed System

Pickup/ Trip	Displacement voltage	$3U_0$>	1 V to 150 V	(steps 1 V)
	Time delay	$T_{Sens.E/F}$	0.00 s to 320.00 s	(steps 0.01 s)
	Optional trip with additional time delay	$T_{Sens.E/F\ TRIP}$	0.00 s to 320.00 s	(steps 0.01 s)
	Measuring tolerance		5 % of set value	
	Time tolerance		1 % of set value or 10 ms	
	Pick-up time		min. 32 ms	
	Drop-off time		26 ms	
	The set times are pure delay times.			
Phase Determination	Measuring principle		voltage measurement phase-earth	
	Earth fault phase	$U_{ph\ min}$	10 V to 100 V	(steps 1 V)
	Healthy phases	$U_{ph\ max}$	10 V to 100 V	(steps 1 V)
	Messtoleranz		5 % of set value	
Direction Determination	Measuring principle		active / reactive power measurement	
	Pick-up value	$I>_{Sens.E/F}$	0.003 A to 1.000 A ^{2})	(steps 0.001 A)
	Angle correction for cable core balance current transformer		0.0° to 5.0° in 2 steps	(steps 0.1°)
	Measuring tolerance		10 % of set value for tan $\varphi \leq 20$ (for active power)	

^{2}) Sensitive earth current input independent from I_N.

10.12 Automatic Reclosure Function

Automatic Reclosures	Number of reclosures	max. 8, first 4 with individual settings
	Operating modes	1-pole, 3-pole or 1-/3-pole
	Control	with pick-up or trip command
	Action times Initiation possible without pick-up and action time	0.01 s to 300.00 s; ∞ (steps 0.01 s)
	Different dead times before reclosure can be set for all operating modes and cycles	0.01 s to 1800.00 s; ∞ (steps 0.01 s)
	Dead times after evolving fault recognition	0.01 s to 1800.00 s; (steps 0.01 s)
	Reclaim time after reclosure	0.50 s to 300.00 s (steps 0.01 s)
	Blocking time after dynamic blocking	0.5 s
	Blocking time after manual closing	0.50 s to 300.00 s ; 0 (steps 0.01 s)
	Start signal monitoring time	0.01 s to 300.00 s (steps 0.01 s)
	Circuit-breaker supervision time	0.01 s to 300.00 s (steps 0.01 s)
Adaptive Dead Time (ADT)/ Reduced Dead Time (RDT)/ Dead Line Check	Operating modes (ADT)	with voltage measurement or with close command transmission
	Action time Initiation possible without pick-up and action time	0.01 s to 300.00 s; ∞ (steps 0.01 s)
	Maximum dead time	0.50 s to 3000.00 s; ∞ (steps 0.01 s)
	Voltage measurement dead-line or bus	2 V to 70 V (phase-to-earth) (steps 1 V)
	Voltage measurement live or bus	30 V to 90 V (phase-to-earth) (steps 1 V)
	Voltage supervision time for dead / live line or bus	0.10 s to 30.00 s (steps 0.01 s)
	Time delay for close command transmission	0.00 s to 300 s; ∞ (steps 0.01 s)

10.13 Synchronism and Voltage Check (Dead-line / Dead-bus Check)

Operating Modes	Operating modes with automatic reclosure	Synchronism check, dead-line / live-bus dead-bus / live-line, dead-bus and dead-line bypassing or similar combinations of the above
	Synchronism	Closing possible under non-synchronous system conditions (with consideration of circuit-breaker operating time)
	Control programs for manual closing	as for automatic reclosure, independently selectable
Voltages	Minimal operating voltage	1 V
	Maximum operating voltage	20 V to 140 V (phase-to-phase) (steps 1 V)
	U> for dead-line / dead-bus check	1 V to 60 V (phase-to-phase) (steps 1 V)
	U< for live-line/ live-bus check	20 V to 125 V (phase-to-phase) (steps 1 V)
	Tolerances	2 % of pick-up value or 2 V
	Drop-off to pick-up ratios	approx. 0.9 (U>) or 1.1 (U<)
ΔU-Measurement	Voltage difference	1 V to 40 V (phase-to-phase) (steps 0.1 V)
	Tolerance	1 V
Synchronous System Conditions	Δφ–measurement	2° to 60° (steps 1°)
	Tolerance	2°
	Δf-measurement	0.03 Hz to 2.00 Hz (steps 0.01 Hz)
	Tolerance	15 mHz
	Release delay	0.00 s to 30.00 s (steps 0.01 s)
Non-Synchronous System Conditions	Δf-measurement	0.03 Hz to 2.00 Hz (steps 0.01 Hz)
	Tolerance	15 mHz
	Threshold synchronous / non-synchronous	0.01 Hz
	Circuit-breaker operating time	0.01 s to 0.60 s
Times	Minimum measuring time	approx. 80 ms
	Maximum time delay	0.01 s to 600.00 s; ∞ (steps 0.01 s)
	Tolerance of all timers	1 % of set value or 10 ms

10.14 Voltage Protection

Overvoltage Phase–Earth	Overvoltage	$U_{Ph}>>$	1.0 V to 170.0 V	(steps 0.1 V)
	Time delay	$T_{UPh>>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Overvoltage	$U_{Ph}>$	1.0 V to 170.0 V	(steps 0.1 V)
	Time delay	$T_{UPh>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		0.50 to 0.98	(steps 0.01)
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Overvoltage Phase–Phase	Overvoltage	$U_{PhPh}>>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{UPhPh>>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Overvoltage	$U_{PhPh}>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{UPhPh>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		0.50 to 0.98	(steps 0.01)
	Pick-up time		ca. 30 ms	
	Drop-off time		ca. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Overvoltage Positive Sequence System U_1	Overvoltage	$U_1>>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{U1>>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Overvoltage	$U_1>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{U1>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		0.50 to 0.98	(steps 0.01)
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Overvoltage Negative Sequence System U_2	Overvoltage	$U_2>>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{U2>>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Overvoltage	$U_2>$	2.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{U2>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		0.50 to 0.98	(steps 0.01)
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Overvoltage Zero Sequence System $3U_0$ or any Single-Phase Voltage U_X	Overvoltage	$3U_0>>$	1.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{3U0>>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Overvoltage	$3U_0>$	1.0 V to 220.0 V	(steps 0.1 V)
	Time delay	$T_{3U0>}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		0.50 to 0.98	(steps 0.01)

	Pick-up time		approx. 75 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Undervoltage Phase–Earth	Undervoltage	$U_{Ph}<<$	1.0 V to 100.0 V	(steps 0.1 V)
	Time delay	$T_{UPh<<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Undervoltage	$U_{Ph}<$	1.0 V to 100.0 V	(steps 0.1 V)
	Time delay	$T_{UPh<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 1.05	
	Current criterion		can be switched on/off	
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Undervoltage Phase–Phase	Undervoltage	$U_{PhPh}<<$	1.0 V to 175.0 V	(steps 0.1 V)
	Time delayTime delay	$T_{UPhPh<<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Undervoltage	$U_{PhPh}<$	1.0 V to 175.0 V	(steps 0.1 V)
	Time delay	$T_{UPhPh<<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 1.05	
	Current criterion		can be switched on/off	
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	
Undervoltage Positive Sequence System U_1	Undervoltage	$U_1<<$	1.0 V to 100.0 V	(steps 0.1 V)
	Time delay	$T_{U1<<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Undervoltage	$U_1<$	1.0 V to 100.0 V	(steps 0.1 V)
	Time delay	$T_{U1<<}$	0.00 s to 30.00 s; ∞	(steps 0.01 s)
	Drop-off to pick-up ratio		approx. 1.05	
	Current criterion		can be switched on/off	
	Pick-up time		approx. 30 ms	
	Drop-off time		approx. 30 ms	
	Tolerances	voltages	3 % of set value or 1 V	
		times	1 % of set value or 10 ms	

10.15 Fault Location

Start	with trip command or drop-off
Setting range reactance (secondary)	0.005 Ω/km to 6.500 Ω/km 2) (steps 0.001 Ω/km) or 0.005 Ω/mile to 10.000 Ω/mile 2) (steps 0.001 Ω/mile)
Parallel line compensation	can be switched on/off Set values are the same as for distance protection (see Section 10.2)
Load current compensation for single-phase earth faults	correction of the X-value can be switched on/off
Output of the fault distance	in Ω primary and Ω secondary, in km or miles line 1), in % of the line length 1)
Measuring tolerances with sinusoidal measured quantities	2.5 % of line length at $30° \leq \varphi_k \leq 90°$ and $U_k/U_N \geq 0.1$
Further output options (dependent on order variant)	as analog value 0 mA to 22.5 mA; as BCD–code 4 bit units + 4 bit tens + 1 bit hundreds + 1 validity bit
output time, settable	0.01 s to 30.00 s; ∞ (steps 0.01 s)

1) Output of the fault distance in km, miles, and % requires homogeneous lines.

2) Secondary values based on I_N = 1 A; for I_N = 5 A the impedances are to be divided by 5.

10.16 Circuit Breaker Failure Protection

Circuit Breaker Monitoring	Current flow monitoring	0.05 A to 20.00 A1) (steps 0.01 A)
	Drop-off to pick-up ratio	approx. 0.95
	Tolerance	5 % of the set value or 0.01 A1)
	Monitoring of circuit-breaker auxiliary contact position	
	- for three-pole tripping	binary input for circuit breaker auxiliary contact
	- for single-pole tripping	1 binary input for auxiliary contact per pole or 1 binary input for series connection NO contact and NC contact

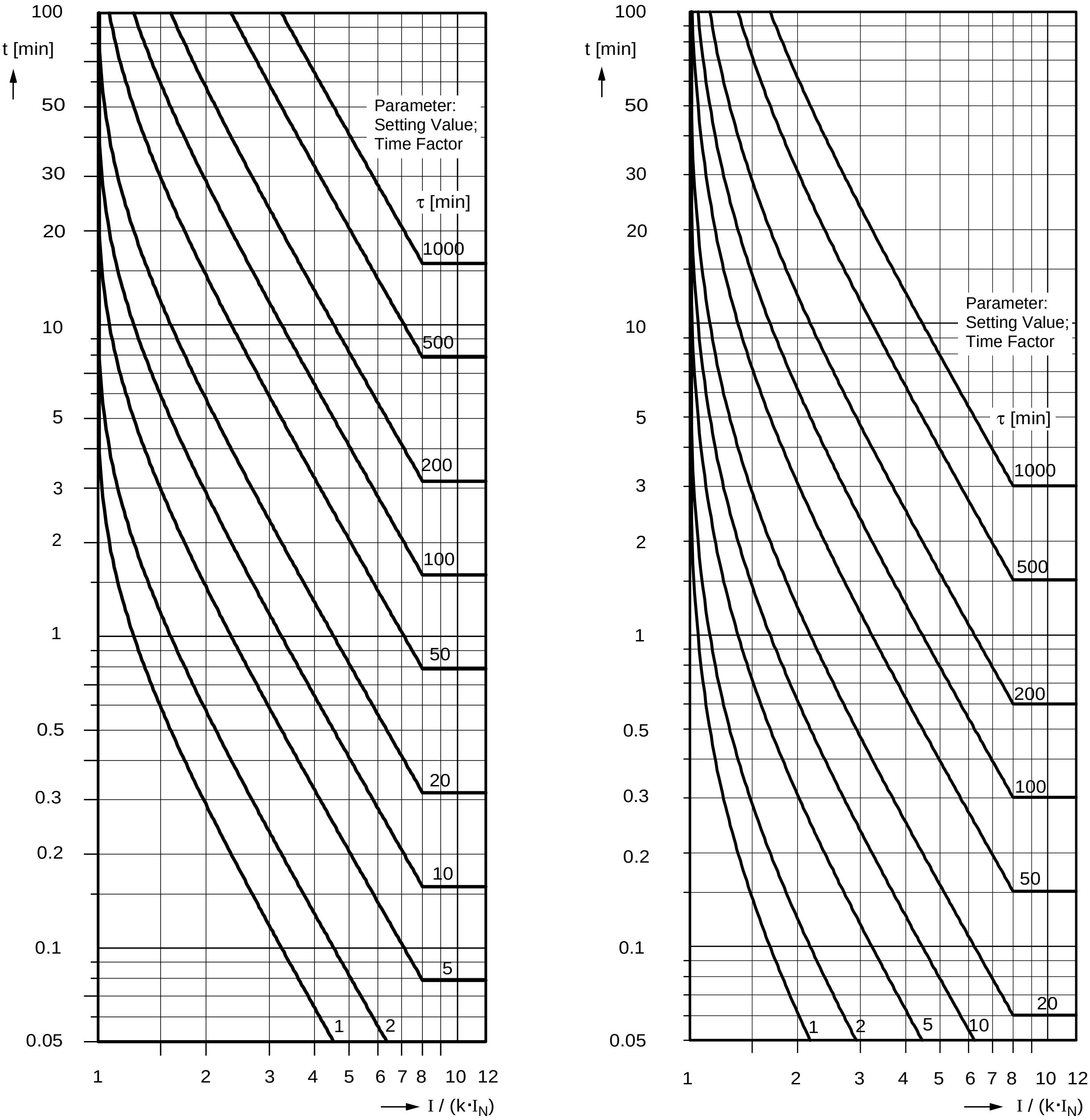
Note: The circuit breaker failure protection can also operate without the indicated circuit breaker auxiliary contacts, but the function range is then reduced. Auxiliary contacts are necessary for the circuit breaker failure protection for tripping without or with a very low current flow (e.g. Buchholz protection), stub fault protection, circuit breaker pole discrepancy monitoring.

1) Secondary values based on I_N = 1 A; for I_N = 5 A the currrent values are to be multiplied by 5.

Initiation Conditions	For circuit breaker failure protection	single-pole tripping internal three-pole tripping internal single-pole tripping external [1]) three-pole tripping external [1]) three-pole tripping without current [1]) [1]) via binary inputs
Times	Pick-up time	approx. 7 ms with measured quantities present prior to start, approx. 20 ms after switch-on of measured values
	Drop-off time,internal (overshoot time)	approx. 12 ms for sinusoidal measured values, approx. 25 ms maximum
	Delay times for all stages	0.00 s to 30.00 s; ∞ (steps 0.01 s)
	Tolerance	1 % of the set value or 10 ms
End Fault Protection	With trip command transmission to the remote end	
	Delay times for all stages	0.00 s to 30.00 s; ∞ (steps 0.01 s)
	Tolerance	1 % of the set value or 10 ms
Breaker Pole Discrepancy Monitoring	Initiation criterion	not all poles are closed or open
	Monitoring time	0.00 s to 30.00 s; ∞ (steps 0.01 s)
	Tolerance	1 % of the set value or 10 ms

10.17 Thermal Overload Protection

Setting Ranges	Factor k according to IEC 60255–8	0.10 to 4.00	(steps 0.01)
	Time factor τ	1.0 min to 999.9 min	(steps 0.1 min)
	Alarm temperaturerise $\Theta_{alarm}/\Theta_{trip}$	50 % to 100 % related to the trip temperaturerise	(steps 1 %)
	Current alarm stage I_{alarm}	0.10 A to 4.00 A^1)	(steps 0.01 A ^{1})
	^{1}) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied with 5.		
Calculation Method	Calculation method temperaturerise	maximum temperaturerise of 3 phases means of temperaturerise of 3 phases temperature rise from maximum current	
Tripping Characteristic		see Figure 10-6	
	Tripping characteristic for $(I/ k \cdot I_N) \leq 8$	$t = \tau \cdot ln\frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1}$	
	Meaning of abbreviations:	t	Tripping time
		τ	Temperature rise time factor
		I	Load current
		I_{pre}	Previous load current
		k	Setting factor according to IEC 60255–8
		I_N	Rated current of protected object
Drop-off Ratios	Θ/Θ_{trip}	drop-off with Θ_{alarm}	
	Θ/Θ_{alarm}	approx. 0.99	
	I/I_{alarm}	approx. 0.97	
Tolerances	Relating to $k \cdot I_N$	2 %, or. 10 mA^1); class 2 % according to IEC 60 255–8	
	Relating to Tripping time	3 %, or. 1 s; class 3 % according to IEC 60 255–8 for $I/(k \cdot I_N) > 1.25$	
	^{1}) Secondary values based on I_N = 1 A; for I_N = 5 A they must be multiplied by 5.		
Influencing Quantities relating to $k \cdot I_N$	Auxiliary direct voltage range $0.8 \leq U_{DC}/U_{NDC} \leq 1.15$	1 %	
	Temperaturerange $-5\ °C \leq \vartheta_{amb} \leq 55\ °C$	0.5 %/10 K	
	Frequency range $0.95 \leq f/f_N \leq 1.05$	1 %	



without Previous Load Current:

with 90 % Previous Load Current:

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [\mathrm{min}]$$

$$t = \tau \cdot ln \frac{\left(\frac{I}{k \cdot I_N}\right)^2 - \left(\frac{I_{pre}}{k \cdot I_N}\right)^2}{\left(\frac{I}{k \cdot I_N}\right)^2 - 1} \quad [\mathrm{min}]$$

Figure 10-6 Tripping characteristic of the thermal overload protection

10.18 Monitoring Functions

Measured Values	Current sum	$I_F = \|\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} + k_I \cdot \underline{I}_E\| >$ SUM.I Threshold · I_N + SUM.I factor· I_{max}	
	– SUM.I Threshold	0.05 A to 2.00 A	(steps 0.01)
	– SUM.I factor	0.00 to 0.95	(steps 0.01)
	Voltage sum	$U_F = \|\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3} + k_U \underline{U}_{EN}\| > 25\ V$	
	Current symmetry	$\|I_{min}\| / \|I_{max}\| <$ BAL.FACTOR I as long as $I_{max} / I_N >$ BAL.I LIMIT / I_N	
	– BAL.FACTOR I	0.10 to 0.95	(steps 0.01)
	– BAL.I LIMIT	0.10 A to 1.00 A	(steps 0.01 A)
	Broken conductor	one conductor without current, the others with current	
	Voltage symmetry	$\|U_{min}\| / \|U_{max}\| <$ BAL.FACTOR U as long as |Umax| > BAL.U LIMIT	
	– BAL.FACTOR U	0.58 to 0.95	(steps 0.01)
	– BAL.U LIMIT	10 V to 100 V	(steps 1 V)
	Voltage phase rotation	$\underline{U}_{L1}$ before $\underline{U}_{L2}$ before $\underline{U}_{L3}$ as long as $\|\underline{U}_{L1}\|,\ \|\underline{U}_{L2}\|,\ \|\underline{U}_{L3}\| > 40\ V/\sqrt{3}$	
	Fuse–Failure–Monitor (non-symmetrical voltages)	$3 \cdot U_0 >$ *FFM U>* OR $3 \cdot U_2 >$ *FFM U>* *AND* at the same time $3 \cdot I_0 <$ *FFM I<* AND $3 \cdot I_2 <$ *FFM I<*	
	– FFM U>	10 V to 100 V	(steps 0.01 V)
	– FFM I<	0.10·A to 1.00·A[1]	(steps 0.01·A)
	Fuse–Failure–Monitor (three-phase)	all $U_{Ph\text{-}E} <$ FFM U<max *AND* at the same time all $\Delta I_{Ph} <$ FFM Idelta *AND* all $I_{Ph} > (I_{Ph}>$ (Dist.)) *OR* all $U_{Ph\text{-}E} <$ FFM U<max *AND* at the same time all $I_{Ph} < (I_{Ph}>$ (Dist.)) *AND* all $I_{Ph} > 40$ mA	
	– FFM U<max	2 V to 100 V	(steps 1 V)
	– FFM I_{delta}	0.05·A to 1.00·A[1]	(steps 0.01·A)

[1] Secondary values based on $I_N = 1$ A; for $I_N = 5$ A they must be multiplied by 5.

Trip Circuit Supervision	Number of monitored circuits	1 to 3	
	Operation	with 1 binary input or with 2 binary inputs	
	Alarm delay	1 s to 30 s	(steps 1 s)

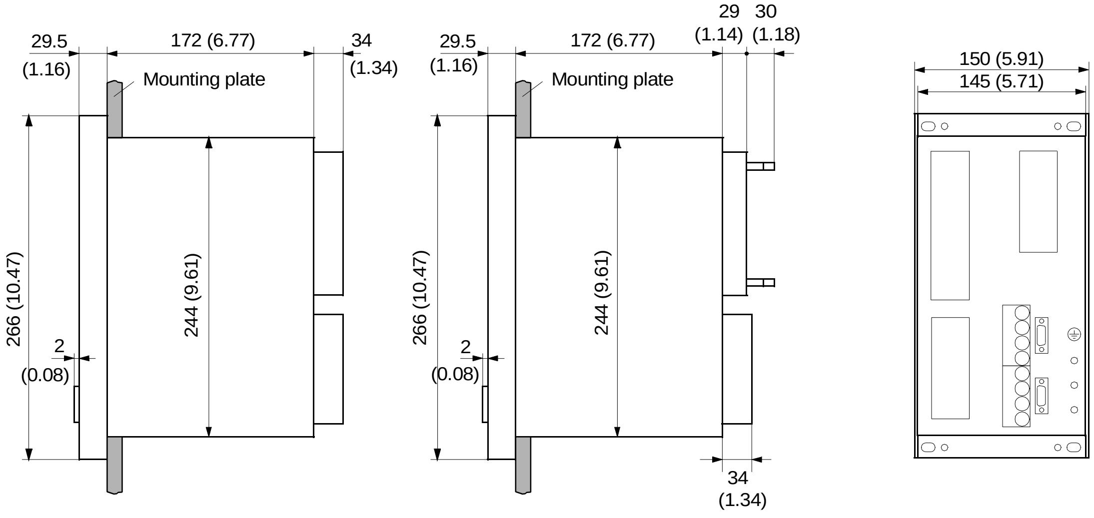
10.19 Supplementary Functions

Measured Value Processing	Operational measured values of currents	I_{L1}; I_{L2}; I_{L3}; $3I_0$; I_1; I_2; I_Y; I_P in A primary and secondary and in % I_N
	– Tolerance	0.5 % of measured value or 0.5 % of I_N
	Operational measured values of voltages	U_{L1-E}; U_{L2-E}; U_{L3-E}; U_X in kV primary and V second. and % $U_N/\sqrt{3}$
	– Tolerance	0.5 % of measured value or 0.5 % of U_N
	Operational measured values of voltages	$3U_0$ in kV primary and V secondary and % $U_N \cdot \sqrt{3}$
	– Tolerance	0.5 % of measured value or 0.5 % of U_N
	Operational measured values of voltages	U_{L1-L2}; U_{L2-L3}; U_{L3-L1}; U_1; U_2; U_x in kV primary and V secondary and % U_N
	– Tolerance	0.5 % of measured value or 0.5 % of U_N
	Operational measured values of impedances	R_{L1-E}; R_{L2-E}; R_{L3-E}; R_{L1-L2}; R_{L2-L3}; R_{L3-L1}; X_{L1-E}; X_{L2-E}; X_{L3-E}; X_{L1-L2}; X_{L2-L3}; X_{L3-L1} in Ω primary and secondary
	Operational measured values of power	S; P; Q (apparent, active and reactive power) in MVA; MW; Mvar primary and % S_N (operational nominal power) = $\sqrt{3} \cdot U_N \cdot I_N$
	– Tolerance	1 % of measured value or 1 MVA/MW/Mvar
	Operational measured values of power factor	cos φ
	– Tolerance	0.02
	Operational measured value of frequency	f in Hz and % f_N
	– Range	96 % to 104 % of f_N
	– Tolerance	10 mHz or 0.2 %
	Thermal measured values	$\Theta_{L1}/\Theta_{TRIP}$; $\Theta_{L2}/\Theta_{TRIP}$; $\Theta_{L3}/\Theta_{TRIP}$; Θ/Θ_{TRIP} related to tripping temperature rise
	Operational measured values of synchro check	U_{line}; U_{sync}; U_{diff} in kV primary f_{line}; f_{sync}; f_{diff} in Hz; φ_{diff} in °
	Measured values of earth fault detection in non-earthed systems	I_{Ea}; I_{Er} (active and reactive component of earth fault current (residual current) in A primary and mA secondary

	Long–term mean value	I_{L1}dmd; I_{L2}dmd; I_{L3}dmd; I_1dmd; Pdmd; Pdmd Forw, Pdmd Rev; Qdmd; Qdmd Forw; Qdmd Rev; Sdmd in primary values
	Minimum and maximum values	I_{L1}; I_{L2}; I_{L3}; I_1; I_{L1}d; I_{L2}d; I_{L3}d; I_1d; U_{L1-E}; U_{L2-E}; U_{L3-E}; U_1; U_{L1-L2}; U_{L2-L3}; U_{L3-L1};$3U_0$; P Forw; P Rev; Q Forw; Q Rev; S; Pd; Qd; Sd; cos φ Pos; cos φ Neg; f in primary values
Analog Outputs (optional)	Quantity	max. 4 (dependent on order variant)
	Possible measured values	I_{L2}; U_{L2-L3}; |P|; |Q| in %
	Possible fault values	fault distance d in % or km/miles; latest max. fault current
	Range	0 mA to 22.5 mA
	Output time for fault values	0.10 s to 30.00 s; ∞ (steps 0.01 s)
Operation Event Log Buffer	Capacity	200 records
Earth Fault Detection Buffer (Non-earthed Systems)	Capacity	8 earth faults with a total sum of max. 200 records
Fault Protocol (Trip Log Buffer)	Capacity	8 faults with a total sum of max. 600 records
Fault Recording	Number of stored fault records	max. 8
	Total storage period	max. 5 s for each fault
		approx. 15 s totally
	Sampling rate at f_N = 50 Hz	1 ms
	Sampling rate at f_N = 60 Hz	0.83 ms
Statistics	Number of trip events caused by 7SA6	pole segregated
	Total of interrupted currents caused by 7SA6	pole segregated
Real Time Clock and Buffer Battery	Resolution for operational events	1 ms
	Resolution for fault events	1 ms
	Buffer battery	3 V/1 Ah, type CR 1/2 AA self-discharging time approx. 10 years

10.20 Dimensions

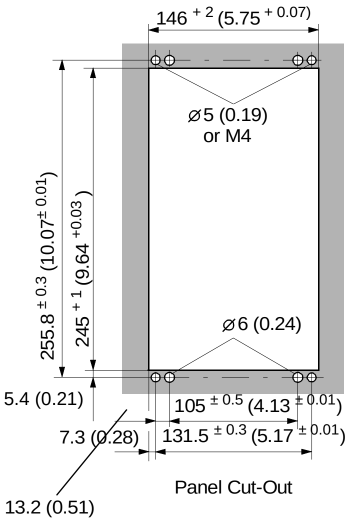
Housing for Panel Flush Mounting or Cubicle Installation (Size $^1/_3$ x 19”)



Side View (with screwed terminals)

Side View (with plug-in terminals)

Rear View



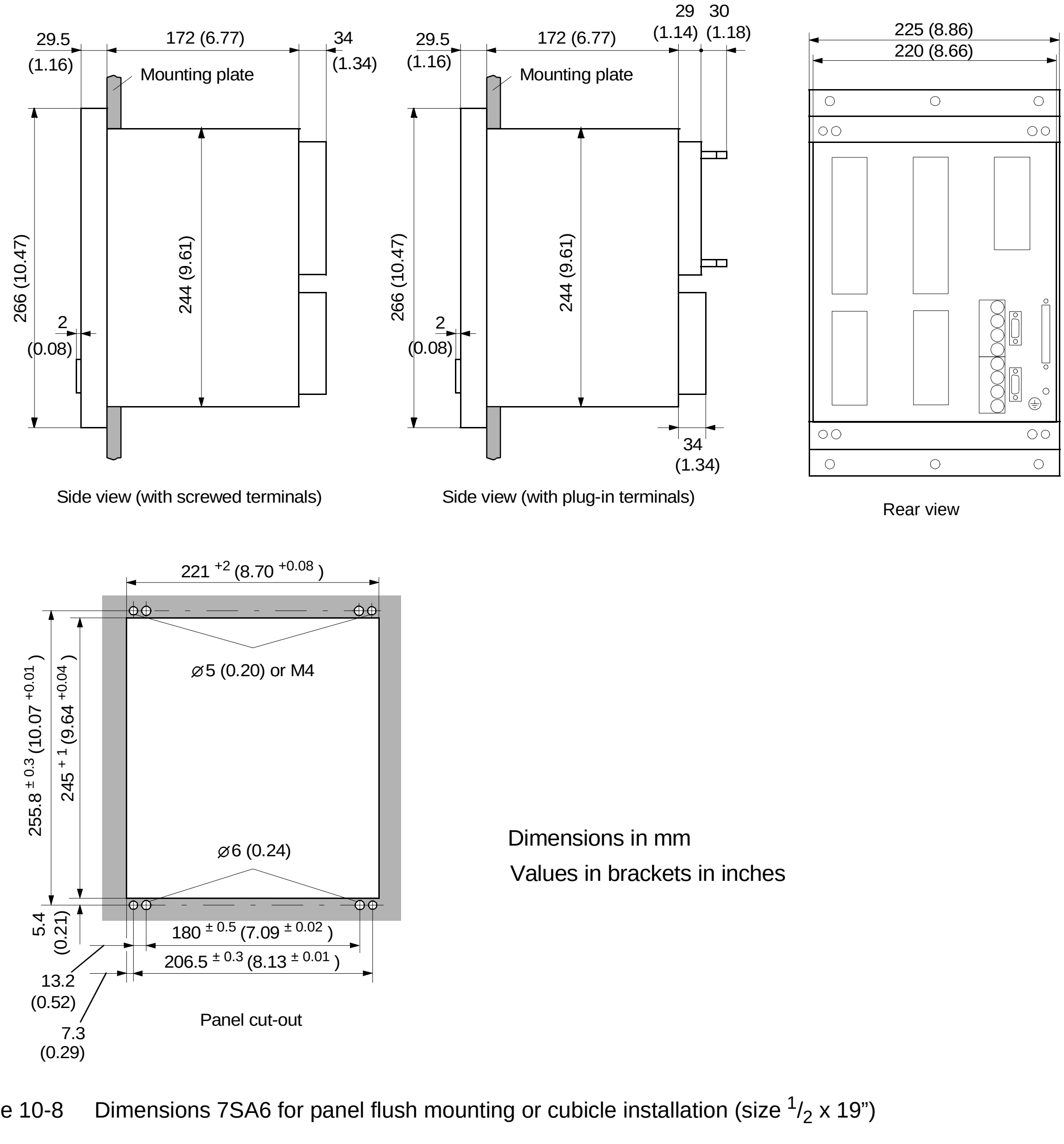
Panel Cut-Out

Dimensions in mm

Values in brackets in inches

Figure 10-7 Dimensions 7SA6 for panel flush mounting or cubicle installation (size $^1/_3$ x 19”)

Housing for Panel Flush Mounting or Cubicle Installation (Size $^1/_2$ x 19")


Side view (with screwed terminals)

Side view (with plug-in terminals)

Rear view

Panel cut-out

Dimensions in mm

Values in brackets in inches

Figure 10-8 Dimensions 7SA6 for panel flush mounting or cubicle installation (size $^1/_2$ x 19")

Housing for Panel Flush Mounting or Cubicle Installation (Size $^1/_1$ x 19”)

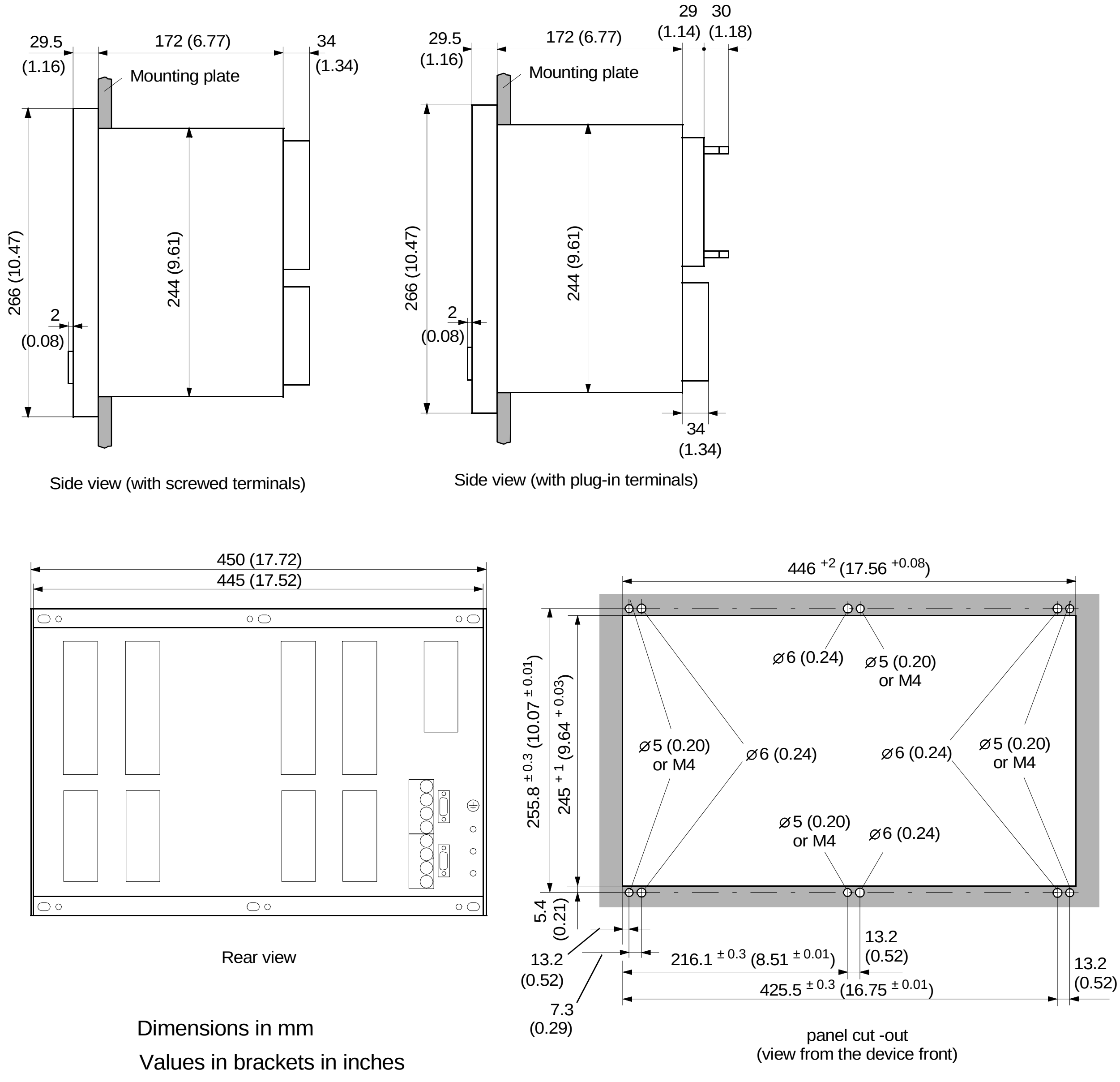
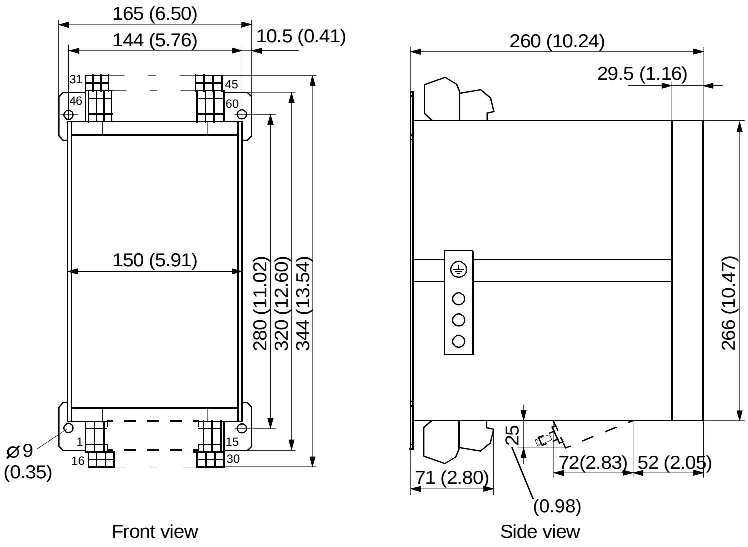


Figure 10-9 Dimensions 7SA6 for panel flush mounting or cubicle installation (size $^1/_1$ x 19”)

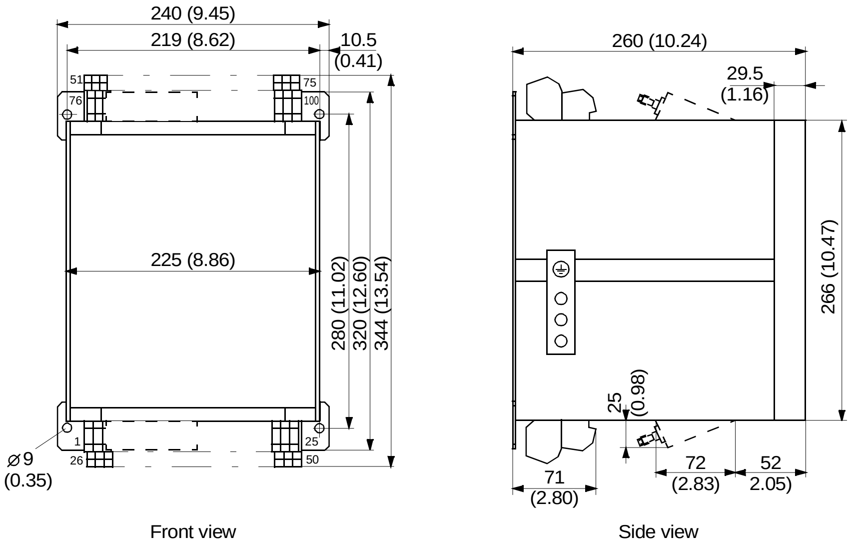
Housing for Panel Surface Mounting (Size $^1/_3$ x 19”)



Dimensions in mm
Values in brackets in inches

Figure 10-10 Dimensions 7SA6 for panel surface mounting (size $^1/_3$ x 19”)

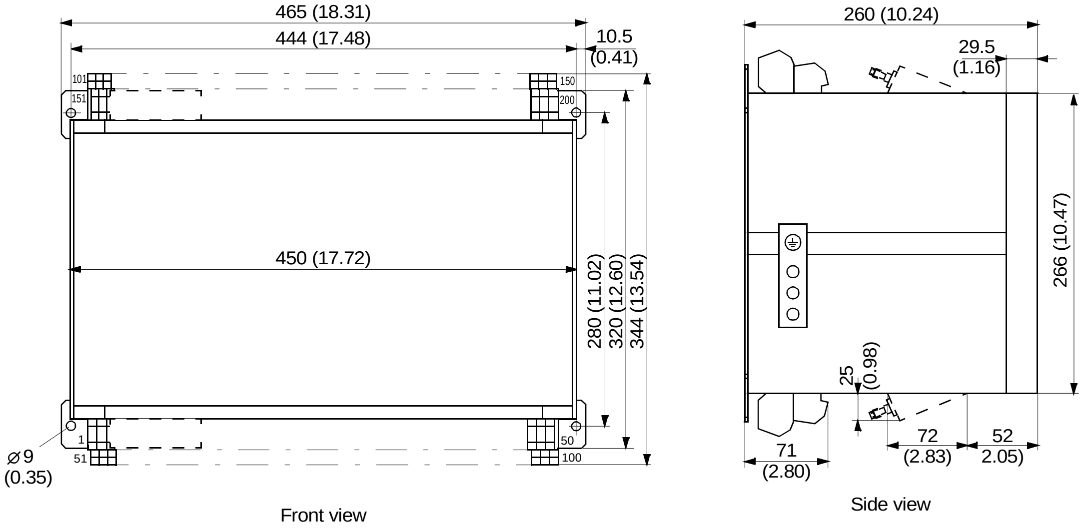
Housing for Panel Surface Mounting (Size $^1/_2$ x 19”)



Dimensions in mm
Values in brackets in inches

Figure 10-11 Dimensions 7SA6 for panel surface mounting (size $^1/_2$ x 19”)

Housing for Panel Surface Mounting (Size $^1/_1$)

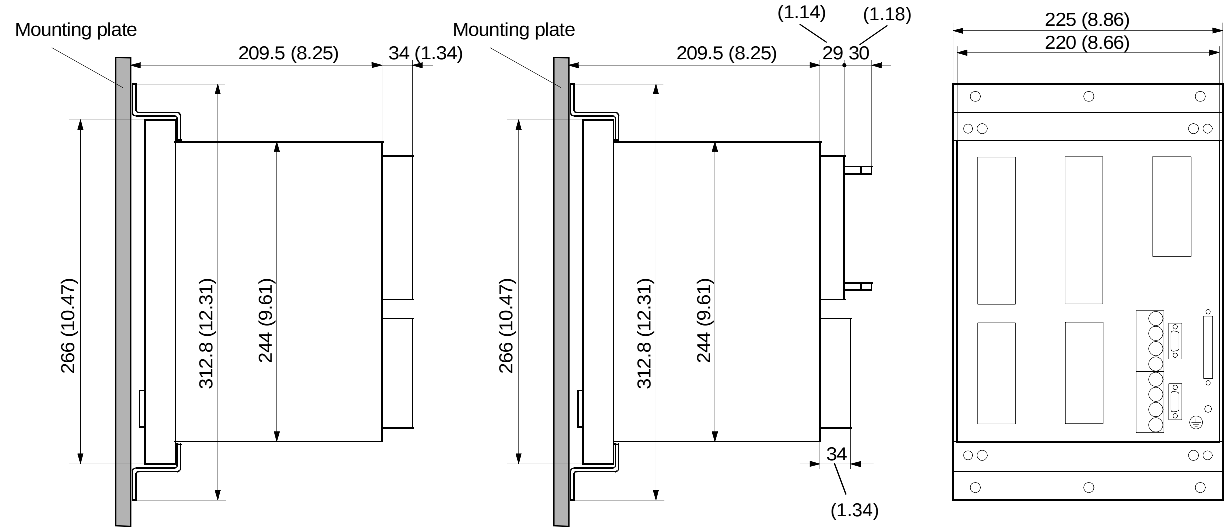


Dimensions in mm

Values in brackets in inches

Figure 10-12 Dimensions 7SA6 for panel surface mounting (size $^1/_1$ x 19”)

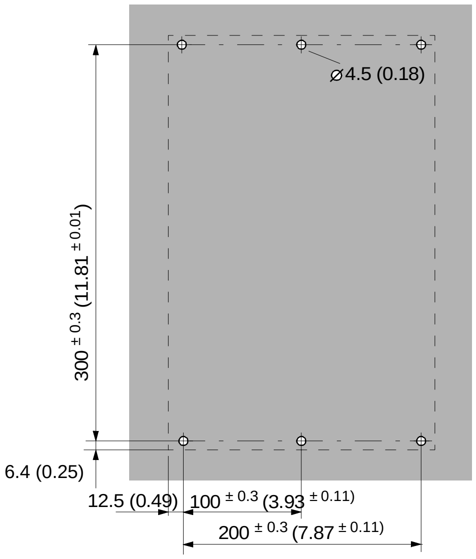
Housing for Mounting with Detached Operator Panel (Size $^1/_2$ x 19”)



Side view (with screw terminals)

Side view (with plug-in terminals)

Side view



Mounting Holes of
Mounting Plate

Dimensions in mm
Values in brackets in inches

Figure 10-13 Dimensions 7SA6 for mounting with detached operator panel (size $^1/_2$ x 19”)

Housing for Mounting with Detached Operator Panel (Size $^1/_1$ x 19”)

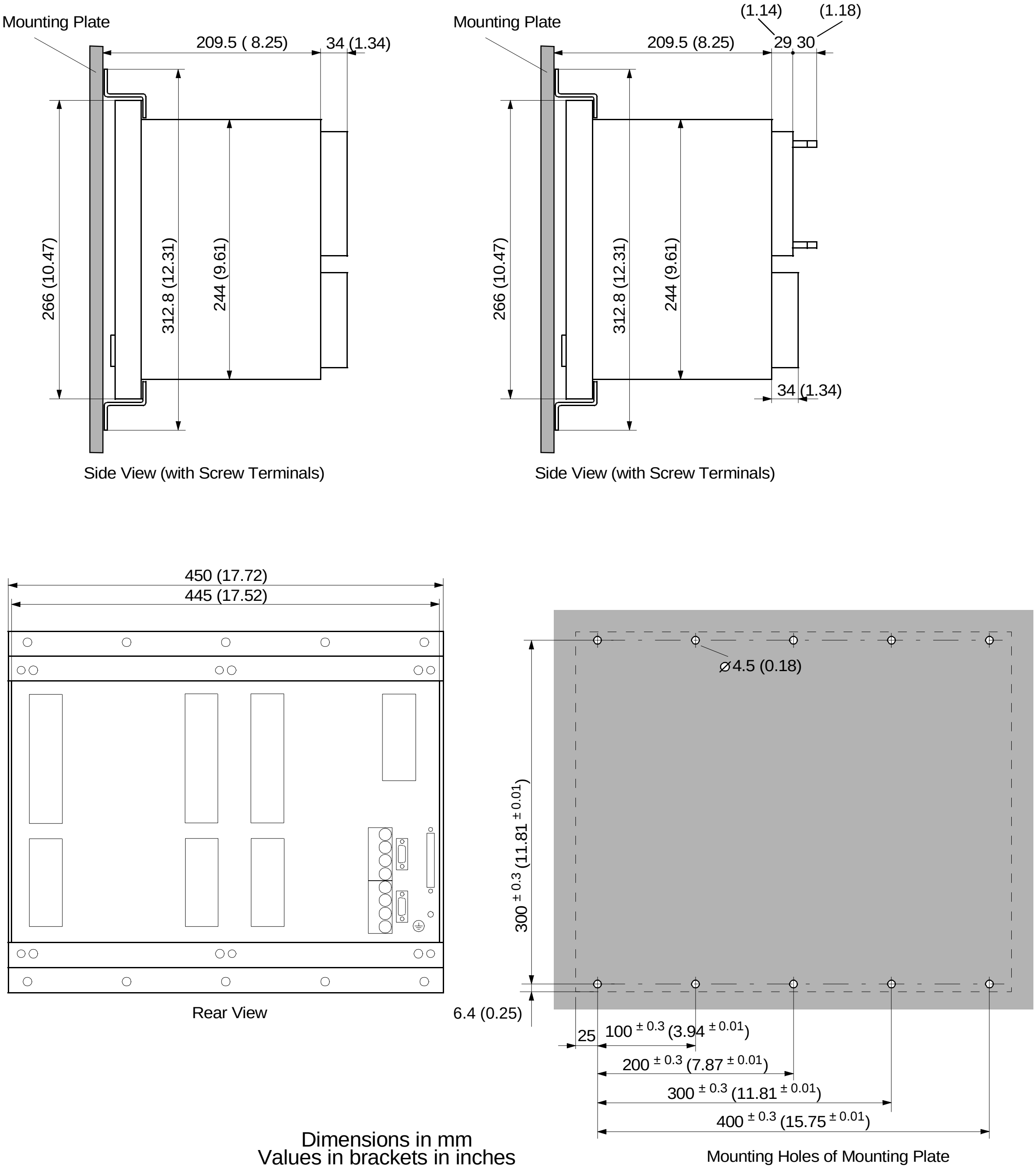
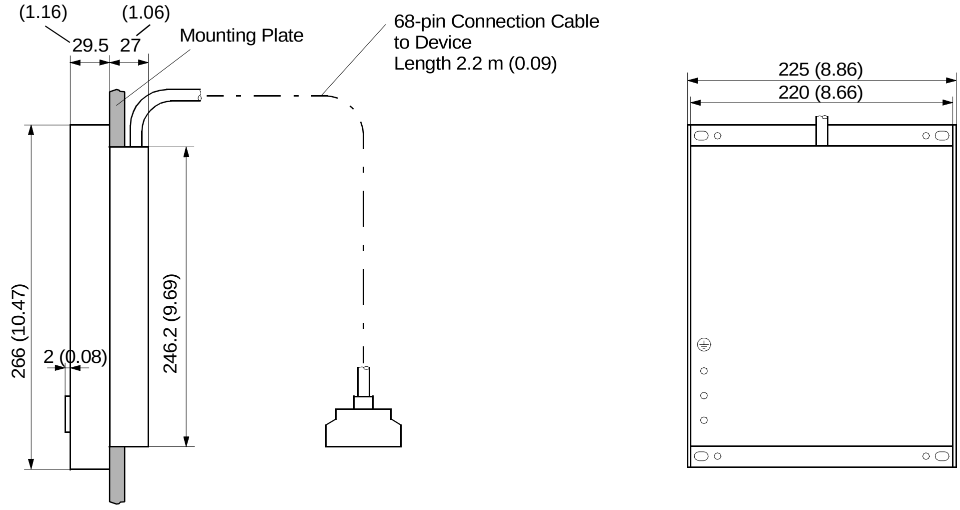


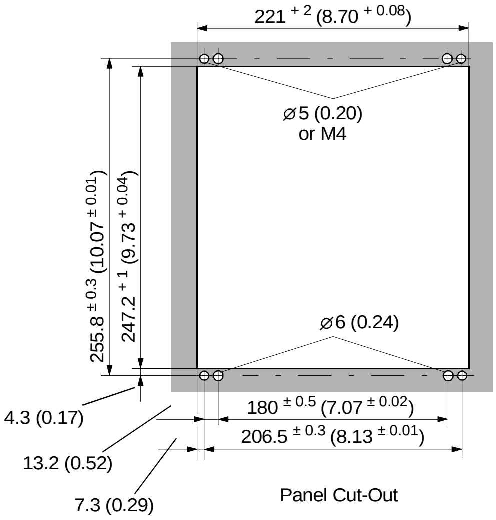
Figure 10-14 Dimensions 7SA6 for mounting with detached operator panel (size $^1/_1$ x 19”)

Detached Operator Panel



Side View

Rear View



Panel Cut-Out

Figure 10-15 Dimensions of a detached operator panel for a 7SA6 device

■

Appendix A

This appendix is primarily a reference for the experienced user. This Chapter provides ordering information for the models of 7SA6. General diagrams indicating the terminal connections of the 7SA6 models are included. Connection examples show the proper connections of the device to primary equipment in typical power system configurations. Tables with all settings and all information available in a 7SA6 equipped with all options are provided.

A.1 Ordering Information and Accessories

5 6 7 – 8 9 10 11 12 – 13 14 15 16

Digital Distance Protection (position 1 to 9) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Version

Distance Protection with 4-line display)	1

Type of Device

Distance Protection, medium voltage / high voltage, housing size $^1/_3$ x 19“	0

Measured Current Inputs (4 x U, 4 x I)

Iph = 1 A, Ie = 1 A (min. = 0.05 A)	1
Iph = 1 A, Ie = sensitive (min. = 0.005 A)	2
Iph = 5 A, Ie = 5 A (min. = 0.25 A)	5
Iph = 5 A, Ie = sensitive (min. = 0.005 A)	6

Auxiliary Voltage (PowerSupply, Pick-up Threshold of Binary Inputs)

DC 24 V to 48 V, Threshold Binary Input 17 V 2)	2
DC 60 V to 125 V 1), Threshold Binary Input 17 V 2)	4
DC 110 V to 250 V 1), AC 115 V, Threshold Binary Input 73 V 2)	5

Housing / Number of Binary Inputs (BI) and Outputs (BO)
BI = Binary Inputs, BO = Binary Outputs

Flush mounting housing, $^1/_3$ x 19“, 5 BI, 8 BO, 1 Live status contact	A
Flush mounting housing, $^1/_3$ x 19“, 7 BI, 5 BO, 1 Live status contact	B
Surface mounting housing, $^1/_3$ x 19“, 5 BI, 8 BO, 1 Live status contact	E
Surface mounting housing, $^1/_3$ x 19“, 7 BI, 5 BO, 1 Live status contact	F
Flush mounting housing with plug-in terminals, $^1/_3$ x 19“, 5 BI, 8 BO, 1 Live status contact	J
Flush mounting housing with plug-in terminals, $^1/_3$ x 19“, 7 BI, 5 BO, 1 Live status contact	K

1) with plug-in jumper one of the 2 voltage ranges can be selected
2) for each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

For details on positions 10 to 16 see page A-7 and A-8

5 6 7 – 8 9 10 11 12 – 13 14 15 16

Digital Distance Protection (position 1 to 9) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Version	
Distance Protection with 4-line display	1
Distance Protection with graphic display and control keys (integrated)	3

Type of Device	
Distance Protection, medium voltage / high voltage, housing size $^1/_2$ x 19“	1

Measured Current Inputs (4 x U, 4 x I)	
Iph = 1 A, Ie = 1 A (min. = 0.05 A)	1
Iph = 1 A, Ie = sensitive (min. = 0.005 A)	2
Iph = 5 A, Ie = 5 A (min. = 0.25 A)	5
Iph = 5 A, Ie = sensitive (min. = 0.005 A)	6

Auxiliary Voltage (Powersupply, Pick-up Threshold of Binary Inputs)	
DC 24 V to 48 V, Threshold Binary Input 17 V 2)	2
DC 60 V to 125 V 1), Threshold Binary Input 17 V 2)	4
DC 110 V to 250 V 1), AC 115 V, Threshold Binary Input 73 V 2)	5

Housing / Number of Binary Inputs (BI) and Outputs (BO) **BI = Binary Inputs, BO = Binary Outputs**	
Flush mounting housing, $^1/_2$ x 19“, 13 BI, 16 BO (7 fast), 1 Live status contact	A
Flush mounting housing, $^1/_2$ x 19“, 20 BI, 8 BO, 4 (2) Power Relay, 1 Live status contact	B
Surface mounting housing, $^1/_2$ x 19“, 13 BI, 16 BO (7 fast), 1 Live status contact	E
Surface mounting housing, $^1/_2$ x 19“, 20 BI, 8 BO, 4 (2) Power Relay, 1 Live status contact	F
Flush mounting housing with plug-in terminals, $^1/_2$ x 19“, 13 BI, 16 BO (7 fast), 1 Live status contact	J
Flush mounting housing with plug-in terminals, $^1/_2$ x 19“, 20 BI, 8 BO, 4 (2) Power Relay, 1 Live status contact	K

4 (2) Power Relay: 4 Power Relay (can be used in pairs)

1) with plug-in jumper one of the 2 voltage ranges can be selected
2) for each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

For details on positions 10 to 16 see page A-7 and A-8

5 6 7 – 8 9 10 11 12 – 13 14 15 16

Digital Distance Protection (position 1 to 9) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Version

Distance Protection with 4-line display)	1
Distance Protection with graphic display and control keys (integrated)	3

Type of Device

Distance Protection, medium voltage / high voltage, housing size $^1/_1$ x 19“	2

Measured Current Inputs (4 x U, 4 x I)

Iph = 1 A, Ie = 1 A (min. = 0.05 A)	1
Iph = 1 A, Ie = sensitive (min. = 0.005 A)	2
Iph = 5 A, Ie = 5 A (min. = 0.25 A)	5
Iph = 5 A, Ie = sensitive (min. = 0.005 A)	6

Auxiliary Voltage (Power Supply, Pick-up Threshold of Binary Inputs)

DC 24 V to 48 V, Threshold Binary Input 17 V 2)	2
DC 60 V to 125 V 1), Threshold Binary Input 17 V 2)	4
DC 110 V to 250 V 1), AC 115 V, Threshold Binary Input 73 V 2)	5

Housing / Number of Binary Inputs (BI) and Outputs (BO)
BI = Binary Inputs, BO: = Binary Outputs

Flush mounting housing, $^1/_1$ x 19“, 21 BI, 24 BO (7 fast), 1 Live status contact	A
Flush mounting housing, $^1/_1$ x 19“, 29 BI, 32 BO (7 fast), 1 Live status contact	B
Flush mounting housing, $^1/_1$ x 19“, 33 BI, 11 BO, 8 (4) Power Relay, 1 Live status contact	C
Surface mounting housing, $^1/_1$ x 19“, 21 BI, 24 BO (7 fast), 1 Live status contact	E
Surface mounting housing, $^1/_1$ x 19“, 29 BI, 32 BO (7 fast), 1 Live status contact	F
Surface mounting housing, $^1/_1$ x 19“, 33 BI, 11 BO, 8 (4) Power Relay, 1 Live status contact	G
Flush mounting housing with plug-in terminals, $^1/_1$ x 19“, 21 BI, 24 BO (7 fast), 1 Live status contact	J
Flush mounting housing with plug-in terminals, $^1/_1$ x 19“, 29 BI, 32 BO (7 fast), 1 Live status contact	K
Flush mounting housing with plug-in terminals, $^1/_1$ x 19“, 33 BI, 11 BO, 8 (4) Power Relay, 1 Live status contact	L

8 (4) Power Relay: 8 Power Relay (can only be used in pairs)

1) with plug-in jumper one of the 2 voltage ranges can be selected
2) for each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

For details on positions 10 to 16 see page A-7 and A-8

5 6 7 – 8 9 10 11 12 – 13 14 15 16

Digital Distance Protection (positon 1 to 9) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Version	
Distance Protection with graphic display and detached operator panel	4

Type of Device	
Distance Protection, medium voltage / high voltage, housing size $^1/_2$ x 19“	1

Measured Current Inputs (4 x U, 4 x I)	
Iph = 1 A, Ie = 1 A (min. = 0.05 A)	1
Iph = 1 A, Ie = sensitive (min. = 0.005 A)	2
Iph = 5 A, Ie = 5 A (min. = 0.25 A)	5
Iph = 5 A, Ie = sensitive (min. = 0.005 A)	6

Auxiliary Voltage (Power supply, Pick-up Threshold of Binary Inputs)	
DC 24 V to 48 V, Threshold Binary Input 17 V ^{2})	2
DC 60 V to 125 V ^{1}), Threshold Binary Input 17 V ^{2})	4
DC 110 V to 250 V ^{1}), AC 115 V, Threshold Binary Input 73 V ^{2})	5

Housing with Detached Operator Panel / Number of Binary Inputs (BI) and Outputs (BO) **BI = Binary Inputs, BO: = Binary Outputs**	
Housing, $^1/_2$ x 19“, with screwed terminals, 13 BI, 16 BO (7 fast), 1 Live status contact	A
Housing, $^1/_2$ x 19“, with screwed terminals, 20 BI, 8 BO, 4 (2) Power Relay, 1 Live status contact	B
Housing, $^1/_2$ x 19“, plug-in terminals, 13 BI, 16 BO (7 fast), 1 Live status contact	J
Housing, $^1/_2$ x 19“, plug-in terminals, 20 BI, 8 BO, 4 (2) Power Relay, 1 Live status contact	K

4 (2) Power Relay: 4 Power Relay (can only be used in pairs)

1) with plug-in jumper one of the 2 voltage ranges can be selected
2) for each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

For details on positions 10 to 16 see page A-7 and A-8

5 6 7 8 9 10 11 12 13 14 15 16

Digital Distance Protection (position 1 to 9) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Version	
Distance Protection with graphic display and detached operator panel	4

Type of Device	
Distance Protection, medium voltage / high voltage, housing size $^1/_1$ x 19“	2

Measured Current Inputs (4 x U, 4 x I)	
Iph = 1 A, Ie = 1 A (min. = 0.05 A)	1
Iph = 1 A, Ie = sensitive (min. = 0.005 A)	2
Iph = 5 A, Ie = 5 A (min. = 0.25 A)	5
Iph = 5 A, Ie = sensitive (min. = 0.005 A)	6

Auxiliary Voltage (Powersupply, Pick-up Threshold of Binary Inputs)	
DC 24 V to 48 V, Threshold Binary Input 17 V ^{2})	2
DC 60 V to 125 V ^{1}), Threshold Binary Input 17 V ^{2})	4
DC 110 V to 250 V ^{1}), AC 115 V, Threshold Binary Input 73 V ^{2})	5

Housing with Detached Operator Panel / Number of Binary Inputs (BI) and Outputs (BO) **BI = Binary Inputs, BO = Binary Outputs**	
Housing, $^1/_1$ x 19“, with screwed terminals, 21 BI, 24 BO (7 fast), 1 Live status contact	A
Housing, $^1/_1$ x 19“, with screwed terminals, 29 BI, 32 BO (7 fast), 1 Live status contact	B
Housing, $^1/_1$ x 19“, with screwed terminals, 33 BI, 11 BO, 8 (4) Power Relay, 1 Live status contact	C
Housing, $^1/_1$ x 19“, plug-in terminals, 21 BI, 24 BO (7 fast), 1 Live status contact	J
Housing, $^1/_1$ x 19“, plug-in terminals, 29 BI, 32 BO (7 fast), 1 Live status contact	K
Housing, $^1/_1$ x 19“, plug-in terminals, 33 BI, 11 BO, 8 (4) Power Relay, 1 Live status contact	L

8 (4) Power Relay: 8 Power Relay (can be used in pairs)

1) with plug-in jumper one of the 2 voltage ranges can be selected
2) for each binary input one of 2 pick-up threshold ranges can be selected with plug-in jumper

For details on positions 10 to 16 see page A-7 and A-8

5 6 7 8 9 10 11 12 13 14 15 16

Distance Protection (position 10 to 12) **7SA6** ☐☐☐ – ☐☐☐☐☐ – ☐☐☐☐

Region-Specific Default/Language Settings and Function Versions	
Region GE, language German (language can be changed)	A
Region world, language English (GB) (language can be changed)	B
Region US, language English (USA) (language can be changed)	C
Region world, language German (language cannot be changed)	M
Region world, 50/60 Hz, IEC/ANSI, language English (GB) (language cannot be changed)	N
Region US, 60 Hz, ANSI, language English (USA) (language cannot be changed)	P

Regulations on region-specific presettings and function versions:
Region US and World: Stub bus DT visible by other kind of protection function
Region GE: Stub bus DT not visible by other kind of protection function; no ANSI; no miles
Region US: f = 60 Hz; only ANSI-curves; fault detector preset to miles

Port B: Function and Hardware	
None	0
System port, IEC protocol, electrical RS232	1
System port, IEC protocol, electrical RS485	2
System port, IEC protocol, optical 820 nm, ST-connector	3
System port, Profibus FMS Slave, electrical RS485	4
System port, Profibus FMS Slave, optical, single-ended ring, ST-connector	5
System port, Profibus FMS Slave, optical, double-ended ring, ST-connector	6
Analog Output 2 x 0 to 20 mA	7

Port C	
DIGSI 4, electrical RS232	1
DIGSI 4, electrical RS485	2
With Analog Output see addtional information “M”	9

Port C and Port D	+ M☐☐
DIGSI 4, electrical RS232 (Port C)	1
DIGSI 4, electrical RS485 (Port C)	2
Analog Output 2 x 0 to 20 mA (Port D)	K

see page A-8

5 6 7 8 9 10 11 12 13 14 15 16

Digital Distance Protection (positon 13 to 16)

7SA6 □□□ – □□□□□ – □□□□

Functions 1

Only three-pole tripping	without overload protection	without BCD-output fault location	0
Only three-pole tripping	without overload protection	with BCD-output fault location	1
Only three-pole tripping	with overload protection	without BCD-output fault location	2
Only three-pole tripping	with overload protection	with BCD-output fault location	3
Single-/three-pole tripping	without overload protection	without BCD-output fault location	4
Single-/three-pole tripping	without overload protection	with BCD-output fault location	5
Single-/three-pole tripping	with overload protection	without BCD-output fault location	6
Single-/three-pole tripping	with overload protection	with BCD-output fault location	7

Functions 2

Pickup I>	without power swing option	without parallel line compensation	A
Pickup U,I	without power swing option	without parallel line compensation	B
Pickup Z<, Polygon	without power swing option	without parallel line compensation	C
Pickup Z<, Polygon, U, I, φ	without power swing option	without parallel line compensation	D
Pickup Z<, Polygon	with power swing option	without parallel line compensation	F
Pickup Z<, Polygon, U, I, φ	with power swing option	without parallel line compensation	G
Pickup U,I	without power swing option	with parallel line compensation 2)	J
Pickup Z<, Polygon	without power swing option	with parallel line compensation 2)	K
Pickup Z<, Polygon, U, I, φ	without power swing option	with parallel line compensation 2)	L
Pickup Z<, Polygon	with power swing option	with parallel line compensation 2)	N
Pickup Z<, Polygon, U, I, φ	with power swing option	with parallel line compensation 2)	P

Functions 3

Automatic Reclosure	**Synchro-Check**	**Breaker Failure Protection**	**Voltage Protection**	
without	without	without	without	A
without	without	without	with	B
without	without	with	without	C
without	without	with	with	D
without	with	without	without	E
without	with	without	with	F
without	with	with	without	G
without	with	with	with	H
with	without	without	without	J
with	without	without	with	K
with	without	with	without	L
with	without	with	with	M
with	with	without	without	N
with	with	without	with	P
with	with	with	without	Q
with	with	with	with	R

Functions 4

Earth Fault Protection / Directional for Earthed Systems	**Earth Fault Detection for Resonant-Earthed / Isolated Systems**	**Measured Values, Extended, Min/Max Values**	
without	without	without	0
without	without	with	1
without	with 1)	without	2
without	with 1)	with	3
with	without	without	4
with	without	with	5
with	with 1)	without	6
with	with 1)	with	7

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1) only available with „2“ or „6“ on position 7

2) only available with „1“ or „5“ on position 7

A.1.1 Accessories

Circuit-Breaker for Voltage Transformers

Nominal Values	Order No.
Thermal 1.6 A; magnetic 6 A	3RV1611-1AG14

Interface Modules

Exchange Modules for Interfaces

Name	Order No.
RS232	C53207-A322-D631-1
RS485	C53207-A322-D632-1
LWL 820 nm	C53207-A322-D633-1
Profibus FMS RS485	C53207-A322-D601-1
Profibus FMS Doppelring	C53207-A322-D602-1
Profibus FMS Einfachring	C53207-A322-D603-1
AN20	C53207-A322-D661-1

Terminal Block Covering Caps

Terminal Block Covering Cap for Block Type	Order No.
18 terminal voltage, 12 terminal current block	C73334-A1-C31-1
12 terminal voltage, 8 terminal current block	C73334-A1-C32-1

Short Circuit Links

Short Circuit Links for Purpose / Terminal Type	Order No.
Voltage connections (18 terminal or 12 terminal)	C73334-A1-C34-1
Current connections (12 terminal, or 8 terminal)	C73334-A1-C33-1

Plug-in Connectors

Connector Type	Order No.
2 pin	C73334-A1-C35-1
3 pin	C73334-A1-C36-1

Mounting Rail for 19"-Racks

Name	Order No.
Angle Strip (Mounting Rail)	C73165-A63-C200-2

Battery

Lithium-Battery 3 V/1 Ah, Type CR 1/2 AA	Order No.
VARTA	6127 101 501

Interface Cable

An interface cable is necessary for communication between the SIPROTEC device and a PC. Requirements for the computer are Windows 95 or Windows NT4 and the operating software DIGSI® 4

Interface Cable between PC or SIPROTEC device	Order No.
Cable with 9-pin male/female connections	7XV5100-4

Operating Software DIGSI® 4

Software for setting and operating SIPROTEC® 4 devices

Operating Software DIGSI® 4	Order No.
DIGSI® 4, basic version with license for 10 computers	7XS5400-0AA00
DIGSI® 4, complete version with all option packages	7XS5402-0AA0

Graphical Analysis Program DIGRA

Software for graphical visualization, analysis and evaluation of fault data. Option package of the complete version of DIGSI® 4

Graphical Analysis Program DIGRA®	Order No.
Full version with license for 10 machines	7XS5410-0AA0

Display Editor

Software for creating basic and power system control pictures. Option package of the complete version of DIGSI® 4

Display Editor 4	Order No.
Full version with license for 10 machines	7XS5420-0AA0

Graphic Tools

Graphical Software to aid in the setting of characteristic curves and provide zone diagrams for overcurrent and distance protective devices. Option package of the complete version of DIGSI® 4.

Graphic Tools 4	Order No.
Full version with license for 10 machines	7XS5430-0AA0

DIGSI REMOTE 4

Software for remote operating protective devices via a modem (and possibly a star connector) using DIGSI® 4. (Option package of the complete version of DIGSI® 4.

DIGSI REMOTE 4	Order No.
Full version with license for 10 machines	7XS5440-1AA0

SIMATIC CFC 4

Software for graphical setting interlocking (latching) control conditions and creating additional function is SIPROTEC 4 devices. Option package for the complete version of DIGSI® 4.

SIMATIC CFC 4	Order No.
Full version with license for 10 machines	7XS5450-0AA0

A.2 General Diagrams

A.2.1 Panel Flush Mounting or Cubicle Mounting

7SA610∗–∗A/J

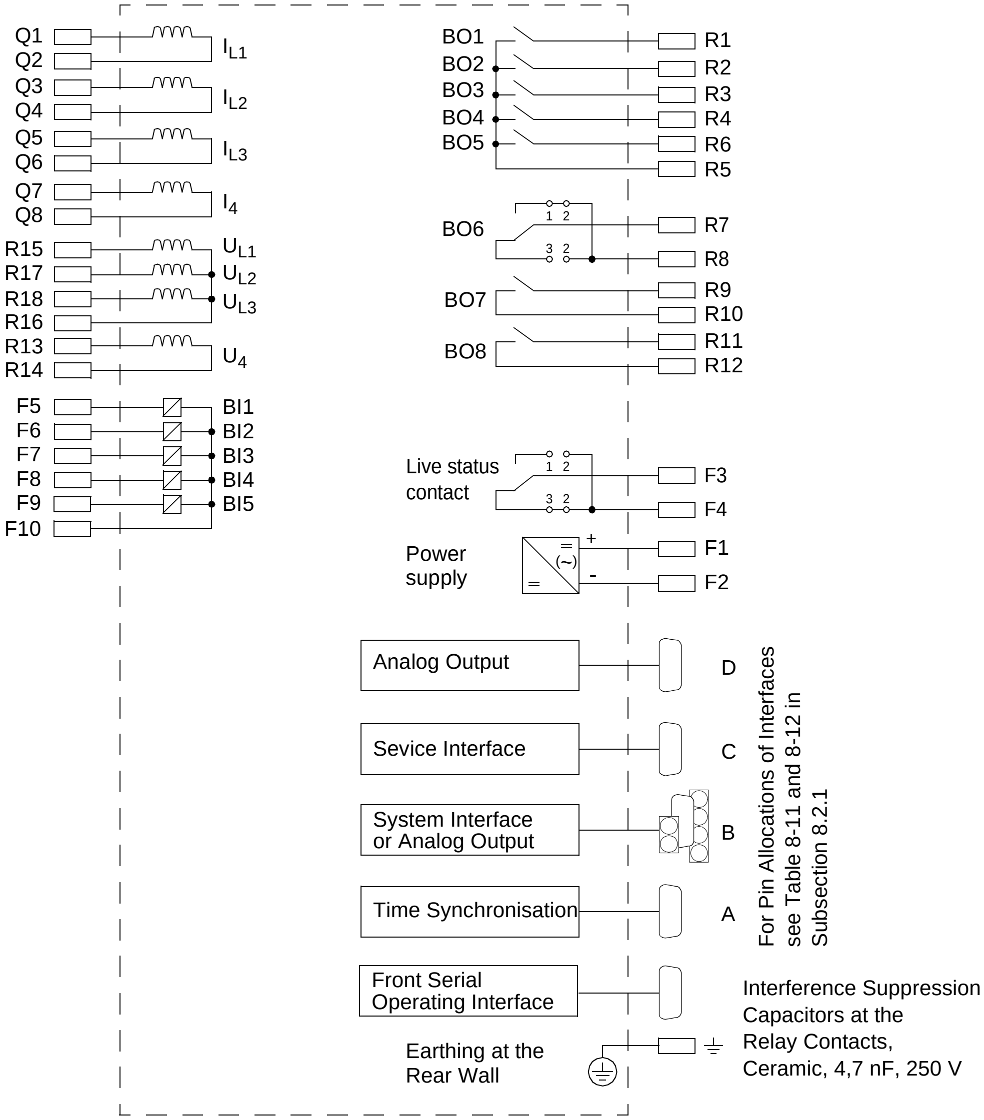


Figure A-1 General Diagram 7SA610∗–∗A/J (panel flush mounted or cubicle mounted)

7SA610∗–∗B/K

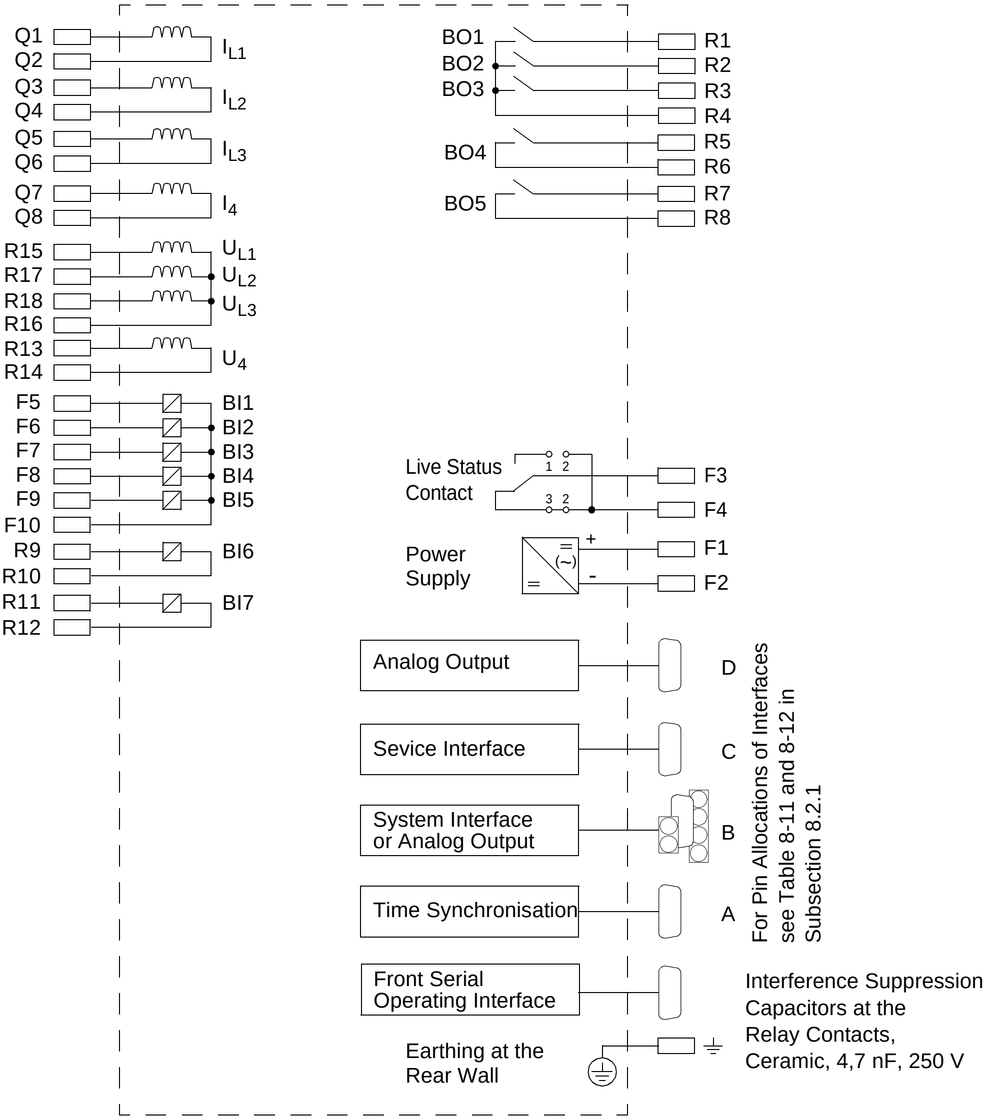


Figure A-2 General Diagram 7SA610∗–∗B/K (panel flush mounted or cubicle mounted)

7SA6∗1∗–∗A/J

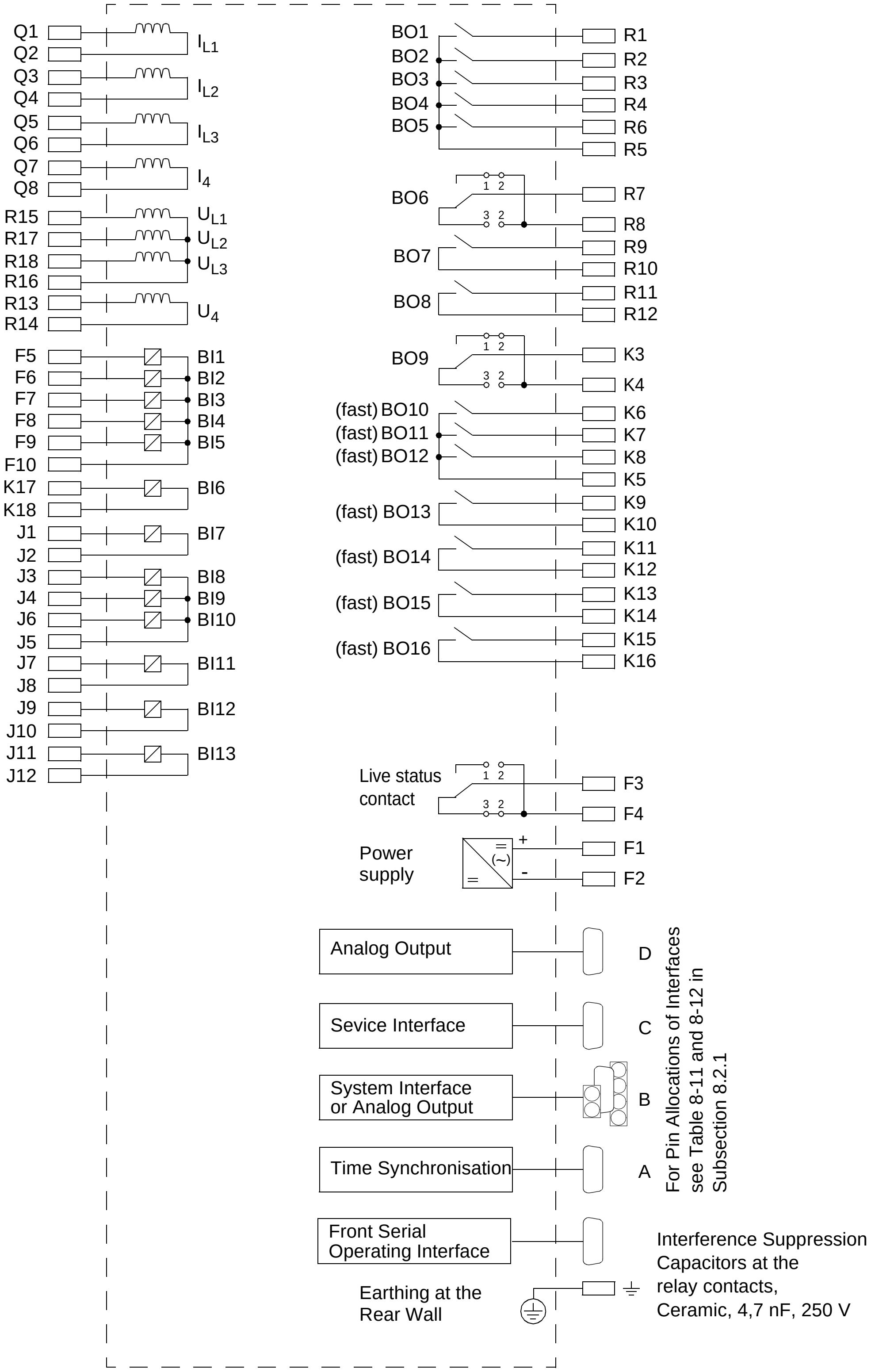


Figure A-3 General Diagram 7SA6∗1∗–∗A/J (panel flush mounted or cubicle mounted)

7SA6∗1∗–∗B/K

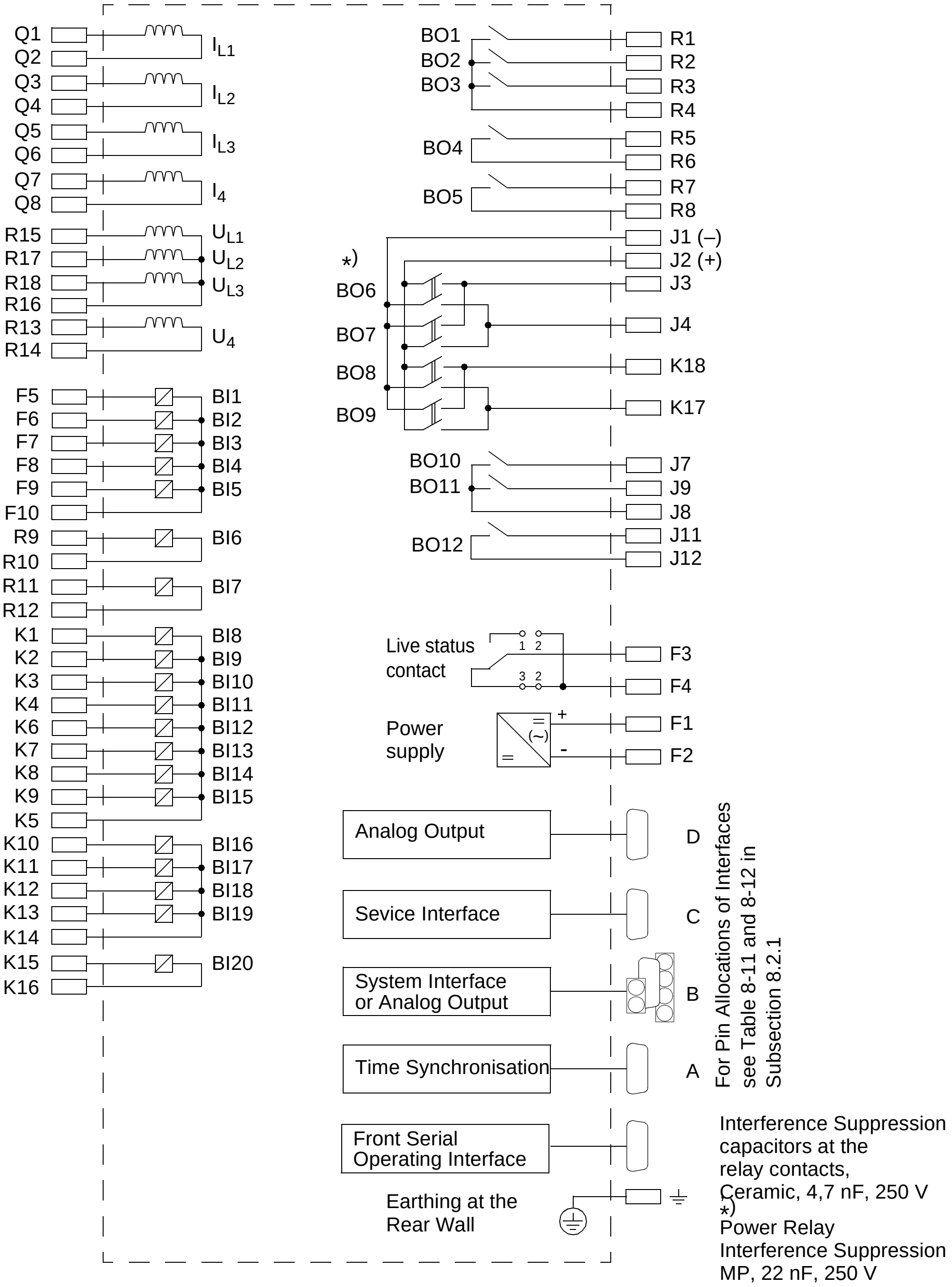
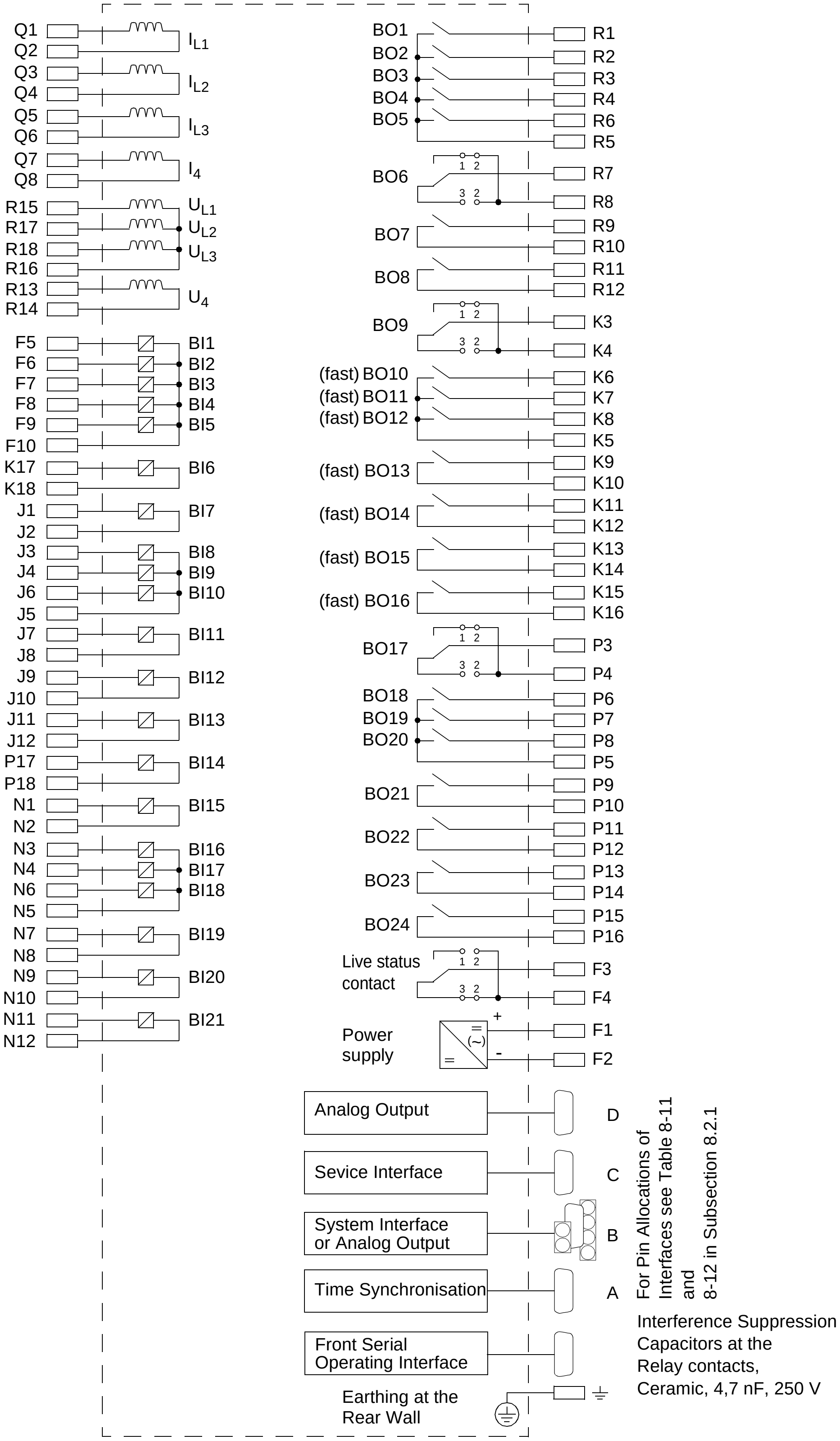


Figure A-4 General Diagram 7SA6∗1∗–∗B/K (panel flush mounted or cubicle mounted)

7SA6∗2∗–∗A/J

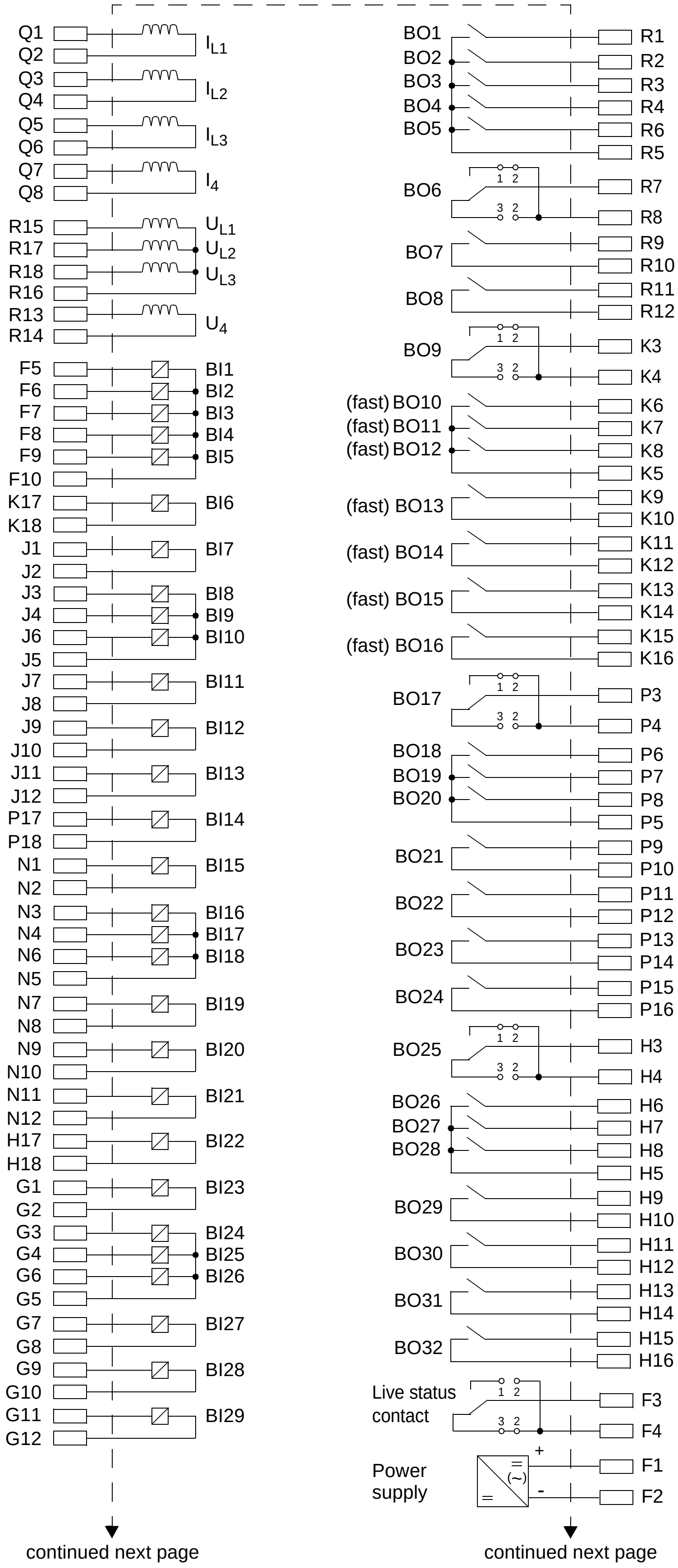


For Pin Allocations of Interfaces see Table 8-11 and 8-12 in Subsection 8.2.1

Interference Suppression Capacitors at the Relay contacts, Ceramic, 4,7 nF, 250 V

Figure A-5 General Diagram 7SA6∗2∗–∗A/J (panel flush mounted or cubicle mounted)

7SA6∗2∗–∗B/K



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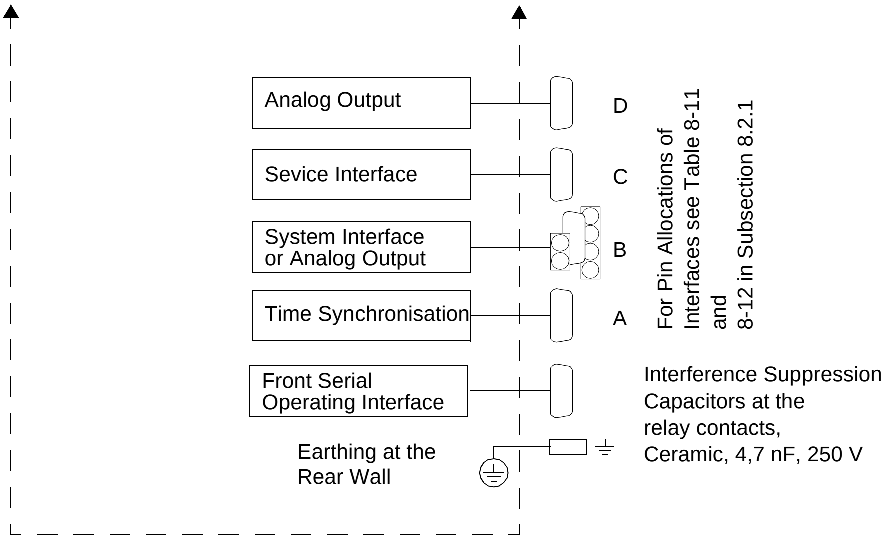
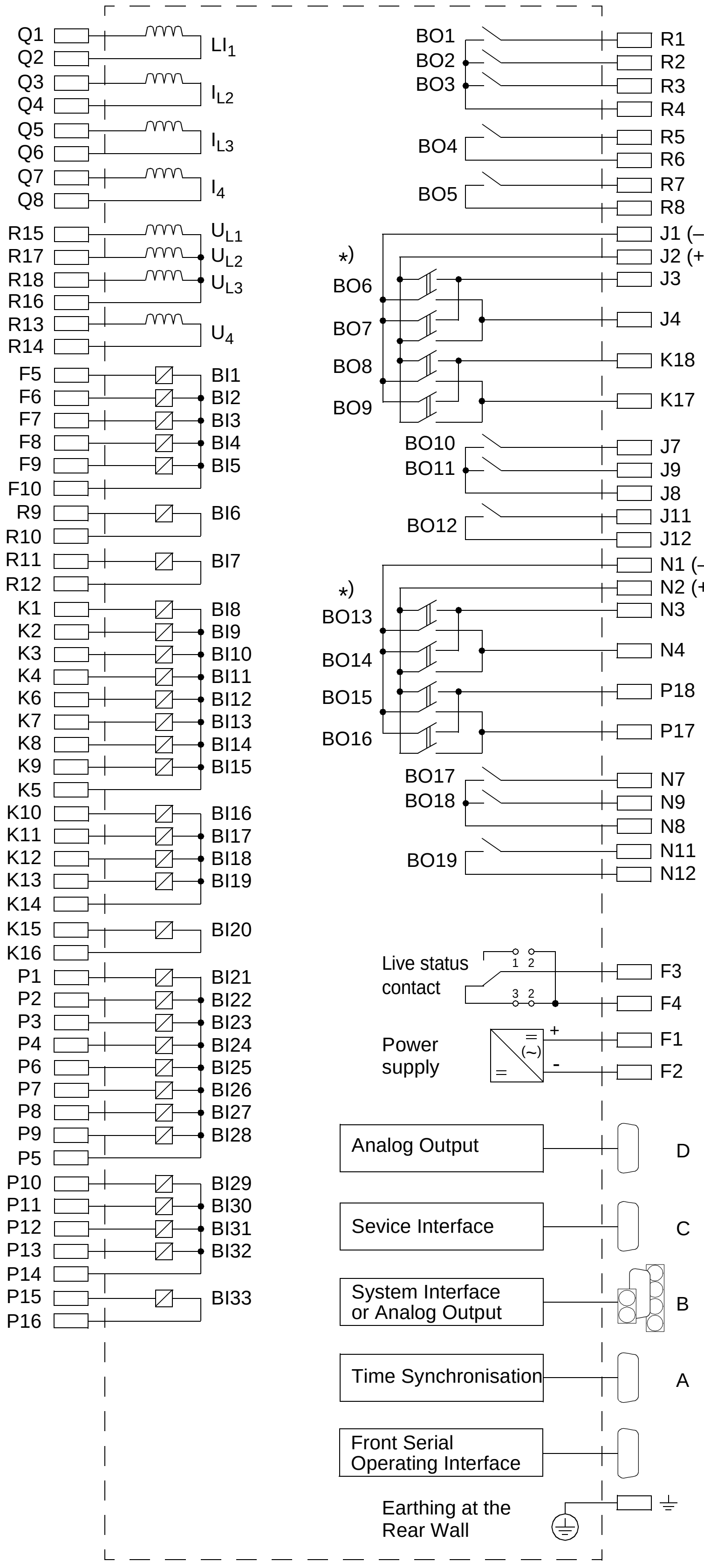


Figure A-6 General Diagram 7SA6∗2∗–∗B/K (panel flush mounted or cubicle mounted)

7SA6∗2∗–∗C/L



For Pin Allocations of Interfaces see Table 8-11 and 8-12 in Subsection 8.2.1

Interference Suppression Capacitors at the relay contacts, Ceramic, 4,7 nF, 250 V

∗)
Power Relay Interference Suppression MP, 22 nF, 250 V

Figure A-7 General Diagram 7SA6∗2∗–∗C/L (panel flush mounted or cubicle mounted)

A.2.2 Panel Surface Mounting

7SA610∗–∗E

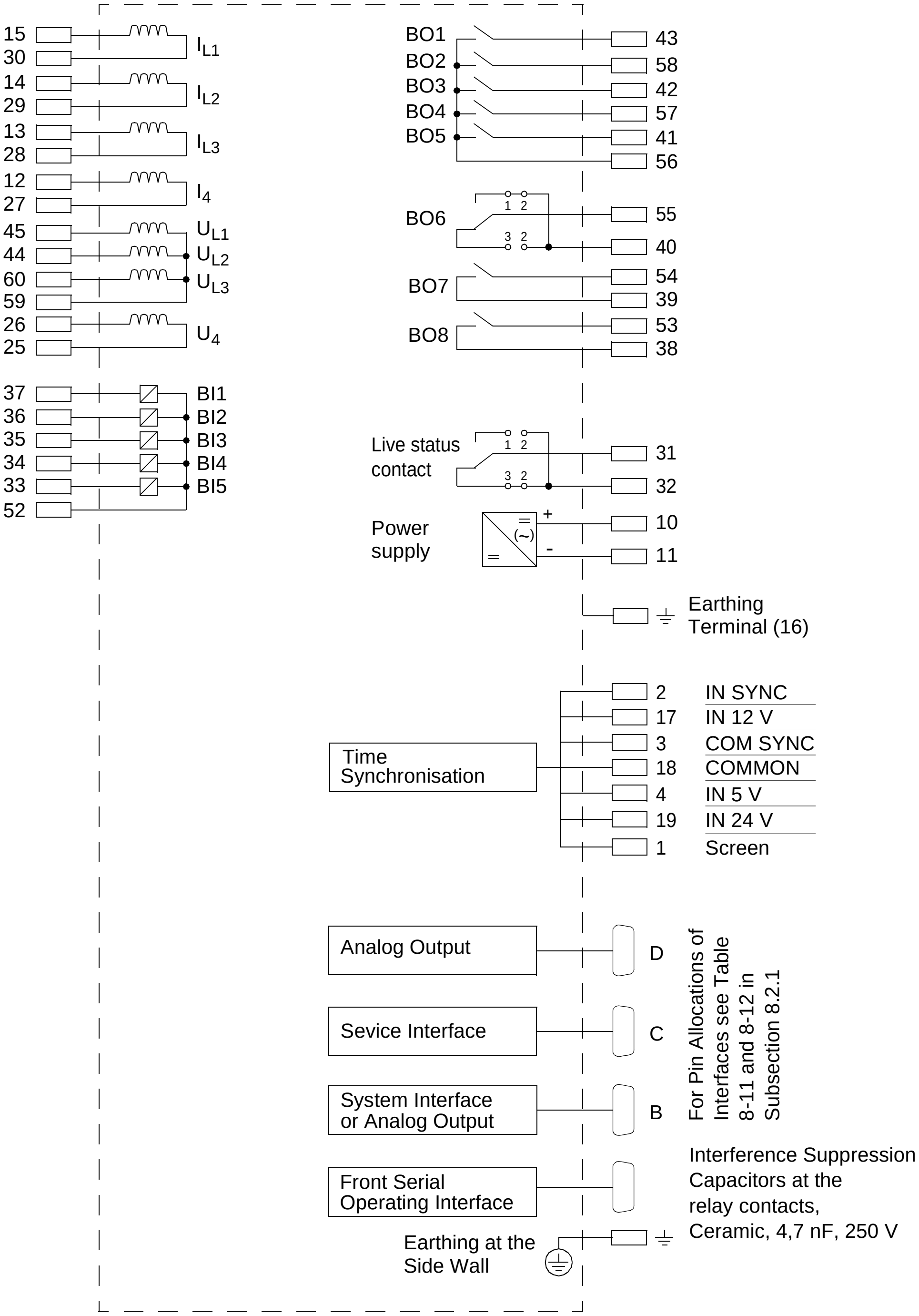


Figure A-8 General Diagram 7SA610∗–∗E (Panel Surface Mounting)

7SA610∗–∗F

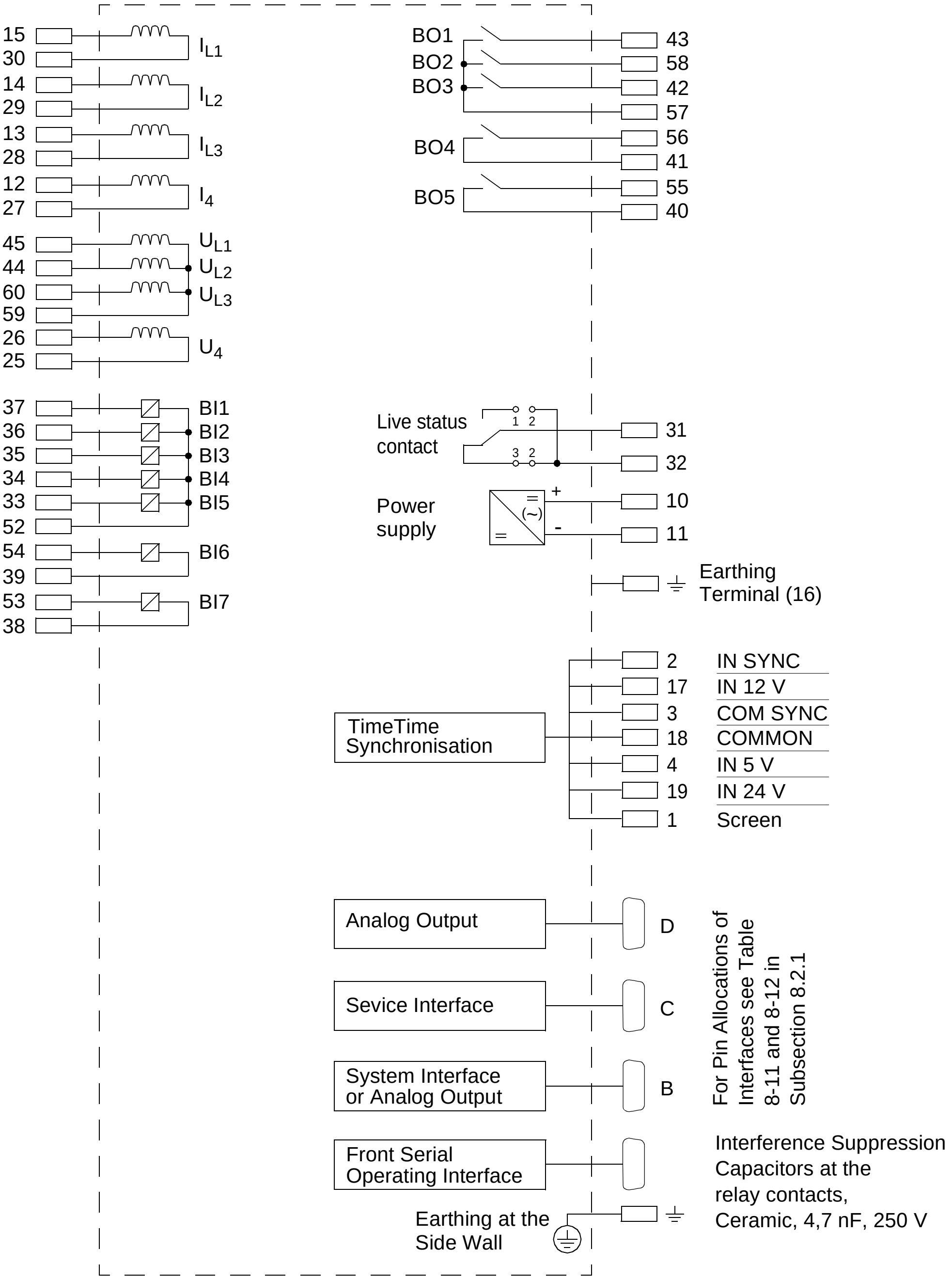


Figure A-9 General Diagram 7SA610∗–∗F (Panel Surface Mounting)

7SA6∗1∗–∗E

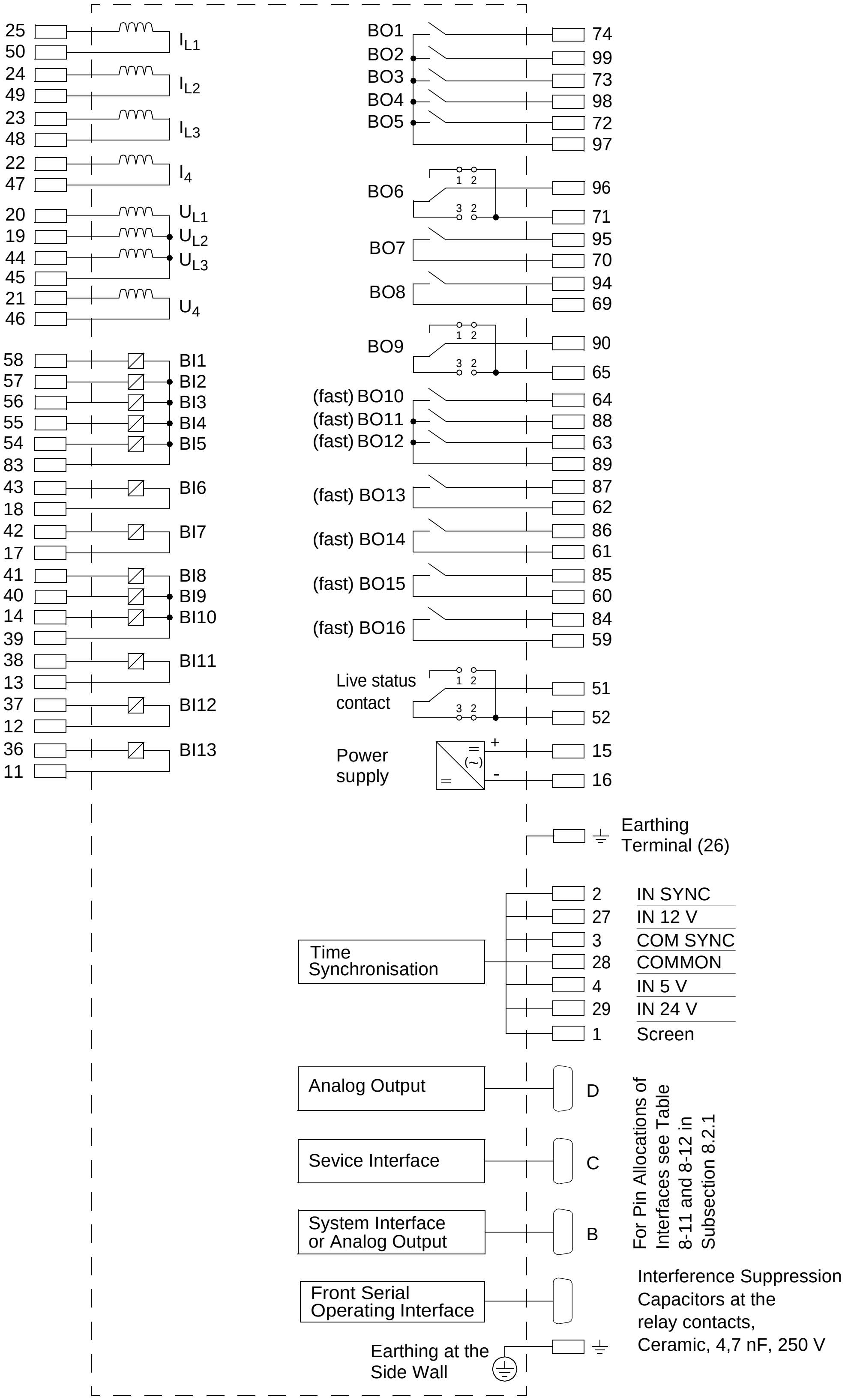


Figure A-10 General Diagram 7SA6∗1∗–∗E (Panel Surface Mounting)

7SA6∗1∗–∗F

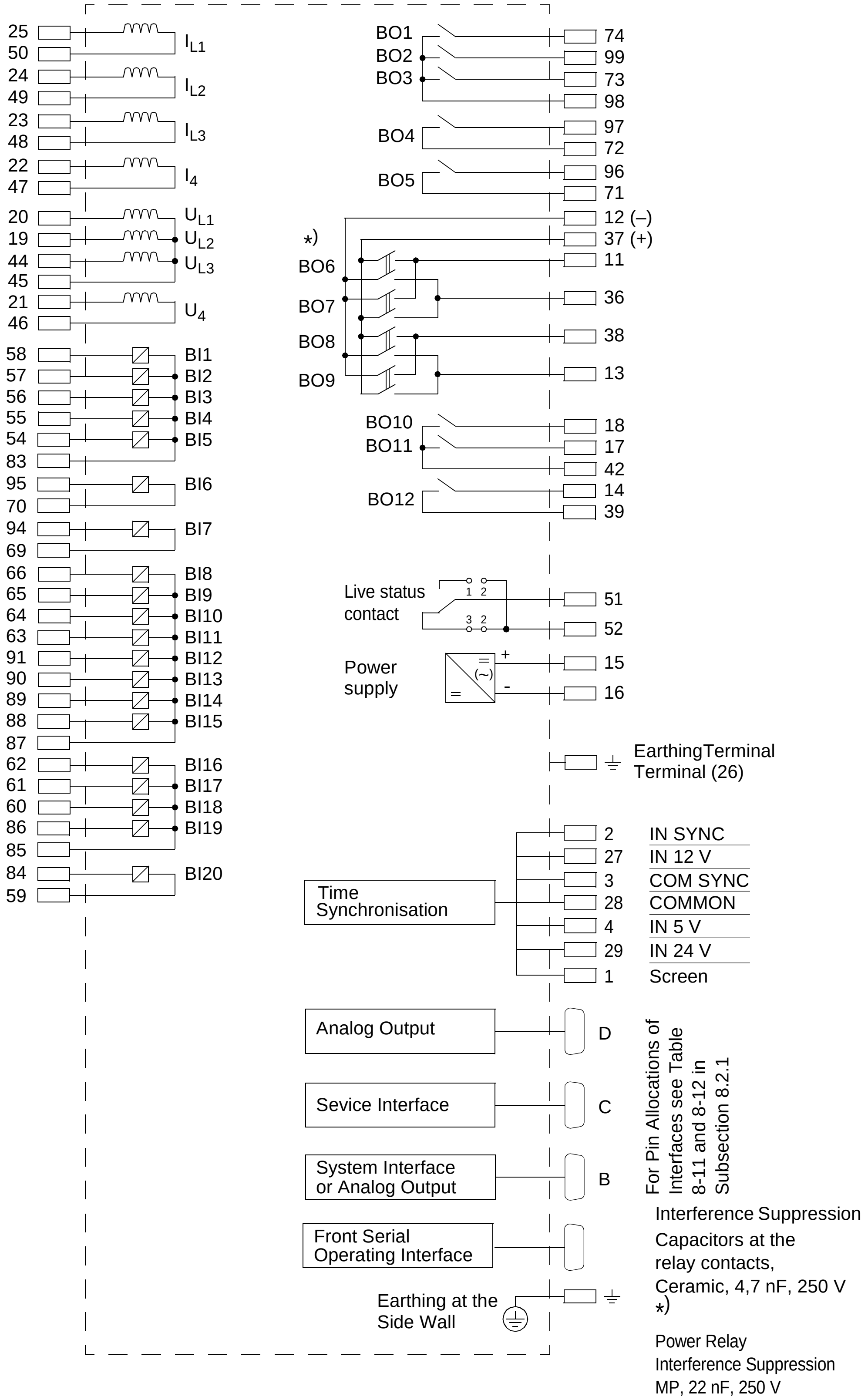
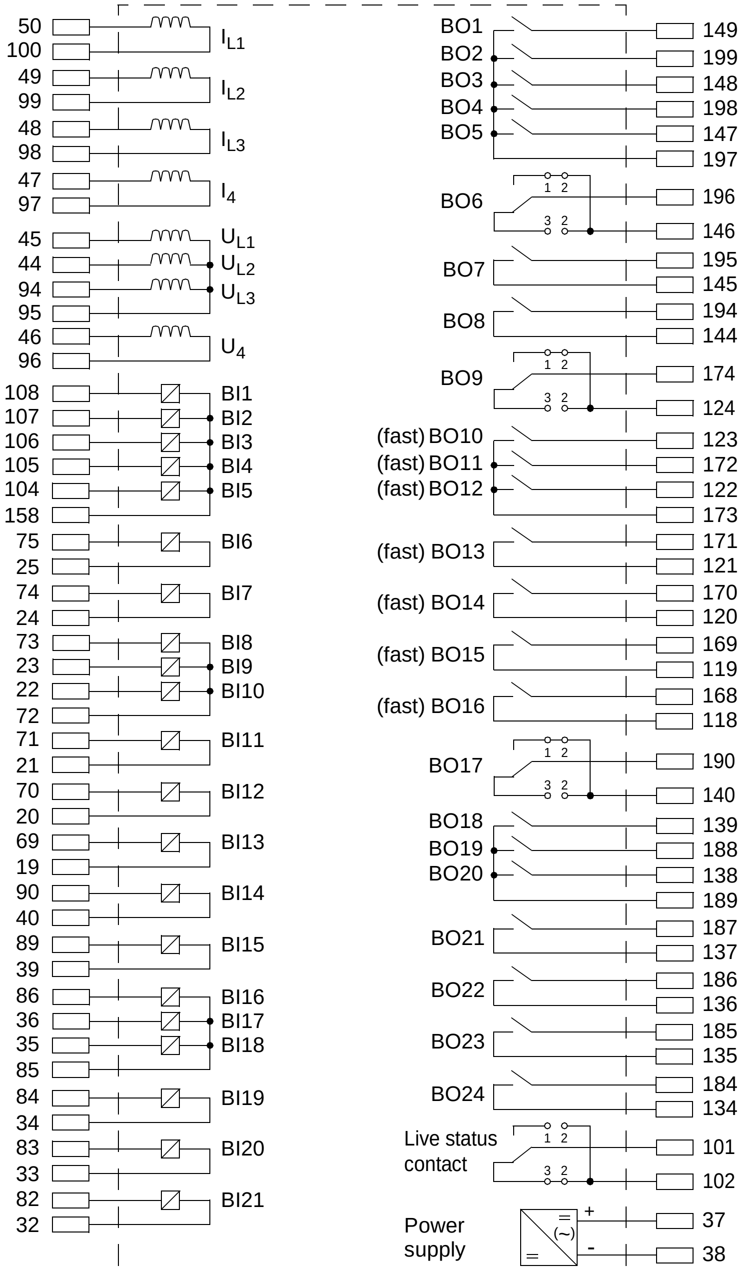


Figure A-11 General Diagram 7SA6∗1∗–∗F (Panel Surface Mounting)

7SA6∗2∗–∗E



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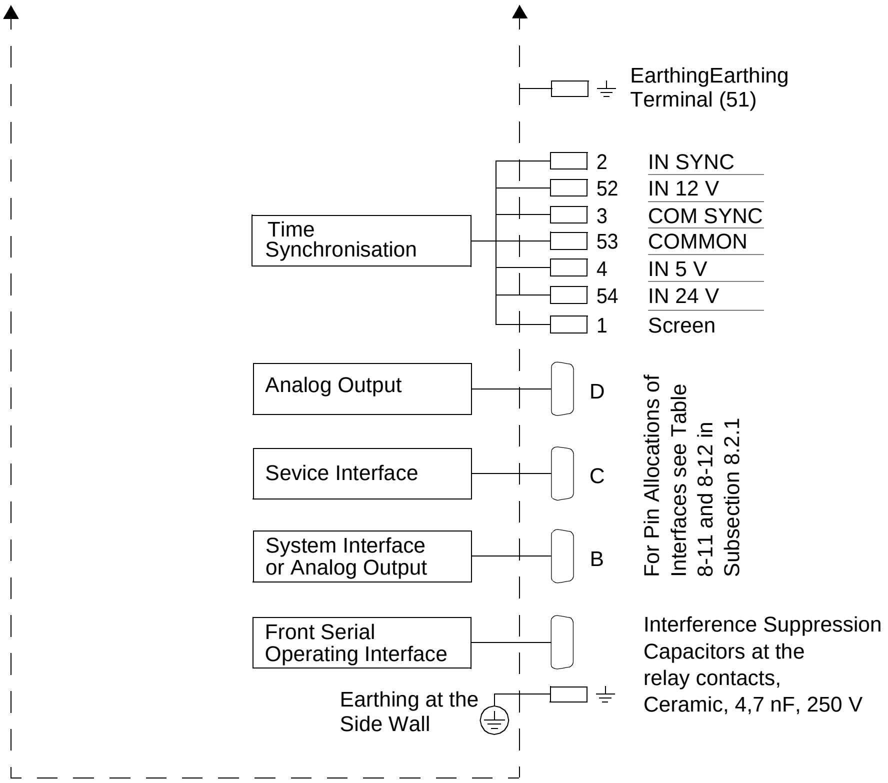
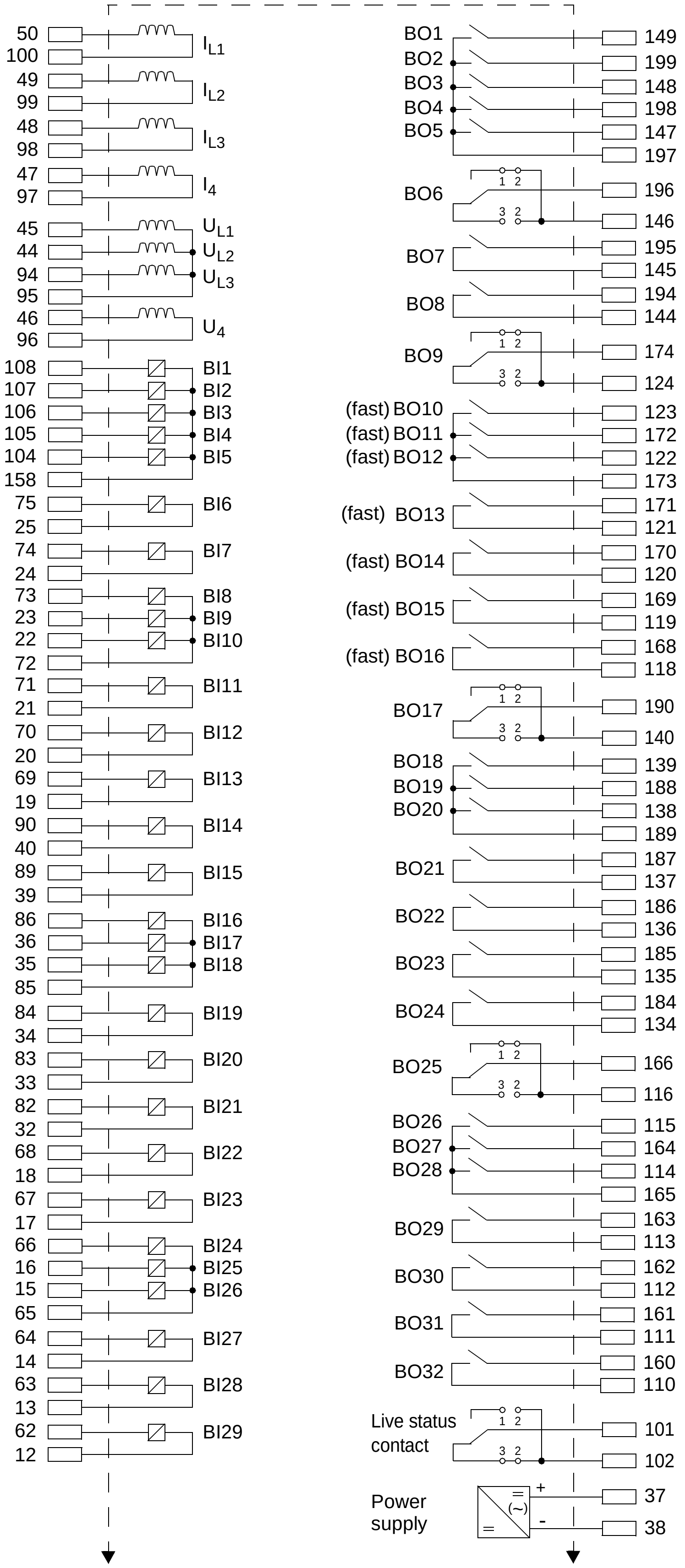


Figure A-12 General Diagram 7SA6∗2∗–∗E (Panel Surface Mounting)

7SA6∗2∗–∗F



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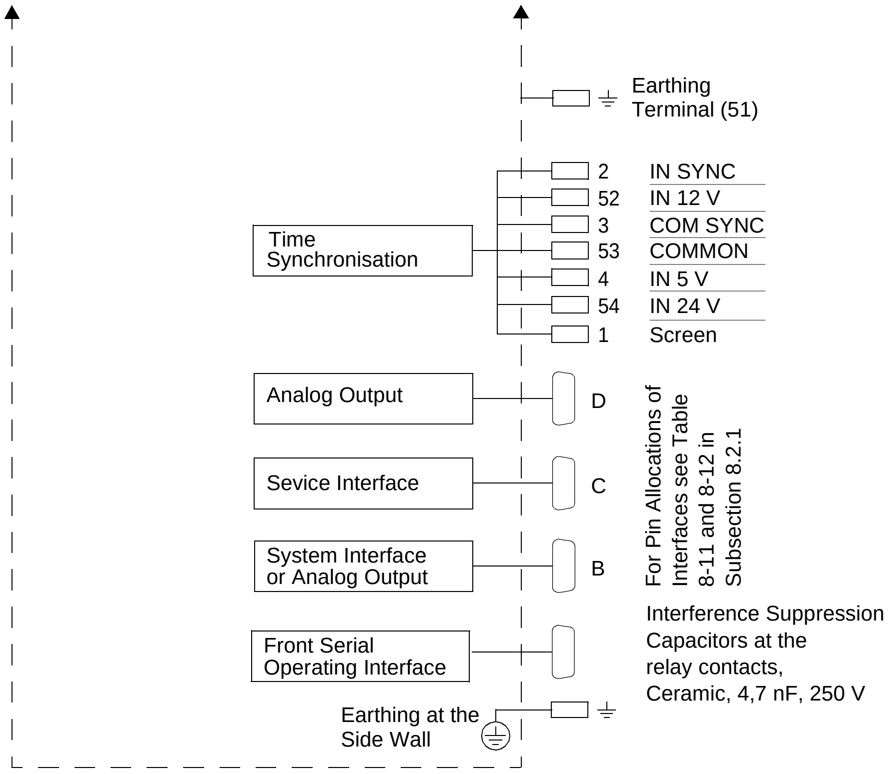
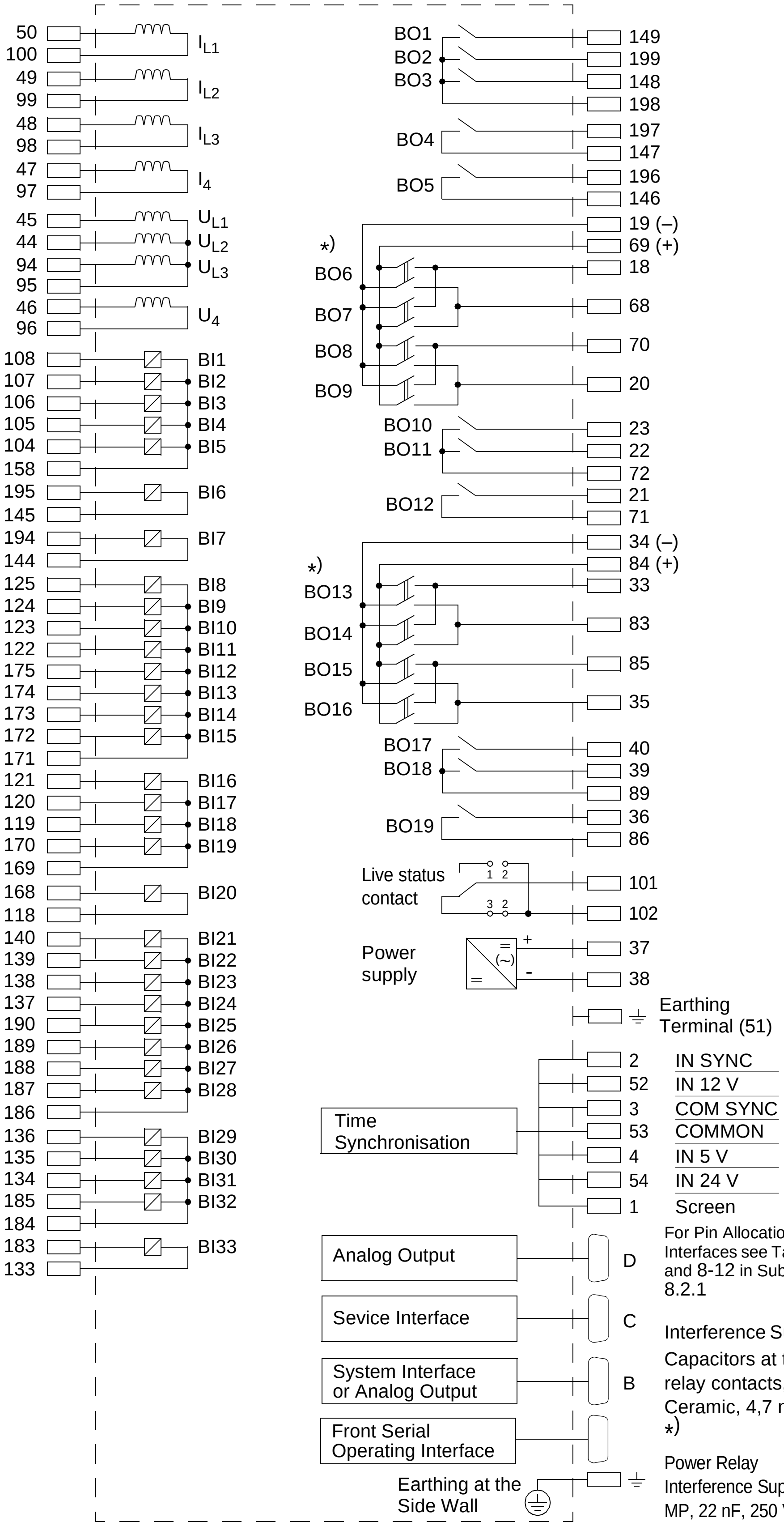


Figure A-13 General Diagram 7SA6∗2∗–∗F (Panel Surface Mounting)

7SA6∗2∗–∗G



For Pin Allocations of Interfaces see Table 8-11 and 8-12 in Subsection 8.2.1

Interference Suppression Capacitors at the relay contacts, Ceramic, 4,7 nF, 250 V

∗) Power Relay Interference Suppression MP, 22 nF, 250 V

Figure A-14 General Diagram 7SA6∗2∗–∗G (Panel Surface Mounting)

A.2.3 Housing for Mounting with Detached Operator Panel

7SA641∗–∗A/J

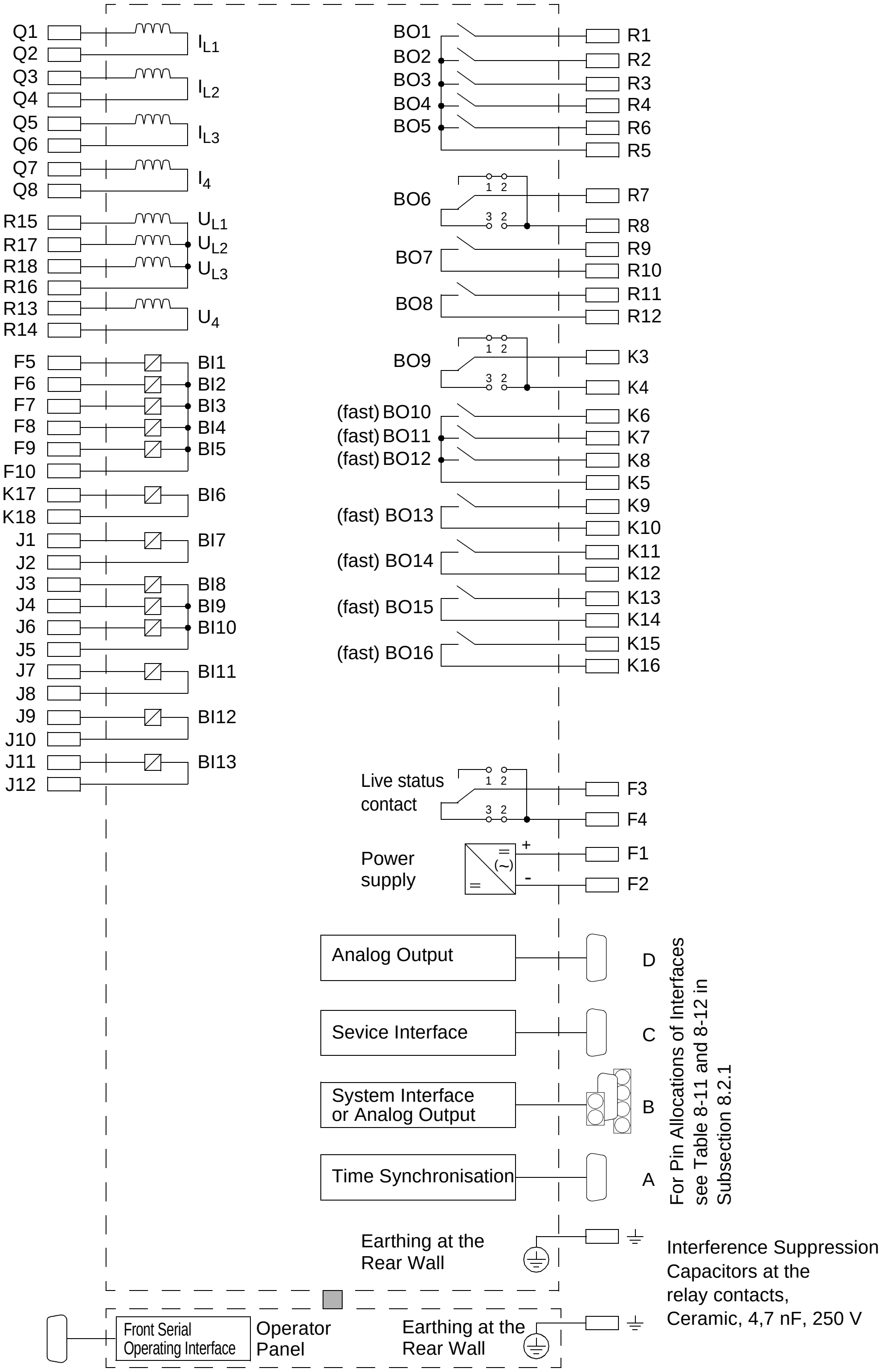
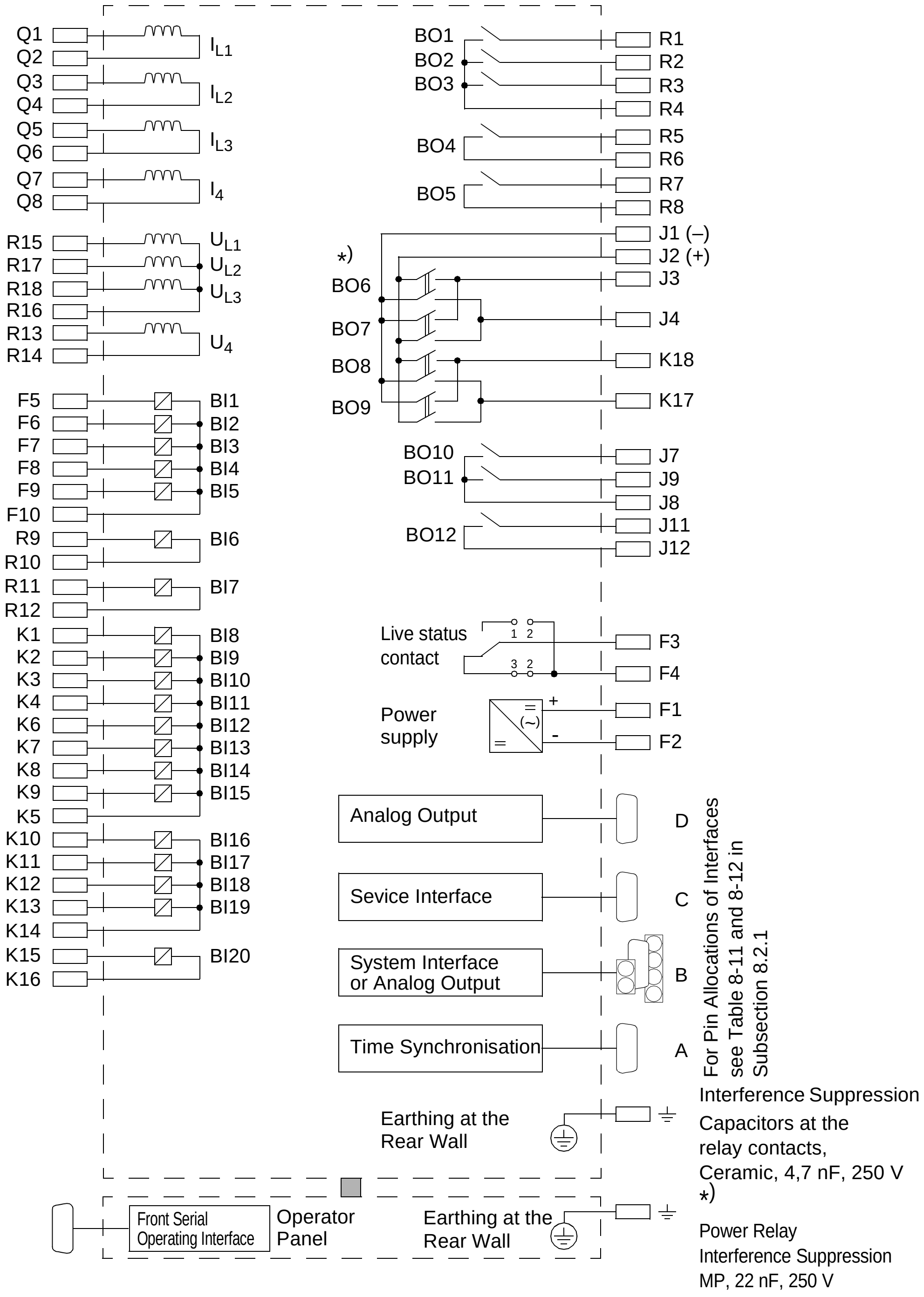


Figure A-15 General Diagram 7SA641∗–∗A/J (Mounting with detached operator panel)

7SA641∗–∗B/K

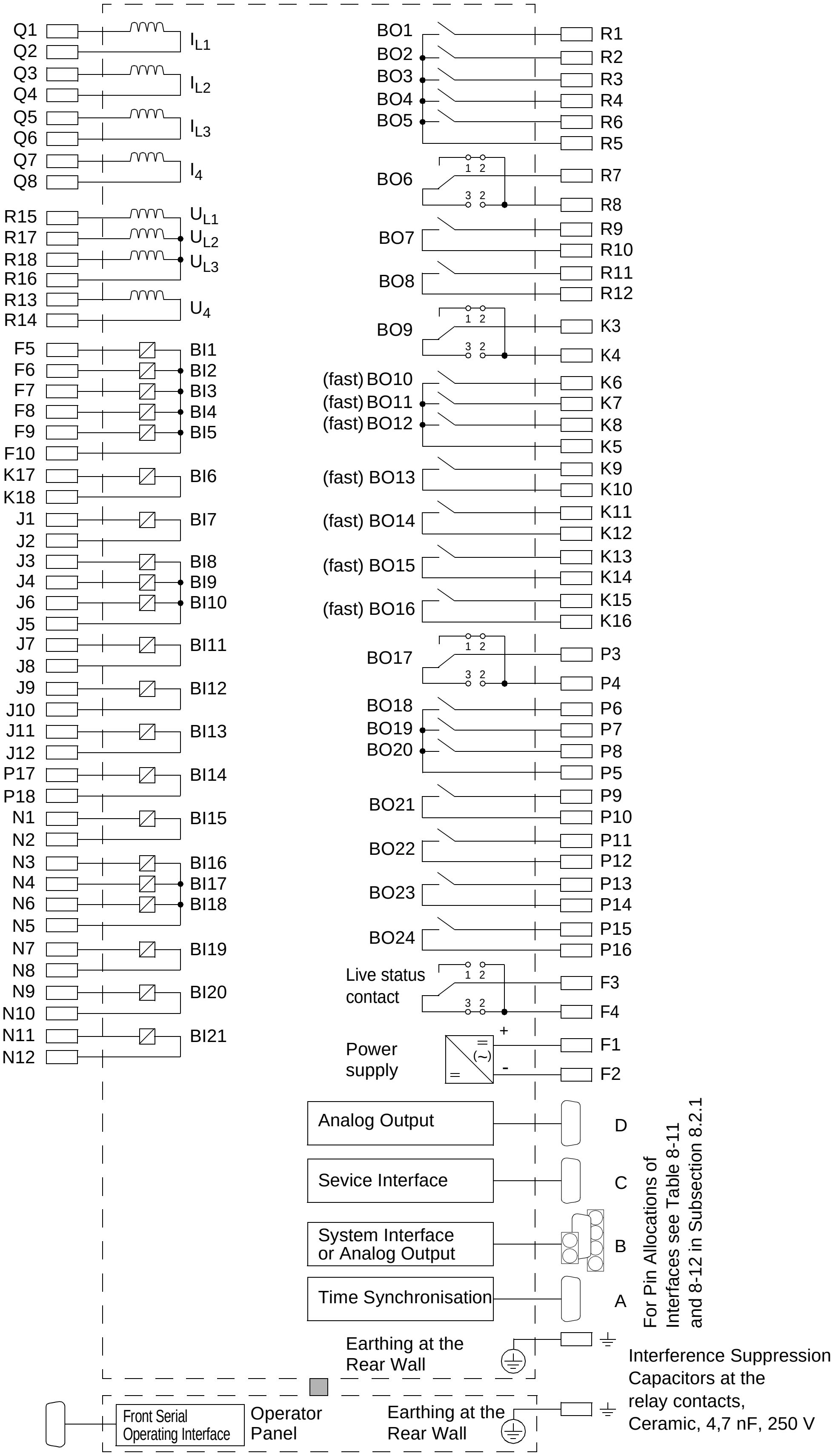


Interference Suppression Capacitors at the relay contacts, Ceramic, 4,7 nF, 250 V

∗) Power Relay Interference Suppression MP, 22 nF, 250 V

Figure A-16 General Diagram 7SA641∗–∗B/K (Mounting with detached operator panel)

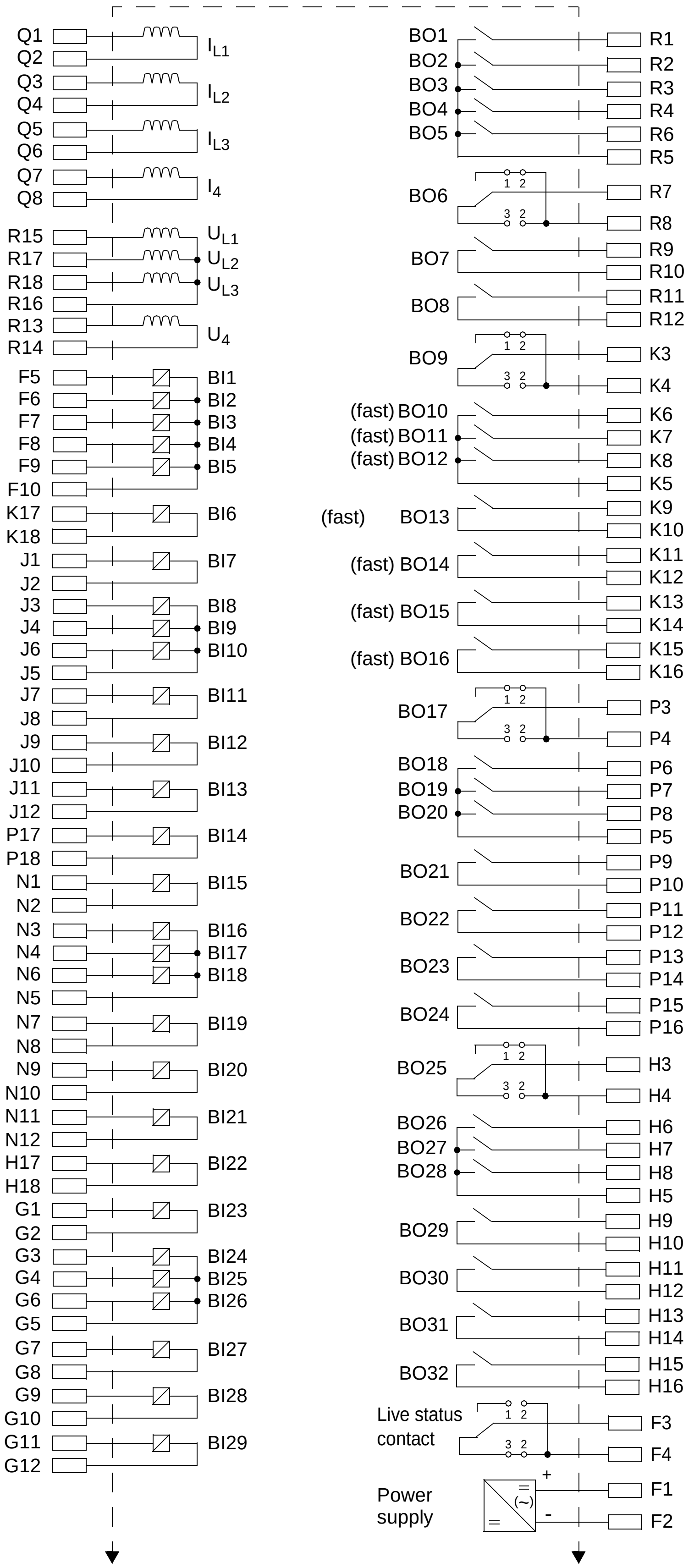
7SA642∗–∗A/J



Interference Suppression Capacitors at the relay contacts, Ceramic, 4,7 nF, 250 V

Figure A-17 General Diagram 7SA642∗–∗A/J (Mounting with detached operator panel)

7SA642∗–∗B/K



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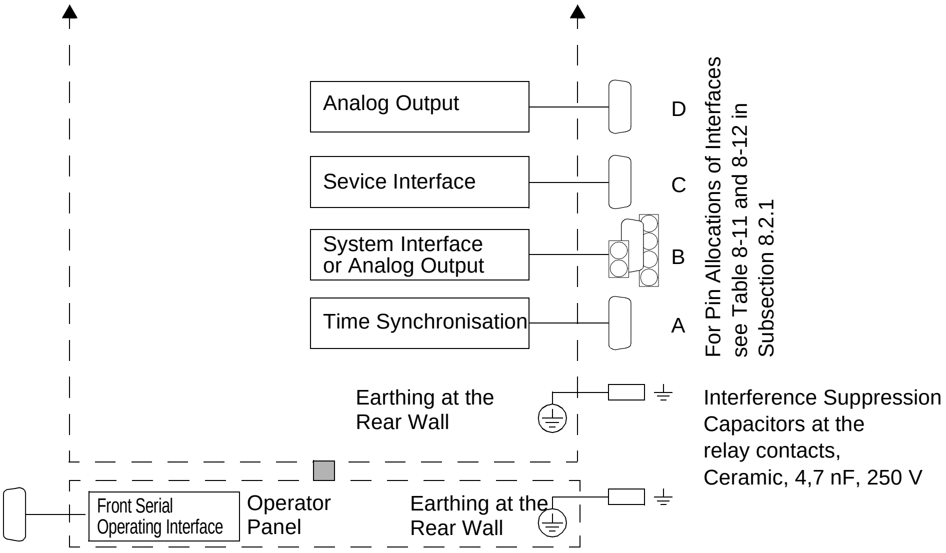
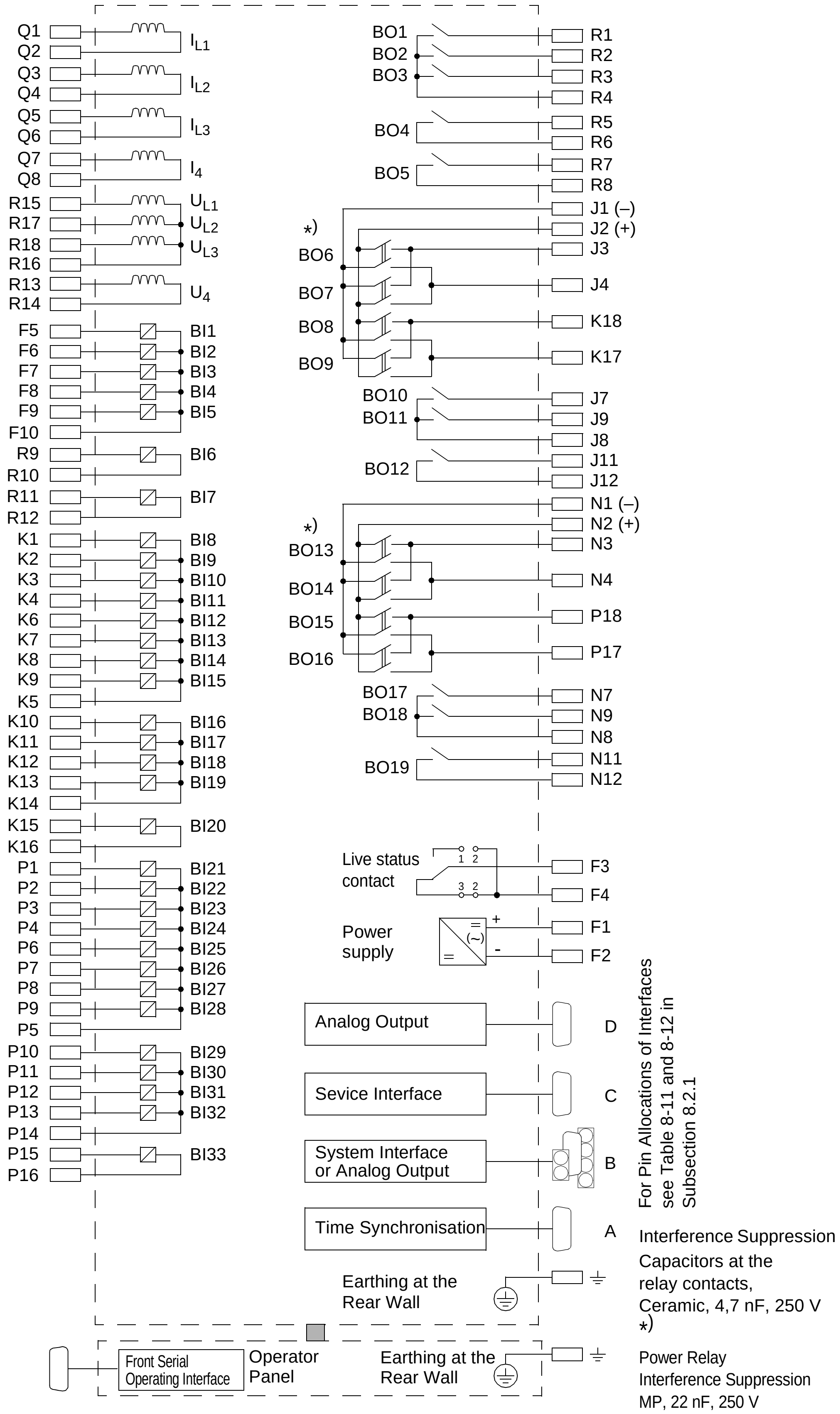


Figure A-18 General Diagram 7SA642∗–∗B/K (Mounting with detached operator panel)

7SA642∗−∗C/L



For Pin Allocations of Interfaces see Table 8-11 and 8-12 in Subsection 8.2.1

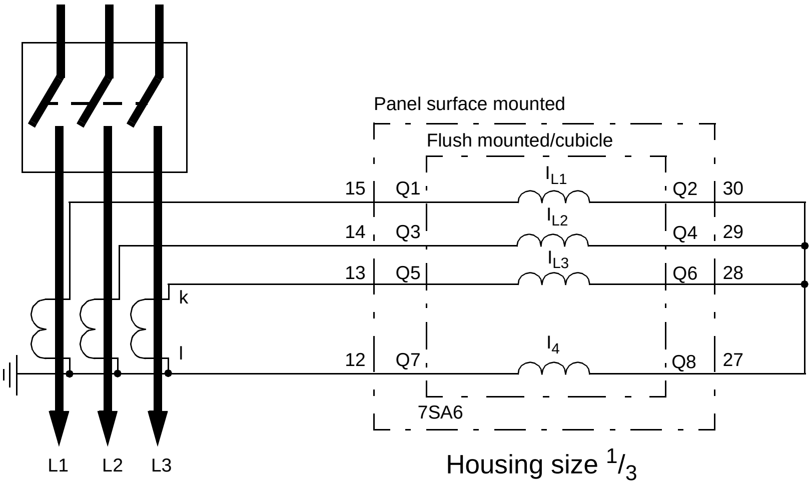
Interference Suppression Capacitors at the relay contacts, Ceramic, 4,7 nF, 250 V

∗) Power Relay Interference Suppression MP, 22 nF, 250 V

Figure A-19 General Diagram 7SA642∗–∗C/L (Mounting with detached operator panel)

A.3 Connection Examples

Current Transformer Connection Examples



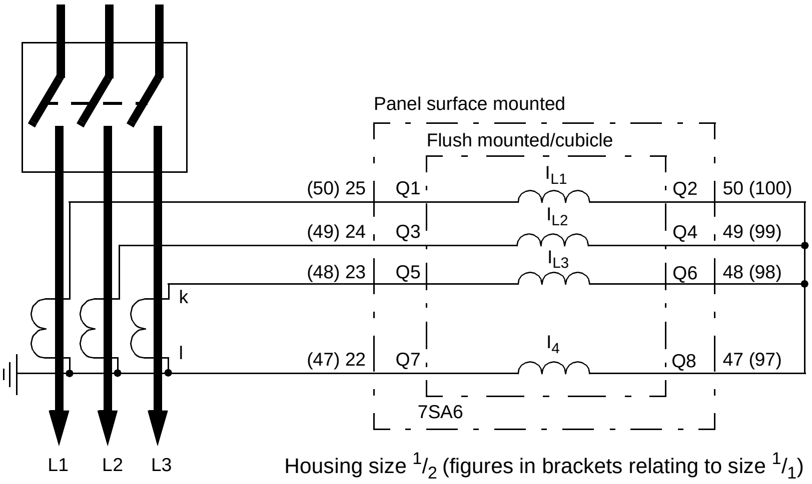
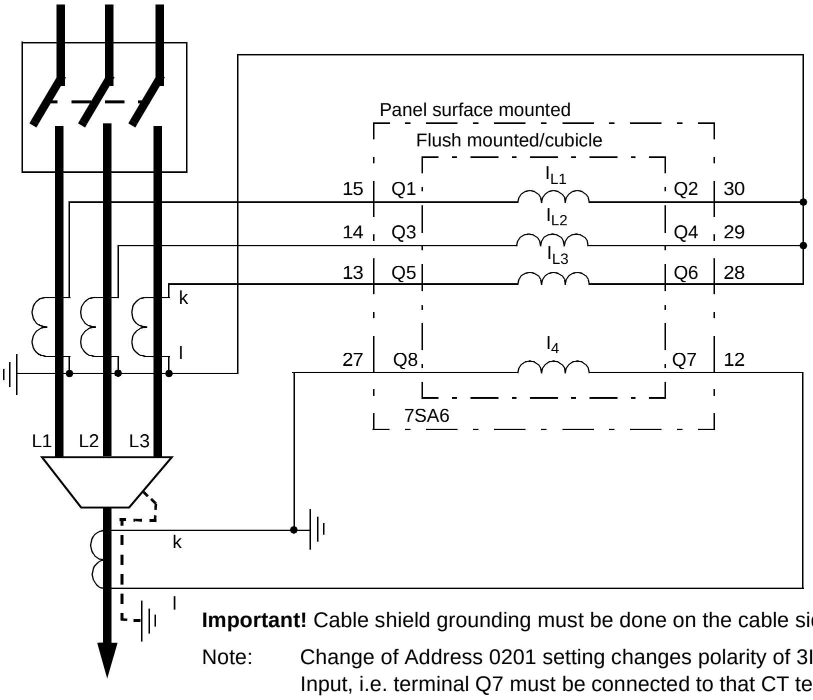


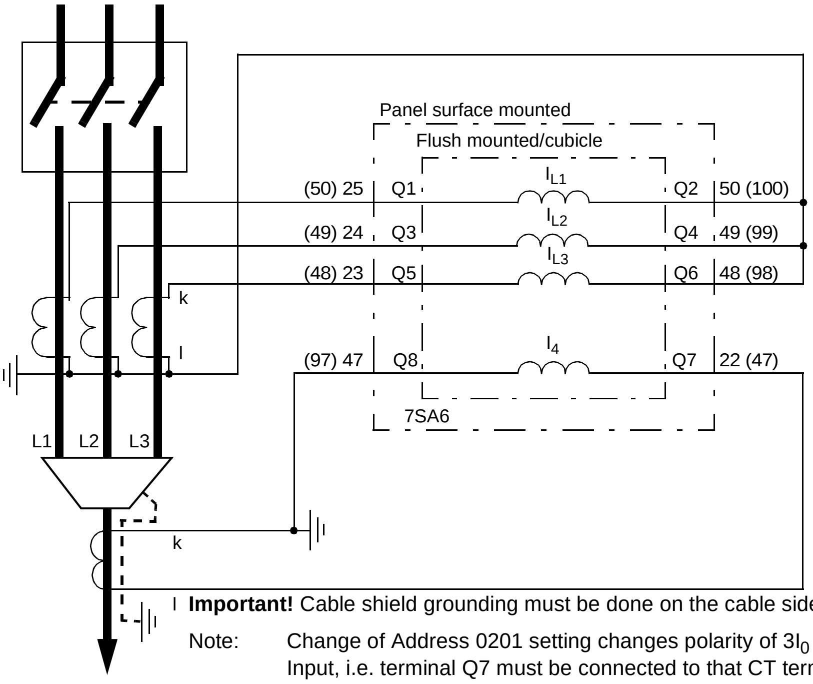
Figure A-20 Current connections to three current transformers with a star-point connection for earth current (residual $3I_0$ neutral current), normal circuit layout — appropriate for all networks



Important! Cable shield grounding must be done on the cable side!

Note: Change of Address 0201 setting changes polarity of $3I_0$ Current Input, i.e. terminal Q7 must be connected to that CT terminal pointing in the same direction as the starpoint of the phase current CTs (towards “Line side” in this diagram)

Housing size $^1/_3$

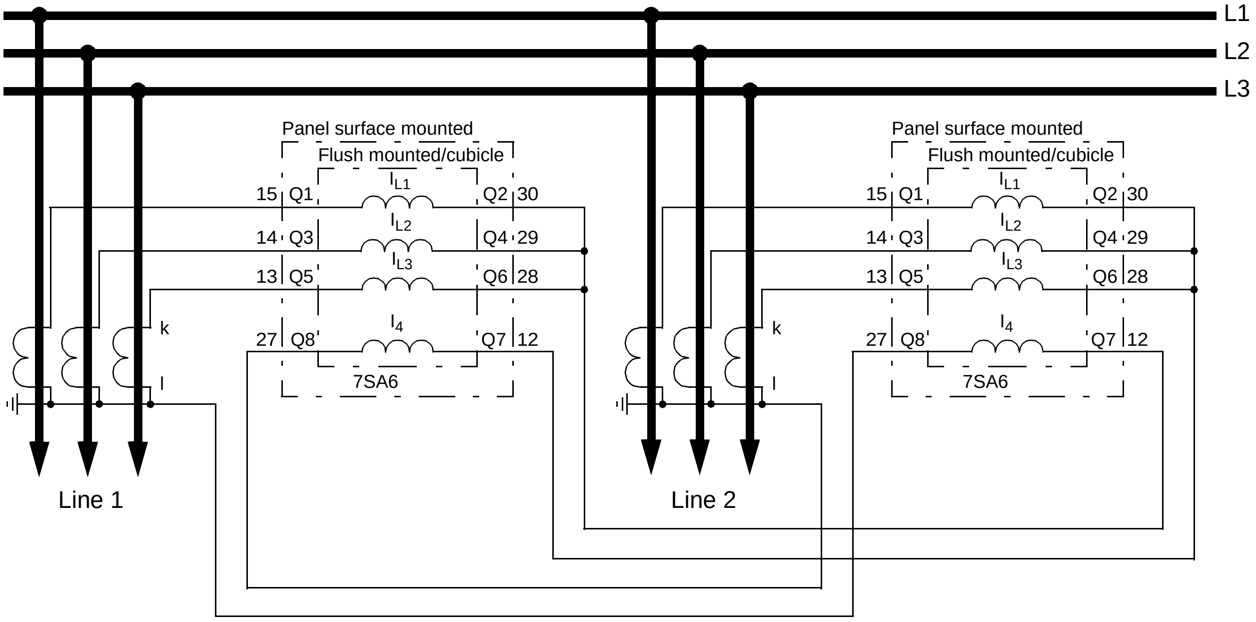


Important! Cable shield grounding must be done on the cable side!

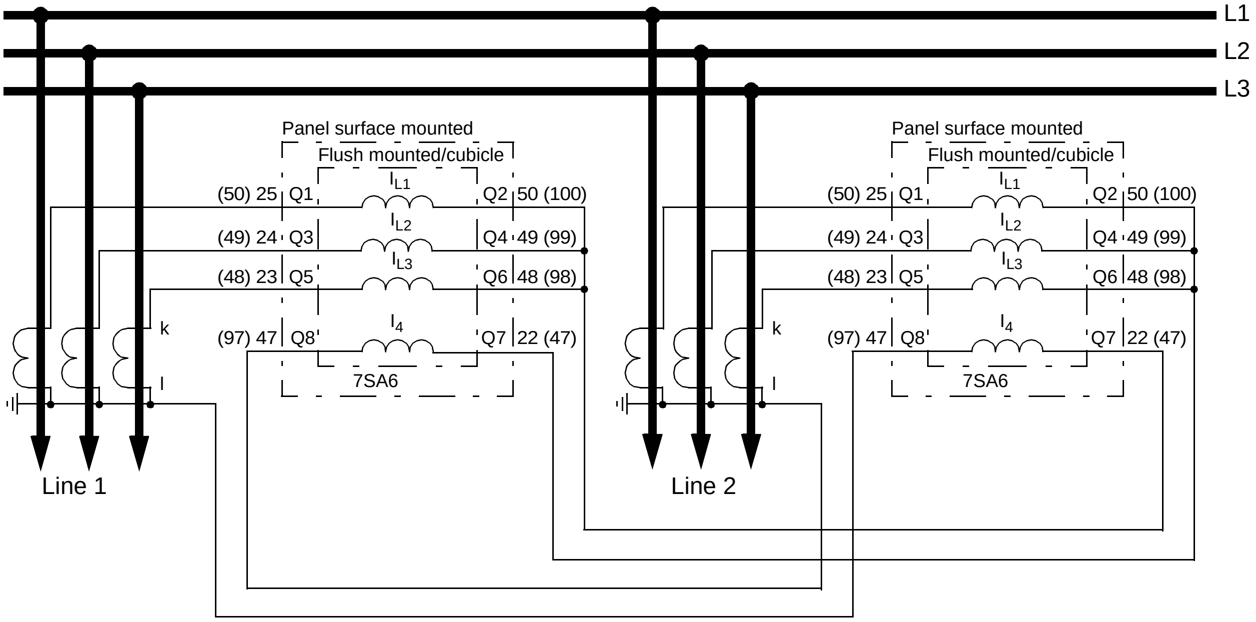
Note: Change of Address 0201 setting changes polarity of $3I_0$ Current Input, i.e. terminal Q7 must be connected to that CT terminal pointing in the same direction as the starpoint of the phase current CTs (towards “Line side” in this diagram)

Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-21 Current connections to three current transformers with separate earth current transformer (summation current transformer or cable core balance current tranformer)

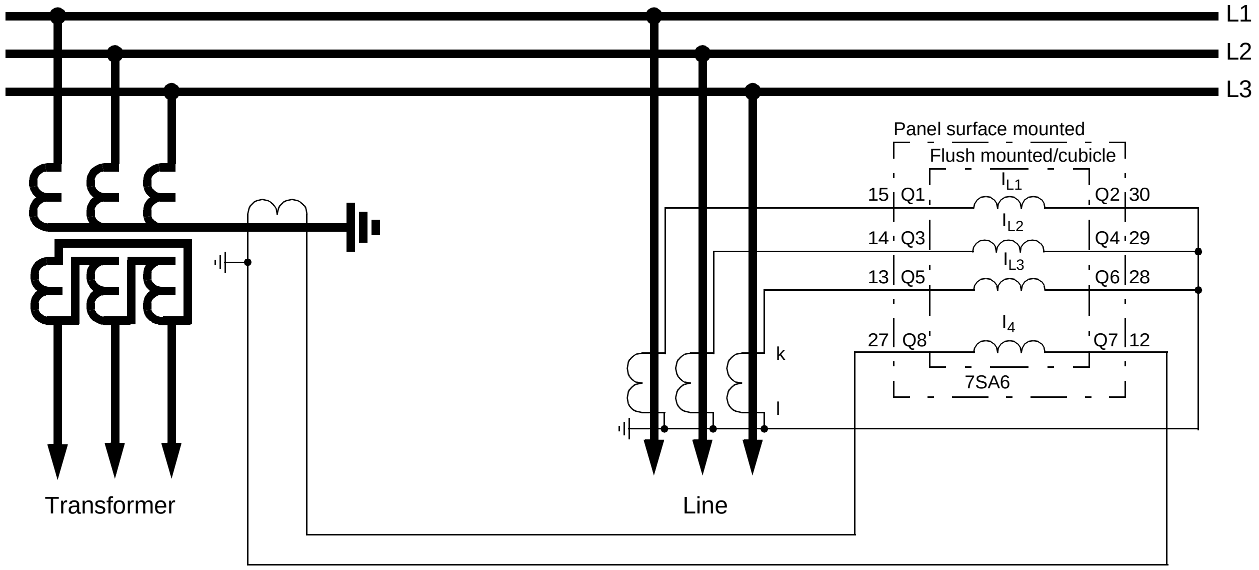


Housing size $^1/_3$

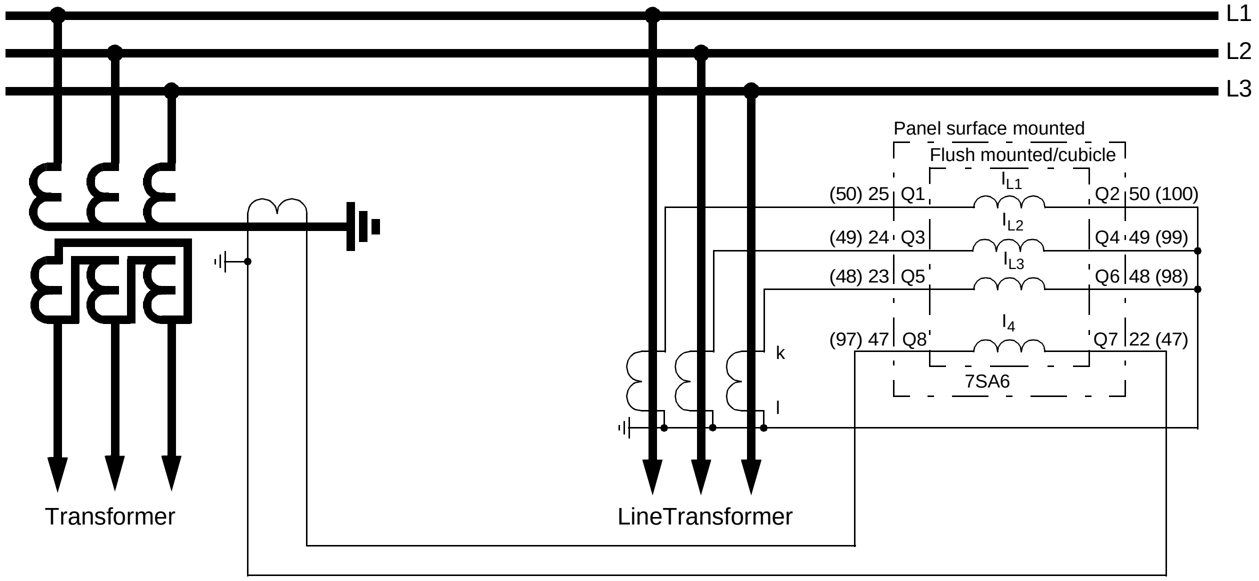


Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-22 Current connections to three transformers with a starpoint connection to the current transformer set of the corresponding parallel line (for parallel line compensation)



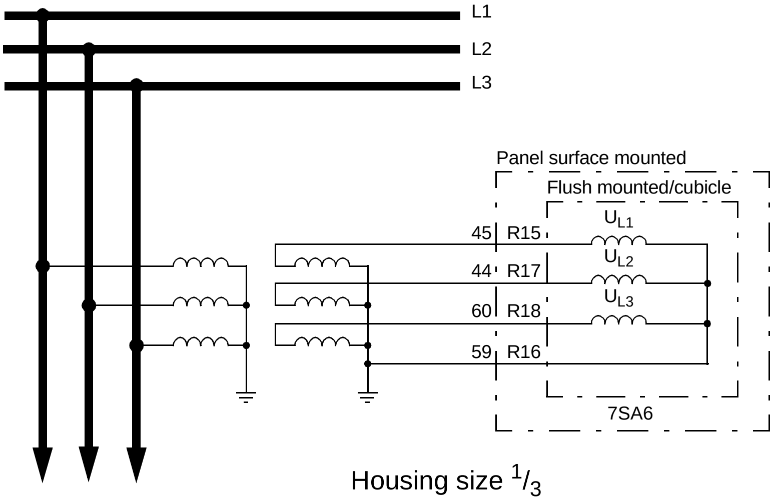
Housing size $^1/_3$



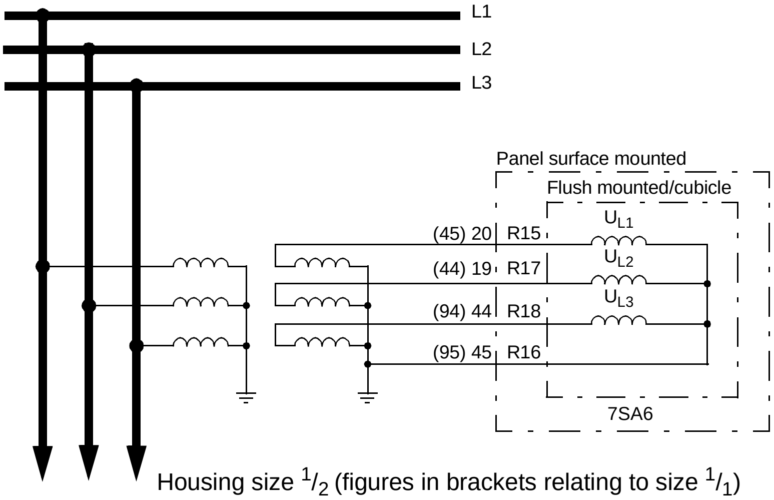
Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-23 Current connections to three current transformers and earth current from the star-point connection of an earthed power transformer (for directional-controlled earth fault protection)

Voltage Transformer Connection Examples

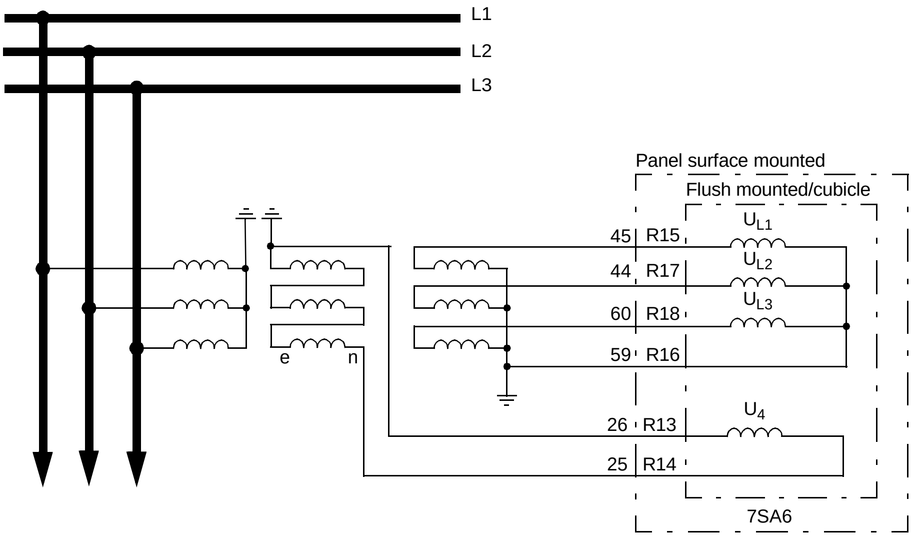


Housing size $^1/_3$

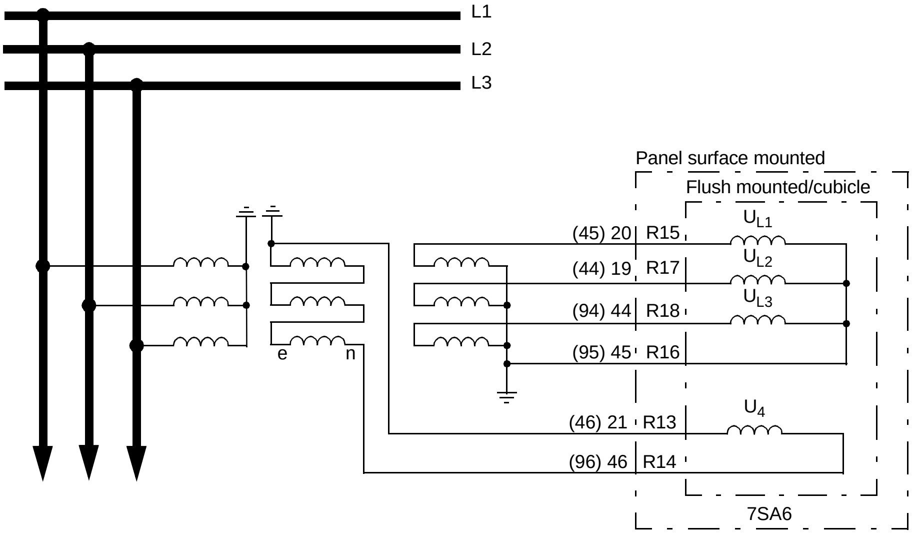


Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-24 Voltage connections to three Wye-connected voltage transformers (normal circuit layout)

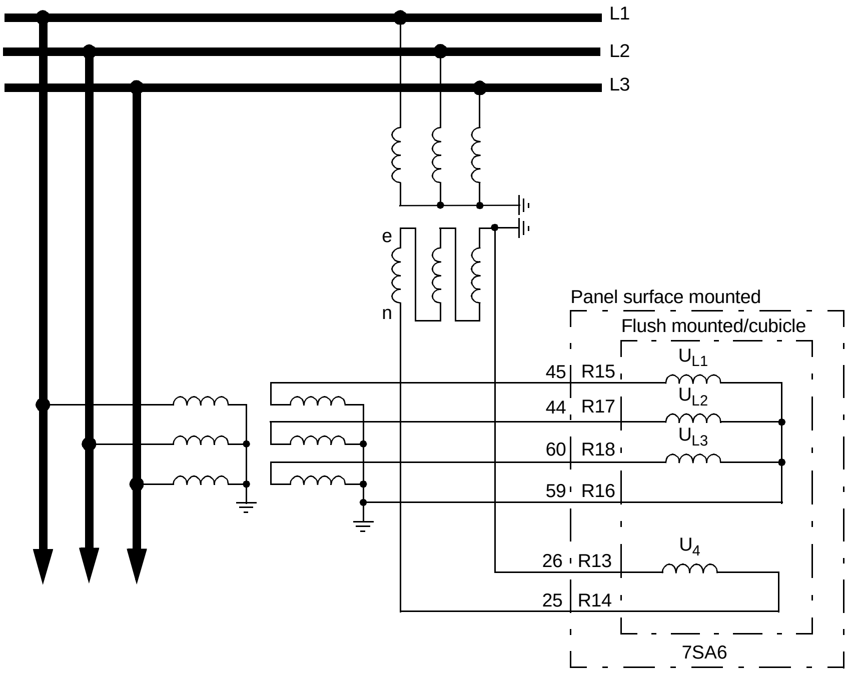


Housing size $^1/_3$

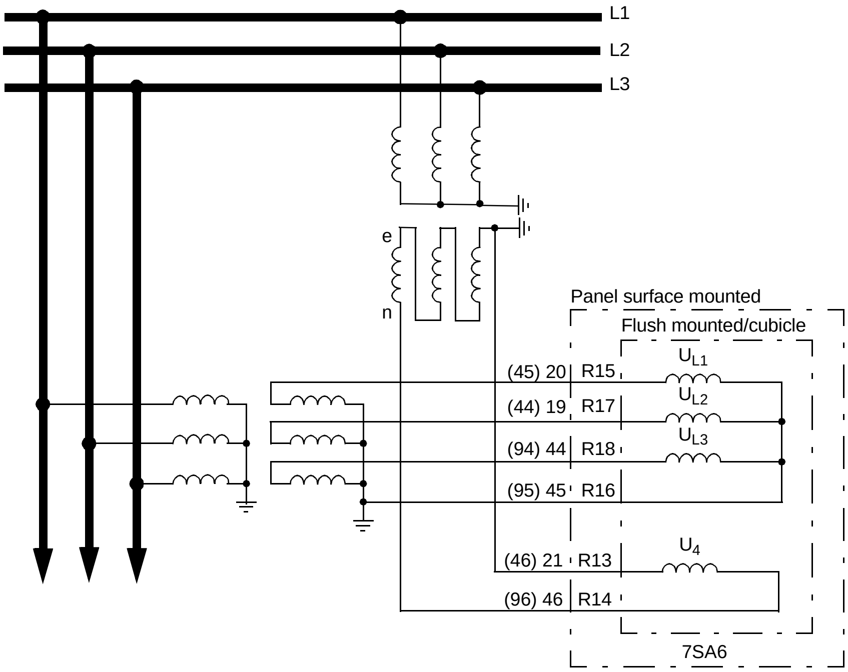


Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-25 Voltage connections to three Wye-connected voltage transformers with additional open-delta windings (e–n–winding)

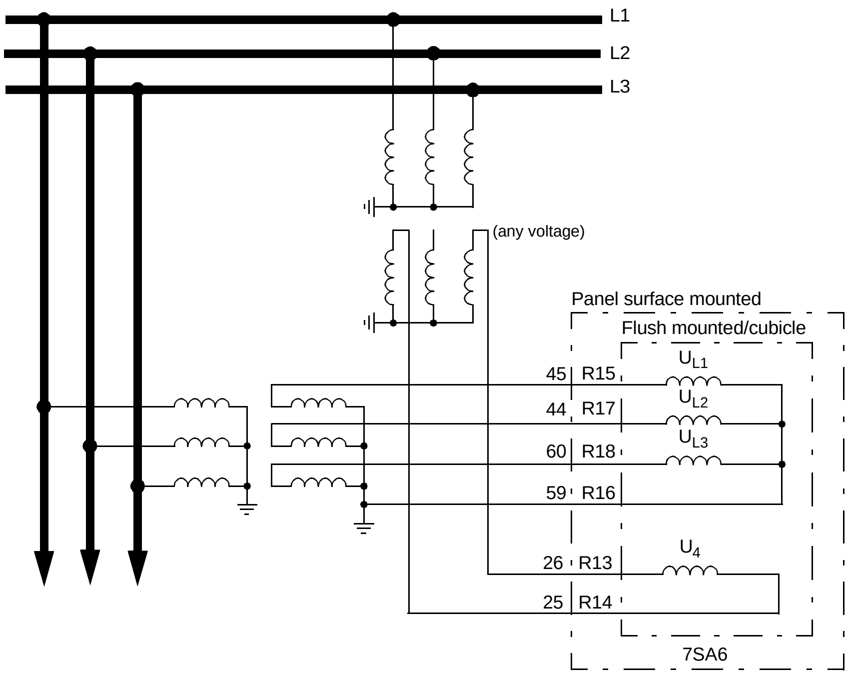


Housing size $^1/_3$

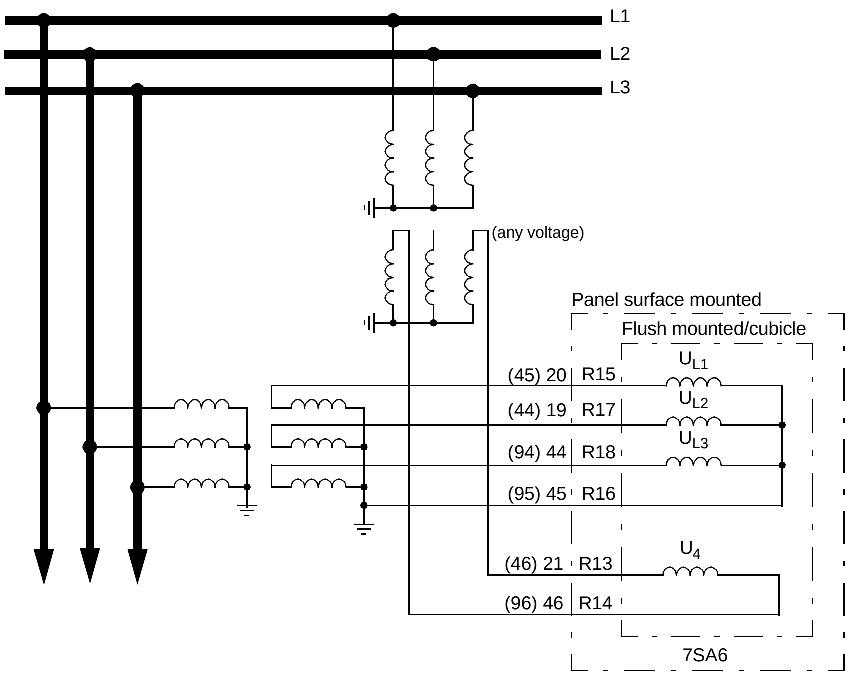


Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-26 Voltage connections to three Wye-connected voltage transformers with additional open-delta windings (e–n–winding) from the busbar



Housing size $^1/_3$



Housing size $^1/_2$ (figures in brackets relating to size $^1/_1$)

Figure A-27 Voltage connections to three Wye-connected voltage transformers and additionally to any phase-to-phase voltage (for overvoltage protection and/or synchronism check)

A.4 Preset Configurations

Presettings

The LED indication presettings which are preset in the device when it leaves the factory are summarised in Table A-1. Please take into consideration that LED8 to LED14 is not available in 7SA610.

The presettings of the binary inputs are listed (dependent on the ordering variant) in Tables A-2 to A-4.

The presettings of the binary outputs are listed (dependent on the ordering variant) in Tables A-5 to A-9. The General Diagrams in Appendix A, A.2 show which binary outputs can be used as accelerated binary outputs, i. e. suited for a fast command tripping.

Positions that are not indicated in the following tables have no presetting.

Table A-1 LED indication presettings

LED	LCD Text	Function No.	Remarks
LED1	Relay PICKUP L1	0511	Device (general) trip, latched
LED 2	Relay PICKUP L2	0503	Device (general) pick up phase L1, latched
LED3	Relay PICKUP L2	0504	Device (general) pick up phase L2, latched
LED4	Relay PICKUP L3	0505	Device (general) pick up phase L3, latched
LED5	Relay PICKUP E	0506	Device (general) pick up earth fault, latched
LED6	EF reverse Dis. reverse	1359 3720	Device (general) pick up reverse fault, latched
LED7	— [2])	— [2])	no pre-setting [2])
	Relay TRIP 1pL1 Relay TRIP 1pL2 Relay TRIP 1pL3	0512 [1]) 0513 [1]) 0514 [1])	Device (general) trip 1-pole, latched [1])
LED8	Dis.TripZ1/1p DisTRIP3p. Z1sf DisTRIP3p. Z1mf	3811 [1]) 3823 3824	Distance protection trip in zone Z1, latched
LED9	Dis.TripZ1B1p DisTRIP3p.Z1Bsf DisTRIP3p Z1Bmf	3813 [1]) 3825 3826	Distance protection trip in zone Z1B, latched
LED10	Dis.TripZ2/1p Dis.TripZ2/3p	3816 [1]) 3817	Distance protection trip in zone Z2, latched
LED11	Dis.TripZ3/T3 Dis.TRIP 3p. Z4 Dis.TRIP 3p. Z5	3818 3821 3822	Distance protection trip in zones Z3 to Z5, latched

[1]) devices with single- and three-pole tripping

[2]) devices with three-pole tripping only

[3]) devices with automatic reclosure

Table A-1 LED indication presettings

LED	LCD Text	Function No.	Remarks
LED12	AR not ready	2784 ^{3})	Automatic reclosure not ready at present, unlatched ^{3})
LED13	>Door open >CB wait	—	High voltage system, door open or CB waiting for spring charged, unlatched
LED14	Alarm Sum Event	0160	General alarm, unlatched

^{1}) devices with single- and three-pole tripping

^{2}) devices with three-pole tripping only

^{3}) devices with automatic reclosure

Table A-2 Binary input presettings

Binary Input	LCD Text	Function No.	Remarks
BI1	>Reset LED	0005	Reset of LED indications, H–active
BI2	>Manual Close	0356	Manual close of circuit breaker, H–active
	—	—	no presetting ^{2})
BI3	>FAIL:Feeder VT >I-STUB ENABLE	0361	Voltage transformer secondary miniture circuit breaker, H–active
BI4	>DisTel Rec.Ch1	4006	Distance protection teleprotection receive signal, H–active
BI5	>CB1 Ready	371	Circuit breaker 1 ready, L–active
	>CB wait	—	CB waiting for spring charged, L–active

^{1}) only devices without power relays

^{2}) only devices with power relays

Table A-3 Further binary input presettings for 7SA6**10***–***B/F/K**

Binary Input	LCD Text	Function No.	Remarks
BI6	>CB 3p Open >CB1 3p Open	380 411	Circuit breaker position 3pole Open, H-active
BI7	>CB 3p Closed >CB1 3p Closed	379 410	Circuit breaker position 3pole Closed, H-active

Table A-4 Further binary input presettings for7SA6***1** and 7SA6***2**

Binary Input	LCD Text	Function No.	Remarks
BI6	>TripC1 TripRel	6854	Trip Circuit Supervision (TripCirc.Superv), Circuit 1, H–active
BI8	>CB 3p Open >CB1 3p Open Breaker (open)²)	380 411 —	Circuit breaker position 3pole Open, H–active
BI9	>CB 3p Closed >CB1 3p Closed Breaker (closed) ²)	397 410 —	Circuit breaker position 3pole Closed, H–active
BI10	Disc.Swit.(open) ²)	—	Disconnect switch Open, H–active ²)
BI11	Disc.Swit. (closed) ²)	—	Disconnect switch Closed, H–active ²)
BI12	EarthSwit (open) ²)	—	Earth switch open, H–active ²)
BI13	EarthSwit (closed) ²)	—	Earth switch closed, H–active ²)
BI16	>Door open	—	High voltage system, Door open, H–active ²)
(further)	—	—	no presetting ²)

¹) only devices without power relays

²) only devices with power relays

Table A-5 Further binary output presettings for **all** ordering variants

Binary Output	LCD Text	Function No.	Remarks
BO1	Relay PICKUP	0501	Device (general) pickup
BO5	Alarm Sum Event	0160	Alarm Summary Event

Table A-6 Further binary output presettings for 7SA6**10***–***A/E/J**

Binary Output	LCD Text	Function No.	Remarks
BO3	AR CLOSE Cmd.	2851	Automatic reclosure close command ³)
BO7	Dis.T.SEND	4056	Distance protection teleprotection send signal

Table A-7 Further binary output presettings 7SA6**10***–***B/F/K**

Binary Output	LCD Text	Function No.	Remarks
BO3	AR CLOSE Cmd.	2851	Automatic reclosure close command [3])

Table A-8 Further binary output presettings 7SA6***1–***A/E/J** and 7SA6***2–***A/E/J/B/F/K**

Binary Output	LCD Text	Function No.	Remarks
BO2	Relay TRIP	0511	Device (general) trip command [2])
BO10	Dis.T.SEND	4056	Distance protection teleprotection send signal
BO12	AR CLOSE Cmd.	2851 [3])	Automatic reclosure close command [3])
BO14	Relay TRIP	0511 [2])	Device (general) trip command [2])
	Relay TRIP 1pL1 Relay TRIP 3ph. [1])	0512 [1]) 0515 [1])	Device (general) trip command for breaker pole L1 [1])
BO15	— [2])	— [2])	no pre-setting [2])
	Relay TRIP 1pL2 Relay TRIP 3ph.	0513 [1]) 0515 [1])	Device (general) trip command for breaker pole L2 [1])
BO16	— [2])	— [2])	no pre-setting [2])
	Relay TRIP 1pL3 Relay TRIP 3ph.	0514 [1]) 0515 [1])	Device (general) trip command for breaker pole L3 [1])
[1]) devices with single- and three-pole tripping [2]) devices with three-pole tripping only [3]) devices with automatic reclosure			

Table A-9 Further binary output presettings 7SA6***1***–***B/F/K** and 7SA6***2***–***C/G/L**

Binary Output	LCD Text	Function No.	Remarks
BO2	Breaker (open) Relay TRIP [2])	— 0511[2])	Circuit breaker open or Relay (general) trip command [2])
BO3	Breaker (close) AR CLOSE Cmd.	— 2851 [3])	Circuit breaker close or AR CLOSE Cmd. [3])
BO4	Breaker (close) AR CLOSE Cmd.	— 2851 [3])	Circuit breaker close or AR CLOSE Cmd. [3])
BO6	Disc.Swit.(open)	—	Disconnect switch open
BO7	Disc.Swit. (closed)	—	Disconnect switch closed
BO8	EarthSwit (open)	—	Earth switch open
BO9	EarthSwit (close)	—	Earth switch close
[1]) devices with single- and three-pole tripping [2]) devices with three-pole tripping only [3]) devices with automatic reclosure			

Table A-9 Further binary output presettings 7SA6***1***–***B/F/K** and 7SA6***2***–***C/G/L**

Binary Output	LCD Text	Function No.	Remarks
BO10	— 2)	— 2)	no presetting 2)
	Relay TRIP 1pL1 Relay TRIP 3ph.	0512 1) 0515 1)	Device (general) trip command for breaker pole L1 1)
BO11	— 2)	— 2)	no presetting 2)
	Relay TRIP 1pL2 Relay TRIP 3ph.	0513 1) 0515 1)	Device (general) trip command for breaker pole L2 1)
BO12	— 2)	— 2)	no presetting 2)
	Relay TRIP 1pL3 Relay TRIP 3ph.	0514 1) 0515 1)	Device (general) trip command for breaker pole L3 1)

1) devices with single- and three-pole tripping

2) devices with three-pole tripping only

3) devices with automatic reclosure

A.5 Protocol Dependent Functions

Protocol →	**IEC 60870–5–103**	**Profibus FMS**	**Additional Service Interface (optional)**
Function ↓			
Operational Measured Values	Yes	Yes	Yes
Metering Values	Yes	Yes	Yes
Fault Recording	Yes	Yes	Yes
Protective Setting from Remote	No. Only via Additional Service Interface	Yes	Yes
User-defined Alarms and Switching Objects	Yes	Yes	Yes
Time Sychronism	Via Protocol; DCF77/IRIG B; Interface; Binary Input	Via Protocol; DCF77/IRIG B; Interface; Binary Input	–
Alarms with Time Stamp	Yes	Yes	Yes
Commissioning Tools: • Alarm and Measured Value Transmission Blocking	Yes	Yes	Yes
• Generate Test Alarms	Yes	Yes	Yes

Physical Mode	Asynchronous	Asynchronous	–
Transmission Mode	Cyclic/Event	Cyclic/Event	–
Baudrate	4800 to 38400	Up to 1.5 MBaud	2400 to 115200
Type	RS232 RS485 Optical Fibres	RS485 Optical Fibres • Single-ended Ring • Double-ended Ring	RS232 RS485 Optical Fibres

Appendix B

This appendix is primarily a reference for the experienced user. Tables with all settings and all information available in a 7SA6 equipped with all options are provided.

B.1 Settings

Please see "*Note*" for settings right at the end of Section B.1**.**

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
103	Grp Chge OPTION	Scope of Functions	Disabled Enabled	Disabled	Setting Group Change Option
110	Trip mode	Scope of Functions	3pole only 1-/3pole	3pole only	Trip mode
114	Dis. PICKUP	Scope of Functions	Z< (quadrilat.) I> (overcurr.) U/I U/I/<phi> Disabled	I> (overcurr.)	Distance protection pickup program
120	Power Swing	Scope of Functions	Disabled Enabled	Disabled	Power Swing detection
121	Teleprot. Dist.	Scope of Functions	PUTT (Z1B) PUTT (Pickup) POTT Dir.Comp.Pickup UNBLOCKING BLOCKING Rev. Interlock Pilot wire comp Disabled	Disabled	Teleprotection for Distance prot.
122	DTT Direct Trip	Scope of Functions	Disabled Enabled	Disabled	DTT Direct Transfer Trip
124	SOTF Overcurr.	Scope of Functions	Disabled Enabled	Disabled	Instantaneous HighSpeed SOTF Overcurrent
125	Weak Infeed	Scope of Functions	Disabled Enabled	Disabled	Weak Infeed (Trip and/or Echo)
126	Back-Up O/C	Scope of Functions	Disabled TOC IEC TOC ANSI	TOC IEC	Backup overcurrent
130	Sens. Earth Flt	Scope of Functions	Disabled Enabled	Disabled	Sensitive Earth Flt.(comp/ isol. starp.)
131	Earth Fault O/C	Scope of Functions	Disabled TOC IEC TOC ANSI TOC Logarithm. Definite Time U0 inverse	Disabled	Earth fault overcurrent
132	Teleprot. E/F	Scope of Functions	Dir.Comp.Pickup UNBLOCKING BLOCKING Disabled	Disabled	Teleprotection for Earth fault overcurr.
133	Auto Reclose	Scope of Functions	Disabled 1 AR-cycle 2 AR-cycles 3 AR-cycles 4 AR-cycles 5 AR-cycles 6 AR-cycles 7 AR-cycles 8 AR-cycles ADT	Disabled	Auto-Reclose Function
134	AR control mode	Scope of Functions	Pickup w/ Tact Pickup w/o Tact Trip w/ Tact Trip w/o Tact	Pickup w/ Tact	Auto-Reclose control mode
135	Synchro-Check	Scope of Functions	Disabled Enabled	Disabled	Synchronism and Voltage Check
137	Overvoltage	Scope of Functions	Disabled Enabled	Disabled	Overvoltage

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
138	Fault Locator	Scope of Functions	Disabled Enabled with BCD-output	Enabled	Fault Locator
139	BREAKER FAILURE	Scope of Functions	Disabled Enabled	Disabled	Breaker Failure Protection
140	TripCirc.Superv	Scope of Functions	Disabled 1 trip circuit 2 trip circuits 3 trip circuits	Disabled	Trip Circuit Supervision
142	Ther. OVERLOAD	Scope of Functions	Disabled Enabled	Disabled	Thermal overload protection
150	AnalogOutput B1	Scope of Functions	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output B1 (Port B)
151	AnalogOutput B2	Scope of Functions	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output B2 (Port B)
152	AnalogOutput D1	Scope of Functions	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output D1 (Port D)
153	AnalogOutput D2	Scope of Functions	Disabled IL2 [%] UL23 [%] |P| [%] |Q| [%] Fault location d [%] Fault location d [km] Trip current Imax [primary]	Disabled	Analog Output D2 (Port D)
201	CT Starpoint	Power System Data 1	towards Line towards Busbar	towards Line	CT Starpoint
203	Unom PRIMARY	Power System Data 1	1.0..1200.0 kV	400.0 kV	Rated Primary Voltage
204	Unom SECONDARY	Power System Data 1	80..125 V	100 V	Rated Secondary Voltage (L-L)
205	CT PRIMARY	Power System Data 1	10..5000 A	1000 A	CT Rated Primary Current
206	CT SECONDARY	Power System Data 1	1A 5A	1A	CT Rated Secondary Current
207	SystemStarpoint	Power System Data 1	Solid Earthed Peterson-Coil earthed Isolated	Solid Earthed	System Starpoint is
210	U4 transformer	Power System Data 1	not connected Udelta transformer Usync transformer Ux reference transformer	not connected	U4 voltage transformer is
211	Uph / Udelta	Power System Data 1	0.10..9.99	1.73	Matching ratio Phase-VT To Open-Delta-VT

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
212	Usync connect.	Power System Data 1	L1-E L2-E L3-E L1-L2 L2-L3 L3-L1	L1-L2	VT connection for sync. voltage
214 A	φ Usync-Uline	Power System Data 1	0..360 °	0 °	Angle adjustment Usync-Uline
215	U-line / Usync	Power System Data 1	0.80..1.20	1.00	Matching ratio U-line / Usync
220	I4 transformer	Power System Data 1	not connected Neutral Current (of the protected line) Neutral Current of the parallel line Starpoint Curr. of earthed power transf.	Neutral Current (of the protected line)	I4 current transformer is
221	I4/Iph CT	Power System Data 1	0.010..5.000	1.000	Matching ratio I4/Iph for CT's
230	Rated Frequency	Power System Data 1	50 Hz 60 Hz	50 Hz	Rated Frequency
235	PHASE SEQ.	Power System Data 1	L1 L2 L3 L1 L3 L2	L1 L2 L3	Phase Sequence
236	Distance Unit	Power System Data 1	km Miles	km	Distance measurement unit
237	Format Z0/Z1	Power System Data 1	Zero seq. comp. factors RE/RL and XE/XL Zero seq. comp. factor K0 and angle(K0)	Zero seq. comp. factors RE/RL and XE/XL	Setting format for zero seq.comp. format
239	T-CB close	Power System Data 1	0.01..0.60 sec	0.06 sec	Closing (operating) time of CB
240	TMin TRIP CMD	Power System Data 1	0.02..30.00 sec	0.10 sec	Minimum TRIP Command Duration
241	TMax CLOSE CMD	Power System Data 1	0.01..30.00 sec	0.10 sec	Maximum Close Command Duration
242	T-CBtest-dead	Power System Data 1	0.00..30.00 sec	0.10 sec	Dead Time for CB test-auto reclosure
302	CHANGE	Change Group	Group A Group B Group C Group D Binary Input Protocol	Group A	Change to Another Setting Group
402A	WAVEFORMTRIGGER	Oscillographic Fault Records	Save with Pickup Save with TRIP Start with TRIP	Save with Pickup	Waveform Capture
403A	WAVEFORM DATA	Oscillographic Fault Records	Fault event Power System fault	Fault event	Scope of Waveform Data
410	MAX. LENGTH	Oscillographic Fault Records	0.30..5.00 sec	1.00 sec	Waveform Capture
411	PRE. TRIG. TIME	Oscillographic Fault Records	0.05..0.50 sec	0.10 sec	Captured Waveform Prior to Trigger
412	POST REC. TIME	Oscillographic Fault Records	0.05..0.50 sec	0.10 sec	Captured Waveform after Event
415	BinIn CAPT.TIME	Oscillographic Fault Records	0.10..5.00 sec; ∞	0.50 sec	Capture Time via Binary Input
610	FltDisp.LED/LCD	Device	Display Targets on every Pickup Display Targets on TRIP only	Display Targets on every Pickup	Fault Display on LED / LCD
615	Spont. FltDisp.	Device	NO YES	NO	Spontaneous display of flt.annunciations

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1103	FullScaleVolt.	Power System Data 2	1.0..1200.0 kV	400.0 kV	Measurement: Full Scale Voltage (100%)
1104	FullScaleCurr.	Power System Data 2	10..5000 A	1000 A	Measurement: Full Scale Current (100%)
1105	Line Angle	Power System Data 2	30..89 °	85 °	Line Angle
1110	x’	Power System Data 2	0.005..6.500 Ohm / km	0.150 Ohm / km	x’ - Line Reactance per length unit
1111	Line Length	Power System Data 2	1.0..1000.0 km	100.0 km	Line Length
1112	x’	Power System Data 2	0.005..10.000 Ohm / mile	0.242 Ohm / mile	x’ - Line Reactance per length unit
1113	Line Length	Power System Data 2	0.6..650.0 Miles	62.1 Miles	Line Length
1116	RE/RL(Z1)	Power System Data 2	-.33..7.00	1.00	Zero seq. comp. factor RE/RL for Z1
1117	XE/XL(Z1)	Power System Data 2	-.33..7.00	1.00	Zero seq. comp. factor XE/XL for Z1
1118	RE/RL(Z1B...Z5)	Power System Data 2	-.33..7.00	1.00	Zero seq. comp.factor RE/RL for Z1B...Z5
1119	XE/XL(Z1B...Z5)	Power System Data 2	-.33..7.00	1.00	Zero seq. comp.factor XE/XL for Z1B...Z5
1120	K0 (Z1)	Power System Data 2	0.000..4.000	1.000	Zero seq. comp. factor K0 for zone Z1
1121	Angle K0(Z1)	Power System Data 2	-135.00..135.00 °	0.00 °	Zero seq. comp. angle for zone Z1
1122	K0 (> Z1)	Power System Data 2	0.000..4.000	1.000	Zero seq.comp.factor K0,higher zones >Z1
1123	AngleI K0(> Z1)	Power System Data 2	-135.00..135.00 °	0.00 °	Zero seq. comp. angle, higher zones >Z1
1126	RM/RL ParalLine	Power System Data 2	0.00..8.00	0.00	Mutual Parallel Line comp. ratio RM/RL
1127	XM/XL ParalLine	Power System Data 2	0.00..8.00	0.00	Mutual Parallel Line comp. ratio XM/XL
1128	RATIO Par. Comp	Power System Data 2	50..95 %	85 %	Neutral current RATIO Parallel Line Comp
1130A	PoleOpenCurrent	Power System Data 2	0.05..1.00 A	0.10 A	Pole Open Current Threshold
1131A	PoleOpenVoltage	Power System Data 2	2..70 V	30 V	Pole Open Voltage Threshold
1132A	SI Time all Cl.	Power System Data 2	0.01..30.00 sec	0.05 sec	Seal-in Time after ALL closures
1134	Line Closure	Power System Data 2	Manual Close BI only Current OR Voltage or Manual close BI CBaux OR Current or Manual close BI Current flow or Manual close BI	Manual Close BI only	Recognition of Line Closures with
1135	Reset Trip CMD	Power System Data 2	with Pole Open Current Threshold only with CBaux AND Pole Open Current	with Pole Open Current Threshold only	RESET of Trip Command
1140A	I-CTsat. Thres.	Power System Data 2	0.2..50.0 A; ∞	10.0 A	CT Saturation Threshold
1150A	SI Time Man.Cl	Power System Data 2	0.01..30.00 sec	0.30 sec	Seal-in Time after MANUAL closures

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1151	SYN.MAN.CL	Power System Data 2	with Synchronism-check without Synchronism-check NO	without Synchronism-check	Manual CLOSE COMMAND generation
1155	3pole coupling	Power System Data 2	with Pickup with Trip	with Trip	3 pole coupling
1156A	Trip2phFlt	Power System Data 2	3pole 1pole, leading phase 1pole, lagging phase	3pole	Trip type with 2phase faults
1201	FCT Distance	Distance protection, general settings	ON OFF	ON	Distance protection is
1202	Minimum Iph>	Distance protection, general settings	0.10..4.00 A	0.10 A	Phase Current threshold for dist. meas.
1203	3I0> Threshold	Distance protection, general settings	0.05..4.00 A	0.10 A	3I0 threshold for neutral current pikkup
1204	3U0> Threshold	Distance protection, general settings	1..100 V; ∞	5 V	3U0 threshold zero seq. voltage pikkup
1205	3U0> COMP/ISOL.	Distance protection, general settings	10..200 V	40 V	3U0> pickup (comp/ isol. star-point)
1206	T3I0 1PHAS	Distance protection, general settings	0.00..0.50 sec	0.04 sec	Delay 1ph-faults (comp/isol. star-point)
1207A	3I0>/ Iphmax	Distance protection, general settings	0.05..0.30	0.10	3I0>-pickup-stabilisation (3I0> /Iphmax)
1215	Paral.Line Comp	Distance protection, general settings	NO YES	NO	Mutual coupling parall.line compensation
1220	PHASE PREF.2phe	Distance protection, general settings	L3 (L1) acyclic L1 (L3) acyclic L2 (L1) acyclic L1 (L2) acyclic L3 (L2) acyclic L2 (L3) acyclic L3 (L1) cyclic L1 (L3) cyclic all loops	L3 (L1) acyclic	Phase preference for 2ph-e faults
1221A	2Ph-E faults	Distance protection, general settings	block leading ph-e loop block lagging ph-e loop all loops only phase-phase loops only phase-earth loops	block leading ph-e loop	Loop selection with 2Ph-E faults
1232	SOTF zone	Distance protection, general settings	with Pickup (non-directional) with Zone Z1B Inactive	Inactive	Instantaneous trip after SwitchOnTo-Fault
1241	R load (Ø-E)	Distance protection, general settings	0.10..250.00 Ohm; ∞	∞ Ohm	R load, minimum Load Impedance (ph-e)
1242	φ load (Ø-E)	Distance protection, general settings	20..60 °	45 °	PHI load, maximum Load Angle (ph-e)
1243	R load (Ø-Ø)	Distance protection, general settings	0.10..250.00 Ohm; ∞	∞ Ohm	R load, minimum Load Impedance (ph-ph)
1244	φ load (Ø-Ø)	Distance protection, general settings	20..60 °	45 °	PHI load, maximum Load Angle (ph-ph)

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1301	Op. mode Z1	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z1
1302	R(Z1) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	1.25 Ohm	R(Z1), Resistance for ph-ph-faults
1303	X(Z1)	Distance zones (quadrilateral)	0.05..250.00 Ohm	2.50 Ohm	X(Z1), Reactance
1304	RE(Z1) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	2.50 Ohm	RE(Z1), Resistance for ph-e faults
1305	T1-1phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.00 sec	T1-1phase, delay for single phase faults
1306	T1-multi-phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.00 sec	T1multi-ph, delay for multi phase faults
1307	Zone Reduction	Distance zones (quadrilateral)	0..30 °	0 °	Zone Reduction Angle (load compensation)
1311	Op. mode Z2	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z2
1312	R(Z2) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	2.50 Ohm	R(Z2), Resistance for ph-ph-faults
1313	X(Z2)	Distance zones (quadrilateral)	0.05..250.00 Ohm	5.00 Ohm	X(Z2), Reactance
1314	RE(Z2) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	5.00 Ohm	RE(Z2), Resistance for ph-e faults
1315	T2-1phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.30 sec	T2-1phase, delay for single phase faults
1316	T2-multi-phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.30 sec	T2multi-ph, delay for multi phase faults
1317A	Trip 1pole Z2	Distance protection, general settings Distance zones (quadrilateral)	NO YES	NO	Single pole trip for faults in Z2
1321	Op. mode Z3	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Reverse	Operating mode Z3
1322	R(Z3) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	5.00 Ohm	R(Z3), Resistance for ph-ph-faults
1323	X(Z3)	Distance zones (quadrilateral)	0.05..250.00 Ohm	10.00 Ohm	X(Z3), Reactance
1324	RE(Z3) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	10.00 Ohm	RE(Z3), Resistance for ph-e faults
1325	T3 DELAY	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.60 sec	T3 delay

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1331	Op. mode Z4	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Non-Directional	Operating mode Z4
1332	R(Z4) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	R(Z4), Resistance for ph-ph-faults
1333	X(Z4)	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	X(Z4), Reactance
1334	RE(Z4) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	RE(Z4), Resistance for ph-e faults
1335	T4 DELAY	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.90 sec	T4 delay
1341	Op. mode Z5	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Inactive	Operating mode Z5
1342	R(Z5) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	R(Z5), Resistance for ph-ph-faults
1343	X(Z5)+	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	X(Z5)+, Reactance for Forward direction
1344	RE(Z5) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	12.00 Ohm	RE(Z5), Resistance for ph-e faults
1345	T5 DELAY	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.90 sec	T5 delay
1346	X(Z5)-	Distance zones (quadrilateral)	0.05..250.00 Ohm	4.00 Ohm	X(Z5)-, Reactance for Reverse direction
1351	Op. mode Z1B	Distance zones (quadrilateral)	Forward Reverse Non-Directional Inactive	Forward	Operating mode Z1B (overrreach zone)
1352	R(Z1B) Ø-Ø	Distance zones (quadrilateral)	0.05..250.00 Ohm	1.50 Ohm	R(Z1B), Resistance for ph-ph-faults
1353	X(Z1B)	Distance zones (quadrilateral)	0.05..250.00 Ohm	3.00 Ohm	X(Z1B), Reactance
1354	RE(Z1B) Ø-E	Distance zones (quadrilateral)	0.05..250.00 Ohm	3.00 Ohm	RE(Z1B), Resistance for ph-e faults
1355	T1B-1phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.00 sec	T1B-1phase, delay for single ph. faults
1356	T1B-multi-phase	Distance protection, general settings Distance zones (quadrilateral)	0.00..30.00 sec; ∞	0.00 sec	T1B-multi-ph, delay for multi ph. faults
1357	1st AR -> Z1B	Distance protection, general settings Distance zones (quadrilateral)	NO YES	YES	Z1B enabled before 1st AR (int. or ext.)
1601	PROGAM U/I	Distance protection, general settings	Ph-E: Uphe/ Ph-Ph: Uphph Ph-E: Uphph/Ph-Ph: Uphph Ph-E: Uphe/Ph-Ph: Uphe Ph-E: Uphe/Ph-Ph: I>>	Ph-E: Uphe/ Ph-Ph: Uphph	Pickup program U/I

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
1602	DELAY FORW. PU	Distance protection, general settings	0.00..30.00 sec; ∞	1.20 sec	Trip delay for Forward-PICKUP
1603	DELAY NON-DIR	Distance protection, general settings	0.00..30.00 sec; ∞	1.20 sec	Trip delay for Reverse/Non-direc. PICKUP
1610	Iph>>	Distance protection, general settings	0.25..10.00 A	1.80 A	Iph>> Pickup (overcurrent)
1611	Iph>	Distance protection, general settings	0.10..4.00 A	0.20 A	Iph> Pickup (minimum current)
1612	Uph-e (I>>)	Distance protection, general settings	20..70 V	48 V	Undervoltage (ph-e) at Iph>>
1613	Uph-e (I>)	Distance protection, general settings	20..70 V	48 V	Undervoltage (ph-e) at Iph>
1614	Uph-ph (I>>)	Distance protection, general settings	40..130 V	80 V	Undervoltage (ph-ph) at Iph>>
1615	Uph-ph (I>)	Distance protection, general settings	40..130 V	80 V	Undervoltage (ph-ph) at Iph>
1616	Iphi>	Distance protection, general settings	0.10..8.00 A	0.50 A	Iphi> Pickup (minimum current at phi>)
1617	Uph-e (Iphi>)	Distance protection, general settings	20..70 V	48 V	Undervoltage (ph-e) at Iphi>
1618	Uph-ph (Iphi>)	Distance protection, general settings	40..130 V	80 V	Undervoltage (ph-ph) at Iphi>
1619A	EFFECT φ	Distance protection, general settings	forward and reverse Forward	forward and reverse	Effective direction of phi-pickup
1620	φ >	Distance protection, general settings	30..60 °	50 °	PHI> pickup (lower setpoint)
1621	φ <	Distance protection, general settings	90..120 °	110 °	PHI< pickup (upper setpoint)
1630A	1ph FAULTS	Distance protection, general settings	phase-earth phase to phase only	phase-earth	1ph-pickup loop selection (PU w/o earth)
2002	P/S Op. mode	Power Swing	all zones blocked Z1/Z1B blocked Z2 to Z5 blocked Z1,Z1B,Z2 blocked	all zones blocked	Power Swing Operating mode
2006	PowerSwing trip	Power Swing	NO YES	NO	Power swing trip
2101	FCT Telep. Dis.	Teleprotection for Distance prot.	ON OFF	ON	Teleprotection for Distance prot. is
2102	Type of Line	Teleprotection for Distance prot.	Two Terminals Three Terminals	Two Terminals	Type of Line
2103A	Send Prolong.	Teleprotection for Distance prot.	0.00..30.00 sec	0.05 sec	Time for send signal prolongation
2107A	Delay for alarm	Teleprotection for Distance prot.	0.00..30.00 sec	10.00 sec	Unblocking: Time Delay for Alarm
2108	Release Delay	Teleprotection for Distance prot.	0.000..30.000 sec	0.000 sec	Time Delay for release after pickup

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2109A	TrBlk Wait Time	Teleprotection for Distance prot.	0.00..30.00 sec; ∞	0.04 sec	Transient Block.: Duration external flt.
2110A	TrBlk BlockTime	Teleprotection for Distance prot.	0.00..30.00 sec	0.05 sec	Transient Block.: Blk.T. after ext. flt.
2201	FCT Direct Trip	DTT Direct Transfer Trip	ON OFF	OFF	Direct Transfer Trip (DTT)
2202	Trip Time DELAY	DTT Direct Transfer Trip	0.00..30.00 sec; ∞	0.01 sec	Trip Time Delay
2401	FCT SOTF-O/C	Instantaneous High-Speed SOTF Overcurrent	ON OFF	ON	Inst. High Speed SOTF-O/C is
2404	I>>>	Instantaneous High-Speed SOTF Overcurrent	1.00..25.00 A	2.50 A	I>>> Pickup
2501	FCT Weak Infeed	Weak Infeed (Trip and/or Echo)	OFF Echo only Echo and Trip	Echo only	Weak Infeed function is
2502A	Trip/Echo DELAY	Weak Infeed (Trip and/or Echo)	0.00..30.00 sec	0.04 sec	Trip / Echo Delay after carrier receipt
2503A	Trip EXTENSION	Weak Infeed (Trip and/or Echo)	0.00..30.00 sec	0.05 sec	Trip Extension / Echo Impulse time
2505	UNDERVOLTAGE	Weak Infeed (Trip and/or Echo)	2..70 V	25 V	Undervoltage (ph-e)
2601	Operating Mode	Backup overcurrent	ON Only Active with Loss of VT sec. circuit OFF	Only Active with Loss of VT sec. circuit	Operating mode
2610	Iph>>	Backup overcurrent	0.10..25.00 A; ∞	2.00 A	Iph>> Pickup
2611	T Iph>>	Backup overcurrent	0.00..30.00 sec; ∞	0.30 sec	T Iph>> Time delay
2612	3I0>> PICKUP	Backup overcurrent	0.05..25.00 A; ∞	0.50 A	3I0>> Pickup
2613	T 3I0>>	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0>> Time delay
2614	I>> Telep/BI	Backup overcurrent	NO YES	YES	Instantaneous trip via Teleprot./BI
2615	I>> SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
2620	Iph>	Backup overcurrent	0.10..25.00 A; ∞	1.50 A	Iph> Pickup
2621	T Iph>	Backup overcurrent	0.00..30.00 sec; ∞	0.50 sec	T Iph> Time delay
2622	3I0>	Backup overcurrent	0.05..25.00 A; ∞	0.20 A	3I0> Pickup
2623	T 3I0>	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0> Time delay
2624	I> Telep/BI	Backup overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
2625	I> SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
2630	Iph> STUB	Backup overcurrent	0.10..25.00 A; ∞	1.50 A	Iph> STUB Pickup
2631	T Iph STUB	Backup overcurrent	0.00..30.00 sec; ∞	0.30 sec	T Iph STUB Time delay
2632	3I0> STUB	Backup overcurrent	0.05..25.00 A; ∞	0.20 A	3I0> STUB Pickup
2633	T 3I0 STUB	Backup overcurrent	0.00..30.00 sec; ∞	2.00 sec	T 3I0 STUB Time delay
2634	I-STUB Telep/BI	Backup overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
2635	I-STUB SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
2640	Ip>	Backup overcurrent	0.10..4.00 A; ∞	∞ A	Ip> Pickup
2642	T Ip Time Dial	Backup overcurrent	0.05..3.00 sec; ∞	0.50 sec	T Ip Time Dial
2643	Time Dial TD Ip	Backup overcurrent	0.50..15.00; ∞	5.00	Time Dial TD Ip

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2646	T Ip Add	Backup overcurrent	0.00..30.00 sec	0.00 sec	T Ip Additional Time Delay
2650	3I0p PICKUP	Backup overcurrent	0.05..4.00 A; ∞	∞ A	3I0p Pickup
2652	T 3I0p TimeDial	Backup overcurrent	0.05..3.00 sec; ∞	0.50 sec	T 3I0p Time Dial
2653	TimeDial TD3I0p	Backup overcurrent	0.50..15.00; ∞	5.00	Time Dial TD 3I0p
2656	T 3I0p Add	Backup overcurrent	0.00..30.00 sec	0.00 sec	T 3I0p Additional Time Delay
2660	IEC Curve	Backup overcurrent	Normal Inverse Very Inverse Extremely Inverse Long time inverse	Normal Inverse	IEC Curve
2661	ANSI Curve	Backup overcurrent	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
2670	I(3I0)p Tele/BI	Backup overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
2671	I(3I0)p SOTF	Backup overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
2680	SOTF Time DELAY	Backup overcurrent	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
2801	DMD Interval	Demand Measurement Setup	15 Min per., 1 Sub 15 Min per., 3 Subs 15 Min per., 15 Subs 30 Min per., 1 Sub. 60 Min per., 1 Sub.	60 Min per., 1 Sub.	Demand Calculation Intervals
2802	DMD Sync.Time	Demand Measurement Setup	On the Hour 15 Min. after Hour 30 Min. after Hour 45 Min. after Hour	On the Hour	Demand Synchronization Time
2811	MinMax cycRESET	Min/Max Measurement Setup	NO YES	YES	Automatic Cyclic Reset Function
2812	MiMa RESET TIME	Min/Max Measurement Setup	0..1439 min	0 min	MinMax Reset Timer
2813	MiMa RESETCYCLE	Min/Max Measurement Setup	1..365 day(s)	7 day(s)	MinMax Reset Cycle Period
2814	MinMaxRES.START	Min/Max Measurement Setup	1..365 Days	1 Days	MinMax Start Reset Cycle in
2901	MEASURE. SUPERV	Measurement Supervision	ON OFF	ON	Measurement Supervision
2902A	BALANCE U-LIMIT	Measurement Supervision	10..100 V	50 V	Voltage Threshold for Balance Monitoring
2903A	BAL. FACTOR U	Measurement Supervision	0.58..0.95	0.75	Balance Factor for Voltage Monitor
2904A	BALANCE I LIMIT	Measurement Supervision	0.10..1.00 A	0.50 A	Current Balance Monitor
2905A	BAL. FACTOR I	Measurement Supervision	0.10..0.95	0.50	Balance Factor for Current Monitor
2906A	ΣI THRESHOLD	Measurement Supervision	0.05..2.00 A	0.10 A	Summated Current Monitoring Threshold
2907A	ΣI FACTOR	Measurement Supervision	0.00..0.95	0.10	Summated Current Monitoring Factor
2910	FUSE FAIL MON.	Measurement Supervision	ON OFF	ON	Fuse Failure Monitor
2911A	FFM U>(min)	Measurement Supervision	10..100 V	30 V	Minimum Voltage Threshold U>
2912A	FFM I< (max)	Measurement Supervision	0.10..1.00 A	0.10 A	Maximum Current Threshold I<

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
2913A	FFM U<max (3ph)	Measurement Supervision	2..100 V	5 V	Maximum Voltage Threshold U< (3phase)
2914A	FFM Idelta (3p)	Measurement Supervision	0.05..1.00 A	0.10 A	Delta Current Threshold (3phase)
2921	T mcb	Measurement Supervision	0..30 ms	0 ms	T mcb
3001	Sens. Earth Flt	Sensitive Earth Flt.(comp/ isol. starp.)	Alarm Only ON OFF	Alarm Only	Sensitive Earth Flt.(comp/ isol. starp.)
3002	3U0>	Sensitive Earth Flt.(comp/ isol. starp.)	1..150 V	50 V	3U0> pickup
3003	Uph-e min	Sensitive Earth Flt.(comp/ isol. starp.)	10..100 V	40 V	Uph-e min of faulted phase
3004	Uph-e max	Sensitive Earth Flt.(comp/ isol. starp.)	10..100 V	75 V	Uph-e max of healthy phases
3005	3I0>	Sensitive Earth Flt.(comp/ isol. starp.)	0.003..1.000 A	0.050 A	3I0> Release directional element
3006	T Sens.E/F	Sensitive Earth Flt.(comp/ isol. starp.)	0.00..320.00 sec	1.00 sec	Time delay for sens. E/F detection
3007	T 3U0>	Sensitive Earth Flt.(comp/ isol. starp.)	0.00..320.00 sec	0.00 sec	Time delay for sens. E/F trip
3008A	TRIP Direction	Sensitive Earth Flt.(comp/ isol. starp.)	Forward Reverse Non-Directional	Forward	Direction for sens. E/F trip
3010	CT Err. I1	Sensitive Earth Flt.(comp/ isol. starp.)	0.003..1.600 A	0.050 A	Current I1 for CT Angle Error
3011	CT Err. F1	Sensitive Earth Flt.(comp/ isol. starp.)	0.0..5.0 °	0.0 °	CT Angle Error at I1
3012	CT Err. I2	Sensitive Earth Flt.(comp/ isol. starp.)	0.003..1.600 A	1.000 A	Current I2 for CT Angle Error
3013	CT Err. F2	Sensitive Earth Flt.(comp/ isol. starp.)	0.0..5.0 °	0.0 °	CT Angle Error at I2
3101	FCT EarthFltO/C	Earth fault overcurrent	ON OFF	ON	Earth Fault overcurrent function is
3102	BLOCK for Dist.	Earth fault overcurrent	with every Pickup with single-phase Pickup with multi-phase Pickup NO	with every Pickup	Block E/F for Distance protection
3103	BLOCK 1pDeadTim	Earth fault overcurrent	YES NO	NO	Block E/F for 1pole Dead time
3104A	Iph-STAB. Slope	Earth fault overcurrent	0..30 %	10 %	Stabilisation Slope with Iphase
3105A	3IoMin Teleprot	Earth fault overcurrent	0.01..1.00 A	0.50 A	3Io-Min threshold for Teleprot. schemes
3105A	3IoMin Teleprot	Earth fault overcurrent	0.003..1.000 A	0.500 A	3Io-Min threshold for Teleprot. schemes
3110	Op. mode 3I0>>>	Earth fault overcurrent	Forward Reverse Non-Directional Inactive	Inactive	Operating mode

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3111	3I0>>>	Earth fault overcurrent	0.50..25.00 A	4.00 A	3I0>>> Pickup
3112	T 3I0>>>	Earth fault overcurrent	0.00..30.00 sec; ∞	0.30 sec	T 3I0>>> Time delay
3113	3I0>>> Telep/BI	Earth fault overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
3114	3I0>>>SOTF-Trip	Earth fault overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
3115	3I0>>>InrushBlk	Earth fault overcurrent	NO YES	NO	Inrush Blocking
3120	Op. mode 3I0>>	Earth fault overcurrent	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3121	3I0>>	Earth fault overcurrent	0.20..25.00 A	2.00 A	3I0>> Pickup
3122	T 3I0>>	Earth fault overcurrent	0.00..30.00 sec; ∞	0.60 sec	T 3I0>> Time Delay
3123	3I0>> Telep/BI	Earth fault overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
3124	3I0>> SOTF-Trip	Earth fault overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
3125	3I0>> InrushBlk	Earth fault overcurrent	NO YES	NO	Inrush Blocking
3130	Op. mode 3I0>	Earth fault overcurrent	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3131	3I0>	Earth fault overcurrent	0.05..25.00 A	1.00 A	3I0> Pickup
3131	3I0>	Earth fault overcurrent	0.003..25.000 A	1.000 A	3I0> Pickup
3132	T 3I0>	Earth fault overcurrent	0.00..30.00 sec; ∞	0.90 sec	T 3I0> Time Delay
3133	3I0> Telep/BI	Earth fault overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
3134	3I0> SOTF-Trip	Earth fault overcurrent	NO YES	NO	Instantaneous trip after SwitchOnTo-Fault
3135	3I0> InrushBlk	Earth fault overcurrent	NO YES	NO	Inrush Blocking
3140	Op. mode 3I0p	Earth fault overcurrent	Forward Reverse Non-Directional Inactive	Inactive	Operating mode
3141	3I0p PICKUP	Earth fault overcurrent	0.05..25.00 A	1.00 A	3I0p Pickup
3141	3I0p PICKUP	Earth fault overcurrent	0.003..25.000 A	1.000 A	3I0p Pickup
3142	3I0p MinT-DELAY	Earth fault overcurrent	0.00..30.00 sec	1.20 sec	3I0p Minimum Time Delay
3143	3I0p Time Dial	Earth fault overcurrent	0.05..3.00 sec; ∞	0.50 sec	3I0p Time Dial
3144	3I0p Time Dial	Earth fault overcurrent	0.50..15.00; ∞	5.00	3I0p Time Dial
3145	3I0p Time Dial	Earth fault overcurrent	0.05..15.00 sec; ∞	1.35 sec	3I0p Time Dial
3146	3I0p MaxT-DELAY	Earth fault overcurrent	0.00..30.00 sec	5.80 sec	3I0p Maximum Time Delay

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3147	Add.T-DELAY	Earth fault overcurrent	0.00..30.00 sec; ∞	1.20 sec	Additional Time Delay
3148	3I0p Telep/BI	Earth fault overcurrent	NO YES	NO	Instantaneous trip via Teleprot./BI
3149	3I0p SOTF-Trip	Earth fault overcurrent	NO YES	NO	Instantaneous trip after SwitchOnToFault
3150	3I0p InrushBlk	Earth fault overcurrent	NO YES	NO	Inrush Blocking
3151	IEC Curve	Earth fault overcurrent	Normal Inverse Very Inverse Extremely Inverse Long time inverse	Normal Inverse	IEC Curve
3152	ANSI Curve	Earth fault overcurrent	Inverse Short Inverse Long Inverse Moderately Inverse Very Inverse Extremely Inverse Definite Inverse	Inverse	ANSI Curve
3153	LOG Curve	Earth fault overcurrent	Logarithmic inverse	Logarithmic inverse	LOGARITHMIC Curve
3154	3I0p Startpoint	Earth fault overcurrent	1.0..4.0	1.1	Start point of inverse characteristic
3160	POLARIZATION	Earth fault overcurrent	with U0 and IY (dual polarized) with IY (transformer star point current) with U2 and I2 (negative sequence)	with U0 and IY (dual polarized)	Polarization
3162A	Dir. ALPHA	Earth fault overcurrent	0..360 °	338 °	ALPHA, lower angle for forward direction
3163A	Dir. BETA	Earth fault overcurrent	0..360 °	122 °	BETA, upper angle for forward direction
3164	3U0>	Earth fault overcurrent	0.5..10.0 V	0.5 V	Min. zero seq.voltage 3U0 for polarizing
3165	IY>	Earth fault overcurrent	0.05..1.00 A	0.05 A	Min. earth current IY for polarizing
3166	3U2>	Earth fault overcurrent	0.5..10.0 V	0.5 V	Min. neg. seq. polarizing voltage 3U2
3167	3I2>	Earth fault overcurrent	0.05..1.00 A	0.05 A	Min. neg. seq. polarizing current 3I2
3170	2nd InrushRest	Earth fault overcurrent	10..45 %	15 %	2nd harmonic ratio for inrush restraint
3171	Imax InrushRest	Earth fault overcurrent	0.50..25.00 A	7.50 A	Max.Current, overriding inrush restraint
3172	SOTF Op. Mode	Earth fault overcurrent	with Pickup (non-directional) with Pickup and direction	with Pickup and direction	Instantaneous mode after SwitchOnToFault
3173	SOTF Time DELAY	Earth fault overcurrent	0.00..30.00 sec	0.00 sec	Trip time delay after SOTF
3182	3U0>(U0 inv)	Earth fault overcurrent	1.0..10.0 V	5.0 V	3U0> setpoint
3183	U0inv. minimum	Earth fault overcurrent	0.1..5.0 V	0.2 V	Minimum voltage U0min for T->oo
3184	T forw. (U0inv)	Earth fault overcurrent	0.00..32.00 sec	0.90 sec	T-forward Time delay (U0inv)
3185	T rev. (U0inv)	Earth fault overcurrent	0.00..32.00 sec	1.20 sec	T-reverse Time delay (U0inv)
3201	FCT Telep. E/F	Teleprotection for Earth fault overcurr.	ON OFF	ON	Teleprotection for Earth Fault O/C

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3202	Line Config.	Teleprotection for Earth fault overcurr.	Two Terminals Three Terminals	Two Terminals	Line Configuration
3203A	Send Prolong.	Teleprotection for Earth fault overcurr.	0.00..30.00 sec	0.05 sec	Time for send signal prolongation
3207A	Delay for alarm	Teleprotection for Earth fault overcurr.	0.00..30.00 sec	10.00 sec	Unblocking: Time Delay for Alarm
3208	Release Delay	Teleprotection for Earth fault overcurr.	0.000..30.000 sec	0.000 sec	Time Delay for release after pickup
3209A	TrBlk Wait Time	Teleprotection for Earth fault overcurr.	0.00..30.00 sec; ∞	0.04 sec	Transient Block.: Duration external flt.
3210A	TrBlk BlockTime	Teleprotection for Earth fault overcurr.	0.00..30.00 sec	0.05 sec	Transient Block.: Blk.T. after ext. flt.
3401	AUTO RECLOSE	Automatic Reclosure	OFF ON	ON	Auto-Reclose function
3402	CB? 1.TRIP	Automatic Reclosure	YES NO	NO	CB ready interrogation at 1st trip
3403	T-RECLAIM	Automatic Reclosure	0.50..300.00 sec	3.00 sec	Reclaim time after successful AR cycle
3404	T-BLOCK MC	Automatic Reclosure	0.50..300.00 sec	1.00 sec	AR blocking duration after manual close
3406	EV. FLT. RECOG.	Automatic Reclosure	with Pickup with Trip	with Trip	Evolving fault recognition
3407	EV. FLT. MODE	Automatic Reclosure	blocks AR starts 3pole AR-cycle	starts 3pole AR-cycle	Evolving fault (during the dead time)
3408	T-Start MONITOR	Automatic Reclosure	0.01..300.00 sec	0.50 sec	AR start-signal monitoring time
3409	CB TIME OUT	Automatic Reclosure	0.01..300.00 sec	3.00 sec	Circuit Breaker (CB) Supervision Time
3410	T RemoteClose	Automatic Reclosure	0.00..300.00 sec; ∞	∞ sec	Send delay for remote close command
3411A	T-DEAD EXT.	Automatic Reclosure	0.50..300.00 sec; ∞	∞ sec	Maximum dead time extension
3420	AR w/ DIST.	Automatic Reclosure	YES NO	YES	AR with distance protection
3421	AR w/ SOTF-O/C	Automatic Reclosure	YES NO	YES	AR with switch-onto-fault overcurrent
3422	AR w/ W/I	Automatic Reclosure	YES NO	YES	AR with weak infeed tripping
3423	AR w/ EF-O/C	Automatic Reclosure	YES NO	YES	AR with earth fault overcurrent prot.
3424	AR w/ DTT	Automatic Reclosure	YES NO	YES	AR with direct transfer trip
3425	AR w/ BackUpO/C	Automatic Reclosure	YES NO	YES	AR with back-up overcurrent
3430	AR TRIP 3pole	Automatic Reclosure	YES NO	YES	3pole TRIP by AR
3431	DLC or RDT	Automatic Reclosure	Without Reduced Dead Time (RDT) Dead Line Check (DLC)	Without	Dead Line Check or Reduced Dead Time
3433	T-ACTION ADT	Automatic Reclosure	0.01..300.00 sec; ∞	0.20 sec	Action time
3434	T-MAX ADT	Automatic Reclosure	0.50..3000.00 sec	5.00 sec	Maximum dead time
3435	ADT 1p allowed	Automatic Reclosure	YES NO	NO	1pole TRIP allowed
3436	ADT CB? CLOSE	Automatic Reclosure	YES NO	NO	CB ready interrogation before reclosing

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3437	ADT SynRequest	Automatic Reclosure	YES NO	NO	Request for synchro-check after 3pole AR
3438	T U-stable	Automatic Reclosure	0.10..30.00 sec	0.10 sec	Supervision time for dead/ live voltage
3440	U-live>	Automatic Reclosure	30..90 V	48 V	Voltage threshold for live line or bus
3441	U-dead<	Automatic Reclosure	2..70 V	30 V	Voltage threshold for dead line or bus
3450	1.AR: START	Automatic Reclosure	YES NO	YES	Start of AR allowed in this cycle
3451	1.AR: T-ACTION	Automatic Reclosure	0.01..300.00 sec; ∞	0.20 sec	Action time
3453	1.AR Tdead 1Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3454	1.AR Tdead 2Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3455	1.AR Tdead 3Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3456	1.AR Tdead1Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1pole trip
3457	1.AR Tdead3Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3458	1.AR: Tdead EV.	Automatic Reclosure	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3459	1.AR: CB? CLOSE	Automatic Reclosure	YES NO	NO	CB ready interrogation before reclosing
3460	1.AR SynRequest	Automatic Reclosure	YES NO	NO	Request for synchro-check after 3pole AR
3461	2.AR: START	Automatic Reclosure	YES NO	NO	AR start allowed in this cycle
3462	2.AR: T-ACTION	Automatic Reclosure	0.01..300.00 sec; ∞	0.20 sec	Action time
3464	2.AR Tdead 1Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3465	2.AR Tdead 2Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3466	2.AR Tdead 3Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3467	2.AR Tdead1Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3468	2.AR Tdead3Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3469	2.AR: Tdead EV.	Automatic Reclosure	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3470	2.AR: CB? CLOSE	Automatic Reclosure	YES NO	NO	CB ready interrogation before reclosing
3471	2.AR SynRequest	Automatic Reclosure	YES NO	NO	Request for synchro-check after 3pole AR
3472	3.AR: START	Automatic Reclosure	YES NO	NO	AR start allowed in this cycle
3473	3.AR: T-ACTION	Automatic Reclosure	0.01..300.00 sec; ∞	0.20 sec	Action time
3475	3.AR Tdead 1Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3476	3.AR Tdead 2Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3477	3.AR Tdead 3Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3478	3.AR Tdead1Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3479	3.AR Tdead3Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3480	3.AR: Tdead EV.	Automatic Reclosure	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3481	3.AR: CB? CLOSE	Automatic Reclosure	YES NO	NO	CB ready interrogation before reclosing
3482	3.AR SynRequest	Automatic Reclosure	YES NO	NO	Request for synchro-check after 3pole AR
3483	4.AR: START	Automatic Reclosure	YES NO	NO	AR start allowed in this cycle
3484	4.AR: T-ACTION	Automatic Reclosure	0.01..300.00 sec; ∞	0.20 sec	Action time
3486	4.AR Tdead 1Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 1phase faults
3487	4.AR Tdead 2Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	1.20 sec	Dead time after 2phase faults
3488	4.AR Tdead 3Flt	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3phase faults
3489	4.AR Tdead1Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	∞ sec	Dead time after 1pole trip
3490	4.AR Tdead3Trip	Automatic Reclosure	0.01..1800.00 sec; ∞	0.50 sec	Dead time after 3pole trip
3491	4.AR: Tdead EV.	Automatic Reclosure	0.01..1800.00 sec	1.20 sec	Dead time after evolving fault
3492	4.AR: CB? CLOSE	Automatic Reclosure	YES NO	NO	CB ready interrogation before reclosing
3493	4.AR SynRequest	Automatic Reclosure	YES NO	NO	Request for synchro-check after 3pole AR
3501	FCT Synchronism	Synchronism and Voltage Check	ON OFF	ON	Synchronism and Voltage Check function
3502	Dead Volt. Thr.	Synchronism and Voltage Check	1..60 V	5 V	Voltage threshold dead line / bus (ph-e)
3503	Live Volt. Thr.	Synchronism and Voltage Check	20..125 V	90 V	Voltage threshold live line / bus (ph-e)
3504	Umax	Synchronism and Voltage Check	20..140 V	110 V	Maximum permissible voltage
3507	T-SYN. DURATION	Synchronism and Voltage Check	0.01..600.00 sec; ∞	1.00 sec	Maximum duration of synchronism-check
3508	T SYNC-STAB	Synchronism and Voltage Check	0.00..30.00 sec	0.00 sec	Synchronous condition stability timer
3510	Op.mode with AR	Synchronism and Voltage Check	with consideration of CB closing time without consideration of CB closing time	without consideration of CB closing time	Operating mode with AR
3511	Max. Volt. Diff	Synchronism and Voltage Check	1.0..40.0 V	2.0 V	Maximum voltage difference
3512	Max. Freq. Diff	Synchronism and Voltage Check	0.03..2.00 Hz	0.10 Hz	Maximum frequency difference
3513	Max. Angle Diff	Synchronism and Voltage Check	2..60 °	10 °	Maximum angle difference
3515A	SYNC-CHECK	Synchronism and Voltage Check	YES NO	YES	Live bus / live line and Sync before AR

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3516	Usync> U-line<	Synchronism and Voltage Check	YES NO	NO	Live bus / dead line check before AR
3517	Usync< U-line>	Synchronism and Voltage Check	YES NO	NO	Dead bus / live line check before AR
3518	Usync< U-line<	Synchronism and Voltage Check	YES NO	NO	Dead bus / dead line check before AR
3519	OVERRIDE	Synchronism and Voltage Check	YES NO	NO	Override of any check before AR
3530	Op.mode with MC	Synchronism and Voltage Check	with consideration of CB closing time without consideration of CB closing time	without consideration of CB closing time	Operating mode with Man.Cl
3531	MC maxVolt.Diff	Synchronism and Voltage Check	1.0..40.0 V	2.0 V	Maximum voltage difference
3532	MC maxFreq.Diff	Synchronism and Voltage Check	0.03..2.00 Hz	0.10 Hz	Maximum frequency difference
3533	MC maxAngleDiff	Synchronism and Voltage Check	2..60 °	10 °	Maximum angle difference
3535A	MC SYNCHR	Synchronism and Voltage Check	YES NO	YES	Live bus / live line and Sync before MC
3536	MC Usyn> Uline<	Synchronism and Voltage Check	YES NO	NO	Live bus / dead line check before Man.Cl
3537	MC Usyn< Uline>	Synchronism and Voltage Check	YES NO	NO	Dead bus / live line check before Man.Cl
3538	MC Usyn< Uline<	Synchronism and Voltage Check	YES NO	NO	Dead bus / dead line check before Man.Cl
3539	MC O/RIDE	Synchronism and Voltage Check	YES NO	NO	Override of any check before Man.Cl
3701	Uph-e>(>)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode Uph-e overvoltage prot.
3702	Uph-e>	Voltage Protection	1.0..170.0 V	85.0 V	Uph-e> Pickup
3703	T Uph-e>	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T Uph-e> Time Delay
3704	Uph-e>>	Voltage Protection	1.0..170.0 V	100.0 V	Uph-e>> Pickup
3705	T Uph-e>>	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T Uph-e>> Time Delay
3709A	Uph-e>(>) RESET	Voltage Protection	0.50..0.98	0.98	Uph-e>(>) Reset ratio
3711	Uph-ph>(>)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode Uph-ph overvoltage prot.
3712	Uph-ph>	Voltage Protection	2.0..220.0 V	150.0 V	Uph-ph> Pickup
3713	T Uph-ph>	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T Uph-ph> Time Delay
3714	Uph-ph>>	Voltage Protection	2.0..220.0 V	175.0 V	Uph-ph>> Pickup
3715	T Uph-ph>>	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T Uph-ph>> Time Delay
3719A	Uphph>(>) RESET	Voltage Protection	0.50..0.98	0.98	Uph-ph>(>) Reset ratio
3721	3U0>(>) (or Ux)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode 3U0 (or Ux) overvoltage
3722	3U0>	Voltage Protection	1.0..220.0 V	30.0 V	3U0> Pickup (or Ux>)
3723	T 3U0>	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T 3U0> Time Delay (or T Ux>)
3724	3U0>>	Voltage Protection	1.0..220.0 V	50.0 V	3U0>> Pickup (or Ux>>)
3725	T 3U0>>	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T 3U0>> Time Delay (or T Ux>>)
3729A	3U0>(>) RESET	Voltage Protection	0.50..0.98	0.95	3U0>(>) Reset ratio (or Ux)

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3731	U1>(>)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode U1 overvoltage prot.
3732	U1>	Voltage Protection	2.0..220.0 V	150.0 V	U1> Pickup
3733	T U1>	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T U1> Time Delay
3734	U1>>	Voltage Protection	2.0..220.0 V	175.0 V	U1>> Pickup
3735	T U1>>	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T U1>> Time Delay
3739A	U1>(>) RESET	Voltage Protection	0.50..0.98	0.98	U1>(>) Reset ratio
3741	U2>(>)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode U2 overvoltage prot.
3742	U2>	Voltage Protection	2.0..220.0 V	30.0 V	U2> Pickup
3743	T U2>	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T U2> Time Delay
3744	U2>>	Voltage Protection	2.0..220.0 V	50.0 V	U2>> Pickup
3745	T U2>>	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T U2>> Time Delay
3749A	U2>(>) RESET	Voltage Protection	0.50..0.98	0.98	U2>(>) Reset ratio
3751	Uph-e<(<)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode Uph-e undervoltage prot.
3752	Uph-e<	Voltage Protection	1.0..100.0 V	30.0 V	Uph-e< Pickup
3753	T Uph-e<	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T Uph-e< Time Delay
3754	Uph-e<<	Voltage Protection	1.0..100.0 V	10.0 V	Uph-e<< Pickup
3755	T Uph-e<<	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T Uph-e<< Time Delay
3758	CURR.SUP. Uphe<	Voltage Protection	ON OFF	ON	Current supervision (Uph-e)
3761	Uph-ph<(<)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode Uph-ph undervoltage prot.
3762	Uph-ph<	Voltage Protection	1.0..175.0 V	50.0 V	Uph-ph< Pickup
3763	T Uph-ph<	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T Uph-ph< Time Delay
3764	Uph-ph<<	Voltage Protection	1.0..175.0 V	17.0 V	Uph-ph<< Pickup
3765	T Uphph<<	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T Uph-ph<< Time Delay
3768	CURR.SUP.Uphph<	Voltage Protection	ON OFF	ON	Current supervision (Uph-ph)
3771	U1<(<)	Voltage Protection	OFF Alarm Only ON	OFF	Operating mode U1 undervoltage prot.
3772	U1<	Voltage Protection	1.0..100.0 V	30.0 V	U1< Pickup
3773	T U1<	Voltage Protection	0.00..30.00 sec; ∞	2.00 sec	T U1< Time Delay
3774	U1<<	Voltage Protection	1.0..100.0 V	10.0 V	U1<< Pickup
3775	T U1<<	Voltage Protection	0.00..30.00 sec; ∞	1.00 sec	T U1<< Time Delay
3778	CURR.SUP.U1<	Voltage Protection	ON OFF	ON	Current supervision (U1)
3802	START	Fault Locator	Pickup TRIP	Pickup	Start fault locator with
3805	Paral.Line Comp	Fault Locator	NO YES	NO	Mutual coupling parall.line compensation
3806	Load Compensat.	Fault Locator	NO YES	NO	Load Compensation
3811	Tmax OUTPUT BCD	Fault Locator	0.10..30.00 sec	0.30 sec	Maximum output time via BCD

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
3901	FCT BreakerFail	Breaker Failure	ON OFF	ON	Breaker Failure Protection is
3902	I> BF	Breaker Failure	0.05..20.00 A	0.10 A	Pick-up threshold I>
3903	1p-RETRIP (T1)	Breaker Failure	NO YES	YES	1pole retrip with stage T1 (local trip)
3904	T1-1pole	Breaker Failure	0.00..30.00 sec; ∞	0.00 sec	T1, Delay after 1pole start (local trip)
3905	T1-3pole	Breaker Failure	0.00..30.00 sec; ∞	0.00 sec	T1, Delay after 3pole start (local trip)
3906	T2	Breaker Failure	0.00..30.00 sec; ∞	0.15 sec	T2, Delay of 2nd stage (busbar trip)
3907	T3-BkrDefective	Breaker Failure	0.00..30.00 sec; ∞	0.00 sec	T3, Delay for start with defective bkr.
3908	Trip BkrDefect.	Breaker Failure	NO trips with T1-trip-signal trips with T2-trip-signal trips with T1 and T2-trip-signal	NO	Trip output selection with defective bkr
3909	Chk BRK CONTACT	Breaker Failure	NO YES	YES	Check Breaker contacts
3921	End Flt. stage	Breaker Failure	ON OFF	OFF	End fault stage is
3922	T-EndFault	Breaker Failure	0.00..30.00 sec; ∞	2.00 sec	Trip delay of end fault stage
3931	PoleDiscrepancy	Breaker Failure	ON OFF	OFF	Pole Discrepancy supervision
3932	T-PoleDiscrep.	Breaker Failure	0.00..30.00 sec; ∞	2.00 sec	Trip delay with pole discrepancy
4001	FCT TripSuperv.	Trip Circuit Supervision	ON OFF	OFF	TRIP Circuit Supervision is
4002	No. of BI	Trip Circuit Supervision	1..2	2	Number of Binary Inputs per trip circuit
4003	Alarm Delay	Trip Circuit Supervision	1..30 sec	2 sec	Delay Time for alarm
4201	Ther. OVERLOAD	Thermal Overload	OFF ON Alarm Only	OFF	Thermal overload protection
4202	K-FACTOR	Thermal Overload	0.10..4.00	1.10	K-Factor
4203	TIME CONSTANT	Thermal Overload	1.0..999.9 min	100.0 min	Time constant
4204	Θ ALARM	Thermal Overload	50..100 %	90 %	Thermal Alarm Stage
4205	I ALARM	Thermal Overload	0.10..4.00 A	1.00 A	Current Overload Alarm setpoint
4206	CALC. METHOD	Thermal Overload	Theta Max Average Theta Theta from Imax	Theta Max	Method of Acquiring Temperature
5001	20 mA (B1) =	AnalogOutputs	10.0..1000.0 %	200.0 %	20 mA (B1) correspond to
5002	20 mA (B1) =	AnalogOutputs	10..100000 A	20000 A	20 mA (B1) correspond to
5003	20 mA (B1) =	AnalogOutputs	1.0..1000.0 km	50.0 km	20 mA (B1) correspond to
5004	20 mA (B1) =	AnalogOutputs	1.0..1000.0 Miles	50.0 Miles	20 mA (B1) correspond to
5006	MIN VALUE (B1)	AnalogOutputs	0.0..5.0 mA	4.0 mA	Output value (B1) valid from
5007	NEG VALUE (B1)	AnalogOutputs	19.00..22.50 mA	19.84 mA	Output value (B1) for negative values
5008	OVERFLOW (B1)	AnalogOutputs	19.00..22.50 mA	22.50 mA	Output value (B1) for overflow
5009	Tmax OUTPUT(B1)	AnalogOutputs	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (B1)
5011	20 mA (B2) =	AnalogOutputs	10.0..1000.0 %	200.0 %	20 mA (B2) correspond to
5012	20 mA (B2) =	AnalogOutputs	10..100000 A	20000 A	20 mA (B2) correspond to
5013	20 mA (B2) =	AnalogOutputs	1.0..1000.0 km	50.0 km	20 mA (B2) correspond to
5014	20 mA (B2) =	AnalogOutputs	1.0..1000.0 Miles	50.0 Miles	20 mA (B2) correspond to
5016	MIN VALUE (B2)	AnalogOutputs	0.0..5.0 mA	4.0 mA	Output value (B2) valid from

Addr.	Setting Title	Function	Setting Options	Default Setting	Comments
5017	NEG VALUE (B2)	AnalogOutputs	19.00..22.50 mA	19.84 mA	Output value (B2) for negative values
5018	OVERFLOW (B2)	AnalogOutputs	19.00..22.50 mA	22.50 mA	Output value (B2) for overflow
5019	Tmax OUTPUT(B2)	AnalogOutputs	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (B2)
5021	20 mA (D1) =	AnalogOutputs	10.0..1000.0 %	200.0 %	20 mA (D1) correspond to
5022	20 mA (D1) =	AnalogOutputs	10..100000 A	20000 A	20 mA (D1) correspond to
5023	20 mA (D1) =	AnalogOutputs	1.0..1000.0 km	50.0 km	20 mA (D1) correspond to
5024	20 mA (D1) =	AnalogOutputs	1.0..1000.0 Miles	50.0 Miles	20 mA (D1) correspond to
5026	MIN VALUE (D1)	AnalogOutputs	0.0..5.0 mA	4.0 mA	Output value (D1) valid from
5027	NEG VALUE (D1)	AnalogOutputs	19.00..22.50 mA	19.84 mA	Output value (D1) for negative values
5028	OVERFLOW (D1)	AnalogOutputs	19.00..22.50 mA	22.50 mA	Output value (D1) for overflow
5029	Tmax OUTPUT(D1)	AnalogOutputs	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (D1)
5031	20 mA (D2) =	AnalogOutputs	10.0..1000.0 %	200.0 %	20 mA (D2) correspond to
5032	20 mA (D2) =	AnalogOutputs	10..100000 A	20000 A	20 mA (D2) correspond to
5033	20 mA (D2) =	AnalogOutputs	1.0..1000.0 km	50.0 km	20 mA (D2) correspond to
5034	20 mA (D2) =	AnalogOutputs	1.0..1000.0 Miles	50.0 Miles	20 mA (D2) correspond to
5036	MIN VALUE (D2)	AnalogOutputs	0.0..5.0 mA	4.0 mA	Output value (D2) valid from
5037	NEG VALUE (D2)	AnalogOutputs	19.00..22.50 mA	19.84 mA	Output value (D2) for negative values
5038	OVERFLOW (D2)	AnalogOutputs	19.00..22.50 mA	22.50 mA	Output value (D2) for overflow
5039	Tmax OUTPUT(D2)	AnalogOutputs	0.10..30.00 sec; ∞	5.00 sec	Maximum output time (D2)

Note:

Depending on the version and the variant ordered some addresses are not used or have different default settings. The setting ranges and presettings listed in the table refer to a nominal current value I_N = 1 A. For a secondary nominal current value I_N = 5 A the current values are to be multiplied by 5. For setting primary values the transformation ratio of the transformer also must be taken into consideration. Settings specified with an "A" can only be changed with DIGSI® 4 under "Additional Settings".

B.2 List of Information

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3	>Synchronize Internal Real Time Clock (>Time Synch)	Device	SP	*	*			LED	BI		BO					
4	>Trigger Waveform Capture (>Trig.Wave.Cap.)	Oscillographic Fault Records	SP	ON	*		M	LED	BI		BO					
5	>Reset LED (>Reset LED)	Device	SP	*	*			LED	BI		BO					
7	>Setting Group Select Bit 0 (>Set Group Bit0)	Change Group	SP	*	*			LED	BI		BO					
8	>Setting Group Select Bit 1 (>Set Group Bit1)	Change Group	SP	*	*			LED	BI		BO					
15	>Test mode (>Test mode)	Device	SP	ON OFF	*			LED	BI		BO		135	53	1	GI
16	>Stop data transmission (>DataStop)	Device	SP	*	*			LED	BI		BO		135	54	1	GI
51	Device is Operational and Protecting (Device OK)	Device	OUT	ON OFF	*			LED			BO		135	81	1	GI
52	At Least 1 Protection Funct. is Active (ProtActive)	Device	IntSP	ON OFF	*			LED			BO		128	18	1	GI
55	Reset Device (Reset Device)	Device	OUT	*	*			LED			BO		128	4	1	
56	Initial Start of Device (Initial Start)	Device	OUT	ON	*			LED			BO		128	5	1	
60	Reset LED (Reset LED)	Device	OUT_Ev	ON	*			LED			BO		128	19	1	
67	Resume (Resume)	Device	OUT	ON	*			LED			BO		135	97	1	
68	Clock Synchronization Error (Clock SyncError)	Device	OUT	ON OFF	*			LED			BO					
69	Daylight Saving Time (DayLightSavTime)	Device	OUT	ON OFF	*			LED			BO					
70	Setting calculation is running (Settings Calc.)	Device	OUT	ON OFF	*			LED			BO		128	22	1	GI
71	Settings Check (Settings Check)	Device	OUT	*	*			LED			BO					
72	Level-2 change (Level-2 change)	Device	OUT	ON OFF	*			LED			BO					
73	Local setting change (Local change)	Device	OUT	*	*											
110	Event lost (Event Lost)	Device	OUT_Ev	ON	*			LED			BO		135	130	1	
113	Flag Lost (Flag Lost)	Device	OUT	ON	*		M	LED			BO		135	136	1	GI
125	Chatter ON (Chatter ON)	Device	OUT	ON OFF	*			LED			BO		135	145	1	GI
126	Protection ON/OFF (via system port) (ProtON/OFF)	Device	IntSP	ON OFF	*			LED			BO					
127	Auto Reclose ON/OFF (via system port) (AR ON/OFF)	Device	IntSP	ON OFF	*			LED			BO					
128	Teleprot. ON/OFF (via system port) (TelepONoff)	Device	IntSP	ON OFF	*			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
140	Error with a summary alarm (Error Sum Alarm)	Device	OUT	ON OFF	*			LED			BO		128	47	1	GI
144	Error 5V (Error 5V)	Device	OUT	ON OFF	*			LED			BO		135	164	1	GI
160	Alarm Summary Event (Alarm Sum Event)	Device	OUT	*	*			LED			BO		128	46	1	GI
161	Failure: General Current Supervision (Fail I Superv.)	Measurement Supervision	OUT	*	*			LED			BO		128	32	1	GI
162	Failure: Current Summation (Failure Σ I)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	182	1	GI
163	Failure: Current Balance (Fail I balance)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	183	1	GI
164	Failure: general Voltage Supervision (Fail U Superv.)	Measurement Supervision	OUT	*	*			LED			BO		128	33	1	GI
165	Failure: Voltage summation Phase-Earth (Fail Σ U Ph-E)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	184	1	GI
167	Failure: Voltage Balance (Fail U balance)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	186	1	GI
169	VT Fuse Failure (alarm >10s) (VT FuseFail>10s)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	188	1	GI
170	VT Fuse Failure (alarm instantaneous) (VT FuseFail)	Measurement Supervision	OUT	ON OFF	*			LED			BO					
171	Failure: Phase Sequence (Fail Ph. Seq.)	Measurement Supervision	OUT	ON OFF	*			LED			BO		128	35	1	GI
177	Failure: Battery empty (Fail Battery)	Device	OUT	ON OFF	*			LED			BO		135	193	1	GI
181	Error: A/D converter (Error A/D-conv.)	Device	OUT	ON OFF	*			LED			BO		135	178	1	GI
182	Alarm: Real Time Clock (Alarm Clock)	Device	OUT	ON OFF	*			LED			BO		135	194	1	GI
183	Error Board 1 (Error Board 1)	Device	OUT	ON OFF	*			LED			BO		135	171	1	GI
184	Error Board 2 (Error Board 2)	Device	OUT	ON OFF	*			LED			BO		135	172	1	GI
185	Error Board 3 (Error Board 3)	Device	OUT	ON OFF	*			LED			BO		135	173	1	GI
186	Error Board 4 (Error Board 4)	Device	OUT	ON OFF	*			LED			BO		135	174	1	GI
187	Error Board 5 (Error Board 5)	Device	OUT	ON OFF	*			LED			BO		135	175	1	GI
188	Error Board 6 (Error Board 6)	Device	OUT	ON OFF	*			LED			BO		135	176	1	GI
189	Error Board 7 (Error Board 7)	Device	OUT	ON OFF	*			LED			BO		135	177	1	GI
190	Error Board 0 (Error Board 0)	Device	OUT	ON OFF	*			LED			BO		135	210	1	GI
192	Error:1A/5Ajumper different from setting (Error1A/5Awrong)	Device	OUT	ON OFF	*			LED			BO		135	169	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
193	Alarm: NO calibration data available (Alarm NO calibr)	Device	OUT	ON OFF	*			LED			BO		135	181	1	GI
194	Error: Neutral CT different from MLFB (Error neutralCT)	Device	OUT	ON OFF	*			LED			BO		135	180	1	GI
195	Failure: Broken Conductor (Fail Conductor)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	195	1	GI
196	Fuse Fail Monitor is switched OFF (Fuse Fail M.OFF)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	196	1	GI
197	Measurement Supervision is switched OFF (MeasSup OFF)	Measurement Supervision	OUT	ON OFF	*			LED			BO		135	197	1	GI
203	Waveform data deleted (Wave. deleted)	Oscillographic Fault Records	OUT_Ev	ON	*			LED			BO		135	203	1	
273	Set Point Phase L1 dmd> (SP. IL1 dmd>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	230	1	GI
274	Set Point Phase L2 dmd> (SP. IL2 dmd>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	234	1	GI
275	Set Point Phase L3 dmd> (SP. IL3 dmd>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	235	1	GI
276	Set Point positive sequence I1dmd> (SP. I1dmd>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	236	1	GI
277	Set Point |Pdmd|> (SP. |Pdmd|>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	237	1	GI
278	Set Point |Qdmd|> (SP. |Qdmd|>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	238	1	GI
279	Set Point |Sdmd|> (SP. |Sdmd|>)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	239	1	GI
285	Power factor alarm (cosφ alarm)	Set Points (Measured Values)	OUT	on off	*			LED			BO		135	245	1	GI
351	>Circuit breaker aux. contact: Pole L1 (>CB Aux. L1)	Power System Data 2	SP	*	*			LED	BI		BO		150	1	1	GI
352	>Circuit breaker aux. contact: Pole L2 (>CB Aux. L2)	Power System Data 2	SP	*	*			LED	BI		BO		150	2	1	GI
353	>Circuit breaker aux. contact: Pole L3 (>CB Aux. L3)	Power System Data 2	SP	*	*			LED	BI		BO		150	3	1	GI
356	>Manual close signal (>Manual Close)	Power System Data 2	SP	*	*			LED	BI		BO		150	6	1	GI
357	>Block all Close commands from external (>Close Cmd. Blk)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	7	1	GI
361	>Failure: Feeder VT (MCB tripped) (>FAIL:Feeder VT)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		128	38	1	GI
362	>Failure: Busbar VT (MCB tripped) (>FAIL:Bus VT)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	12	1	GI
366	>CB1 Pole L1 (for AR,CB-Test) (>CB1 Pole L1)	Power System Data 2	SP	*	*			LED	BI		BO		150	66	1	GI
367	>CB1 Pole L2 (for AR,CB-Test) (>CB1 Pole L2)	Power System Data 2	SP	*	*			LED	BI		BO		150	67	1	GI
368	>CB1 Pole L3 (for AR,CB-Test) (>CB1 Pole L3)	Power System Data 2	SP	*	*			LED	BI		BO		150	68	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
371	>CB1 READY (for AR,CB-Test) (>CB1 Ready)	Power System Data 2	SP	*	*			LED	BI		BO		150	71	1	GI
378	>CB faulty (>CB faulty)	Power System Data 2	SP	*	*			LED	BI		BO					
379	>CB aux. contact 3pole Closed (>CB 3p Closed)	Power System Data 2	SP	*	*			LED	BI		BO		150	78	1	GI
380	>CB aux. contact 3pole Open (>CB 3p Open)	Power System Data 2	SP	*	*			LED	BI		BO		150	79	1	GI
381	>Single-phase trip permitted from ext.AR (>1p Trip Perm)	Power System Data 2	SP	ON OFF	*			LED	BI		BO					
382	>External AR programmed for 1phase only (>Only 1ph AR)	Power System Data 2	SP	ON OFF	*			LED	BI		BO					
383	>Enable all AR Zones / Stages (>Enable ARzones)	Power System Data 2	SP	ON OFF	ON OFF			LED	BI		BO					
385	>Lockout SET (>Lockout SET)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	35	1	GI
386	>Lockout RESET (>Lockout RESET)	Power System Data 2	SP	ON OFF	*			LED	BI		BO		150	36	1	GI
395	>I MIN/MAX Buffer Reset (>I MinMax Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
396	>I1 MIN/MAX Buffer Reset (>I1 MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
397	>U MIN/MAX Buffer Reset (>U MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
398	>Uphph MIN/MAX Buffer Reset (>UphphMiMaRes)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
399	>U1 MIN/MAX Buffer Reset (>U1 MiMa Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
400	>P MIN/MAX Buffer Reset (>P MiMa Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
401	>S MIN/MAX Buffer Reset (>S MiMa Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
402	>Q MIN/MAX Buffer Reset (>Q MiMa Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
403	>Idmd MIN/MAX Buffer Reset (>Idmd MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
404	>Pdmd MIN/MAX Buffer Reset (>Pdmd MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
405	>Qdmd MIN/MAX Buffer Reset (>Qdmd MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
406	>Sdmd MIN/MAX Buffer Reset (>Sdmd MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
407	>Frq. MIN/MAX Buffer Reset (>Frq MiMa Reset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
408	>Power Factor MIN/MAX Buffer Reset (>PF MiMaReset)	Min/Max Measurement Setup	SP	ON	*			LED	BI		BO					
410	>CB1 aux. 3p Closed (for AR, CB-Test) (>CB1 3p Closed)	Power System Data 2	SP	*	*			LED	BI		BO		150	80	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
411	>CB1 aux. 3p Open (for AR, CB-Test) (>CB1 3p Open)	Power System Data 2	SP	*	*			LED	BI		BO		150	81	1	GI
501	Relay PICKUP (Relay PICKUP)	Power System Data 2	OUT	*	*		M	LED			BO		128	84	2	GI
503	Relay PICKUP Phase L1 (Relay PIKKUP L1)	Power System Data 2	OUT	*	*		M	LED			BO		128	64	2	GI
504	Relay PICKUP Phase L2 (Relay PICKUP L2)	Power System Data 2	OUT	*	*		M	LED			BO		128	65	2	GI
505	Relay PICKUP Phase L3 (Relay PICKUP L3)	Power System Data 2	OUT	*	*		M	LED			BO		128	66	2	GI
506	Relay PICKUP Earth (Relay PICKUP E)	Power System Data 2	OUT	*	*		M	LED			BO		128	67	2	GI
507	Relay TRIP command Phase L1 (Relay TRIP L1)	Power System Data 2	OUT	*	*		M	LED			BO		128	69	2	
508	Relay TRIP command Phase L2 (Relay TRIP L2)	Power System Data 2	OUT	*	*		M	LED			BO		128	70	2	
509	Relay TRIP command Phase L3 (Relay TRIP L3)	Power System Data 2	OUT	*	*		M	LED			BO		128	71	2	
510	Relay GENERAL CLOSE command (Relay CLOSE)	Power System Data 2	OUT	*	*	*		LED			BO		128	128	1	
511	Relay GENERAL TRIP command (Relay TRIP)	Power System Data 2	OUT	*	OFF		M	LED			BO		128	68	2	
512	Relay TRIP command - Only Phase L1 (Relay TRIP 1pL1)	Power System Data 2	OUT	*	*			LED			BO					
513	Relay TRIP command - Only Phase L2 (Relay TRIP 1pL2)	Power System Data 2	OUT	*	*			LED			BO					
514	Relay TRIP command - Only Phase L3 (Relay TRIP 1pL3)	Power System Data 2	OUT	*	*			LED			BO					
515	Relay TRIP command Phases L123 (Relay TRIP 3ph.)	Power System Data 2	OUT	*	*			LED			BO					
530	LOCKOUT is active (LOCKOUT)	Power System Data 2	IntSP	ON OFF	ON OFF			LED			BO		150	170	1	GI
533	Primary fault current IL1 (IL1 =)	Power System Data 2	OUT	*	ON OFF								150	177	4	
534	Primary fault current IL2 (IL2 =)	Power System Data 2	OUT	*	ON OFF								150	178	4	
535	Primary fault current IL3 (IL3 =)	Power System Data 2	OUT	*	ON OFF								150	179	4	
536	Relay Definitive TRIP (Definitive TRIP)	Power System Data 2	OUT	ON	ON	*		LED			BO		150	180	2	
545	Time from Pickup to drop out (PU Time)	Power System Data 2	OUT													
546	Time from Pickup to TRIP (TRIP Time)	Power System Data 2	OUT													
560	Single-phase trip was coupled 3phase (Trip Coupled 3p)	Power System Data 2	OUT	*	ON			LED			BO		150	210	2	
561	Manual close signal detected (Man.Clos.Detect)	Power System Data 2	OUT	ON	*			LED			BO		150	211	1	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
562	CB CLOSE command for manual closing (Man.Close Cmd)	Power System Data 2	OUT	*	*			LED			BO		150	212	1	
563	CB alarm suppressed (CB Alarm Supp)	Power System Data 2	OUT	*	*	*		LED			BO					
601	I L1 (IL1 =)	Measurement	MV										128 134	148 124	3 9	
602	I L2 (IL2 =)	Measurement	MV										128 134	148 124	3 9	
603	I L3 (IL3 =)	Measurement	MV										128 134	148 124	3 9	
610	3I0 (zero sequence) (3I0 =)	Measurement	MV										134	124	9	
611	3I0sen (sensitive zero sequence) (3I0sen=)	Measurement	MV													
612	IY (star point of transformer) (IY =)	Measurement	MV													
613	3I0par (parallel line neutral) (3I0par=)	Measurement	MV													
619	I1 (positive sequence) (I1 =)	Measurement	MV													
620	I2 (negative sequence) (I2 =)	Measurement	MV													
621	U L1-E (UL1E=)	Measurement	MV										128 134	148 124	3 9	
622	U L2-E (UL2E=)	Measurement	MV										128 134	148 124	3 9	
623	U L3-E (UL3E=)	Measurement	MV										128 134	148 124	3 9	
624	U L12 (UL12=)	Measurement	MV										134	124	9	
625	U L23 (UL23=)	Measurement	MV										134	124	9	
626	U L31 (UL31=)	Measurement	MV										134	124	9	
631	3U0 (zero sequence) (3U0 =)	Measurement	MV													
632	Usync (synchronism) (Usync =)	Measurement	MV													
633	Ux (separate VT) (Ux =)	Measurement	MV													
634	U1 (positive sequence) (U1 =)	Measurement	MV													
635	U2 (negative sequence) (U2 =)	Measurement	MV													
636	U-diff (line-bus) (Udiff =)	Measurement	MV													
637	U-line (Uline =)	Measurement	MV													
641	P (active power) (P =)	Measurement	MV										128 134	148 124	3 9	
642	Q (reactive power) (Q =)	Measurement	MV										128 134	148 124	3 9	
643	Power Factor (PF =)	Measurement	MV										134	124	9	
644	Frequency (Freq=)	Measurement	MV										128 134	148 124	3 9	
645	S (apparent power) (S =)	Measurement	MV													
646	Frequency (busbar) (F-bus =)	Measurement	MV													

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
647	Frequency (difference line-bus) (F-diff=)	Measurement	MV													
648	Angle (difference line-bus) (φ-diff=)	Measurement	MV													
649	Frequency (line) (F-line=)	Measurement	MV													
701	Active 3I0 sen (sensitive Ie) (3I0 sen A)	Measurement	MV										134	124	9	
702	Reactive 3I0 sen (sensitive Ie) (3I0 sen R)	Measurement	MV										134	124	9	
966	R L1E (R L1E=)	Measurement	MV													
967	R L2E (R L2E=)	Measurement	MV													
970	R L3E (R L3E=)	Measurement	MV													
971	R L12 (R L12=)	Measurement	MV													
972	R L23 (R L23=)	Measurement	MV													
973	R L31 (R L31=)	Measurement	MV													
974	X L1E (X L1E=)	Measurement	MV													
975	X L2E (X L2E=)	Measurement	MV													
976	X L3E (X L3E=)	Measurement	MV													
977	X L12 (X L12=)	Measurement	MV													
978	X L23 (X L23=)	Measurement	MV													
979	X L31 (X L31=)	Measurement	MV													
1000	Number of breaker TRIP commands (# TRIPs=)	Statistics	OUT													
1001	Number of breaker TRIP commands L1 (TripNo L1=)	Statistics	OUT													
1002	Number of breaker TRIP commands L2 (TripNo L2=)	Statistics	OUT													
1003	Number of breaker TRIP commands L3 (TripNo L3=)	Statistics	OUT													
1027	Accumulation of interrupted current L1 (Σ IL1 =)	Statistics	OUT													
1028	Accumulation of interrupted current L2 (Σ IL2 =)	Statistics	OUT													
833	I1 (positive sequence) Demand	MV														
834	Active Power Demand	MV														
835	Reactive Power Demand	MV														
836	Apparent Power Demand	MV														
837	I L1 Demand Minimum	MVT														
838	I L1 Demand Minimum	MVT														
839	I L1 Demand Maximum	MVT														
840	I L2 Demand Minimum	MVT														
841	I L2 Demand Maximum	MVT														
842	I L3 Demand Minimum	MVT														

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
843	I L3 Demand Maximum	MVT														
844	I1 (positive sequence) Demand Minimum	MVT														
845	I1 (positive sequence) Demand Maximum	MVT														
846	Active Power Demand Minimum	MVT														
847	Active Power Demand Maximum	MVT														
848	Reactive Power Demand Minimum	MVT														
849	Reactive Power Demand Maximum	MVT														
850	Apparent Power Demand Minimum	MVT														
851	Apparent Power Demand Maximum	MVT														
852	I L1 Minimum	MVT														
853	I L1 Maximum	MVT														
854	I L2 Mimimum	MVT														
855	I L2 Maximum	MVT														
856	I L3 Minimum	MVT														
857	I L3 Maximum	MVT														
858	Positive Sequence Minimum	MVT														
859	Positive Sequence Maximum	MVT														
860	U L1E Minimum	MVT														
861	U L1E Maximum	MVT														
862	U L2E Minimum	MVT														
863	U L2E Maximum	MVT														
864	U L3E Minimum	MVT														
865	U L3E Maximum	MVT														
867	U L12 Minimum	MVT														
868	U L12 Maximum	MVT														
869	U L23 Minimum	MVT														
870	U L23 Maximum	MVT														
871	U L31 Minimum	MVT														
10102	3U0min =	MVT														
10103	3U0max =	MVT														
874	U1 (positive sequence) Voltage Minimum	MVT														
875	U1 (positive sequence) Voltage Maximum	MVT														
880	Apparent Power Minimum	MVT														
881	Apparent Power Maximum	MVT														
882	Frequency Minimum	MVT														

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
883	Frequency Maximum	MVT														
1040	Active Power Minimum Forward	MVT														
1041	Active Power Maximum Forward	MVT														
1042	Active Power Minimum Reverse	MVT														
1043	Active Power Maximum Reverse	MVT														
1044	Reactive Power Minimum Forward	MVT														
1045	Reactive Power Maximum Forward	MVT														
1046	Reactive Power Minimum Reverse	MVT														
1047	Reactive Power Maximum Reverse	MVT														
1048	Power Factor Minimum Forward	MVT														
1049	Power Factor Maximum Forward	MVT														
1050	Power Factor Minimum Reverse	MVT														
1051	Power Factor Maximum Reverse	MVT														
1000	Number of breaker TRIP commands (# TRIPs=)	Statistics	OUT													
1001	Number of breaker TRIP commands L1 (TripNo L1=)	Statistics	OUT													
1002	Number of breaker TRIP commands L2 (TripNo L2=)	Statistics	OUT													
1003	Number of breaker TRIP commands L3 (TripNo L3=)	Statistics	OUT													
1027	Accumulation of interrupted current L1 (Σ IL1 =)	Statistics	OUT													
1028	Accumulation of interrupted current L2 (Σ IL2 =)	Statistics	OUT													
1029	Accumulation of interrupted current L3 (Σ IL3 =)	Statistics	OUT													
1030	Last fault current Phase L1 (Last IL1 =)	Statistics	OUT													
1031	Last fault current Phase L2 (Last IL2 =)	Statistics	OUT													
1032	Last fault current Phase L3 (Last IL3 =)	Statistics	OUT													
1052	Pdmd Forw=	MV														
1053	Pdmd Rev =	MV														
1054	Qdmd Forw=	MV														
1055	Qdmd Rev =	MV														
1114	Flt Locator: primary RESISTANCE (Rpri =)	Fault Locator	OUT		ON OFF								151	14	4	
1115	Flt Locator: primary REACTANCE (Xpri =)	Fault Locator	OUT		ON OFF								128	73	4	
1117	Flt Locator: secondary RESISTANCE (Rsec =)	Fault Locator	OUT		ON OFF								151	17	4	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1118	Flt Locator: secondary REACTANCE (Xsec =)	Fault Locator	OUT		ON OFF								151	18	4	
1119	Flt Locator: Distance to fault (dist =)	Fault Locator	OUT		ON OFF								151	19	4	
1120	Flt Locator: Distance [%] to fault (d[%] =)	Fault Locator	OUT		ON OFF								151	20	4	
1122	Flt Locator: Distance to fault (dist =)	Fault Locator	OUT		ON OFF								151	22	4	
1123	Fault Locator Loop L1E (FL Loop L1E)	Fault Locator	OUT_Ev		ON											
1124	Fault Locator Loop L2E (FL Loop L2E)	Fault Locator	OUT_Ev		ON											
1125	Fault Locator Loop L3E (FL Loop L3E)	Fault Locator	OUT_Ev		ON											
1126	Fault Locator Loop L1L2 (FL Loop L1L2)	Fault Locator	OUT_Ev		ON											
1127	Fault Locator Loop L2L3 (FL Loop L2L3)	Fault Locator	OUT_Ev		ON											
1128	Fault Locator Loop L3L1 (FL Loop L3L1)	Fault Locator	OUT_Ev		ON											
1131	Flt Locator: primary FAULT RESISTANCE (RFpri=)	Fault Locator	OUT		ON OFF								151	31	4	
1132	Fault location invalid (Flt.Loc.invalid)	Fault Locator	OUT	*	ON			LED			BO					
1133	Fault locator setting error K0,angle(K0) (Flt.Loc.ErrorK0)	Fault Locator	OUT	*	ON			LED			BO					
1143	BCD Fault location [1%] (BCD d[1%])	Fault Locator	OUT	*	*			LED			BO					
1144	BCD Fault location [2%] (BCD d[2%])	Fault Locator	OUT	*	*			LED			BO					
1145	BCD Fault location [4%] (BCD d[4%])	Fault Locator	OUT	*	*			LED			BO					
1146	BCD Fault location [8%] (BCD d[8%])	Fault Locator	OUT	*	*			LED			BO					
1147	BCD Fault location [10%] (BCD d[10%])	Fault Locator	OUT	*	*			LED			BO					
1148	BCD Fault location [20%] (BCD d[20%])	Fault Locator	OUT	*	*			LED			BO					
1149	BCD Fault location [40%] (BCD d[40%])	Fault Locator	OUT	*	*			LED			BO					
1150	BCD Fault location [80%] (BCD d[80%])	Fault Locator	OUT	*	*			LED			BO					
1151	BCD Fault location [100%] (BCD d[100%])	Fault Locator	OUT	*	*			LED			BO					
1152	BCD Fault location valid (BCD dist. VALID)	Fault Locator	OUT	*	*			LED			BO					
1219	Active 3I0sen (sensitive Ie) = (3I0senA=)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON OFF										

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1220	Reactive 3I0sen (sensitive Ie) = (3I0senR=)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON OFF										
1251	>Switch on sensitive E/F detection (>SensEF on)	Sensitive Earth Flt.(comp/ isol. starp.)	SP	*	*			LED	BI		BO					
1252	>Switch off sensitive E/F detection (>SensEF off)	Sensitive Earth Flt.(comp/ isol. starp.)	SP	*	*			LED	BI		BO					
1253	>Block sensitive E/F detection (>SensEF block)	Sensitive Earth Flt.(comp/ isol. starp.)	SP	*	*			LED	BI		BO					
1260	Sensitve E/F detection ON/OFF via BI (SensEF on/offBI)	Sensitive Earth Flt.(comp/ isol. starp.)	IntSP	ON OFF	*			LED			BO					
1261	Sensitve E/F detection is switched OFF (SensEF OFF)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	ON OFF	*			LED			BO		151	161	1	GI
1262	Sensitve E/F detection is BLOCKED (SensEF BLOCK)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	ON OFF	ON OFF			LED			BO		151	162	1	GI
1263	Sensitve E/F detection is ACTIVE (SensEF ACTIVE)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	ON OFF	*			LED			BO		151	163	1	GI
1271	Sensitve E/F detection picked up (SensEF Pickup)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	ON OFF	ON OFF	ON	M	LED			BO					
1272	Sensitve E/F detection Phase L1 (SensEF Phase L1)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		128	48	2	GI
1273	Sensitve E/F detection Phase L2 (SensEF Phase L2)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		128	49	2	GI
1274	Sensitve E/F detection Phase L3 (SensEF Phase L3)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		128	50	2	GI
1276	Sensitve E/F detection Forward (SensEF Forward)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		128	51	2	GI
1277	Sensitve E/F detection Reverse (SensEF Reverse)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		128	52	2	GI
1278	Sensitve E/F detection Undef. Direction (SensEF undefDir)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*	ON		LED			BO		151	178	2	GI
1281	Sensitve E/F detection TRIP command (SensEF TRIP)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	ON	ON		LED			BO		151	181	2	GI
1291	Sensitve E/F detection 3U0> pickup (SensEF 3U0>)	Sensitive Earth Flt.(comp/ isol. starp.)	OUT	*	*			LED			BO					
1305	>Earth Fault O/C Block 3I0>>> (>EF BLK 3I0>>>)	Earth fault overcurrent	SP	ON OFF	*			LED	BI		BO		166	5	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1307	>Earth Fault O/C Block 3I0>> (>EF BLOCK 3I0>>)	Earth fault overcurrent	SP	ON OFF	*			LED	BI		BO		166	7	1	GI
1308	>Earth Fault O/C Block 3I0> (>EF BLOCK 3I0>)	Earth fault overcurrent	SP	ON OFF	*			LED	BI		BO		166	8	1	GI
1309	>Earth Fault O/C Block 3I0p (>EF BLOCK 3I0p)	Earth fault overcurrent	SP	ON OFF	*			LED	BI		BO		166	9	1	GI
1310	>Earth Fault O/C Instantaneous trip (>EF InstTRIP)	Earth fault overcurrent	SP	ON OFF	ON OFF			LED	BI		BO		166	10	1	GI
1311	>E/F Teleprotection ON (>EF Teleprot.ON)	Teleprotection for Earth fault overcurr.	SP	*	*			LED	BI		BO					
1312	>E/F Teleprotection OFF (>EF TeleprotOFF)	Teleprotection for Earth fault overcurr.	SP	*	*			LED	BI		BO					
1313	>E/F Teleprotection BLOCK (>EF TeleprotBLK)	Teleprotection for Earth fault overcurr.	SP	ON OFF	*			LED	BI		BO		166	13	1	GI
1318	>E/F Carrier RECEPTION, Channel 1 (>EF Rec.Ch1)	Teleprotection for Earth fault overcurr.	SP	on off	on			LED	BI		BO		166	18	1	GI
1319	>E/F Carrier RECEPTION, Channel 2 (>EF Rec.Ch2)	Teleprotection for Earth fault overcurr.	SP	on off	on			LED	BI		BO		166	19	1	GI
1320	>E/F Unblocking: UNBLOCK, Channel 1 (>EF UB ub 1)	Teleprotection for Earth fault overcurr.	SP	ON OFF	ON			LED	BI		BO		166	20	1	GI
1321	>E/F Unblocking: BLOCK, Channel 1 (>EF UB bl 1)	Teleprotection for Earth fault overcurr.	SP	ON OFF	ON			LED	BI		BO		166	21	1	GI
1322	>E/F Unblocking: UNBLOCK, Channel 2 (>EF UB ub 2)	Teleprotection for Earth fault overcurr.	SP	ON OFF	ON			LED	BI		BO		166	22	1	GI
1323	>E/F Unblocking: BLOCK, Channel 2 (>EF UB bl 2)	Teleprotection for Earth fault overcurr.	SP	ON OFF	ON			LED	BI		BO		166	23	1	GI
1324	>E/F BLOCK Echo Signal (>EF BlkEcho)	Teleprotection for Earth fault overcurr.	SP	ON OFF	ON			LED	BI		BO		166	24	1	GI
1331	Earth fault protection is switched OFF (E/F Prot. OFF)	Earth fault overcurrent	OUT	ON OFF	*			LED			BO		166	31	1	GI
1332	Earth fault protection is BLOCKED (E/F BLOCK)	Earth fault overcurrent	OUT	ON OFF	ON OFF			LED			BO		166	32	1	GI
1333	Earth fault protection is ACTIVE (E/F ACTIVE)	Earth fault overcurrent	OUT	*	*			LED			BO		166	33	1	GI
1345	Earth fault protection PICKED UP (EF Pickup)	Earth fault overcurrent	OUT	*	OFF		M	LED			BO		166	45	2	GI
1354	E/F 3I0>>> PICKED UP (EF 3I0>>>Pickup)	Earth fault overcurrent	OUT	*	ON			LED			BO					
1355	E/F 3I0>> PICKED UP (EF 3I0>> Pikkup)	Earth fault overcurrent	OUT	*	ON			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1356	E/F 3I0> PICKED UP (EF 3I0> Pikkup)	Earth fault over-current	OUT	*	ON			LED			BO					
1357	E/F 3I0p PICKED UP (EF 3I0p Pikkup)	Earth fault over-current	OUT	*	ON			LED			BO					
1358	E/F picked up FORWARD (EF forward)	Earth fault over-current	OUT	*	ON			LED			BO		166	58	2	
1359	E/F picked up REVERSE (EF reverse)	Earth fault over-current	OUT	*	ON			LED			BO		166	59	2	
1361	E/F General TRIP command (EF Trip)	Earth fault over-current	OUT	*	*			LED			BO		166	61	2	
1366	E/F 3I0>>> TRIP (EF 3I0>>> TRIP)	Earth fault over-current	OUT	*	ON			LED			BO		166	66	2	
1367	E/F 3I0>> TRIP (EF 3I0>> TRIP)	Earth fault over-current	OUT	*	ON			LED			BO		166	67	2	
1368	E/F 3I0> TRIP (EF 3I0> TRIP)	Earth fault over-current	OUT	*	ON			LED			BO		166	68	2	
1369	E/F 3I0p TRIP (EF 3I0p TRIP)	Earth fault over-current	OUT	*	ON			LED			BO		166	69	2	
1370	E/F Inrush picked up (EF InrushPU)	Earth fault over-current	OUT	*	ON OFF			LED			BO		166	70	2	
1380	E/F Teleprot. ON/OFF via BI (EF TeleON/offBI)	Teleprotection for Earth fault over-curr.	IntSP	ON OFF	*			LED			BO					
1381	E/F Teleprotection is switched OFF (EF Telep. OFF)	Teleprotection for Earth fault over-curr.	OUT	ON OFF	*			LED			BO		166	81	1	GI
1384	E/F Telep. Carrier SEND signal (EF Tele SEND)	Teleprotection for Earth fault over-curr.	OUT	on	on			LED			BO		166	84	2	
1386	E/F Telep. Transient Blocking (EF TeleTransBlk)	Teleprotection for Earth fault over-curr.	OUT	*	ON			LED			BO		166	86	2	
1387	E/F Telep. Unblocking: FAILURE Channel 1 (EF TeleUB Fail1)	Teleprotection for Earth fault over-curr.	OUT	ON OFF	*			LED			BO		166	87	1	GI
1388	E/F Telep. Unblocking: FAILURE Channel 2 (EF TeleUB Fail2)	Teleprotection for Earth fault over-curr.	OUT	ON OFF	*			LED			BO		166	88	1	GI
1389	E/F Telep. Blocking: carrier STOP signal (EF Tele BL STOP)	Teleprotection for Earth fault over-curr.	OUT	*	on			LED			BO		166	89	2	
1390	E/F Tele.Blocking: Send signal with jump (EF Tele BL Jump)	Teleprotection for Earth fault over-curr.	OUT	*	*			LED			BO		166	90	2	
1401	>BF: Switch on breaker fail protection (>BF on)	Breaker Failure	SP	*	*			LED	BI		BO					
1402	>BF: Switch off breaker fail protection (>BF off)	Breaker Failure	SP	*	*			LED	BI		BO					
1403	>BLOCK Breaker failure (>BLOCK BkrFail)	Breaker Failure	SP	ON OFF	*			LED	BI		BO		166	103	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1415	>BF: External start 3pole (>BF Start 3pole)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1432	>BF: External release (>BF release)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1435	>BF: External start L1 (>BF Start L1)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1436	>BF: External start L2 (>BF Start L2)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1437	>BF: External start L3 (>BF Start L3)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1439	>BF: External start 3pole (w/o current) (>BF Start w/o I)	Breaker Failure	SP	ON OFF	*			LED	BI		BO					
1440	Breaker failure prot. ON/OFF via BI (BkrFailON/offBI)	Breaker Failure	IntSP	ON OFF	*			LED			BO					
1451	Breaker failure is switched OFF (BkrFail OFF)	Breaker Failure	OUT	ON OFF	*			LED			BO		166	151	1	GI
1452	Breaker failure is BLOCKED (BkrFail BLOCK)	Breaker Failure	OUT	ON OFF	ON OFF			LED			BO		166	152	1	GI
1453	Breaker failure is ACTIVE (BkrFail ACTIVE)	Breaker Failure	OUT	*	*			LED			BO		166	153	1	GI
1461	Breaker failure protection started (BF Start)	Breaker Failure	OUT	*	ON OFF			LED			BO		166	161	1	GI
1472	BF Trip T1 (local trip) - only phase L1 (BF T1-TRIP 1pL1)	Breaker Failure	OUT	*	ON			LED			BO					
1473	BF Trip T1 (local trip) - only phase L2 (BF T1-TRIP 1pL2)	Breaker Failure	OUT	*	ON			LED			BO					
1474	BF Trip T1 (local trip) - only phase L3 (BF T1-TRIP 1pL3)	Breaker Failure	OUT	*	ON			LED			BO					
1476	BF Trip T1 (local trip) - 3pole (BF T1-TRIP L123)	Breaker Failure	OUT	*	ON			LED			BO					
1493	BF Trip in case of defective CB (BF TRIP CBdefec)	Breaker Failure	OUT	*	ON			LED			BO					
1494	BF Trip T2 (busbar trip) (BF T2-TRIP(bus))	Breaker Failure	OUT	*	ON			LED			BO					
1495	BF Trip End fault stage (BF EndFlt TRIP)	Breaker Failure	OUT	*	ON			LED			BO					
1496	BF Pole discrepancy pickup (BF CBdiscrSTART)	Breaker Failure	OUT	*	ON OFF			LED			BO					
1497	BF Pole discrepancy pickup L1 (BF CBdiscr L1)	Breaker Failure	OUT	*	ON OFF			LED			BO					
1498	BF Pole discrepancy pickup L2 (BF CBdiscr L2)	Breaker Failure	OUT	*	ON OFF			LED			BO					
1499	BF Pole discrepancy pickup L3 (BF CBdiscr L3)	Breaker Failure	OUT	*	ON OFF			LED			BO					
1500	BF Pole discrepancy Trip (BF CBdiscr TRIP)	Breaker Failure	OUT	*	ON			LED			BO					
1503	>BLOCK Thermal Overload Protection (>BLK ThOverload)	Thermal Overload	SP	ON OFF	*			LED	BI		BO		167	3	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
1511	Thermal Overload Protection OFF (Th.Overload OFF)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	11	1	GI
1512	Thermal Overload Protection BLOKKED (Th.Overload BLK)	Thermal Overload	OUT	ON OFF	ON OFF			LED			BO		167	12	1	GI
1513	Thermal Overload Protection ACTIVE (Th.O/L ACTIVE)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	13	1	GI
1515	Th. Overload: Current Alarm (I alarm) (Th.O/L I Alarm)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	15	1	GI
1516	Th. Overload Alarm: Near Thermal Trip (Th.O/L Θ Alarm)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	16	1	GI
1517	Th. Overload Pickup before trip (Th.O/L Pickup)	Thermal Overload	OUT	ON OFF	*			LED			BO		167	17	1	GI
1521	Th. Overload TRIP command (Th.O/L TRIP)	Thermal Overload	OUT	*	ON		M	LED			BO		167	21	1	
2054	Emergency mode (Emer. mode)	Backup overcurrent	OUT	ON OFF	ON OFF			LED			BO		128	37	1	GI
2701	>AR: Switch on auto-reclose function (>AR on)	Automatic Reclosure	SP	*	*			LED	BI		BO		40	1	1	
2702	>AR: Switch off auto-reclose function (>AR off)	Automatic Reclosure	SP	*	*			LED	BI		BO		40	2	1	
2703	>AR: Block auto-reclose function (>AR block)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	3	1	GI
2711	>External start of internal Auto reclose (>AR Start)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	11	2	GI
2712	>AR: External trip L1 for AR start (>Trip L1 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	12	2	GI
2713	>AR: External trip L2 for AR start (>Trip L2 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	13	2	GI
2714	>AR: External trip L3 for AR start (>Trip L3 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	14	2	GI
2715	>AR: External 1pole trip for AR start (>Trip 1pole AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	15	2	GI
2716	>AR: External 3pole trip for AR start (>Trip 3pole AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	16	2	GI
2727	>AR: Remote Close signal (>AR RemoteClose)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	22	2	GI
2731	>AR: Sync. release from ext. sync.-check (>Sync.release)	Automatic Reclosure	SP	*	*			LED	BI		BO		40	31	2	GI
2737	>AR: Block 1pole AR-cycle (>BLOCK 1pole AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	32	1	GI
2738	>AR: Block 3pole AR-cycle (>BLOCK 3pole AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	33	1	GI
2739	>AR: Block 1phase-fault AR-cycle (>BLK 1phase AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	34	1	GI
2740	>AR: Block 2phase-fault AR-cycle (>BLK 2phase AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	35	1	GI
2741	>AR: Block 3phase-fault AR-cycle (>BLK 3phase AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	36	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
2742	>AR: Block 1st AR-cycle (>BLK 1.AR-cycle)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	37	1	GI
2743	>AR: Block 2nd AR-cycle (>BLK 2.AR-cycle)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	38	1	GI
2744	>AR: Block 3rd AR-cycle (>BLK 3.AR-cycle)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	39	1	GI
2745	>AR: Block 4th and higher AR-cycles (>BLK 4.-n. AR)	Automatic Reclosure	SP	ON OFF	*			LED	BI		BO		40	40	1	GI
2746	>AR: External Trip for AR start (>Trip for AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	41	2	GI
2747	>AR: External pickup L1 for AR start (>Pickup L1 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	42	2	GI
2748	>AR: External pickup L2 for AR start (>Pickup L2 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	43	2	GI
2749	>AR: External pickup L3 for AR start (>Pickup L3 AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	44	2	GI
2750	>AR: External pickup 1phase for AR start (>Pickup 1ph AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	45	2	GI
2751	>AR: External pickup 2phase for AR start (>Pickup 2ph AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	46	2	GI
2752	>AR: External pickup 3phase for AR start (>Pickup 3ph AR)	Automatic Reclosure	SP	*	ON			LED	BI		BO		40	47	2	GI
2781	AR: Auto-reclose is switched off (AR off)	Automatic Reclosure	OUT	ON OFF	*			LED			BO		40	81	1	GI
2782	AR: Auto-reclose is switched on (AR on)	Automatic Reclosure	IntSP	*	*			LED			BO		128	16	1	GI
2783	AR: Auto-reclose is blocked (AR is blocked)	Automatic Reclosure	OUT	ON OFF	*			LED			BO		40	83	1	GI
2784	AR: Auto-reclose is not ready (AR not ready)	Automatic Reclosure	OUT	*	ON			LED			BO		128	130	1	GI
2787	AR: Circuit breaker not ready (CB not ready)	Automatic Reclosure	OUT	*	*			LED			BO		40	87	1	
2788	AR: CB ready monitoring window expired (AR T-CBreadyExp)	Automatic Reclosure	OUT	*	ON			LED			BO		40	88	2	
2796	AR: Auto-reclose ON/OFF via BI (AR on/off BI)	Automatic Reclosure	IntSP	*	*			LED			BO					
2801	AR in progress (AR in progress)	Automatic Reclosure	OUT	*	ON			LED			BO		40	101	2	GI
2809	AR: Start-signal monitoring time expired (AR T-Start Exp)	Automatic Reclosure	OUT	*	ON			LED			BO		40	174	1	
2810	AR: Maximum dead time expired (AR TdeadMax Exp)	Automatic Reclosure	OUT	*	ON			LED			BO		40	175	1	
2818	AR: Evolving fault recognition (AR evolving Flt)	Automatic Reclosure	OUT	*	ON			LED			BO		40	118	2	GI
2820	AR is set to operate after 1p trip only (AR Program1pole)	Automatic Reclosure	OUT	*	*			LED			BO		40	143	1	
2821	AR dead time after evolving fault (AR Td. evol.Flt)	Automatic Reclosure	OUT	*	ON			LED			BO		40	197	2	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
2839	AR dead time after 1pole trip running (AR Tdead 1pTrip)	Automatic Reclosure	OUT	*	ON			LED			BO		40	148	2	GI
2840	AR dead time after 3pole trip running (AR Tdead 3pTrip)	Automatic Reclosure	OUT	*	ON			LED			BO		40	149	2	GI
2841	AR dead time after 1phase fault running (AR Tdead 1pFlt)	Automatic Reclosure	OUT	*	ON			LED			BO		40	150	2	GI
2842	AR dead time after 2phase fault running (AR Tdead 2pFlt)	Automatic Reclosure	OUT	*	ON			LED			BO		40	151	2	GI
2843	AR dead time after 3phase fault running (AR Tdead 3pFlt)	Automatic Reclosure	OUT	*	ON			LED			BO		40	154	2	GI
2844	AR 1st cycle running (AR 1stCyc. run.)	Automatic Reclosure	OUT	*	ON			LED			BO		40	155	2	GI
2845	AR 2nd cycle running (AR 2ndCyc. run.)	Automatic Reclosure	OUT	*	ON			LED			BO		40	157	2	GI
2846	AR 3rd cycle running (AR 3rdCyc. run.)	Automatic Reclosure	OUT	*	ON			LED			BO		40	158	2	GI
2847	AR 4th or higher cycle running (AR 4thCyc. run.)	Automatic Reclosure	OUT	*	ON			LED			BO		40	159	2	GI
2848	AR cycle is running in ADT mode (AR ADT run.)	Automatic Reclosure	OUT	*	ON			LED			BO		40	130	2	GI
2851	AR: Close command (AR CLOSE Cmd.)	Automatic Reclosure	OUT	*	ON		M	LED			BO		40	128	1	
2852	AR: Close command after 1pole, 1st cycle (AR Close1.Cyc1p)	Automatic Reclosure	OUT	*	*			LED			BO		40	152	1	
2853	AR: Close command after 3pole, 1st cycle (AR Close1.Cyc3p)	Automatic Reclosure	OUT	*	*			LED			BO		40	153	1	
2854	AR: Close command 2nd cycle (and higher) (AR Close 2.Cyc)	Automatic Reclosure	OUT	*	*			LED			BO		128	129	1	
2861	AR: Reclaim time is running (AR T-Recl. run.)	Automatic Reclosure	OUT	*	*			LED			BO		40	161	1	
2862	AR successful (AR successful)	Automatic Reclosure	OUT	*	*			LED			BO		40	162	1	
2864	AR: 1pole trip permitted by internal AR (AR 1p Trip Perm)	Automatic Reclosure	OUT	*	*			LED			BO		40	164	1	GI
2865	AR: Synchro-check request (AR Sync.Request)	Automatic Reclosure	OUT	*	*			LED			BO		40	165	2	GI
2871	AR: TRIP command 3pole (AR TRIP 3pole)	Automatic Reclosure	OUT	*	ON			LED			BO		40	171	2	GI
2889	AR 1st cycle zone extension release (AR 1.CycZoneRel)	Automatic Reclosure	OUT	*	*			LED			BO		40	160	1	
2890	AR 2nd cycle zone extension release (AR 2.CycZoneRel)	Automatic Reclosure	OUT	*	*			LED			BO		40	169	1	
2891	AR 3rd cycle zone extension release (AR 3.CycZoneRel)	Automatic Reclosure	OUT	*	*			LED			BO		40	170	1	
2892	AR 4th cycle zone extension release (AR 4.CycZoneRel)	Automatic Reclosure	OUT	*	*			LED			BO		40	172	1	
2893	AR zone extension (general) (AR Zone Release)	Automatic Reclosure	OUT	*	*			LED			BO		40	173	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
2894	AR Remote close signal send (AR Remote Close)	Automatic Reclosure	OUT	*	ON			LED			BO		40	129	1	
2895	No. of 1st AR-cycle CLOSE commands,1pole (AR #Close1./1p=)	Statistics	OUT													
2896	No. of 1st AR-cycle CLOSE commands,3pole (AR #Close1./3p=)	Statistics	OUT													
2897	No. of higher AR-cycle CLOSE commands,1p (AR #Close2./1p=)	Statistics	OUT													
2898	No. of higher AR-cycle CLOSE commands,3p (AR #Close2./3p=)	Statistics	OUT													
2901	>Switch on synchro-check function (>Sync. on)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2902	>Switch off synchro-check function (>Sync. off)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2903	>BLOCK synchro-check function (>BLOCK Sync.)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2906	>Start synchro-check (>Sync. Start)	Synchronism and Voltage Check	SP	on off	*			LED	BI		BO					
2907	>Sync-Prog. Live bus / live line / Sync (>Sync. synch)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2908	>Sync-Prog. Dead bus / live line (> Usyn< U-line>)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2909	>Sync-Prog. Live bus / dead line (> Usyn> U-line<)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2910	>Sync-Prog. Dead bus / dead line (> Usyn< U-line<)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2911	>Sync-Prog. Override (bypass) (>Sync. o/ride)	Synchronism and Voltage Check	SP	*	*			LED	BI		BO					
2930	Synchro-check ON/OFF via BI (Sync. on/off BI)	Synchronism and Voltage Check	IntSP	ON OFF	*			LED			BO					
2931	Synchro-check is switched OFF (Sync. OFF)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	31	1	GI
2932	Synchro-check is BLOCKED (Sync. BLOCK)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO		41	32	1	GI
2934	Synchro-check function faulty (Sync. faulty)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	34	1	GI
2935	Synchro-check supervision time expired (Sync.Tsup.Exp)	Synchronism and Voltage Check	OUT	ON	ON			LED			BO		41	35	1	
2941	Synchronization is running (Sync. running)	Synchronism and Voltage Check	OUT	ON OFF	ON			LED			BO		41	41	1	GI
2942	Synchro-check override/bypass (Sync.Override)	Synchronism and Voltage Check	OUT	ON OFF	ON			LED			BO		41	42	1	GI
2943	Synchronism detected (Synchronism)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	43	1	GI
2944	Sync. dead bus / live line detected (Usyn< U-line>)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	44	1	GI
2945	Sync. live bus / dead line detected (Usyn> U-line<)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	45	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
2946	Sync. dead bus / dead line detected (Usyn< U-line<)	Synchronism and Voltage Check	OUT	ON OFF	*			LED			BO		41	46	1	GI
2947	Sync. Voltage diff. greater than limit (Sync. Udiff>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO		41	47	1	GI
2948	Sync. Freq. diff. greater than limit (Sync. fdiff>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO		41	48	1	GI
2949	Sync. Angle diff. greater than limit (Sync. φ-diff>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO		41	49	1	GI
2951	Synchronism release (to ext. AR) (Sync. release)	Synchronism and Voltage Check	OUT	*	*			LED			BO		41	51	1	GI
2961	Close command from synchro-check (Sync.CloseCmd)	Synchronism and Voltage Check	OUT	*	*			LED			BO		41	61	1	GI
2970	Sync. Bus frequency > (fn + 3Hz) (Sync. f-bus>>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2971	Sync. Bus frequency < (fn - 3Hz) (Sync. f-bus<<)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2972	Sync. Line frequency > (fn + 3Hz) (Sync. f-line>>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2973	Sync. Line frequency < (fn - 3Hz) (Sync. f-line<<)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2974	Sync. Bus voltage > Umax (P.3504) (Sync. U-syn>>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2975	Sync. Bus voltage < U> (P.3503) (Sync. U-syn<<)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2976	Sync. Line voltage > Umax (P.3504) (Sync. U-line>>)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
2977	Sync. Line voltage < U> (P.3503) (Sync. U-line<<)	Synchronism and Voltage Check	OUT	ON OFF	ON OFF			LED			BO					
3603	>BLOCK Distance protection (>BLOCK Distance)	Distance protection, general settings	SP	*	*			LED	BI		BO					
3611	>ENABLE Z1B (with setted Time Delay) (>ENABLE Z1B)	Distance protection, general settings	SP	ON OFF	*			LED	BI		BO		28	11	1	GI
3613	>ENABLE Z1B instantanous (w/o T-Delay) (>ENABLE Z1Binst)	Distance protection, general settings	SP	ON OFF	*			LED	BI		BO		28	13	1	GI
3617	>BLOCK Z4-Trip (>BLOCK Z4-Trip)	Distance protection, general settings	SP	ON OFF	*			LED	BI		BO		28	17	1	GI
3618	>BLOCK Z5-Trip (>BLOCK Z5-Trip)	Distance protection, general settings	SP	ON OFF	*			LED	BI		BO		28	18	1	GI
3651	Distance is switched off (Dist. OFF)	Distance protection, general settings	OUT	ON OFF	*			LED			BO		28	51	1	GI
3652	Distance is BLOCKED (Dist. BLOCK)	Distance protection, general settings	OUT	ON OFF	ON OFF			LED			BO		28	52	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3653	Distance is ACTIVE (Dist. ACTIVE)	Distance protection, general settings	OUT	*	*			LED			BO		28	53	1	GI
3654	Setting error K0(Z1) or Angle K0(Z1) (Dis.ErrorK0(Z1))	Distance protection, general settings	OUT	ON OFF	*			LED			BO					
3655	Setting error K0(>Z1) or Angle K0(>Z1) (DisErrorK0(>Z1))	Distance protection, general settings	OUT	ON OFF	*			LED			BO					
3671	Distance PICKED UP (Dis. PICKUP)	Distance protection, general settings	OUT	*	OFF			LED			BO		28	71	2	GI
3672	Distance PICKUP L1 (Dis.Pickup L1)	Distance protection, general settings	OUT	*	*		M	LED			BO		28	72	2	GI
3673	Distance PICKUP L2 (Dis.Pickup L2)	Distance protection, general settings	OUT	*	*		M	LED			BO		28	73	2	GI
3674	Distance PICKUP L3 (Dis.Pickup L3)	Distance protection, general settings	OUT	*	*		M	LED			BO		28	74	2	GI
3675	Distance PICKUP Earth (Dis.Pickup E)	Distance protection, general settings	OUT	*	*		M	LED			BO		28	75	2	GI
3681	Distance Pickup Phase L1 (only) (Dis.Pickup 1pL1)	Distance protection, general settings	OUT	*	ON			LED			BO		28	81	2	
3682	Distance Pickup L1E (Dis.Pickup L1E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	82	2	
3683	Distance Pickup Phase L2 (only) (Dis.Pickup 1pL2)	Distance protection, general settings	OUT	*	ON			LED			BO		28	83	2	
3684	Distance Pickup L2E (Dis.Pickup L2E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	84	2	
3685	Distance Pickup L12 (Dis.Pickup L12)	Distance protection, general settings	OUT	*	ON			LED			BO		28	85	2	
3686	Distance Pickup L12E (Dis.Pickup L12E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	86	2	
3687	Distance Pickup Phase L3 (only) (Dis.Pickup 1pL3)	Distance protection, general settings	OUT	*	ON			LED			BO		28	87	2	
3688	Distance Pickup L3E (Dis.Pickup L3E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	88	2	
3689	Distance Pickup L31 (Dis.Pickup L31)	Distance protection, general settings	OUT	*	ON			LED			BO		28	89	2	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3690	Distance Pickup L31E (Dis.Pickup L31E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	90	2	
3691	Distance Pickup L23 (Dis.Pickup L23)	Distance protection, general settings	OUT	*	ON			LED			BO		28	91	2	
3692	Distance Pickup L23E (Dis.Pickup L23E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	92	2	
3693	Distance Pickup L123 (Dis.Pickup L123)	Distance protection, general settings	OUT	*	ON			LED			BO		28	93	2	
3694	Distance Pickup123E (Dis.Pickup123E)	Distance protection, general settings	OUT	*	ON			LED			BO		28	94	2	
3695	Dist.: Phi phase L1 Pickup (Dis Pikkup φ L1)	Distance protection, general settings	OUT	*	*		M	LED			BO					
3696	Dist.: Phi phase L2 Pickup (Dis Pikkup φ L2)	Distance protection, general settings	OUT	*	*		M	LED			BO					
3697	Dist.: Phi phase L3 Pickup (Dis Pikkup φ L3)	Distance protection, general settings	OUT	*	*		M	LED			BO					
3701	Distance Loop L1E selected forward (Dis.Loop L1-E f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3702	Distance Loop L2E selected forward (Dis.Loop L2-E f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3703	Distance Loop L3E selected forward (Dis.Loop L3-E f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3704	Distance Loop L12 selected forward (Dis.Loop L1-2 f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3705	Distance Loop L23 selected forward (Dis.Loop L2-3 f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3706	Distance Loop L31 selected forward (Dis.Loop L3-1 f)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3707	Distance Loop L1E selected reverse (Dis.Loop L1-E r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3708	Distance Loop L2E selected reverse (Dis.Loop L2-E r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3709	Distance Loop L3E selected reverse (Dis.Loop L3-E r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3710	Distance Loop L12 selected reverse (Dis.Loop L1-2 r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3711	Distance Loop L23 selected reverse (Dis.Loop L2-3 r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3712	Distance Loop L31 selected reverse (Dis.Loop L3-1 r)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3713	Distance Loop L1E selected non-direct. (Dis.Loop L1E<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3714	Distance Loop L2E selected non-direct. (Dis.Loop L2E<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3715	Distance Loop L3E selected non-direct. (Dis.Loop L3E<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3716	Distance Loop L12 selected non-direct. (Dis.Loop L12<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3717	Distance Loop L23 selected non-direct. (Dis.Loop L23<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3718	Distance Loop L31 selected non-direct. (Dis.Loop L31<->)	Distance protection, general settings	OUT	*	ON OFF			LED			BO					
3719	Distance Pickup FORWARD (Dis. forward)	Distance protection, general settings	OUT	*	*		M	LED			BO		128	74	2	
3720	Distance Pickup REVERSE (Dis. reverse)	Distance protection, general settings	OUT	*	*		M	LED			BO		128	75	2	
3741	Distance Pickup Z1, Loop L1E (Dis. Z1 L1E)	Distance protection, general settings	OUT	*	*			LED			BO					
3742	Distance Pickup Z1, Loop L2E (Dis. Z1 L2E)	Distance protection, general settings	OUT	*	*			LED			BO					
3743	Distance Pickup Z1, Loop L3E (Dis. Z1 L3E)	Distance protection, general settings	OUT	*	*			LED			BO					
3744	Distance Pickup Z1, Loop L12 (Dis. Z1 L12)	Distance protection, general settings	OUT	*	*			LED			BO					
3745	Distance Pickup Z1, Loop L23 (Dis. Z1 L23)	Distance protection, general settings	OUT	*	*			LED			BO					
3746	Distance Pickup Z1, Loop L31 (Dis. Z1 L31)	Distance protection, general settings	OUT	*	*			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3747	Distance Pickup Z1B, Loop L1E (Dis. Z1B L1E)	Distance protection, general settings	OUT	*	*			LED			BO					
3748	Distance Pickup Z1B, Loop L2E (Dis. Z1B L2E)	Distance protection, general settings	OUT	*	*			LED			BO					
3749	Distance Pickup Z1B, Loop L3E (Dis. Z1B L3E)	Distance protection, general settings	OUT	*	*			LED			BO					
3750	Distance Pickup Z1B, Loop L12 (Dis. Z1B L12)	Distance protection, general settings	OUT	*	*			LED			BO					
3751	Distance Pickup Z1B, Loop L23 (Dis. Z1B L23)	Distance protection, general settings	OUT	*	*			LED			BO					
3752	Distance Pickup Z1B, Loop L31 (Dis. Z1B L31)	Distance protection, general settings	OUT	*	*			LED			BO					
3755	Distance Pickup Z2 (Dis. Pickup Z2)	Distance protection, general settings	OUT	*	*			LED			BO					
3758	Distance Pickup Z3 (Dis. Pickup Z3)	Distance protection, general settings	OUT	*	*			LED			BO					
3759	Distance Pickup Z4 (Dis. Pickup Z4)	Distance protection, general settings	OUT	*	*			LED			BO					
3760	Distance Pickup Z5 (Dis. Pickup Z5)	Distance protection, general settings	OUT	*	*			LED			BO					
3771	DistanceTime Out T1 (Dis.Time Out T1)	Distance protection, general settings	OUT	*	*			LED			BO		128	78	2	
3774	DistanceTime Out T2 (Dis.Time Out T2)	Distance protection, general settings	OUT	*	*			LED			BO		128	79	2	
3777	DistanceTime Out T3 (Dis.Time Out T3)	Distance protection, general settings	OUT	*	*			LED			BO		128	80	2	
3778	DistanceTime Out T4 (Dis.Time Out T4)	Distance protection, general settings	OUT	*	*			LED			BO		128	81	2	
3779	DistanceTime Out T5 (Dis.Time Out T5)	Distance protection, general settings	OUT	*	*			LED			BO		128	82	2	
3780	DistanceTime Out T1B (Dis.TimeOut T1B)	Distance protection, general settings	OUT	*	*			LED			BO		28	180	2	
3781	DistanceTime Out Forward PICKUP (Dis.TimeOut Tfw)	Distance protection, general settings	OUT	*	*			LED			BO		28	160	2	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3782	DistanceTime Out Reverse/Non-dir. PICKUP (Dis.TimeOut Trv)	Distance protection, general settings	OUT	*	*			LED			BO		28	161	2	
3801	Distance protection: General trip (Dis.Gen. Trip)	Distance protection, general settings	OUT	*	*			LED			BO		28	201	2	
3802	Distance TRIP command - Only Phase L1 (Dis.Trip 1pL1)	Distance protection, general settings	OUT	*	ON			LED			BO		28	202	2	
3803	Distance TRIP command - Only Phase L2 (Dis.Trip 1pL2)	Distance protection, general settings	OUT	*	ON			LED			BO		28	203	2	
3804	Distance TRIP command - Only Phase L3 (Dis.Trip 1pL3)	Distance protection, general settings	OUT	*	ON			LED			BO		28	204	2	
3805	Distance TRIP command Phases L123 (Dis.Trip 3p)	Distance protection, general settings	OUT	*	ON			LED			BO		28	205	2	
3811	Distance TRIP single-phase Z1 (Dis.TripZ1/1p)	Distance protection, general settings	OUT	*	*			LED			BO		28	211	2	
3813	Distance TRIP single-phase Z1B (Dis.TripZ1B1p)	Distance protection, general settings	OUT	*	*			LED			BO		28	213	2	
3816	Distance TRIP single-phase Z2 (Dis.TripZ2/1p)	Distance protection, general settings	OUT	*	*			LED			BO		28	216	2	
3817	Distance TRIP 3phase in Z2 (Dis.TripZ2/3p)	Distance protection, general settings	OUT	*	*			LED			BO		28	217	2	
3818	Distance TRIP 3phase in Z3 (Dis.TripZ3/T3)	Distance protection, general settings	OUT	*	*			LED			BO		28	218	2	
3819	Dist.: Trip by fault detection, forward (Dis.Trip FD->)	Distance protection, general settings	OUT	*	*			LED			BO		28	219	2	
3820	Dist.: Trip by fault detec, rev/non-dir. (Dis.Trip <->)	Distance protection, general settings	OUT	*	*			LED			BO		28	220	2	
3821	Distance TRIP 3phase in Z4 (Dis.TRIP 3p. Z4)	Distance protection, general settings	OUT	*	*			LED			BO		28	209	2	
3822	Distance TRIP 3phase in Z5 (Dis.TRIP 3p. Z5)	Distance protection, general settings	OUT	*	*			LED			BO		28	210	2	
3823	DisTRIP 3phase in Z1 with single-ph Flt. (DisTRIP3p. Z1sf)	Distance protection, general settings	OUT	*	*			LED			BO		28	224	2	
3824	DisTRIP 3phase in Z1 with multi-ph Flt. (DisTRIP3p. Z1mf)	Distance protection, general settings	OUT	*	*			LED			BO		28	225	2	

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
3825	DisTRIP 3phase in Z1B with single-ph Flt (DisTRIP3p.Z1Bsf)	Distance protection, general settings	OUT	*	*			LED			BO		28	244	2	
3826	DisTRIP 3phase in Z1B with multi-ph Flt. (DisTRIP3p Z1Bmf)	Distance protection, general settings	OUT	*	*			LED			BO		28	245	2	
3850	DisTRIP Z1B with Teleprotection scheme (DisTRIP Z1B Tel)	Distance protection, general settings	OUT	*	*			LED			BO		28	251	2	
4001	>Distance Teleprotection ON (>Dis.Telep. ON)	Teleprotection for Distance prot.	SP	*	*			LED	BI		BO					
4002	>Distance Teleprotection OFF (>Dis.Telep.OFF)	Teleprotection for Distance prot.	SP	*	*			LED	BI		BO					
4003	>Distance Teleprotection BLOCK (>Dis.Telep. Blk)	Teleprotection for Distance prot.	SP	ON OFF	ON OFF			LED	BI		BO		29	3	1	GI
4005	>Dist. teleprotection: Carrier faulty (>Dis.RecFail)	Teleprotection for Distance prot.	SP	on off	*			LED	BI		BO					
4006	>Dis.Tele. Carrier RECEPTION Channel 1 (>DisTel Rec.Ch1)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	6	1	GI
4007	>Dis.Tele.Carrier RECEPTION Channel 1,L1 (>Dis.T.RecCh1L1)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	7	1	GI
4008	>Dis.Tele.Carrier RECEPTION Channel 1,L2 (>Dis.T.RecCh1L2)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	8	1	GI
4009	>Dis.Tele.Carrier RECEPTION Channel 1,L3 (>Dis.T.RecCh1L3)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	9	1	GI
4010	>Dis.Tele. Carrier RECEPTION Channel 2 (>Dis.T.Rec.Ch2)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	10	1	GI
4030	>Dis.Tele. Unblocking: UNBLOCK Channel 1 (>Dis.T.UB ub 1)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	30	1	GI
4031	>Dis.Tele. Unblocking: BLOCK Channel 1 (>Dis.T.UB bl 1)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	31	1	GI
4032	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L1 (>Dis.T.UB ub1L1)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	32	1	GI
4033	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L2 (>Dis.T.UB ub1L2)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	33	1	GI
4034	>Dis.Tele. Unblocking: UNBLOCK Ch. 1, L3 (>Dis.T.UB ub1L3)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	34	1	GI
4035	>Dis.Tele. Unblocking: UNBLOCK Channel 2 (>Dis.T.UB ub 2)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	35	1	GI
4036	>Dis.Tele. Unblocking: BLOCK Channel 2 (>Dis.T.UB bl 2)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	36	1	GI
4040	>Dis.Tele. BLOCK Echo Signal (>Dis.T.BlkEcho)	Teleprotection for Distance prot.	SP	on off	on			LED	BI		BO		29	40	1	GI
4050	Dis. Teleprotection ON/OFF via BI (Dis.T.on/off BI)	Teleprotection for Distance prot.	IntSP	ON OFF	*			LED			BO					
4051	Teleprotection is switched ON (Telep. ON)	Device	IntSP	*	*			LED			BO		128	17	1	GI
4052	Dis. Teleprotection is switched OFF (Dis.Telep. OFF)	Teleprotection for Distance prot.	OUT	ON OFF	*			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
4054	Dis. Telep. Carrier signal received (Dis.T.Carr.rec.)	Teleprotection for Distance prot.	OUT	*	*			LED			BO		128	77	2	
4055	Dis. Telep. Carrier CHANNEL FAILURE (Dis.T.Carr.Fail)	Teleprotection for Distance prot.	OUT	*	*			LED			BO		128	39	1	GI
4056	Dis. Telep. Carrier SEND signal (Dis.T.SEND)	Teleprotection for Distance prot.	OUT	on	on			LED			BO		128	76	2	
4057	Dis. Telep. Carrier SEND signal, L1 (Dis.T.SEND L1)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4058	Dis. Telep. Carrier SEND signal, L2 (Dis.T.SEND L2)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4059	Dis. Telep. Carrier SEND signal, L3 (Dis.T.SEND L3)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4060	Dis.Tele.Blocking: Send signal with jump (DisJumpBlocking)	Teleprotection for Distance prot.	OUT	*	*			LED			BO		29	60	2	
4068	Dis. Telep. Transient Blocking (Dis.T.Trans.Blk)	Teleprotection for Distance prot.	OUT	*	ON			LED			BO		29	68	2	
4070	Dis. Tele.Blocking: carrier STOP signal (Dis.T.BL STOP)	Teleprotection for Distance prot.	OUT	*	ON			LED			BO		29	70	2	
4080	Dis. Tele.Unblocking: FAILURE Channel 1 (Dis.T.UB Fail1)	Teleprotection for Distance prot.	OUT	on off	*			LED			BO		29	80	1	GI
4081	Dis. Tele.Unblocking: FAILURE Channel 2 (Dis.T.UB Fail2)	Teleprotection for Distance prot.	OUT	on off	*			LED			BO		29	81	1	GI
4082	DisTel Blocking: carrier STOP signal, L1 (Dis.T.BL STOPL1)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4083	DisTel Blocking: carrier STOP signal, L2 (Dis.T.BL STOPL2)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4084	DisTel Blocking: carrier STOP signal, L3 (Dis.T.BL STOPL3)	Teleprotection for Distance prot.	OUT	*	*			LED			BO					
4164	Power Swing detected (Power Swing)	Power Swing	OUT	ON OFF	ON OFF			LED			BO		29	164	1	GI
4166	Power Swing TRIP command (Pow. Swing TRIP)	Power Swing	OUT	ON	ON			LED			BO		29	166	1	
4167	Power Swing detected in L1 (Pow. Swing L1)	Power Swing	OUT	ON OFF	ON OFF			LED			BO					
4168	Power Swing detected in L2 (Pow. Swing L2)	Power Swing	OUT	ON OFF	ON OFF			LED			BO					
4169	Power Swing detected in L3 (Pow. Swing L3)	Power Swing	OUT	ON OFF	ON OFF			LED			BO					
4203	>BLOCK Weak Infeed Trip function (>BLOCK Weak Inf)	Weak Infeed (Trip and/or Echo)	SP	*	*			LED	BI		BO					
4221	Weak Infeed Trip fct. is switched OFF (WeakInf. OFF)	Weak Infeed (Trip and/or Echo)	OUT	ON OFF	*			LED			BO		25	21	1	GI
4222	Weak Infeed Trip function is BLOKKED (Weak Inf. BLOCK)	Weak Infeed (Trip and/or Echo)	OUT	ON OFF	ON OFF			LED			BO		25	22	1	GI
4223	Weak Infeed Trip function is ACTIVE (Weak Inf ACTIVE)	Weak Infeed (Trip and/or Echo)	OUT	*	*			LED			BO		25	23	1	GI
4231	Weak Infeed Trip function PICKED UP (WeakInf. PICKUP)	Weak Infeed (Trip and/or Echo)	OUT	*	OFF			LED			BO		25	31	2	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
4232	Weak Infeed Trip function PICKUP L1 (W/I Pickup L1)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO					
4233	Weak Infeed Trip function PICKUP L2 (W/I Pickup L2)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO					
4234	Weak Infeed Trip function PICKUP L3 (W/I Pickup L3)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO					
4241	Weak Infeed General TRIP command (WeakInfeed TRIP)	Weak Infeed (Trip and/or Echo)	OUT	*	*			LED			BO		25	41	2	
4242	Weak Infeed TRIP command - Only L1 (Weak TRIP 1p.L1)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO		25	42	2	
4243	Weak Infeed TRIP command - Only L2 (Weak TRIP 1p.L2)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO		25	43	2	
4244	Weak Infeed TRIP command - Only L3 (Weak TRIP 1p.L3)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO		25	44	2	
4245	Weak Infeed TRIP command L123 (Weak TRIP L123)	Weak Infeed (Trip and/or Echo)	OUT	*	ON			LED			BO		25	45	2	
4246	ECHO Send SIGNAL (ECHO SIGNAL)	Weak Infeed (Trip and/or Echo)	OUT	ON	ON			LED			BO		25	46	2	GI
4253	>BLOCK Instantaneous SOTF Overcurrent (>BLOCK SOTF-O/C)	Instantaneous HighSpeed SOTF Overcurrent	SP	*	*			LED	BI		BO					
4271	SOTF-O/C is switched OFF (SOTF-O/C OFF)	Instantaneous HighSpeed SOTF Overcurrent	OUT	ON OFF	*			LED			BO		25	71	1	GI
4272	SOTF-O/C is BLOCKED (SOTF-O/C BLOCK)	Instantaneous HighSpeed SOTF Overcurrent	OUT	ON OFF	ON OFF			LED			BO		25	72	1	GI
4273	SOTF-O/C is ACTIVE (SOTF-O/C ACTIVE)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	*			LED			BO		25	73	1	GI
4281	SOTF-O/C PICKED UP (SOTF-O/C PICKUP)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	OFF			LED			BO		25	81	2	GI
4282	SOTF-O/C Pickup L1 (SOF O/CpickupL1)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	82	2	GI
4283	SOTF-O/C Pickup L2 (SOF O/CpickupL2)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	83	2	GI
4284	SOTF-O/C Pickup L3 (SOF O/CpickupL3)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	84	2	GI
4295	SOTF-O/C TRIP command L123 (SOF O/CtripL123)	Instantaneous HighSpeed SOTF Overcurrent	OUT	*	ON			LED			BO		25	95	2	
4403	>BLOCK Direct Transfer Trip function (>BLOCK DTT)	DTT Direct Transfer Trip	SP	*	*			LED	BI		BO					
4412	>Direct Transfer Trip INPUT Phase L1 (>DTT Trip L1)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
4413	>Direct Transfer Trip INPUT Phase L2 (>DTT Trip L2)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
4414	>Direct Transfer Trip INPUT Phase L3 (>DTT Trip L3)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
4417	>Direct Transfer Trip INPUT 3ph L123 (>DTT Trip L123)	DTT Direct Transfer Trip	SP	ON OFF	*			LED	BI		BO					
4421	Direct Transfer Trip is switched OFF (DTT OFF)	DTT Direct Transfer Trip	OUT	ON OFF	*			LED			BO		51	21	1	GI
4422	Direct Transfer Trip is BLOCKED (DTT BLOCK)	DTT Direct Transfer Trip	OUT	ON OFF	ON OFF			LED			BO		51	22	1	GI
4432	DTT TRIP command - Only L1 (DTT TRIP 1p. L1)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	32	2	
4433	DTT TRIP command - Only L2 (DTT TRIP 1p. L2)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	33	2	
4434	DTT TRIP command - Only L3 (DTT TRIP 1p. L3)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	34	2	
4435	DTT TRIP command L123 (DTT TRIP L123)	DTT Direct Transfer Trip	OUT	*	ON			LED			BO		51	35	2	
6854	>Trip circuit superv. 1: Trip Relay (>TripC1 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6855	>Trip circuit superv. 1: Breaker Relay (>TripC1 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6856	>Trip circuit superv. 2: Trip Relay (>TripC2 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6857	>Trip circuit superv. 2: Breaker Relay (>TripC2 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6858	>Trip circuit superv. 3: Trip Relay (>TripC3 TripRel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6859	>Trip circuit superv. 3: Breaker Relay (>TripC3 Bkr.Rel)	Trip Circuit Supervision	SP	ON OFF	*			LED	BI		BO					
6861	Trip circuit supervision OFF (TripC OFF)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
6865	Failure Trip Circuit (FAIL: Trip cir.)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
6866	TripC1 blocked: Binary input is not set (TripC1 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
6867	TripC2 blocked: Binary input is not set (TripC2 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
6868	TripC3 blocked: Binary input is not set (TripC3 ProgFAIL)	Trip Circuit Supervision	OUT	ON OFF	*			LED			BO					
7104	>BLOCK Backup OverCurrent I>> (>BLOCK O/C I>>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	4	1	GI
7105	>BLOCK Backup OverCurrent I> (>BLOCK O/C I>)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	5	1	GI
7106	>BLOCK Backup OverCurrent Ip (>BLOCK O/C Ip)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	6	1	GI
7110	>Backup OverCurrent InstantaneousTrip (>O/C InstTRIP)	Backup overcurrent	SP	ON OFF	ON OFF			LED	BI		BO		64	10	1	GI
7130	>BLOCK I-STUB (>BLOCK I-STUB)	Backup overcurrent	SP	ON OFF	*			LED	BI		BO		64	30	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
7131	>Enable I-STUB-Bus function (>I-STUB ENABLE)	Backup overcurrent	SP	ON OFF	ON OFF			LED	BI		BO		64	31	1	GI
7151	Backup O/C is switched OFF (O/C OFF)	Backup overcurrent	OUT	ON OFF	*			LED			BO		64	51	1	GI
7152	Backup O/C is BLOCKED (O/C BLOCK)	Backup overcurrent	OUT	ON OFF	ON OFF			LED			BO		64	52	1	GI
7153	Backup O/C is ACTIVE (O/C ACTIVE)	Backup overcurrent	OUT	*	*			LED			BO		64	53	1	GI
7161	Backup O/C PICKED UP (O/C PIKKUP)	Backup overcurrent	OUT	*	OFF		M	LED			BO		64	61	2	GI
7162	Backup O/C PICKUP L1 (O/C Pickup L1)	Backup overcurrent	OUT	*	ON			LED			BO		64	62	2	GI
7163	Backup O/C PICKUP L2 (O/C Pickup L2)	Backup overcurrent	OUT	*	ON			LED			BO		64	63	2	GI
7164	Backup O/C PICKUP L3 (O/C Pickup L3)	Backup overcurrent	OUT	*	ON			LED			BO		64	64	2	GI
7165	Backup O/C PICKUP EARTH (O/C Pickup E)	Backup overcurrent	OUT	*	ON			LED			BO		64	65	2	GI
7171	Backup O/C Pickup - Only EARTH (O/C PU only E)	Backup overcurrent	OUT	*	ON			LED			BO		64	71	2	
7172	Backup O/C Pickup - Only L1 (O/C PU 1p. L1)	Backup overcurrent	OUT	*	ON			LED			BO		64	72	2	
7173	Backup O/C Pickup L1E (O/C Pickup L1E)	Backup overcurrent	OUT	*	ON			LED			BO		64	73	2	
7174	Backup O/C Pickup - Only L2 (O/C PU 1p. L2)	Backup overcurrent	OUT	*	ON			LED			BO		64	74	2	
7175	Backup O/C Pickup L2E (O/C Pickup L2E)	Backup overcurrent	OUT	*	ON			LED			BO		64	75	2	
7176	Backup O/C Pickup L12 (O/C Pickup L12)	Backup overcurrent	OUT	*	ON			LED			BO		64	76	2	
7177	Backup O/C Pickup L12E (O/C Pikkup L12E)	Backup overcurrent	OUT	*	ON			LED			BO		64	77	2	
7178	Backup O/C Pickup - Only L3 (O/C PU 1p. L3)	Backup overcurrent	OUT	*	ON			LED			BO		64	78	2	
7179	Backup O/C Pickup L3E (O/C Pickup L3E)	Backup overcurrent	OUT	*	ON			LED			BO		64	79	2	
7180	Backup O/C Pickup L31 (O/C Pickup L31)	Backup overcurrent	OUT	*	ON			LED			BO		64	80	2	
7181	Backup O/C Pickup L31E (O/C Pikkup L31E)	Backup overcurrent	OUT	*	ON			LED			BO		64	81	2	
7182	Backup O/C Pickup L23 (O/C Pickup L23)	Backup overcurrent	OUT	*	ON			LED			BO		64	82	2	
7183	Backup O/C Pickup L23E (O/C Pikkup L23E)	Backup overcurrent	OUT	*	ON			LED			BO		64	83	2	
7184	Backup O/C Pickup L123 (O/C Pikkup L123)	Backup overcurrent	OUT	*	ON			LED			BO		64	84	2	
7185	Backup O/C Pickup L123E (O/C PickupL123E)	Backup overcurrent	OUT	*	ON			LED			BO		64	85	2	

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				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
7191	Backup O/C Pickup I>> (O/C PICKUP I>>)	Backup overcurrent	OUT	*	ON			LED			BO		64	91	2	GI
7192	Backup O/C Pickup I> (O/C PICKUP I>)	Backup overcurrent	OUT	*	ON			LED			BO		64	92	2	GI
7193	Backup O/C Pickup Ip (O/C PICKUP Ip)	Backup overcurrent	OUT	*	ON			LED			BO		64	93	2	GI
7201	O/C I-STUB Pickup (I-STUB PIKKUP)	Backup overcurrent	OUT	*	ON OFF			LED			BO		64	101	2	GI
7211	Backup O/C General TRIP command (O/C TRIP)	Backup overcurrent	OUT	*	*			LED			BO		64	111	2	
7212	Backup O/C TRIP - Only L1 (O/C TRIP 1p.L1)	Backup overcurrent	OUT	*	ON			LED			BO		64	112	2	
7213	Backup O/C TRIP - Only L2 (O/C TRIP 1p.L2)	Backup overcurrent	OUT	*	ON			LED			BO		64	113	2	
7214	Backup O/C TRIP - Only L3 (O/C TRIP 1p.L3)	Backup overcurrent	OUT	*	ON			LED			BO		64	114	2	
7215	Backup O/C TRIP Phases L123 (O/C TRIP L123)	Backup overcurrent	OUT	*	ON			LED			BO		64	115	2	
7221	Backup O/C TRIP I>> (O/C TRIP I>>)	Backup overcurrent	OUT	*	ON			LED			BO		64	121	2	
7222	Backup O/C TRIP I> (O/C TRIP I>)	Backup overcurrent	OUT	*	ON			LED			BO		64	122	2	
7223	Backup O/C TRIP Ip (O/C TRIP Ip)	Backup overcurrent	OUT	*	ON			LED			BO		64	123	2	
7235	O/C I-STUB TRIP (I-STUB TRIP)	Backup overcurrent	OUT	*	ON			LED			BO		64	135	2	
7325	CB1-TEST TRIP command - Only L1 (CB1-TESTtrip L1)	Testing	OUT	ON OFF	*			LED			BO		153	25	2	GI
7326	CB1-TEST TRIP command - Only L2 (CB1-TESTtrip L2)	Testing	OUT	ON OFF	*			LED			BO		153	26	2	GI
7327	CB1-TEST TRIP command - Only L3 (CB1-TESTtrip L3)	Testing	OUT	ON OFF	*			LED			BO		153	27	2	GI
7328	CB1-TEST TRIP command L123 (CB1-TESTtrip123)	Testing	OUT	ON OFF	*			LED			BO		153	28	2	GI
7329	CB1-TEST CLOSE command (CB1-TEST close)	Testing	OUT	ON OFF	*			LED			BO		153	29	2	GI
7345	CB-TEST is in progress (CB-TEST running)	Testing	OUT	ON OFF	*			LED			BO		153	45	2	GI
7346	CB-TEST canceled due to Power Sys. Fault (CB-TSTstop FLT.)	Testing	OUT_Ev	ON	*											
7347	CB-TEST canceled due to CB already OPEN (CB-TSTstop OPEN)	Testing	OUT_Ev	ON	*											
7348	CB-TEST canceled due to CB was NOT READY (CB-TSTstop NOTr)	Testing	OUT_Ev	ON	*											
7349	CB-TEST canceled due to CB stayed CLOSED (CB-TSTstop CLOS)	Testing	OUT_Ev	ON	*											

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
7350	CB-TEST was succesful (CB-TST .OK.)	Testing	OUT_Ev	ON	*											
10201	>BLOCK Uph-e>(>) Overvolt. (phase-earth) (>Uph-e>(>) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10202	>BLOCK Uph-ph>(>) Overvolt (phase-phase) (>Uph-ph>(>) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10203	>BLOCK 3U0>(>) Overvolt. (zero sequence) (>3U0>(>) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10204	>BLOCK U1>(>) Overvolt. (positive seq.) (>U1>(>) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10205	>BLOCK U2>(>) Overvolt. (negative seq.) (>U2>(>) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10206	>BLOCK Uph-e<(<) Undervolt (phase-earth) (>Uph-e<(<) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10207	>BLOCK Uphph<(<) Undervolt (phase-phase) (>Uphph<(<) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10208	>BLOCK U1<(<) Undervolt (positive seq.) (>U1<(<) BLK)	Voltage Protection	SP	*	*			LED	BI		BO					
10215	Uph-e>(>) Overvolt. is switched OFF (Uph-e>(>) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	15	1	GI
10216	Uph-e>(>) Overvolt. is BLOCKED (Uph-e>(>) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	16	1	GI
10217	Uph-ph>(>) Overvolt. is switched OFF (Uph-ph>(>) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	17	1	GI
10218	Uph-ph>(>) Overvolt. is BLOCKED (Uph-ph>(>) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	18	1	GI
10219	3U0>(>) Overvolt. is switched OFF (3U0>(>) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	19	1	GI
10220	3U0>(>) Overvolt. is BLOCKED (3U0>(>) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	20	1	GI
10221	U1>(>) Overvolt. is switched OFF (U1>(>) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	21	1	GI
10222	U1>(>) Overvolt. is BLOCKED (U1>(>) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	22	1	GI
10223	U2>(>) Overvolt. is switched OFF (U2>(>) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	23	1	GI
10224	U2>(>) Overvolt. is BLOCKED (U2>(>) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	24	1	GI
10225	Uph-e<(<) Undervolt. is switched OFF (Uph-e<(<) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	25	1	GI
10226	Uph-e<(<) Undervolt. is BLOCKED (Uph-e<(<) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	26	1	GI
10227	Uph-ph<(<) Undervolt. is switched OFF (Uph-ph<(<) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	27	1	GI
10228	Uphph<(<) Undervolt. is BLOCKED (Uph-ph<(<) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	28	1	GI
10229	U1<(<) Undervolt. is switched OFF (U1<(<) OFF)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	29	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
10230	U1<(<) Undervolt. is BLOCKED (U1<(<) BLK)	Voltage Protection	OUT	ON OFF	ON OFF			LED			BO		73	30	1	GI
10231	Over-/Under-Voltage protection is ACTIVE (U</> ACTIVE)	Voltage Protection	OUT	ON OFF	*			LED			BO		73	31	1	GI
10240	Uph-e> Pickup (Uph-e> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	40	2	GI
10241	Uph-e>> Pickup (Uph-e>> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	41	2	GI
10242	Uph-e>(>) Pickup L1 (Uph-e>(>) PU L1)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	42	2	GI
10243	Uph-e>(>) Pickup L2 (Uph-e>(>) PU L2)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	43	2	GI
10244	Uph-e>(>) Pickup L3 (Uph-e>(>) PU L3)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	44	2	GI
10245	Uph-e> TimeOut (Uph-e> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10246	Uph-e>> TimeOut (Uph-e>> Time-Out)	Voltage Protection	OUT	*	*			LED			BO					
10247	Uph-e>(>) TRIP command (Uph-e>(>) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	47	2	GI
10255	Uph-ph> Pickup (Uphph> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	55	2	GI
10256	Uph-ph>> Pickup (Uphph>> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	56	2	GI
10257	Uph-ph>(>) Pickup L1-L2 (Uphph>(>)PU L12)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	57	2	GI
10258	Uph-ph>(>) Pickup L2-L3 (Uphph>(>)PU L23)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	58	2	GI
10259	Uph-ph>(>) Pickup L3-L1 (Uphph>(>)PU L31)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	59	2	GI
10260	Uph-ph> TimeOut (Uphph> Time-Out)	Voltage Protection	OUT	*	*			LED			BO					
10261	Uph-ph>> TimeOut (Uphph>> Time-Out)	Voltage Protection	OUT	*	*			LED			BO					
10262	Uph-ph>(>) TRIP command (Uphph>(>) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	62	2	GI
10270	3U0> Pickup (3U0> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	70	2	GI
10271	3U0>> Pickup (3U0>> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	71	2	GI
10272	3U0> TimeOut (3U0> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10273	3U0>> TimeOut (3U0>> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10274	3U0>(>) TRIP command (3U0>(>) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	74	2	GI
10280	U1> Pickup (U1> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	80	2	GI
10281	U1>> Pickup (U1>> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	81	2	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
10282	U1> TimeOut (U1> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10283	U1>> TimeOut (U1>> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10284	U1>(>) TRIP command (U1>(>) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	84	2	GI
10290	U2> Pickup (U2> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	90	2	GI
10291	U2>> Pickup (U2>> Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	91	2	GI
10292	U2> TimeOut (U2> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10293	U2>> TimeOut (U2>> TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10294	U2>(>) TRIP command (U2>(>) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	94	2	GI
10300	U1< Pickup (U1< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	100	2	GI
10301	U1<< Pickup (U1<< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	101	2	GI
10302	U1< TimeOut (U1< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10303	U1<< TimeOut (U1<< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10304	U1<(<) TRIP command (U1<(<) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	104	2	GI
10310	Uph-e< Pickup (Uph-e< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	110	2	GI
10311	Uph-e<< Pickup (Uph-e<< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	111	2	GI
10312	Uph-e<(<) Pickup L1 (Uph-e<(<) PU L1)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	112	2	GI
10313	Uph-e<(<) Pickup L2 (Uph-e<(<) PU L2)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	113	2	GI
10314	Uph-e<(<) Pickup L3 (Uph-e<(<) PU L3)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	114	2	GI
10315	Uph-e< TimeOut (Uph-e< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10316	Uph-e<< TimeOut (Uph-e<< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10317	Uph-e<(<) TRIP command (Uph-e<(<) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	117	2	GI
10325	Uph-ph< Pickup (Uph-ph< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	125	2	GI
10326	Uph-ph<< Pickup (Uph-ph<< Pickup)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	126	2	GI
10327	Uphph<(<) Pickup L1-L2 (Uphph<(<)PU L12)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	127	2	GI
10328	Uphph<(<) Pickup L2-L3 (Uphph<(<)PU L23)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	128	2	GI
10329	Uphph<(<) Pickup L3-L1 (Uphph<(<)PU L31)	Voltage Protection	OUT	*	ON OFF			LED			BO		73	129	2	GI
10330	Uphph< TimeOut (Uphph< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
10331	Uphph<< TimeOut (Uphph<< TimeOut)	Voltage Protection	OUT	*	*			LED			BO					
10332	Uphph<(<) TRIP command (Uphph<(<) TRIP)	Voltage Protection	OUT	*	ON			LED			BO		73	132	2	GI
	>Back Light on (>Light on)	Device	SP	ON OFF	*				BI							
	>Cabinet door open (>Door open)	Process Data	SP	on off	*			LED	BI		BO	CB	101	1	1	GI
	>CB waiting for Spring charged (>CB wait)	Process Data	SP	on off	*			LED	BI		BO	CB	101	2	1	GI
	>Error Control Voltage (>ErrCntrlU)	Process Data	SP	on off	*			LED	BI		BO	CB	240	182	1	GI
	>Error Meter (>Err Meter)	Process Data	SP	on off	*			LED	BI		BO	CB	240	184	1	GI
	>Error Motor Voltage (>Err Mot U)	Process Data	SP	on off	*			LED	BI		BO	CB	240	181	1	GI
	>SF6-Loss (>SF6-Loss)	Process Data	SP	on off	*			LED	BI		BO	CB	240	183	1	GI
	>Transformer Danger (>Tx Danger)	Process Data	SP	on off	*			LED	BI		BO	CB	240	186	1	GI
	>Transformer Temperature (>Tx Temp.)	Process Data	SP	on off	*			LED	BI		BO	CB	240	185	1	GI
	Breaker (Breaker)	Control Device	CF_D12	on off	*						BO		240	160	1	GI
	Breaker (Breaker)	Control Device	DP	on off	*				BI			CB	240	160	1	GI
	Breaker OPENED (Brk OPENED)	Device	IntSP	*	*			LED			BO					
	CB1-TEST trip/close Phases L123 (CB1tst 123)	Testing	-	*	*											
	CB1-TEST trip/close - Only L1 (CB1tst L1)	Testing	-	*	*											
	CB1-TEST trip/close - Only L2 (CB1tst L2)	Testing	-	*	*											
	CB1-TEST trip/close - Only L3 (CB1tst L3)	Testing	-	*	*											
	Clock Synchronization (SynchClock)	Device	IntSP_Ev	*	*			LED			BO					
	Control Authority (Cntrl Auth)	Control Authorization	DP	ON OFF	*			LED					101	85	1	GI
	Control Authority (Cntrl Auth)	Control Authorization	IntSP	ON OFF	*			LED								
	Controlmode LOCAL (ModeLOCAL)	Control Authorization	DP	ON OFF	*			LED					101	86	1	GI
	Controlmode LOCAL (ModeLOCAL)	Control Authorization	IntSP	ON OFF	*			LED								
	Controlmode REMOTE (ModeREMOTE)	Control Authorization	IntSP	ON OFF	*			LED								
	Disconnect Switch (Disc.Swit.)	Control Device	CF_D2	on off	*						BO		240	161	1	GI

F.No.	Description	Function	Type of Information	Log-Buffers				Configurable in Matrix					IEC 60870-5-103			
				Event Log On/Off	Trip (Fault) Log On/Off	Ground Fault Log On/Off	Marked in Oscill. Record	LED	Binary Input	Function Key	Binary Output	Chatter Blocking	Type	Information-No	Data Unit (ASDU)	General Interrogation
	Disconnect Switch (Disc.Swit.)	Control Device	DP	on off	*				BI			CB	240	161	1	GI
	Earth Switch (EarthSwit)	Control Device	CF_D2	on off	*						BO		240	164	1	GI
	Earth Switch (EarthSwit)	Control Device	DP	on off	*				BI			CB	240	164	1	GI
	Fan ON/OFF (Fan ON/OFF)	Control Device	CF_D2	on off	*						BO		240	175	1	GI
	Fan ON/OFF (Fan ON/OFF)	Control Device	DP	on off	*				BI			CB	240	175	1	GI
	Fault Recording Start (FltRecSta)	Oscillographic Fault Records	IntSP	ON OFF	*			LED			BO					
	Feeder EARTHED (FdrEARTHED)	Device	IntSP	*	*			LED			BO					
	Group A (Group A)	Change Group	IntSP	ON OFF	*			LED			BO		128	23	1	GI
	Group B (Group B)	Change Group	IntSP	ON OFF	*			LED			BO		128	24	1	GI
	Group C (Group C)	Change Group	IntSP	ON OFF	*			LED			BO		128	25	1	GI
	Group D (Group D)	Change Group	IntSP	ON OFF	*			LED			BO		128	26	1	GI
	Hardware Test Mode (HWTestMod)	Device	IntSP	ON OFF	*			LED			BO					
	Interlocking: 52 Close (52 Close)	Control Device	IntSP	*	*											
	Interlocking: 52 Open (52 Open)	Control Device	IntSP	*	*											
	Interlocking: Disconnect switch Close (Disc.Close)	Control Device	IntSP	*	*											
	Interlocking: Disconnect switch Open (Disc.Open)	Control Device	IntSP	*	*											
	Interlocking: Earth switch Close (E Sw Cl.)	Control Device	IntSP	*	*											
	Interlocking: Earth switch Open (E Sw Open)	Control Device	IntSP	*	*											
	Q2 Open/Close (Q2 Op/Cl)	Control Device	CF_D2	on off	*						BO		240	162	1	GI
	Q2 Open/Close (Q2 Op/Cl)	Control Device	DP	on off	*				BI			CB	240	162	1	GI
	Q9 Open/Close (Q9 Op/Cl)	Control Device	CF_D2	on off	*						BO		240	163	1	GI
	Q9 Open/Close (Q9 Op/Cl)	Control Device	DP	on off	*				BI			CB	240	163	1	GI
	Stop data transmission (DataStop)	Device	IntSP	ON OFF	*			LED			BO		128	20	1	GI
	Test mode (Test mode)	Device	IntSP	ON OFF	*			LED			BO		128	21	1	GI
	Unlock data transmission via BI (UnlockDT)	Control Device	IntSP	*	*											

B.3 Measured Values

Measured Value	**IEC 60870-5-103 compatible** Type 128 Information-No. 148	**IEC 60870-5-103 extended** Type 134 Information-No. 124
1	IL1[%]	IL1[%]
2	IL2[%]	IL2[%]
3	IL3[%]	IL3[%]
4	UIL1E[%]	UL1E[%]
5	UIL2E[%]	UL2E[%]
6	UIL3E[%]	UL3E[%]
7	P[%]	P[%]
8	Q[%]	Q[%]
9	f[%]	f[%]
10		UL12[%]
11		UL23[%]
12		UL31[%]
13		COS PHI
14		IE(3I0)
15		IEEw[mA]
16		IEEb[mA]

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