Operations Manual

COOPER Power Systems

Electrical Apparatus

IM30DRE Feeder Relay

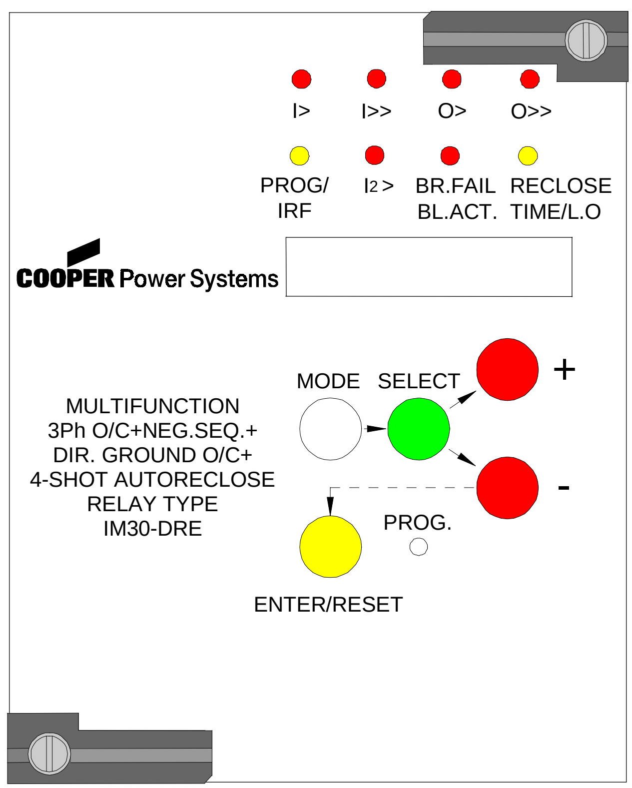
S150-15-1

MICROPROCESSOR OVERCURRENT AND DIRECTIONAL GROUND FAULT PROTECTION RELAY + AUTORECLOSE

TYPE

IM30-DRE

OPERATIONS MANUAL



 The Operations Manual is designed to familiarize the reader with how to install, program, and set up the relay for operation. For programming the relay via computer software, consult the appropriate manual. Contact your local Cooper Power Systems representative for ordering information.

CONTENTS

1. INTRODUCTION

The IM30DRE relay provides all of the basic functions necessary for the protection of network feeders and buses by providing three phase, negative sequence and directional ground overcurrent fault protection. The directional ground elements may be set to operate in either directional supervisory, true directional, or non-directional modes. True RMS values of the currents through the 9th harmonic are used, while the ground current and voltage inputs include 3rd harmonic filtering. Two digital inputs are provided to provide selective blocking of various functions. Five output relays are provided, of which four are programmable. All settings, measurements, and programming of the relay are possible through its front panel controls, or by means of a computer connected to the relay's RS485 communications port. The functions provided by the IM30DRE are:

- Time and instantaneous phase overcurrent (51, 50).
- Negative sequence overcurrent (46).
- Directional time and instantaneous ground overcurrent (67N/51N, 67N/50N).
- Reclosing, 4-shot programmable
- Breaker failure (62 BF).

The directional feature for the ground elements can be disabled, making the element non-directional. It is also possible to disable the instantaneous time overcurrent elements. Separate pickup functions are provided which may be used to operate output relays.

2. HANDLING

As with any piece of electronic equipment, care should be taken when handling the relay, particularly in regards to electrostatic discharge, as the damage may not be immediately obvious. All Edison relays are immune to electrostatic discharge when left in their protective case. However, when the relay is removed from its case, the following practices should be observed.

- Touch the case to ensure that your body and the relay are at the same potential.
- Whenever possible, handle the exposed relay by the front panel, the rear connector, or by the edges of the printed circuit boards. Avoid touching the individual electronic components or the embedded traces on the circuit boards.
- If you must hand the exposed (i.e., drawn-out) relay to another person, make sure both of you are at the same electrical potential.
- When setting the drawn-out relay down, make sure the surface is either anti-static or is at the same electrical potential as your body.
- Relays should always be stored in their protective cases. If storage of a drawn-out relay outside of its protective case is required, then the exposed relay should be placed in a suitable anti-static plastic or foam container.

3. INSTALLATION

Edison relays are shipped either in single or double width cabinets, or in standard 19" 3U rack mount enclosures that are capable of housing up to four Edison relays. Outline dimensions for the single relay housing is shown in Figure 1. For dimensions of other cabinets, see catalog section 150-05.

The double case mounting is similar to the single case, but requires a 113mm L x 142mm H panel opening. The 19" rack mount case is a standard 3U high 19" cabinet.

To remove the relay from its case, refer to Figure 2. The relay may be removed from its protective case by turning with a flat bladed screwdriver the locking screws ① and ② on the front panel latches ③ so that the slot on the screw is parallel to the ground. The latches may then be pulled from the inside edge to release the relay. Carefully pull on the latches to remove the relay from the housing.

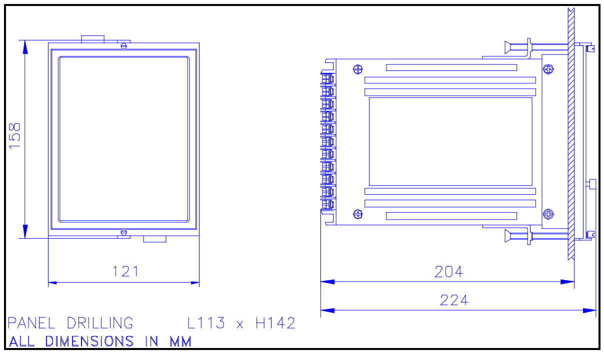


FIGURE 1: SINGLE MODULE ENCLOSURE MOUNTING

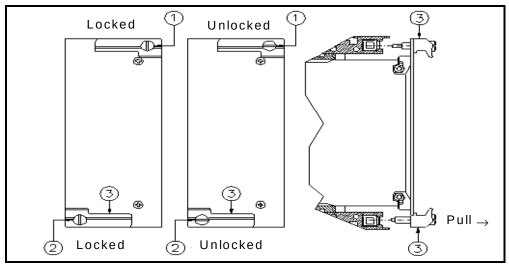


FIGURE 2: LATCH MECHANISM FOR REMOVAL OF RELAY FROM CASE

To re-install the relay into its case, align the printed circuit boards with the guides in the relay case and slide the relay in most of the way. For single and double cases, make sure the locking arm on the back of each of the latches ③ lines up with the locking pins in the case. Then push the latches in, seating the relay. Turn the screws on the latches until the slot is perpendicular to the ground.

4. ELECTRICAL CONNECTIONS

Input quantities are supplied to 1 Potential Transformer and to 4 Current Transformers (three measuring phase currents - one measuring the ground fault zero-sequence current).

Rated current inputs can be either 1 or 5A. The zero sequence polarizing voltage input is rated 100V. The Potential transformer is Primary Phase-Phase Voltage connected Wye with the Secondary connected across a broken delta (VP/√3 :100:3 VS).

Make electric connections in conformity with the diagram reported on relay's enclosure. Check that input currents are same as reported on the diagram and on the test certificate.

Auxiliary power is supplied via terminals 12 and 13, with a chassis ground at terminal 44. All Edison relays are available with one of two interchangeable auto-ranging power supplies. Descriptions of the input voltage ranges are given in Table 1. The input supply voltage is noted on the relay case. If in the event that the relay is fitted with the incorrect power supply, the power supply boards are easily field replaceable. See Bulletin S150-99-1 for instructions and part numbers.

TABLE 1: POWER SUPPLY INPUT RANGES

POWER SUPPLY	DC VOLTAGE RANGE	AC VOLTAGE RANGE
L	24V (-20%) to 125V (+20%)	24V (-20%) to 110V (+15%) 50/60 Hz
H	90V (-20%) to 250V (+20%)	80V (-20%) to 220V (+15%) 50/60 Hz

All electrical connections, including the RS485 connections, are made on the back of the relay (See Figure 3). All of the relay's terminals will accept up to a No. 6 stud size spade connector (or any type of lug up to 0.25" (6.3mm) wide), 12 AWG wire (4 mm²), or FASTON connectors. Electrical connections must be made in accordance with one of the relay's wiring connection diagrams shown in Figures 4 and 5.

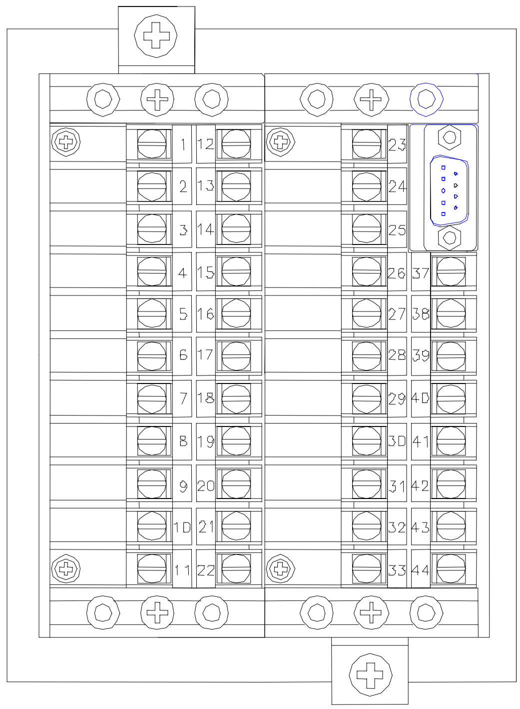


FIGURE 3: REAR VIEW OF TERMINAL CONNECTIONS

In Figure 4 the numbers next to the circles along the functional diagram of the relay indicate the terminal numbers on the back of the relay as shown in Figure 3. Note that two different input configurations are allowed. The left-most connection shown in Figure 4 utilizes a window CT as the source of zero sequence current for the relay. This will provide the most accurate zero sequence current input. If this connection is not practical, then the connection shown to the right will provide the zero sequence current. The PT inputs must be in Y-Y form and in the phase rotation shown.

The relay is shipped with the CT inputs set for either 1A or 5A nominal inputs. The 9th character of the relay's part number will either be "1" or "5" indicating the factory set input range. If the input range needs to be changed, for any of the CT inputs, this may be accomplished via jumpers on the relay's main circuit board (See Figure 6).

5. CONNECTION DIAGRAM

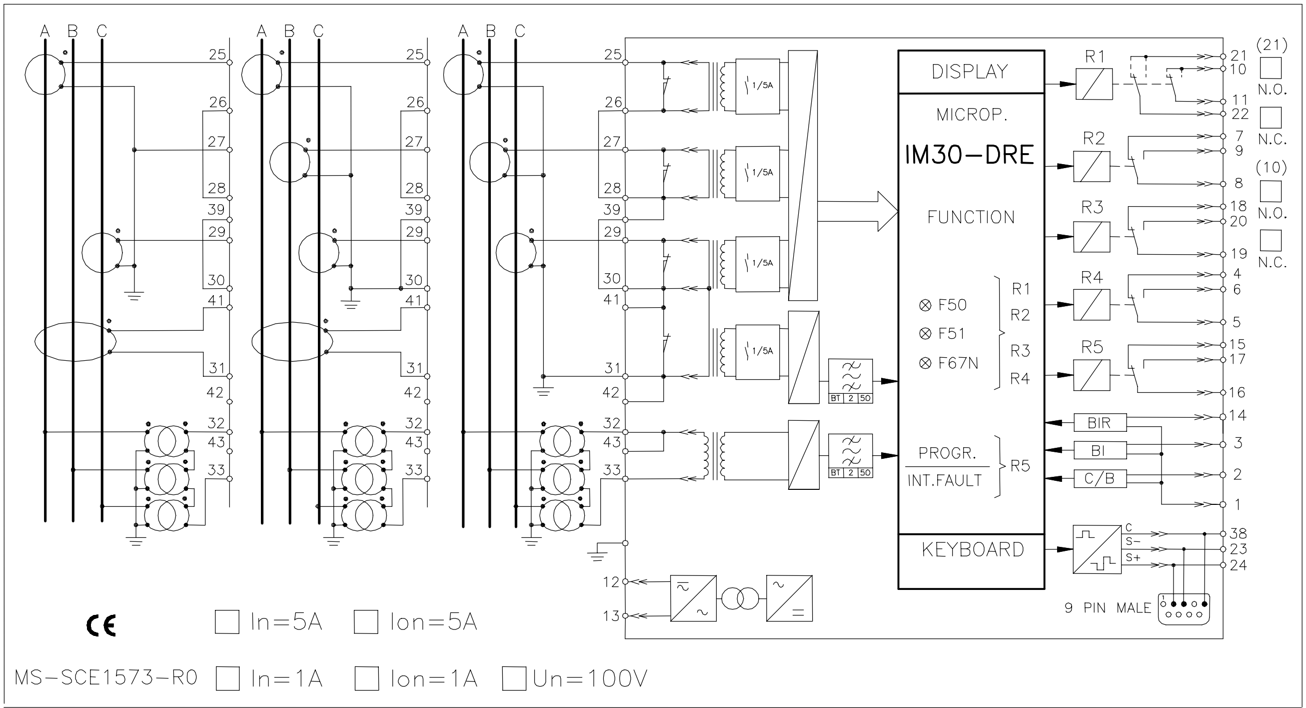


FIGURE 4: Wiring Diagram for the IM30DRE

6. WIRING THE SERIAL COMMUNICATION BUS

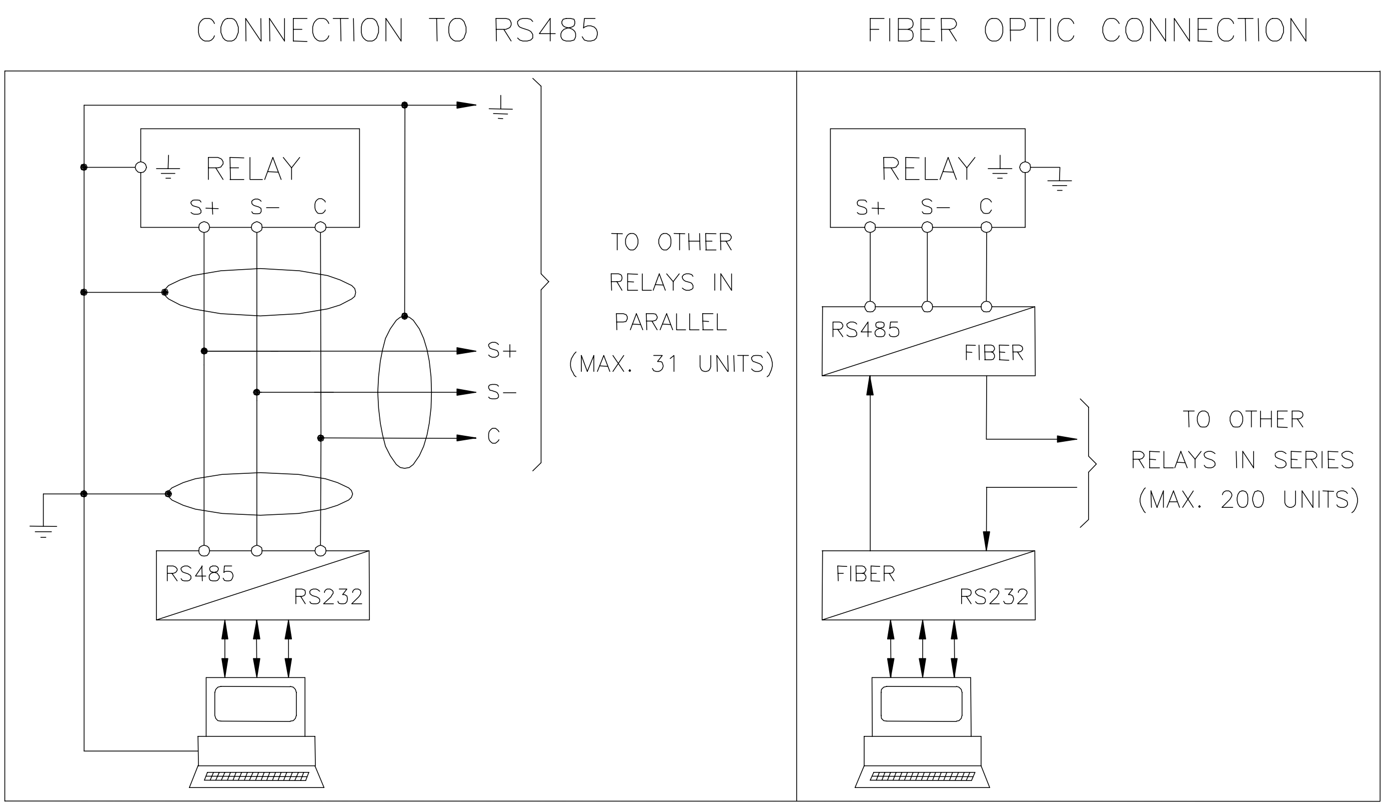


FIGURE 5: Wiring the Serial Communication Bus

7. CHANGE THE CT SECONDARY RATED INPUT, 1 OR 5A

The two possible selections to specify the rated secondary input currents are 1 or 5 Amperes. The jumper placement determines what the secondary rated current values will be. The 5 Amperes rating is selected by either joining the bottom two pins (vertical) or the two leftmost pins (horizontal). The 1 Ampere rating is selected by either joining the top two pins (vertical) or the two rightmost pins (horizontal).

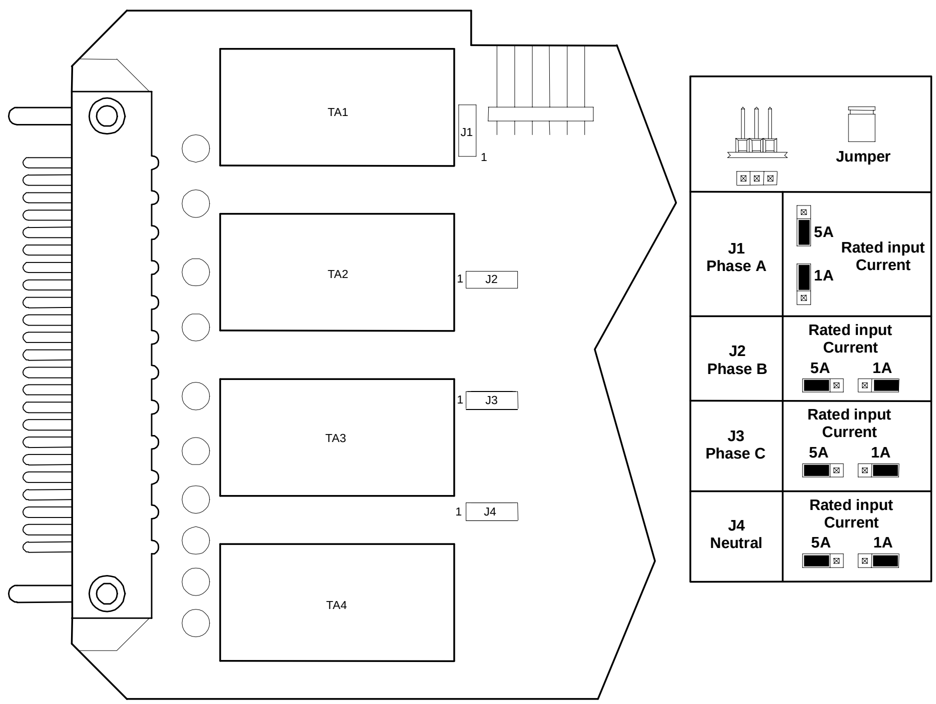


FIGURE 6: SELECTION OF THE RATED SECONDARY INPUT CURRENTS

8. OUTPUT RELAYS

Five output relays are available (R1, R2, R3, R4, R5).

a) - The output relays **R1,R2,R3,R4** are normally de-energized (energized on trip): these output relays are user programmable and any of them can be associated to any of the IM30-DRE's functions. Output relays 1 through 4 are user programmable to operate in conjunction with the tripping of any protective element or elements. Relay 1 consists of two isolated SPST terminals, which may be selected as being either normally open or normally closed. The other three output relays, 2-4, have form C (i.e., SPDT) contact arrangements.

Reset of the output relays after pick-up takes place automatically when the tripping cause is cleared. For relays controlled by the time delayed elements of the protection functions (tI>, tI>>, tO>, tO>>, tI_2>) it is possible to select Automatic reset or Manual Reset by the front reset button (see programming of **tFRes**, section 11.4, Table 4).

The reset of the relay associated to **BT** [Breaker Trip] is always automatic (see section 19.2).

b) - The output relay **R5** is normally energized, is not programmable and it is de-energized on:

- internal fault
- power supply failure
- during programming of the relay.

9. TARGET DESCRIPTION

The front panel of the IM30DRE contains eight LEDs that are normally OFF and which act as the targets for the relay elements. See Figure 7 for identification of the targets. The top row of four targets corresponds to the phase and ground overcurrent elements. The second target (starting from the left) in the second row corresponds the negative sequence overcurrent element. As soon as the measured current level exceeds the trip level defined by the programming variables I>, I>>, I_0>, I_0>> and I_2, the appropriate LED begins to flash. Once the time element associated with that element has expired (tI>, tI>>, t0>, t0>> and tI_2), the relay will have tripped and the LED goes to a constant ON state. Table 2 summarizes the target functions.

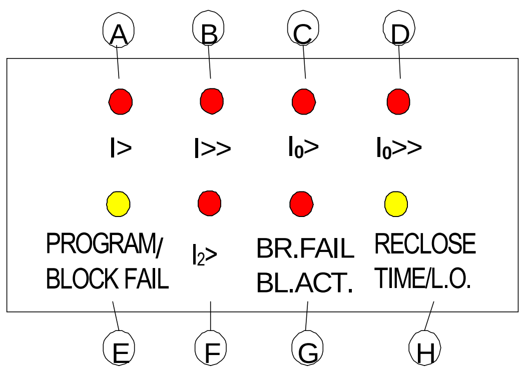


FIGURE 7: FRONT PANEL TARGETS ON THE IM30DRE

TABLE 2: TARGET DESCRIPTION

TARGET ID	COLOR	LEGEND	DESCRIPTION
A	Red	I>	Flashing when measured current exceeds the low set phase overcurrent trip level [I>]. Illuminated on trip after expiration of the low-set trip time delay [tI>].
B	Red	I>>	Same as above, related to the high set phase overcurrent elements [I>>], [tI>>].
C	Red	I_0>	Flashing when measured current exceeds the low set ground overcurrent trip level [I_0>]. Illuminated on trip after expiration of the low-set trip time delay [tI_0>].
D	Red	I_0>>	Same as above, related to the high-set ground overcurrent elements [I_0>>], [tI_0>>].
E	Yellow	PROGRAM/ BLOCK FAIL	Flashes when the relay is in programming mode. Constantly illuminated in case of an Internal Relay Failure.
F	Red	I_2>	Flashes when measured current exceeds the low set negative sequence overcurrent trip level [I_2>]. Illuminated on trips after expiration of the low-set trip time delay [tI_2>].
G	Red	BR.FAIL/ BL.ACT.	Flashes when a blocking signal is present at the relevant input terminal(s). Illuminated when the breaker fail function operates.
H	Yellow	RECLOSE TIME/L.O.	Flashes during the reclose timing (txC). Illuminated when the reclosing function is in the lockout status.

Reset of the LEDs takes place as follows:

- From flashing to OFF, automatically when the tripping cause disappears.
- From ON to OFF, by "ENTER/RESET" push button only if the associated tripping element is not picked up.

In the case of an auxiliary power supply failure the status of the targets is recorded to non-volatile memory. The status of the targets is maintained when auxiliary power is restored.

10. KEYBOARD OPERATION

All measurements, programmed settings, and recorded data may be accessed through the front panel. The five buttons are color-coded and their sequence of operation is indicated on the front panel by means of arrows directing the user to the next appropriate button to press. Figures 9 and 10 give an overview of the keyboard operation.

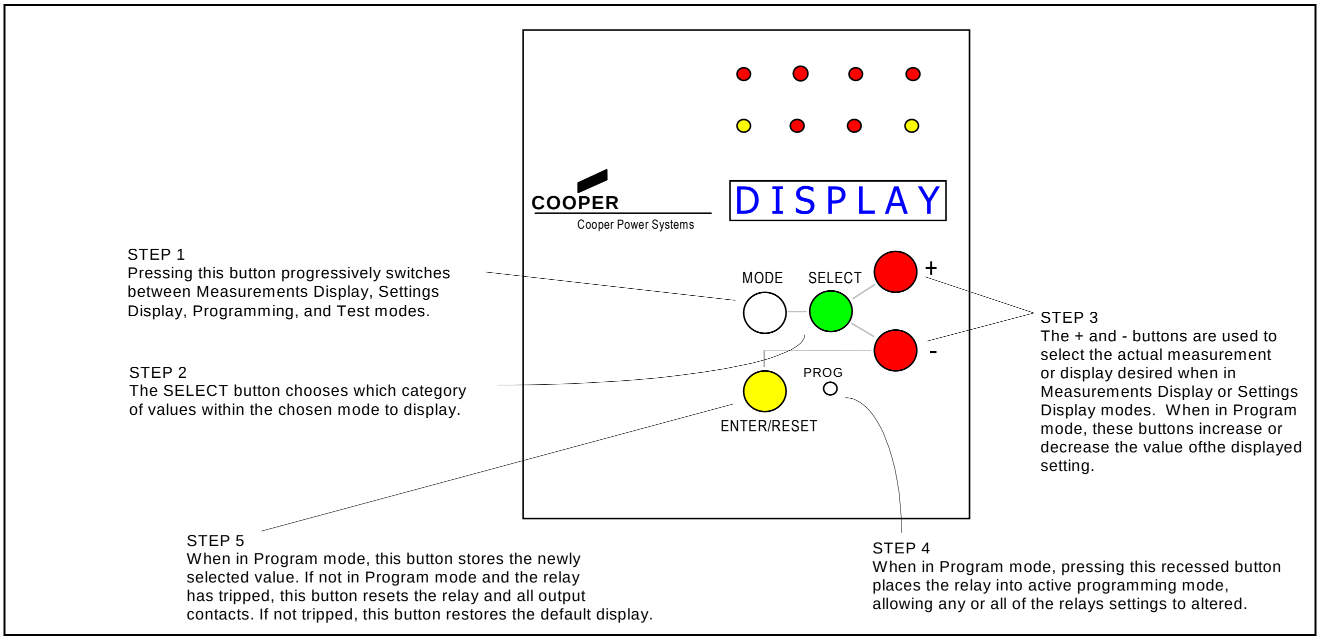


FIGURE 8: Keyboard Operation Overview

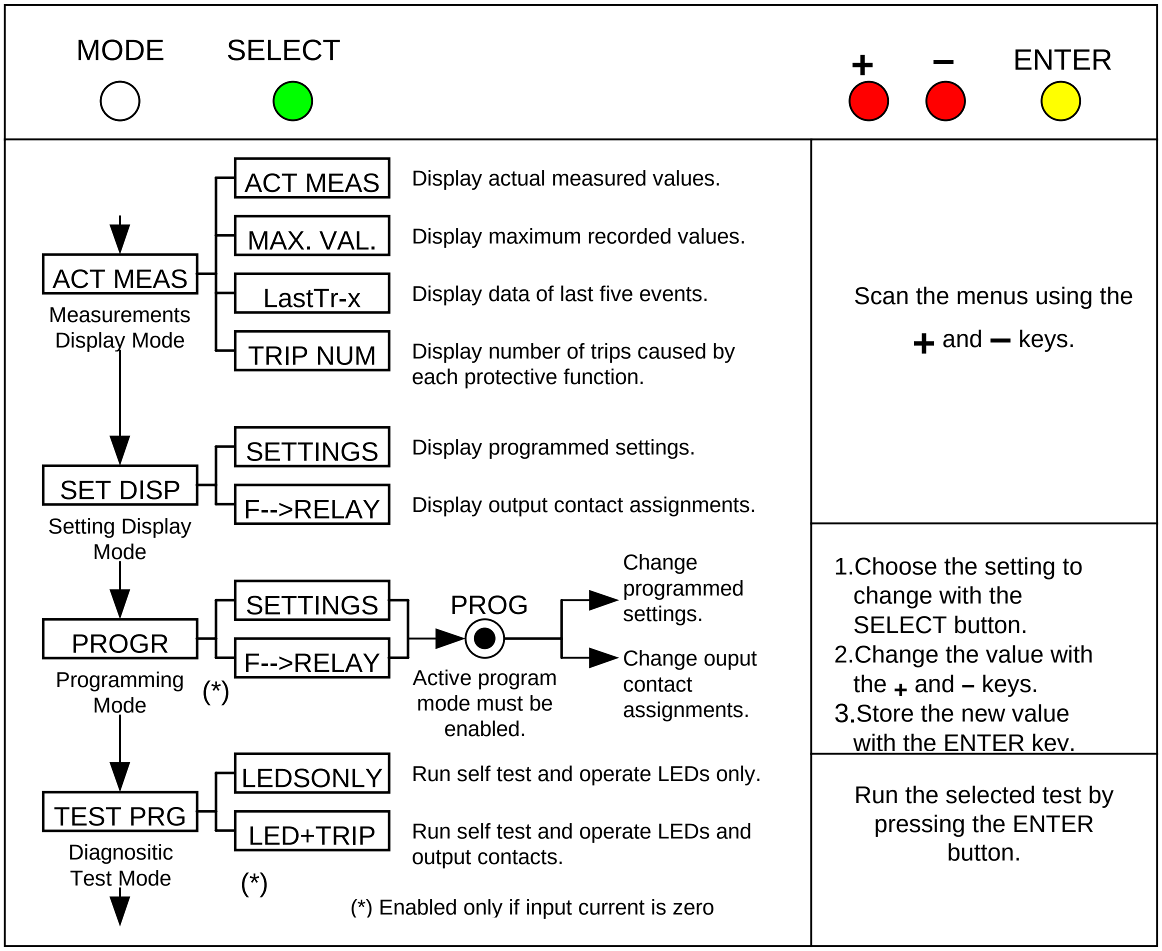


FIGURE 9: KEYBOARD MENU STRUCTURE

11. PROGRAMMING THE RELAY

Two programming modes are available. The first is the SETTINGS mode, where all of the input parameters (e.g., CT ratio, rated frequency) and settings (e.g., time dials, taps) are set. The second is the F➔Relay mode where the various output relays are assigned to the various protective elements. To enter the **PROGRAM** mode, follow these steps:

1. Make sure the input currents are all zero. As a security measure, the relay will not go into program mode when input quantities are not equal to zero. This prevents the settings from being altered while the relay is actively protecting the system. If it is necessary to make setting changes while the relay is in service, the use of the optional EdisonCom software is required.
2. Press the **MODE** button, to get into the **PROGRAM** mode.
3. Press the **SELECT** button to obtain either the **SETTINGS** or **F➔Relay** display.
4. Using a thin tool (e.g., a small screwdriver) press the recessed **PROG** button. The **PROGRAM** LED will now be flashing, indicating that the **PROGRAM** mode has been successfully entered.

11.1 CHANGING A SETTING

Once you have entered into the active PROGRAM SETTINGS mode, relay settings may be changed. For instruction on changing the output relay assignments see the section titled Changing Output Relay Assignments (11.3). Change the settings as follows:

1. Press the SELECT button to scroll through the various input parameters available for programming.
2. When the desired parameter to be changed is displayed, press the + and – buttons to change the displayed value. For numerical values where the range of settings is large, the display may be sped up by pressing the SELECT button at the same time the + or – button is pressed.
3. When the desired value in displayed, press the ENTER/RESET button to store the new setting for that parameter.
4. Repeat steps 1 - 3 for each setting.

When finished, press the MODE button to leave the programming mode and return the relay to normal operation.

11.2 DESCRIPTION OF RELAY SETTING VARIABLES

Table 3 describes each variable in the PROGRAM SETTINGS mode. The following conventions are used:

The name of the variable and any unit of measure displayed (Volts, Hz, etc.) is in bold face type. Some variables do not have a unit of measures displayed. Examples of these are variables that define curve shapes.

The Relay Setting Variables can be entered in both Setting Groups 1 and 2.

The default value is shown in regular typeface.

For example:

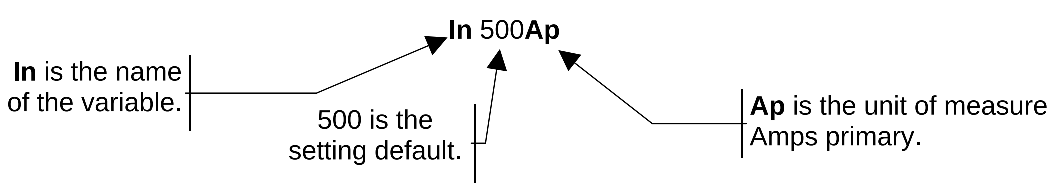


TABLE 3: PROGRAM SETTING VARIABLES

DISPLAY	DESCRIPTION	SETTING RANGE
xxxxxxx	Current Date	DDMMMYY
xx:xx:xx	Current Time	HH:MM:SS
Fn 60 **Hz**	System frequency	50 or 60 Hz
In 500**Ap**	Rated primary current of the phase CTs.	1 to 9999 in 1A steps
0n 500**Ap**	Rated primary current of the CTs or the window CT used for supplying the zero sequence input current.	1 to 9999 in 1A steps
F(I>) D	Operating characteristic of the low set (time overcurrent) phase overcurrent element. Note: IEC curves follow the standard curve definitions as given in IEC Standards 255-3 and 255-4. The US curves follow the formula given in IEEE Draft Standard C37-118. This standard defines three curves, included here as curve names MI, VI and I. The other curves, SI and EI are based on the same formula and represent curve shapes in between the defined standard curves.	D Definite time delay A IEC Inverse time (A curve) B IEC Very Inverse time (B curve) C IEC Extremely Inverse (C curve) MI US Moderate Inverse SI US Standard Inverse VI US Very Inverse I US Inverse EI US Extremely Inverse
I> 1.0**In**	Tap (or pickup level) of the low set phase overcurrent element in per unit of the phase CT's rated current.	Dis, or 0.5 to 4.0 in 0.01 per unit steps
tI> 2.0**s**	*Definite time mode*: Trip time delay of the low-set phase overcurrent element *Inverse time mode*: Time delay at 10 times pickup	0.05 – 30.0 in 0.01 second steps
I>> 2**In**	Pickup level of the high set phase overcurrent element in per unit of the phase CT's rated current.	Dis, or 0.5 to 40 in 0.1 per unit steps
tI>>1.0**s**	Time delay in seconds of the high set phase overcurrent element.	0.05 to 3 seconds in 0.01 second steps
2I>> ON	Automatic Cold Load pick-up	ON or OFF
Uo> 10**V**	Enabling voltage threshold for the zero sequence polarizing element. This is the minimum value of the zero sequence voltage, in secondary volts, which are required in order to enable the operation of the directional element.	2 to 25 V in 1V steps

DISPLAY	DESCRIPTION	SETTING RANGE
Fα Dir	Directional operation mode of the ground overcurrent elements.	Dir = True directional mode Sup = Supervisory directional mode Dis = Directional mode is Disabled. The ground element behaves as a non-directional element.
α= 90º	Maximum torque angle of the ground fault current element.	Dis, or 0º to 359º in 1º steps.
F(0>) D	Operating characteristic of the low set (time overcurrent) ground fault element.	Same curve selections as for F(I>).
0> .1**0n**	Tap (pickup level) of the low set ground overcurrent element in per unit of the zero sequence sensing CT's rated current.	Dis, or 0.02 to 0.4 per unit of 0n in 0.01 per unit steps
t0> 4.0**s**	*Definite time mode*: Trip time delay of the low-set ground overcurrent element *Inverse time mode*: Time delay at 10 times pickup	0.05 - 30.00 in 0.01 second steps
0>> .5**0n**	Tap (pickup level) of the high set ground element in per unit of the zero sequence sensing CT's rated current.	Dis, or 0.02 to 1.00 in 0.01 per unit steps
t0>>3.0**s**	Time delay in seconds of the high set ground overcurrent element.	0.05 to 3.0 seconds in 0.01 second steps
F(I_2) D	Operating characteristic of the negative sequence overcurrent element.	Same curve selections as for F(I>).
I_2 .6**In**	Tap (pickup level) of the negative sequence overcurrent element in per unit of the <u>phase</u> CT's rated current.	Dis, or 0.5 to 4.0 per unit of In in 0.01 per unit steps
tI_2 2.0**s**	*Definite time mode*: Trip time delay of the negative sequence overcurrent element *Inverse time mode*: Time delay at 10 times pickup	0.05 - 30.00 in 0.01 second steps
1C --I-O	Selection of the function(s) to initiate the first reclosing shot 1C (i = tI>; I = tI>>; o = tO>; O = tO>>; N = tI_2)	N i I o O
2C –i-oO	Same as above for second reclosing shot 2C (i = tI>; I = tI>>; o = tO>; O = tO>>; N = tI_2)	N i I o O
3C ---oO	Same as above for third reclosing shot 3C (i = tI>; I = tI>>; o = tO>; O = tO>>; N = tI_2)	N i I o O
4C --I-O	Same as above for fourth reclosing shot 4C (i = tI>; I = tI>>; o = tO>; O = tO>>; N = tI_2)	N i I o O
t1C 2**s**	Reclosing time interval of the first reclosing shot	0.1 to 1800 seconds in 0.1 second steps
t2C 4**s**	Reclosing time interval of the second reclosing shot	0.1 to 1800 seconds in 0.1 second steps

DISPLAY	DESCRIPTION	SETTING RANGE
t3C 6**s**	Reclosing time interval of the third reclosing shot	0.1 to 1800 seconds in 0.1 second steps
t4C 8**s**	Reclosing time interval of the fourth reclosing shot	0.1 to 1800 seconds in 0.1 second steps
tr 8**s**	Reset interval after any successful reclosure	1 to 1200 seconds in 1 second steps
LO# 3	Specifies the number of reclosing shot to Lock-out	1 – 2 – 3 – 4
ChSet 2	Change Setting. This determines when the relay automatically changes from setting group 1 to setting group 2 (not vice versa)	1-2-3-4-Dis
SEQ Coff	Sequence Coordination with downstream recloser	ON or OFF
tBF .25**s**	Time delay for Breaker Failure alarm	0.05 to 0.25 in 0.01 second steps
B→I> OFF	Blocking Input at terminals 1 to 3, blocks the timed output of the function I>	ON or OFF
B→I>>OFF	Same as above, for function I>>	ON or OFF
B→O> OFF	Same as above, for function **O>**	ON or OFF
B→O>>OFF	Same as above, for function **O>>**	ON or OFF
B→$\mathbf{I_2}$**>** OFF	Same as above, for function $\mathbf{I_2}$**>**	ON or OFF
B→RclOFF	Blocking Input at terminals 1 to 3, blocks the reclose function	ON or OFF
TsynIRIG	Synchronized Time Signal: The expected time interval between synchronization pulses. Setting it to IRIG-B sets the relay up to receive IRIG-B time signals. “Dis” disables the time synch.	5, 10, 15, 30, or 60 minutes or IRIG-B or Dis
NodAd 1	Identification number of relay when connected on a serial communication bus.	1 to 250 in steps of 1

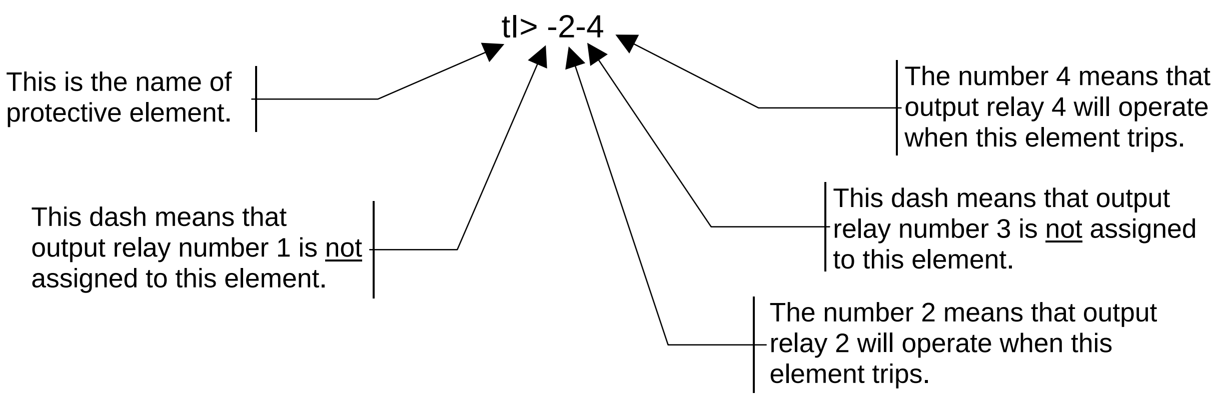
11.3 CHANGING OUTPUT RELAY ASSIGNMENTS

Output relays 1 through 4 may be assigned to any protective element, or any combination of elements. The only exception is that the relay cannot be assigned to both pick-up (start-time) elements, and time dependent protective elements.

1. First, enter the F➔Relay program mode.
2. Press the SELECT button to display the protective element for which the relay's assignments are to be made or changed.
3. Press the + key to select the output relay. Each press of the + key selects the next output relay. Once selected, the relay position blinks.
4. Press the - key to toggle whether the element is assigned to the output relay or not. If assigned, the output relay number appears. If not, only a hyphen (-) will be displayed.
5. Press the ENTER/RESET button to store the changes.
6. Repeat steps 1 through 5 for each protective element.

When finished, press the MODE button to leave programming mode and return the relay to normal operation.

For example:



11.4 DESCRIPTION OF OUTPUT RELAY VARIABLES

This section describes each variable in the PROGRAM, F→Relay mode. The following conventions are used:

- The name of the variable is in bold face type.
- The default output relay settings are shown in regular typeface.

TABLE 4 - OUTPUT RELAY PROGRAMMING DISPLAY DEFINITIONS

DISPLAY	DESCRIPTION
I> ----	Pick-up (or start-time) element associated with the low set phase overcurrent element.
tI> 1---	Time delayed element associated with the low set phase overcurrent element.
I>> ----	Pick-up element associated with the high set phase overcurrent element.
tI>> -2--	Time delayed element associated with the high set phase overcurrent element.
0> ----	Pick-up element associated with the low set ground overcurrent element.
t0> 1---	Time delayed element associated with the low set ground overcurrent element.
0>> ----	Pick-up element associated with the high set ground overcurrent element.
t0>> -2--	Time delayed element associated with the high set ground overcurrent element.
I_2 ----	Pick-up element associated with the low set negative sequence overcurrent element.
tI_2 1---	Time delayed element associated with the low set negative sequence overcurrent element.
C ---4	Reclosure operates relay.
rLO --3-	Reclose Lockout status operates relay.
tBF ----	Breaker failure alarm operates relay.
BT ----	Breaker Trip relay.
tFRes: A	Reset mode for time delay elements. If “A” then reset takes place automatically when the current drops below the pick-up value. When set to “M”, reset is only possible via the front panel ENTER/RESET key. The reset is always automatic for relays assigned to instantaneous elements or to the Reclose functions.

11.5 PROGRAMMABLE BLOCKING VARIABLES

In addition to the output relay programming, the PROGRAM F→Relay mode also provides access to setting four variables which determine which protective elements are affected by the various blocking inputs. Descriptions of these variable names, and their effects are found in Table 5.

11.6 READING OF MEASUREMENTS AND RECORDED PARAMETERS

Enter the MODE "MEASURE", SELECT the menus "ACT.MEAS"-"MAX VAL"-"LASTTRIP"-
-"TRIP NUM", scroll available information by key "+" or "-".

11.6.1 ACT.MEAS

Actual values as measured during the normal operation. The values displayed are continuously refreshed.

TABLE 5 – ACTUAL MEASUREMENTS DISPLAY

DISPLAY	DESCRIPTION
xxxxxxx	Date : Day, Month, Year
xx:xx:xx	Hour : Hours, Minutes, Seconds
Iaxxxx0**A**	True R.M.S. value of the current of phase A displayed as primary Amps. (0 – 99999)
Ibxxxx0**A**	As above, phase B.
Icxxxx0**A**	As above, phase C.
Ioxxxx0**A**	As above, ground fault current.
I_2x.00**In**	Negative Sequence component of the 3-phase current system
Uoxxxxx**V**	True R.M.S. value of the residual voltage displayed as secondary voltage of main V.Ts. (1-210)V
φoxxxxx**°**	Io/Uo phase displacement angle in degrees.

11.6.2 MAX VAL

Highest values recorded starting from 100ms after closing of main Circuit Breaker plus inrush values recorded within the first 100ms from Breaker closing, (refreshed any time the breaker closes).

TABLE 6: MAXIMUM VALUES DISPLAY

DISPLAY	DESCRIPTION
Iaxx.0**In**	Max demand of phase A current after the first 100ms displayed as p.u. of CTs rated current
Ibxx.0**In**	As above, phase B.
Icxx.0**In**	As above, phase C.
Iox.00**On**	As above, ground fault current.
I_2x.00**In**	As above, negative sequence current component
Uoxxxxx**V**	Max value of Uo recorded after the first 100ms.
Saxx.0**In**	Max demand current of phase A during the first 100ms.
SBxx.0**In**	As above, phase B.
SCxx.0**In**	As above, phase C.
Sox.00**On**	As above, ground fault current.
SUoxxxx**V**	Max value of Uo recorded during the first 100ms.

11.6.3 EVENT RECORDING (LASTTRIP)

RECORDING OF THE LAST TEN EVENTS: Display of the function that caused the tripping of the relay plus values of the parameters at the moment of tripping. The memory buffer is refreshed at each new relay tripping. A much more extensive information is available from the RS485 serial port.

Each of the previous ten event records stored into the FIFO memory contains:

- A date and time stamp. (A time synchronization signal can be sent or via serial interface or to the IRIG-B input allowing the use of an external satellite clock to synchronize all relays on the system with 10ms accuracy).
- Each ¼ cycle for 10 cycles (2 pre-fault, 8 post-fault), the following data is recorded:
  - The R.M.S. values of the three phase currents, ground current, negative sequence current, and the residual voltage.
  - Pick-up and trip status of the low and high set phase and ground element, the negative sequence elements and the reclose element
  - Operating status of the five output relays
  - Operating status of the reclose reset timer tr as well as of the timers relevant to any of the Reclose shots.

The data are stored and collected by the MS-COM application program, from which they can be organized by a spreadsheet program (EXCEL).

TABLE 7: Last Trip Display

DISPLAY	DESCRIPTION
LastTr-x	Indication of the recorded event (x= 0 to 9) Example: Last event (LastTr –0) Last but one event (LastTr-1) etc…
F:xxxxxx	Display of the function which caused the last tripping: **i = tI>**; **I = tI>>**; **o = tO>**; **O = tO>>**; **N=tI$_2$>**
Iaxx.0**In**	Current of phase A.
Ibxx.0**In**	Current of phase B.
Icxx.0**In**	Current of phase C.
Iox.00**On**	Ground fault current.
I$_2$x.00**In**	Negative Sequence component of current.
Uoxxxx0**V**	Residual voltage.
φoxxxx0**°**	Io/Uo phase displacement.
trxx.00**s**	Remaining time to elapse of **tr** – If tr≠0 the trip has taken place during **tr** after a closure

11.6.4 TRIP NUM

Counters of the number of operations for each of the relay functions.

TABLE 8: Trip Number Display

DISPLAY	DESCRIPTION
I>xxxxx0	Low set timed overcurrent element [tI>] operations
I>>xxxx0	High set overcurrent element [tI>>] operations
Io>xxxx0	Low set ground fault element [tO>] operations
Io>>xxx0	High set ground fault element [tO>>] operations
I_2xxxxx0	Negative Sequence overcurrent element [tI>>] operations
1Cxxxxx0	N° of reclosures operated by the first reclosing shot 1C
2Cxxxxx0	N° of reclosures operated by the 2nd reclosing shot 2C
3Cxxxxx0	N° of reclosures operated by the 3rd reclosing shot 3C
4Cxxxxx0	N° of reclosures operated by the 4th reclosing shot 4C
OPSxxxx0	Number of Circuit Breaker's operations

12. OVERCURRENT ELEMENT CHARACTERISTICS

Both the phase and ground overcurrent elements in the IM30DRE consist of a selectable time overcurrent characteristic element and an instantaneous element. The negative sequence overcurrent element has only a selectable time overcurrent characteristic element. Figure 7 shows a typical composite relay curve. These are non-directional elements. In addition, the IM30DRE provides protective elements that operate upon pick-up of any of the above elements. These are referred to as the pick-up elements.

The time overcurrent elements, being sensitive to lower current levels, are more generically referred to as low set elements.

In Curve Mode, the IM30DRE may be programmed to mimic one of eight predefined characteristics, which include the three standard IEC curve shapes, the three standard IEEE curve shapes, two other typical US characteristics. Additionally, there is a user defined definite time curve. The predefined curves are modeled based on the following formula per IEEE Draft Standard C37-118:

$$t(I) = \left(\frac{A}{M^{P} - 1} + B\right) K\ (T_s)$$

Where: A, B, and P are constants elected to provide the desired curve characteristics.

M is the ratio (I_{input}/I_{pickup})

T_s is the time setting of the relay and corresponds to either tI>, tI_2> or t_0> depending upon whether the phase, negative sequence or ground low set element is being set.

K is a constant, which allows for a very simple method of determining the time delay setting for the relay. See the section titled "Easy Set Curve Placement".

Table 9 summarizes the values that the variables take for each characteristic.

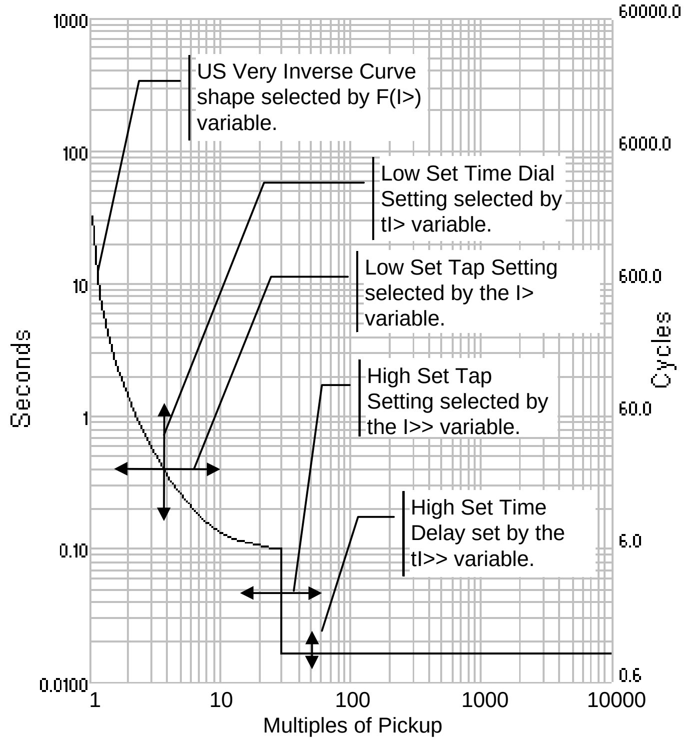


FIGURE 10: EXAMPLE OF COMPOSITE US VERY NVERSE CURVE WITH INSTANTANEOUS (HIGH SET) ELEMENT

TABLE 9: TIME OVERCURRENT VARIABLES

Curve Name	Description	A	B	P	K
A	IEC Inverse	0.14	0	0.02	0.3366
B	IEC Very Inverse	13.500	0	1	0.6667
C	IEC Extremely Inverse	80.000	0	2	1.2375
MI	US Moderate Inverse	0.0104	0.0226	0.02	4.1106
SI	US Standard Inverse	0.00342	0.00262	0.02	13.3001
VI	US Very Inverse	3.88	0.0963	2	7.3805
I	US Inverse	5.95	0.18	2	4.1649
EI	US Extremely Inverse	5.67	0.0352	2	10.814
D	Definite Time	t = Ts			

NOTE: Settings for the time dial (time delay) may be determined using either the time dial or Easy Set[SM] methods.

13. EASY SET[SM] CURVE PLACEMENT METHOD

Instead of traditional time dial settings, the IM30DRE relay uses a time delay setting for moving the TCC curves vertically on the TCC graph. These time delay settings are tI> for the phase element, tI_2> for the negative sequence element and tI_0> for the ground element. The traditional time dial setting may be calculated by multiplying the time setting by the constant K from Table 6 for the appropriate curve shape.

The Easy Set system allows multiple TCC curves to be drawn on a single TCC chart. Figures 13 and 14 show the IEEE and IEC curve families respectively. Note that all of the curves cross at the same point, pickup multiple of 10, and a time of 1x the set time delay.

Once the desired placement of the curve is determined, the time delay setting may be determined by noting the actual time delay in seconds at the pickup multiple of 10. That time delay is equal to the time delay setting (tI>, tI_2> or tI_O>) for the relay.

For example, the phase overcurrent element is set up to use the IEEE VI curve. The curve has been determined to be correctly located as shown in Figure 11. The TCC curve crosses the Pickup Multiple=10 line at 2.0 seconds. Therefore the tI> time delay setting is 2.0.

14. TIME DIAL METHOD

Figures 12 through 22 show a representative sample of the various curve shapes along with their Time Dial settings. The Time Dial settings are converted to the appropriate tI>, tI_2> or tI_O> settings by dividing the time dial by the value of K (see Table 6) for the appropriate curve shape.

To convert an existing time delay setting (either tI>, tI_2> or tI_0>) to a time dial value, multiply the time delay by the K factor in Table 9 for the appropriate curve.

Going back to the example shown in Figure 11, the time dial for the curve would be equal to 2.0 seconds multiplied by the constant K for the IEEE Very Inverse curve (7.3805). Therefore, the time dial would equal 14.8.

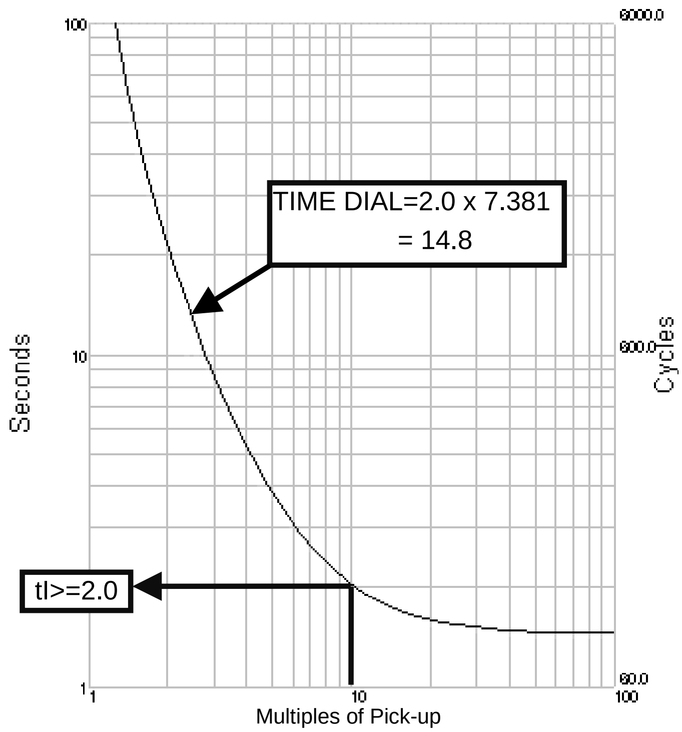


FIGURE 11: EXAMPLE OF IEEE VERY INVERSE CURVE TIME DELAY SETTING DETERMINATION

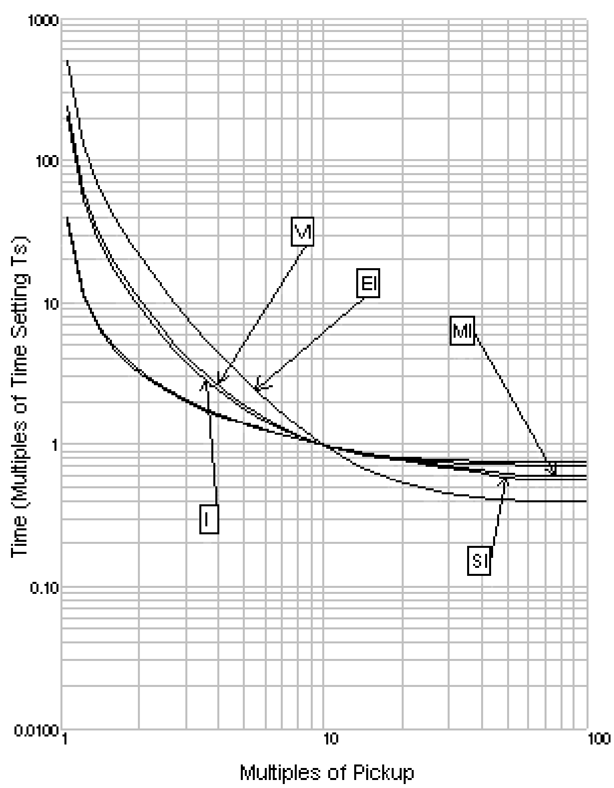


FIGURE 12: Easy Set Curve Set for IEEE TCC Curves

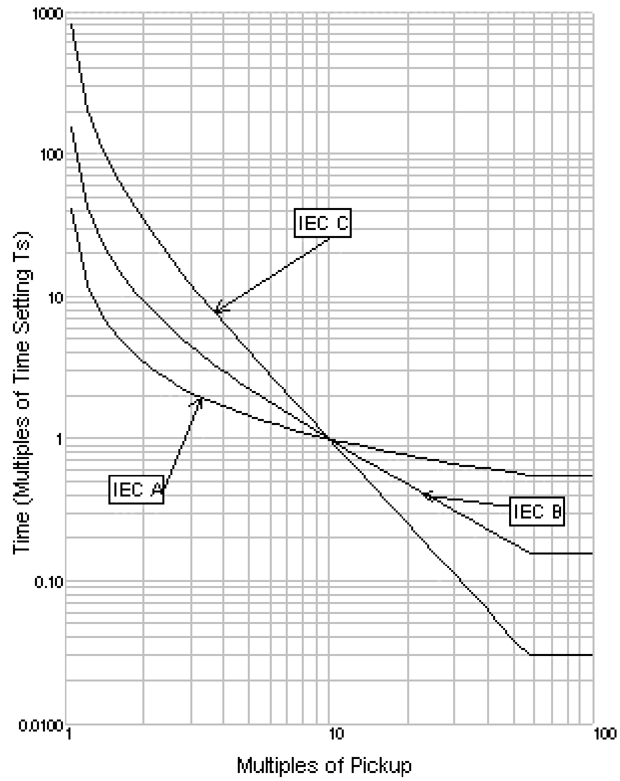


FIGURE 13: EASY SET CURVE SET FOR IEC TCC CURVES

15. CURVE CHARACTERISTICS

The following figures show the curve shapes available and their setting ranges in terms of time dial settings. The time dial settings must be translated into time delay settings by dividing the time dial setting by the value of K shown on the figures. Note, time dial settings (and corresponding time delays) in between those indicated are possible.

Because of this characteristic, each of the curves have different absolute time dial ranges. However, the time dial range for any of the relays is much wider than typical, therefore it may be considered that all of the IEEE curves have a common time dial range from 0.7 to 123. All IEC curves have a common time dial range of 0.07 to 10. Table 10 summarizes the actual time dial limits.

Note: Actual time delays will be equal to the shown time delay plus output contact closing time and any algorithm processing time. This additional time delay (pickup time) ranges from 7 to 12 msec, with a mean of 9 msec.

TABLE 10: ABSOLUTE TIME DIAL RANGES FOR TCC CURVE TYPES

CURVE NAME	CURVE CHARACTERISTIC	MINIMUM TIME DIAL	MAXIMUM TIME DIAL
A	IEC A - Normal Inverse	0.017	10.099
B	IEC B - Very Inverse	0.033	20.000
C	IEC C - Extremely Inverse	0.062	37.125
MI	IEEE Moderate Inverse	0.21	123.3
SI	IEEE Standard Inverse	0.67	399.0
VI	IEEE Very Inverse	0.37	221.4
I	IEEE Inverse	0.21	124.9
EI	IEEE Extremely Inverse	0.54	324.4

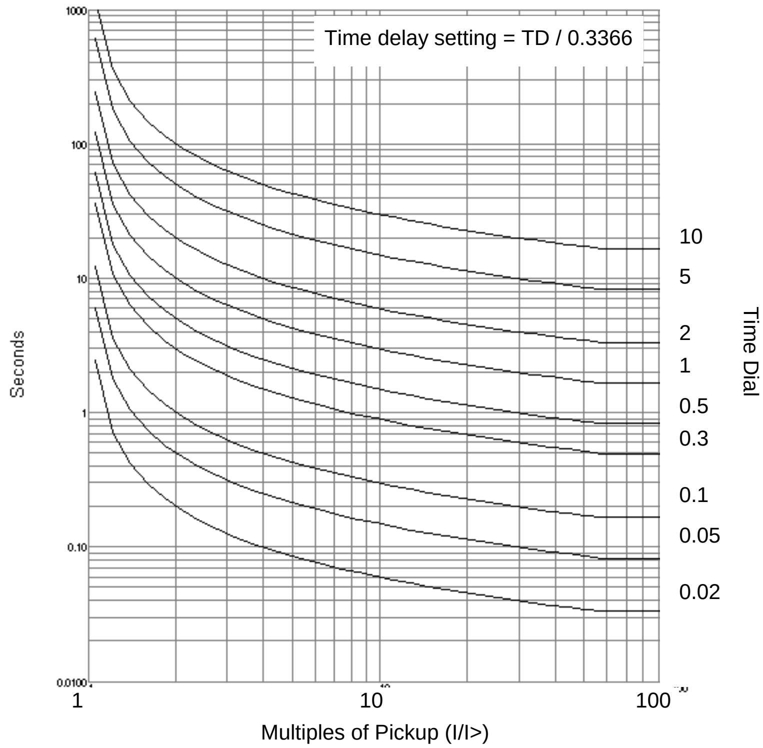


FIGURE 14 – IEC INVERSE CURVE (A)

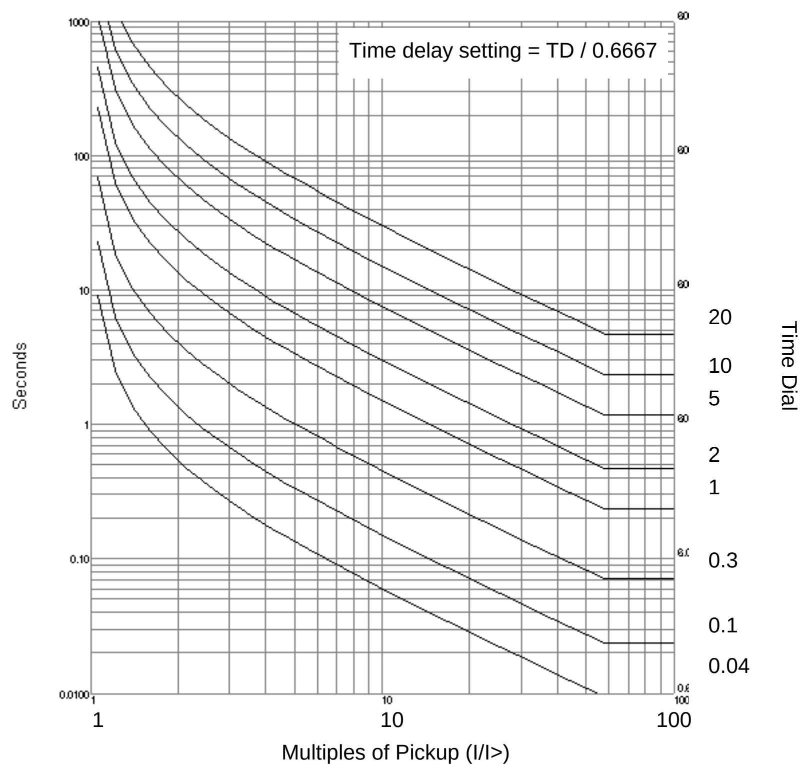


FIGURE 15 – IEC VERY INVERSE CURVE (B)

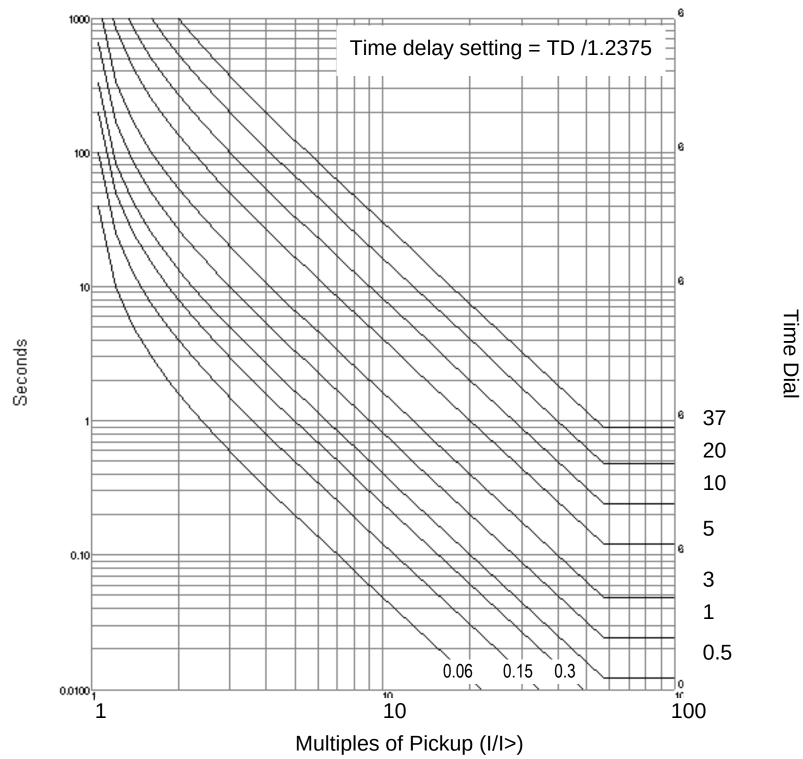


FIGURE 16 – IEC EXTREMELY INVERSE CURVE (C)

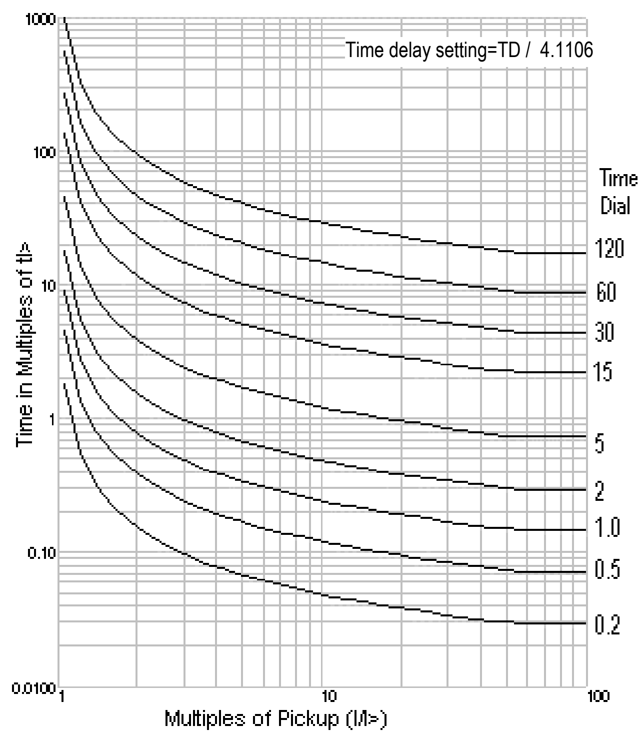


FIGURE 17 - US MODERATELY INVERSE CURVE (MI)

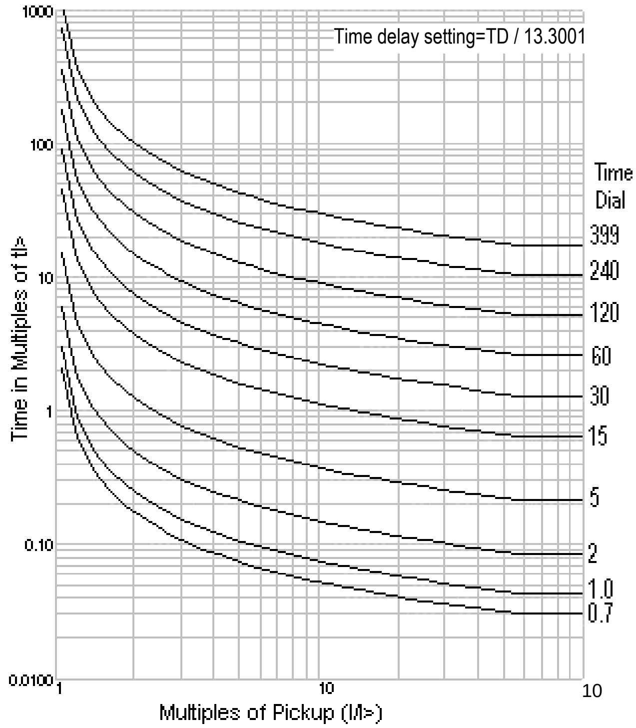


FIGURE 18: US STANDARD INVERSE CURVE (SI)

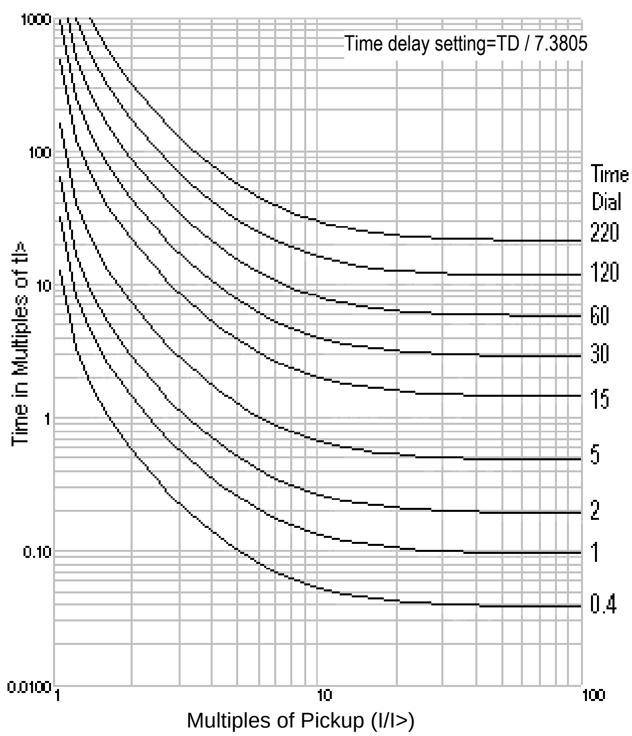


FIGURE 19: US VERY INVERSE CURVES (VI)

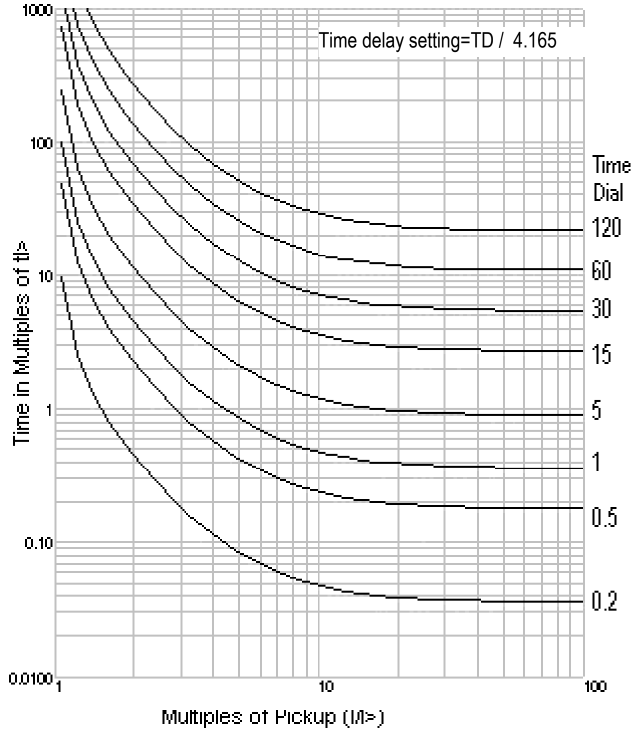


FIGURE 20 - US INVERSE CURVES (I)

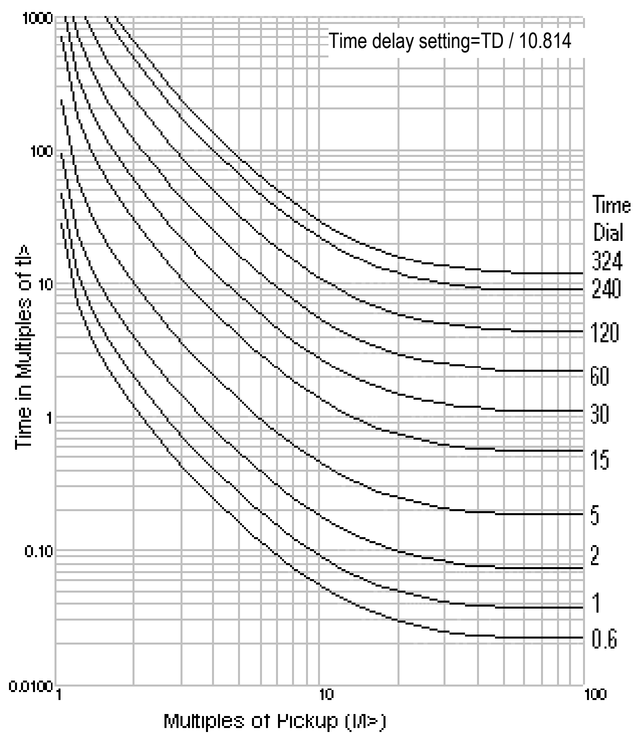


FIGURE 21: US EXTREMELY INVERSE CURVES (EI)

16. OPERATION OF THE DIRECTIONAL GROUND FAULT ELEMENT

The operation of the ground overcurrent elements may be selected to operate in one of three modes, as set by the variable Fα.

- Non-directional (Fα=Dis): In this case the ground elements are simple 50/51 elements.
- Directional supervision (Fα=Sup): In this mode the ground elements will respond to a fault current only if the current is within +/- 90° of the set maximum torque angle.
- True directional mode (Fα=Dir): In this mode the ground elements respond only to the component of current in phase with the maximum torque angle.

16.1 NON-DIRECTIONAL MODE, Fα = DIS.

The element operates as a normal overcurrent element. See Figure 22.

The element operates if: 3I0 ≥ [Is]

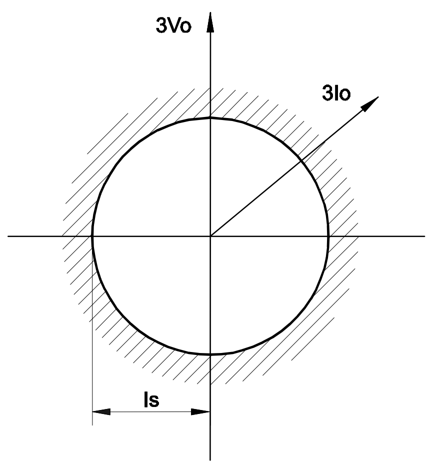


FIGURE 22: NON-DIRECTIONAL GROUND OVERCURRENT MODE.

16.2 DIRECTIONAL SUPERVISION MODE, Fα = SUP.

This is the classic directional mode, which permits operation of the overcurrent element if the fault current's characteristic angle is +/- 90° of the set maximum torque angle. The element operates if the following 3 conditions are present:

- The input residual voltage $3V_0$ exceeds the setting U_0 $3V_0 \geq [U_0]$
- The input residual current $3I_0$ exceeds the setting Is $3I_0 \geq [Is]$
- The displacement angle α_0 of I_0 from V_0 is within ± 90° from the set maximum torque angle, α.

$$\alpha - 90 \leq \varphi_o \leq \alpha + 90$$

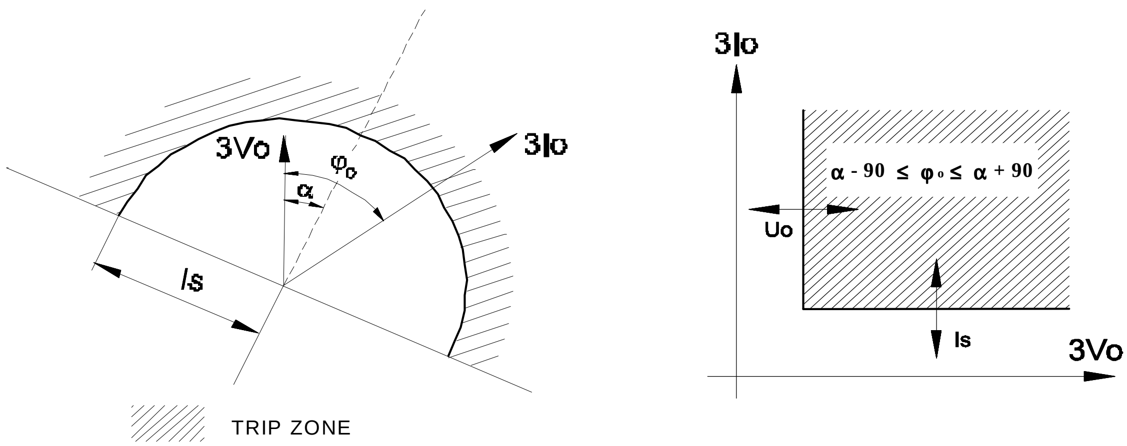


FIGURE 23: PHASOR RELATIONS FOR DIRECTIONAL SUPERVISION MODE

16.3 TRUE DIRECTIONAL MODE, Fα = DIR

The element performs a complete directional operation; pick-up takes place if the follow conditions are present.

- The input residual voltage $3V_0$ exceeds the setting U_0 : $3V_0 \geq [U_0]$
- The component of the input residual current $3I_0$ in the direction α exceeds the setting level Is : $3I_0 \cos(\varphi_0 - \alpha) \geq [Is]$

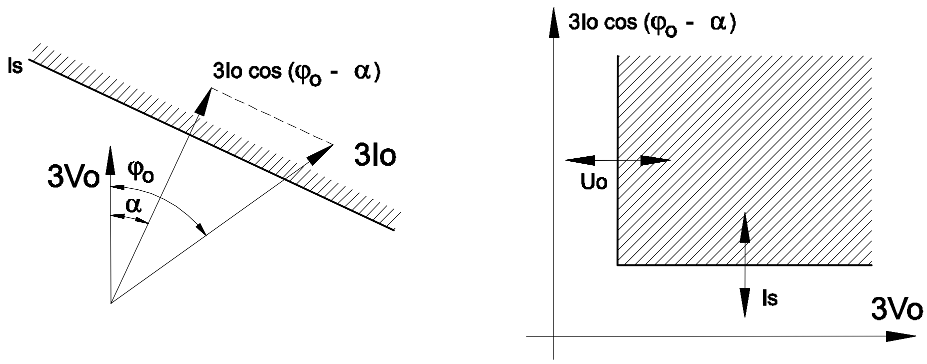


Figure 24: Phasor Relations for True Directional Current Mode

Because only the component of I_0 in the direction of α_0 is used, if the actual direction of I_0, φ, is at an angle other than α, then the sensitivity of the ground element will vary. The sensitivity is at its maximum when the angle of I_0 is equal to α_0, and will approach zero as the angle approaches $\alpha \pm 90°$. See Figure 24.

The characteristic angle of the relay should be set according to the kind of grounding used in the power system; typical values would be:

- Ungrounded neutral $\alpha_0 = 90°$
- Neutral grounded via resistor $\alpha_0 = 0°$
- Solidly grounded neutral $\alpha_0 = 60°$.

17. AUTOMATIC COLD LOAD PICK-UP

When selected (2I>>=ON), the pick-up level of the high set overcurrent element is changed as follows.

If during the first 60 msec of the breaker closing, the current exceeds 1.5 pu of the CTs rated primary current, the setting for the phase high set element is doubled until such time that the phase current drops below 1.25 pu of the rated CT primary current. This prevents nuisance trips associated with an extended cold load pick-up situation, or transformer inrush situation.

18. BREAKER FAILURE

A programmable time delay (tBF) relay is set equal to the breaker's clearing time. If the fault is not cleared (i.e., the element has not dropped out) before this timer expires, a breaker failure is indicated.

19. OPERATION OF THE AUTORECLOSE FUNCTION

19.1 RECLAIM TIME tr AND LOCKOUT STATUS L.O.

Any time the Circuit Breaker (CB) is closed either manually or automatically the Reclaim time tr is started. After a manual closure of the CB, tripping of any of the relay's time delayed protection elements during **tr** makes the relay enter into the LockOut status (L.O.).

With the relay in L.O. status, the relay will not produce any command for automatic reclose. The lockout status is monitored by the relevant LED flashing and (if programmed) by pick-up of one output relay.

Reset from the L.O. status takes places when the CB is opened and then manually reclosed.

If no tripping by any of the relay's elements takes place during the tr time frame after a manual closure of the CB, the relay will be ready to start the Automatic Reclose Sequence.

19.2 PROGRAMMABLE RECLOSING SEQUENCE

A reclose sequence can be programmed to operate between 1 to 4 reclose shots before lockout.

The variable " LO# "= 1, 2, 3, 4 determines the number of shots to Lockout. Each of the four reclose shots (1C, 2C, 3C, 4C) can be programmed to be initiated when the Circuit Breaker has been opened by tripping of any of the relay's time delayed protection elements (see Section 11).

The elements which are programmed for 1C, 2C, 3C, 4C can also operate one of the output relays " BT " which then acts as a breaker trip relay.

Example :	1C	=	tI> + tI>> + tO> + tO>> + tI_2>
	2C	=	tI_2> + tO> + tO>>
	3C	=	tI> + tO>
	4C	=	- - - - - - - - -

- 1^{st} Reclosure shot is started if the CB opening was caused by tripping of any of the relay's timed protection elements.
- 2^{nd} Reclosure shot is started only if the CB's opening was caused by tripping of one of the relay's timed element tI_2>, tO>, tO>>. If tripping was caused by another protection element not included in this list, then the relay will enter into the lockout status.
- 3^{rd} Reclosure shot is started only if the CB's opening was caused by tripping initiated by either the tI> or tO> elements.
- 4^{th} Reclosure shot is not programmed: any new tripping of the CB after the 3^{rd} reclosure will make the relay enter into the L.O. status.

  By not setting any elements to be enabling elements for a given reclose shot, it is possible to shorten the reclosing cycle.

  For example, by not defining any overcurrent elements for the 3^{rd} and 4^{th} reclose shots, then any fault sensed after the second reclose shot will cause a lock-out condition.

In this manner, it is possible to set up either a one, two, three or four shot to lockout reclosing sequence.

It is also possible to have one of the output relays programmed as the Breaker Trip (BT) relay. If this is done, then any element which is enabled for the reclosing sequence and only these, will operate the

BT relay output contact. If the tripping of the breaker is controlled only by the BT relay output contact, then the operation of any relay element not in the list of the programmable reclosing sequence will not open the breaker and thus will not start a reclosure.

When the programmed number of shots to Lockout is achieved, the relay locks-out and no further reclosing is initiated.

19.3 DUAL SETTING

Two setting groups allow for two different reclosing sequences to be made available for changing system conditions: for example, for “storm” and for “clear weather” conditions.

Selection between which setting group is active can be made manually via the relay’s keyboard or via serial interface programming.

Switching from setting program 1 to setting program 2 can be made automatically after any of the reclosing shots by programming the variable “ ChSet = 1-2-3-4-Dis ”.

For example: Programming ChSet = 3 means that after the third reclose shot the relay will automatically switch from setting 1 to setting 2 (if setting 2 was already active no change will take place).

19.4 RECLOSE COMMAND

When the system CB controlled by the IM30DRE relay is opened due to tripping by one of the relay’s elements, the automatic reclosing sequence is started. The relevant reclose time delay (t1C, t2C, t3C, and t4C) is initiated, and at the end of this txC time the reclose command is issued by the relay. The CB is then automatically closed and the waiting time tr is started again. If during tr the CB is again opened by a relay’s element programmed to initiate the next automatic reclose, the next reclose takes place after the relevant time txC. The CB is reclosed and tr restarted. When the last Automatic Reclose shot of the sequence is completed, then any further tripping during tr produces a relay lockout status. If after any reclosing shot no tripping takes place during tr, the Reclose Sequence is restarted from the beginning (starting from the first reclose shot 1C).

19.5 SEQUENCE COORDINATION

When (SEQ = ON) is selected, Sequence Coordination has been activated. This allows the reclose element to count downstream recloser operations as its own, thereby preventing unnecessary operations of the back-up device for a fault beyond the downstream device. This is particularly useful when the back-up breaker feeds several branch reclosers, only one of which is experiencing a fault.

19.6 EXTERNAL LOCK-OUT

Activating the digital input BI (terminals 1-2) can also produce the lockout status, if this input was programmed for reclose lockout. If the lockout input is removed when the CB is still closed, the relay will come back to its normal status after a time delay tr.

19.7 RECLOSE COUNTERS

Any automatic Reclose Shot is counted by an individual counter (1Cn°, 2Cn°, 3Cn°, 4Cn°) and displayed in the menu “TripNum”. If after a reclose command the status of the CB does not change, the CB will not open, the reclose shot is not counted and the relay goes into the lock-out status.

Another counter counts any CB’s operation (OPSn°).

20. SERIAL COMMUNICATION

The relay which is fitted with the serial communication option can be connected via a cable bus or (with proper adapters) a fiber optic bus for interfacing with a Personal Computer (type IBM or compatible).

All the operations that can be performed locally (for example reading of measured data and changing of relay's settings) are also possible via the serial communication interface. Furthermore, the serial port allows the user to read the oscillographic recording data. The unit has a RS485 interface that can be connected either directly to a P.C. via a dedicated cable or to a RS485 serial bus. Therefore, many relays can exchange data with a single master P.C. using the same physical serial line. An optional RS485/232 converter is available.

The communication protocol is MODBUS RTU, but only functions 3, 4 and 16 are implemented. Each relay is identified by its programmable address code (NodAd) and can be called from the P.C. Dedicated communication software EdisonCom for Windows 3.11 and Windows 95 is available. Please refer to the EdisonCom instruction manual for more information. A separate Modbus communication reference manual is available. Request reference bulletin R150-05-3.

21. DIGITAL AND TIME SYNCHRONIZATION INPUTS

21.1 THREE OPTOISOLATED DIGITAL INPUTS ARE AVAILABLE:

Open circuit voltage at relevant terminals (1-2, 1-3, 1-14) is 15V dc. Internal resistance is 2.2kΩ.

The inputs are activated when relevant terminals are shorted (external resistance < 2kΩ)

- BI (terminals 1-3): This blocks the operation of the selected time delayed elements and the operation of the Reclose function (see Section 11.4)

For the protection functions, the blocking input prevents the operation of the output relay of the function blocked but not its time delay element. When the blocking input is removed, the output relay will trip instantaneously if the function's trip time delay has already expired or after any remaining time delay.

For the Auto-reclose function, the blocking input makes the reclose lockout LED **H** (Figure 7) pick-up and the reclose function to go into the Locked Status.

When the blocking input is removed, the relay reverts to the normal status after the waiting time **5s**. The presence of a blocking input signal is indicated by the red flashing LED **G** (Figure 7).

- CB (terminals 1-2): This is connected to a normally open auxiliary contact (52a) of the Circuit Breaker, it discriminates Open Status (contact open) or Closed Status (contact closed) of the CB.

This input is used for operation of the auto-reclose functions.

- BIR (terminals 1-14): Another optoisolated input is available for an IRIG-B time Synchronization input from GPS. Accuracy 10ms. Time Synchronization can also be made via serial communication interface (See Section 21.2.1).

21.2 CLOCK AND CALENDAR

The unit features a built in clock calendar with Years, Months, Days, Hours, Minutes, Seconds, Tenths of seconds and Hundredths of seconds.

21.2.1 Clock synchronization.

The clock can be synchronised via the IRIG-B digital input (terminals 1 – 14) or the serial communication interface.
By programming the variable (T_{syn} = 5', 10', 15', 30', 60', IRGI-B, Dis) Synchronisation can be achieved in several different manners:

a)	T_{syn} = Dis:	The current date can only be modified manually either via the front panel keyboard (SETTING MENU) or via the serial communication interface (programming mode).
b)	T_{syn} = IRIG-B:	The date is automatically updated by the IRIG-B input signal.
c)	T_{syn} = 5', 10', 15', 30', 60':	The date is updated via the serial interface as follows :

The unit expects to receive a sync signal at the beginning of every hour and once every T_{syn} minutes. When a sync signal is received, the clock is automatically set to the nearest expected synchronisation time.
For example: if T_{syn} is 10min and a sync signal is received at 20:03:10 January the 10^{th}, 98, then the clock is set to 20:00:00 January the 10^{th}, 1998. On the other hand, if the same sync signal were received at 20:06:34, the clock would be set to 20:10:00, January the 10^{th} 98.
Note that if a sync signal is received exactly in the middle of a T_{syn} period, the clock is set to the previous expected synchronisation time.

21.2.2 Date and time setting

When the PROG/SETTINGS menu is entered, the current date is displayed with one of the groups of digits (YY, MMM or DD) blinking.

The DOWN key operates as a cursor. It moves through the groups of digits in the sequence

YY => MMM => DD => YY => …

The UP key allows the user to modify the currently blinking group of digits.

If the ENTER button is pressed the currently displayed date is captured.

Pressing the SELECT button leaves the current date unchanged and scrolls the SETTINGS menu. Current time can now be modified using the same procedure described above.

If synchronization is enabled and the date (or time) is modified, the clock is stopped until a sync signal is received (via digital input or the serial port). This allows the user to manually set many units and have them start their clocks in a synchronized fashion.

If synchronization is disabled the clock continues to run.

Note that the setting of a new time always clears 10ths and 100ths of sec.

21.2.3 Time resolution

The clock has a 10ms resolution. This means that any event can be time-stamped with a 10ms resolution, although the information concerning 10ths and 100ths of sec. can be accessed only via the serial communication interface.

22. TEST

Besides the normal "WATCHDOG" and "POWERFAIL" functions, a comprehensive program of self-test and self-diagnostic provides:

Diagnostic and functional test: This checks the program routines and the memory's content. This runs every time the auxiliary power is switched-on. The display shows the type of relay and its version Number.

Dynamic functional test: This runs during the normal operation of the relay every 15 min. The relay is disabled for less than 10 ms. If an internal fault is detected, the display shows a fault message, the LED "**PROG/IRF**" illuminates and the relay R5 is de-energized.

Complete test: This may be activated by the keyboard or via the communication bus either with or without tripping of the output relays. The output relay assigned to reclosing is not energized during this test.

23. RUNNING THE TEST PROGRAMS

23.1 MODE "TESTPROG" SUBPROGRAM "W/O TRIP"

Operation of the yellow key activates a complete test of the electronics and the process routines.

All the LEDs are lit and the display shows (TEST RUN).

If the test routine is successfully completed, the display switches-over to the default reading (xx:xx:xx).

If an internal fault is detected, the display shows the fault identification code and the relay R5 is de-energized. This test can be carried-out even during the operation of the relay without affecting the relay tripping in the event that a fault occurs during the test itself.

23.2 MODE "TESTPROG" SUBPROGRAM "WITHTRIP"

Access to this program is enabled only if the current detected is zero (breaker open).

After pressing the yellow key, the display shows "TEST RUN?". A second operation of the yellow key starts a complete test, which includes the activation of all of the output relays.

The display shows (TEST RUN) with the same procedure as for the test with W/O TRIP.

Every 15 minutes during the normal operation, the relay automatically initiates an auto test procedure (duration ≤ 10ms). If an internal fault is detected during the auto test, the relay R5 is de-energized, and he relevant LED is activated with the applicable fault code displayed.

⚠ CAUTION

Running the **LED+TRIP** test will operate <u>all</u> of the output relays. Care must be taken to ensure that no unexpected or harmful equipment operations will occur as a result of running this test. It is generally recommended that this test be run only when all dangerous output connections are removed.

24. SPECIFICATIONS

Operating Temperature Range .... -20 to +60°C at 95% humidity
Storage Temperature .... -30 to +80°C
Rated input Current .... In=1 or 5A, On=1 or 5A
Rated Input Voltage 125V
Current Overload .... 200A for 1 sec; 10A continuous
Voltage Circuits Overload .... 2.0 pu rated voltage, Continuous
Burden on current inputs .... Phase: 0.01 VA at In=1A; 0.2VA at In=5A
Burden on Voltage Inputs .... 0.08 VA at rated voltage
Dielectric test Voltage .... 2000V, 50/60Hz, 1 minute
Impulse Test Voltage .... 5 kV common mode, 1 kV differential mode, 1.2 x 50 µsec.
Immunity to high frequency burst .... 1 kV common mode, 0.5 kV differential mode at 100 kHz,
.... 2.5 kV common mode, 1 kV differential mode at 1 MHz
Immunity to electrostatic discharge .... 15 kV
Immunity to sinusoidal wave burst .... 100V over 10 - 1000kHz range
Immunity to radiated electromagnetic field .... 10V/m over 20 - 1000MHz range
Immunity to high energy burst .... 4 kV common mode, 2V differential mode
Immunity to pulse magnetic field .... 1000 A/m, 8 x 20 seconds
Immunity to magnetic burst .... 100 A/m over 100 - 1000kHz range
Resistance to vibration .... 1g from 10 -500 Hz
Rear Connection Terminals .... Up to 12AWG ($4mm^2$) stranded wire
.... Lugs up to 0.25 inch (6.5mm) wide
Output Contacts .... rated current 5 A
.... rated voltage 380 V
.... nominal switching power with AC resistive load 1100W(380V max.)
.... breaking capacity at 110 VDC: 0.3A with L/R=40ms for 100,000 operations
.... make and carry capacity for 0.5 sec = 30 A (peak)
.... mechanical life over 2,000,000 (2×10^6) operations
PC Board Connectors .... Gold plated, 10A continuous, 200A 1 sec.
Power Supply Input Voltage Range: .... Two Available at 24 - 110 V AC-DC ± 20%
.... or 90 – 220 V AC-DC; ± Ave 20%
Average Power Supply consumption .... 8.5 VA
Weight (in single relay case) 2.3kg (5.0lbs)

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Variable	Factory default	Units	Description	Range	Step	Setting
xxxxxxx	DDMM MYY	---	Current Date			
xx:xx:xx	HH:M M:SS	---	Current Time			
Fn	60	Hz	System frequency	50 or 60 Hz	---	
In	500	Primary Amps	Rated primary current of the phase CTs.	1 to 9999 in 1A steps	1.0	
0n	500	Primary Amps	Rated primary current of the CTs or the window CT used for supplying the zero sequence input current.	1 to 9999	1.0	
F(I>)	D	None	Operating characteristic of the low set (time overcurrent) phase overcurrent element.	D, A, B, C, MI, SI, VI, I, EI	---	
I>	1.0	Per unit	Tap (or pickup level) of the low set phase overcurrent element in per unit of the phase CT’s rated current.	Dis, or 0.5 to 4.0	0.01	
tI>	2.0	Seconds	Definite time mode: Trip time delay of the low-set phase overcurrent element Inverse time mode: Time delay at 10 times pickup	0.05 – 30.0	0.01	
I>>	2.0	Per unit	Pickup level of the high set phase overcurrent element in per unit of the phase CT’s rated current.	Dis, or 0.5 to 40	0.1	
tI>>	1.0	seconds	Time delay in seconds of the high set phase overcurrent element.	0.05 to 3	0.01	
2I>>	ON	---	Automatic Cold Load pick-up	ON or OFF	---	
Uo>	10	Volts	Enabling voltage threshold for the zero sequence polarizing element.	2 to 25 V	1.0	
Fα	Dir	None	Directional operation mode of the ground overcurrent elements.	Dir, Sup, Dis	---	
α=	90º	Degrees	Maximum torque angle of the ground overcurrent current elements.	Dis, or 0º to 359º	1.0	
F(0>)	D	---	Operating characteristic of the low set (time overcurrent) ground overcurrent element.	Same curve selections as for F(I>).	---	

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Variable	Factory default	Units	Description	Range	Step	Setting
0>	0.1	Per unit	Tap (pickup level) of the low set ground overcurrent element in per unit of the zero sequence sensing CT's rated current.	Dis, or 0.02 to 0.4	0.01	
t0>	4.0	Seconds	Definite time mode: Trip time delay of the low-set ground overcurrent element Inverse time mode: Time delay at 10 times pickup	0.05 - 30.00	0.01	
0>>	0.5	Per unit	Tap (pickup level) of the high set ground element in per unit of the zero sequence sensing CT's rated current.	Dis, or 0.02 to 1.00	0.01	
t0>>	3.0	Seconds	Time delay in seconds of the high set ground overcurrent element.	0.05 to 3.0	0.01	
F(I_2)	D	None	Operating characteristic of the negative sequence low set overcurrent element.	D, A,B,C,MI, SI, VI, I, EI	---	
I_2	0.6	Per unit	Tap (or pickup level) of the low set negative sequence overcurrent element in per unit of the phase CT's rated current.	Dis, or 0.5 to 4.0	0.01	
tI_2	2.0	Seconds	Definite time mode: Trip time delay of the low-set ground overcurrent element Inverse time mode: Time delay at 10 times pickup	0.05 to 3.0	0.01	
1C	--I-O	---	Selection of the function(s) enabled to initiate the first reclosing	N i I o O	---	
2C	-i-oO	---	As above for the second reclosing shot 2C	N i I o O	---	
3C	---oO	---	As above for the third reclosing shot 3C	N i I o O	---	
4C	--I-O	---	As above for the fourth reclosing shot 4C	N i I o O	---	
t1C	2.0	Seconds	Reclosing time interval of the first reclosing shot	0.1 to 1800	0.1	
t2C	4.0	Seconds	Reclosing time interval of the second reclosing shot	0.1 to 1800	0.1	
t3C	6.0	Seconds	Reclosing time interval of the third reclosing shot	0.1 to 1800	0.1	

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Variable	Factory default	Units	Description	Range	Step	Setting
t4C	8.0	Seconds	Reclosing time interval of the fourth reclosing shot	0.1 to 1800	0.1	
tr	8	Seconds	Reset interval after any successful reclosure	1 to 1200	1.0	
LO#	3	---	Specifies the number of reclosing shots to Lock-out	1 – 2 – 3 – 4	---	
ChSet	2	---	Change Setting. This determines when the relay automatically changes from setting group 1 to setting group 2 (not vice versa)	1-2-3-4-Dis	---	
SEQ C	OFF	---	Sequence coordination with downstream recloser	ON or OFF	---	
tBF	0.25	Seconds	Time delay for Breaker Failure alarm	0.05 to 0.25	0.01	
B→I>	OFF	---	Blocking Input at terminals 1 to 3, blocks the timed output of the function I>	ON or OFF	---	
B→I>>	OFF	---	Same as above, for function I>>	ON or OFF	---	
B→O>	OFF	---	Same as above, for function O>	ON or OFF	---	
B→O>>	OFF	---	Same as above, for function O>>	ON or OFF	---	
B→I_2>	OFF	---	Same as above, for function I_2>	ON or OFF	---	
B→Rcl	OFF	---	Blocking Input at terminals 1 to 3, blocks the reclose function	ON or OFF	---	
Tsyn	IRIG	Minutes	Synchronized Time Signal: The expected time interval between synchronization pulses. Setting it to IRIG-B sets the relay up to receive IRIG-B time signals. "Dis" disables the time synch.	5, 10, 15, 30 or 60 minutes or IRIG-B or Dis	---	
NodAd	1	---	Modbus communication Address.	1 to 250	1	

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OUTPUT RELAY PROGRAMMING ASSIGNMENTS (ACCESSIBLE VIA THE F→Relay PROGRAM MODE.)					
Variable	**Factory default**	**Units**	**Description**	**Range**	**Setting**
I>	- - - -	Outputs	Pick-up (or start-time) element associated with the low set phase overcurrent element.	1 2 3 4	
tI>	1 - - -	Outputs	Time delayed element associated with the low set phase overcurrent element.	1 2 3 4	
I>>	- - - -	Outputs	Pick-up element associated with the high set phase overcurrent element.	1 2 3 4	
tI>>	- 2 - -	Outputs	Time delayed element associated with the high set phase overcurrent element.	1 2 3 4	
0>	- - - -	Outputs	Pick-up element associated with the low set ground overcurrent element.	1 2 3 4	
t0>	1 - - -	Outputs	Time delayed element associated with the low set ground overcurrent element.	1 2 3 4	
0>>	- - - -	Outputs	Pick-up element associated with the high set ground overcurrent element.	1 2 3 4	
t0>>	- 2 - -	Outputs	Time delayed element associated with the high set ground overcurrent element.	1 2 3 4	
I_2	- - - -	Outputs	Pick-up element associated with the low set negative sequence overcurrent element.	1 2 3 4	
tI_2	1 - - -	Outputs	Time delayed element associated with the low set negative sequence overcurrent element.	1 2 3 4	
C	- - - 4	Outputs	Reclosure	1 2 3 4	
rLO	- - 3 -	Outputs	Reclose Lock-out status	1 2 3 4	
tBF	- - - -	Outputs	Breaker failure alarm	1 2 3 4	
BT	- - - -	Outputs	Breaker Trip relay	1 2 3 4	
tFRes	A	---	Reset mode for time delay elements. If “A” then reset takes place automatically when the current drops below the pick-up value. When set to “M”, reset is only possible via the front panel ENTER/RESET key.	A, M	

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