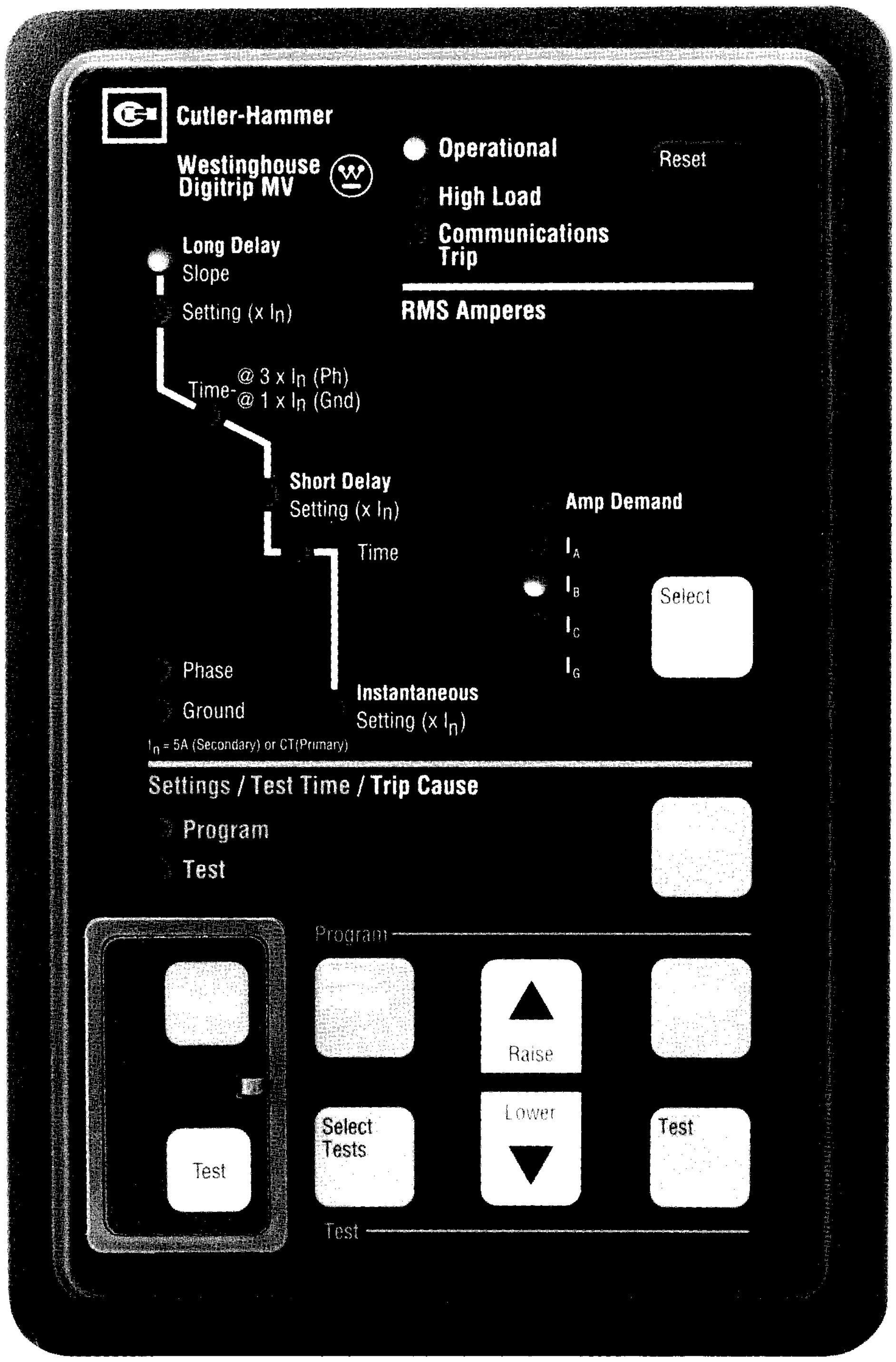
Instructions for Installation, Operation and Maintenance of Westinghouse **Digitrip** MV Trip Units



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SECTION 1: INTRODUCTION

1-1 PRELIMINARY COMMENTS AND SAFETY PRECAUTIONS

This technical document is intended to cover most aspects associated with the installation, application, operation and maintenance of the Westinghouse Digitrip Medium Voltage (MV)Trip Unit. This document is provided as a guide for authorized and qualified personnel only in the selection and application of Digitrip MV Trip Units. Please refer to the specific WARNING and CAUTION in Section 1-1.2 before proceeding. If further information is required by the purchaser regarding a particular installation, application or maintenance activity, a Cutler-Hammer representative should be contacted.

1-1.1 WARRANTY AND LIABILITY INFORMATION

NO WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE OF MERCHANTABILITY, OR WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE, ARE MADE REGARDING THE INFORMATION, RECOMMENDATIONS AND DESCRIPTIONS CONTAINED HEREIN. In no event will Cutler-Hammer be responsible to the purchaser or user in contract, in tort (including negligence), strict liability or otherwise for any special, indirect, incidental or consequential damage or loss whatsoever, including but not limited to damage or loss of use of equipment, plant or power system, cost of capital, loss of power, additional expenses in the use of existing power facilities, or claims against the purchaser or user by its customers resulting from the use of the information and descriptions contained herein.

1-1.2 SAFETY PRECAUTIONS

All safety codes, safety standards and/or regulations must be strictly observed in the installation, operation and maintenance of this device.

WARNING

THE WARNINGS AND CAUTIONS INCLUDED AS PART OF THE PROCEDURAL STEPS IN THIS DOCUMENT ARE FOR PERSONNEL SAFETY AND PROTECTION OF EQUIPMENT FROM DAMAGE. AN EXAMPLE OF A TYPICAL WARNING LABEL HEADING IS SHOWN ABOVE TO FAMILIARIZE PERSONNEL WITH THE STYLE OF PRESENTATION. THIS WILL HELP TO INSURE THAT PERSONNEL ARE ALERT TO WARNINGS, WHICH MAY APPEAR THROUGHOUT THE DOCUMENT. IN ADDITION, CAUTIONS ARE ALL UPPER CASE AND BOLDFACE.

CAUTION

COMPLETELY READ AND UNDERSTAND THE MATERIAL PRESENTED IN THIS DOCUMENT BEFORE ATTEMPTING INSTALLATION, OPERATION OR APPLICATION OF THE EQUIPMENT. IN ADDITION, ONLY QUALIFIED PERSONS SHOULD BE PERMITTED TO PERFORM ANY WORK ASSOCIATED WITH THE EQUIPMENT. ANY WIRING INSTRUCTIONS PRESENTED IN THIS DOCUMENT MUST BE FOLLOWED PRECISELY. FAILURE TO DO SO COULD CAUSE PERMANENT EQUIPMENT DAMAGE.

1-2 GENERAL INFORMATION

The Digitrip MV Trip Unit is a panel mounted multi-function, micro-processor based overcurrent trip unit, designed for both ANSI and IEC applications (Figure 1-1). It is a self-contained device which operates from either AC or DC control power, and provides true RMS sensing of each phase and ground current. Only one trip unit is required per three-phase circuit. Current monitoring and operator selectable protective functions are integral to each device.

CAUTION

THE LOSS OF CONTROL VOLTAGE WILL CAUSE THE DIGITRIP MV TO BE INOPERATIVE. IF AC CONTROL VOLTAGE IS USED, AN APPROPRIATE RELIABLE POWER SOURCE/SCHEME SHOULD BE SELECTED (POSSIBLY A UPS SYSTEM) TO SUPPLY POWER TO THE TRIP UNIT.

Two styles are available, both offering the same features and functions, except for the communication capability. One style includes a built-in INCOM communication capability compatible with the Westinghouse IMPACC system. The other style provides for a future add-on communication capability via a field installed communication module, such as an INCOM PONI module or a RS-232 module (Figure 1-2).

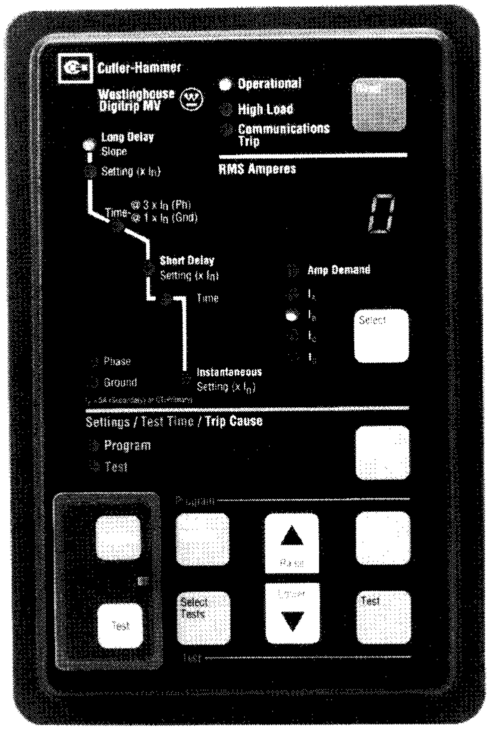


Figure 1-1 *Digitrip MV Trip Unit (Front View)*

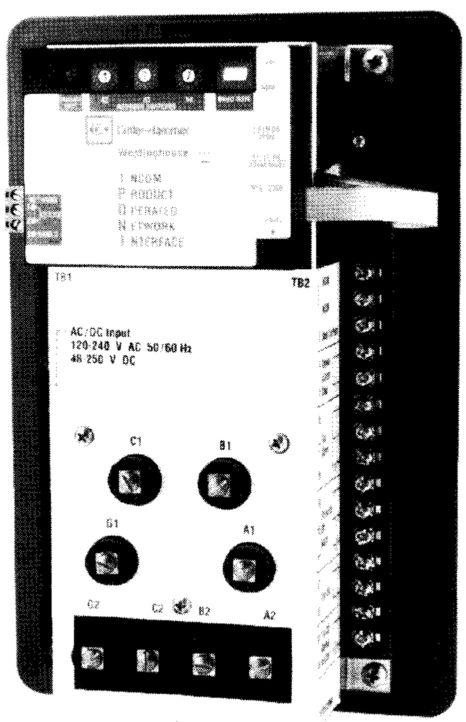


Figure 1-2 *Digitrip MV Trip Unit with Installed INCOM PONI Module (Rear View)*

The Digitrip MV Trip Unit provides protection for most types of medium voltage electrical power distribution systems. It was designed for use with Westinghouse Type VCP-W vacuum circuit breakers, as well as other manufacturers' medium and high voltage circuit breakers (Figure 1-3). Digitrip MV Trip Units are compatible for use with all circuit breakers utilizing a shunt trip coil. Protection curves are similar to those on low voltage power circuit breaker trip units, and provide close coordination with both downstream and upstream devices. One Digitrip MV Trip Unit replaces the normal complement of three or four conventional electromagnetic overcurrent relays, an ammeter, a demand ammeter, an ammeter switch, and, in some situations, a lockout relay switch (device 86).

1-3 FUNCTIONS/FEATURES/OPTIONS

The primary function of the Digitrip MV Trip Unit is circuit protection. This is achieved by analyzing the secondary current signals received from the switchgear current transformers. When pre-determined current levels and time delay settings are exceeded, the closing of trip contact(s) is used to initiate breaker tripping.

The Digitrip MV Trip Unit operates from the 5 ampere secondary output of standard switchgear current transformers. It is operator configured to fit specific distribution system requirements. The current transformer ratio information is programmed into the Digitrip MV Trip Unit via DIP switch settings (Table 5.1) made at the back of the trip unit (Figure 1-4).

Protective functions are configured by using the membrane pushbuttons located on the faceplate of the trip unit. For safety and security reasons, programming can only take place when the circuit breaker is open. Additionally, long delay protection for the phase element cannot be disabled. This insures that all phase protection cannot be disabled. The trip unit also automatically exits the program mode, if there is no programming activity for 2-1/2 minutes. Programming and test mode security is provided by a sealable, hinged access cover on the front of the trip unit. Direct reading displays indicate the value currently being considered, while multicolored LEDs indicate operational conditions and specific functions (Figure 1-1).

In addition to performing a continuous self-testing of internal circuitry as a part of normal operation, all Digitrip MV Trip Units include a front accessible, integral field testing capability. In the integral test mode, a test current simulates an overload or short circuit condition, to check that all tripping features are functioning properly. The test function is user selectable to trip or not trip

Figure 1-3 *A Digitrip MV Trip Unit [RHS] Installed on a Metal Assembly Panel*

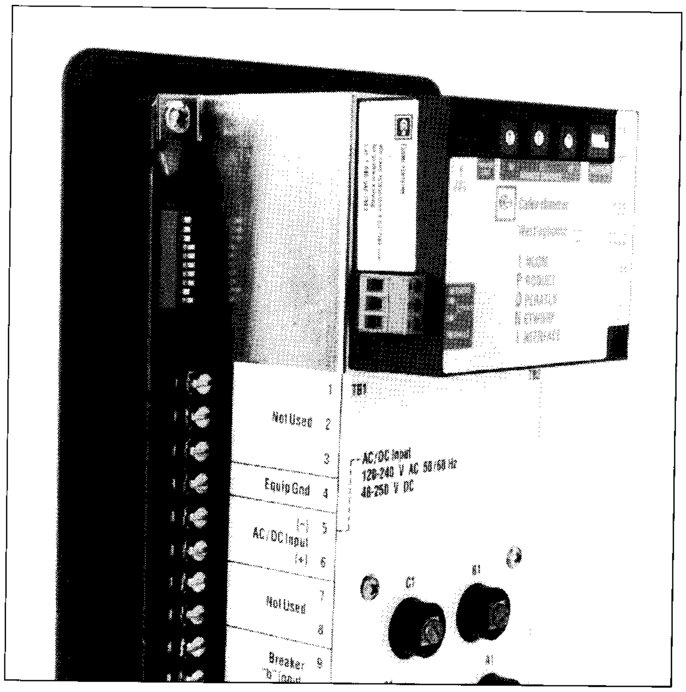


Figure 1-4 *Digitrip MV Trip Unit with DIP Switches Shown in Upper Left (Rear View)*

the breaker. Refer to Paragraph 2-1.5 for additional information.

The Digitrip MV Trip Unit provides five protective functions for both phase and ground protection. The ground element is capable of a residual, an external source ground or a zero sequence connection. If ground protection is not desired, the ground element does not have to be connected.

The five protective functions are:

- Long Delay Setting
- Long Delay Time
- Short Delay Setting
- Short Delay Time
- Instantaneous Setting

Each of the protective functions are independently programmed for various combinations to fit specific system requirements. For protective functions not required, the trip unit will allow all of the protective functions on ground and all but the long delay function on phase to be disabled. When the Digitrip MV Trip Unit does not utilize an instantaneous trip function, a true making current release (discriminator) is available. If not desired, the discriminator can be disabled.

Digitrip MV Trip Units provide circuit breakers with greater selective coordination potential, by permitting curve shaping not previously available in medium voltage applications. For example, the slope of the long time protection curve is selectable to coordinate with existing electromagnetic overcurrent relays and power fuses. Four selectable slopes are available (Figure 1-5):

- It
- I^2t
- I^4t
- Flat

A pictorial representation of a characteristic curve shape is provided on the face of the trip unit for reference purposes (Figure 1-1).

All Digitrip MV Trip Units have zone selective interlocking capabilities for phase and ground fault protection. Zone selective interlocking is a means by which two or more coordinated trip devices can communicate to alter their pre-set tripping modes to provide a faster response

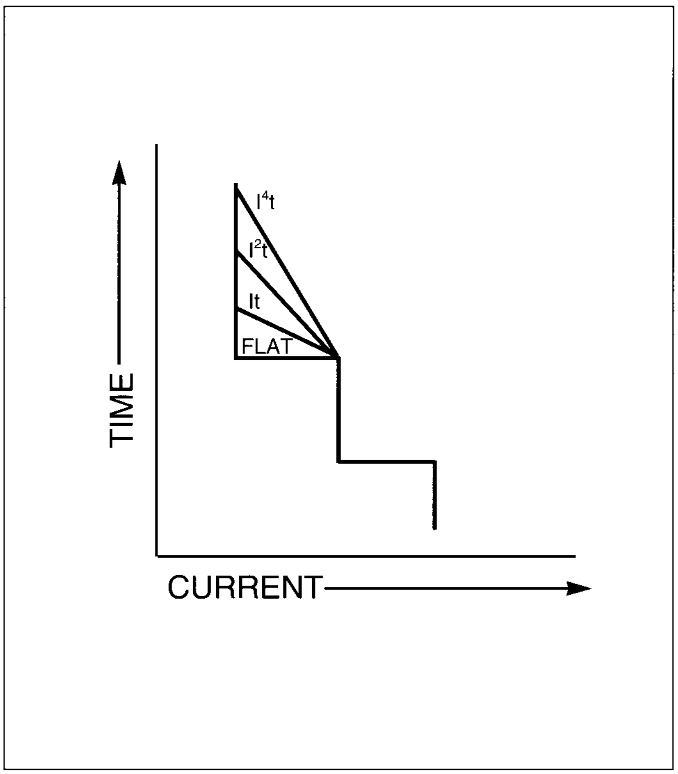


Figure 1-5 *Representative Curve Showing Four Selectable Slopes Available with Digitrip MV*

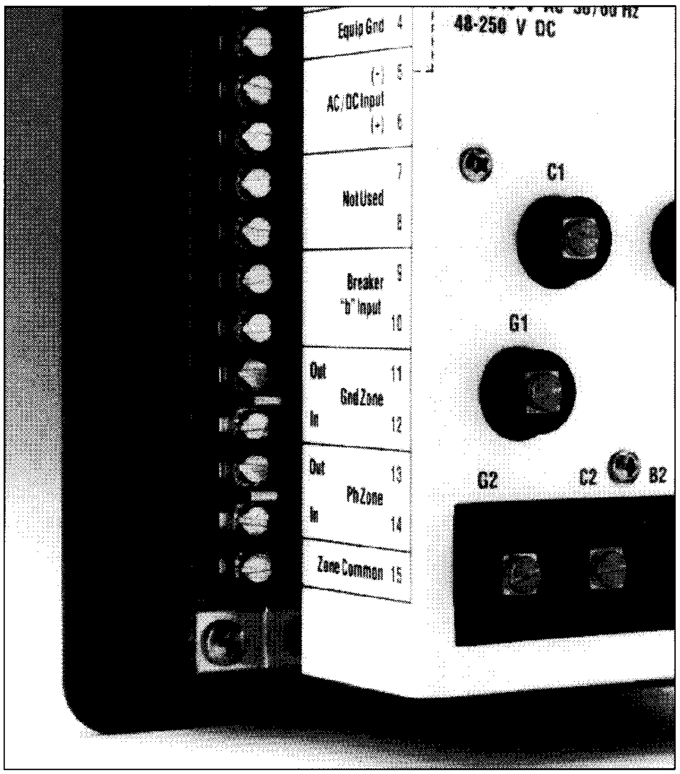


Figure 1-6 *Installed Jumpers in Place on Terminal Block TB-1 Disabling the Zone Interlocking Feature*

for certain upstream fault conditions. The trip unit is shipped with the zone selective interlocking feature disabled by the use of the two jumpers on the rear mounted terminal strip TB1(Figure 1-6).

Digitrip MV Trip Unit operating parameters and troubleshooting information are displayed on the front of the trip unit, via the two display windows. This is considered "ON DEVICE" information. In addition, all trip unit information can be transmitted to a remote location via an optional built-in communication system or external communication means. This type of information is referred to as "COMMUNICATED INFORMATION." In addition to being able to provide a circuit breaker "OPEN" or "CLOSED" status to the remote location, the Digitrip MV trip unit displays and remotely transmits parameters, such as:

- Individual phase currents
- Ground current
- Maximum current for each phase and ground since last reset (Amp. Demand)
- Magnitude and phase of current causing trip
- Cause of trip
- Current transformer ratio
- Existing setpoint settings

The remote communications capability is made possible by the optional Westinghouse developed Integrated Communications (INCOM) Chip and Protocol. The protocol permits a remote master computer to perform:

(1) Interrogation of trip unit data
(2) Implementation of circuit breaker "Close" and"Trip" commands
(3) "Reset" of the trip unit after a trip

Reliable two-way communications can be provided over a twisted pair communications network. The Digitrip MV Trip Unit supplied with a built-in communications capability is compatible with the Westinghouse IMPACC system. Units supplied without a built-in communications capability can have this capability added later. Field installed PONI (Product Operated Network Interface) modules provide this capability and are available in several versions. The three versions are the INCOM PONI, RS-232 PONI and PONI Modem.

1-4 STANDARDS

Digitrip MV Trip Units are "Component Recognized" by the Underwriters Laboratory, Inc.® under UL File E154862.

SECTION 2: FUNCTIONAL DESCRIPTION

2-1 PROTECTION, TESTING AND COMMUNICATION CAPABILITIES

2-1.1 RMS SENSING

Digitrip MV Trip Units are AC current sensing devices employing micro-processor based technology to provide true RMS sensing for proper correlation with the thermal characteristics of conductors and equipment. The root mean square (rms) value is determined by a micro-processor calculation of discrete sampled points of the current waveform. This root mean square value is used for the protection response and metering displays of the trip unit.

2-1.2 PICKUP SETTING

A Digitrip MV Trip Unit pickup setting is a discrete, pres-elected value of current used to initiate a tripping action. Whether the action is immediate or delayed depends upon what protective function (long, short or instantaneous) is being considered. The pickup value is a multiple of (I_n), where (I_n) is the current transformer rating.

Example: CT Rating = I_n = 1200A.
Pickup Setting = 0.95
Pickup (amps) = (1200)(0.95)
= 1140A.

2-1.3 TIME SETTING

A Digitrip MV Trip Unit time setting is a preselected time delay initiated when a pickup point on the long or short curve is exceeded. If the current value drops below the pickup value, the timing function resets. No memory is provided. If the current value does not drop below pickup, the amount of delay before tripping occurs is a function of the current magnitude and the time setting. The delay can be determined from the appropriate time-current curves.

2-1.4 PROTECTION CURVE SETTINGS

Slope Selection: Extensive flexibility on Long Delay (phase and ground) curve shaping is possible with the four available slope settings. The selection is determined by the type of slope that best fits the coordination requirements (Figure 1-5 and Tables 2.1 and 2.2). The same slope settings apply to both phase and ground protection.

Table 2.1 *Slope Selection*

Selection	Result
IT Setting	"Moderately Inverse" Type Curve
I^2T Setting	"Inverse" Type Curve
I^4T Setting	"Extremely Inverse" Type Curve
Flat Setting	"Definite" or "Fixed Time" Curve

Phase Long Delay Pickup Setting: The available pickup settings, shown in Table 2.2, range from 0.2 to 2.2 times (I_n).

Phase Long Delay Time Setting: The available time settings, also shown in Table 2.2, vary depending on the type of slope selected. These settings represent trip unit operating times at a current value equal to 3 times (I_n).

Phase Short Delay Pickup Setting: The available pickup settings, shown in Table 2.2, range from 1 to 11 times (I_n) or NONE. If NONE is selected, the short delay protective function is disabled.

Phase Short Delay Time Setting: The available time settings, shown in Table 2.2, range from 0.05 to 1.5 seconds at currents equal to or above the short delay pickup setting selected. If NONE was selected for the Phase Short Delay Pickup Setting, the trip unit will bypass requesting the time setting.

Phase Instantaneous Setting: The available pickup settings, shown in Table 2.2, range from 1 to 25 times (I_n) or NONE. If NONE is selected, the instantaneous protective function is disabled and a choice of whether to turn the discriminator option on (DON) or off (DOFF) is offered. The discriminator is a true making current release. When the circuit breaker closes, the discriminator function, if selected to be on, is functional in an instantaneous trip mode for 10 cycles after the breaker closes. The breaker will trip instantaneously via the discriminator, if the fault current is above 11 times (I_n). After the 10 cycle period has passed, the discriminator will no longer be functional. It becomes functional again only when the breaker opens and then is reclosed.

Ground Fault Settings: After the phase instantaneous setting is established, the ground long delay pickup, ground long delay time, ground short delay pickup, ground short delay time and ground instantaneous settings are selected. The available settings are shown in Table 2.3. Note that the same curve slope previously

Table 2.2 *Characteristic for Phase Element*

TYPE SETTING	AVAILABLE SETTINGS	TOLERANCE	CURVE #
LONG DELAY SLOPE (Phase slope and ground slope are identical.)	IT, I^2T, I^4T, FLAT		
LONG DELAY	0.20, 0.25, 0.30, 0.35, 0.40, 0.50, 0.55, 0.60, 0.65, 0.70 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.10, 1.20,1.30, 1.40, 1.50, 1.60, 1.70, 1.80, 1.90, 2.00, 2.10, 2.20	± 5%	
LONG DELAY TIME @3 x I_n (Seconds)			
For Flat Slope Setting	0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.25, 1.50, 1.75, 2.00	± 0.05 SEC	FLAT SC 5393-92
For IT, I^2T, I^4T Curves①	0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.25, 1.50, 1.75, 2.00, 2.25, 2.50, 2.75, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 10.0, 12.5 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 35.0, 40.0	±10%② ③	IT SC-5392-92-A I^2T SC-5391-92-A I^4T SC-5390-92-A
SHORT DELAY	1.00, 1.25, 1.50, 1.75, 2.0 2.25, 2.5, 2.75, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 11.0 NONE	± 10%	SC-5394-92
SHORT DELAY TIME (In Seconds)	0.05, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.70, 0.75, 0.80, 0.85, 0.90, 0.95, 1.00, 1.25, 1.50	± 0.05 SEC	SC-5394-92
INSTANTANEOUS	1.0, 1.25, 1.50, 1.75, 2.0, 2.25, 2.50, 2.75, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 7.0, 7.5, 8.0, 8.5, 9.0, 9.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0 NONE	± 10%	SC-5396-92
DISCRIMINATOR/ (If Phase INST set to NONE)	Don Doff Fixed At 11 x I_n	± 10%	

NOTES: ① Curves go flat after 30 x I_n. Minimum time is 0.05 seconds.
② Tolerance: ±10% or ±0.09 seconds whichever is larger.
③ For Phase Pickup ≤ 0.3pu; time tolerance is ±15%.

Table 2.3 *Characteristic for Ground Element* ③ ⑤

TYPE SETTING	AVAILABLE SETTINGS	TOLERANCE	CURVE #
LONG DELAY	0.1, 0.125, 0.15, 0.2, 0.225, 0.275, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.25, 1.5, 1.75, 2.0, NONE	± 5%④	
LONG DELAY TIME @ 1 x I_n (Seconds)			
For Flat Slope Setting	0.2, .0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.60, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.25, 1.5, 1.75, 2.0	±0.05 SEC	FLAT SC-5402-92
For IT, I^2T, I^4T Slope Setting①	0.2, 0.25, 0.3, 0.35, 0.04, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 7.0, 7.5, 8.0, 8.5, 9.0, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, 25.0, 27.5, 30.0, 35.0, 40.0	±10%② ④	IT SC-5401-92-A I^2T SC-5400-92-A I^4T SC-5399-92-A
SHORT DELAY	0.1, 0.125, 0.15, 0.175, 0.20, 0.225, 0.25, 0.275, 0.30, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.80, 0.85, 0.9, 0.95, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, 9.0, 9.5, 10.0, 11.0, NONE	± 10%	SC-4503-92
SHORT DELAY TIME (In Seconds)	0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.50, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.25, 1.5	± 0.05 SEC	SC-5403-92
INSTANTANEOUS	0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0,9, 0.95, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25, 2.5, 2.75, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 8.0, 8.5, 9.0, 10.0, 11.0, NONE	± 10%	SC-5396-92

NOTES: ① Curves go flat after 30 x I_n. Minimum time is 0.05 seconds.
② Tolerance: ± 10% or ± 0.09 seconds whichever is larger.
③ Ground slope same as phase.
④ For Ground Pick-up ≤ 0.2pu: time tolerance is ± 15%.
⑤ I_n = 5A (Secondary). Ground Sensor input can be different than Phase Sensor for Source Ground Scheme.

Table 2.4 *Miscellaneous Settings*

TYPE SETTING	AVAILABLE SETTINGS
HIGHLOAD TIME (pickup fixed @ 0.85 X Phase Long Delay Setting)	0 Sec, 5 Sec, 10 Sec, 30 Sec, 1 min, 2 min, 5 min,
FREQUENCY	50 Hz, 60 Hz
TEST	
Phase	P1, P2, P3, P4, P5, P6, P7, P8, P9, P10, P12, P14, P16 P18, P20, P22, P25
Phase Trip	P3T, P10T, P25T
Ground	G.1, G.2, G.3, G.4, G.5, G.6, G.7, G.8, G.9, G1, G2, G3, G4 G5, G6, G10
Ground Trip	G1T, G3T, G10T

selected for the phase long delay slope also applies to the ground long delay slope.

Programming the ground settings is done in the same manner as the phase settings, except there is no discriminator option for ground instantaneous, and there is a NONE selection for the long delay pickup setting.

High Load Setting: The available high load time-out settings are shown in Table 2.4. At a current 85% or above the long delay phase setting value, the high load function will begin timing to the time setting selected and the High Load LED will blink. If the current drops below the 85% value, the high load timer will reset, and only start again when the 85% value is again reached. When the high load timer times out, the "High Load" LED on the front of the trip unit comes on steady and an alarm signal is sent over the communication network.

System Frequency Selection: The last setting to be programmed via the program panel is the system frequency. Either 60Hz or 50Hz may be selected (Table 2.4).

Default Settings: In the unlikely event of missing or invalid settings, the Operational LED will blink Red instead of Green and the trip unit will default to the following protection settings:

- SLOPE = I^2T
- PHASE LONG DELAY PICKUP = 2.2 (I_n)
- PHASE LONG DELAY TIME = 40 seconds
- PHASE SHORT DELAY PICKUP = 11 (I_n)
- PHASE SHORT DELAY TIME = 1.5 seconds
- PHASE INSTANTANEOUS = 25 (I_n)
- DISCRIMINATOR = OFF
- GROUND LONG DELAY PICKUP = 2.0 (I_n)
- GROUND LONG DELAY TIME = 40 seconds
- GROUND SHORT DELAY PICKUP = 11 (I_n)
- GROUND SHORT DELAY TIME = 1.5 seconds
- GROUND INSTANTANEOUS = 11 (I_n)
- PHASE HIGH LOAD TIME = 5 minutes
- FREQUENCY = 60 Hz

2-1.5 INTEGRAL TESTING

Digitrip MV Trip Units have a front accessible, integral field testing capability. This feature introduces a selected level of internal test current to simulate an overload or short circuit. It checks proper functioning of the trip unit and verifies that curve settings have been set-up correctly. The integral test function provides selectable "Trip" and "No Trip" test settings for both phase and ground testing. Refer to Table 2.4 for available test settings. The "P" used in Table 2.4 refers to a phase current test setting, while the "G" refers to a ground current test setting. "T" in the table means that the test will initiate a breaker trip. All settings are in per unit current values times the In value, which is the selected CT rating.

CAUTION

THE TEST MODE SHOULD NOT BE USED FOR LIVE CURRENT INTERRUPTION. IF A LIVE CURRENT OF GREATER THAN 0.1 TIMES THE (I_n) VALUE IS FLOWING IN EITHER A PHASE OR GROUND CIRCUIT, THE TEST MODE IS AUTOMATICALLY EXITED, ACCOMPANIED BY AN ERROR MESSAGE IN THE SETTINGS/TEST TIME/ TRIP CAUSE WINDOW.

2-1.6 COMMUNICATIONS

An important function of the Digitrip MV Trip Unit is communications and control via the Westinghouse developed Integrated Communications (INCOM) Protocol. It allows the combining of electrical distribution and control products with personal computers into a comprehensive communications and control network.

The Digitrip MV Trip Unit's communications chip permits the interrogation of trip unit data, the implementation of breaker "Close" and "Trip" commands, and the "Reset" of the trip unit after a trip from a remote master computer. Communications is accomplished from the trip unit to the master computer via a 115.2 KHz. frequency carrier signal over a shielded twisted pair of conductors. The receiving terminal is a remote mounted master computer (IBM compatible). Refer to Figure 2-1 for a typical communications wiring diagram.

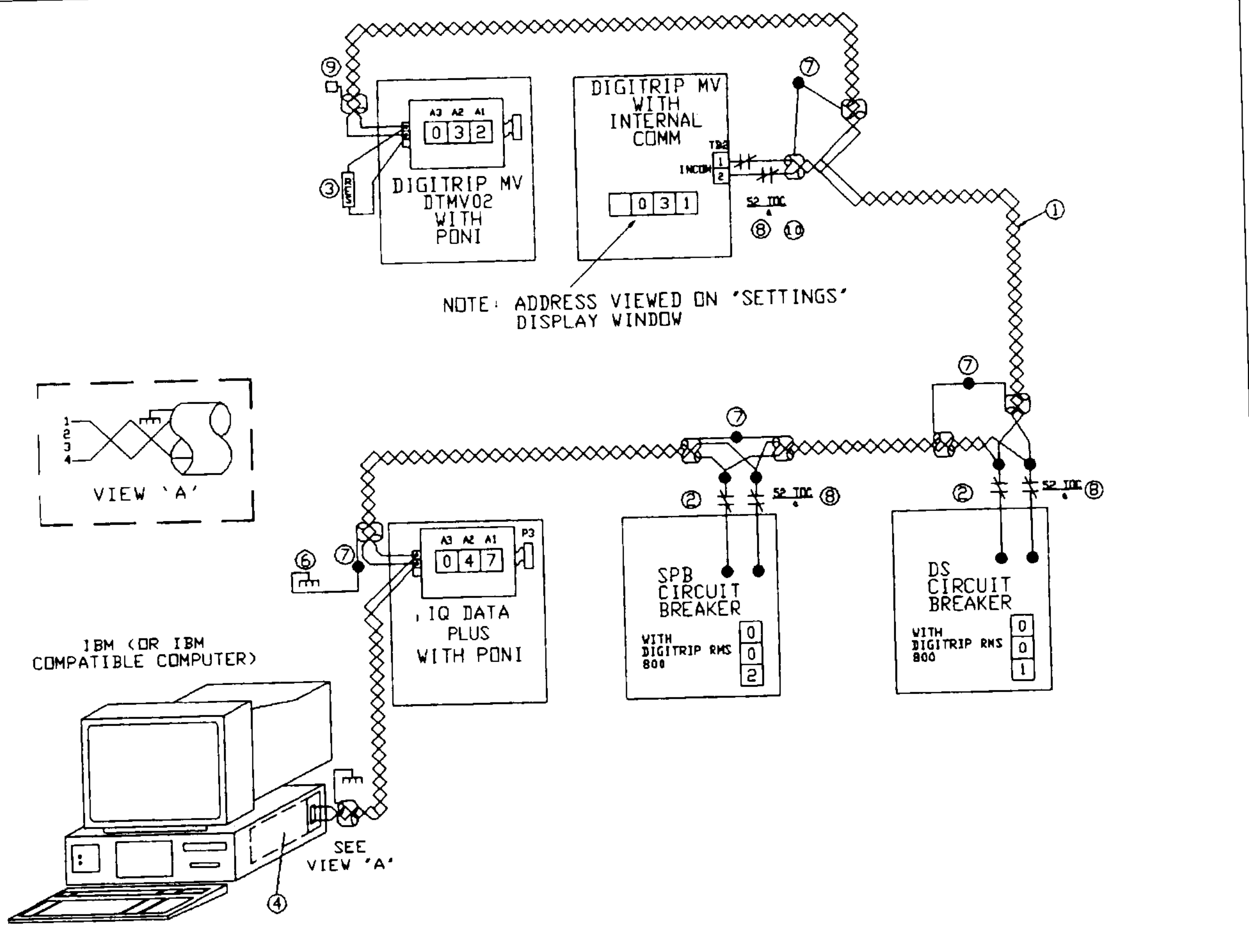
2-2 TRIP UNIT HARDWARE

2-2.1 FRONT OPERATIONS PANEL

The operations panel, which is normally accessible from the outside of the switchgear panel door, provides a means to program, monitor and test the unit (Figure 1-1). For the purpose of familiarization, the panel is divided into three sub-sections:

1. Pushbuttons
2. LEDs
3. Display Windows

Pushbuttons: The front operations panel supports eleven membrane pushbuttons. Pushbuttons are color



① FOR NETWORK INTERCONNECTION CABLE, SEE CABLE SPECIFICATIONS ON FIG. 3-1.

② REFER TO CIRCUIT BREAKER WIRING DIAGRAMS FOR ACTUAL CONNECTIONS.

③ CARBON COMPOSITION RESISTOR **MUST** BE INSTALLED ON THE MOST REMOTE DEVICE AS SHOWN:
- 150 OHM, 1/2 WATT FOR 1200 BAUD RATE COMMUNICATIONS.
- 100 OHM, 1/2 WATT FOR 9600 BAUD RATE COMMUNICATIONS.

④ A WESTINGHOUSE CONI (COMPUTER OPERATED NETWORK INTERFACE) CARD MUST BE INSERTED INTO THE COMPUTER FRAME.

⑤ CUSTOMER TO SUPPLY A COMPUTER AND MODULAR TELEPHONE CONNECTOR TYPE RJ11 AND WIRE PER VIEW A

⑥ GROUND SHIELDING AT ONE PLACE ONLY.

⑦ WHERE DEVICES ARE DAISY CHAINED, TIE SHIELDING TOGETHER FOR CONTINUITY. SOME PRODUCTS WILL PROVIDE AN EXTRA TERMINAL FOR A TIE POINT FOR THE CABLES SHIELD LEAD.

⑧ CIRCUIT BREAKER TRUCK OPERATED CELL TOC SWITCH (SHOWN FOR CIRCUIT BREAKER IN "CONNECTED" POSITION) IS OPTIONAL TO AUTOMATICALLY DISCONNECT TRIP UNIT FROM THE COMMUNICATION NETWORK WHEN CIRCUIT BREAKER IS IN THE "TEST" POSITION.

⑨ ON LAST DEVICE IN NETWORK TIE BACK SHIELD AND TAPE.

⑩ WHEN TOC SWITCH IS USED, DOWN LOADING OF PROTECTION SETTINGS FROM THE COMPUTER WILL NOT BE POSSIBLE WITH BREAKER IN THE "TEST" POSITION.

Figure 2-1 *Typical Communications Wiring Diagram* coded (red, white, blue, yellow) by their function to be operational friendly. For example, blue pushbuttons are associated with actual program functions, yellow pushbuttons with integral testing functions, and white pushbuttons are common to both operations or are independent. White pushbuttons accomplish their function when depressed. They can be held down and not released to accelerate their function. Blue and Yellow pushbuttons accomplish their function after having been pressed and released.

Reset Pushbutton (Red)
The Reset pushbutton is used to reset any of the following: the trip relays (overcurrent and instantaneous), the trip alarm relay, the trip LEDs, and the ampere demand current. Reset applies to both normal operations and integral testing. If the unit is in the auto-reset mode, as set by DIP switch #9 on the back of the unit, the trip relays and the trip alarm relay will automatically reset when the circuit breaker is opened after a trip.

Program Mode Pushbutton (Blue)
The Program Mode pushbutton, which is accessed by opening the sealable, hinged access cover, is used to enter and exit the program mode. When this pushbutton is pressed and released, the program LED flashes and setpoints can be altered. The program mode cannot be entered if the circuit breaker is closed. Any selections made in the program mode are only saved when the Save Settings pushbutton, which is described later, is depressed. When programming is concluded, the Program Mode pushbutton should be pressed to exit the program mode. Note that if the Save Settings pushbutton is not depressed prior to exiting the program mode, the previous settings will be retained. The program mode is also exited if the Reset pushbutton is pressed or if there is no programming activity for approximately 2-1/2 minutes.

Note: *Each Digitrip MV Trip Unit is shipped from the factory with nominal protection settings. The trip unit should be programmed by the user before being put into service, as these nominal values may not give optimum system protection or coordination. Remove tag from security door to access the "Program Mode" pushbutton.*

Test Mode Pushbutton (Yellow)
Also located behind the sealable hinged access cover is the Test Mode pushbutton. This pushbutton is used to enter and exit the test mode. When the pushbutton is pressed and released, the word TEST will appear in the Settings/Test Time/Trip Cause display window. If there is more than 0.1 times (I_n) current flowing in either the phase or the ground circuit, the Test Mode cannot be initiated and the error message "ERR" will appear in the display window. The test mode will also automatically be exited if there is no activity for 2-1/2 minutes.

Select Test Pushbutton (Yellow)
The Select Test pushbutton is used, after the test mode has been entered, to select the type of test. There are phase and ground tests to trip or not trip the breaker. (See Section 3-3).

Test Pushbutton (Yellow)
The selected test operation is initiated by pressing and releasing the Test pushbutton.

Select Settings Pushbutton (Blue)
In the program mode of operation, the Select Settings pushbutton is used to step to the next setpoint by pressing and releasing the pushbutton. This pushbutton steps forward. To step back, the Select Settings pushbutton can be pressed and held, while pressing and releasing the Lower pushbutton.

Raise/Lower Pushbutton (White)
The Raise and Lower pushbuttons are used during the program and test modes to increase or decrease the value of the displayed setpoint. The Lower pushbutton also serves a dual function in conjunction with the Select Settings pushbutton, as described under Select Settings Pushbutton.

Save Settings Pushbutton (Blue)
While in the program mode, selected setpoints can be saved by depressing and releasing the Save Settings pushbutton. Settings can be saved individually or one time as a group. If the Save Settings pushbutton is not used, the previous setpoints will remain when the program mode is exited.

View Settings Pushbutton (Blue)
The View Settings pushbutton is functional only when the unit is in the normal operating mode, not the program or test modes. It functions to display the unit's setpoints, including the phase and ground current transformer ratio selected by the DIP switch setting.

Select Pushbutton (White)
The Select pushbutton is used to step between any of the eight current values that are displayed in the RMS Amperes window. The eight currents are IA, IB, IC, IG, IA ampere demand, IB ampere demand, IC ampere demand, and IG ampere demand. Stepping with this pushbutton is in the sequence just given. The currents displayed are the present RMS values; the ampere demand currents are the averaged RMS values sensed over a 10 minute period of time. The largest of these values is displayed.

LEDs: LEDs are used to indicate a number of functions, operations and/or warnings. Many of the LEDs used provide different indication messages. The specific message is determined by the color and a constant on or blinking operation. Several of the LEDs are bi-colored and can be lit green or red.

Operational LED
The Operational LED at the top of the trip unit should be green and blink on for approximately one second and then off for one second. This indicates that the trip unit is functioning properly in its normal operation mode. If this LED is blinking red, it indicates the trip unit may need reprogramming. If this LED is lit in any color shade other than a definite green or red, or if it is not blinking at all, an internal problem has been detected requiring replacement of the trip unit.

High Load LED
The High Load LED will blink green when high load settings are being selected in the program mode. In the operational or test modes, the High Load LED will blink red when a load current of 85% or above the long delay phase pick-up setting is reached. If the load current remains at 85% or above the long delay phase pickup setting for the time interval setting, the LED will change to steady red at the end of the time interval. Whenever the load current drops below the 85% level, the timer will reset and the LED will turn off.

Communication Trip LED
This LED, will be continuous red when the breaker has been tripped by the master computer via INCOM. The LED will turn off when the Reset pushbutton is pressed or the circuit breaker is reclosed

Long Delay Slope LED
This LED will blink green when the slope setpoint is displayed in the Settings/Test Time/Trip Cause window while in the program mode. When the slope setpoint is being viewed in the unit's normal operating mode, this LED will be a continuous green.

Long Delay Setting LED
This LED is bi-colored. While in the program mode, the LED will blink green when the long delay pickup setpoint is displayed in the Settings/Test Time/Trip Cause window. It will be a continuous green when the long delay pickup setpoint is being viewed in the unit's normal operating mode. The LED will blink red whenever the load current exceeds the long delay pickup setpoint. If the trip unit trips on long delay, the LED will be continuous red.

Long Delay Time LED
This LED will blink green when the LED long delay time setpoint is displayed in the Settings/Test Time/Trip Cause window while in the program mode. When the long delay time setting is being viewed in the unit's normal operating mode, the LED is continuous green.

Short Delay Setting LED
This LED is bi-colored and operates like the long delay setting LED.

Short Delay Time LED
The short delay time LED, when lit is green, and operates like the long delay time LED.

Instantaneous LED
This LED is bi-colored and operates like the long delay setting LED.

Phase LED
The phase LED is bi-colored. The LED will blink green when the phase long delay setting, long delay time, short delay setting, short delay time, and instantaneous setpoints are displayed in the Settings/Test Time/Trip Cause window while in the program mode. When these setpoints are viewed in the normal operating mode, this LED will be continuous green.

The LED will blink red, along with the long delay setting LED whenever the phase load current exceeds the long delay pickup setpoint.

The LED will be continuous red, whenever a trip is initiated by the phase long delay, short delay, or instantaneous protective functions.

Ground LED
The ground LED is also bi-colored (green/red). The ground LED operates exactly like the phase LED for all ground associated functions.

Amp Demand LED
This LED will be continuous green when an ampere demand current is being viewed in the RMS Amperes window.

I_A, I_B, I_C, I_G LEDs
The specific phase or ground current LEDs will be continuous green when that phase or ground current is being displayed in the RMS Amperes window. When the Amp Demand LED is also lit, the displayed current is the Ampere Demand Current.

Program LED
This LED is continuous green when the trip unit is in the program mode.

Test LED
This LED is continuous green when the trip unit is in the test mode.

Display Windows: Two windows are used to display all of the trip unit's data, setpoints and messages. One window is located in the upper portion of the trip unit's faceplate and is labeled RMS Amperes. A second window is located in the lower portion of the faceplate adjacent to the program and test LEDs. It is labeled Settings/Test Time/Trip Cause.

RMS Amperes Window

This window has a five digit numeric display. It is used to show:

1. Present phase or ground currents
2. Largest phase or ground demand currents since last reset
3. Fault current (displayed after a trip until a reset action is initiated)
4. Phase and ground current transformer CT setting (when "View Settings" pushbutton is used with the trip unit in the normal operating mode)

Settings/Test Time/Trip Cause Window

This window is a four character Trip Cause Window alphanumeric display used to show the value of the setpoints, the test time, or the cause of trip.

2-2.2 REAR ACCESS PANEL

The rear access panel of the Digitrip MV Trip Unit is normally accessible from the rear of an open panel door (Figure 1-2). All wiring connections to the Digitrip MV Trip Unit are made at the chassis' rear. For the sake of uniform identification, the frame of reference when discussing the rear access panel is facing the back of the trip unit with the panel door open. The DIP switches, for example, are located on the upper left of the rear panel (Figure 1-4). Review Figure 2-2 and become familiar with the functions and connections involved, especially the following:

DIP Switches: A set of ten DIP switches are located in the upper left portion of the rear panel. Their basic functions are as follows:

1. Switches S1 through S5 are used to set the phase current transformer ratings.
2. Switches S6 and S7 are used to set the ground current transformer ratings.
3. Switch S8 is used to enable/disable the ability to download setpoints from the communication interface (host computer).
4. Switch S9 is used to select whether the trip unit should be self-reset or manually reset (lock out function). For additional details refer to the following paragraphs entitled "Manual Reset" and "Auto Reset."
5. Switch S10 is a spare.

Manual Reset: (DIP Switch S9 OFF) In this mode the Trip Instantaneous contact (TB2 12 and 13), Trip Overcurrent contact (TB2 14 and 15) and the Trip Alarm contact (TB2 6, 7 and 8) change state after a protection trip operation. The contacts stay in that state until the "Reset" Pushbutton is depressed. In addition, the front panel will hold the cause of trip in the "Trip Cause" window and the fault current magnitude in the "RMS Ampere" window until the "Reset" pushbutton is depressed. On trip units with communication capability, a RESET COMMAND can be sent to the Digitrip MV Trip Unit by a master computer to remotely reset the Digitrip MV Trip Unit.

Auto Reset: (DIP Switch S9 ON) In this mode the Trip Instantaneous contacts (TB2 12 and 13) or Trip Overcurrent contacts (TB2 14 and 15) are momentarily closed after a protection trip operation. The contacts will remain closed until the breaker's 52b auxiliary switch contact closes. The Trip Alarm Relay, however, remains energized until the "Reset" Pushbutton is depressed or a RESET COMMAND is received from a communication system master. In this mode after a trip is initiated and the breaker has opened, the display will BLINK the cause of the trip in the "Trip Cause" window and the "RMS Ampere" window will show the fault current magnitude. Both displays clear when the circuit breaker is reclosed.

Communication Port: A communication port located in the upper right portion of the rear panel is designed to connect with an optional Communication Module (PONI Card) for the remote communications option. This port is functional for Catalog Number DTMV02 style only, which does not have a built-in communication capability.

Communicating LED: A red LED just above terminal block (TB2) is used in conjunction with the Digitrip MV Trip Unit that is factory supplied with an internal communications capability (Catalog Number DTMV01). The LED strobes red when the trip unit is communicating. If the trip unit is the type designed to accept field installation of a communication module at a later date, this LED is not functional at any time.

Terminal Block One (TB1): TB1 is located on the left side of the rear panel, and is numbered 1 through 15, with 1, 2, 3, 7 and 8 not used.

Terminals 5 and 6 are provided for the AC or DC input control power connections and Terminal 4 is the connection for equipment ground.

Terminal 9 and 10 provide for connection to a required dry "52b" contact and to a 52 TOC contact from the circuit breaker. **Note that when the trip unit has input control power, Terminals 9 and 10 will have this potential on them.**

Terminals 11 and 12 are used for ground zone interlocking, long delay protection and short delay protection. The zone interlocking function is a low level DC signal used to coordinate with "downstream" and "up-stream" breakers that see or do not see the fault. If the function is not used but a long delay or short delay time is desired, the two terminals should stay jumpered as they were when shipped from the factory.

Terminals 13 and 14 are used for phase zone interlocking, long delay protection and short delay protection.

Terminal 15 is the zone signal common.

Refer to Figure 4-2 for a typical phase zone interlocking/wiring scheme.

Note: *Digitrip MV Trip Units are shipped with a phase zone interlocking jumper (across terminals TB1-13 and 14) and a ground zone interlocking jumper (across terminals TB1-11 and 12). For phase or ground zone capability, the respective jumpers must be removed.*

Terminal Block Two (TB2): TB2 is located on the right side of the rear panel and is numbered 1 through 15. Terminals 1 and 2 are only active on the Digitrip MV that is factory supplied with internal communication capability (Catalog Number DTMV01), and are used for the internal INCOM communications interface. Terminal 3 can be used for an INCOM shield tie point. It is not connected to ground or any electrical circuit in the Digitrip MV. Terminals 4 and 5 are a N.O. contact from an output relay and are wired in to the circuit breaker close circuit, if a communication interface is present and it is desired to be able to close the circuit breaker from the remote master computer.

Terminals 6, 7 and 8 are Form "C" contacts on the trip alarm relay and change state whenever any protective trip is initiated by the trip unit. They do not change state when the master computer initiates an opening of the circuit breaker via the communication interface. After a protective trip, the contacts remain in the changed state until the "Reset" Pushbutton is depressed, whether the trip unit is in the Manual Reset Mode or the Auto Reset Mode. For

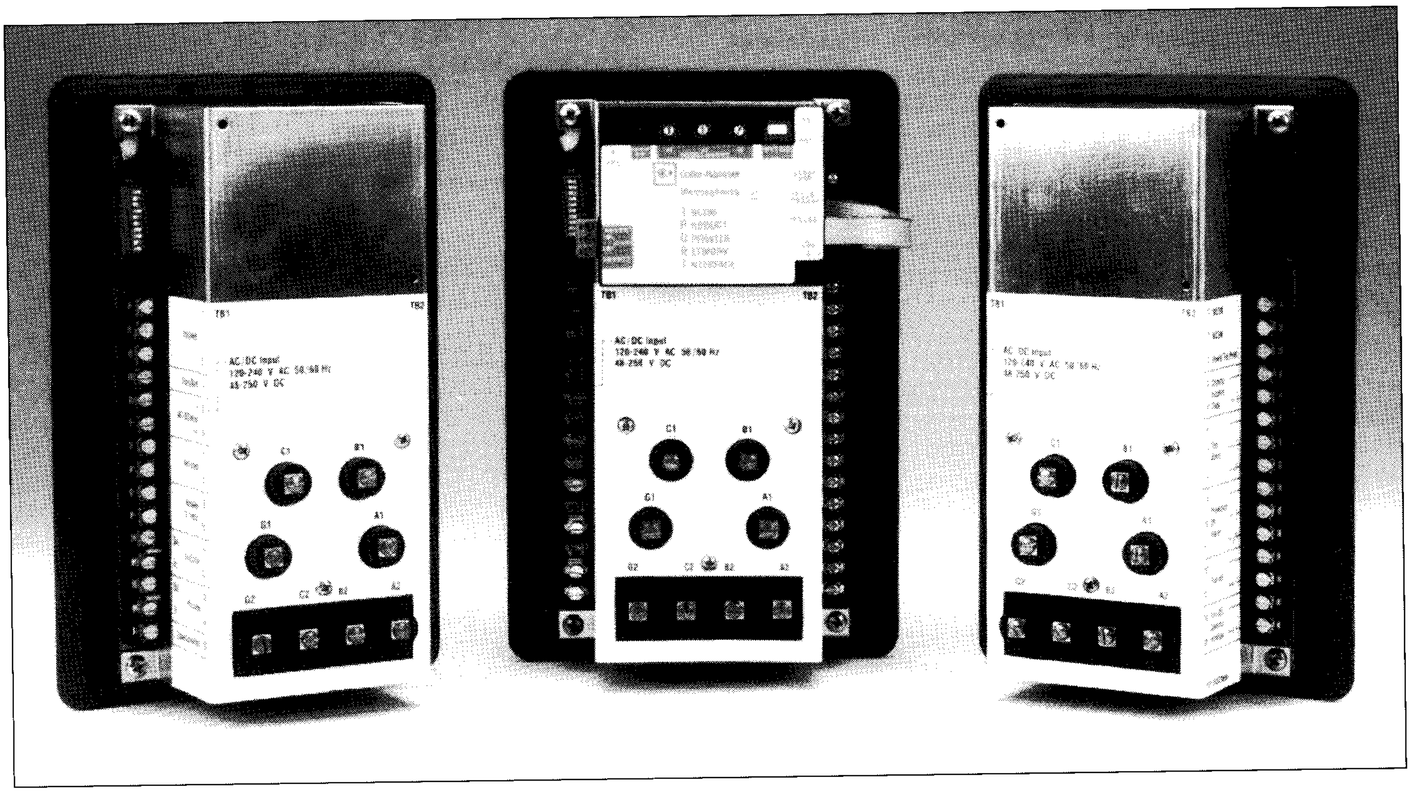


Figure 2-2 *Digitrip MV Trip Unit (Rear Views)*

additional details about Manual and Auto Reset Modes, refer to specific paragraphs earlier in this section.

Terminals 9, 10 and 11 are Form "C" contacts on the protection off alarm relay. The contacts change state when nominal control power is applied to the trip unit and no internal errors are detected.

Terminals 12 and 13 are a "NO" contact of the instantaneous trip relay which changes state when the trip unit discerns the need for a trip of the circuit breaker due to a phase or ground instantaneous fault or the discriminator function.

Terminals 14 and 15 forms a "NO" contact and changes state when the trip unit discerns the need for a trip of the circuit breaker due to a long time or short time function, and also when the communication interface initiates an action to open the circuit breaker.

Rear Surface Terminals: The rear surface terminals, identified as (A1, A2), (B1, B2), (C1, C2) and (G1, G2) provide the current transformer input connection points and are rated for 5 ampere inputs. (A1, A2), (B1, B2) and (C1, C2) are phase A,B,C current inputs respectively, while (G1, G2) is the ground current input.

2-2.3 EXTERNAL HARDWARE

The Digitrip MV Trip Unit requires that a customer supplied source of input control power be wired into the TB1 terminal block located on the rear panel. Refer to the typical wiring diagram in Figure 3-1. A power supply can be either AC or DC voltage within the acceptable voltage ranges outlined in Paragraph 2-3 entitled "UL Testing and Specification Summary."

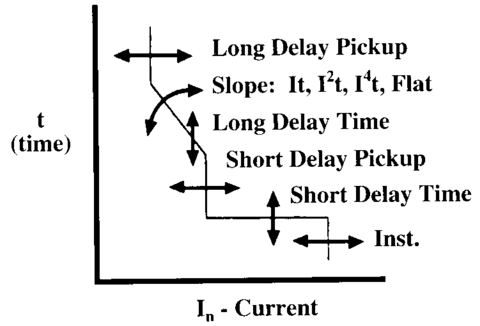
2-3 UL TESTING AND SPECIFICATION SUMMARY (CONTINUED NEXT PAGE)

ANSI C37.90 (UL REQUIRED): ■ Make and Carry Ratings Sec. 6.7 ■ Temperature Test Sec. 7 ■ Dielectric Test Sec. 8 ■ Surge Withstand Test Sec. 9	**ADDITIONAL TESTS (UL REQUIRED):** ■ Hot and Cold Calibration of Phase Elements ■ Meter Readout Accuracy ■ Zone Interlocking Functionality
UL 1053 (UL REQUIRED): ■ Current Withstand Test Sec. 27 ■ Control Power Test Sec. 18 ■ Output Test Sec. 19 ■ Temperature Test Sec. 20 ■ Calibration of Ground Element Sec. 21 ■ Overvoltage Sec. 22 ■ Overload Sec. 23 ■ Endurance – Verify with Calibration Tests Sec. 24 ■ Dielectric Voltage Withstand Test Sec. 25	**UL 991 (UL SUPPLEMENTAL):** ■ EMI Susceptibility Sec. 11: (Radiated Electric Field of 10v./meter) - Radiated EMI Test Par. 11.12 through 11.15 - Digital Equipment Modulation Interference Test Par. 11.16 - Keying Interference Test Par. 11.17 ■ Electrostatic Air Discharge Test Par. 12, Rating of 10kV **EMISSIONS TESTS (UL SUPPLEMENTAL):** (Conducted and Radiated) ■ CFR 47 FCC Part 15 Subpart b Class A ■ CISPR 11 Class A ■ IEC 801-3

2-3 UL TESTING AND SPECIFICATION SUMMARY (CONTINUED FROM PREVIOUS PAGE)

SµRE-FLEX COORDINATION

Typical curves for Phase and Ground Elements



CURRENT INPUTS:

■ CT's:	5 Amp Secondary
■ CT Burden:	<0.004 ohm <0.1VA @ Rated Current(5A)
■ I_n:	5A(Secondary) or CT(Primary)
■ Saturation:	30 x I_n
■ Momentary:	100 x I_n for 1 Second

CT(PRIMARY) SETTINGS AVAILABLE:

■ Phase:	50/75/100/150/200/250/300/400/500/ 600/630/800/1000/1200/1250/1500/ 2000/2400/2500/3000/3200/4000
■ Ground:	50/100/400 or Same as Phase CT Setting

ZONE SELECTIVE INTERLOCKS:

■ Phase:	Long and Short Delay
■ Ground:	Long and Short Delay

CONTROL POWER:

■ Input Voltage:	Nominal: 48 to 250VDC 120 to 240VAC 50/60Hz Operating Range: 28 to 280VDC 90 to 254VAC 50/60Hz
■ Power Consumption:	25VA

OUTPUT TRIP CONTACTS:

■ Trip OC/Communication: [Time Delay]	Make 30 Amps for 0.25 Seconds 0.25 Amp Break @ 250VDC
■ Trip Instantaneous	5 Amp Break @ 120/240VAC
■ Communications Close	Meets ANSI C37.90, Paragraph 6.7

ENVIRONMENT:

■ Operating Temperature:	-30 to +55 Degrees C
■ Operating Humidity:	0 to 95% Relative Humidity [Non-condensing]
■ Storage Temperature:	-40 to +70 Degrees C

AUXILIARY ALARM CONTACTS:

■ Protection Off Alarm:	5 Amp Continuous
■ Trip Alarm	5 Amp Break @ 120/240 VAC

PHASE AND GROUND TIME-CURRENT CURVES:

■ Long Delay Slope:	It	[Moderately Inverse]
	I^2t	[Very Inverse]
	I^4t	[Extremely Inverse]
	Flat	[Definite Time]

PHASE OVERCURRENT PICKUP RANGES:

■ Long Delay Setting:	(0.2 to 2.2) x I_n [28 settings]
■ Short Delay Setting:	(1 to 11) x I_n, None [25 settings]
■ Instantaneous Setting:	(1 to 25) x I_n, None [30 settings]

GROUND OVERCURRENT PICKUP RANGES:

■ Long Delay Setting:	(0.1 to 2.0) x I_n, None [26 settings]
■ Short Delay Setting:	(0.1 to 11) x I_n, None [45 settings]
■ Instantaneous Setting:	(0.5 to 11) x I_n, None [33 settings]

TIME DELAY SETTINGS:

■ Long Delay Time: [@3xI_n(Ph), @1xI_n(Gnd)]	Flat Slope: 0.2 to 2 Seconds, [21 Settings] It, I^2t, I^4t Slope: 0.2 to 40 Seconds [47 Settings]
■ Short Delay Time:	0.05 to 1.5 sec. [22 Settings]

CURRENT MONITORING:

■ True RMS Sensing:	3-Phase and Ground
■ Display Accuracy:	±1% of Full Scale [I_n] from 0.04 x I_n to 1 x I_n ±2% of Full Scale [I_n] from 1 x I_n to 2 x I_n
■ Amp Demand:	Average Demand over 10 Minute Sampling Window
■ High Load:	85% of Long Delay Setting

TIMING ACCURACY: ①

■ Long Delay Time:	±10% of Programmed Setting
■ Short Delay Time:	±50ms

COMMUNICATIONS:

■ IMPACC Compatible	
■ Baud Rate:	1200 or 9600 Baud
■ Catalog DTMV01:	Built In INCOM
■ Catalog DTMV02:	Provision for future field installed communication module [i.e. INCOM PONI, RS232 PONI, Modem PONI]

TESTS:

■ Dielectric Strength:	Current Inputs: 3000VAC for 1 Minute Phase to Phase
■ Seismic Test:	Meets requirements for UBC and California Building Code Zone 4. ZPA=3.5

① *For Ground Pickup ≤ 0.2pu; Time Tolerance ±15%.*
For Phase Pickup ≤ 0.3pu; Time Tolerance ± 15%.

SECTION 3: OPERATION

3-1 INTRODUCTION

This section specifically describes the operation and functional use of the Digitrip MV Trip Unit. It does not address in detail rear power connections and DIP switch settings for current transformer selections. These topics are covered in SECTION 5 entitled "INSTALLATION/TESTING/STARTUP." It would be helpful, however, to become familiar with the trip unit's wiring diagram before proceeding with the rest of this section (Figure 3-1).

3-2 POWER-UP AND SELF TESTING

When the proper AC or DC control voltage is applied to terminals 5 and 6 of TB1, the unit will initiate a "Power On Reset" to its chip circuitry. This causes the unit's firmware to perform some self-testing and initialization of its ROM, RAM and E^2 (non-volatile) memory. If any problem exists, a diagnostic message will be displayed in the Settings/Test Time/Trip Cause Window. A complete list of messages and their meanings are given in Table 3.1. Additionally, if a problem does exist, the "Operational LED" will light red and the "Protection Off Alarm" relay will not energize. When all self checks are good, the "Protection Off Alarm" relay will energize, and the "Operational LED" will blink green.

3-3 PANEL OPERATIONS

Begin by reviewing the material presented in SECTION 2 entitled "FUNCTIONAL DESCRIPTION." Since basic definitions and explanations were given in SECTION 2, no further explanation as to function will be offered in this section. It is assumed that the operator is now familiar with Digitrip MV Trip Unit terms, available settings and overall capabilities.

3-3.1 CHARACTERISTIC CURVE

Digitrip MV Trip Units provide circuit breakers with an extensive degree of selective coordination potential and permit curve shaping over a wide range. Available pickup settings, delay time settings and long delay (phase and ground) slope selections are addressed here with respect to their effect on the resultant characteristic curve. In general, an IT slope selection is used for a moderately inverse curve, an I^2T slope selection for an inverse curve, an I^4T slope selection for an extremely inverse curve, and a Flat selection for a definite or fixed time curve. The operating characteristics of the trip unit are graphically represented by time-current characteristic curves. These curves show how and when a particular trip unit will act for given values of time and current. The more versatile the trip unit, the easier it is to accomplish close coordination and achieve optimum protection. Since the Digitrip MV Trip Unit is very versatile, the makeup of a typical curve is presented for clarification purposes.

For the sake of simplification, the curve discussion will center around a single line curve. Keep in mind, however, that a characteristic curve in reality is represented by a band of minimum and maximum values, not a line (Figure 3-2). Minimum and maximum values are generally the result of tolerances introduced by the manufacturing process for components and the trip unit's accuracy. Any expected value of tripping current or time could be the nominal value anticipated within the plus or minus tolerance. The tolerances just mentioned are usually stated in terms of the trip unit's accuracy and frequently highlighted on the actual working curves. Accuracy is stated in terms of a plus or minus percentage and represents a permitted fluctuation on either side of the nominal tripping point for a family of trip units, like the Digitrip MV Trip Unit.

The adjustability and continuous current of the Digitrip MV Trip Unit are two factors that contribute significantly to the great flexibility of the trip unit.

a) Adjustability: The adjustability of the trip unit permits movement of its characteristic curve or parts of the curve. This movement can be done in both a horizontal and vertical direction on the time current grid. The actual shape of the curve can be changed along with the curve movement, because of the Flat to I^2T selectable slope capabilities. This adjustability permits distinct curves to be established that will better match the electrical protection to the application need (Figures 3-3 through 3-12).

b) Nominal Continuous Current: The Digitrip MV Trip Unit's nominal continuous primary current (In) is established by the ratio of the selected current transformers. The current transformer ratio must be set by the DIP switches on the back of the trip unit (Table 5-1). These DIP switch settings must agree with the circuit current transformers to which the trip unit is connected. Therefore, I_n is established by the current transformer ratio used and becomes the primary scale factor for the trip functions and readouts.

Before proceeding with the curve explanation, it should be noted that combining functional capabilities, such as long, short and instantaneous, is a coordination activity. The effects of one set of settings on another set should always be evaluated to determine if the results under all possible circumstances are acceptable. This helps to avoid unexpected operations or non-operations in the

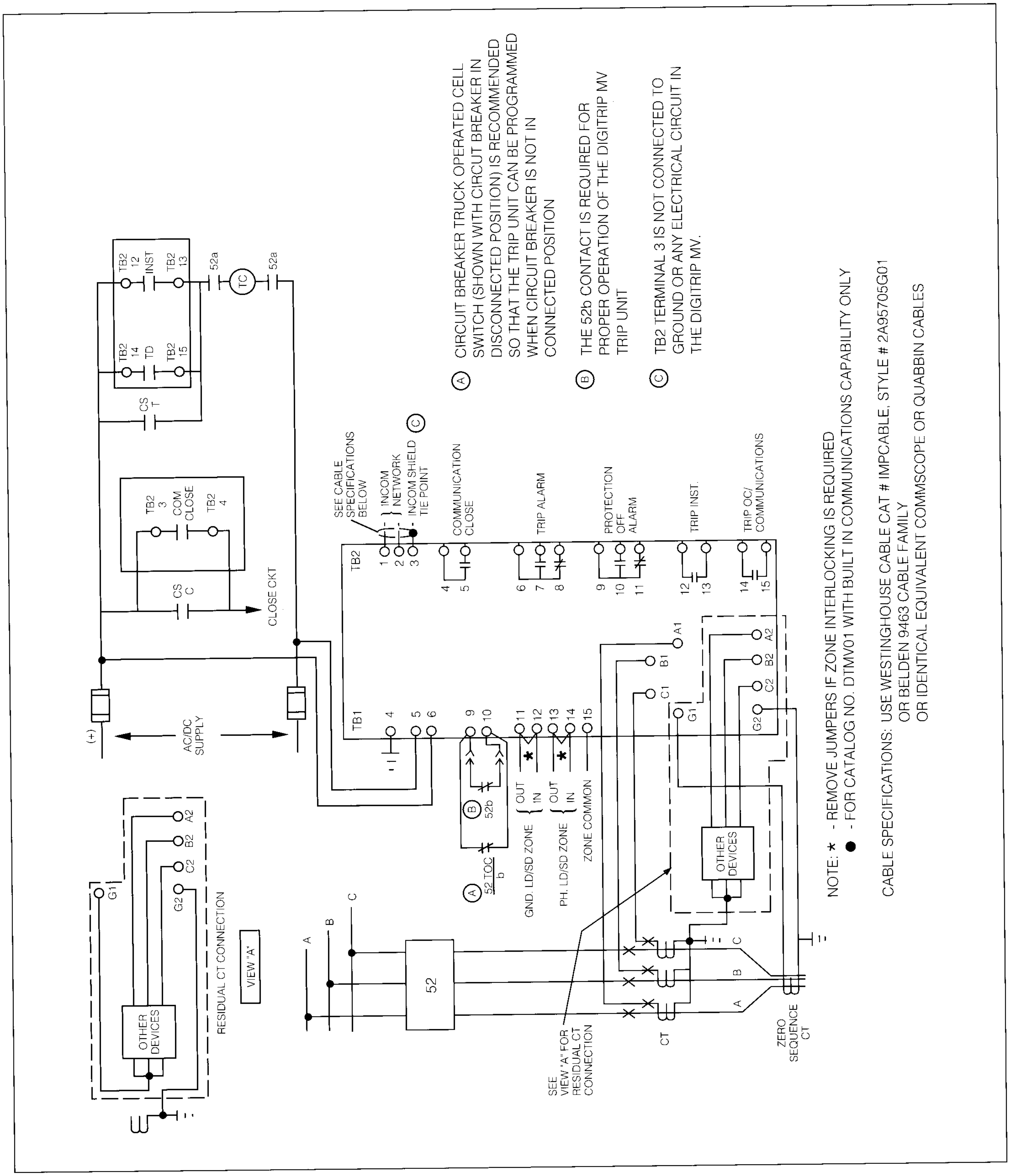


Figure 3-1 *Digitrip MV Typical Wiring Diagram*

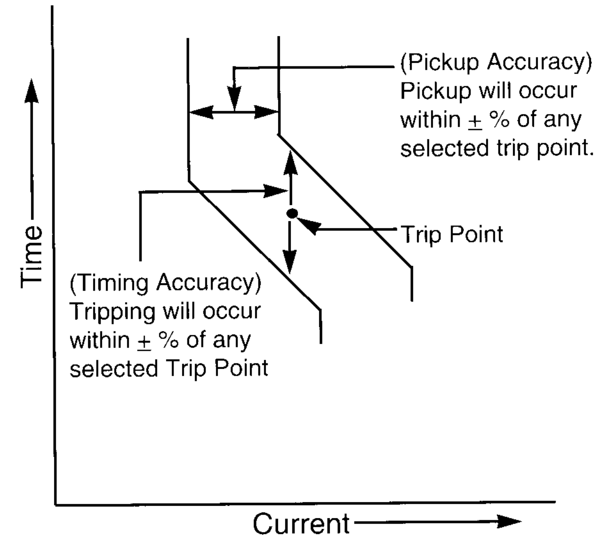


Figure 3-2 *Sample Electronic Trip Curve*

future. Such possibilities are highlighted at the end of this discussion as a reminder when establishing trip unit characteristic parameters.

Phase Long Time Protection

Long time (overload and fault) protection consists of a long time current setting and a long delay time setting. The phase long delay function offers four possible slopes to the time line (Figure 1-5 and Table 2.2). When programming the trip unit, this will be the first choice to make. The slope and its effect on the curve will be covered with the phase long delay time explanations.

The Phase Long Delay setting establishes the current level pickup at which the trip unit's long time tripping function begins timing. If, after a predetermined amount of time, the current condition that started the timing process still exists, the trip unit's trip relay is energized. Pickup settings can be adjusted from 0.20 to 2.20 times In. Refer to Table 2.2 for a complete set of available settings. Figure 3-4 graphically illustrates how the Phase Long Delay Pickup portion of the overall curve can be moved horizontally on the time current grid by means of the pickup settings. The Phase Long Delay Pickup is represented by the dotted lines, while the rest of the curve is represented by a solid line. It should be noted that this movement is independent of the rest of the curve.

The Phase Long Delay Time setting is used to select a predetermined amount of time a sustained overload condition will be carried before the breaker trips. On a Digitrip MV trip unit, a value of ($3 \times I_n$) is the reference point where the programmed long delay time setting is fixed on the curve. A wide range of time settings are available and depend upon the slope selection. Refer to Table 2.2 for a complete list of available time settings. As time settings are varied, the Phase Long Delay Time portion of the overall curve is moved vertically up or down on the time current grid. This movement is also independent of the other portions of the curve. Figure 3-5 graphically illustrates the vertical time line movement with a Flat slope selection. Figures 3-6, 3-7 and 3-8 illustrate a similar vertical movement for the remaining three slope possibilities, IT, I^2T and I^4T.

Phase Short Time Protection

Short time (fault) protection responds to short circuit conditions. Similar to the long time function, the short time function is comprised of a short time current setting and a short delay time setting. The Phase Short Delay setting establishes the current level at which the trip unit's short time tripping function begins timing. The Phase Short Delay Time setting establishes the amount of time a short-circuit will be carried before the trip unit's trip relay is energized. As is the case with long delay protection, short delay protection also offers a range of settings for both pickup and time. Refer to Table 2.2 for available selections.

Two points should be made concerning the available selections: 1) In Table 2.2 covering Phase Short Delay Pickup settings, "NONE" is one of the available selections. If "NONE" is selected, the Phase Short Delay function is disabled and there will be no short time protection. Also, if "NONE" is selected, a Phase Short Delay Time selection is not offered. 2) There is no slope selection for the Phase Short Delay Time portion of the curve. A flat response curve is automatic.

When a short delay setting other than "NONE" is selected, the Phase Short Delay pickup and the Phase Short Delay Time portions of the overall curve are moved horizontally and vertically in a similar manner to the long time protection functions. Refer to Figures 3-9 and 3-10 for graphic illustrations of this movement.

Note that the scope of protection offered by the Digitrip MV Trip Unit is a coordinated effort. This is especially true when a number of protective functions, such as long time and short time protection are combined into one cooperative curve. Figure 3-11 shows a typical time-current which has both long and short time protection, and an I^2T slope selected for the long delay time. Because of the pickup, time and slope selections made

E·T·N

for this illustration, a triangle (shaded area on the illustration) is formed by the intersection of the different time and pickup lines. Internally, the Digitrip MV Trip Unit design looks at this particular curve as if the shaded triangular area does not exist. Therefore, in an actual performance situation, the phase short delay time function would take precedence over that portion of the phase long delay time line forming the one leg of the triangle. This does not create a problem from a protection or coordination standpoint. In fact, it is recommended on certain applications to set the minimum time the Digitrip MV Trip Unit can respond and where it will intersect the long time curve. If only the Short Delay Time is required, it is recommended that the Short Delay setting be set at 11 times (I_n). It could, however, cause confusion if the combination of protection functions is not viewed as a coordinated activity. For example, an individual might expect a tripping action based on a selected low value for Phase Long Delay Time. The expected tripping action will not take place at the expected time, if the Phase Short Delay Time selected is in the higher end of time selection possibilities. It should also be noted that this situation is similar for other slope selections. The only thing that changes with different slope selections is the general shape of the triangle. When the Phase Short Delay Time setting is low enough, this situation will not exist. In summary, for a long time and short time cooperative curve, the minimum trip time cannot be less than the short delay time setting.

Instantaneous Protection

Instantaneous (short circuit) protection reacts to high level fault currents. The instantaneous setting establishes the current level at which the trip unit's instantaneous trip relay will be energized with no time delay and is the instantaneous setting times (I_n).

Table 2.2 specifies the possible settings, which are from 1 through 25 and "NONE." If "NONE" is selected, the instantaneous trip function is disabled and the discriminator option is offered. See Section 2-1.4 to review the discriminator option details.

If a Phase Instantaneous Setting other than "NONE" is selected, the instantaneous portion of the overall curve can be moved independently in a horizontal direction. Figure 3-12 graphically illustrates this horizontal movement.

The instantaneous protection (INST) is designed to provide a nominal 1 cycle total response time. To provide this fast response time the rms current detection level and display readout may differ somewhat from a true rms ampere value, if a significant percentage harmonic current is present.

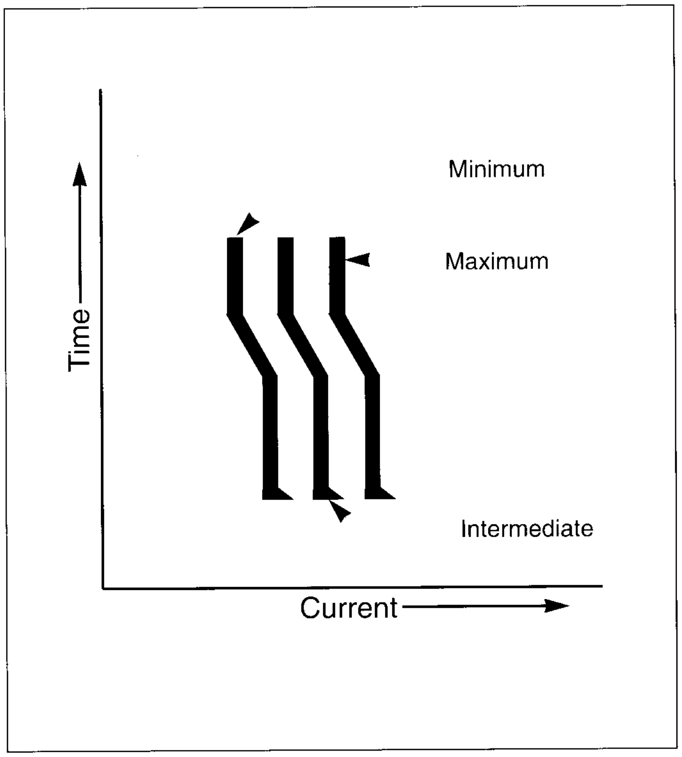


Figure 3-3 *Typical Trip Curve Horizontal Movement*

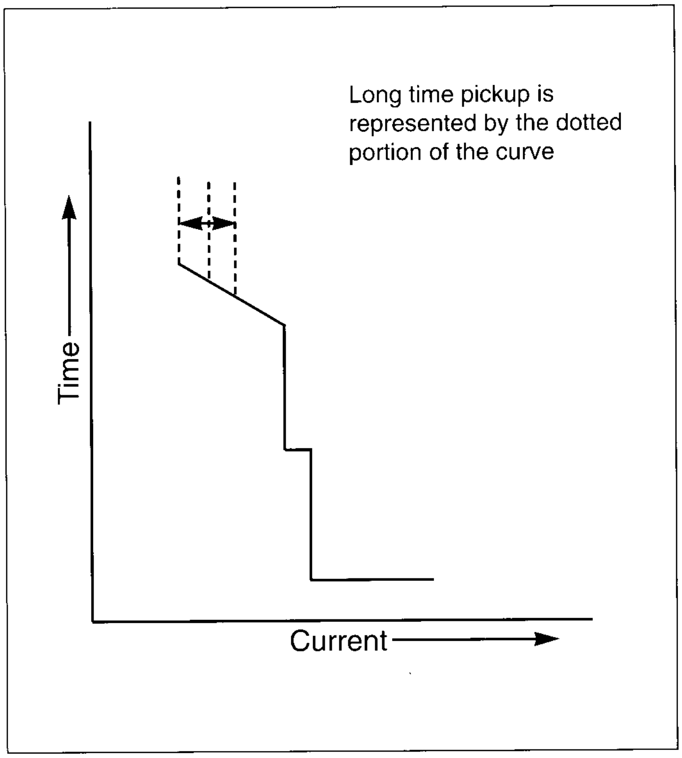


Figure 3-4 *Typical Phase Long Delay Setting Adjustment*

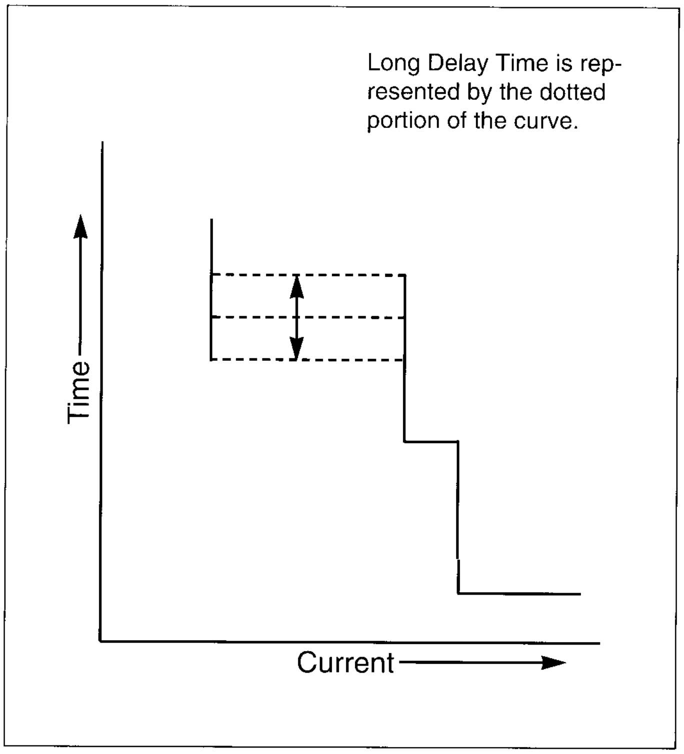


Figure 3-5 *Typical Phase Long Delay Time Adjustment (Flat Response).*

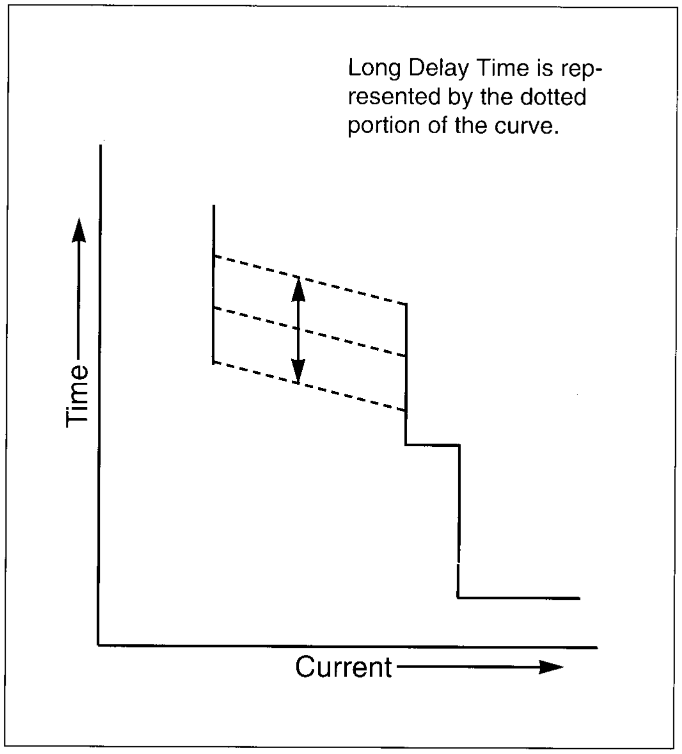


Figure 3-6 *Typical Phase Long Delay Time Adjustment (IT Response).*

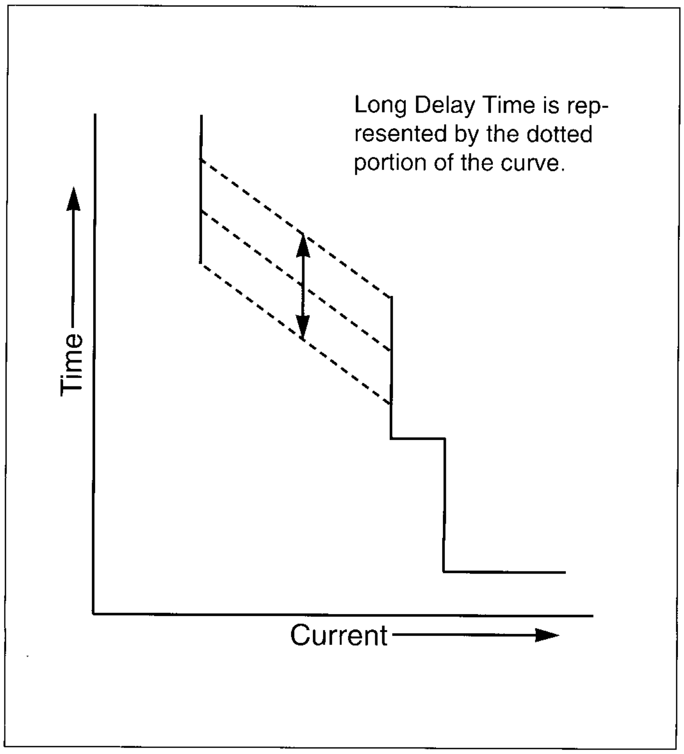


Figure 3-7 *Typical Phase Long Delay Time Adjustment (I^2T Response).*

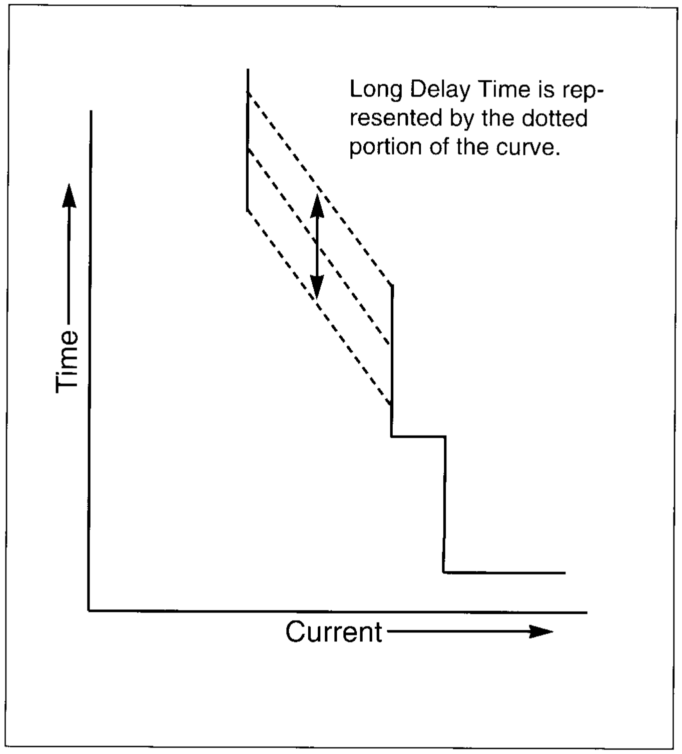


Figure 3-8 *Typical Phase Long Delay Time Adjustment (I^4T Response).*

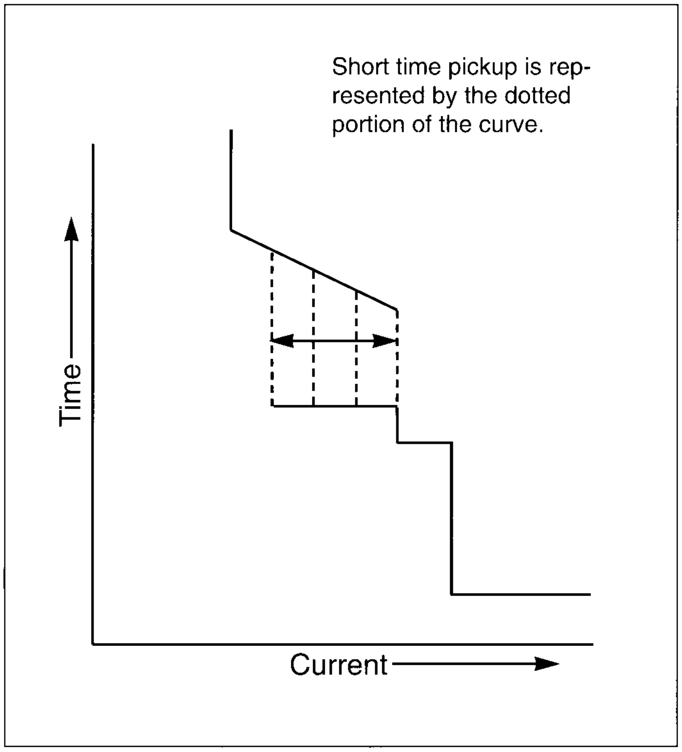


Figure 3-9 *Phase Short Delay Setting Adjustment*

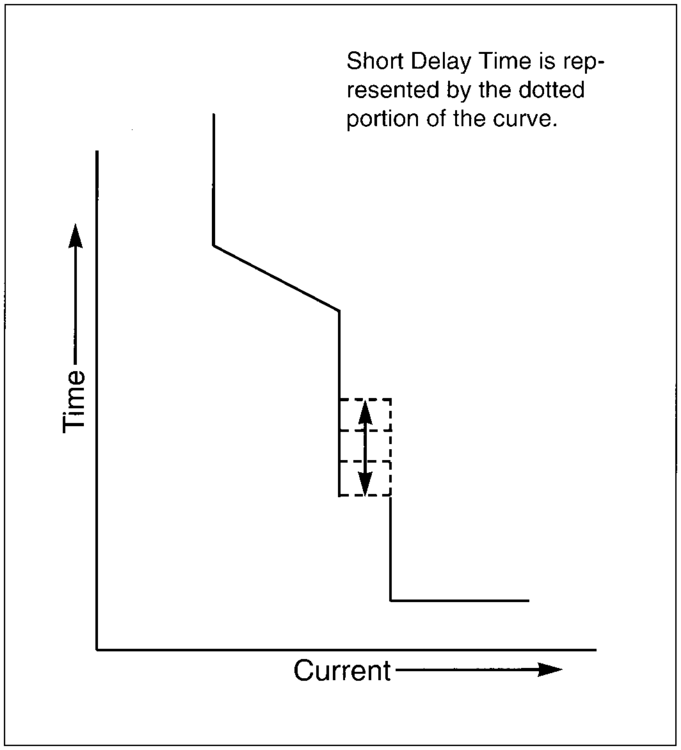


Figure 3-10 *Phase Short Delay Time Adjustment*

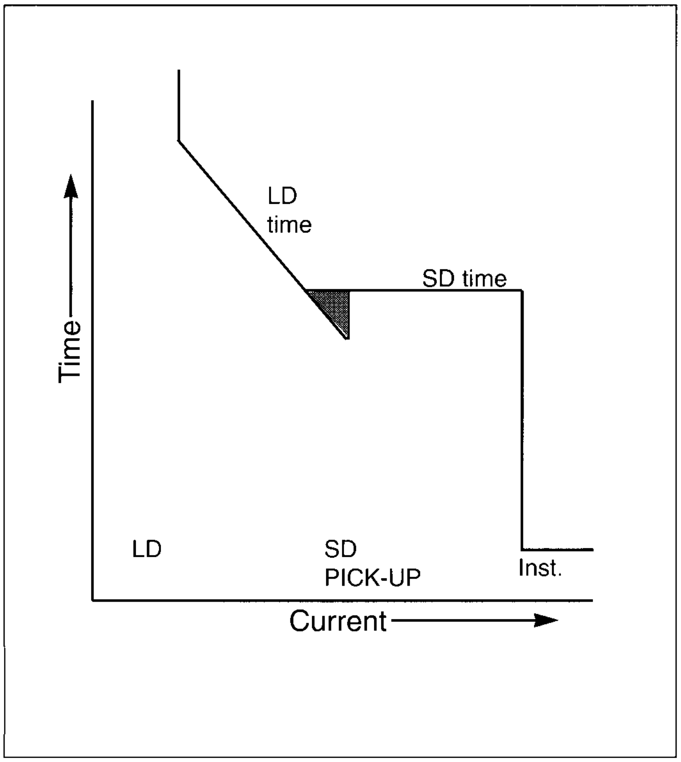


Figure 3-11 *Typical LS Curve With I^2T Slope*

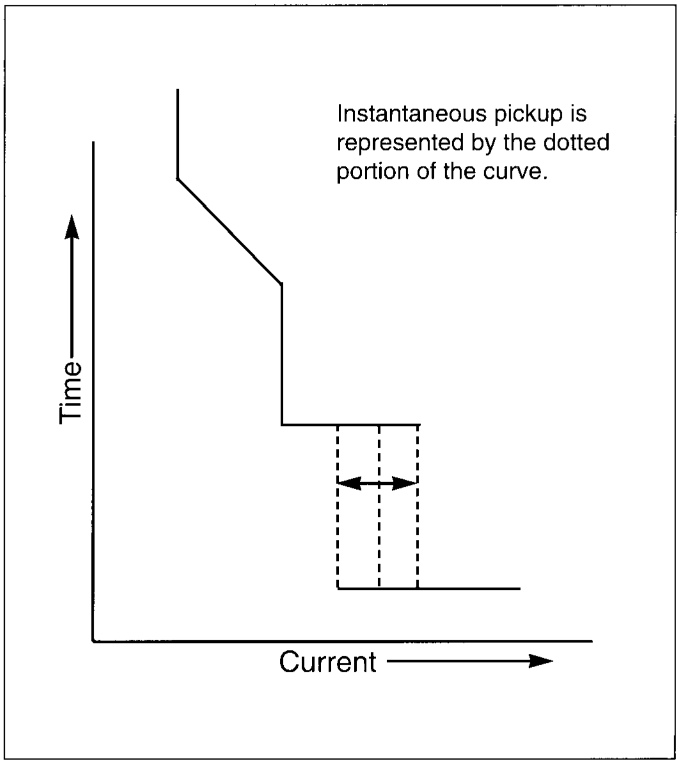


Figure 3-12 *Phase Instantaneous Setting Adjustment*

Ground Fault Protection

The ground fault protection function can be a composite of the ground: 1) long delay setting and time, 2) short delay setting and time, 3) instantaneous setting. Its curve is the same slope as the Phase slope. There are two differences between Digitrip MV phase and ground functions: 1) Long time values for the ground function are for ($1 \times I_n$) while the phase is ($3 \times I_n$). 2) The short delay settings are more sensitive and can be set from ($0.1 \times I_n$) to ($11 \times I_n$). Movement of the pickup portion of the curve in a horizontal direction and, when applicable, the time portion of the curve in a vertical direction is similar to phase long delay, short delay and instantaneous functions previously described. Therefore, ground fault curve movement is not graphically illustrated. Refer to Table 2.3 for the available ground fault settings. When programming ground fault protection, keep in mind that if "NONE" is selected, the ground fault protection is disabled. Even if the ground fault protection is disabled, a detectable ground current will still be displayed. If "NONE" is not selected for the Ground Long Delay setting, the slope selection made previously for the phase function will be applicable to the Ground Long Delay function.

Characteristic Curve Reminders

As previously mentioned, combining protective capabilities is a matter of coordination. The effects of one selection should always be evaluated against other selections to determine if the overall desired result is obtained. For this reason, keep in mind the following Digitrip MV selection possibilities and trip unit design features when programming the unit to closely coordinate with system protective needs:

1. When "NONE" is selected as a setting, the associated tripping function is disabled.
2. When "NONE" is selected for the Phase Instantaneous Setting, a Phase Discriminator option is offered.
3. The internal design of the Digitrip MV Trip Unit is such that the Phase Short Delay Time setting might take precedence over the Phase Long Delay Time. This is graphically illustrated in Figure 3-11.

3-3.2 PROGRAM MODE

⚠ CAUTION

DIGITRIP MV TRIP UNIT SETTINGS MUST BE PROGRAMMED BEFORE THE TRIP UNIT IS PUT INTO OPERATION.

Notes: *1. The Program Mode cannot be entered if the circuit breaker is closed. The circuit breake position is determined via the normally closed breaker "b" contact on terminals 9 and 10 of TB1. Refer to the typical wiring diagran in Figure 3-1.*

2. The settings that are altered during a pro gramming session will not be saved until the Save Settings pushbutton is pressed and released.

3. If the circuit breaker is closed during a pro gramming session, the unit will exit the Program Mode without saving any new set point values and the message "ERR" wi appear in the Settings/Test Time/Trip Cause window.

4. When programming is concluded and nev setpoints saved, the Program Mode pushbut ton should be pressed and released to ex the Program Mode.

5. The Program Mode is also exited if the Rese pushbutton is pressed and released or there is no programming activity for approx mately 2-1/2 minutes.

⚠ CAUTION

IT IS IMPORTANT TO VERIFY ALL TRIP UNIT SET TINGS BEFORE THE BREAKER IS CLOSED SINCI INCORRECT SETTINGS CANNOT BE ALTEREI UNTIL THE BREAKER IS AGAIN OPENED. THI "VIEW SETTINGS" PUSHBUTTON IS USED FOI THIS VERIFICATION.

Refer to Section 3-3.3 (Programming Overview) and th following specific details to become familiar with the pro gramming process.

To enter the Program Mode, open the protective acces cover and press and release the Program Mode On/O pushbutton. The Program LED will blink green, indicat ing that the Program Mode has been entered. The pre sent value of the first setpoint to be programmed (Lon Delay Slope) will appear in the Settings/Test Time/Tri Cause Window, which will be referred to as the Alpha numeric Display for the rest of this discussion. The Lon Delay Slope LED will be blinking green. The Raise o Lower pushbuttons can now be used to change th value of the setpoint. Keep in mind that the Raise an Lower pushbuttons will roll over from highest to lowes and lowest to highest respectively. If either of the pushbuttons is held down and not released, their function is accelerated. This is true for all white pushbuttons on the panel face.

Remember that the slope setting applies to both the phase and ground protection curves. Refer to Section 2-1.4 and Table 2.1 to review slope selection possibilities.

Pressing and releasing the Select Settings pushbutton will cause the unit to step to the next setpoint. This is the Phase Long Delay Setting. The Long Delay Setting LED will blink green. Simultaneously, the Phase LED will be blinking green, indicating that this setting is associated with the phase protection curve.

After the Raise and/or Lower pushbuttons are used to arrive at the desired Phase Long Delay Setting, the Select Settings pushbutton can be pressed and released to step to the next setpoint, which is the Phase Long Delay Time setting. The Long Delay Time setting LED will blink green along with the Phase LED. Refer to Table 2.2 for the available settings and note that the available settings can vary, depending upon which slope was previously selected.

Pressing and releasing the Select Settings pushbutton will cause the unit to step to the Phase Short Delay setting. Refer to Table 2.2 for the available settings. This function can be disabled by selecting the "NONE" setting. The Short Delay setting LED and the Phase LED will blink green. After the Raise and/or Lower pushbuttons are used to arrive at the desired setting, the Select Settings pushbutton is pressed and released to move to the next setpoint. The next setpoint is Short Delay Time setting (Table 2.2), unless "NONE" was selected for the Short Delay setting. If "NONE" was selected, the Short Delay Time setting will automatically be bypassed in favor of the next in order setting, Phase Instantaneous.

When at the Phase Instantaneous setting, both the Instantaneous setting LED and the Phase LED will blink green. Refer to Table 2.2 for the available instantaneous settings. Once a selection other than "NONE" is made and the Select Settings pushbutton is pressed and released, the unit steps to the next setpoint. If "NONE" is the setting selected and the Select Settings pushbutton is pressed and released, the Phase and Instantaneous LEDs remain on and the unit will now offer a choice of whether to turn the discriminator option on or off. Refer to Section 2-1.4 to review the discriminator option details. Once the discriminator option selection is made and the Select Settings pushbutton is pressed and released, the unit steps to the next setpoint.

Ground Long Delay setting is the next setpoint. The Ground Long Delay setting LED and the Ground LED will blink green. A slope selection choice will not be offered, since the slope choice made for Phase Long Delay Protection also applies for the Ground Long Delay Protection curve.

Programming the ground setpoints is handled in the same manner as was used in selecting the phase setpoints, except for the following:

1. The Ground Long Delay setting can be disabled by selecting "NONE." This is not possible on the Phase Long Delay setting.
2. If "NONE" is selected for the Ground Instantaneous setting, there is no discriminator option, as was the case for Phase Instantaneous setting.

For a complete listing of all the available ground setpoints, refer to Table 2.3.

When all of the ground setpoints are established and the Select Settings pushbutton is pressed and released, the unit steps to the High Load Setting. The High Load LED will blink green and the last programmed value for the High Load time setting will appear in the alphanumeric display. Refer to Section 2-1.4 and Table 2.3 to review the High Load function and/or to select the appropriate High Load time setting. Once this selection is made and the Select Settings pushbutton is pressed and released, the unit steps to the last setpoint.

The last setpoint selection to be made is the Frequency. The choices are 60Hz and 50Hz. When this selection is made and the Select Settings pushbutton is pressed and released, the unit cycles back to the first setpoint, the Long Delay Slope.

It is possible to step backwards through the setpoints by pressing and holding down the Select Settings pushbutton, while pressing and releasing the Lower pushbutton.

To save the new settings at any time, press and release the Save Settings pushbutton. When the Save Settings pushbutton is pressed and released, the unit will blank the alphanumeric display for two seconds, and then display the last setting. At this moment, the unit will use the new setpoints for protection. After pressing the Save Settings pushbutton, the Program Mode can be exited by any one of three ways:

1. Press and release the Program Mode On/Off pushbutton.
2. Press and release the Reset pushbutton.
3. Perform no programming activity for 2 1/2 minutes.

⚠ CAUTION

THE SAVE SETTINGS PUSHBUTTON MUST BE PRESSED AND RELEASED BEFORE EXITING THE PROGRAM MODE. OTHERWISE, THE CHANGED SET-POINTS WILL NOT BE SAVED. IN ADDITION, AFTER THE PROGRAMMING OF SETTINGS IS COMPLETE, IT IS VERY IMPORTANT TO VERIFY ALL THE SETTINGS BY DEPRESSING THE "VIEW SETTINGS" PUSHBUTTON AND STEPPING THROUGH THE SETTINGS.

3-3.3 PROGRAMMING OVERVIEW

An overview of the programming function is presented here in terms of two flow charts. These flow charts are intended as quick references after the material presented in Section 3-3.2 has been reviewed.

The flow chart entitled "Programming Sequence Preview" (Figure 3-13) presents the general programming steps the Digitrip MV trip unit follows, always beginning with the "Slope" selection. Each time the "Select Settings" pushbutton is pressed and released, the trip unit advances to the next sequential step.

The flow chart entitled "Local Programming Sequence Flow Chart" (Figure 3-14) presents details of the programming function. A specific setting decision is called for at each DIAMOND SHAPED decision point. After a decision is made to either accept or change the displayed setting, the "Select Settings" pushbutton is pressed and released to move to the next setting in the programming order. Notes to the right of the flow chart and connected by dotted lines to the "Select Settings" pushbutton boxes are used to highlight what displays will be activated and observed as the trip unit moves through the programming steps.

3-3.4 TEST MODE

The Test Mode is not intended for live primary current interruption. The intent is to permit the periodic performance of simple tests that verify the functional performance of the trip unit. To enter the Test Mode, open the protective access cover. Press and release the Test Mode On/Off pushbutton. The following should be verified before proceeding:

1. The word TEST appears in the alphanumeric display.
2. The Test LED is blinking green.

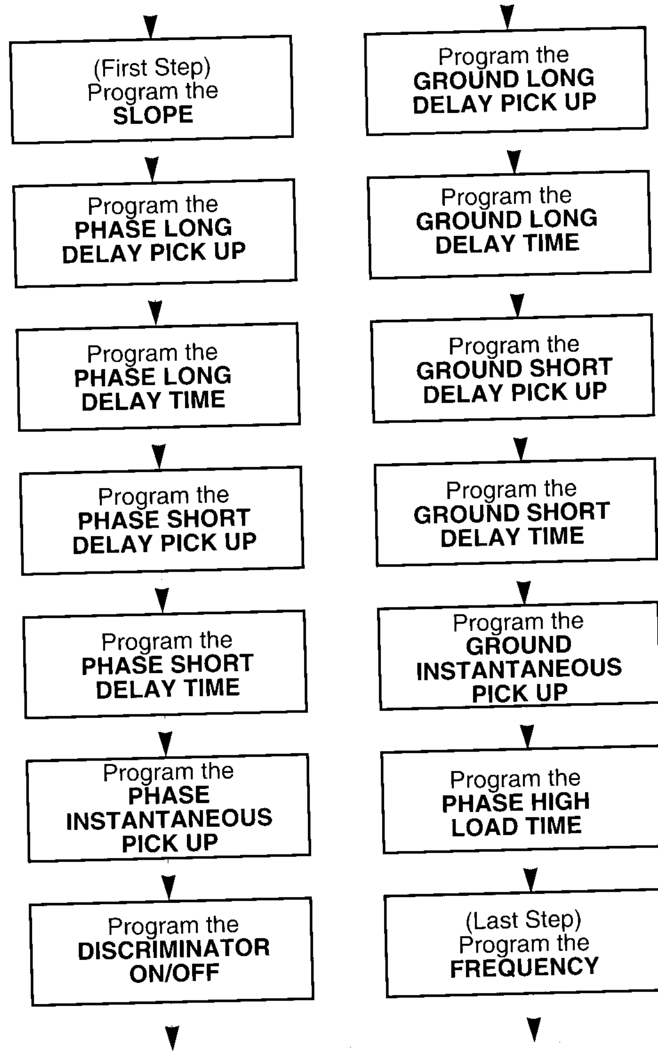


Figure 3-13 *Programming Sequence Preview*

3. The RMS Amperes (numeric display window is bla
4. An error message (ERR) does not appear in alphanumeric display.

If there is greater than 0.1 per unit of current flowing either a phase or ground circuit, the error mess (ERR) will appear and there will be an automatic from the Test Mode. This maximum current value be determined by multiplying 0.1 times the CT prin current amperes rating. The CT primary current amp rating is established by the DIP switch setting on back of the unit. Refer to Section 5-4 entitled "In Start-Up" and Tables 5.1 and 5.2 for a translation of switch settings to CT primary ampere ratings.

Programming Notes:

1) New Settings can be saved individually at anytime during the programming process or in total at the end of the programming process by pressing the "Save Settings" pushbutton. This must be done prior to exiting the "Program Mode."

2) Any pushbutton used during programming must be pressed and released to accomplish its function.

3) In some instances, use of the "Select Setting" pushbutton can result in movement to 1 of 2 possible next programming setpoints. It depends on the last selection made.

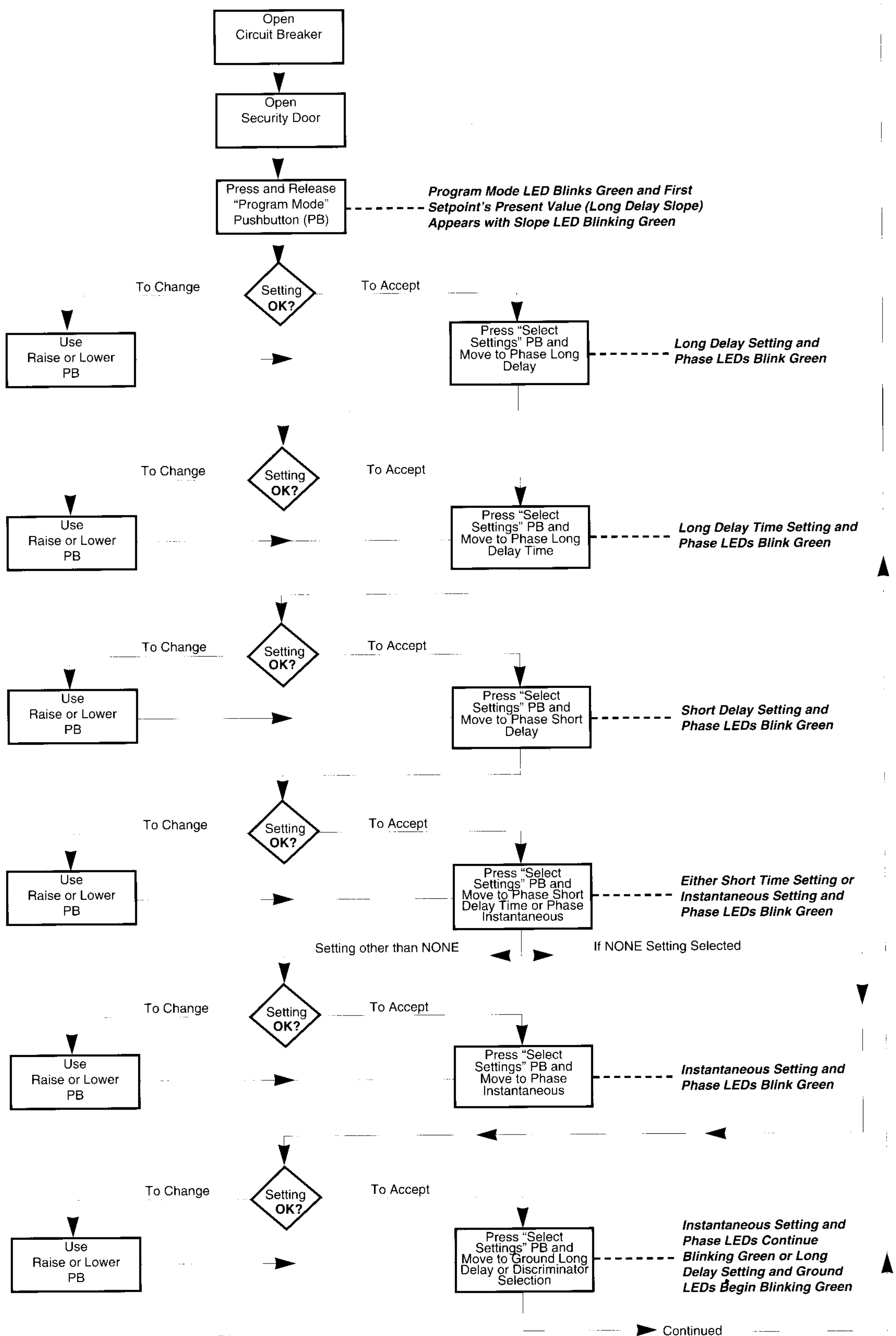
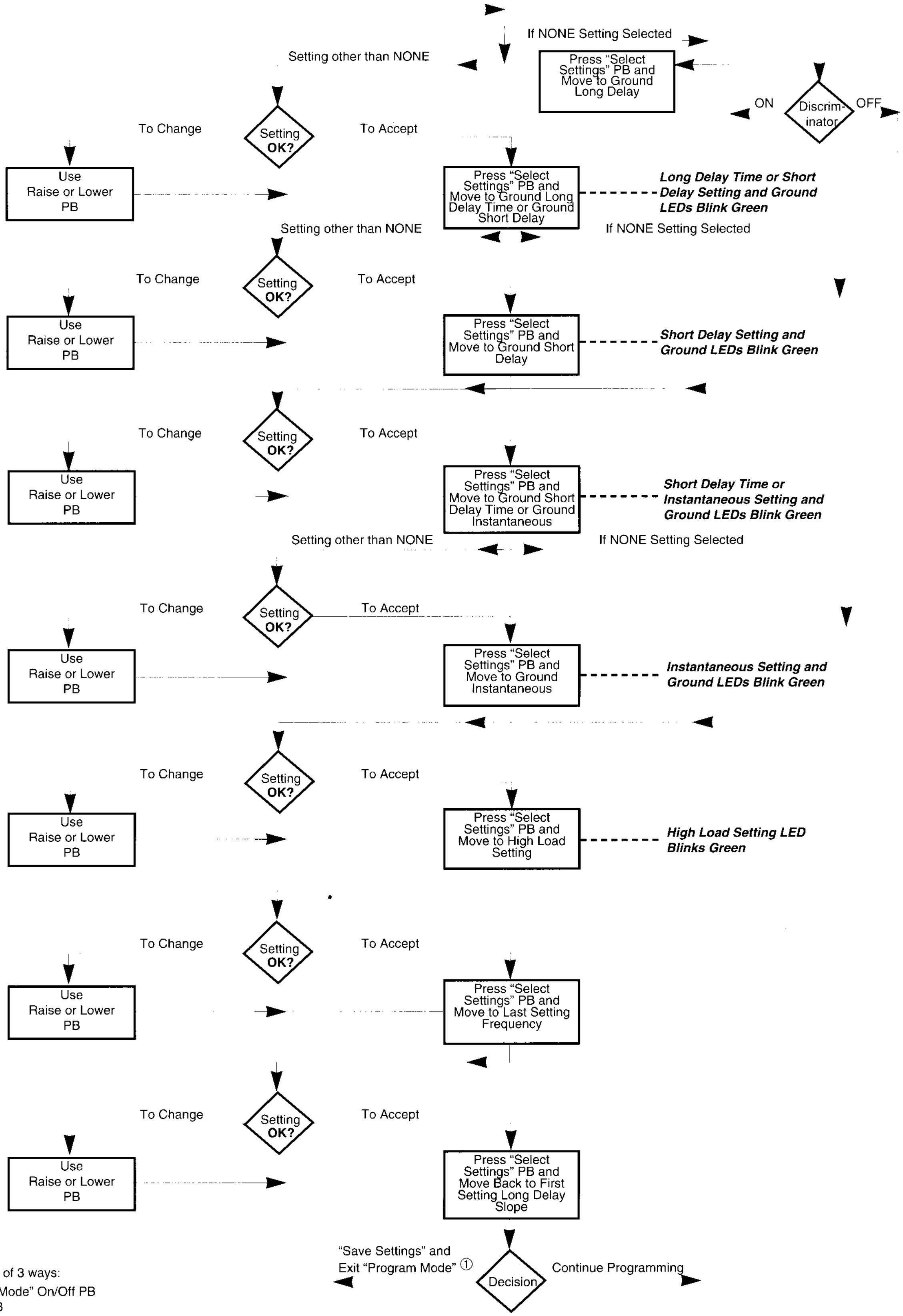


Figure 3-14 *Local Programming Sequence Flow Chart*



① Exit the "Program Mode" in 1 of 3 ways:

(a) Press "Program Mode" On/Off PB
(b) Press "Reset" PB
(c) Perform no programming activity for 2-1/2 minutes

Table 2.4 shows the test matrix that can be performed. A translation of the test matrix elements is as follows:

a) "P" signifies a phase current test.
b) "G" signifies a ground current test.
c) "T" signifies that the test will initiate closing of the unit's trip contacts.
d) The numerical values are the per unit values referenced to the I_n value, which is determined by the CT rating setting.

Tests can be done on both phase and ground elements. For either of these tests a trip or no trip mode can be selected. A trip test will activate the trip coil while a no trip test exercises the trip function without activating the trip coil.

When in the Test Mode, the Select Tests pushbutton is pressed and released to step between the four groups of settings shown vertically in Table 2.4.

The Raise and Lower pushbuttons will move the display between the setpoints for each of the four groups. Within a group, the setpoints move horizontally (Table 2.4).

Pressing and releasing the Test pushbutton will initiate the selected test.

When the initiated test is complete, the appropriate front panel LEDs will be red to indicate the cause of the trip. The alphanumeric display shows the time to trip, and the numeric display shows the magnitude of the trip current. The Test Mode can be exited as follows:

1. Press and release the Test Mode On/Off pushbutton.
2. Press and release the Reset pushbutton.
3. Perform no testing activity for approximately 2 1/2 minutes.

3-4 COMMUNICATIONS FUNCTION

The communication function can deliver all the data and flags that can be viewed locally on the trip unit to a host computer equipped with an appropriate software package. In addition, the host computer can initiate a "Communication Trip" and "Communication Close" control type command.

The Catalog Number DTMV01 trip unit has a built in INCOM communication network port that is available on terminals 1 and 2 of TB2 (Figure 3-1). The device Address and the desired BAUD Rate are programmed using the following pushbuttons located on the front panel: "Select Tests," "Test," "Raise" and "Lower" and "Select Settings."

To enter the mode that permits changing the device Address and/or BAUD Rate, depress and hold the "Test" Pushbutton and then depress and release the "Select Tests" Pushbutton. The BAUD Rate and Address respectively will appear in the Settings/Test Time/Trip Cause Window. The "Test" Pushbutton can now be released. The last digit on the right flashes. Press and release "Select Settings" Pushbutton to shift the flashing portion of the display horizontally from the lowest address digit on the right to the last display on the left, which is the BAUD rate. The BAUD rate will flash with an "H" (High BAUD Rate = 9600) or an "L" (Low BAUD Rate = 1200). To increase or decrease the flashing digit or flashing baud rate, press and release the "Raise" or "Lower" Pushbuttons. When completed, depress the "Save Setpoints" Pushbutton to save and exit this mode. Table 3.1 outlines display possibilities and their meanings.

The Catalog Number DTMV02 trip unit has provisions and mounting holes to accept a PONI Module (Figure 1-2). When the PONI module is the communication medium, the BAUD Rate and Address are established on the PONI. Refer to the PONI Instruction Leaflet for details.

Table 3.1 *Digitrip MV Display Messages*

Message	Meaning
"TEST"	Entered test mode.
"RAM"	A ram check error was detected.
"ERR"	An error in the test mode has occurred/or an error in the EPROM setpoints was detected.
"PRGM"	Entered the program mode.
"LDT"	Digitrip MV tripped via the long delay function.
"SDT"	Digitrip MV tripped via the short delay function.
"INST"	Digitrip MV tripped via the instantaneous function.
"DISC"	Digitrip MV tripped via the discriminator function.
"EXTT"	External trip via INCOM communications.
"OVER"	Override trip (Digitrip MV tripped via 100 per unit fixed instantaneous).
"ORNG"	Overrange value (trip value is greater than 28 per unit).

SECTION 4: APPLICATION CONSIDERATIONS

4-1 GENERAL

To date, characteristics of relays used with medium voltage circuit breakers have been electromagnetic induction disk relay characteristics or electronically generated imitations. The most likely reason for this was the belief that this characteristic provided better coordination. It was thought that the additional effort required to make electronic trip unit characteristics of that form was justified by the performance potential. Medium voltage overcurrent protection generally implies the use of devices producing induction disk relay type characteristics.

When electronic circuit capability was first introduced in low voltage circuit breaker trip units, designs to achieve responses that imitated thermal bimetal trip units were not sought after. Such responses would have been quite difficult to achieve or make economically feasible. If smoothly curve characteristics would have been absolutely required, the development of economical electronic trip units would have been set back. This set back would have lasted until smaller electronic components, today's digital electronic circuit chips and related manufacturing technologies became available. Instead, the natural tendency, at the time, was to utilize the capabilities of electronic circuits to form mathematically simpler trip unit characteristics made up of, as much as possible, connected straight line segments, and to provide all of the requisite functions for protection. Mathematical integration of sensed signal current magnitudes over time could be accomplished readily in these electronic circuits, and straight line alternatives to the smooth curve bimetal trip unit heater characteristics became acceptable and commonplace in low voltage breaker trip units. Through continued development over a period of time, electronic trip unit circuit designers were able to add features like short-time delay and zone interlocking to produce even more effective protective devices.

In taking a new look at the distribution system from this new and more balanced perspective, it was possible to see the potential benefit of a medium voltage trip unit design incorporating all of the advantages of the proven low voltage devices with an upstream interface that could more readily be adapted to familiar medium voltage practices. By utilizing the straight line segment approach to building time-current characteristics, more of the digital logic capability of the trip unit could be used for functional utility, and less of it for shaping response characteristics. The new functions of It and I^4t are introduced in the Digitrip MV Trip Unit. The user can now choose definite time, It, I^2t or I^4t functions or slopes for the straight line characteristics, suggestive of the terminology of inverse, moderately inverse, and extremely inverse when referring to traditional induction disk relay applications.

Relative to the characteristic time-current curves, it was decided to follow the existing medium voltage practice of using a single line characteristic to describe a trip unit response rather than the two line band characteristic used for low voltage applications. This distinguishes medium voltage characteristics from low voltage characteristics when referring to coordination curves. It also implies that time difference for coordination of medium voltage trip unit characteristics with other overcurrent device characteristics should be handled in the same manner as other medium voltage trip devices, such as induction disk relays. For this reason, separation required between characteristics can be smaller. A 0.3 second separation would be more appropriate than the 0.4 second interval used for induction disk relays.

In addition to the flexibility of new slope options in the characteristics and the inherently available IEEE function logic the output contacts incorporate (i.e. functions 50, 51, 86 and 87 devices), the straight line segment characteristic curves of the Digitrip MV Trip Unit can facilitate the design of very effective and flexible selectively coordinated systems.

4-2 ZONE INTERLOCKING CAPABILITIES

To minimize damage to the system, faults should be cleared as quickly as possible. Zone selective interlocking provides this capability better than a system with only selective coordination.

When the "Ground Zone Interlocking" feature is utilized, an immediate trip is initiated when the fault is in the breaker's zone of protection, regardless of its preset time delay. When the "Phase Zone Interlocking" feature is utilized, the long delay and short delay phase elements work as follows. The short delay phase element will initiate an immediate trip when the fault is in the breaker's zone of protection, regardless of its preset time delay. For the long delay phase element, the current sensed by the Digitrip MV must exceed 300 percent ($3 \times I_n$) for the zone selective interlocking to initiate an immediate trip signal. This interlocking signal requires only a pair of wires from the downstream breaker to the upstream breaker.

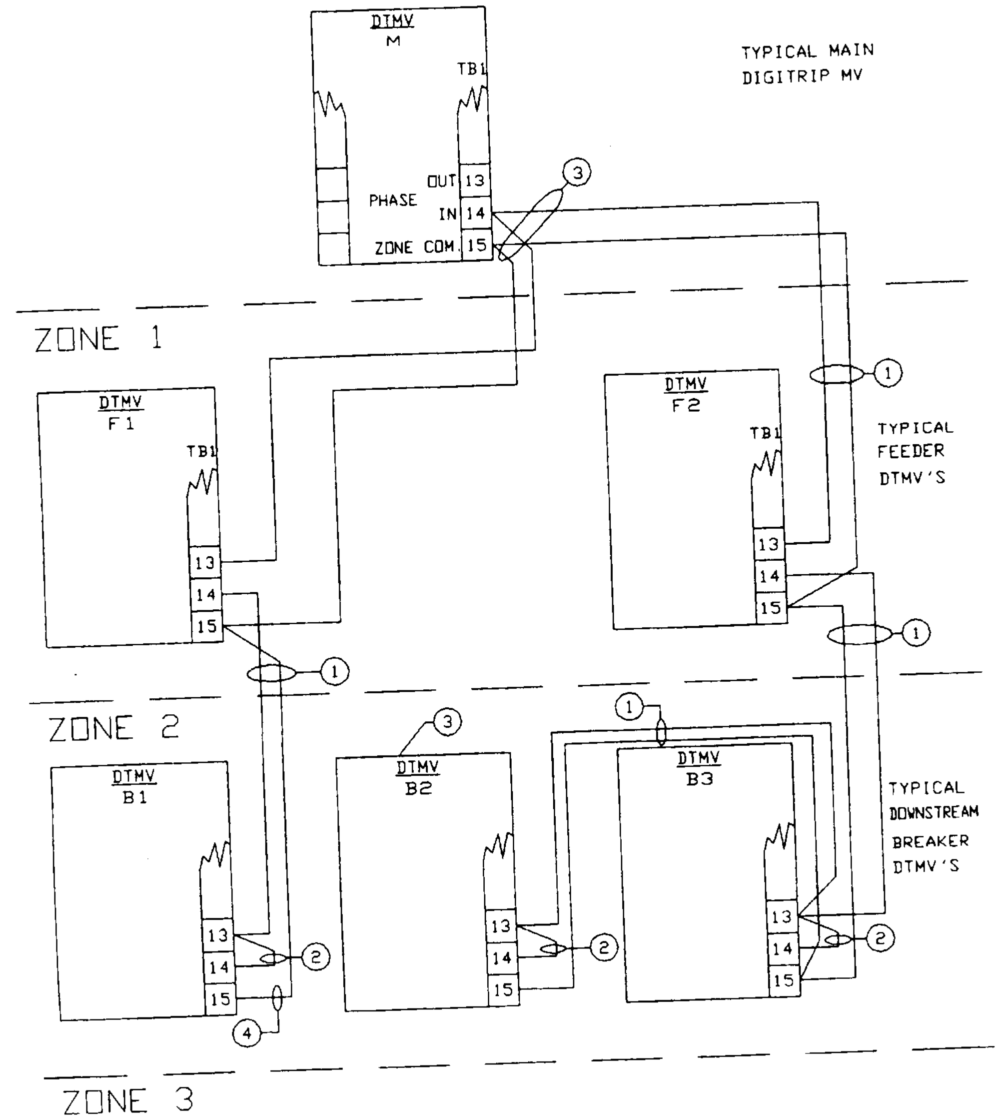
When a Digitrip MV initiates a trip signal, the zone interlocking signal stays active for an additional 175 milliseconds. Therefore, if a downstream Digitrip MV is zone interlocked to an upstream Digitrip MV, the downstream breaker will have 175 milliseconds to clear the fault before the upstream Digitrip MV is allowed to react to that same fault.

Zone interlocking, therefore, provides fast tripping in the zone of protection, but gives positive coordination between mains, feeders and downstream breakers. For faults outside the zone of protection, the Digitrip MV on the breaker nearest the fault sends an interlocking signal to the Digitrip MV protective devices of the upstream breakers. This interlocking signal restrains tripping of the upstream breakers until their set coordination times are reached. Thus zone interlocking, applied correctly, can result in minimum damage with a resultant minimum disruption of service.

Zone selective interlocking is available on Digitrip MV trip units for the long time and short time functions on the phase and ground elements. Refer to Figure 4-1 for a typical phase zone selection interlocking wiring diagram or refer to Figure 4-2 for a typical ground zone selection interlocking wiring diagram.

4-3 CONCLUSION

This brief discussion shows users the capabilities of the Digitrip MV Trip Unit and the new logical approach to practical system coordination. The principles of application demonstrated indicate that the full latitude of the Digitrip MV Trip Unit functions can only be fully appreciated by working out more coordination exercises. A user may begin coordinating the trip unit by tracing its printed curves, as is the present day practice for tracing non-linear curves. As familiarity is gained, a switch to logical implementation is likely to follow.



NOTES:

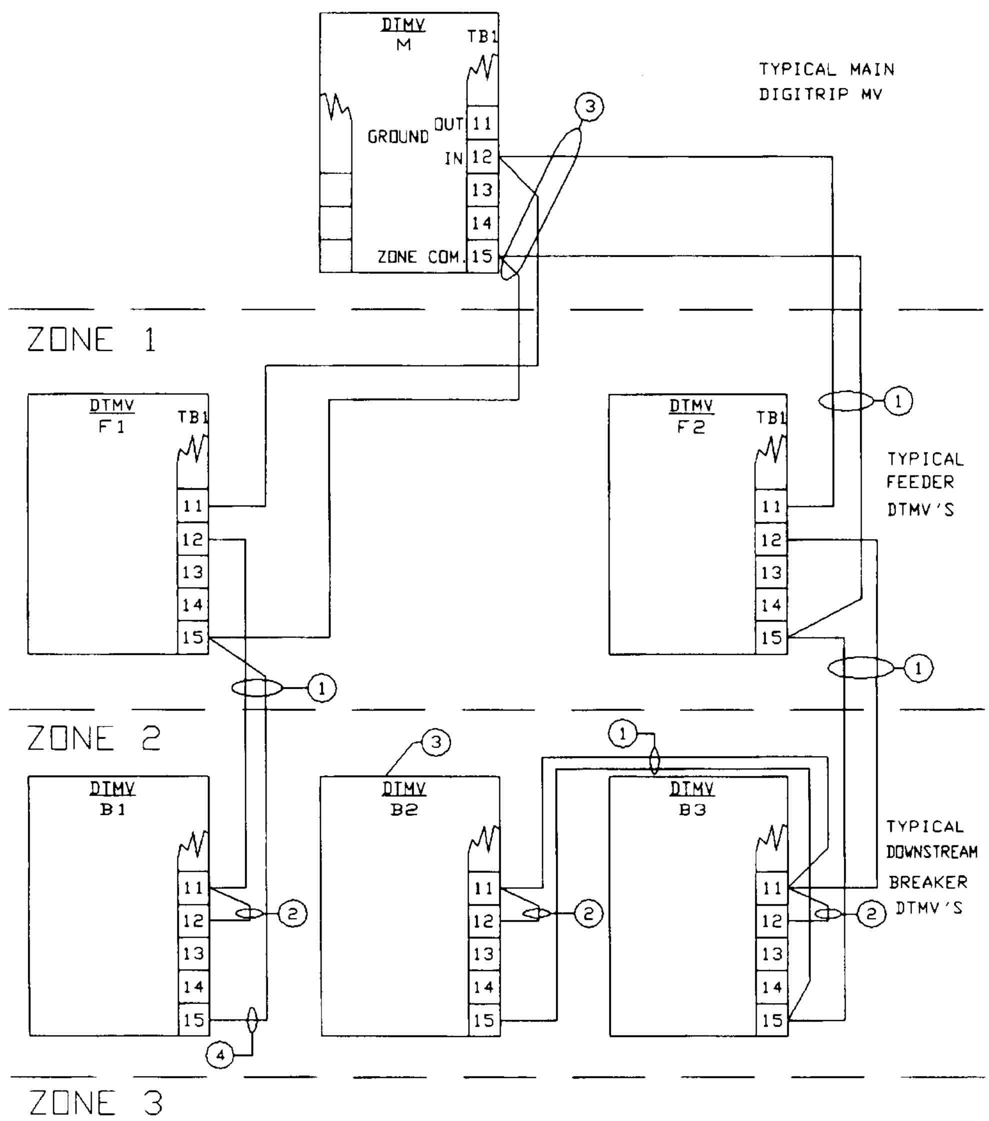
① FOR PHASE ZONE INTERCONNECTION CABLE, SEE CABLE SPECIFICATIONS ON FIG. 3-1. MAXIMUM DISTANCE BETWEEN FIRST AND LAST ZONE SHOULD BE 250 FEET. ROUTE SEPARATE FROM POWER CONDUCTORS.

② JUMPER ON DEVICES IN LAST ZONE USED TO PROVIDE TIME DELAY PER LONG DELAY OR SHORT DELAY TIME SETTING. IF JUMPER NOT USED DIGITRIP MV WILL INITIATE TRIP WITHOUT TIME DELAY (NOMINALLY 0.1 SECONDS).

③ UP TO 10 DIGITRIP DEVICES MAY BE WIRED IN PARALLEL TO PROVIDE A SINGLE UPSTREAM RESTRAINT SIGNAL.

④ ONLY 1 ZONE COMMON USED FOR BOTH PHASE AND GROUND. **DO NOT CONNECT ZONE COMMON TO EARTH GROUND.**

Figure 4-1 *Connection Diagram for Typical Phase Zone Selective Interlocking*



NOTES:

① FOR GROUND ZONE INTERCONNECTION CABLE, SEE CABLE SPECIFICATIONS ON FIG. 3-1. MAXIMUM DISTANCE BETWEEN FIRST AND LAST ZONE SHOULD BE 250 FEET. ROUTE SEPARATE FROM POWER CONDUCTORS.

② JUMPER ON DEVICES IN LAST ZONE USED TO PROVIDE TIME DELAY PER LONG DELAY OR SHORT DELAY TIME SETTING. IF JUMPER NOT USED DIGITRIP MV WILL INITIATE TRIP WITHOUT TIME DELAY (NOMINALLY 0.1 SECONDS).

③ UP TO 10 DIGITRIP DEVICES MAY BE WIRED IN PARALLEL TO PROVIDE A SINGLE UPSTREAM RESTRAINT SIGNAL.

④ ONLY 1 ZONE COMMON USED FOR BOTH PHASE AND GROUND. **DO NOT CONNECT ZONE COMMON TO EARTH GROUND.**

Figure 4-2 *Connection Diagram for Typical Ground Zone Selective Interlocking*

SECTION 5: INSTALLATION, STARTUP AND TESTING

5-1 INTRODUCTION

This section describes mounting, wiring, startup and miscellaneous testing details associated with the Digitrip MV Trip Unit.

WARNING

INSURE THAT THE INCOMING AC POWER AND FOREIGN POWER SOURCES ARE TURNED OFF AND LOCKED OUT BEFORE PERFORMING ANY WORK ON THE DIGITRIP MV TRIP UNIT OR ITS ASSOCIATED EQUIPMENT. FAILURE TO OBSERVE THIS PRACTICE COULD RESULT IN SERIOUS INJURY, DEATH AND/OR EQUIPMENT DAMAGE.

5-2 PANEL PREPARATION

This section describes the panel preparation and mounting of the Digitrip MV Trip Unit.

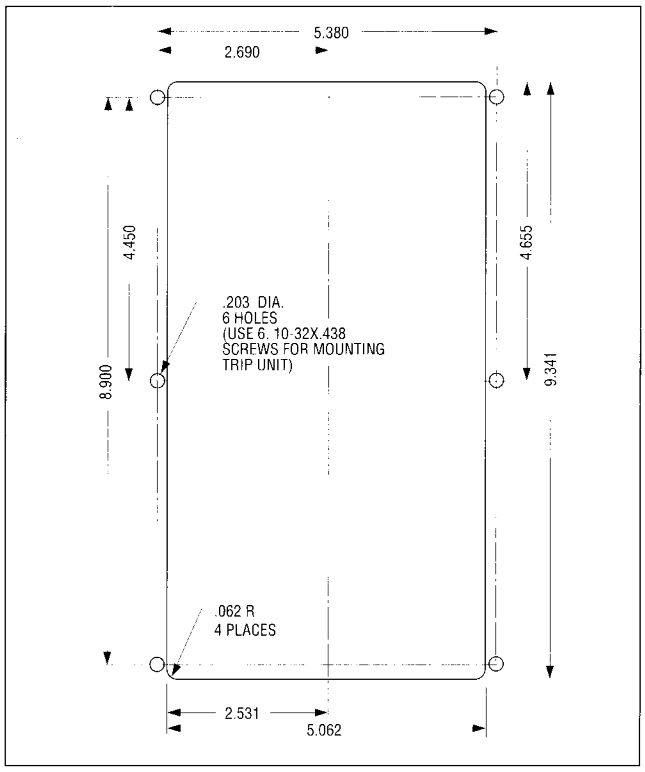


Figure 5-1 *Cutout Dimensions (Inches)*

5-2.1 CUTOUT

Since the Digitrip MV Trip Unit is typically mounted on a cabinet door, it is necessary to prepare a cutout in which it will be placed. The dimensions for this cutout, along with the location of the six mounting holes, are shown in Figure 5-1. Before actually cutting the panel, be sure that the required 3-dimensional clearances for the trip unit chassis allow mounting in the desired location. Digitrip MV Trip Unit dimensions are shown in Figure 5-2.

It is necessary to hold the tolerances shown when making the cutouts and placing the holes for the mounting screws. In particular, the horizontal dimensions between the center of the mounting holes and the vertical edge of the cutout must be within 0 and +0.050 in. (0.13 cm).

5-2.2 MOUNTING

Do not use a tap on the face of the trip unit since this will remove excessive plastic from the holes, resulting in less threaded material to secure the trip unit to it mounting panel.

Place the Digitrip MV Trip Unit through the cutout in the panel. Be sure the Operator Panel faces outward. Use the 0.38 in. (0.9 cm) long screws included with the trip unit to mount the unit on a single-thickness panel. Be sure to start the screws from INSIDE the panel, so they go through the metal first.

Note: *When field installing an INCOM-PONI module, be certain to carefully follow all the installation instructions supplied with the PONI module.*

5-3 WIRING

The wiring of the Digitrip MV Trip Unit must follow a suitable "wiring plan drawing." The term wiring plan, as used here, refers to the drawings made for the specific application. It describes all electrical connections between the Digitrip MV Trip Unit and external equipment. This drawing is made by the user. It may also be helpful to refer to the trip unit's specific wiring diagram shown in Figure 3-1. An example of a typical wiring plan is shown in Figure 2-1. Note the following:

1. The wires to the terminal blocks must not be larger than AWG No. 14. Larger wire will not connect properly to the terminal block. However, larger size wires can be used for the CT connections, with appropriate ring terminal.

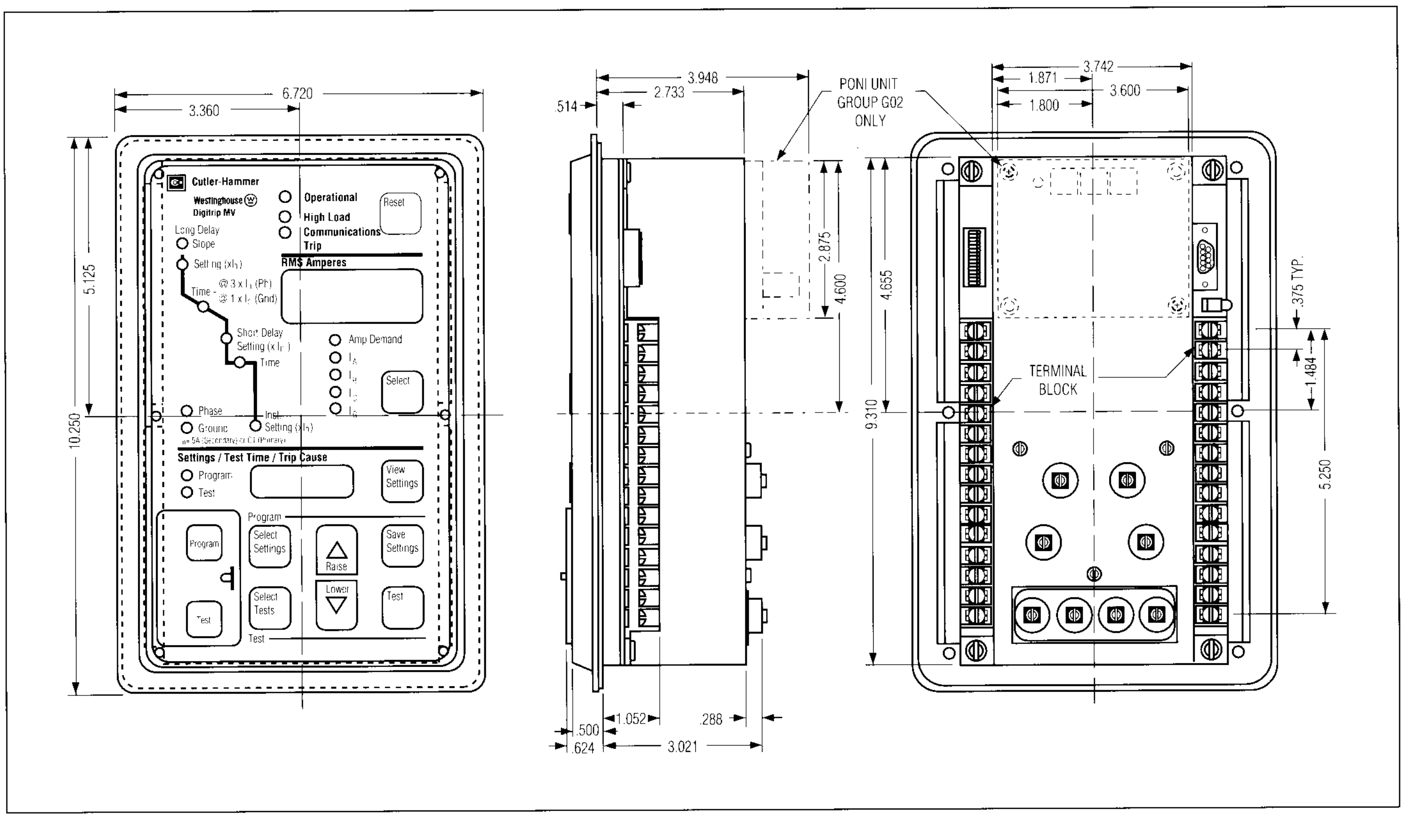


Figure 5-2 *Digitrip MV Trip Unit Dimensions (Inches)*

2. The terminal block has No. 6-32 sems pressure saddle screws.

3. All contacts are shown in their de-energized position. Note that the Protection Off Alarm Relay is energized when control power is applied.

4. The Digitrip MV comes with zone interlocking jumpers installed (TB1 Terminals 11 to 12 and 13 to 14). Depending on the application of zone interlocking, these jumpers may have to be removed.

All wiring must conform to applicable federal, state and local codes.

5-4 INITIAL STARTUP

The information here is intended to be used when first applying control power to the Digitrip MV Trip Unit.

5-4.1 BEFORE POWER APPLICATION

a) Verify that all wiring is correct, as shown on the wiring plan drawing.

b) If a field installed optional PONI module is to be used, connect it to the trip unit with the control power off.

c) Set the DIP switches per Tables 5.1, 5.2 and 5.3. Table 5.1 Dip Switch Settings for Phase Current Transformer.

5-4.2 INITIAL POWER APPLICATION

a) Apply control power to the Digitrip MV Trip Unit. Refer to Paragraph 3-2 entitled "Power-up And Self Testing."

b) Insure that the Operational LED on the front of the trip unit is blinking green.

Table 5.1 *Dip Switch Settings for Phase Current Transformer*

CT Primary	S1	S2	S3	S4	S5
50	OFF	OFF	OFF	OFF	OFF
75	ON	OFF	OFF	OFF	OFF
100	ON	ON	ON	ON	ON
150	OFF	ON	ON	ON	ON
200	ON	OFF	ON	ON	ON
250	OFF	OFF	ON	ON	ON
300	ON	ON	OFF	ON	ON
400	OFF	ON	OFF	ON	ON
500	ON	OFF	OFF	ON	ON
600	OFF	OFF	OFF	ON	ON
630	OFF	ON	OFF	OFF	OFF
800	ON	ON	ON	OFF	ON
1000	OFf	ON	ON	OFF	ON
1200	ON	OFF	ON	OFF	ON
1250	ON	ON	OFF	OFF	OFF
1500	OFF	OFF	ON	OFF	ON
1600	ON	ON	OFF	OFF	ON
2000	OFF	ON	OFF	OFF	ON
2400	ON	OFF	ON	ON	OFF
2500	ON	OFF	OFF	OFF	ON
3000	OFF	OFF	OFF	OFF	ON
3200	ON	ON	ON	ON	OFF
4000	OFF	ON	ON	ON	OFF

Table 5.2 *Dip Switch Settings for Ground Current Transformer*

CT Primary	S6	S7
Same as Phase	ON	ON
50	OFF	ON
100	ON	OFF
400	OFF	OFF

Table 5.3 *Miscellaneous Dip Switch Setting*

Feature	S8	S9	S10
Enable Download Set Point	ON	XXX	SPARE
Disable Download Set Point	OFF	XXX	SPARE
Auto Reset	XXX	ON	SPARE
Manual Reset	XXX	OFF	SPARE

5-5 MISCELLANEOUS TESTING

CAUTION

DO NOT PERFORM DIELECTRIC TESTING BETWEEN THE DIGITRIP'S METAL BACKPLATE OR THE EARTH GROUND TERMINAL (TB1-4) AND EITHER OF THE CONTROL VOLTAGE INPUT TERMINALS (TB1-5,TB1-6) AND AUXILIARY "52B" INPUT TERMINALS (TB1-9, TB1-10). BOTH OF THESE SETS OF TERMINALS HAVE SURGE PROTECTION MOVS INSTALLED TO EARTH GROUND AND COULD BE ADVERSELY AFFECTED BY SUCH TESTING.

Dielectric Notes:

1. The current transformer input terminals labeled (A1,A2), (B1,B2), (C1,C2) and (G1,G2) are 5 ampere type current, transformer inputs. These inputs have a 3000 volt ac breakdown rating for 1 minute between phases.

2. The relay output contacts COMMUNICATIONS CLOSE, TRIP INST AND TRIP OC/COMMUNICATIONS have a 2000 volt ac breakdown rating for 1 minute between open contacts. The relays trip alarm and protection off alarm have a 1000 volt ac breakdown rating.

3. All other terminals have a 1500 volt ac breakdown voltage for 1 minute to earth ground except for the above CAUTION restraint.

SECTION 6: MAINTENANCE AND STORAGE

6-1 GENERAL

The Digitrip MV Trip Unit is designed to be a self contained and maintenance free unit. The printed circuit boards are calibrated and conformally coated at the factory. They are intended for service by factory trained personnel only. The Troubleshooting Guide (Table 6-1) is intended for service personnel to identify whether a problem being observed is external or internal to the unit. If a problem is identified to be internal, the unit should be returned to the factory for repair or replacement as described in Paragraph 6-3.

6-1.1 STORAGE

The Digitrip MV trip Unit should be stored in an environment that does not exceed the specified storage temperature range of -40°C to +70°C. The environment should also be free of excess humidity. There are no aluminum electrolytic capacitors used in the trip unit, therefore it is not a requirement to power the unit occasionally. If possible, the trip unit should be stored in its original packing material and container.

6-2 TROUBLESHOOTING GUIDE (TABLE 6-1)

⚠ WARNING

ALL MAINTENANCE PROCEDURES MUST BE PERFORMED ONLY BY QUALIFIED PERSONNEL WHO ARE FAMILIAR WITH THE DIGITRIP MV TRIP UNIT, THE ASSOCIATED BREAKER AND CURRENT LINES BEING MONITORED. FAILURE TO OBSERVE THIS WARNING COULD RESULT IN SERIOUS INJURY, DEATH AND/OR EQUIPMENT DAMAGE.

TROUBLESHOOTING PROCEDURES MAY INVOLVE WORKING IN EQUIPMENT AREAS WITH EXPOSED LIVE PARTS WHERE THE HAZARD OF A FATAL ELECTRIC SHOCK IS PRESENT. PERSONNEL MUST EXERCISE EXTREME CAUTION TO AVOID INJURY OR EVEN DEATH.

ALWAYS DISCONNECT AND LOCK OUT THE CURRENT SOURCE AND CONTROL POWER SUPPLY BEFORE TOUCHING THE COMPONENTS ON THE REAR OF THE DIGITRIP MV TRIP UNIT.

6-3 REPLACEMENT

Follow these procedural steps to replace the Digitrip MV Trip Unit.

Step 1: Turn off control power at the main disconnect or isolation switch of the control power supply. If the switch is not located in view from the trip unit, lock it out to guard against other personnel accidentally turning it on.

Step 2: Verify that all "foreign" power sources wired to the trip unit are deenergized. These may also be present on the alarm terminal block. Current transformer inputs must be temporarily shorted at a point prior to the trip unit's terminals before attempting to open these terminals on the Digitrip MV trip unit.

Step 3: Before disconnecting any wires from the unit, make sure they are individually identified to assure that reconnection can be correctly performed. Make a sketch to help with the task of terminal and wire identification.

Step 4: If an optional cable connects with the Communications Port, carefully disconnect it.

Step 5: Remove wires by loosening or removing the screw terminal where there is a wire connection.

Step 6: Remove the 6 mounting screws holding the unit against the door or panel. These are accessed from the rear of the trip unit.

⚠ CAUTION

SUPPORT THE TRIP UNIT FROM THE FRONT SIDE WHEN THE SCREWS ARE LOOSENED OR REMOVED. WITHOUT SUCH SUPPORT, THE TRIP UNIT COULD FALL OR THE PANEL COULD BE DAMAGED.

Step 7: Carefully lay the screws aside for later use.

Step 8: Mount the replacement unit. Read paragraph 5-2.2 before attempting this.

Step 9: Reverse the procedure outlined in Steps 4 through 6.

Step 10: Using the sketch mentioned in Step 3, replace each wire at the correct terminal. Be sure that each is firmly tightened. Remove temporary shorts on incoming current transformers.

Step 11: Restore control power. Refer to paragraphs 5-4.2 entitled "Initial Power Application."

Table 6.1 *Troubleshooting Guide*

Symptom	Probable Cause	Possible Solution(s)	Reference
Operational LED is Off	Trip Unit's Control Power is Deficient or Absent	Verify that Control Power is Connected Between TB1-5 and TB1-6 and that it is within Specifications	Figure 3-1 and Paragraph 2-3
	Trip Unit is Malfunctioning	Replace the Trip Unit	Paragraph 6-3
Operational LED is On but Does not Blink	Trip Unit's Control Power is Deficient or Absent	Verify that Control Power is Connected Between TBI-5 and TBI-6 and it is within Specifications	Figure 3-1 and Paragraph 2-3
	Trip Unit is Malfunctioning	Replace the Trip Unit	Paragraph 6-3
Operational LED Blinks Red or is any Color other than a Definite Red or Green	Internal Problem Detected	Press Reset Pushbutton	Paragraphs 2-2.1 and 3-2
		Reprogram Setpoints	
		Replace Trip Unit if Symptom Persists	Paragraph 6-3
"PGRM" Appears in Settings Display Window	Setpoints are Invalid	Reprogram Setpoints	Paragraph 3-3.2
	Check sum did not Match	Replace Trip Unit if "PGRM" Reappears After Saving Settings	Paragraph 6-3
"ERR" Appears in Setting	There was an Error During Setpoint Programming	Make Sure the Circuit Breaker Stays Open During Programming Operation	
	There was an Error While in the Test Mode	More than 0.1 Per Unit of Current Cannot Flow While in Test Mode	Paragraph 3-3.3
"RAM" Appears in Settings Display Window	An Internal RAM Check Failed	Remove Power from the Trip Unit and then Reapply Power – If the Symptom Persists, Replace the Trip Unit	Paragraph 6-3
Current Readings Appear Incorrect	Incorrect CT Ratio used in Equipment	Verify CT Ratio in Equipment	
	CT Ratio DIP Switch Set Incorrectly	Check for Proper DIP Switch Setting	Tables 5.1 and 5.2
	Incorrect Current Wiring	Verify Connections on CT Wiring	Figures 3-1 and 5-3
Current Readings Appear Incorrect	Incorrect System Frequency Programmed	Set to Correct Frequency	Paragraph 3-3.2
	Breaker "b" Contact to trip unit not functioning	Insure "b" Contact Type is Connected to Trip Unit and Functioning	Figure 3-1

Table 6.1 *Troubleshooting Guide (continued)*

Symptom	Probable Cause	Possible Solution(s)	Reference
Circuit Breaker Trips Much Faster than Expected on Long Delay	Incorrect Settings	Check Settings	Paragraph 3-3.2 and Tables 5.1 and 5.2
	Phase Zone Interlocking not used and Jumper Missing	Check for Phase Zone Interlocking Jumper Between TB1-13 and TB1-14	Figure 3-1
	Ground Zone Interlocking not Used and Jumper Missing	Check for Ground Zone Interlocking Jumper Between TB1-11 and TB1-12	Figure 3-1
	Zone Interlocking Used	Check for Absence of Blocking Signal from "Down-Stream" Breaker ***NOTE:*** *During an Internal Test, there is No Blocking Signal from a "Down-Stream" Breaker, therefore, add jumper for test.*	Figure 5-3
Circuit Breaker Trips Much Slower than Expected on Long Delay	The Short Delay Time Setting Determines the Minimum Long Delay Time	Check Coordination Curves for Short Delay and Long Delay Settings	Section 7, Paragraph 3-3.1 and Figure 3-12
Trip Unit Indicates a Trip, but Circuit Breaker Doesn't Open	Improper Wiring from Trip Unit	Check Trip Relay Wiring ***NOTE:*** *Instantaneous and Override Trip Functions Close the Contact Between TB2-12 and TB2-13, while Long Delay and External Trip Functions Close the Contact Between TB2-14 and TB2-15*	Figures 3-1 and 5-3
		Check that Trip Contact on Trip Unit makes	Figure 3-1
	Unit in Test Mode with "No Trip Test Selected"	Select Trip Test while in the Test Mode	Paragraph 3-3.3
		Check Wiring from Trip Unit to Circuit Breaker Trip Coil	Wiring Plan Drawing
		Check that Circuit Breaker has Source of Tripping Power	Wiring Plan Drawing
Auto-Reset Function not Operational	Breaker "b" Contact to Trip Unit not Functioning	Check wiring from Breaker "b" Dry Contact to TB1-9 and TB1-10 of Trip Unit Terminal Block	Figure 3-1 and 5-3
	DIP Switch S9 not set correctly	Check DIP Switch S9 Setting	Table 5.3
		Check that "b" Contact is Operational	Figure 5-3
Caution: When the Digitrip MV Trip Unit is Powered, it Supplies Voltage to the "b" Contacts			
Manual Reset Function not Operational	Dip Switch S9 not set correctly	Check the Switch Setting	Table 5.3
	Damaged Reset Pushbutton	Replace Trip Unit	Paragraph 6-3

SECTION 7: TIME-CURRENT CURVES

The specific time-current curves applicable to the Digitrip MV Trip Unit are included in this section.

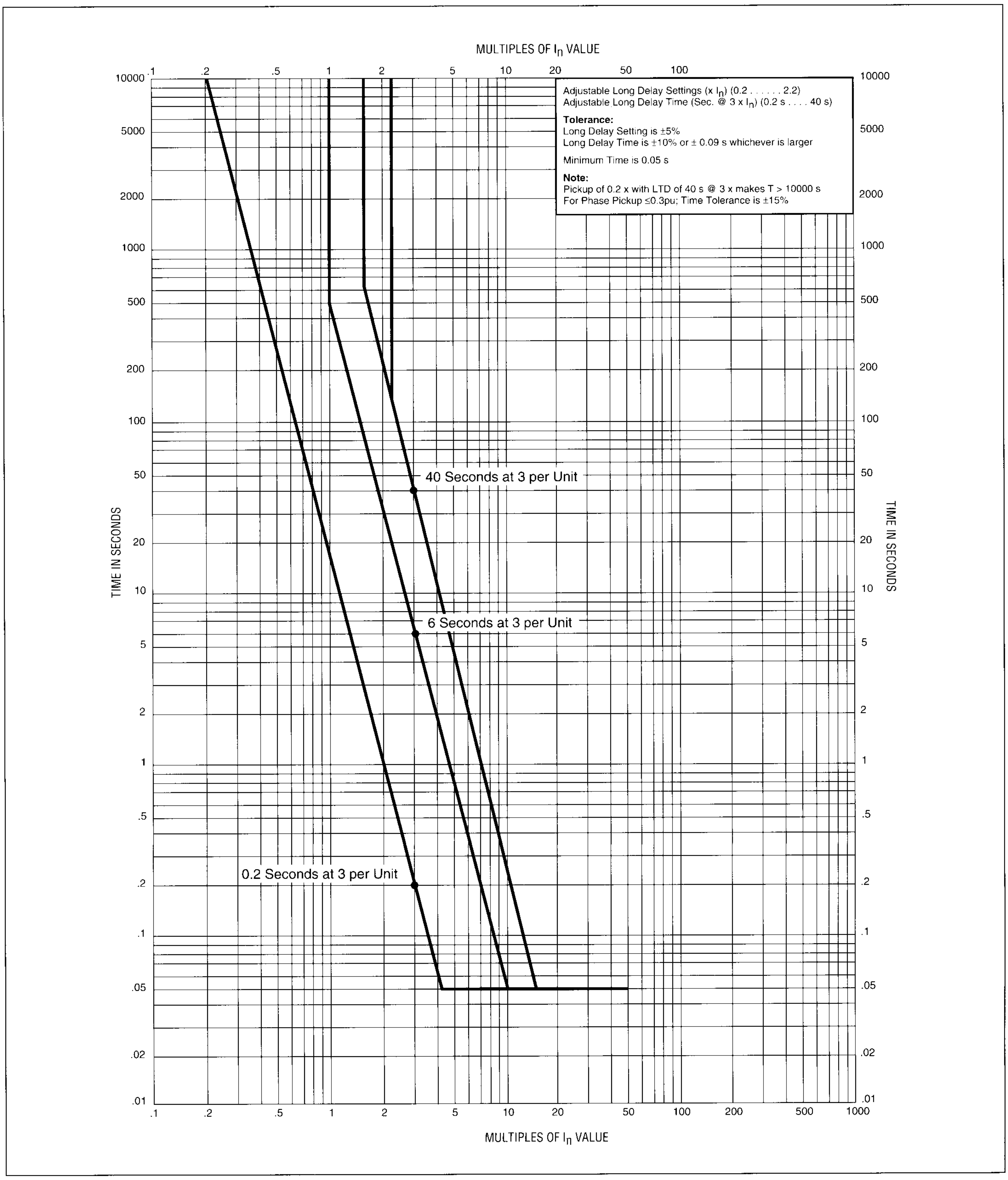


Figure 7-1 *Long Delay Phase, I^4T Curves (SC-5390-92-A)*

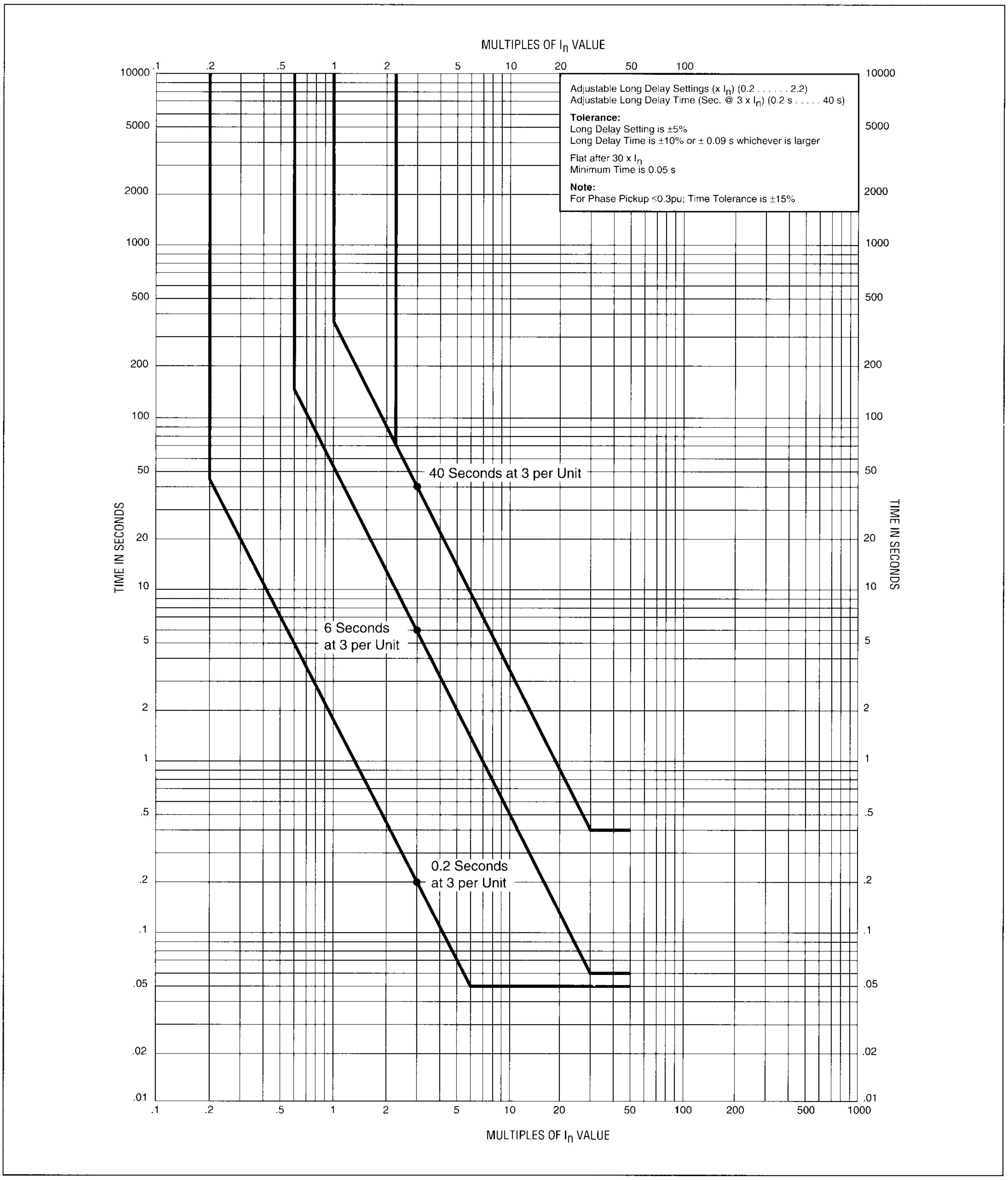


Figure 7-2 *Long Delay Phase, I^2T Curves (SC-5391-92-A)*

E·T·N

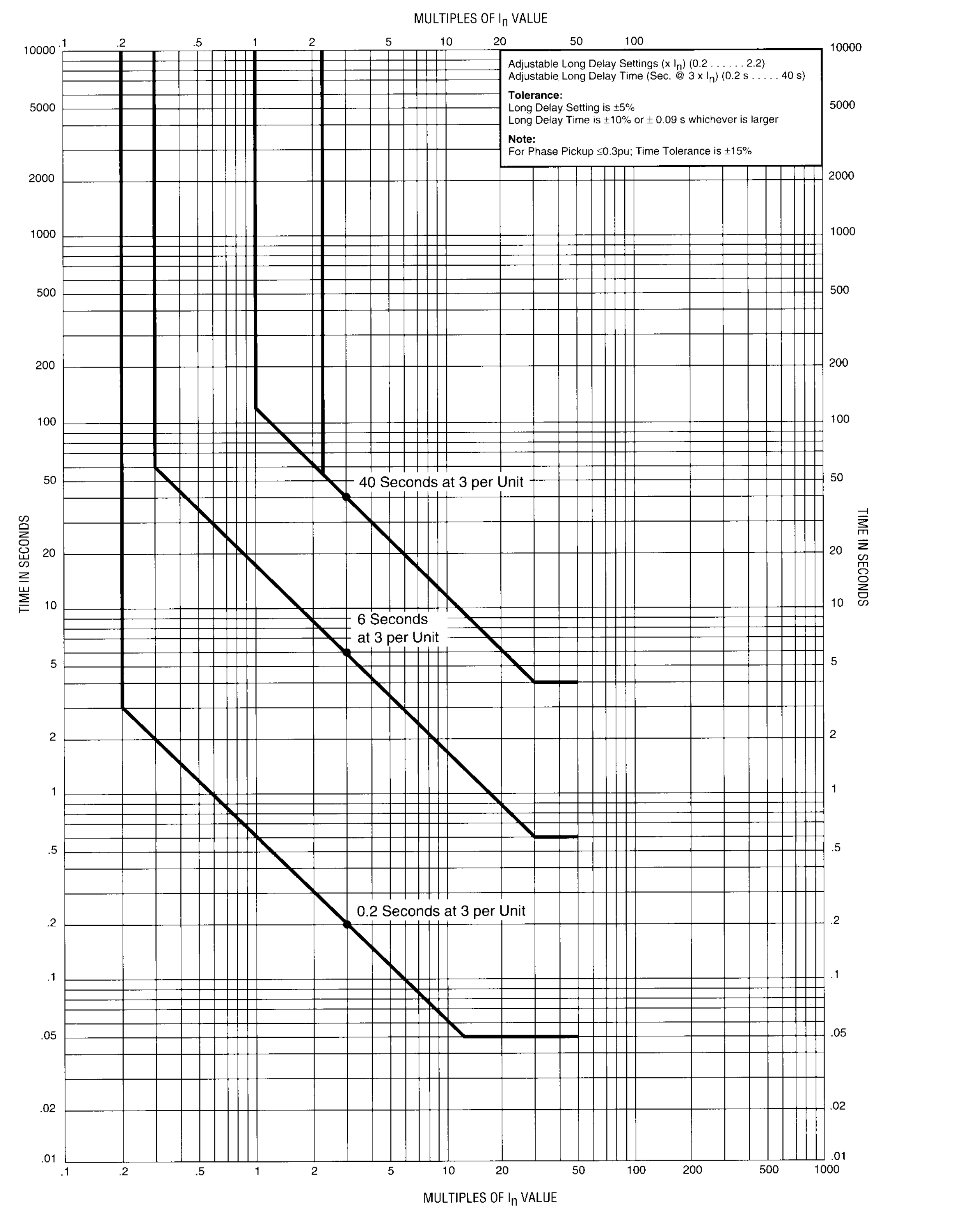


Figure 7-3 *Long Delay Phase, IT Curves (SC-5392-92-A)*

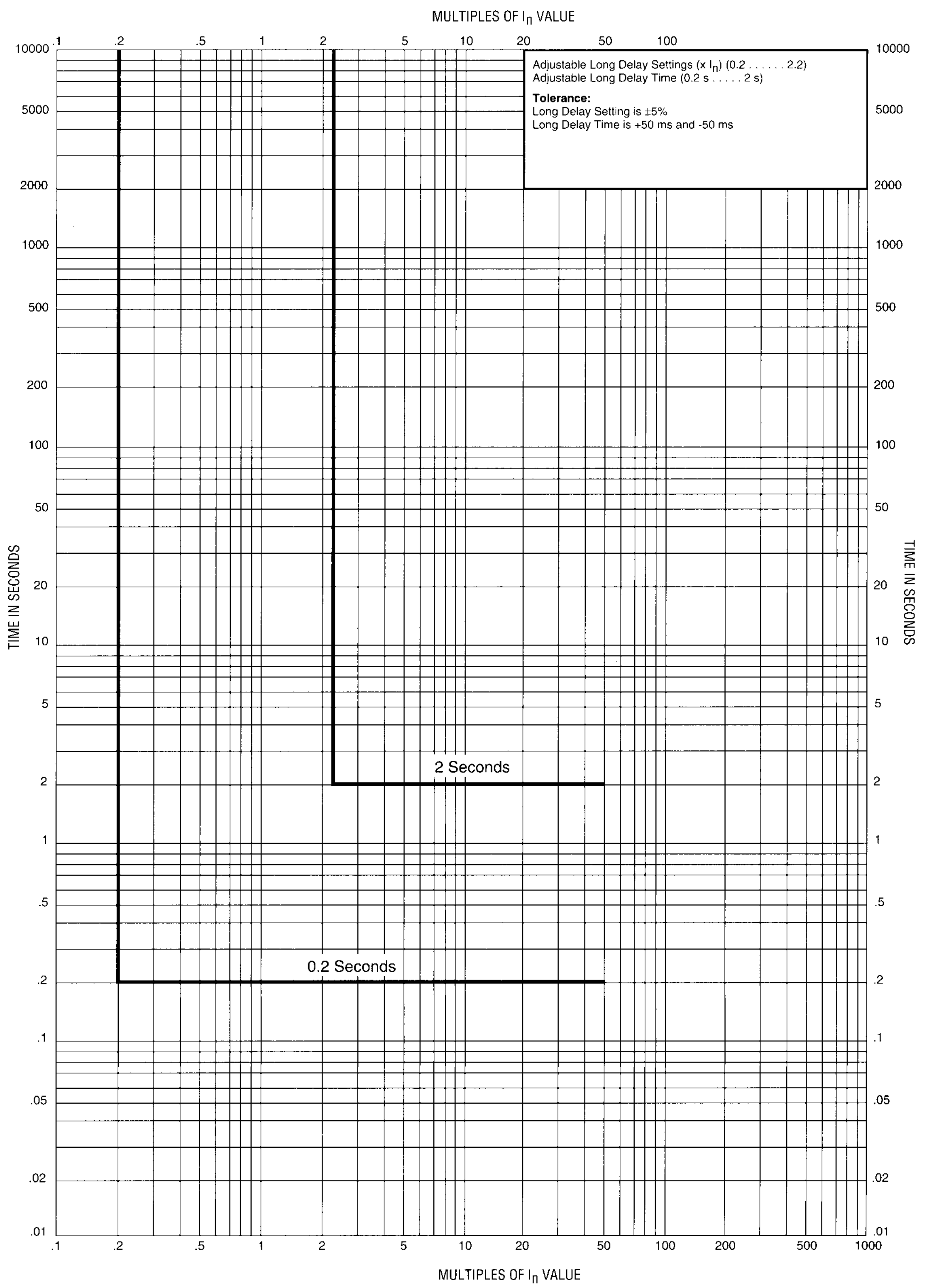


Figure 7-4 *Long Delay Phase, Flat Curves (SC-5393-92)*

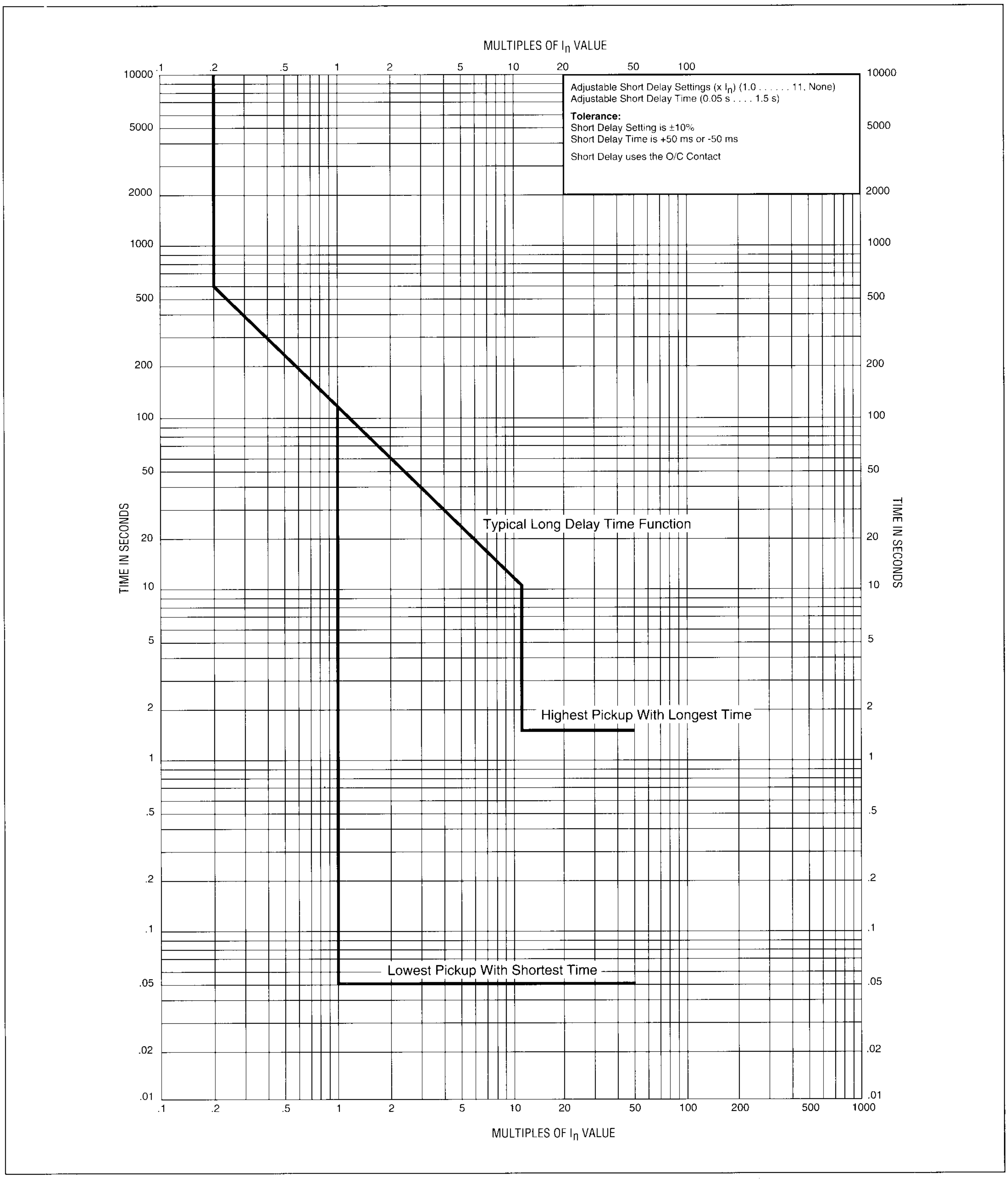


Figure 7-5 *Short Delay Phase Curves (SC-5394-92)*

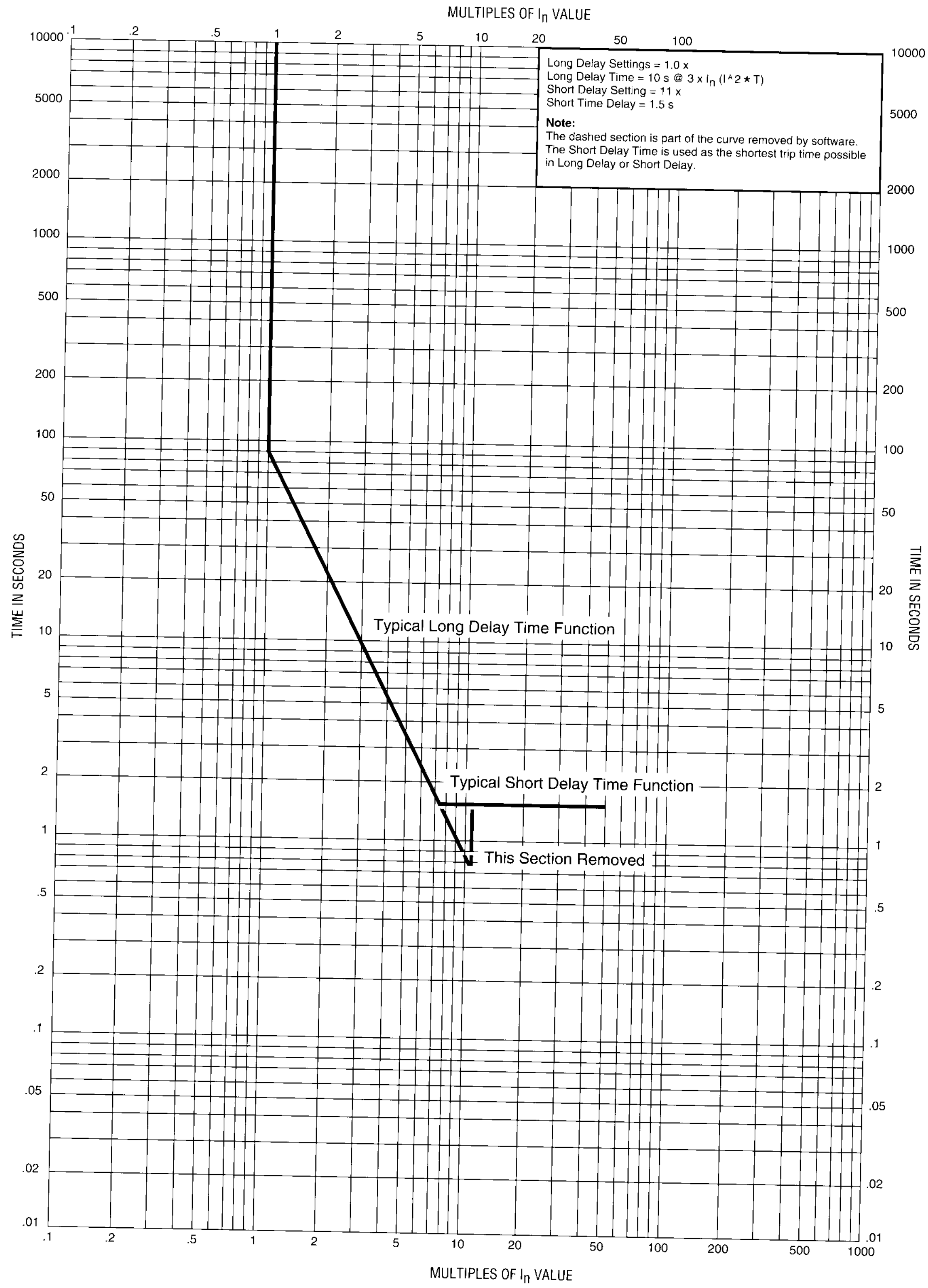


Figure 7-6 *Long Delay/Short Delay Curves (SC-5395-92)*

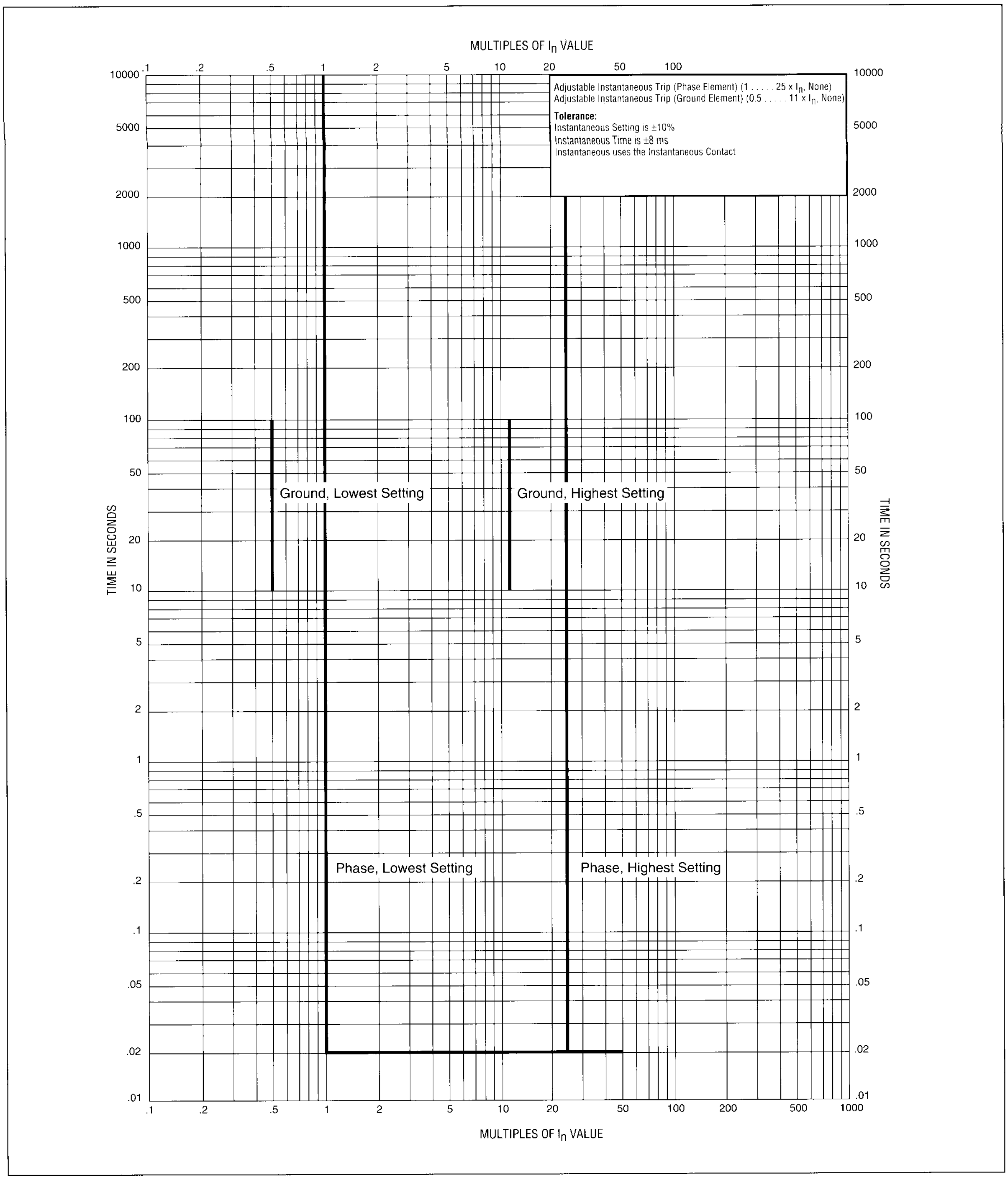


Figure 7-7 *Instantaneous Curves (SC-5396-92)*

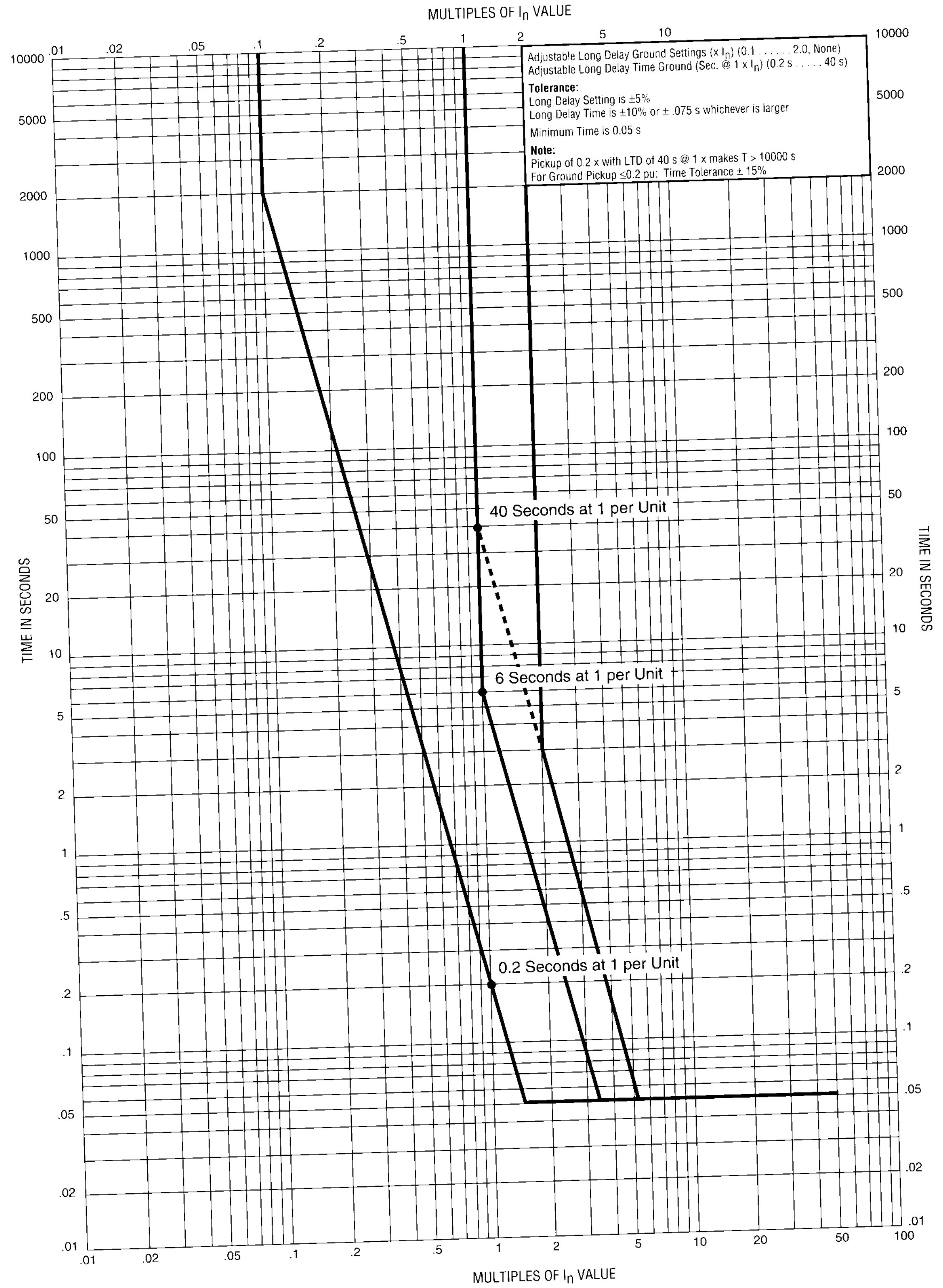


Figure 7-8 *Long Delay Ground, I^4T Curves (SC-5399-92-A)*

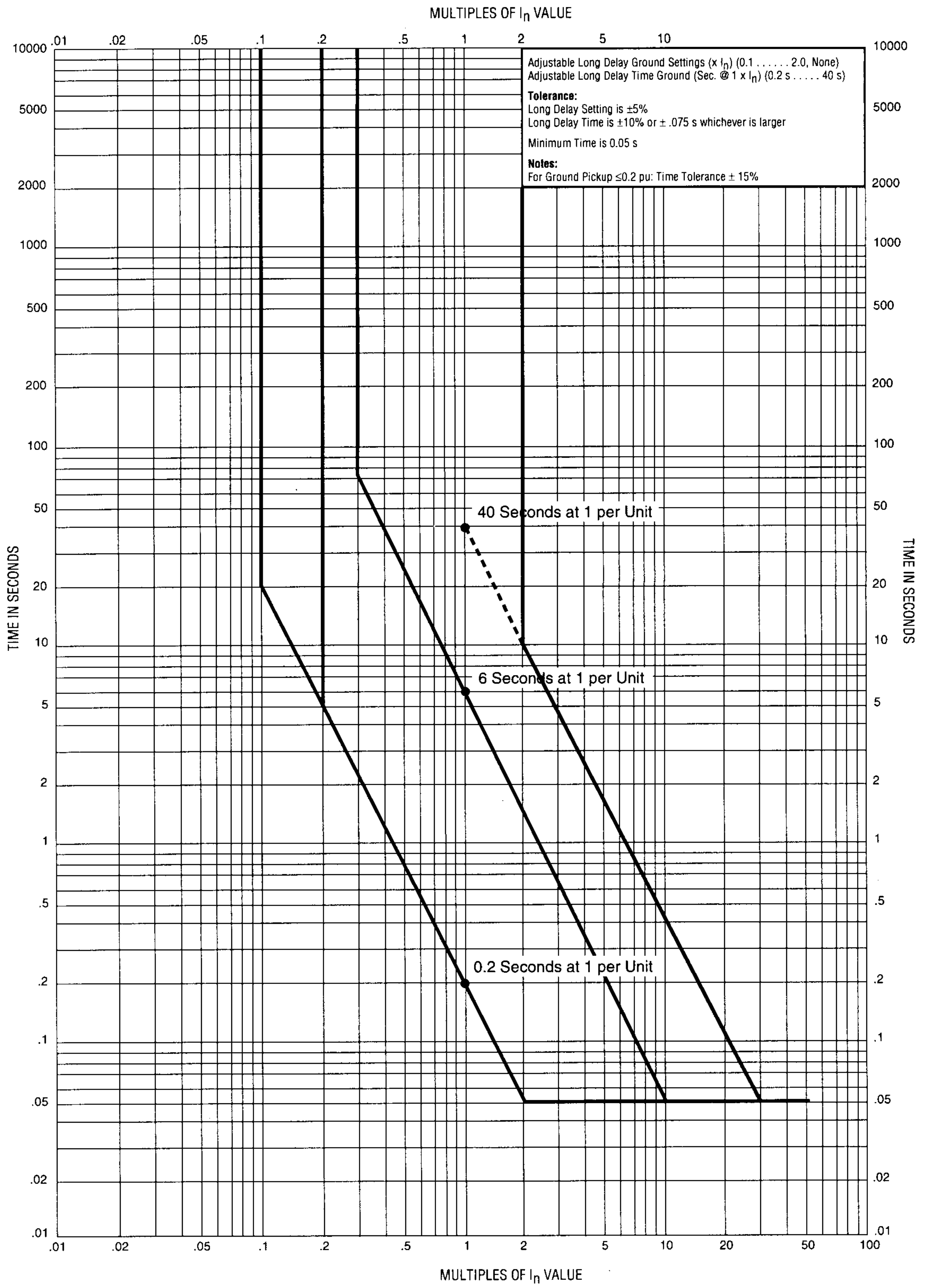


Figure 7-9 *Long Delay Ground, I^2T Curves (SC-5400-92-A)*

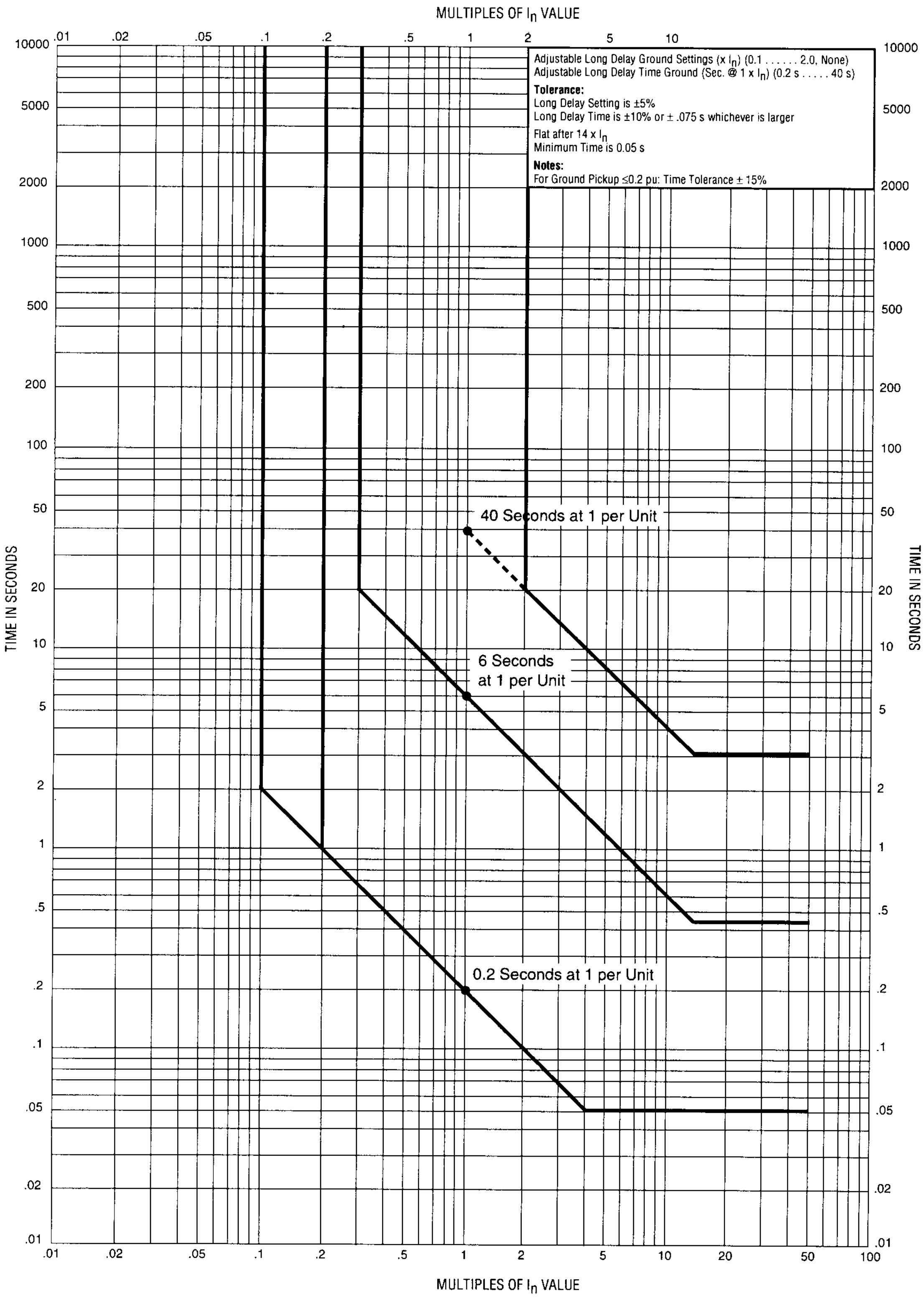


Figure 7-10 *Long Delay Ground, IT Curves (SC-5401-92-A)*

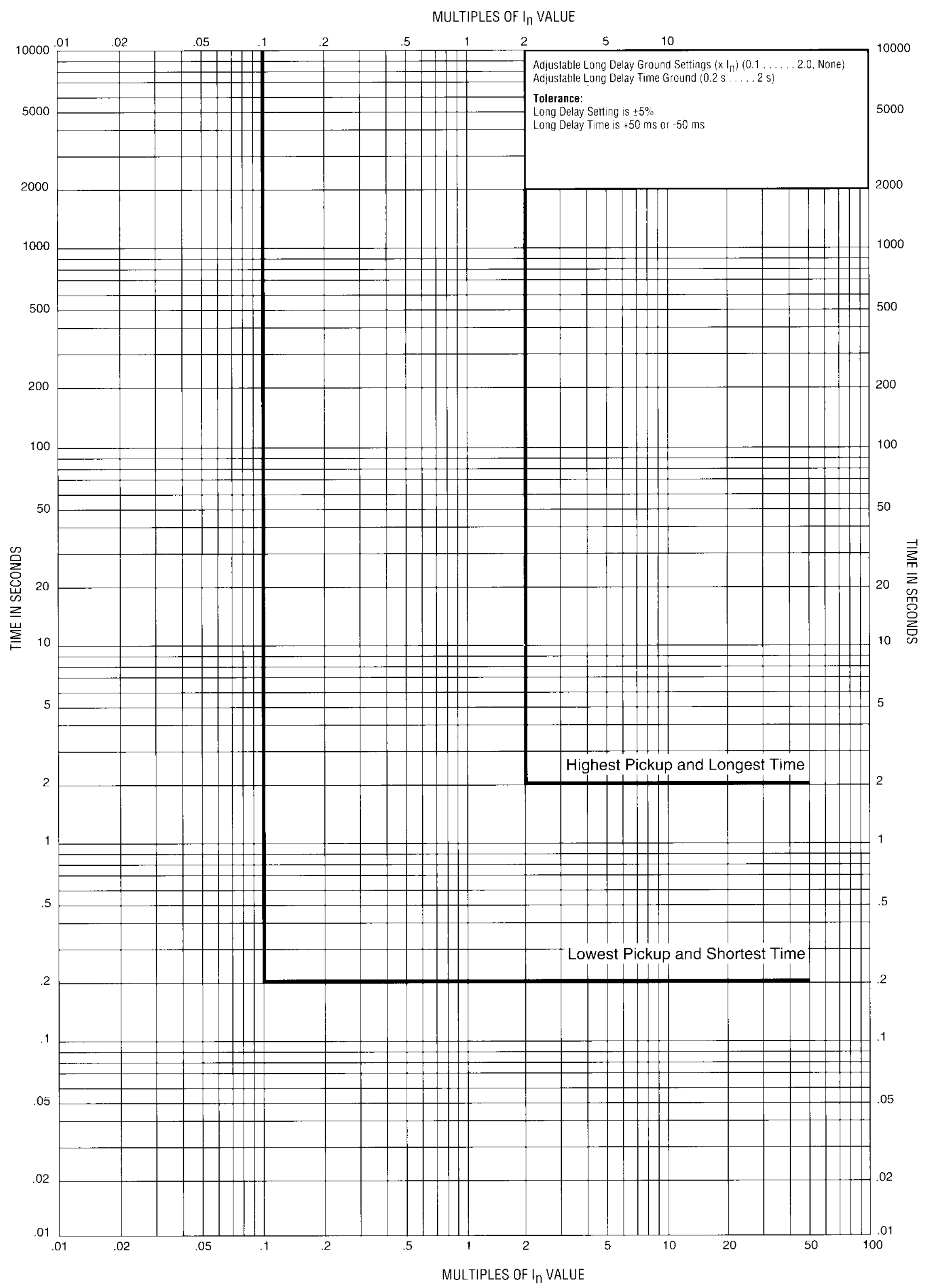


Figure 7-11 *Long Delay Ground, Flat Curves (SC-5402-92)*

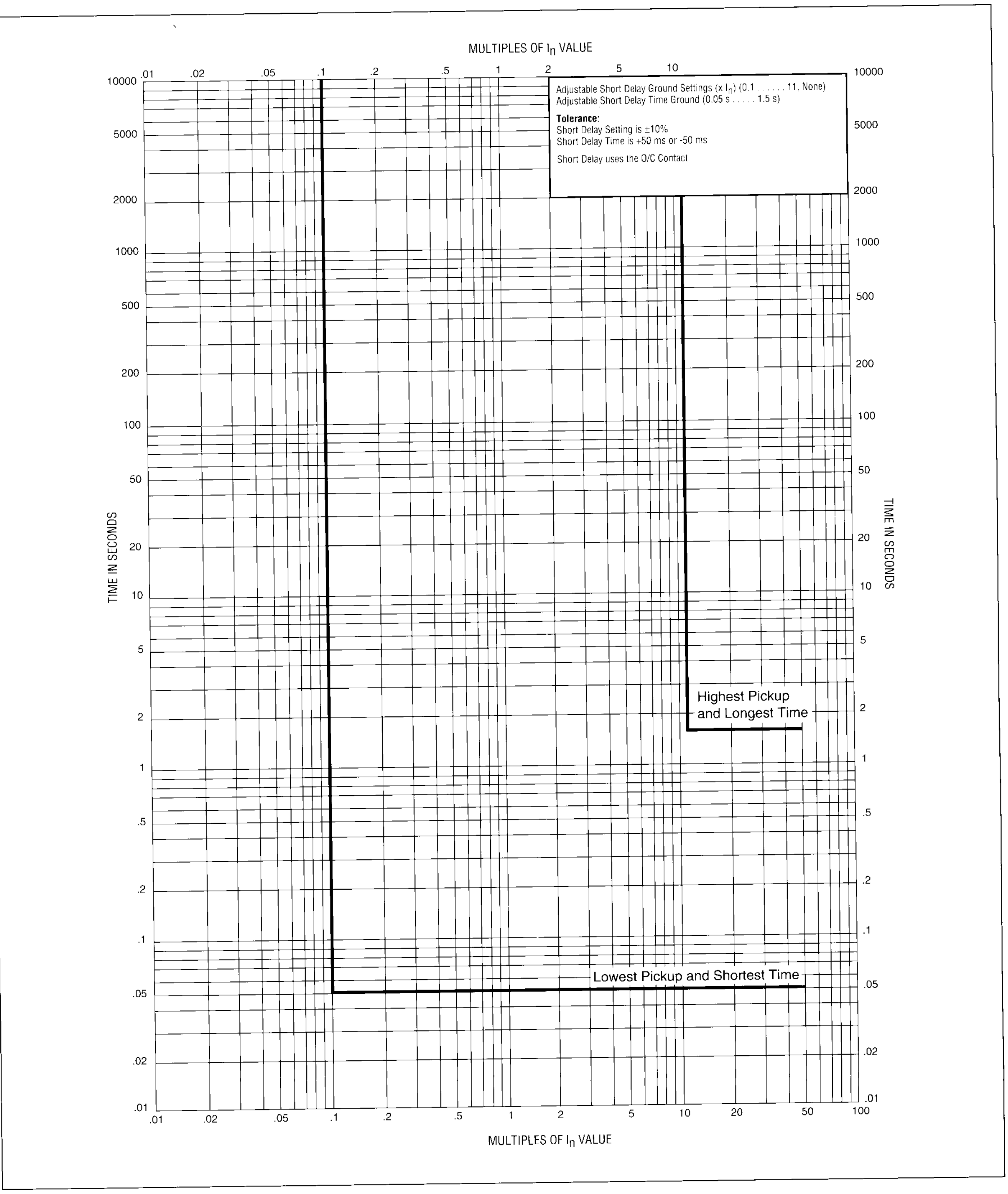


Figure 7-12 *Short Delay Ground Curves (SC-5403-92)*

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Effective 12/95
Printed in U.S.A./CCI

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