



LPS-O

Line Protection™ System

Instruction Manual

LPS-O Revision: V0001.03AA20

Manual P/N: GEK-106266A

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Note: All relays must be powered up at least once per year to avoid deterioration of electrolytic capacitors and subsequent relay failure.

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Manufactured under an
ISO9002 Registered system.

These instructions do not purport to cover all details or variations in equipment nor provide for every possible contingency to be met in connection with installation, operation, or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purpose, the matter should be referred to the General Electric Company.

To the extent required the products described herein meet applicable ANSI, IEEE, and NEMA standards; but no such assurance is given with respect to local codes and ordinances because they vary greatly.

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Before attempting to install or use this relay, it is imperative that all WARNINGS and CAUTIONS in this manual are reviewed to help prevent personal injury, equipment damage, and/or downtime.

Unpack the relay, the mounting brackets, and the hardware for attaching the mounting brackets to the sides of the relay. Examine the relay for any damage sustained in transit, and if damage is evident, notify the shipping company and the nearest GE sales office immediately.

Prior to applying power, ensure that the model number of the relay listed on the front panel corresponds to the model ordered. Make sure that the DC supply power matches the rated voltage listed on the front panel. Refer to the elementary diagram in Figure 1–11: ELEMENTARY DIAGRAM on page 1–25 for the locations of the DC power inputs

Instructions on how to use the keypad to change settings and put the relay into test mode can be found in Section 4.1.7: SETTING CHANGES on page 4–3. Complete instructions on how to operate the keypad are found in Chapter 8: LOCAL USER INTERFACE.

GE Power Management contact information:

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1.1.2 PASSWORDS: FACTORY SET

The LPS-O relay requires the use of passwords to change Settings or to perform Actions. No password is required to obtain information from the relay, including viewing the existing settings. The relay is shipped from the factory with the following Local User Interface (LUI) passwords:

SETTINGS: 123.

ACTIONS: 456.

MASTER: 789.

NOTE: The decimal point following the digits is part of the password. Factory passwords MUST be changed before the user can modify settings or initiate Actions.

To change the default password, follow these steps:

1. Press the ACTIONS [ACT] key.
2. Press the ENTER [ENT] key.
3. Scroll to the **CHANGE PASSWORD** option.
4. Select the Password Privilege level to be changed.
5. Press [ENT].
6. Enter the factory password (for example: 789. for Master Password).

7. Enter your password.
8. Re-enter your password.
9. Press [END], press [ENT], then press [CLR].

The keypad passwords stored in the relay may be viewed, in encoded format, via remote communications.

1.1.3 REMOTE COMMUNICATIONS VIA LOCAL PC

To communicate with the relay via a local PC, connect the relay to a serial port of an IBM compatible computer with a null-modem cable. Connection can be made either to the 25 pin D-connector on the back of the relay (PL2A) or the 9 pin D-connector on the front (PL1). Detailed cable diagrams are shown in the following figures:

- Figure 8–2: MODEM CABLE on page 8–26
- Figure 8–3: 25-PIN NULL MODEM CABLE on page 8–26
- Figure 8–4: 25-PIN NULL MODEM CABLE on page 8–30
- Figure 8–5: NULL MODEM CABLE FOR PORT PL1 on page 8–30

The communications software required to access the relay, LPSO-Link, is included on the accompanying GE Power Management Products CD. Follow instructions in Section 11.2.4: SOFTWARE INSTALLATION on page 11–4 to load LPSO-Link onto the PC.

1.1.4 PASSWORDS WITH LPSO-LINK

The LPSO-Link program requires the use of passwords to obtain information from the relay, to change Settings, or to perform Actions. The relay is shipped from the factory with the following communications passwords:

VIEW: VIEW!

SETTINGS: SETTING!

ACTIONS: CONTROL!

MASTER: MASTER!

NOTE: The exclamation point following the letters is part of the factory password. The factory passwords MUST be changed before the user can modify Settings or initiate Actions. The user can log into the relay at any password level. After logging into the relay, the password may be changed under the ACTIONS menu by selecting CHANGE PASSWORD.

Before the user can change another password it is necessary to logout from the LPS-O. The user can then change the remaining passwords by first logging into the LPS-O using another default password. The communications passwords may be viewed, in an encoded format, via the keypad with the [INF] (Information) key.

To log into the relay, follow the instructions in Section 4.1.9: USING COMMUNICATIONS (OPTIONAL) on page 4–5. Any one of the factory passwords can be used to log in to the relay. The Unit ID (General Setting 101: **UNITID**) is factory set to 0.

Table 1–1: ORDER CODES FOR THE LPS-O

	LPS	*	*	*	*	*	*	*	*	*	*	*	*	*
Base Unit	LPS													Base Unit
Distance Relay	O													Phase Distance and Ground Overcurrent Relay with Out-of-Step Tripping
Software	B													Revision Level
Tripping Logic	3													Three Phase Tripping Logic
Current Rating	1													1 Ampere rated current
	5													5 Ampere rated current
Series Caps.	U													For applications without series capacitors
Battery	0													48V DC battery voltage
Voltage	1													110/125 V DC battery voltage
	2													220/250 V DC battery voltage
Trip Outputs	1													SCR trip outputs & contact channel interface
	2													Contact trip outputs & contact channel interface
Comm Ports	3													Front RS232 port & 2 settable RS232/RS485 rear ports (GEmodem/ASCII)
Mounting	H													Horizontal mounting
	V													Vertical mounting
Oscillography	E													Extended oscillography memory
OST	1													With out-of-step tripping
Recloser	N													No recloser

EXAMPLE: LPSOB35U23VE1N = LPS-O Digital Line Protection Distance Relay; revision B; three phase tripping logic; rated at 5 amperes; without series capacitor protection; 110/125 VDC supply; contact tripping outputs; 3 communications ports; vertical mounting; with extended memory; with OST functions; and no recloser.

1.2.1 DESCRIPTION

The Line Protection System (LPS) is a microprocessor-based digital relay system that uses waveform sampling with appropriate algorithms to provide three phase tripping schemes for transmission line protection and system backup. The LPS-O models covered by this instruction book are intended for three-phase tripping applications. The LPS-O relay samples the current and voltage inputs from the power system 64 times per cycle. The protection algorithms process the sampled data in sets of four, sixteen times per cycle. The LPS-O relay also uses advanced Fourier calculation techniques and adaptive measuring functions to achieve high-speed tripping for severe faults.

The LPS-O is packaged in a compact 3 Rack Unit high (one RU = 1.75 Inch) 19-inch rack mount case which is available for either horizontal or vertical mounting. The case outline and mounting dimensions for the LPS-O are shown in Figure 3–1: FRONT AND REAR VIEWS OF THE LPS-O on page 3–1.

All models of the LPS-O relay include a full keypad and a liquid crystal display (LCD) for local access to relay data and settings. In addition, up to three communication ports are provided for both local and remote access via a PC. Each port may be independently set for an ASCII protocol or GEmodem protocol.

1.2.2 APPLICATION

The LPS-O is a modified version of the ALPS relay system. It is primarily intended for system backup (Phase impedance) and out-of-step trip protection at generator terminals. The overcurrent and impedance functions of the LPS-O can be used to complement Generator Protection relay systems like the DGP and SR489.

Also, the LPS-O may be used for line protection. It can provide three zones of phase distance and ground overcurrent protection for either solidly grounded or resistance grounded systems where ground distance functions may not provide reliable protection.

The external connections for the LPS-O are shown in the elementary diagram of Figure 1–11: ELEMENTARY DIAGRAM on page 1–25. Note that the relay uses 3-wire voltage inputs and is suitable for either delta or wye connected VTs. All Contact Converter inputs and Contact Outputs of the LPS-O are user configurable. The elementary diagram also shows default assignments of the Inputs/Outputs which can be changed by the user.

The measurement functions included are listed in Table 1–2: LPS-O MEASUREMENT FUNCTIONS.

1.2.3 PROTECTION FUNCTIONS

The measurement functions included are listed in Table 1–2: LPS-O MEASUREMENT FUNCTIONS below.

The Zone 1 distance functions provide secure tripping for all fault types over most of the protected line. The Zone 1 phase distance functions are variable-mho distance functions.

Overreaching Zone 2 phase distance functions can be used for the Step Distance protection scheme. Ground-directional overcurrent functions can be selected to replace or supplement the Zone 2 phase-distance functions in the Step Distance scheme. The Zone 2 phase distance functions are provided with independent timers for time delayed backup protection.

Zone 3 phase distance functions are provided with independent timers for time delayed backup protection.

The Zone 4 variable-mho phase distance functions can be used when a reversed function is required. The Zone 4 phase distance functions are provided with independent timers for time delayed backup protection.

Table 1–2: LPS-O MEASUREMENT FUNCTIONS

Zone or Type	Functions
Zone 1	<ul style="list-style-type: none"> 3 Variable-Mho phase-distance functions with time delay
Zone 2 (Pilot Zone)	<ul style="list-style-type: none"> 3 Variable-Mho phase distance functions with time delay and Ground directional-overcurrent functions consisting of: IPT: Ground Trip overcurrent NT: Negative Sequence Directional Trip IPB: Ground Block overcurrent NB: Negative Sequence directional block
Zone 3	<ul style="list-style-type: none"> 3 Variable-Mho phase-distance functions with time delay
Zone 4	<ul style="list-style-type: none"> 3 Variable-Mho phase-distance functions (reverse looking) with time delay.
Out of Step Blocking (OSB)	3 Variable-Mho phase-distance functions
Overcurrent Backup	50 — Phase-overcurrent direct trip (directional or nondirectional) 50G — Ground-overcurrent direct trip (directional or nondirectional) 51G — Ground time-overcurrent direct trip (directional or nondirectional)
Overcurrent Supervision	IT — Trip-supervision overcurrent IB — Block-supervision overcurrent
Fault Detector	FD
Line-Pickup Overcurrent	I1
Remote-Open Detectors	ROD
Line-Overload Detectors	Level 1 Overcurrent Level 2 Overcurrent
Over/Undervoltage	Three adjustable over or under voltage detectors with time delay
Out of Step Tripping (OST)	3 Variable-Mho positive sequence-distance functions

When phase distance functions are used for a zone of protection, three individual measuring functions are available. The algorithm that implements the variable-mho measuring functions is derived from designs that have evolved through several different families of static analog and digital relay systems which have accumulated decades of dependable and secure in-service experience.

An instantaneous overcurrent tripping function (50G) provides direct tripping for severe phase-to-ground faults. A time-overcurrent tripping function (51G) provides time-delayed backup tripping for phase-to-ground faults. Either or both of these ground-overcurrent functions can be controlled by the NT negative-sequence directional trip unit, at the customer's discretion.

1.3.1 INTRODUCTION

The LPS-O offers a high degree of custom programmability. Custom programming of the LPS-O relay is accomplished using the Xpression Builder software. Xpression Builder is a Windows based program that allows the user to graphically design Programmable Logic and create I/O (Input/Output) assignments for the LPS-O and other GE Power Management relays. Xpression Builder is included on the GE Power Management CD-ROM or may be downloaded from the GE Power Management website. A complete description of the LPS-O custom programming features and Xpression Builder is included in Chapter 13: XPRESSION BUILDER.

1.3.2 CONFIGURABLE INPUTS

All of the contact converters (Digital Inputs) in the LPS-O are user configurable. However, each LPS-O relay is shipped with the Default Contact Converter Assignments shown in Table 1–3: LPS-O DEFAULT CONTACT CONVERTER ASSIGNMENTS below and the elementary diagram Figure 1–11: ELEMENTARY DIAGRAM on page 1–25.

Table 1–3: LPS-O DEFAULT CONTACT CONVERTER ASSIGNMENTS

INPUT	DESCRIPTION	MNEMONIC	INDEX NUMBER	NOTE
CC1	SPARE			
CC2	SPARE			
CC3	SPARE			
CC4	SPARE			
CC5	BKR 1 52b	52B_1A	1	
CC6	BKR 2 52b	52B_2A	4	
CC7	SPARE			
CC8	SPARE			
CC9	SPARE			
CC10	SPARE			
CC11	SPARE			
CC12	SPARE			

1.3.3 CONFIGURABLE OUTPUTS

All of the output relays in the LPS-O, except the alarm output relays, are user-configurable. However, each LPS-O relay is shipped with the Default Output Relay Assignments shown in Table 1–4: LPS-O DEFAULT OUTPUT CONTACT ASSIGNMENTS below and the elementary diagram Figure 1–11: ELEMENTARY DIAGRAM on page 1–25.

Table 1–4: LPS-O DEFAULT OUTPUT CONTACT ASSIGNMENTS

RELAY	DESCRIPTION	MNEMONIC	INDEX NUMBER
T1	TRIP CIRCUIT #1	TRIP	33
T2	TRIP CIRCUIT #2	TRIP	33
T3	TRIP CIRCUIT #3	TRIP	33
T4	TRIP CIRCUIT #4	TRIP	33
T5	SPARE		
T6	SPARE		
A1	MANUAL CLOSE BREAKER 1	MNCLS1	58
A2	MANUAL CLOSE BREAKER 2	MNCLS2	59
A3	BREAKER FAILURE INITIATE #1	TRIP	33
A4	BREAKER FAILURE INITIATE #2	TRIP	33
A5	RECLOSE INITIATE #1	RI	37
A6	RECLOSE INITIATE #2	RI	37
A7	RECLOSE CANCEL	RC	38
A8	OVERLOAD ALARM	LNOVLD	45
A9	ANY ZONE 1 PHASE DISTANCE FUNCTION	Z1PH	77
A10	ANY ZONE 2 PHASE DISTANCE FUNCTION	Z2PH	78
A11	OUT-OF-STEP BLOCKING	OSB	120
A12	OUT-OF-STEP TRIP	OST	121
KT1	SPARE		
KT2	SPARE		
KT3	SPARE		
KT4	SPARE		
C1	NON-CRITICAL ALARM	NCALM	52
C2	PT FUSE FAILURE ALARM	FF	115

1.3.4 PROGRAMMABLE LOGIC

In addition to configurable I/O, the LPS-O relay includes the capability for the design of custom logic. This logic may be used to supplement or to replace the built-in scheme logic. The programmable logic includes the following: up to 40 logic gates (AND, OR, NOT), each with up to 4 inputs; 8 programmable timers, each with a settable pickup and dropout delay; 8 counters; and 8 latches.

1.4.1 POTENTIAL TRANSFORMER FUSE FAILURE (PTFF)

1

Because distance or directional functions may operate for a full or partial loss of AC potential caused by one or more blown fuses, PTFF is provided to block distance and directional function tripping when a fuse failure is detected. If the backup overcurrent functions (50, 50G, and 51G) are not directionally controlled, they are allowed to trip during a potential fuse failure condition. If any backup overcurrent function (50, 50G or 51G) is directionally supervised, then it is not allowed to trip; rather, a second overcurrent function (50_FF, 50G_FF, or 51G_FF) is placed in service during the fuse failure condition. The pickup level setting of these functions is independent from the normal pickup setting. Figure 1–1: PTFF LOGIC DIAGRAM shows the functional logic for the PTFF function.

If AC potential is lost on one or more phases, the voltage detector produces a logic 0 output which is inverted and fed to the upper input of AND1. The phase undervoltage pickup setting is fixed at 75% of nominal and the pickup-to-dropout ratio is virtually 100%. The lower input to AND1 is dependent upon whether the fault detector FD has operated or whether one or more phases of the protected line are de-energized (open). When one or more phases of protected line are open, PTFF is disabled.

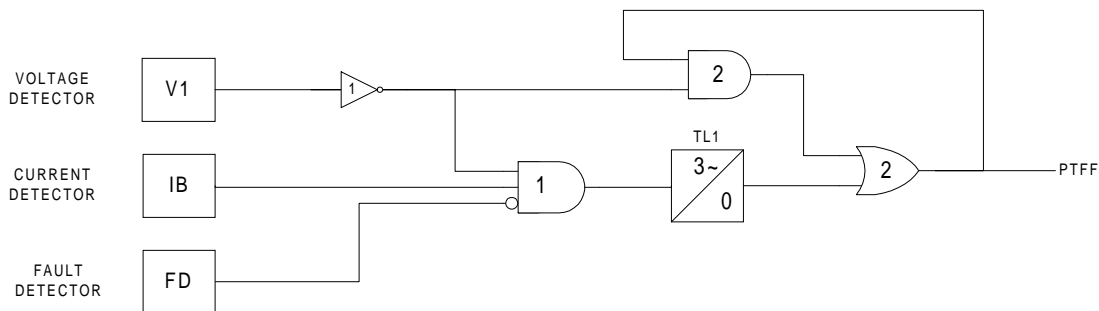


Figure 1–1: PTFF LOGIC DIAGRAM

If AC potential is lost for any reason, including a blown fuse or fuses, and there is no disturbance on the power system so that the fault detector has not operated, AND1 produces an output that causes timer TL1 to time out and produce a PTFF output via OR2. The output of OR2 is routed to AND2 to seal in the PTFF output, based on the voltage detector output. As such, the PTFF output is maintained as long as the potential is below normal. Protection Setting 705: **FUSEFAIL** determines whether PTFF operation blocks distance/directional tripping (**FUSEFAIL** = YES) or merely issues an event (**FUSEFAIL** = NO). When the potential returns to normal, the voltage detector resets to remove the seal-in, allowing the PTFF output to reset.

When a fault occurs, with an attendant drop in potential, the voltage detector picks up, but the fault detector operates to prevent an output from AND1. PTFF does not operate on fault conditions.

1.4.2 LINE PICKUP

The Line Pickup (Close-onto-Fault) logic provides tripping in the event that the breaker is closed into a zero-voltage bolted fault (for example, if grounding chains were left on the line following maintenance). For this three-phase zero voltage fault, the Mho distance functions can not operate because they do not have a source of polarizing voltage. Figure 1–2: LINE PICKUP LOGIC DIAGRAM shows the functional logic for Line Pickup on the LPS-O.

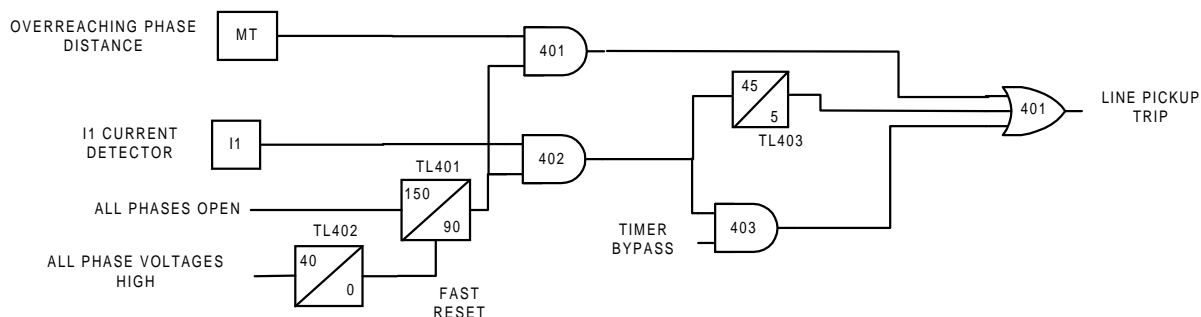


Figure 1-2: LINE PICKUP LOGIC DIAGRAM

When the line is de-energized, the open breaker is detected by the All Phases Open input. The resulting output causes timer TL401 to pickup 150 ms later. Consequently, when the line is energized and a fault current higher than the setting of I1 exists, current detector I1 picks up and AND402 produces an output. If the Timer Bypass setting is set to YES, AND403 immediately produces an output to initiate tripping of the breaker. If the Timer Bypass setting is set to NO, then tripping occurs after the 45 ms pickup delay of timer TL403. Line Pickup is primarily intended to trip for closing into zero-voltage bolted faults where the distance functions connected to line-side potential will not operate. However, regardless of the I1 pickup setting, Line Pickup can also be used to trip on any type of permanent fault along the entire line length that produces sufficient voltage at the relay location to operate a Zone 2 distance function, but insufficient to pickup the All Phase Voltages High signal. This is accomplished by routing Zone 2 phase distance function outputs to AND401. The step distance backup timers are bypassed by the Line Pickup logic.

If the line is energized and no fault exists, the all Phase Voltages High signal picks up and timer TL401 will begin timing; 40 ms later the output of TL401 resets timer TL401 via the fast reset input. AND401 and AND402 have their lower input removed at that time to take the Line Pickup out of service.

Timer TL403 is provided for those cases where simultaneous high-speed reclosing is employed at both ends of the line, and where the I1 function must be set to pick up below the maximum load current that can occur at that time. TL403 then allows time for the voltage to return to normal and take Line Pickup out of service before it can trip on load current. If simultaneous high-speed reclosing is not used, timer TL403 can be permanently bypassed.

1.4.3 REMOTE-OPEN DETECTOR

The Remote-Open Detector (ROD) function issues a trip signal when the remote breaker opens during an unbalanced internal fault. This function detects that the remote breaker has opened by recognizing charging current on one or more phases following opening of the remote breaker. The Remote-Open Detector will not operate when a balanced three phase fault is present.

ROD tripping can speed up tripping at the end of the line that otherwise would be the slowest to respond in a sequential-tripping condition. In a Step Distance scheme, ROD tripping is beneficial for any unbalanced internal fault not detected by Zone 1.

Figure 1-3: REMOTE-OPEN DETECTOR LOGIC below is a functional logic diagram of the ROD function. The sequence of events that results in an ROD output is as follows:

1. No charging current is detected prior to the fault – logic 0 output from AND2.
2. A fault is detected – logic 1 output from ANY ZONE2 PHASE-DISTANCE FUNCTION.
3. The remote breaker opens – logic 1 output from AND3.
4. The fault is still present, so the two inputs to AND4 persist for the time-delay setting of timer TL20.

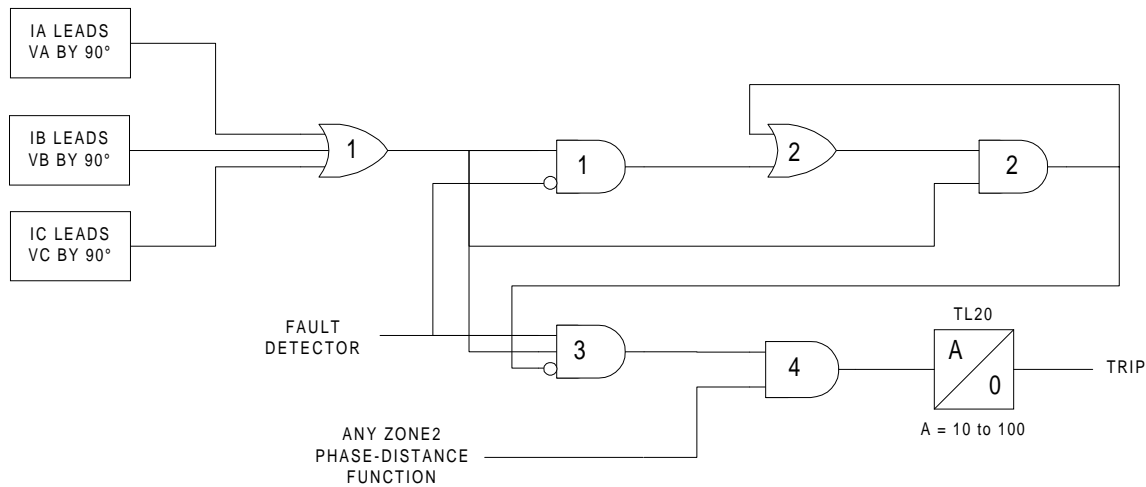


Figure 1-3: REMOTE-OPEN DETECTOR LOGIC

If charging current is initially detected but the fault detector (FD) is not picked up, indicating no fault on the power system, then OR1 and AND1 produce outputs. AND2 produces an output and seals itself in on the output of OR1 via OR2. AND3 is now blocked from producing an output as long as charging current is detected, regardless of whether FD is picked up. If a subsequent fault occurs and the remote breaker opens, ROD is prevented from producing an output.

If sufficient load current is flowing prior to the fault, then there is no output from OR1, indicating that no charging current is detected, and AND3 is not blocked, since there is no output from AND2. If an unbalanced fault subsequently occurs, FD blocks AND1 to prevent an AND2 output. AND3 is allowed to produce an output when the remote breaker opens, provided there is sufficient charging current to operate one or more of the three charging-current-detectors that are the inputs to OR1. The capacitive charging current must be 60 mA or more (secondary phase current) to assure operation of ROD. If the fault is still present an ROD trip follows the expiration of the TL20 security time delay.

1.4.4 OUT-OF-STEP BLOCKING

Figure 1-4: OSB LOGIC DIAGRAM and Figure 1-5: OSB R-X DIAGRAM represent the functional logic for out-of-step blocking and the R-X diagram depicting an assumed swing-impedance locus superimposed on the associated distance relay characteristics. For an out-of-step condition, the impedance locus will first enter the MOB characteristic, then afterwards the MT (phase-distance trip function) characteristic.

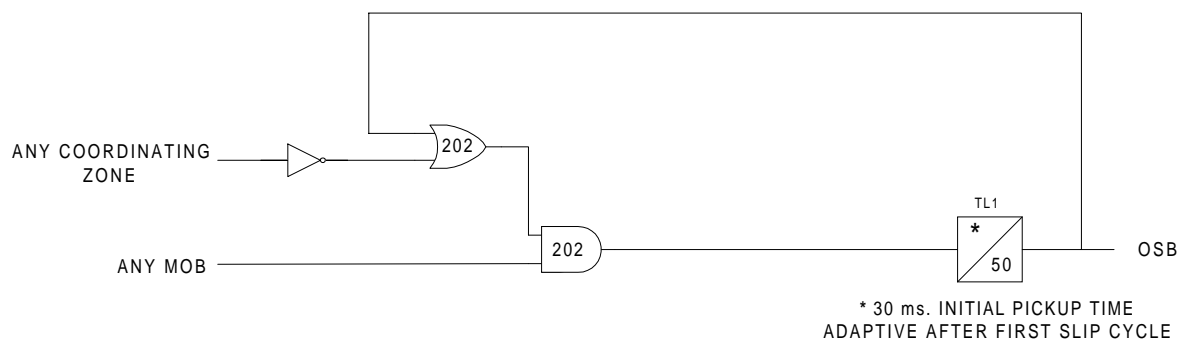


Figure 1-4: OSB LOGIC DIAGRAM

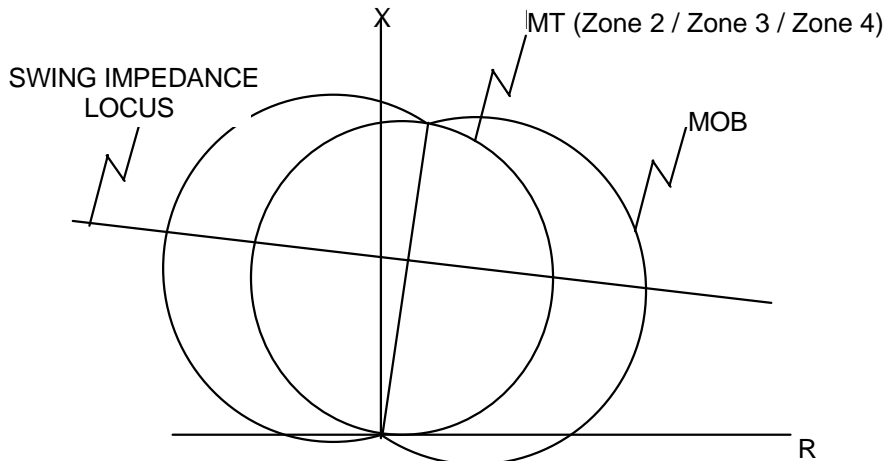


Figure 1-5: OSB R-X DIAGRAM

When MOB (A-B) picks up during the power swing, it applies the lower input to AND202. The top input is present from the NOT via OR202, since MT (A-B) has not operated yet. The AND202 output energizes timer TL1.

If the impedance stays between the MOB and MT characteristics for the pickup time of TL1, an OSB output results. The OSB output is routed back to the top input of AND202 via OR202 to seal-in the OSB output for as long as MOB is picked up. The OSB output resets 50 ms after the swing-impedance locus leaves the MOB characteristic. The same logic is repeated for the distance functions associated with phase pairs B-C and C-A, and all three phase-pair outputs energize TL1. OSB is always routed to block tripping of:

1. All functions (Protection Setting 1303, **BLOCKWHAT** = BLKALL)
2. All distance functions (Protection Setting 1303, **BLOCKWHAT** = BLKDIST)
3. Only the phase distance functions (Protection Setting 1303, **BLOCKWHAT** = BLKPHAS)
4. No functions (Protection Setting 1303, **BLOCKWHAT** = BLKNONE)

For 2 and 3 above, each of the four distance zones (Zones 1, 2, 3, or 4) may be selected to be blocked (or not) via Protection Settings 1304 through 1307 (**BLOCKZ1**, **BLOCKZ2**, **BLOCKZ3**, and **BLOCKZ4**).

Timer TL1 has an adaptive pickup feature with an initial pickup setting of 30 ms for the first slip cycle, with the pickup delay becoming progressively lower during successive slip cycles. This adaptive pickup provides improved capability to maintain the out-of-step output during the increasing slip frequencies that are typically encountered after the first slip cycle.

1.5.1 FLASH MEMORY

The program code resides in Flash memory rather than the EPROM. This new technology provides the same functionality during normal operations of the relay. The advantage to the Flash Memory is it allows for software upgrades without opening the relay. The Flash contents can be overwritten through the communications ports provided in the relay. This procedure requires special software which does not come with the standard communications packages available for the LPS-O.

1.5.2 LINE OVERLOAD

The Line Overload function provides an event and a programmable signal. This signal can be used to provide alarm indication (contact closure) that the load current on the protected line has exceeded a set level for a set time interval. Two alarm levels are included. Level 1 is generally set with a lower pickup setting and a longer time delay than level 2.

1.5.3 CURRENT UNBALANCE DETECTION

If the Fault Detector, FD, remains picked up for 60 seconds, a non-critical alarm is issued and an event message generated. This function indicates sustained unbalanced current conditions such as an open or shorted current transformer.

1.5.4 FAULT REPORT

When a fault or oscillography trigger occurs, pertinent information (consisting of unit ID, date and time, operating time, prefault currents, fault currents and voltages, fault type, trip type, and selected events) is stored in memory. The number of fault events that are stored is selectable by the user and may be set for 6, 12, 24, or 36 events. Each fault report is associated with an oscillography data file. See Chapters 8: LOCAL USER INTERFACE and 11: LPSO-LINK USER GUIDE for a complete description of the Fault Report function.

1.5.5 OSCILLOGRAPHY

Oscillography data are stored in memory each time the LPS-O issues a trip and, optionally, when an internal oscillography trigger flag is set or an external contact closed. Protection Setting 1626: **CONFOSC** allows a configurable oscillography trigger to be assigned by Xpression Builder.

Note that the OSC Trigger stores oscillography data, but does not necessarily set $t = 0$, where t is the time sample that delineates between prefault and postfault oscillography cycles. The term *disturbance period* is defined as the number of cycles of oscillography data (prefault plus postfault) as determined by General Setting 301: **NUMFLTS**. If the internal Fault Detector (FD) comes up initially and OSC Trigger follows within the disturbance period, oscillography data are stored whether or not the LPS-O issues a trip.

If the LPS-O issues a trip, then a normal fault report is stored as part of the oscillography data. If the LPS-O does not issue a trip, a pseudofault report is created. The trip type is listed as OSC, the trip time is the time of the OSC Trigger, the operating time is set to zero, and the fault type and location are computed with post-OSC Trigger data. The local LCD display does not show target information, but an event message and fault report are stored in memory. In either case, $t = 0$ is determined by the internal Fault Detector (FD).

If OSC Trigger comes up initially and FD follows within the disturbance period, the same actions occur and FD determines $t = 0$. If only OSC Trigger occurs, then a pseudofault report is created and OSC Trigger determines $t = 0$. This arrangement assures that the oscillography function always captures an LPS-O trip, with FD determining $t = 0$, regardless of whether an optional internal or external trigger is used.

Oscillography data include station and line identification, a complete list of the active relay settings, the fault report, internal flags, and a selectable number of prefault and postfault data samples. Further description of this function can be found in Section 11.8.5: OSCILLOGRAPHY REPORT on page 11–24.

The LPS-O does not store flags for functions that are disabled.

1.5.6 PLAYBACK

The LPS-O relay system has the ability to replay stored digital current and voltage signals from oscillography files through the protection algorithms. The currents and voltages may be obtained from a factory stored file, from any oscillography file currently stored in the relay, or from an oscillography file stored on a PC. See Sections 8.1.19: PLAYBACK on page 8–15 and 11.8.5: OSCILLOGRAPHY REPORT on page 11–24 for a complete description of the Playback feature.

1.5.7 SEQUENCE OF EVENTS

This function time tags and stores the last 150 events in memory. The resolution of the time-tagging is 1 millisecond. The event list contains power system events, operator actions, and self-test alarms. The sequence of events can be accessed remotely via the front panel port, PL-1 or PL-2, and a PC. A full description of this function is contained in Section 11.8.9: EVENT REPORT on page 11–25.

1.5.8 EQUIPMENT DUTY

When the LPS-O is applied with a single breaker, the LPS-O relay system incorporates the ability to monitor the number of breaker operations and the breaker duty. Alarm levels can be set for both the total number of breaker operations and the total equipment duty. See Chapter 2: CALCULATION OF SETTINGS, Chapter 8: LOCAL USER INTERFACE, and Chapter 11: LPSO-LINK USER GUIDE for a complete description of the Equipment Duty feature.

1.5.9 SELECTABLE GROUPS OF SETTINGS

Four groups of protection settings may be stored in nonvolatile memory. Only one group can be active at a given time, but the active group may be selected by external contacts, by a command issued from the local keypad, or remote communication software. If the selection is to be made by an external switch, then two of the digital inputs (contact converters) are used. A four-position SB1 or SBM switch with two stages (two effective contacts) could be used to select the active group of settings, as shown in Figure 1–6: SWITCH SELECTION OF ACTIVE SETTING GROUP.

Note: For this example CC5 has been assigned to “CGST2” (Change Setting Group Input, Bit 1), and CC6 has been assigned to “CGST1” (Change Setting Group Input, Bit 0). Other contact converters may be assigned to these functions.





1

Table 1–5: TRUTH TABLE FOR SETTINGS GROUP

CC5	CC6	SETTINGS GROUP
0	0	G1
0	1	G2
1	0	G3
1	1	G4

CC5 → bit 1 CC6 → bit 0

Table 1–6: SETTINGS GROUP SWITCH 16SB1 _____

CONTACT NUMBER			G4	G3	G2	G1
1 	2 	1	X	X		
		2				
3 	4 	3	X		X	
		4				

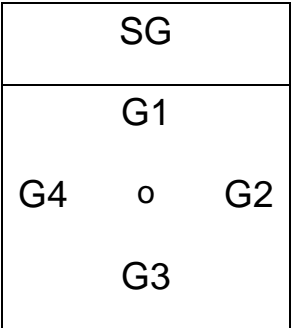
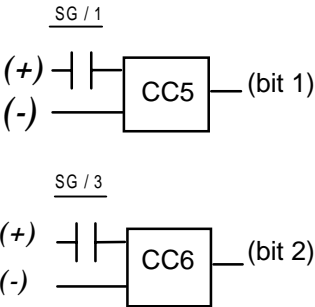


Figure 1–6: SWITCH SELECTION OF ACTIVE SETTING GROUP

1.5.10 TIME SYNCHRONIZATION

The LPS-O includes a clock that can run freely from the internal oscillator or be synchronized from an external signal. An unmodulated IRIG-B signal connected to the IRIG-B terminals, located on terminal block “D” on the rear panel, may be used to synchronize the clock. The clock in a given LPS-O is synchronized to within ± 1 ms of any other LPS-O clock if the two relays are wired to the same synchronizing signal.

1.5.11 TRIP BUS CHECK

1

After a settings change is made in the active settings group, the LPS-O automatically returns to its normal protection-on mode following:

- Storage of the new setting values in nonvolatile memory.
- A Trip Bus Check to determine that the changed settings have not caused any of the trip functions to operate for system conditions (that is, current and voltage at the relay) at that instant.

A Trip Bus Check also occurs before a newly selected settings group is allowed to become the active settings group. If Trip Bus Check finds a picked-up trip function, protection is turned off and a critical alarm is issued.

This check provides a degree of confidence in the new settings, but it does not guarantee that one or more trip functions might not operate as system conditions change. For example, a subsequent increase in load current might cause the Zone 3 phase-distance function to operate, even though it did not operate at the instant the Trip Bus Check was made.

1.5.12 TRIP CIRCUIT MONITOR

The DC battery voltage across each of the open trip contacts (or SCRs) may be continuously monitored to determine if the associated trip circuit is intact. If the monitored DC voltage drops to zero, then the trip circuit has failed to open or the breaker 52/a contact (which is normally wired in series with the trip coil) has opened. This function is intended to replace the red light indicator typically used for trip-circuit monitoring, and it can be selectively disabled for each breaker.

There are four trip contacts (or SCRs) in the LPS-O. The voltage across each contact (or SCR) is monitored separately. Any combination of trip circuits may be monitored by General Setting 107: **NUM_MON**.

Operation of the Trip Circuit Monitor causes a noncritical alarm event. If one or more poles of the breaker are opened in some manner other than by a trip issued by the LPS-O, then the 52/a contact normally wired in series with the trip coil opens and drops the voltage across the open contact to zero. To avoid a noncritical alarm for this condition, closure of the associated 52/b contact disables the Trip Circuit Monitor function for the involved pole.

1.5.13 ALARMS

Two separate alarms are provided. The output relays associated with these alarms are not user programmable. Both of these alarms have form C contacts and are energized under normal conditions.

- The critical alarm de-energizes when the relay self-test logic detects a problem that warrants taking the relay system out of service.
- The power supply alarm de-energizes when the power supply fails or is turned off.

A user programmable non-critical alarm is also provided. Operation of the non-critical alarm will cause an event to be logged and may be programmed to a user-assigned output contact. The non-critical alarm is de-energized in normal conditions. The default inputs to the non-critical alarm include the following conditions:

1. Trip Circuit Alarm
2. Zone Flags On Alarm
3. Overcurrent Alarm
4. Unbalance Current Alarm Detector

Additional inputs, such as Line Overload alarm, may be added with Xpression Builder.

1.5.14 METERING

Metering values may be obtained from the keypad or through remote communications. The following quantities are available: RMS voltage and current, phasor voltage and current, Watts, Vars, Power Factor, system frequency, and Breaker health. The voltage and current values are accurate to 1% of reading. Refer to Chapter 8: LOCAL USER INTERFACE for a description on how to use the metering function.

To ensure proper power metering, connect the LPS-O as follows:

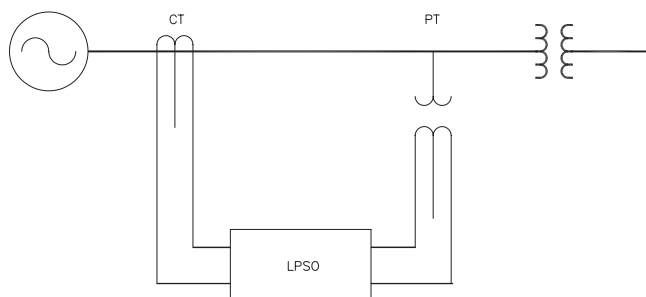


Figure 1-7: POWER METERING CONFIGURATION

1.5.15 BREAKER CONTROL

Two different breakers may be selectively tripped or closed via the local keypad or a remote PC connected to the RS232 port. The commands are as follows:

- Trip Breaker 1 and Trip Breaker 2 use the same output contacts or SCRs as a fault trip command.
- Close Breaker 1 and Close Breaker 2 use separate auxiliary relays. The contact of each auxiliary relay must be wired to the appropriate breaker's close circuit.

Remote breaker tripping and closing are enabled or disabled with a jumper on the Processor module as shown in Figure 3-6: INPUT BOARD DIAGRAM on page 3-9. The LPS-O is shipped from the factory with this jumper removed and Breaker Control enabled. Install the jumper to disable Remote Breaker Control.

1.6.1 KEYPAD AND DISPLAY

1

A local user interface, incorporating a keypad and liquid crystal display (LCD), is provided to enter settings, display present values, view fault target information, and access stored data. This feature is fully described in Chapter 8: LOCAL USER INTERFACE.

Passwords provide security for the Local User Interface (keypad). Three different passwords provide local keypad security against inadvertent breaker operations and settings changes. No password is required to view data stored in the relay. The three levels of password protection are:

- **CONTROL:** Allows control operations (trip and close the breakers).
- **SETTINGS:** Allows settings changes.
- **MASTER:** Allows both control operations and settings changes.

Refer to Section 8.1.20: CHANGE PASSWORD on page 8–17 for a description of the keypad password usage.

1.6.2 SERIAL COMMUNICATIONS

Three serial communications ports are standard on the LPS-O. A DB-9 plug RS232 port (Port 1) located on the front panel of the unit provides local serial communication with the LPS-O via an IBM PC-compatible computer. Two rear ports are provided for RS232 or RS485 serial communications. When Port 2 is configured as RS232, connection is made using a DB25 plug; when Port 2 is configured as RS485, connection is made using a 4-pin Phoenix plug. Port 3 uses a DB25 plug for either RS232 or RS485 communications. The communications protocol for each port may be selected independently as either GE-Modem or ASCII. Each port may be set independently for data communications from 300 to 19200 bps. In addition, Port 3 has the ability to accept a plug-in communication module that can support other communications protocols.

Four different passwords provide remote serial communications security. The four levels of password protection are:

- **VIEW:** Allows remote access to the LPS-O to view and retrieve stored data.
- **CONTROL:** Allows control operations (trip and close the breakers).
- **SETTINGS:** Allows settings changes.
- **MASTER:** Allows both control operations and settings changes.

Refer to Section 11.7.4: CHANGE PASSWORD on page 11–21 for a description of using LPSO-Link to change passwords.

1.7.1 START-UP SELF-TESTS

The most comprehensive testing of the LPS-O is performed during power-up. Since the LPS-O is not engaged in any protection activities at that time, tests (such as RAM tests) that would normally disrupt run-time processing are performed.

Both processors participate in the start-up self-testing. The processors communicate their results to each other so that any failures can be reported and to ensure each processor successfully completes its assigned self-tests before the LPS-O begins protection activity.

During power-up, both microprocessors perform start-up self-tests on their associated hardware (including Flash Memory, EPROM, local RAM, shared RAM, interrupt controller, timer chip, serial I/O ports, nonvolatile memory, analog and digital I/O circuitry, and Keypad/LCD Display hardware). In addition, the LPS-O verifies that the PROM version numbers on both processor boards are compatible and the Model Number stored in nonvolatile memory agrees with the LPS-O configuration. The components tested at start-up are listed in Table 9-1: COMPONENTS TESTED DURING START-UP TESTS on page 9-2.

In most cases, if any critical self-test failure is detected, the LPS-O discontinues start-up and does not reset. It attempts to store the LPS-O status and to initialize the KEYPAD/LCD DISPLAY and remote communications hardware/software for communicating the status. The critical alarm output is energized.

If no failures are detected, the LPS-O completes initialization of its hardware and software. This includes reading information from the serial non-volatile RAM (NVRAM) in the magnetics module, stored during the manufacturing process, to determine the relay current rating (1 A or 5 A). Next, the i960 processor enables the outputs. As the final step, the LPS-O checks the results of all tests to determine whether to turn on the green status LED on the front panel.

The start-up procedure takes approximately one minute. As soon as the i960 CPU successfully completes its PROM test and initializes the display hardware, the message **INITIALIZING** appears on the display. When all LPS-O initialization is completed satisfactorily, the LPS-O begins acquiring and processing data.

1.7.2 RUN-TIME SELF-TESTS

Both of the processors have idle time when the LPS-O is not performing fault or post-fault processing. During this idle time, each processor performs background self-tests that do not interfere with the foreground tasks' use of serial and parallel ports and that do not inhibit interrupts to any processor. If any background self-test fails, the test is repeated. For a component to be declared as failed, the test must fail three consecutive times. In the case of most critical failures, the LPS-O forces a reset to attempt to get the failed component working again.

The LPS-O is able to distinguish between a start-up (power-up) and a reset caused automatically by a LPS-O malfunction. The reset is a fault-tolerant feature of the LPS-O; it is performed as an attempt to resume operation after an intermittent failure. The reset activities are identical to the start-up activities except that not all start-up self-tests are performed. If the reset was caused by failure of a specific background self-test, then only the start-up self-tests associated with that same hardware are performed.

A reset is not reported by the LPS-O. If the reset is successful, no failure status is recorded and the critical alarm output is not energized. However, during the reset procedure, the red LED on the front panel is lit and a failure code may appear on the display. Therefore, if the reset is not successful, the processor board is shut down, leaving the error information displayed on the LCD screen. Refer to Section 9.3.7: SERVICE SYSTEM STATUS FAILURES on page 9-6 for a complete list of error messages. To prevent continual resets in the case of a solid failure, both hardware and software permit only four resets in a one-hour period. On the fifth reset, the LPS-O does not initialize, but attempts to initialize the display, communications, and the critical-alarm output, as in the case of a start-up with a critical self-test failure. The reset procedure takes approximately one second, depending upon which start-up self-tests are to be run.

The components tested in the background are listed in Table 9–2: RUN-TIME BACKGROUND SELF-TESTS on page 9–3. Testing of I/O hardware is done in the foreground so that the processors know when a component or port is in use and not available for testing. The components tested in the foreground are listed in Table 9–3: RUN-TIME FOREGROUND SELF-TESTS on page 9–3. Some foreground tests are performed every sample period, while others are performed less frequently.

As with background self-tests, any failed foreground test is repeated and must fail three consecutive times to be considered a failure. Although not specifically a self-test, the trip circuit continuity monitoring is performed as a foreground test. Refer to Section 1.5.12: TRIP CIRCUIT MONITOR on page 1–15 for details.

The operator may initiate a visual-response test of the keypad and display components. Refer to Chapter 4: ACCEPTANCE/PERIODIC TESTS for details.

1.7.3 CONTINUOUS MONITOR

The LPS-O relay includes a Continuous Monitor feature in addition to its self-test features. The continuous monitor is intended to detect any LPS-O tripping units (Zone 2 or Zone 3 phase distance functions, 50G or 50 overcurrent functions) that are in the picked-up condition without a corresponding operation of the Fault Detector. If such a condition occurs and persists for 1 second, the LPS-O relay will issue a non-critical alarm and log a continuous monitor event.

These Continuous Monitor Alarm points can be found in Table 2–6: INDEX NUMBERS – CONFIGURABLE LOGIC & PROGRAMMABLE OUTPUT SIGNALS on page 2–33. The Index numbers used for the Continuous Monitor are as follows: 48 (Trip Circuit alarm); 49 (Zone flags On alarm); 50 (Overcurrent alarm); and 51 (Unbalanced Current Detector alarm). They are assigned in the default settings as inputs to the non-critical alarm. These flags may also be used in configurable logic or assigned to other alarm contacts.

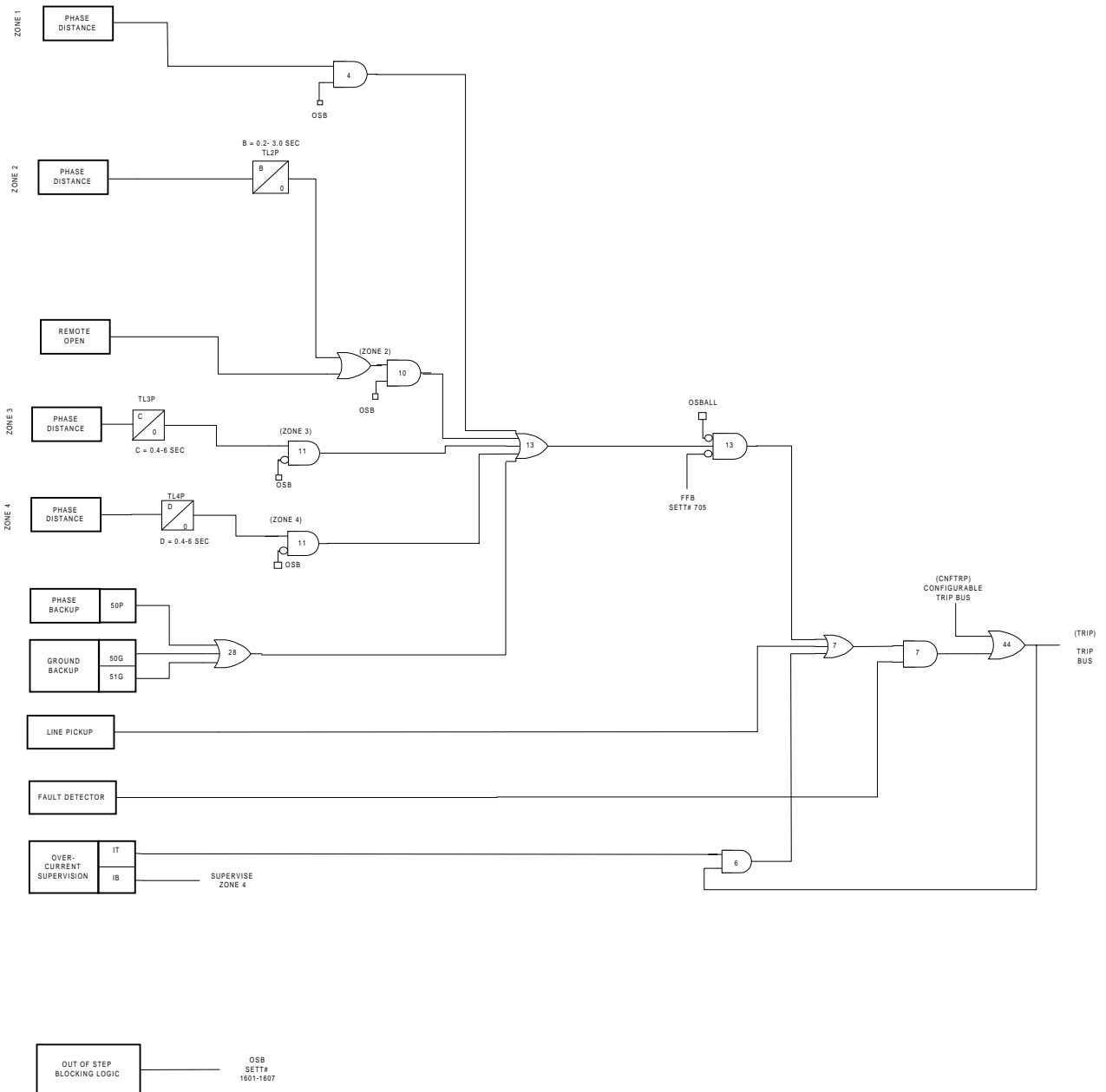
1.8.1 INTRODUCTION

The Step Distance protection scheme for phase protection only is included with the LPS-O. The functional logic diagram is shown in Figure 1–8: STEP DISTANCE LOGIC DIAGRAM. The elementary diagram in Figure 1–11: ELEMENTARY DIAGRAM on page 1–25 shows the external connections to the LPS-O relay system. Note that all of the output relays and input contact converters included in the LPS-O are fully programmable by the user. However, for ease of application, the LPS-O relay is shipped with the inputs and outputs as assigned in Figure 1–11: ELEMENTARY DIAGRAM on page 1–25. The programmability of the LPS-O is discussed in Chapter 13: XPRESSION BUILDER.

1.8.2 STEP DISTANCE

Figure 1–8: STEP DISTANCE LOGIC DIAGRAM on page 1–21 is the logic diagram for the Step Distance scheme. The Zone 1 phase distance functions are set to reach no greater than 90% of the positive-sequence impedance of the protected line. There can be as many as three time-delayed zones. At a minimum, Zone 2 should be selected to provide protection for the last 10% of the protected line not covered by Zone 1.

The phase-distance functions may be placed in or out of service by specifying a separate setting for each protection zone. Zones 2, 3, and 4 each have independently set zone timers.



STP_DST3.VSD

Figure 1–8: STEP DISTANCE LOGIC DIAGRAM

1.9.1 DESCRIPTION

The Out-of-Step Tripping (OST) feature is a positive-sequence static distance relay designed to provide out-of-step tripping protection. It uses three modified Mho characteristics, all with the same reach along a common maximum reach angle, but each having a different shape (such as lens, circle or tomato). It includes logic and time delay circuits that work with the modified Mho characteristics to detect an out-of-step condition.

The OST function does not have a dedicated output relay, nor does it automatically initiate tripping via the LPS-O trip output relays. Rather, the output of the OST logic must be assigned by the user to an output relay, or to the configurable trip bus input (CNFTRP, Index #122) if it is desired to trip the same circuit breaker as for a line fault.

Loss of synchronism or a power swing between two areas of a power system is detected by measuring the positive sequence impedance seen by the relay as the power swing develops over a period of time. Since the OST option measures positive-sequence impedance as seen at the relay location, there is less chance of setting up blocking for non-swing conditions (such as close in single phase to ground faults on series compensated lines where gap flashing and capacitor reinsertion can cause the fault impedance to vary greatly) than there is for a relay that measures phase impedance.

The OST option includes three positive-sequence offset Mho distance relay characteristics. These characteristics have the same reach along a common angle of maximum reach, but have different reaches along the R-axis. An out-of-step condition is detected by measuring the time for the apparent impedance seen by the OST to travel from a load impedance value to a point along the protected line. A fault on the line will cause this impedance change to occur immediately and will not set up out-of-step tripping. For a swing condition the impedance will change slowly. If the impedance passes through the three characteristics in the proper sequence, an out-of-step trip output is produced.

The basic mode of operation is with all three characteristics (OUTER, MIDDLE, INNER). However, with Protection Setting 1402: **NUMBRCHAR**, the MIDDLE characteristic can be bypassed, thereby using only the OUTER and INNER characteristics for out-of-step detection. The decision whether to use two or three characteristics depends largely on the maximum slip frequency expected during a swing condition. Three characteristics are preferred if the slip frequency is low enough to permit making the minimum recommended settings on TLOS1, TLOS2 and TLOS3. In some applications only two characteristics may be necessary, because the combination of a fast moving swing locus (high slip frequency) and a restricted OUTER characteristic (due to heavy load transfer) prevents setting up the proper logic sequence.

There is another setting option that provides a choice between tripping as soon as the out-of-step condition is confirmed: on entering the INNER characteristic (Protection Setting 1403: **TRIPIN_OUT** = IN) or delaying tripping until the two system voltages are more nearly in phase; that is, on leaving the OUTER characteristic (Protection Setting 1403: **TRIPIN_OUT** = OUT). Some users prefer this delayed tripping to reduce the risk of damage to the circuit breaker doing the tripping.

1.9.2 OST CHARACTERISTIC SHAPE

The shape of the offset Mho characteristic may be expanded or restricted by changing the characteristic timer setting. Figure 1-16 shows three Mho characteristics used in the OST function. All three have the same forward and reverse reach along the maximum reach angle, but the OUTER characteristic is an expanded Mho (tomato-shaped) while the INNER characteristic is a restricted Mho (lens-shaped). The angle of maximum reach of the three characteristics is determined by the positive-sequence impedance angle of the protected line (Protection Setting 1201: **POSSEQANG**).

In Figure 1–9: OST MHO CHARACTERISTIC on page 1–23, the dotted line, SWING LOCUS, represents one possible path that would be followed by the apparent impedance resulting from a swing. It may travel either left to right or right to left. Also, the SWING LOCUS may be above the location shown, depending on the relationship between the relay location and the electrical center of the power system.

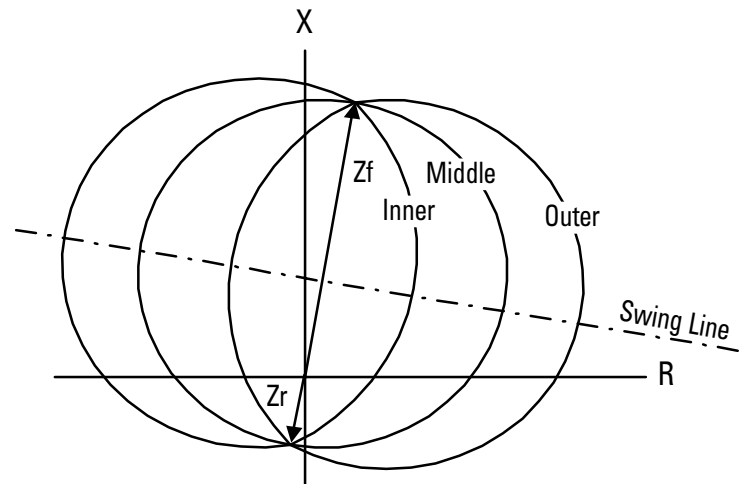


Figure 1-9: OST MHO CHARACTERISTIC

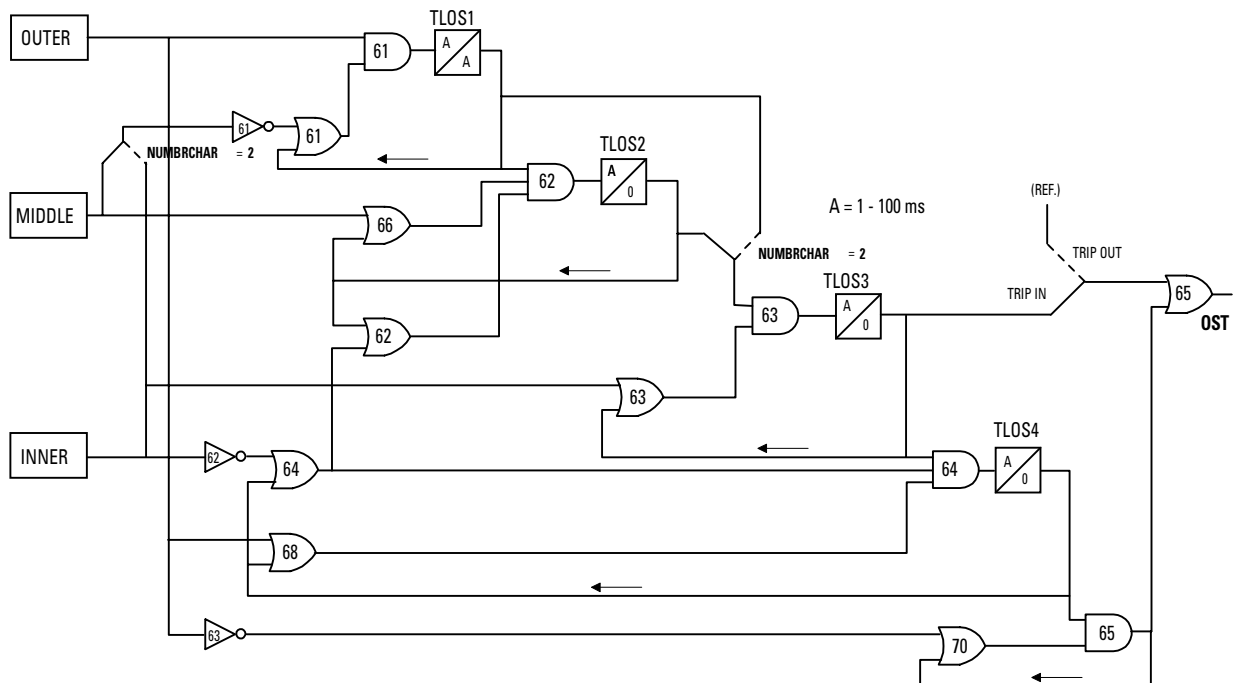


Figure 1-10: OUT-OF-STEP TRIPPING LOGIC DIAGRAM

The discrimination between a fault condition and a system swing is accomplished by checking the time required for the apparent impedance to move from the load condition (far outside the OUTER characteristic) to a point within the INNER characteristic. This change occurs immediately for a fault condition, but occurs at a much slower rate for a swing.

1.9.3 OUT-OF-STEP DETECTION

The actual out-of-step detection in the OST option is accomplished by a software algorithm. This algorithm is represented by the logic diagram in Figure 1–10: OUT-OF-STEP TRIPPING LOGIC DIAGRAM on page 1–23. The operation of this logic diagram is explained below. Note: this discussion assumes that Protection Setting 1402: **NUMBRCHAR** = 3 and all three OST Mho characteristics are used.

STEP 1:

The power swing enters the OUTER characteristic. Thus AND61 will have one input from the OUTER and a second input from OR61 since NOT61 has no input. If the swing impedance remains between the OUTER and MIDDLE characteristics for the pickup setting of TLOS1, TLOS1 operates, sealing in one input of AND61. When a fault occurs, the OUTER and MIDDLE characteristics operate almost simultaneously, and the MIDDLE blocks AND61 through NOT61, thus preventing TLOS1 from operating.

STEP 2:

The swing now enters the MIDDLE characteristic but remains outside the INNER characteristic. One input of AND62 is energized by TLOS1, a second input is proved by the MIDDLE, and the third is supplied by NOT62. If the swing impedance remains between the MIDDLE and INNER characteristics long enough for TLOS2 to pick up, TLOS2 seals in the lower two inputs to AND62. AND62 is therefore controlled by TLOS1, which in turn is controlled by the OUTER characteristic.

STEP 3:

The swing now enters the INNER characteristic. One input to AND63 is provided by TLOS2, the second by the INNER. If the swing impedance remains inside the INNER characteristic for the pickup setting of TLOS3, TLOS3 will provide one input to AND64. At this point the decision to trip has been made and sealed in. The out-of-step tripping output will be provided immediately if Protection Setting 1403: **TRIPIN_OUT** = IN.

STEP 4:

The swing now leaves the INNER characteristic (traveling in either direction), but remains inside the OUTER characteristic. One input to AND64 is provided by TLOS3, a second input is supplied by the OUTER, the third input is energized by NOT62 through OR64. If the output from AND64 lasts for the pickup setting of TLOS4, TLOS4 operates and seals in. The output of TLOS4 also provides one input of AND65.

STEP 5:

If Protection Setting 1403: **TRIPIN_OUT** = OUT, tripping is not initiated until the swing has passed through the OUTER characteristic for the second time. When the OUTER resets, the second input of AND65 is supplied by NOT63. AND65, through OR65, picks up the out-of-step tripping relay, OST. This output lasts for 50 milliseconds (three cycles at 60 Hz) after the OUTER resets, which is the dropout time of TLOS1.

1.9.4 TWO-CHARACTERISTIC OPERATION

Operation with two characteristics instead of three (Protection Setting 1402: **NUMBRCHAR** = 2) is essentially the same as described above, except that the MIDDLE characteristic and TLOS2 are taken out of the circuit. Only the OUTER and INNER characteristics are involved in the two characteristic mode of operation.

1.9.5 OUT-OF-STEP OSCILLOGRAPHY CAPTURE

The Out-of-Step Tripping option includes an out-of-step oscillography feature. The OS data file contains the real and imaginary components of the phase currents and voltages, sampled once per cycle for 180 cycles; 60 pre-trigger samples and 120 post-trigger samples are stored. Data are stored whenever an Out-of-Step Block (OSB) condition or an Out-of-Step Trip (OST) condition is detected. If both an OSB and OST are detected, the data is stored based on the OST operation. Only one OS data file is stored in the LPS-O. Once the data is captured, it will not be overwritten until it is retrieved from the LPS-O or cleared by an OS data reset command.

1.10.1 ELEMENTARY DIAGRAM

1

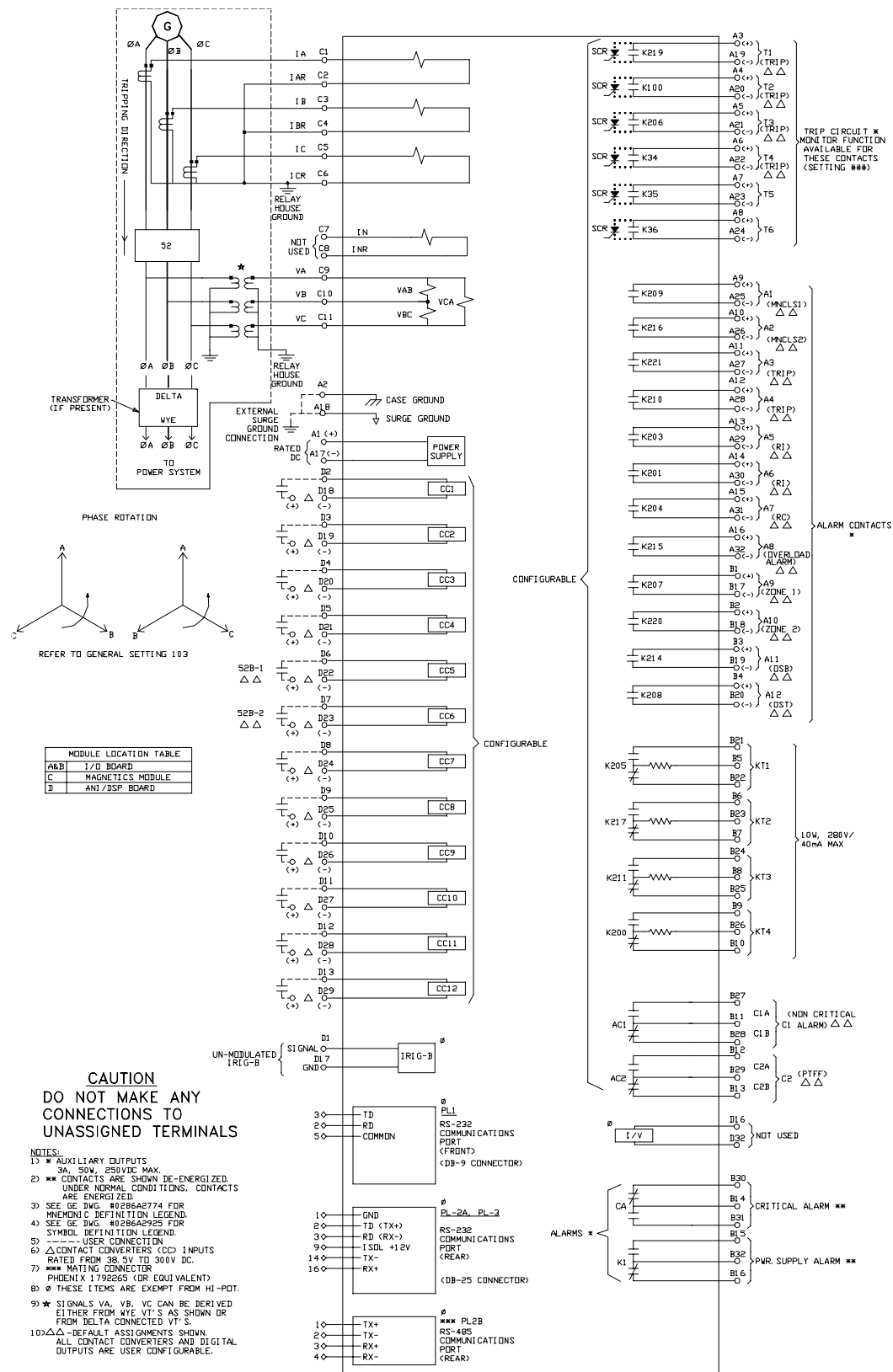


Figure 1–11: ELEMENTARY DIAGRAM

2.1.1 DESCRIPTION

There are a number of settings that must be made in the LPS-O relaying system. These settings are divided into two categories, with each category divided into the sub-groups shown below:

a) GENERAL SETTINGS

- Configuration
- Communications
- Oscillography
- Equipment Duty
- Programmable Inputs

b) PROTECTION SETTINGS

- Z1DISTANCE
- Z2DISTANCE
- Z3DISTANCE
- Z4DISTANCE
- CURSUPVISN
- OVERCURRNT
- VOLTAGE
- LINEPICKUP
- REMOTEOPEN
- OVERLOAD
- LINE QTY
- OS BLOCKING
- NON-CRITICAL ALARM
- PROGRAMMABLE OUTPUTS

The sub-categories (defined by their mnemonic) are given in the order that they appear when scrolled in the display provided on the front of the LPS-O system.

Up to four separate and distinct **Protection Settings** Groups can be programmed and stored in the LPS-O relaying system. Selection of the settings group to be used can be made via the keypad, through the communications link or through external contacts applied to selected programmable inputs.

The **General Settings** category applies to all schemes and all settings groups regardless of which Settings Group is selected.

The **General Settings** category will be discussed first, followed by the **Protection Settings** category. Scheme specific requirements (when applicable to a particular setting) will be discussed when that setting is described. Blank settings forms are provided on pages 2–47 to 2–54, which may be copied and used to record the settings for any application.

All of the settings used in the LPS-O system are listed in Table 2–1: TRIPPING SCHEMES on page 2–4. These tables also show setting ranges for 5 Amp and 1 Amp rated systems. Note that each specific setting in a subgroup has a distinctly assigned number in addition to a unique mnemonic. These identification numbers can be used to facilitate entering or changing a setting via the keypad or the LPSO-Link communications program provided with the relay.

2

NOTE: All settings must be entered in secondary values (ohms, amperes, volts) unless per unit (p.u.) or other values are called for.

This section is used to determine and calculate the settings for a particular application. Go through this section, setting by setting, and manually record each setting in the blank forms provided (see Section 2.5.4: PROTECTION SETTINGS DATA SHEET on page 2–47 and Section 2.5.5: GENERAL SETTINGS DATA SHEET on page 2–54). Once the form is completed, enter the settings individually via the keypad located on the front of the LPS-O system or through the ASCII communications port (a long and laborious process and not recommended). Alternatively, use the LPSO-Link communications program to access and modify an existing settings file (a sample settings file is included with the LPS-O software). This file can then be downloaded to the LPS-O system and saved for possible modification in the future.

2.2.1 CONFIGURATION

101: UNITID - Unit ID Number

The **UNITID** is a decimal number between 0 and 9999 that uniquely identifies an LPS-O relay system. When the LPS-O system is accessed via one of the serial ports the **UNITID** must be known to establish communication, thus providing an additional measure of security. **UNITID** can only be changed with the keypad. It is not possible to change **UNITID** with the LPSO-Link communications program.

102: SYSFREQ - System Frequency

SYSFREQ establishes the frequency at which the LPS-O system will operate. It can be set to either 50 Hz or 60 Hz. When this setting is changed, it will only be implemented by turning the DC power off and then on to re-initialize the LPS-O system.

103: PHASRRotate - Phase Rotation

PHASRRotate can be set to either ABC or ACB to match the positive-sequence phase rotation for the power system where the LPS-O system is installed. This setting permits the LPS-O system to properly report the faulted phase or phase pair.

104: TIMESYNCH - Select Time Synchronization

TIMESYNCH determines the method of synchronizing the LPS-O internal clock; it can be set to 0 (INTERNAL) or 1 (IRIG-B). **TIMESYNCH** = 0 lets the clock run freely from the internal oscillator. **TIMESYNCH** = 1 synchronizes the clock using an IRIG-B signal connected directly to the LPS-O system via the assigned port.

105: NUM_BKR - Number of Breakers

NUM_BKR can be set to either 1 or 2. When set to 1, the TRIP and CLOSE commands can only be used to activate the BREAKER 1 trip and close outputs. When set to 2, the TRIP and CLOSE commands can selectively be used to activate either the BREAKER 1 or BREAKER 2 outputs.

106: NUM_TC - Number of Trip Circuits

Assignment of the trip outputs in the LPS-O relaying system is made via the **NUM_TC** setting and is directly coupled to the **NUM_BKR** setting.

Four outputs (T1 to T4) are available for tripping and are assigned per the **NUM_TC** setting as shown below in Table 2-1: TRIPPING SCHEMES. If one breaker with a single trip circuit is being used (**NUM_TC** = 1), then outputs T2 to T4 are available for assignment to different tasks through the Xpression Builder program provided with the LPS-O system. Outputs T3 and T4 are used only if two breakers are being controlled and if each of the breakers has two independent trip circuits (**NUM_TC** = 2). If independent trip coils are not being used, then the T3 to T4 contacts can be re-assigned through Xpression Builder.

The LPS-O system is provided with the capability (when enabled) to trip the breaker(s) locally through the keypad, or remotely via the LPSO-Link program or the ASCII commands. In order for the LPS-O system to recognize which breaker should be tripped, the **NUM_TC** setting must be made as given in Table 2-1: TRIPPING SCHEMES and the trip outputs must be connected to the appropriate trip coils as assigned in the tables. For example, if **NUM_TC** = 2, then trip output T1 must be connected to the trip coil TC-1 of breaker number 1 and the output T2 must be connected to the trip coil TC-1 of breaker number 2.

Table 2–1: TRIPPING SCHEMES

		Trip Output Assignments			
		Breaker No. 1		Breaker No. 2	
Number of Breakers NUM_BKR	Number of Trip Circuits NUM_TC	Trip Circuit 1 TC-1	Trip Circuit 2 TC-2	Trip Circuit 1 TC-1	Trip Circuit 2 TC-2
1	1	T1	-	-	-
1	2	T1	T2	-	-
2	1	T1	-	T2	-
2	2	T1	T2	T3	T4

where: TC1, TC2 = Trip Coils; T1 to T4 = LPS-O Trip Outputs

107: NUM_MON - Trip Outputs To Be Monitored

Trip circuit monitoring can be used to check the integrity of the trip circuit to which the selected trip output is connected. It does this by sensing the voltage across the trip output as shown in Figure 2–1: TRIP CIRCUIT MONITOR. If the trip circuit is intact, almost full DC voltage will be detected across the trip output. If the trip circuit is open for some reason, there will be no voltage (or very little voltage) across the trip output. The monitoring circuit will detect this condition and store an event. It can also be programmed to close an alarm contact if so desired.

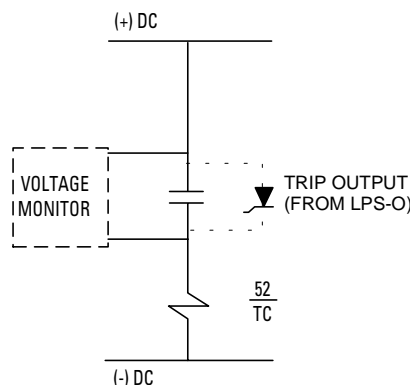


Figure 2–1: TRIP CIRCUIT MONITOR

The trip contacts are also monitored when a trip is initiated by the LPS-O system. If the voltage across the contacts does not drop when the trip is initiated, then it is assumed that the trip circuit is not intact and an alarm is issued. If the voltage does drop concurrently with the trip initiation, then the trip circuit is considered to have been activated and no alarm is issued.

Any or all of the outputs (T1 to T4) can be monitored regardless of whether or not they are used in a trip circuit.

The setting format for **NUM_MON** is *abcd*, where any position can be a zero (0) or a one (1) as shown in Table 2–2: SETTING FORMAT FOR NUM_MON.

Table 2-2: SETTING FORMAT FOR NUM_MON

Position	a	b	c	d
Output	T4	T3	T2	T1
ON	1	1	1	1
OFF	0	0	0	0

As an example, if you are using an LPS-O and outputs T1 and T3 are to be monitored and T2 and T4 are not, the following setting would be used:

NUM_MON = 0101

This setting is entered in to the relay from the LUI in decimal format (that is, **NUM_MON** = 5).

108: DISPLAYVAL - Present Value Display Mode

This setting determines the mode in which the system values (*I*, *V*, etc.) are displayed. Two settings are possible: PRI displays the values in primary quantities, whereas SEC allows secondary values to be displayed.

109: LANGUAGE

Two settings are possible: ENGLISH or SPANISH.

2.2.2 COMMUNICATIONS

201: COMPORT1 - Communications Port 1

COMPORT1 sets the baud rate, parity, and stop bits of RS232 serial port 1. The setting format is **xyz** where:

Baud Rate = **xx** = 03, 12, 24, 48, 96, 19

Parity = **y** = 0 (none), 1 (odd), 2 (even)

Stop Bits = **z** = 1, 2

The baud rate setting of 300, 1200, 2400, 4800, 9600, or 19200 must be set to match the baud rate of the modem or serial device connected to the serial port of the LPS-O relay system. The parity and stop bits must match those selected for the serial port of the remote PC. Normally 1 stop bit is selected. However, certain modems or other communications hardware may require 2 stop bits. LPSO-Link communications software can be configured to match this LPS-O setting for baud rate, parity, and stop bits.

202: COMPORT2 - Communications Port 2

COMPORT2 sets the baud rate, parity, and stop bits of serial port 2. The setting format is **ixyz** where:

interface = **i** = 0 (RS232), 1 (RS485)

Baud Rate = **xx** = 03, 12, 24, 48, 96, 19

Parity = **y** = 0 (none), 1 (odd), 2 (even)

Stop Bits = **z** = 1, 2

The baud rate setting of 300, 1200, 2400, 4800, 9600, or 19200 must be set to match the baud rate of the modem or serial device connected to the serial port of the LPS-O relay system. The parity and stop bits must match those selected for the serial port of the remote PC. Normally 1 stop bit is selected. However, certain modems or other communications hardware may require 2 stop bits. LPSO-Link communications software can be configured to match this LPS-O setting for baud rate, parity, and stop bits.

203: COMPORT3 - Communications Port 3

COMPORT3 sets the baud rate, parity, and stop bits of RS232 serial port 3. The setting format is **ixxyz** where:

interface = **i** = 0 (RS232), 1 (RS485)
 Baud Rate = **xx** = 03, 12, 24, 48, 96, 19
 Parity = **y** = 0 (none), 1 (odd), 2 (even)
 Stop Bits = **z** = 1, 2

The baud rate setting of 300, 1200, 2400, 4800, 9600, or 19200 must be set to match the baud rate of the modem or serial device connected to the serial port of the LPS-O relay system. The parity and stop bits must match those selected for the serial port of the remote PC. Normally 1 stop bit is selected. However, certain modems or other communications hardware may require 2 stop bits. LPSO-Link communications software can be configured to match this LPS-O setting for baud rate, parity, and stop bits.

204: PROTOCOL1 - Communication Port No. 1 Protocol

Two settings are possible:

1. GE-MODEM. Use this setting to communicate with the LPS-O system via the LPSO-Link communications program as described in Chapter 11: LPSO-LINK USER GUIDE.
2. ASCII. Use this setting to communication with the LPS-O system via the ASCII commands provided in Chapter 12: ASCII COMMUNICATIONS.

205: PROTOCOL2 - Communication Port No. 2 Protocol

Two settings are possible:

1. GE-MODEM. Use this setting to communicate with the LPS-O system via the LPSO-Link communications program.
2. ASCII. Use this setting to communicate with the LPS-O system via the ASCII commands provided in Chapter 12: ASCII COMMUNICATIONS.

206: PROTOCOL3 - Communication Port No. 3 Protocol

Two settings are possible:

1. GE-MODEM. Use this setting to communicate with the LPS-O system via the LPSO-Link communications program.
2. ASCII. Use this setting to communication with the LPS-O system via the ASCII commands provided in Chapter 12: ASCII COMMUNICATIONS.

2.2.3 OSCILLOGRAPHY**301: NUMFAULTS - Number Of Faults To Be Captured**

NUMFAULTS selects the maximum number of oscillography storage events (faults) that may be stored in memory. When the maximum number are stored in memory, the oscillography data associated with a subsequent storage event will overwrite the data from the oldest event.

This setting allows the user to apportion a fixed amount of memory into different sized blocks for oscillography storage. Table 2–3: OSCILLOGRAPHY CYCLES PER STORAGE EVENT shows the total number of oscillography cycles allowed per storage event as a function of the **NUMFAULTS** setting.

Table 2-3: OSCILLOGRAPHY CYCLES PER STORAGE EVENT

NUMFAULTS	Storage Cycles
6	72
12	36
24	18
36	12

302: PREFault - Number Of Pre-Fault Cycles To Capture

PREFault selects the number of pre-fault or pre-trigger cycles to be stored in each oscillography record. It can be set over the range from 1 to 8. **NUMFAULTS**, as explained above, determines the total number of cycles per oscillography record, and **PREFault** determines how many of these will be pre-fault cycles.

303: SPLITREC - Split Oscillography Record For Long Duration Faults

The LPS-O system allows a pre-defined number of oscillographic records to be captured per the **NUMFAULTS** setting described above. Each record is a specific number of cycles in length as determined by this setting. If a fault occurs that is greater in length than the number of cycles to be captured, the **SPLITREC** setting will allow the record to be split so that the beginning and the end of the fault can be captured. Note that **SPLITREC** does not affect the number of pre-fault cycles that are captured (as determined by the **PREFault** setting). **SPLITREC** applies only the fault record, exclusive of the pre-fault cycles. **SPLITREC** is set as a percentage with a range of 0 to 100 percent, and splits the record so that the end of the record is equal to the **SPLITREC** percentage and the beginning of the record is equal to (100 – **SPLITREC**). For example, assume that **NUMFAULTS** is set to 4 and **PREFault** is set to 4. This means that the record will capture 4 cycles of pre-fault data and 28 cycles of fault data. The LPS-O system samples at 64 times per cycle, therefore, 2048 samples (64 x 32) of fault data will be captured. Further assume that **SPLITREC** is set to 30 percent. If the fault lasts longer than 32 cycles (2048 samples), then 28 cycles (1792 samples) of the oscillographic record will be split and the display will show 8.4 cycles (538 samples) at the end and 23.6 cycles (1510 samples) at the beginning. If the fault is less than the set number of cycles then **SPLITREC** has no effect and the total fault record will be displayed.

Use a setting for **SPLITREC** that displays the information most desired in a long duration fault (more at the beginning and less at the end, or vice versa).

2.2.4 EQUIPMENT DUTY

The LPS-O system will count the total number of breaker operations and furthermore will calculate and accumulate the total breaker duty on a per phase basis according to the following equation:

$$\text{Total Duty} = \sum I^x t$$

where, I = RMS current

t = breaker operating time

x = user settable exponent

The number of operations and accumulated duty will be compared to set values (entered by the user). When the respective value is reached, an event will be recorded and the non-critical alarm initiated if programmed to do so. The number of operations and the total duty can start from zero, or if the existing number of operations or total duty is known, those values can be entered into the LPS-O system which will use them as the starting point.

401: EXPONENT - Exponent x to use in $I^x t$ Calculation

EXPONENT can be set from 1 to 2 in steps of 0.1. Use a value that matches the specific breaker used in the application.

402: MAX_OP - Maximum Number Of Breaker Operations Permitted

This number can be set from 0 to 9999. Enter the maximum number of operations that the breaker can tolerate before maintenance is required.

403: MAX_IKT - Maximum Breaker Duty

This number can be entered in the range of 0 to 999.9M in steps of 0.1K. Enter a number equal to the maximum duty recommended by the breaker manufacturer. Index Flag 139: Breaker Equipment Duty Alarm (BRMNDT) is set when the Breaker duty equals 80% of the set value. This flag may be directly assigned to an output contact or used in configurable logic.

404: IXTPHASEA - Accumulated Duty, Breaker Phase A

IXTPHASEA can be set over the range of 0 to 999.9M with a step of 0.1K. If the accumulated duty to that point in time is known, enter that value, otherwise, enter an estimated value or use the default value of zero (0).

405: IXTPHASEB - Accumulated Duty, Breaker Phase B

IXTPHASEB can be set over the range of 0 to 999.9M with a step of 0.1K. If the accumulated duty to that point in time is known, enter that value, otherwise, enter an estimated value or use the default value of zero (0).

406: IXTPHASEC - Accumulated Duty, Breaker Phase C

IXTPHASEC can be set over the range of 0 to 999.9M with a step of 0.1K. If the accumulated duty to that point in time is known, enter that value, otherwise, enter an estimated value or use the default value of zero (0).

407: NUM_OP - Present Number Of Breaker Operations

NUM_OP can be set over the range of 0 to 9999 with a step of 1. If the number of operations to that point in time is known, enter that value, otherwise, enter an estimated value or use the default value of zero (0). Index Flag 138: Number of Breaker Operations Alarm (BRMNOP) is set when the Breaker duty equals the set value. This flag may be directly assigned to an output contact or used in configurable logic.

2.2.5 PROGRAMMABLE INPUTS

There are twelve contact converters provided in the LPS-O relay. These contact converters are used to convert contact inputs into logic signals for use within scheme logic. Each of the contact converters can be programmed to be driven by any of the signals defined by the first 32 Index Numbers listed in Table 2–5: INDEX NUMBERS – CONTACT CONVERTER INPUT ASSIGNMENT on page 2–32.

501: CC1 - Contact Converter 1**502: CC2 - Contact Converter 2****503: CC3 - Contact Converter 3****504: CC4 - Contact Converter 4****505: CC5 - Contact Converter 5****506: CC6 - Contact Converter 6****507: CC7 - Contact Converter 7****508: CC8 - Contact Converter 8****509: CC9 - Contact Converter 9****510: CC10 - Contact Converter 10****511: CC11 - Contact Converter 11****512: CC12 - Contact Converter 12**

Use any of the first 32 signals given in Table 2–5 on page 2–32 to define the function of any of the 12 contact converters

2.3.1 Z1DISTANCE

101: Z1PHASE - Zone 1 Phase Distance Functions

Set **Z1PHASE** equal to YES if Zone 1 protection for phase faults is desired. Otherwise set **Z1PHASE** equal to NO. It is highly desirable to use Zone 1 protection in all schemes because it provides independent, high speed direct tripping for all phase faults within the reach setting.

102: Z1PREACH

If potential transformers (PTs) are used, use a reach setting that is no greater than 90 percent of the positive-sequence impedance of the line to be protected.

103: (NOT USED)

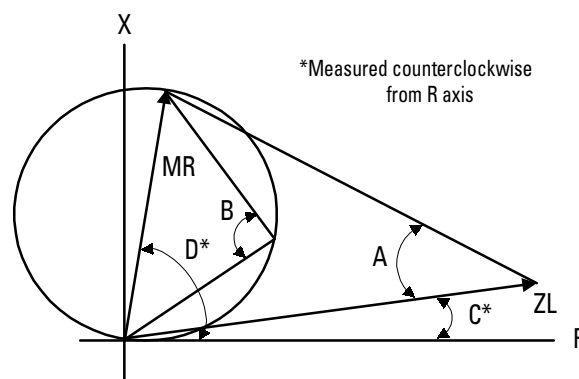
104: Z1P_TIME - Zone 1 Phase Timer

Z1P_TIME can be set from 0.0 to 10.0 seconds and establishes the time delay that the Zone 1 phase functions can be picked up before tripping is initiated. It should be set to zero for traditional Zone 1 application for line protection. For the system backup application, it should be set with appropriate delay consistent with the reach setting.

2.3.2 ZONE 2, ZONE 3, AND ZONE 4 DISTANCE FUNCTIONS

The reach setting to be used on the Mho type distance functions will be established by the specific application. It must not exceed the maximum allowable reach which is dependent on the following:

1. Shape of the characteristic: circle or lens.
2. Angle of maximum reach.
3. Maximum amount of load flow transferred across the transmission line.



MR = Maximum Allowable Reach

ZL = Load Impedance

D = Angle of Maximum Reach

B = Characteristic Angle; $< 90^\circ$ = Lens

C = Load Impedance Angle

Figure 2-2: MAXIMUM ALLOWABLE REACH

The maximum allowable reach (MR) is based on the criteria shown above in Figure 2–2: MAXIMUM ALLOWABLE REACH and can be calculated as follows:

$$MR = \frac{\sin(B - 40^\circ) \times Z_L}{\sin(220^\circ - B - E)}$$

2

where Z_L = minimum load impedance (ohms)
 B = Characteristic angle (degrees)
 = 90° for a circle
 > 90° for a lens
 C = angle of minimum load impedance (degrees)
 D = angle of maximum reach (degrees)
 $E = |D - C|$

Note that this is the maximum reach that can be safely made based on the given parameters. It is based on maintaining a 40° margin between the angle B and the angle A shown in Figure 2–2: MAXIMUM ALLOWABLE REACH. A circular Mho characteristic ($B = 90^\circ$) should be used when possible. However, for larger load flows (smaller load impedances) and for longer reaches, it may be necessary to resort to a lenticular characteristic ($B > 90^\circ$) to remain within the allowable limit. Lenticular settings greater than 120° should never be used. Similarly, the characteristic angle should never be set less than 90° .

For each application, a desired reach should be determined and then checked against the MR using a circular Mho characteristic. If the desired reach is less than the MR , then the setting is acceptable. If the desired reach is greater than the MR , then the angle B should be increased until MR equals, or just exceeds, the desired reach.

2.3.3 Z2DISTANCE

201: Z2PHASE - Zone 2 Phase Distance Function

The choice of settings is YES or NO. Set **Z2PHASE** = YES if the Zone 2 phase functions are to be used, otherwise set **Z2PHASE** = NO.

202: Z2PHREACH - Zone 2 Phase Distance Reach

- *Step Distance Scheme*

In this scheme, the Zone 2 functions must be set to see a multi-phase fault at the remote bus, considering such factors as arc resistance and underreach that may be caused by intermediate fault current sources. Typically, on a two-terminal line, **Z2PHREACH** would be set for 125 to 150% of the positive sequence impedance of the protected line. **Z2PHREACH** should never be set so large as to:

1. Exceed the maximum allowable reach (MR), or,
2. Cause the Zone 2 functions to lose selectivity with the second zone phase distance functions on the shortest adjoining line section. If this requirement cannot be met by limiting the reach, then it may be necessary to get this selectivity by setting timer **PUTL2P** with additional time delay.

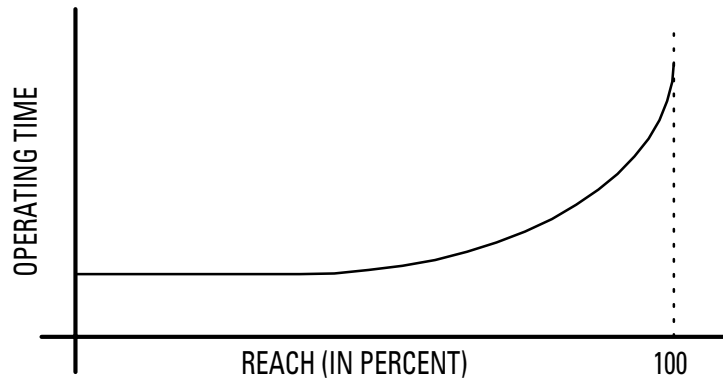


Figure 2-3: OPERATING TIME CHARACTERISTIC

203: Z2PCHARANG - Zone 2 Phase Characteristic Angle

This setting determines the characteristic shape and, consequently, the area of resistance coverage provided by the Zone 2 phase distance functions. **Z2PCHARANG** can be set to 90° to 120° in 5° steps. A 90° setting is recommended. If the desired reach, **Z2PHREACH**, with a 90° characteristic causes the Zone 2 functions to pick up on the maximum load flow, then a "lens-shaped" characteristic must be used to prevent operation on load without having to reduce the reach. The settings of both **Z2PHREACH** and **Z2PCHARANG** may be evaluated by using the formula associated with the Maximum Allowable Reach method of Figure 2-2: MAXIMUM ALLOWABLE REACH on page 2-9.

204: Z2TIMER - Zone 2 Timer

The choice of settings is YES or NO. Set **Z2TIMER** = YES if the Zone 2 phase distance time delay is to be used, otherwise set **Z2TIMER** = NO.

205: Z2P_TIME - Zone 2 Phase Timer

Z2P_TIME can be set over the range of 0.0 to 10.0 seconds and establishes the time delay that the Zone 2 phase functions can be picked up before tripping is initiated. It should be set to 1.0 for traditional Zone 2 application for line protection. For the system backup application, it should be set with appropriate delay consistent with the reach setting.

2.3.4 Z3DISTANCE**301: Z3PHASE - Select Zone 3 Phase**

Z3PHASE can be set to either YES or NO. When Zone 3 is used as part of a Step Distance scheme and Zone 3 phase distance functions are required, then set **Z3PHASE** = YES. If Zone 3 is not used required, set **Z3PHASE** = NO.

302: Z3PHREACH - Zone 3 Phase Reach

In a Step Distance scheme, Zone 3 provides backup protection for adjoining line sections out of the remote bus. **Z3PHREACH** should be set to see a multi-phase fault at the end of the longest adjoining line section out of the remote bus, considering such factors as arc resistance and underreach caused by intermediate fault current sources. **Z3PHREACH** should never be set so large as to:

1. Exceed the maximum allowable reach (*MR*), or,
2. Cause the Zone 3 functions to lose selectivity with the third zone phase distance functions on the shortest adjoining line section. If this requirement cannot be met by limiting the reach, then it may be necessary to get this selectivity by setting timer **Z3P_TIME** with additional time delay.

303: Z3PCHARANG - Zone 3 Phase Characteristic Angle

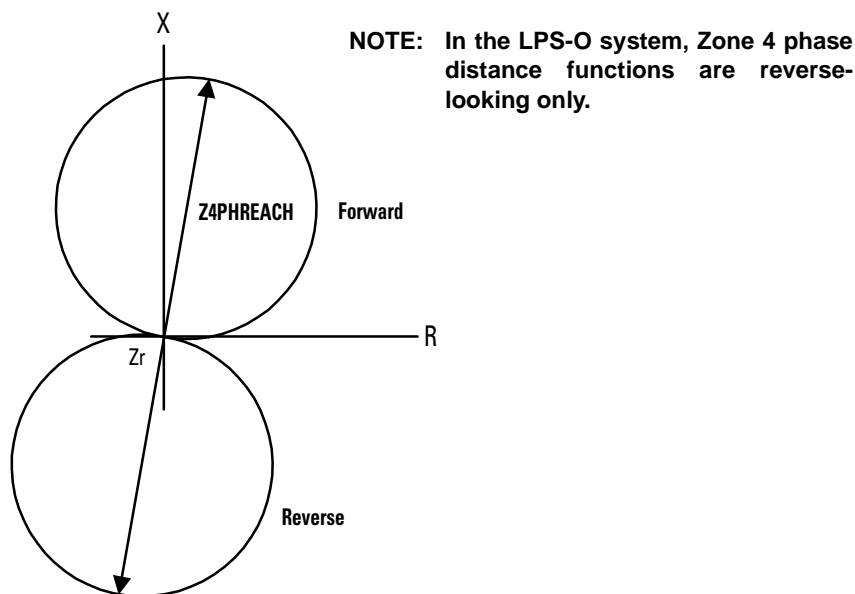
This setting determines the characteristic shape and, consequently, the area of resistance coverage provided by the Zone 3 phase distance functions. **Z3PCHARANG** can be set to 90° to 120° in 5° steps. A 90° setting is recommended. If the desired reach, **Z3PHREACH**, with a 90° characteristic and with maximum load flow does not allow the maximum allowable reach criteria to be met, then a "lens-shaped" characteristic must be used. The settings of both **Z3PHREACH** and **Z3PCHARANG** may be evaluated by using the formula associated with the "Maximum Allowable Reach" method of Figure 2-2: MAXIMUM ALLOWABLE REACH on page 2-9.

304: Z3P_TIME - Zone 3 Phase Timer

Z1P_TIME can be set over the range of 0.0 to 10.0 seconds and establishes the time delay that the Zone 3 phase functions can be picked up before tripping is initiated. It should be set to 2.0 for traditional Zone 3 application for line protection. For the system backup application, it should be set with appropriate delay consistent with the reach setting.

2.3.5 Z4DISTANCE

The settings to be used on the Zone 4 distance functions in the LPS-O system depend on the application. The phase distance functions are set to look in the reverse direction relative to the Zone 1, Zone 2 and Zone 3 phase distance functions (see Figure 2-4: PHASE DISTANCE REACH below). The reverse direction is required in certain applications and/or schemes as described below.

**Figure 2-4: PHASE DISTANCE REACH**

Historically, Zone 4 distance functions have been provided with offset to include the origin of the R-X diagram within their characteristics (see Figure 2-5: R-X DIAGRAM FOR ZONE 4 DISTANCE FUNCTIONS below). Without the offset, memory would have to be relied on to provide an output for a zero voltage fault right at the relay location, and the output would last only as long as the memory lasted. With the offset, the function will operate on current alone and thus provide a continuous output for a zero voltage fault right at the relay location. A continuous output is required from the Zone 4 functions in some schemes to insure that incorrect tripping does not occur for certain fault conditions.

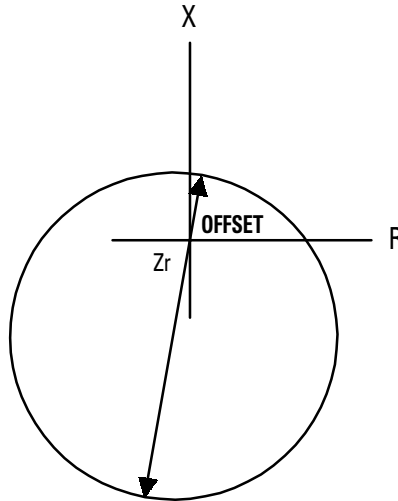


Figure 2-5: R-X DIAGRAM FOR ZONE 4 DISTANCE FUNCTIONS

The Zone 4 phase distance functions in the LPS-O system are not provided with offset because they use an adaptive memory feature to provide the operation needed for bolted three-phase faults at the relay location. The adaptive memory works as follows:

1. If the fault voltage is less than 10 percent of rated voltage, then the voltage prior to the fault will be used to polarize the Zone 4 functions. This voltage will be held, and the functions will remain picked up, until the fault is cleared, at which time they will reset.
2. If the voltage is greater than 10 percent of rated voltage, then the voltage prior to the fault will be held for 5 cycles and will then revert to the actual fault voltage. The functions will stay picked up for the duration of the fault and will reset when the fault clears.

In either case, the functions will provide a continuous output for the duration of the fault and will thus meet the requirements of the particular application.

401: Z4PHASE - Z4 Phase Distance

Z4PHASE can be set to YES or NO and determines whether or not the functions are to be used in the application.

If the Zone 4 phase distance functions are to be used to provide time-delayed backup protection, then set **Z4PHASE** = YES; otherwise, set **Z4PHASE** = NO.

402: Z4PHREACH - Z4 Phase Distance Reach

The Zone 4 phase distance functions can be used to provide an additional zone of time-delayed backup protection. They can be used to provide a fourth zone of protection in a straight step distance scheme, or they can be used to provide the so-called “reversed third zone” of protection.

The Zone 4 functions should be set with a reach commensurate with the application, considering underreach caused by intermediate fault current sources. **Z4PHREACH** should never be set so large as to:

1. Exceed the maximum allowable reach (MR), or,
2. To cause loss of selectivity with phase distance functions providing time-delayed backup on any adjoining line section. If this requirement cannot be met by limiting the reach, then it may be necessary to get this selectivity by setting timer **Z4P_TIME** with additional time delay.

403: Z4PCHARANG - Z4 Phase Characteristic Angle

This setting determines the characteristic shape and, consequently, the area of resistance coverage provided by the Zone 4 phase distance functions. **Z4PCHARANG** can be set to 80° to 120° in 5° steps. A 90° setting is recommended and settings lower than 90° should not be used. If the desired reach, **Z4PHREACH**, with a 90° characteristic and with maximum load flow does not allow the maximum allowable reach criteria to be met, then a "lens-shaped" characteristic must be used. The settings of both **Z4PHREACH** and **Z4PCHARANG** may be evaluated by using the maximum allowable reach formula associated with Figure 2–2: MAXIMUM ALLOWABLE REACH on page 2–9.

405: Z4_TIMERS - Z4 Timers

The choice of settings is YES or NO. Set **Z4TIMERS** = YES if the Zone 4 phase distance time delay is to be used, otherwise set **Z4TIMERS** = NO.

406: Z4P_TIME - Zone 4 Phase Timer

If **Z4_TIMERS** = YES and if the Zone 4 phase distance functions are to provide time-delayed backup protection, then the **Z4P_TIME** time delay should be set long enough to coordinate with the time-delayed operation of the appropriate zone of phase-distance relays in adjacent line sections. If **Z4_TIMERS** = NO then the **Z4P_TIME** can be set to any value within its range with no affect on scheme operation.

2.3.6 CURSUPVISN**501: IT_PICKUP - Trip Supervision Current****502: IB_PICKUP - Block Supervision Current**

These two overcurrent functions provide supervision for the phase distance functions. IT is also used in the trip bus seal-in circuit. To obtain maximum sensitivity, the following settings are proposed:

IT_PICKUP = *minimum*

IB_PICKUP = *minimum*

503: IPT_PICKUP - Ground Overcurrent (Forward)**504: IPB_PICKUP - Ground Overcurrent (Reverse)****505: IPBKFACTOR - IPB I1 Restraint**

The **IPT_PICKUP**, **IPB_PICKUP**, and **IPBKFACTOR** settings have no significance in the step distance scheme used with the LPS-O. However the IPT and IPB functions are available for general purpose use in the LPS-O for configurable outputs. The settings are not user adjustable and are fixed to values shown in the Table below.

Table 2–4: FIXED VALUES FOR PROTECTION SETTINGS 503 TO 505

SETTING #	MNEMONIC	DESCRIPTION	VALUE (5A)	VALUE (1A)
503	IPT_PICKUP	Ground Overcurrent (Forward)	0.50 A	0.10 A
504	IPB_PICKUP	Ground Overcurrent (Reverse)	0.25 A	0.05 A
505	IPBKFACTOR	IPB I1 Restraint	0.0	0.0

506: NT_OFFSET: NT/NB Offset

The NT/NB functions use an offset to provide a reliable polarizing quantity for the conditions shown in Figure 2–6: NT/NB FUNCTIONS below.

In this system, the voltage (V) at the relay is in the proper direction to provide correct directional sensing, but, depending on the source to line impedance ratio (Z_s/Z_L), the magnitude of the voltage may not be sufficient to provide a reliable polarizing quantity. The problem is most onerous on a long transmission line with a strong source impedance behind the relay (Z_s/Z_L is quite small). The effect of the offset in this case is to add a component to the actual voltage so as to replicate the voltage at a point some distance down the transmission line.

NT_OFFSET can be determined as follows:

$$\text{NT_OFFSET} = 0.005 \cdot Z_1 \cdot I_n$$

where Z_1 = positive sequence impedance of protected line (in secondary ohms)

I_n = Magnetics Module CT rating (1A or 5A)

If the calculated value is greater than 0.05, then set **NT_OFFSET** = 0.05. Otherwise, use the calculated value and make the next lowest available setting. For example, if the calculated setting is 0.027, set **NT_OFFSET** = 0.02

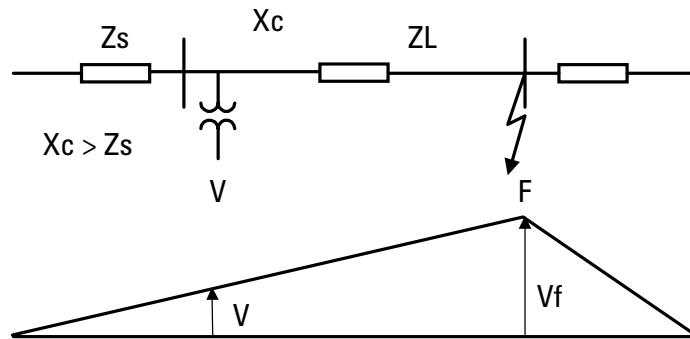


Figure 2-6: NT/NB FUNCTIONS

507: UNBALALARM - Unbalanced Current Alarm

The LPS-O system is supervised by a fault detector (FD) that uses the following operating quantity:

$$FD_{op} = \Delta I_1 + I_2 + I_0$$

Tripping will not be permitted unless there is a concurrent output from the fault detector, resulting in an increase of security. The LPS-O system monitors the output of the fault detector. If it produces an output that lasts for more than 60 seconds, then it is an indication that:

1. there is an unbalance in the current on the system as indicated by the presence of negative-sequence current (I_2) and/or zero-sequence current (I_0), or
2. the fault detector has failed (unlikely).

If either of these conditions is detected an **UNBALARM** signal is produced. This signal can be routed via the Xpression Builder program to drive one of the programmable outputs, or it may be used as an input to one of the programmable outputs that may already have been selected for alarm duty.

2.3.7 OVERCURRENT

601: 50 - Phase Instantaneous Overcurrent

The **50** function can be used in many applications to provide high speed, direct tripping for heavy close-in faults. To use the phase instantaneous overcurrent trip function, set **50** = YES, otherwise set **50** = NO. See Protection Settings 602 and 603 for further discussion on use of **50** function. Also, Protection Setting 201: **Z2PHASE** must be set to YES.

602: 50_DIRCNL - Directional Control Of 50

The **50** function can be set to be either directional or nondirectional. Directionality is obtained through the use of the Zone 2 phase distance functions. Protection Setting 201 must be set to **Z2PHASE** = YES to make the **50** function directional.

If **50** is made directional, the setting is based on the maximum fault current for a fault at the remote end of the line. When **50** is made non-directional, then the setting is based on the maximum fault current for a fault at either end of the line. If the maximum fault current for a fault at either end of the line is approximately the same, then it is proposed that the **50** function be made non-directional.

603: 50PICKUP - 50 Pickup Setting

50 provides direct tripping for multi-phase faults, and it operates on the highest of the three delta currents, IA-IB, IB-IC, or IC-IA. This permits **50** to have the same response for all multi-phase faults at the same location. If **50PICKUP** is non-directional, then it should be set at least 25 percent greater than the maximum delta three-phase fault current for a fault at either terminal of the line. If **50PICKUP** is directional, then it should be set at least 25 percent greater than the maximum delta three-phase fault current for a fault at the remote terminal of the line. The setting is calculated on the basis of the delta current which for a three phase fault is equal to the square root of three times the phase current.

604: 50PICKUPFF - 50 Pickup During Fuse Failure

If **50** is made directional and potential is lost to the relay, then directional control will be lost and the **50** function will not be able to provide any protection. To overcome this drawback, a second setting (**50PICKUPFF**) can be made on the **50** function to provide some backup during a loss of potential. A **50PICKUPFF** setting must always be made and it must always be set at least 25 percent greater than the maximum delta three-phase fault current for a fault at either terminal of the line.

605: 50G - Ground Instantaneous Overcurrent

The **50G** function can be used in many applications to provide high speed, direct tripping for heavy close-in faults. To use the ground instantaneous overcurrent trip function, set **50G** = YES, otherwise set **50G** = NO. See Settings 606 and 607 for further discussion on use of **50G** function.

606: 50G_DIRCNL - Directional Control Of 50G

The **50G** function can be set to be either directional or nondirectional. Directionality is obtained through the use of the negative sequence directional functions by requiring operation of the NT (forward looking) function *and* non-operation of the NB (reverse looking) function.

If **50G** is made directional, the setting to be made on the function is based on the maximum fault current for a fault at the remote end of the line. When **50G** is made non-directional, then the setting is based on the maximum fault current for a fault at either end of the line. If the maximum fault current for a fault at either end of the line is approximately the same, then it is proposed that the **50** function be made non-directional.

607: 50GPICKUP - 50G Pickup Setting

The considerations used to determine the **50G** setting depend on whether **50G** is nondirectional or directionally controlled. If **50G** is nondirectional, then it must be set not to operate on the worst case external fault at *either* end of the line. If **50G** is controlled by the negative sequence directional functions, then it must be set not to operate for the worst case external fault at the *remote* end of the line. In general, directional control should be used when the operating current for a fault behind the relay location is much greater than the operating current for a fault at the remote end of the line.

50G provides direct tripping for single-line-to-ground faults, and its operating quantity is:

$$\mathbf{50G}_{op} = 3 \times |I_0| - \mathbf{50GRESTNT} \times 3 \times |I_1|$$

where **50GRESTNT** = 0 or 0.3

When **50GRESTNT** is set to 0.3, positive-sequence current restraint is used to provide secure operation during steady-state unbalances, error currents, and external faults. The **50G** setting is established by first determining the *maximum positive value* of the operating quantity listed above (taking into account the **50GRESTNT** setting). **50GPICKUP** is then this maximum operate signal plus a margin of 25% of the $3 \times I_0$ value from this same maximum operate signal.

$$\mathbf{50GPICKUP} = 3 \times |I_0| - \mathbf{50GRESTNT} \times 3 \times |I_1| + 0.25 \times 3 \times |I_0|$$

608: 50GPCKUPFF - Pickup During Fuse Failure

If **50G** is made directional and potential is lost to the relay, then directional control will be lost and the **50G** function will not be able to provide any protection. To overcome this drawback, a second setting (**50GPCKUPFF**) can be made on the **50G** function to provide some backup during a loss of potential. A **50GPCKUPFF** setting must always be made and it must always be set as given above and based on the maximum operating quantity that can be obtained for a fault at either end of the line.

609: 50GRESTNT - 50G Restraint Setting

50GRESTNT can be set to 0 or 0.3, and it determines whether or not a portion of the positive-sequence current, is used to restrain the operating quantity, $3 \times |I_0|$. The effect of positive-sequence current restraint is to make the **50G** function more secure during external faults, steady-state unbalances and/or error currents.

610: 51G - Select Ground Time Overcurrent (TOC)

51G can be set to either YES or NO. This setting determines whether the **51G** function is in service (YES) or out of service (NO).

611: 51G_DIRCNL - Select Directional Control of TOC

51G_DIRCNL can be set to either YES or NO. This setting determines whether **51G** is directionally controlled (YES) or not directionally controlled (NO).

612: 51GPICKUP - Ground Time Overcurrent Setting

The **51G** function provides time-delayed backup tripping for single-line-to-ground faults. Its operating quantity is:

$$3 \times |I_0|$$

The curve shape used for **51G** is determined by the **51GCURVE** setting as described below. The pickup and time-dial settings should be selected to provide coordination with similar functions in adjacent line sections.

613: 51GPCKUPFF - 51G Pickup During Fuse Failure

If **51G** is made directional and potential is lost to the relay, then directional control will be lost and the **51G** function will not be able to provide any protection. To overcome this drawback, a second setting (**51GPCKUPFF**) can be made on the **51G** function to provide some backup during a loss of potential. A **51GPCKUPFF** setting must always be set as given above and is based on the maximum operating quantity that can be obtained for a fault at either end of the line.

614: 51GCURVE - Select 51G Characteristic Curve

51GCURVE determines the characteristic curve shape for the **51G** function. The choices are inverse curve (INV; see Figure 2–14: INVERSE CURVE on page 2–29), very inverse curve (V-INV; see Figure 2–15: VERY INVERSE CURVE on page 2–30), extremely inverse (E-INV; see Figure 2–16: EXTREMELY INVERSE CURVE on page 2–31), user-defined custom curve (CUSTOM), and definite time (DEFT).

615: 51GTMDIAL - Ground Time Overcurrent Time Dial

51GTMDIAL selects the time-dial setting for the **51G** function. **51GTMDIAL** can be set over the range of 0.5 to 10.0. The pickup and time-dial settings should be selected to provide coordination with similar functions in adjacent line sections.

616: DEFTIMDELY - Definite Time Delay

When the 51G function is selected to have a definite time characteristic, **DEFTIMDELY** determines the associated fixed time delay. Select a time that meets the specific application.

617: 51G_RESET - Select Time Overcurrent Reset Characteristic

The **51G** function can be set to have a very fast reset (approximately 50 milliseconds for the definite time curve and 4 milliseconds for the variable time curves) following its pickup, or it can be set to have a reset characteristic that emulates the reset time of an electromechanical device with a similar time curve. Select FAST for the fast reset or EM to emulate an electromechanical function.

2.3.8 VOLTAGE**701: RATEDVOLTS - Rated Per Unit Voltage**

This setting establishes the voltage on which per unit voltage values are based. **RATEDVOLTS** can be set to 100, 105, 110, 115 or 120 volts. Use a setting that is closest to the voltage that is applied to the LPS-O system.

702: PHASEOVER - Select Phase Overvoltage

If the phase overvoltage function is to be used, set **PHASEOVER** = YES, otherwise set **PHASEOVER** = NO.

703: PHOVPICKUP - Phase Overvoltage Pickup

PHOVPICKUP can be set from 0.0 to 1.4 per unit based on the **RATEDVOLTS** setting. Use a setting that meets the specific application.

704: PHOVTMDLY - Phase Overvoltage Time Delay

PHOVTMDLY establishes a time delay that is started when the phase overvoltage function operates. **PHOVTMDLY** can be set from 0.0 to 10.0 seconds. Use a setting that meets the specific application.

705: FUSEFAIL - Potential Fuse Failure Blocking

Since a distance or directional function may operate for a full or partial loss of AC potential caused by one or more blown fuses, **FUSEFAIL** is provided to block distance and directional function tripping when a fuse failure is detected. If the backup overcurrent functions **50**, **50G**, and **51G** are non-directional they will be allowed to trip. If **50**, **50G** or **51G** are directional, then they will not be allowed to trip. Figure 2–7: FUSEFAIL FUNCTION LOGIC DIAGRAM shows the functional logic for the **FUSEFAIL** function.

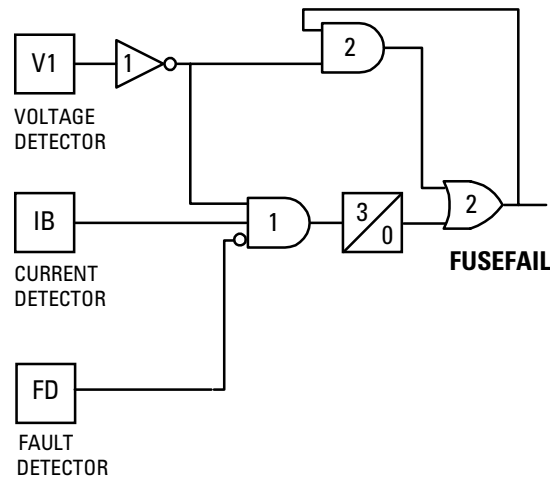


Figure 2-7: FUSEFAIL FUNCTION LOGIC DIAGRAM

If AC potential is lost, the positive-sequence voltage detector V1 drops out, NOT1 produces a logic 1 output, and the upper input is present at AND1. The V1 pickup setting is fixed at 75% of **RATEDVOLTS**. The middle input to AND1 is present if load current is sufficient to operate the current detector IB, while the bottom input is dependent upon whether the fault detector FD has operated or whether one or more poles of the breaker are open.

If AC potential is lost for any reason, including a blown fuse or fuses, and there is no disturbance on the power system so that the fault detector has not operated, AND1 produces an output that causes timer TL1 to time out and produce a **FUSEFAIL** output via OR2. The output of OR2 is routed to AND2 to seal in the **FUSEFAIL** output, based on the output of V1, so that **FUSEFAIL** output is maintained as long as the potential is below normal. When the potential returns to normal, V1 and NOT1 reset to remove the seal-in, allowing the **FUSEFAIL** output to reset.

When a fault occurs, with an attendant drop in potential, the V1 function resets, but the fault detector operates to prevent an output from AND1. **FUSEFAIL** does not operate on fault conditions.

FUSEFAIL can be set to NO or YES. If YES is selected, then an output will be prevented from any function that requires potential to operate (distance, directional and any directionally controlled function). If NO is selected, nothing will be blocked in the event a potential failure occurs.

2.3.9 LINEPICKUP

Line Pickup provides tripping in the event that the breaker is closed into a zero-voltage bolted three-phase fault, such as occurs if the grounding chains are left on the line following maintenance. Figure 2-8: LINE PICKUP FUNCTIONAL LOGIC shows the functional logic for Line Pickup.

2



Line Pickup via the I1 function is intended primarily to trip for zero-voltage bolted faults wherein the distance functions connected to line-side potential will not operate. As an additional feature, operation of any one of the Zone 2 distance functions will also initiate a line pickup trip. This is accomplished by routing the Zone 2 phase-distance function outputs to the upper input of AND1. The other input to AND1 comes from the normal line-pickup-enable output of timer TL2 as previously described. Operating time for the distance functions will be slower than normal since the pre-fault voltage is zero (assuming line-side potential) and it takes the relay several cycles to establish a memory polarizing voltage. However, this feature still results in faster tripping for permanent faults past the Zone 1 reach, and below the pickup of the I1 function.

801: LINEPICKUP - Select Line Pickup

Set **LINEPICKUP** = YES if the line pickup logic is to be used, otherwise set **LINEPICKUP** = NO.

802: BYPASSTL3 - Bypass Line Pickup Time Delay

If simultaneous reclosing is used and if **I1PICKUP** (Protection Setting 803) must be set below full load, then set **BYPASSTL3** = NO, otherwise set **BYPASSTL3** = YES.

803: I1PICKUP - I1 Pickup Setting

I1 is the overcurrent trip unit used in the Line Pickup function, and it operates on the magnitude of the positive-sequence current.

I1PICKUP should be set no greater than two-thirds of the minimum fault current for an internal three-phase fault at the relay location. If the minimum fault current is greater than the maximum load current on the protected line, then the I1 setting can be reduced to provide greater coverage of the line. For this case, a setting of 110% of the maximum load current is proposed.

2.3.10 REMOTEOPEN

The Remote-Open Detector (ROD) function issues a trip signal when the remote breaker opens during an unbalanced internal fault. This function detects that the remote breaker has opened by recognizing charging current on one or more phases following opening of the remote breaker. The Remote-Open Detector will not operate for a balanced three phase fault.

ROD logic can speed up tripping at the end of the line that otherwise would be the slowest to respond in a sequential-tripping condition. In a Step Distance scheme, ROD tripping is beneficial for any unbalanced internal fault not detected by Zone 1. Figure 2–9: ROD LOGIC DIAGRAM is a functional logic diagram of the ROD function. The sequence of events that results in an ROD output is as follows:

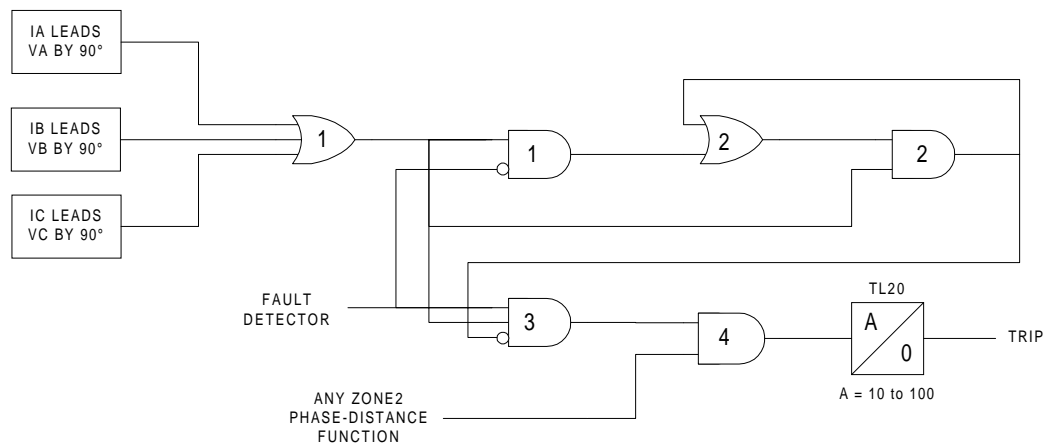


Figure 2–9: ROD LOGIC DIAGRAM

1. No charging current is detected prior to the fault – logic 0 output from AND2.
2. A fault is detected – logic 1 output from OR3.
3. The remote breaker opens and charging current is detected – logic 1 output from AND3.
4. The fault is still present, so the two inputs to AND4 persist and a trip output will be produced following the time-delay setting of timer TL20.

If charging current is initially detected but the fault detector (FD) is not picked up, indicating no fault on the power system, then OR1 and AND1 produce outputs. AND2 produces an output and seals itself in on the output of OR1 via OR2. AND3 is now blocked from producing an output as long as charging current is detected, regardless of whether FD is picked up or not. If a subsequent fault occurs and the remote breaker opens, ROD is prevented from producing an output.

If sufficient load current is flowing prior to the fault, there is no output from OR1, indicating that no charging current is detected, and AND3 is not blocked, since there is no output from AND2. If an unbalanced fault subsequently occurs, FD blocks AND1 to prevent an AND2 output. AND3 is allowed to produce an output when the remote breaker opens, provided there is sufficient charging current to operate one or more of the three charging-current-detectors that are the inputs to OR1. The capacitive charging current must be 60 mA or more (secondary phase current) to assure operation of ROD. If the fault is still present, as indicated by an output from OR3, a ROD trip is initiated following TL20 security time delay setting.

901: REMOTEOPEN - Select Remote Open Detector

Set **REMOTEOPEN** = YES to enable the remote open detection function, otherwise set **REMOTEOPEN** = NO.

902: TL20PICKUP - Remote Open Detector Time Delay

TL20PICKUP the time required for a remote open trip to be initiated following opening of the remote breaker and subsequent detection of charging current flow. Longer settings will provide greater security but slower tripping and vice versa. Use a **TL20PICKUP** setting that meets the specific application.

2.3.11 LINEOVRD

The Line Overload function consists of two overcurrent units (Level 1 and Level 2) with independent time delays. Level 1 is intended to be used with the lower pickup and longer time delay. Level 2 is intended to be used with the higher pickup and shorter time delay. The pickup and time delay settings should be based on short time and emergency loading situations for the protected line.

1001: LINEOVERLD - Select Line Overload Protection

Set **LINEOVERLD** = YES if line overload protection is to be used, otherwise set **LINEOVERLD** = NO. If **LINEOVERLD** = NO, ignore Protection Settings 1102 to 1105.

1002: LEVEL1PU - Level 1 Pickup Current

Use a **LEVEL1PU** setting that meets the specific application.

1003: LEVEL2PU - Level 2 Pickup Current

Use a **LEVEL2PU** setting that meets the specific application.

1004: LEVEL1TDLY - Level 1 Time Delay

Use a **LEVEL1TDLY** setting that meets the specific application.

1005: LEVEL2TDLY - Level 2 Time Delay

Use a **LEVEL2TDLY** setting that meets the specific application.

2.3.12 SCHEME TIMERS

- 1101: TL5PICKUP - BKR1 b sw Coordination Timer Pickup
 1102: TL5DROPOUT - BKR1 b sw Coordination Timer Dropout
 1103: TL6PICKUP - BKR2 b sw Coordination Timer Pickup
 1104: TL6DROPOUT - BKR2 b sw Coordination Timer Dropout

Pickup and Dropout time settings of the timers TL5 and TL6 can be used, if desired, to coordinate the Time Tags of breaker position events with the main contacts of the breaker. There is no other significance of these settings in the LPS-O.

2.3.13 LINE INFO

1201: POSSEQANG - Positive Sequence Impedance Angle

POSSEQANG is common to all of the distance functions and establishes the positive sequence angle of maximum reach. Set **POSSEQANG** to a value that is equal to or just larger than the angle of the positive-sequence impedance of the protected line.

1202: CTRATIO - Current Transformer Ratio

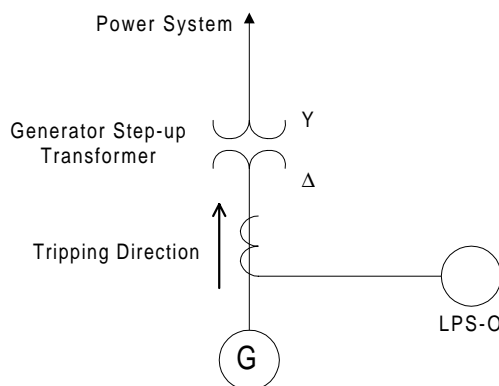
The LPS-O system will report present values in terms of secondary values or primary values as set by General Setting 108: **DISPLAYVAL**. The ratio of the of the current transformers used to supply the system is used in this procedure. Set **CTRATIO** equal to the CT ratio used with the LPS-O system.

1203: PTRATIO - Potential Transformer Ratio

The LPS-O system will report present values in terms of secondary values or primary values as set by General Setting 108: **DISPLAYVAL**. The ratio of the of the potential transformers used to supply the system is used in this procedure. Set **PTRATIO** equal to the PT ratio used with the LPS-O system.

1204: TRSMFRTYPE - Transformer Type

TRSMFRTYPE can be set as NONE, YD1, YD5, YD7, or YD11. It should be set to properly describe the phase shift between the Delta (Δ) and Wye (Y) sides of the Generator Step-up Transformer that may exist between the LPS-O and the protected line/system. Figure 2–10: PROTECTION SETTING 1204: TRSMFRTYPE below shows different transformer configurations and appropriate settings for **TRSMFRTYPE**.



IF:	Protection Setting 1204:
No Transformer	NONE
Δ side lags Y by 30°	YD1
Δ side lags Y by 150°	YD5
Δ side leads Y by 150°	YD7
Δ side leads Y by 30°	YD11

Figure 2–10: PROTECTION SETTING 1204: TRSMFRTYPE

2.3.14 OS BLOCKING

2

Out-of-step blocking (OSB) is offered as a standard feature in the LPS-O system. Refer to Section 1.4.4: OUT-OF-STEP BLOCKING on page 1–10 for a complete description of the OSB logic. The OSB function is implemented through the phase distance functions in the LPS-O system as shown in Figure 2–11: OSB FUNCTION CHARACTERISTIC below. For an out-of-step condition, the apparent impedance seen by the relay will follow a typical swing line. The LPS-O system recognizes an out-of-step condition by sensing that the MOB function operates first, and that the coordinating function (Zone 2 or 3) operates a short time later. The **MOBZONE** setting is used to select which of the zones (Zone 2 or 3) is used as the coordinating zone.

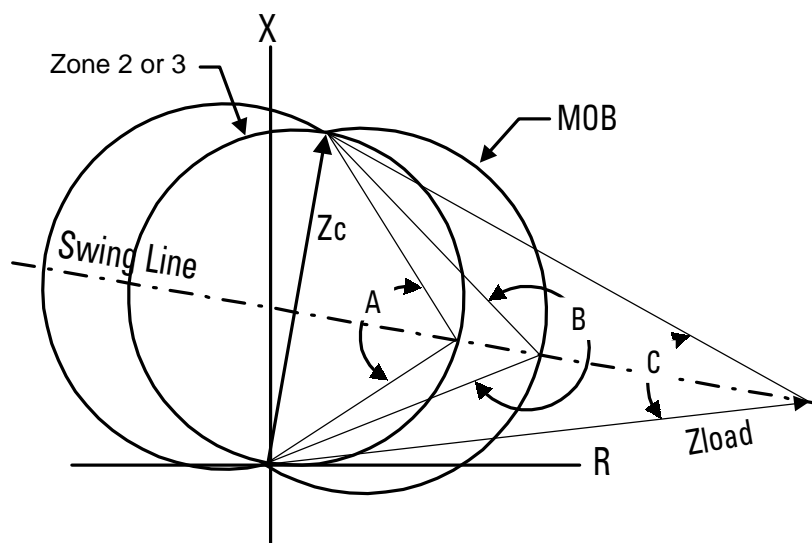


Figure 2–11: OSB FUNCTION CHARACTERISTIC

The angles A, B and C are determined as a function of the reach (Z_c) of the coordinating zone, the maximum load flow (minimum Z_{load}) and the fastest swing (first slip cycle). Angle A is selected via the **ZxPCHARANG** ($x = 2, 3$ or 4) and determines the shape of the coordinating zone characteristic. Angle B is selected via the **MOBCHARANG** setting and determines the shape of the MOB characteristic. Angle B should be set so that the time for the fastest swing to traverse from angle B to angle A is not less than 30 milliseconds. In addition, the A and B angle settings must be selected so that the difference between angle B and angle C is never less than 20° . Note that angle C is determined as a function of the minimum load impedance (Z_{load}) and the reach (Z_c) of the coordinating zone. Load flow and stability studies may have to be run to determine the settings necessary to establish out-of-step blocking.

1301: MOBZONE - Coordinating Zone

Set **MOBZONE** to select a coordinating zone per the criteria described above.

1302: MOBCHARANG - MOB Characteristic Angle

Use the criteria described above to select an appropriate **MOBCHARANG** setting.

1303: BLOCKWHAT - Functions to Block during Out-of-Step Tripping

BLOCKWHAT is used to select which of the following are to be blocked during an out-of-step condition:

1. BLKALL: Block all tripping regardless of what operated to initiate the trip.
2. BLKDIST: Block tripping for operation of any of the distance functions.

3. BLKPHAS: Block tripping by any of the phase distance functions.
4. BLKNONE: allow tripping for any trip condition.

1304: BLOCKZ1 - Block All Zone 1 Functions

Set **BLOCKZ1** = YES to block tripping by any of the Zone 1 functions, otherwise set **BLOCKZ1** = NO.

1305: BLOCKZ2 - Block All Zone 2 Functions

Set **BLOCKZ2** = YES to block tripping by any of the Zone 2 functions, otherwise set **BLOCKZ2** = NO.

1306: BLOCKZ3 - Block All Zone 3 Functions

Set **BLOCKZ3** = YES to block tripping by any of the Zone 3 functions, otherwise set **BLOCKZ3** = NO.

1307: BLOCKZ4 - Block All Zone 4 Functions

Set **BLOCKZ4** = YES to block tripping by any of the Zone 4 functions, otherwise set **BLOCKZ4** = NO.

2.3.15 OS TRIPPING

The LPS-O system is supplied with out-of-step tripping in addition to out-of-step blocking. For a complete description of the operation of the out-of-step tripping logic, see Section 1.9: OUT-OF-STEP TRIPPING on page 1–22. Out-of-step tripping is implemented using positive-sequence phase distance functions (separate from the regular LPS-O distance functions) as shown in Figure 2–12: OUT-OF-STEP TRIPPING. For an out-of-step condition, the apparent impedance seen by the relay will follow a typical swing line as shown below. An out-of-step condition is recognized by sensing that the apparent impedance seen by the system first enters the outer characteristic, then the middle characteristic, and finally the inner characteristic. The traversal from characteristic to characteristic occurs in a finite time that is directly related to the slip frequency of the power system during an out-of-step condition.

The following settings must be made (refer to Figure 2–13: OST REACH CHARACTERISTIC). It will most likely be necessary to run load flow and system swing studies to determine the settings for any given application. The example used below is provided only for use as a guide in describing each of the settings.

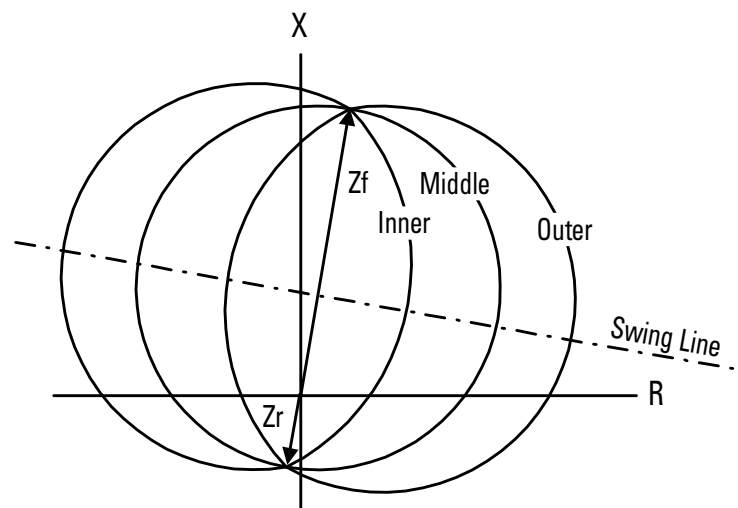


Figure 2–12: OUT-OF-STEP TRIPPING

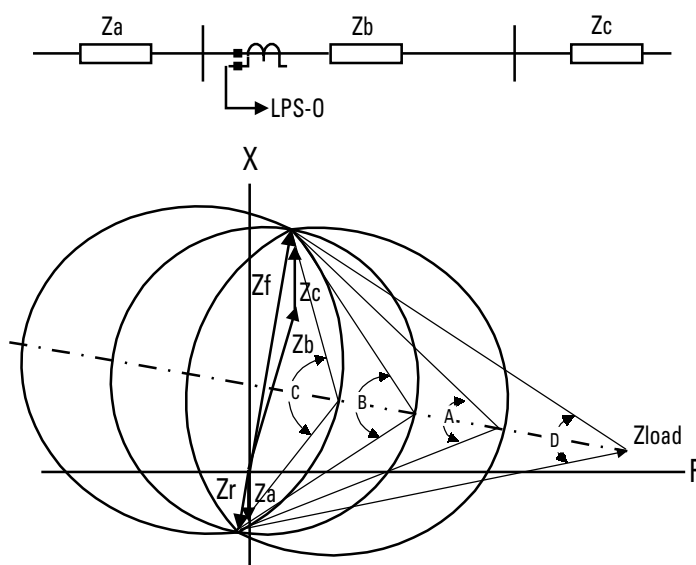


Figure 2-13: OST REACH CHARACTERISTIC

1401: USE_OST - Select OST

Set **USE_OST** = YES if out-of-step tripping is to be used, otherwise set **USE_OST** = NO.

1402: NUMBRCHAR - Select Number Of Characteristics

Depending on the application, it may not be possible to use all three of the characteristics, and the **MIDDLE** characteristic must be bypassed. If only two characteristics are to be used (**MIDDLE** characteristic bypassed), set **NUMBRCHAR** = 2, otherwise set **NUMBRCHAR** = 3.

1403: TRIPIN_OUT - Trip Enter Or Leaving Inner

The OST function can be set so that tripping will be initiated shortly after the impedance enters the inner characteristic (pickup time of TLOS3), or it can be set to trip shortly after the swing leaves the outer characteristic (dropout time of TLOS1). This setting is determined by the capability of the breakers used in the power system:

1. If the circuit breaker is capable of interrupting when the systems are approximately 180° apart (around twice voltage across the breaker contacts) set **TRIPIN_OUT** = IN.
2. If the circuit breaker is not capable of interrupting when the systems are nearly 180° apart, set **TRIPIN_OUT** = OUT.

1404: FWDREACH - OST Forward Reach

For the simple system shown above in Figure 2-13: OST REACH CHARACTERISTIC, set the forward reach long enough to include the line plus the source at the remote end of the line; that is,

$$\text{FWDREACH} > Z_b + Z_c$$

1405: REVREACH: - OST Reverse Reach

For the system shown above in Figure 2-13: OST REACH CHARACTERISTIC, set the reverse reach to include the source behind the LPS-O system; that is,

$$\text{REVREACH} > Z_a$$

1406: OUTER: Outer Characteristic Angle**1407: MIDDLE - Middle Characteristic Angle****1408: INNER - Inner Characteristic Angle**

These three settings are related and the object is to obtain the maximum difference in angle between the inner and outer settings. This provides the best opportunity of detecting the fastest possible power swings. Two factors are used in determining the outer and inner settings:

1. the maximum load flow across the line which determines the minimum load impedance seen by the relay.
2. the maximum swing angle that the power system can tolerate and beyond which the system cannot recover; that is, the system becomes unstable.

The **OUTER** characteristic angle setting (angle A in Figure 2–13: OST REACH CHARACTERISTIC above) is based on the maximum load flow across the system and should be selected so that angle A is always greater than angle D by at least 20 degrees. For example if angle D = 50°, then set **OUTER** = 70°.

The **INNER** characteristic angle (angle C in Figure 2–13: OST REACH CHARACTERISTIC above) sets the point at which an out-of-step trip will be initiated and is dependent on the angle beyond which the system cannot recover. Select an **INNER** setting such that the system is beyond recovering once the inner characteristic is entered. Typical settings for **INNER** would be in the 120° to 150° range.

The **MIDDLE** characteristic angle setting is dependent on the **OUTER** setting and the **INNER** setting, and should be set approximately halfway between the two. For example if **OUTER** = 70° and **INNER** = 150°, then set **MIDDLE** = 110°.

1409: TLOS1PU - Coordinating Timer 1 Pickup**1410: TLOS1DO - Coordinating Timer 1 Dropout****1411: TLOS2PU - Coordinating Timer 2 Pickup****1412: TLOS3PU - Coordinating Timer 3 Pickup****1413: TLOS4PU - Coordinating Timer 4 Pickup**

These five settings are related to each other with the object being to detect the fastest possible swing and to produce an OST output in a secure manner. Refer to Figure 2–12: OUT-OF-STEP TRIPPING on page 2–25 for the out-of-step tripping logic.

The pickup time of TLOS1 establishes the first step in the out-of-step process and sets the time that the swing must remain between the outer and middle characteristics for the first step to be completed. **TLOS1PU** must be set less than the time that it takes for the *fastest* swing to travel from the outer to the middle characteristic. If **TRIPIN_OUT** is set to OUT, the dropout time of TLOS1 sets the time duration for an out-of-step trip output to be produced. A minimum setting for **TLOS1DO** of 50 milliseconds is proposed. If **TRIPIN_OUT** is set to IN, then **TLOS1DO** can be set to any setting within its range.

The pickup time of TLOS2 establishes the second step in the out-of-step process and sets the time that the swing must remain between the middle and inner characteristics for this step to be completed. **TLOS2PU** must be set less than the time that it takes for the *fastest* swing to travel from the outer to the middle characteristic.

The pickup time of TLOS3 establishes the final step in the out-of-step process and determines the time that the swing must remain inside of the inner characteristic before the final decision is made to produce an out-of-step trip. It provides added security to the logic. A minimum setting for **TLOS3PU** of 20 milliseconds is proposed.

2.3.16 NONCRIT_AL

Up to eight of the signals listed in the Index Tables given at the end of this section can be used to produce a non-critical alarm signal (Index Number 52). This signal, when produced, will always be reported as an event and it can also be programmed to drive one of the output relays if an external alarm is required.

1501: NCAIN1 - Non-Critical Alarm Input #1
 1502: NCAIN2 - Non-Critical Alarm Input #2
 1503: NCAIN3 - Non-Critical Alarm Input #4
 1504: NCAIN4 - Non-Critical Alarm Input #4
 1505: NCAIN5 - Non-Critical Alarm Input #5
 1506: NCAIN6 - Non-Critical Alarm Input #6
 1507: NCAIN7 - Non-Critical Alarm Input #7
 1508: NCAIN8 - Non-Critical Alarm Input #8

Set these Protection Settings to one of the available Index numbers given in Table 2–6: INDEX NUMBERS – CONFIGURABLE LOGIC & PROGRAMMABLE OUTPUT SIGNALS on page 2–33.

2.3.17 OUTPUTS

All 24 of the output contacts (Protection Settings 1601 to 1624) in the LPS-O system are configurable. They can be driven by any one of the functions by an index number provided in Table 2–6 on page 2–33. Each of the contacts has a default setting as listed in the Protection Settings listed at the end of this section. The default settings are established through an Xpression Builder file that is downloaded in the LPS-O system in the factory. Any of the settings can be changed by modifying this logic via the Xpression Builder program, by settings change through the LPSO-Link program, or by settings change through the keypad. Note that any index number settings that are changed through the keypad or LPSO-Link will be reflected in the configurable logic file, while any settings that are changed through the configurable logic will be reflected in the settings file.

1601: T1 - T1 Contact	1613: A7 - A7 Contact
1602: T2 - T2 Contact	1614: A8- A8 Contact
1603: T3 - T3 Contact	1615: A9 - A9 Contact
1604: T4 - T4 Contact	1616: A10 - A10 Contact
1605: T5 - T5 Contact	1617: A11 - A11 Contact
1606: T6 - T6 Contact	1618: A12 - A12 Contact
1607: A1 - A1 Contact	1619: C1 - C1 Contact
1608: A2 - A2 Contact	1620: C2 - C2 Contact
1609: A3 - A3 Contact	1621: KT1 - KT1 Contact
1610: A4 - A4 Contact	1622: KT2 - KT2 Contact
1611: A5 - A5 Contact	1623: KT3 - KT3 Contact
1612: A6 - A6 Contact	1624: KT4 - KT4 Contact

If other than the default setting is to be used, change the configurable logic or select an index number reflecting the function by which the contact is to be driven.

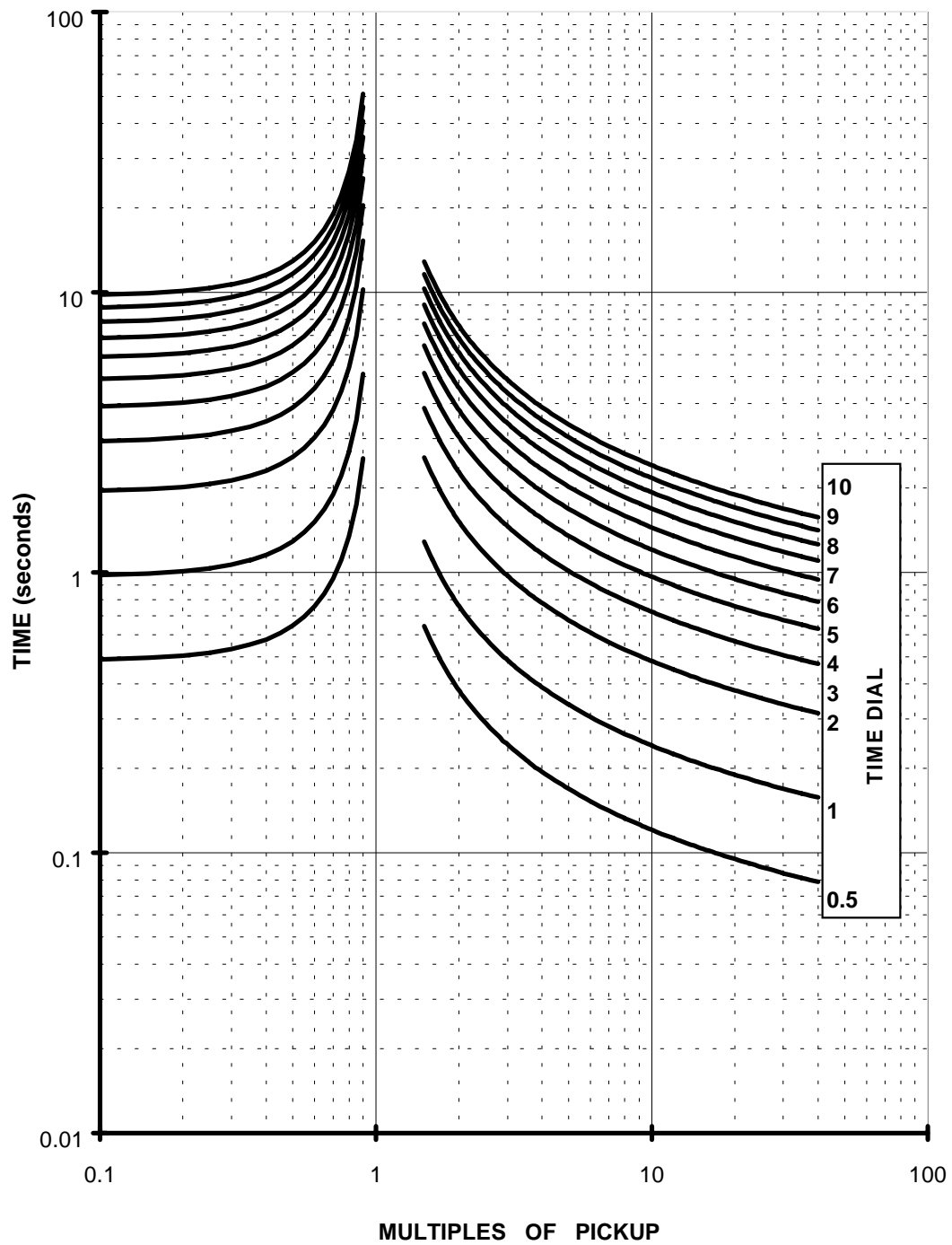
1625: CONFTRIP - Initiate Three Pole Trip

The **CONFTRIP** setting allows tripping to be initiated through the trip output contacts that are used by the scheme logic. **CONFTRIP** can be driven by any one of the functions as described by an index number provided in the Table 2–6: INDEX NUMBERS – CONFIGURABLE LOGIC & PROGRAMMABLE OUTPUT SIGNALS on page 2–33, or separate logic can be designed using the Xpression Builder program.

1626: CONFOSC - Trigger Oscillography

The **CONFOSC** setting allows oscillography data capture to be initiated by the operation of selected signals within the LPS-O logic, or via external input through a contact converter. Regardless of the setting of **CONFOSC**, oscillography data capture will always occur when the LPS-O issues a trip output. Care should be taken to ensure that the signals chosen; if one of the selected triggers can operate frequently, trip oscillography data may be overwritten and lost. **CONFOSC** can be driven by any one of the functions as described by an index number provided in Table 2–6: INDEX NUMBERS – CONFIGURABLE LOGIC & PROGRAMMABLE OUTPUT SIGNALS on page 2–33, or separate logic can be designed using the Xpression Builder program.

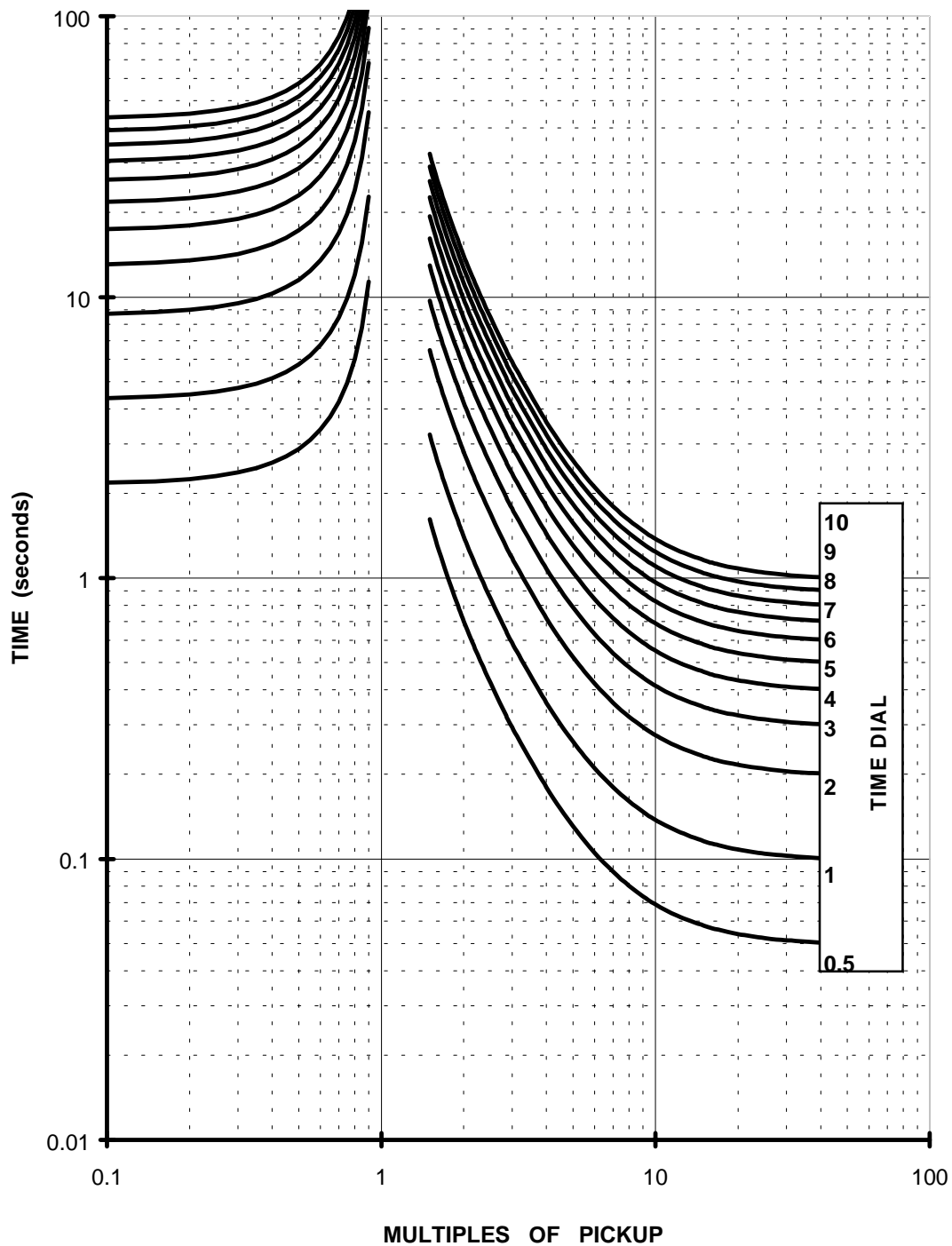
2.4.1 INVERSE CURVE



$$t(RESET) = TD \left[\frac{0.97}{1 - M^2} \right], \quad t(PU) = TD \left[\frac{0.0103}{M^{0.02} - 1} + 0.0228 \right]$$

Figure 2-14: INVERSE CURVE

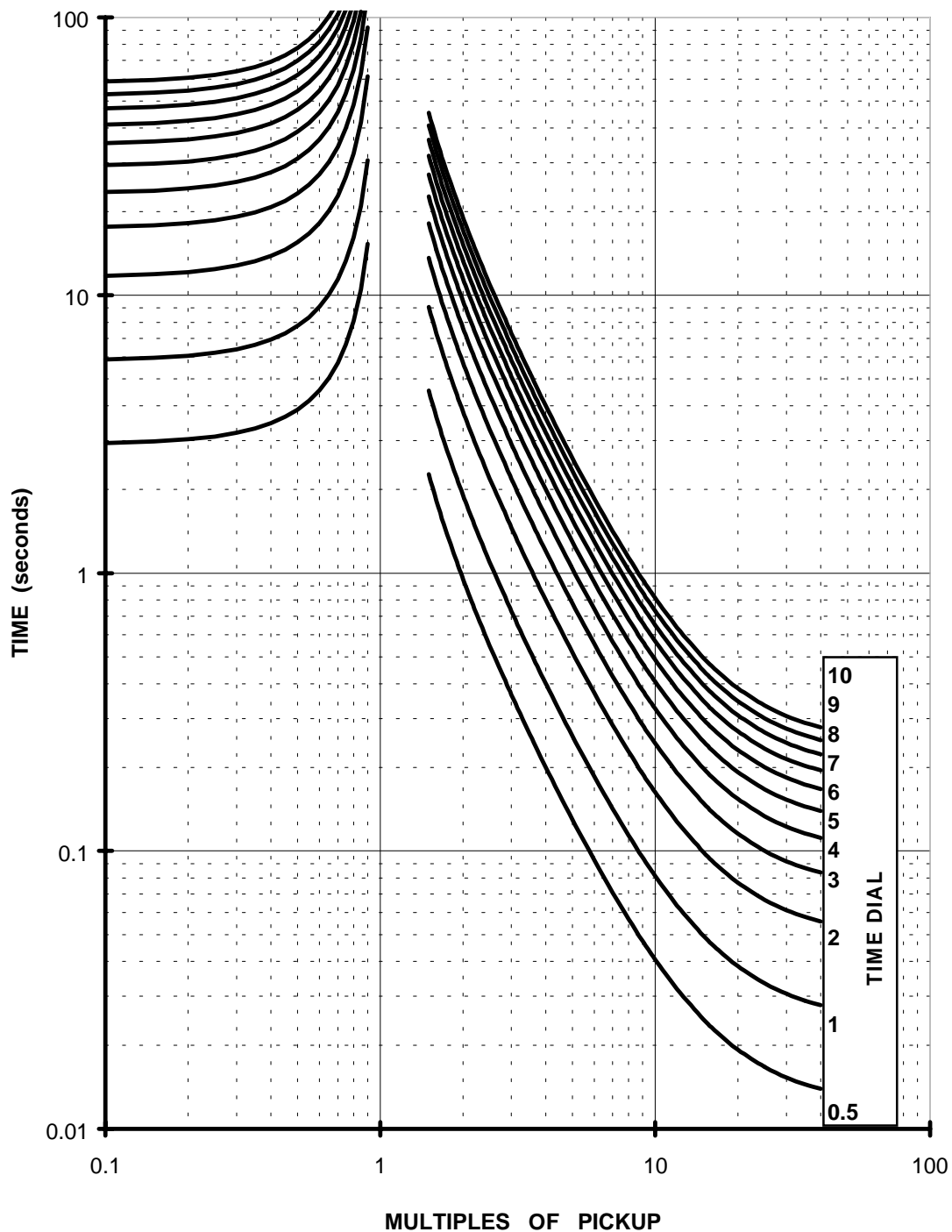
2.4.2 VERY INVERSE CURVE



$$t(RESET) = TD \left[\frac{4.32}{1 - M^2} \right] , \quad t(PU) = TD \left[\frac{3.922}{M^2 - 1} + 0.0982 \right]$$

Figure 2-15: VERY INVERSE CURVE

2.4.3 EXTREMELY INVERSE CURVE



$$t(RESET) = TD \left[\frac{5.82}{1 - M^2} \right] , \quad t(PU) = TD \left[\frac{5.64}{M^2 - 1} + 0.02434 \right]$$

Figure 2-16: EXTREMELY INVERSE CURVE

2.5.1 INDEX NUMBERS

Table 2–5: INDEX NUMBERS – CONTACT CONVERTER INPUT ASSIGNMENT

Index	Description	Mnemonic
1	Breaker #1 52b Contact Input	52B_1
2	Spare	
3	Spare	
4	Breaker #2 52b Contact Input	52B_2
5	Spare	
6	Spare	
7	Spare	
8	Change Setting Group Input (BIT0)	CGST1
9	Change Setting Group Input (BIT1)	CGST2
10	Spare	
11	Spare	
12	Spare	
13	Spare	
14	Spare	
15	Spare	
16	Spare	
17	Spare	
18	Spare	
19	Spare	
20	Spare	
21	Spare	
22	External Contact Input to Disable Outputs	DISOUT

Index	Description	Mnemonic
23	External Contact Input to Trigger Oscillography Capture	OSCTRG
24	Spare	
25	CONFIGURABLE INPUT1	CNFDI2
26	CONFIGURABLE INPUT2	CNFDI2
27	CONFIGURABLE INPUT3	CNFDI3
28	CONFIGURABLE INPUT4	CNFDI4
29	CONFIGURABLE INPUT5	CNFDI5
30	CONFIGURABLE INPUT6	CNFDI6
31	CONFIGURABLE INPUT7	CNFDI7
32	CONFIGURABLE INPUT8	CNFDI8

Note: Any of the above signals (1 to 32) may be assigned to the 12 available LPS-O Contact Converter Inputs (CC1 to CC12). Those 12 signals will also be available for use for the Programmable Outputs and/or the Configurable Logic. Unassigned signals will NOT be available.

TABLE 2–6: INDEX NUMBERS – CONFIGURABLE LOGIC & PROGRAMMABLE OUTPUT SIGNALS

TABLE 2–6: INDEX NUMBERS (Sheet 1 of 8)

Index	Description	Mnemonic
33	Trip Bus	TRIP
34	Not used	
35	Not used	
36	Not used	
37	Initial Reclose from Scheme Logic	RI
38	Reclose Cancel Output from Scheme Logic	CANCL
39	Spare	
40	Spare	
41	Spare	
42	Spare	
43	Warm Restart	WARMST
44	Spare	
45	Line Over Load Alarm Output	LNOVLD
46	Critical Alarm Output	CRTALM
47	Spare	
48	Trip Circuit Alarm	TCMALM
49	Zone Flags On Alarm	ZNALM
50	Overcurrent Alarm	OVRALM
51	Unbalanced Current Detector Alarm Output	UNBAL
52	Non-Critical Alarm Output	NCALM
53	Spare	
54	Spare	
55	Spare	
56	MANUAL OPEN BRK1	MNOPN1
57	MANUAL OPEN BRK2	MNOPN2
58	MANUAL CLOSE BRK1	MNCLS1
59	MANUAL CLOSE BRK2	MNCLS2
60	Fault ID: Phase A Involved	DAFLTA
61	Fault ID: Phase B Involved	DAFLTB

TABLE 2–6: INDEX NUMBERS (Sheet 2 of 8)

Index	Description	Mnemonic
62	Fault ID: Phase C Involved	DAFLTC
63	Fault ID: Neutral Involved	DAFLTN
64	DMA Overrun	DMAOVR
65	Zone 1 AB Distance Function	Z1AB
66	Zone 1 BC Distance Function	Z1BC
67	Zone 1 CA Distance Function	Z1CA
68	Zone 2 AB Distance Function	Z2AB
69	Zone 2 BC Distance Function	Z2BC
70	Zone 2 CA Distance Function	Z2CA
71	Zone 3 AB Distance Function	Z3AB
72	Zone 3 BC Distance Function	Z3BC
73	Zone 3 CA Distance Function	Z3CA
74	Zone 4 AB Distance Function	Z4AB
75	Zone 4 BC Distance Function	Z4BC
76	Zone 4 CA Distance Function	Z4CA
77	Any Z1 Phase Distance Function	Z1PH
78	Any Z2 Phase Distance Function	Z2PH
79	Any Z3 Phase Distance Function	Z3PH
80	Any Z4 Phase Distance Function	Z4PH
81	Spare	
82	Spare	
83	Spare	
84	Spare	
85	Spare	
86	Spare	
87	Spare	
88	Spare	
89	Spare	
90	Spare	
91	Spare	
92	Spare	

TABLE 2-6: INDEX NUMBERS (Sheet 3 of 8)

Index	Description	Mnemonic
93	Spare	
94	Spare	
95	Spare	
96	Spare	
97	Spare	
98	Spare	
99	Spare	
100	All Phases Open	3OPEN
101	Any Phases Open	ANYOPN
102	Not used	
103	Any Phase Undervoltage	ANYUVT
104	All Voltages High (No Phase Undervoltage)	ALLVLT
105	Fault Detector (FD)	FLTDET
106	TL1 Timer Output	TL1
107	IT Detector	IT
108	IB Detector	IB
109	IPT Detector	IPT
110	IPB Detector	IPB
111	Remote Breaker Open Detector	REMOPN
112	Ground Directional Trip (Nt-Ipt)	GRDTRP
113	Ground Directional Block (Nb-Ipb)	GRDBLK
114	Line Pickup	LPU
115	Fuse Failure Alarm	FF
116	Instantaneous Phase Overcurrent (50P/Ph4)	PH4
117	Instantaneous Ground Overcurrent (50G/Idt)	IDT
118	Ground Time Overcurrent Pick Up	TOCACT
119	Ground Time Overcurrent Trip (51G/Toc)	TOCTRP
120	Out of Step Blocking	OSB
121	Out of Step Trip	OST

TABLE 2-6: INDEX NUMBERS (Sheet 4 of 8)

Index	Description	Mnemonic
122	Configurable Trip Bus Input	CNFTRP
123	Configurable Oscillography Trigger	CNFOSC
124	Spare	
125	Spare	
126	Ground Forward Flag (NT)	GRDFWD
127	Ground Reverse Flag (NB)	GRDREV
128	Spare	
129	Spare	
130	Spare	
131	Spare	
132	Z2 Phase Timer	Z2PTMR
133	Z3 Phase Timer	Z3PTMR
134	Z4 Phase Timer	Z4PTMR
135	Any Trip Bus	TRPBUS
136	Spare	
137	Spare	
138	Number of Breaker Operation Alarm	BRMNOP
139	Breaker Equipment Duty Alarm	BRMNDT
140	Any Phase Over Voltage Pickup	OVRVPU
141	Spare	
142	Spare	
143	I1 Line Pickup	I1PU
144	Block Reclose Initiate	BLK_RI
145	Manual Close in Progress	CLS_IP
146	Breaker Close	BKRCLS
147	Trip Circuit #1 Voltage Monitor Status	T1TC
148	Trip Circuit #2 Voltage Monitor Status	T2TC
149	Trip Circuit #3 Voltage Monitor Status	T3TC
150	Trip Circuit #4 Voltage Monitor Status	T4TC

TABLE 2–6: INDEX NUMBERS (Sheet 5 of 8)

Index	Description	Mnemonic
151	Spare	
152	Spare	
153	PHASE A OVERVOLTAGE	AVOVR
154	PHASE B OVERVOLTAGE	BVOVR
155	PHASE C OVERVOLTAGE	CVOVR
156	Spare	
157	Spare	
158	Spare	
159	Spare	
160	Any Phase Overvoltage	OVRLT
161	Programmable Logic Gate #1 Output	G1
162	Programmable Logic Gate #2 Output	G2
163	Programmable Logic Gate #3 Output	G3
164	Programmable Logic Gate #4 Output	G4
165	Programmable Logic Gate #5 Output	G5
166	Programmable Logic Gate #6 Output	G6
167	Programmable Logic Gate #7 Output	G7
168	Programmable Logic Gate #8 Output	G8
169	Programmable Logic Gate #9 Output	G9
170	Programmable Logic Gate #10 Output	G10
171	Programmable Logic Gate #11 Output	G11
172	Programmable Logic Gate #12 Output	G12
173	Programmable Logic Gate #13 Output	G13
174	Programmable Logic Gate #14 Output	G14

TABLE 2–6: INDEX NUMBERS (Sheet 6 of 8)

Index	Description	Mnemonic
175	Programmable Logic Gate #15 Output	G15
176	Programmable Logic Gate #16 Output	G16
177	Programmable Logic Gate #17 Output	G17
178	Programmable Logic Gate #18 Output	G18
179	Programmable Logic Gate #19 Output	G19
180	Programmable Logic Gate #20 Output	G20
181	Programmable Logic Gate #21 Output	G21
182	Programmable Logic Gate #22 Output	G22
183	Programmable Logic Gate #23 Output	G23
184	Programmable Logic Gate #24 Output	G24
185	Programmable Logic Gate #25 Output	G25
186	Programmable Logic Gate #26 Output	G26
187	Programmable Logic Gate #27 Output	G27
188	Programmable Logic Gate #28 Output	G28
189	Programmable Logic Gate #29 Output	G29
190	Programmable Logic Gate #30 Output	G30
191	Programmable Logic Gate #31 Output	G31
192	Programmable Logic Gate #32 Output	G32
193	Programmable Logic Gate #33 Output	G33
194	Programmable Logic Gate #34 Output	G34

TABLE 2-6: INDEX NUMBERS (Sheet 7 of 8)

Index	Description	Mnemonic
195	Programmable Logic Gate #35 Output	G35
196	Programmable Logic Gate #36 Output	G36
197	Programmable Logic Gate #37 Output	G37
198	Programmable Logic Gate #38 Output	G38
199	Programmable Logic Gate #39 Output	G39
200	Programmable Logic Gate #40 Output	G40
201 to 224	Spare	
225	Programmable Logic Timer 1 Output	TM1
226	Programmable Logic Timer 1 RESET	TM1RST
227	Programmable Logic Timer 2 Output	TM2
228	Programmable Logic Timer 2 RESET	TM2RST
229	Programmable Logic Timer 3 Output	TM3
230	Programmable Logic Timer 3 RESET	TM3RST
231	Programmable Logic Timer 4 Output	TM4
232	Programmable Logic Timer 4 RESET	TM4RST
233	Programmable Logic Timer 5 Output	TM5
234	Programmable Logic Timer 5 RESET	TM5RST
235	Programmable Logic Timer 6 Output	TM6
236	Programmable Logic Timer 6 RESET	TM6RST
237	Programmable Logic Timer 7 Output	TM7

TABLE 2-6: INDEX NUMBERS (Sheet 8 of 8)

Index	Description	Mnemonic
238	Programmable Logic Timer 7 RESET	TM7RST
239	Programmable Logic Timer 8 Output	TM8
240	Programmable Logic Timer 8 RESET	TM8RST
241	Programmable Logic Counter 1	CNTR1
242	Programmable Logic Counter 2	CNTR2
243	Programmable Logic Counter 3	CNTR3
244	Programmable Logic Counter 4	CNTR4
245	Programmable Logic Counter 5	CNTR5
246	Programmable Logic Counter 6	CNTR6
247	Programmable Logic Counter 7	CNTR7
248	Programmable Logic Counter 8	CNTR8
249	Programmable Logic LATCH 1	LATCH1
250	Programmable Logic LATCH 2	LATCH2
251	Programmable Logic LATCH 3	LATCH3
252	Programmable Logic LATCH 4	LATCH4
253	Programmable Logic LATCH 5	LATCH5
254	Programmable Logic LATCH 6	LATCH6
255	Programmable Logic LATCH 7	LATCH7
256	Programmable Logic LATCH 8	LATCH8

2.5.2 PROTECTION SETTINGS GUIDE

Table 2–7: PROTECTION SETTINGS GUIDE (Sheet 1 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
Z1DISTANCE					
101	Z1PHASE	Z1 Phase Distance	NO, YES	NO, YES	YES
102	Z1PHREACH	Z1 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	5.40Ω at 5A 27.0Ω at 1A
104	Z1P_TIME	Z1 Phase Timer	0.00 to 10. sec. step 0.01	0.00 to 10. sec. step 0.01	0.0 sec.
Z2 DISTANCE					
201	Z2PHASE	Z2 Phase Distance	NO, YES	NO, YES	YES
202	Z2PHREACH	Z2 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	9.00Ω at 5A 45.0Ω at 1A
203	Z2PCHARANG	Z2 Phase Characteristic Angle	90 to 120 deg. step 5	90 to 120 deg step 5	90 deg.
204	Z2TIMER	Z2 Timer	NO, YES	NO, YES	YES
205	Z2P_TIME	Z2 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	1.0 sec.
Z3DISTANCE					
301	Z3PHASE	Z3 Phase Distance	NO, YES	NO, YES	YES
302	Z3PHREACH	Z3 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	12.0Ω at 5A 60.0Ω at 1A
303	Z3PCHARANG	Z3 Phase Characteristic Angle	90 to 120 deg. step 5	90 to 120 deg step 5	90 deg.
304	Z3P_TIME	Z3 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	2.0 sec.
Z4DISTANCE					
401	Z4PHASE	Z4 Phase Distance	NO, YES	NO, YES	YES
402	Z4PHREACH	Z4 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	18.0Ω at 5A 90.0Ω at 1A
403	Z4PCHARANG	Z4 Phase Characteristic Angle	80 to 120 deg. step 5	80 to 120 deg step 5	90 deg.
404	Not Used				
405	Z4_TIMERS	Z4 Timers	NO, YES	NO, YES	YES
406	Z4P_TIME	Z4 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	0.05 sec.

see TABLE NOTES on page 2–43 for footnote explanation

Table 2-7: PROTECTION SETTINGS GUIDE (Sheet 2 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
CURVSUPVSN					
501	IT_PICKUP	Trip Supervision Current	0.20 to 4.0 amps step 0.01	0.04 to 0.8 amps step 0.01	0.20 A at 5A 0.04 A at 1A
502	IB_PICKUP	Block Supervision Current	0.20 to 4.0 amps step 0.01	0.04 to 0.8 amps step 0.01	0.20 A at 5A 0.04 A at 1A
503	IPT_PICKUP *	GDOC Trip Current	0.50 amps fixed	0.10 amps fixed	0.50 A at 5A 0.10 A at 1A
504	IPB_PICKUP *	GDOC Block Current	0.25 amps fixed	0.05 amps fixed	0.25 A at 5A 0.05 A at 1A
505	IPBKFACTOR *	IPB I1 Restraint	0.0 fixed	0.0 fixed	0.0
506	NT_OFFSET	NT/NB Offset	0.0 to 20.0 ohms step 0.01	0.0 to 100 ohms step 0.01	0.05Ω at 5A 0.25Ω at 1A
507	UNBALALARM	Unbalanced Current Alarm	NO, YES	NO, YES	YES
OVERCURRNT					
601	50	Phase Instantaneous Overcurrent	NO, YES	NO, YES	NO
602	50DIRCNL	Directional Control of 50	NO, YES	NO, YES	YES
603	50PICKUP	50 Pickup Setting	2.0 to 160.0 amps step 0.1	0.4 to 32.0 amps step 0.1	20.0 A at 5A 4.0A at 1A
604	50PICKUPFF	50 Pickup during fuse failure	2.0 to 160.0 amps step 0.1	0.4 to 32.0 amps step 0.1	30.0 A at 5A 6.0 A at 1A
605	50G	Ground Instantaneous Overcurrent	NO, YES	NO, YES	YES
606	50G_DIRCNL	Directional Control of 50G	NO, YES	NO, YES	YES
607	50GPICKUP	50G Pickup Setting	0.5 to 80.0 amps step 0.1	0.1 to 16.0 amps step 0.1	10.0 A at 5A 2.0 A at 1A
608	50GPCKPFF	50G Pickup during fuse failure	0.5 to 80.0 amps step 0.1	0.1 to 16.0 amps step 0.1	15.0 A at 5A 3.0A at 1A
609	50GRESTNT	50G Restraint Setting	0.0, 0.3	0.0, 0.3	0.3
610	51G	Ground Time Overcurrent	NO, YES	NO, YES	YES
611	51G_DIRCNL	Directional Control of 51G	NO, YES	NO, YES	YES
612	51GPICKUP	51G Pickup Setting	0.20 to 15.0 amps step 0.01	0.04 to 3.0 amps step 0.01	1.0 A at 5A 0.2 A at 1A
613	51GPCKUPFF	51G Pickup during fuse failure	0.20 to 15.0 amps step 0.01	0.04 to 3.0 amps step 0.01	2.0 A at 5A 0.4 A at 1A
614	51GCURVE	51G Curve	INV, V-INV, E-INV, CUSTOM, DEFT	INV, V-INV, E-INV, CUSTOM, DEFT	V-INV

see TABLE NOTES on page 2-43 for footnote explanation

Table 2-7: PROTECTION SETTINGS GUIDE (Sheet 3 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
615	51GTIMDIAL	51G Time Dial	0.5 to 10.0 step 0.1	0.5 to 10.0 step 0.1	5
616	DEFTIMDELY	Definite Time Delay	0.5 to 30.0 sec. step 0.1	0.5 to 30.0 sec. step 0.1	1.0 sec.
617	51G_RESET	51G Reset Characteristic	FAST,, EM	FAST, EM	FAST
VOLTAGE					
701	RATEDVOLTS	Rated Per Unit Voltage	100, 105, 110, 115, 120 volts	100, 105, 110, 115, 120 volts	115 volts
702	PHASEOVER	Select Phase Overvoltage	NO, YES	NO, YES	NO
703	PHOV PICKUP	Phase Overvoltage Pickup	0.0 to 1.4 p.u. volts step 0.01	0.0 to 1.4 p.u. volts step 0.01	1.4 V
704	PHOVTMDLY	Phase Overvoltage Time Delay	0.0 to 10.0 sec. step 0.01	0.0 to 10.0 sec. step 0.01	0.50 sec.
705	FUSEFAIL	Potential Fuse Failure Blocking	NO, YES	NO, YES	YES
LINE PICKUP					
801	LINEPICKUP	Select Line Pickup	NO, YES	NO, YES	NO
802	BYPASSTL3	Bypass Line Pickup Time Delay	NO, YES	NO, YES	NO
803	I1PICKUP	I1 Pickup	1.0 to 15.0 amps step 0.1	0.2 to 3.0 amps step 0.1	3.0 A at 5A 0.6 A at 1A
REMOTE OPEN					
901	REMOTEOPEN	Select Remote Open Detector	NO, YES	NO, YES	NO
902	TL20PICKUP	Remote Open Detector Time Delay	10 to 100 msec. step 1	10 to 100 msec. step 1	100 msec.
LINE OVERLOAD					
1001	LINEOVERLD	Select Line Overload Protection	NO, YES	NO, YES	NO
1002	LEVEL1PU	Level 1 pickup current	2.5 to 20 amps step 0.1	0.5 to 4.0 amps step 0.1	10 A at 5A 2 A at 1A
1003	LEVEL2PU	Level 2 pickup current	5.0 to 40.0 amps step 0.1	1.0 to 8.0 amps step 0.1	20 A at 5A 4 A at 1A
1004	LEVEL1TDLY	Level 1 time delay	10 to 200 sec. step 1	10 to 200 sec. step 1	50 sec.
1005	LEVEL2TDLY	Level 2 time delay	10 to 99 sec. step 1	10 to 99 sec. step 1	25 sec.

see TABLE NOTES on page 2-43 for footnote explanation

Table 2–7: PROTECTION SETTINGS GUIDE (Sheet 4 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
SCHEMETIMERS					
1101	TL5PICKUP	BKR1 b sw Coord Timer PU	0 to 200 msec. step 1	0 to 200 msec. step 1	50 msec.
1102	TL5DROPOUT	BKR1 b sw Coord Timer DO	0 to 200 msec. step 1	0 to 200 msec. step 1	50 msec.
1103	TL6PICKUP	BKR2 b sw Coord Timer PU	0 to 200 msec. step 1	0 to 200 msec. step 1	50 msec.
1104	TL6DROPOUT	BKR2 b sw Coord Timer DO	0 to 200 msec. step 1	0 to 200 msec. step 1	50 msec.
LINEINFO					
1201	POSSEQANG	Positive Sequence Impedance Angle	25 to 90 deg. step 1	25 to 90 deg. step 1	85 deg.
1202	CTRATIO	CT Ratio	1 to 5000 step 1	1 to 5000 step 1	400 for 5A 2000 for 1A
1203	PTRATIO	PT Ratio	1 to 7000 step 1	1 to 7000 step 1	3000
1204	TRSFMRTYPE	Transformer Type	NONE, YD1, YD5, YD7, YD11	NONE, YD1, YD5, YD7, YD11	YD1
OS BLOCKING					
1301	MOBZONE	Coordinating Zone	ZONE2, ZONE3	ZONE2, ZONE3	ZONE3
1302	MOBCHARANG	MOB Characteristic Angle	30 to 130 deg. step 1	30 to 130 deg. step 1	70 deg.
1303	BLOCKWHAT	Block during OS	BLKALL, BLKDIST, BLKPHAS, BLKNONE	BLKALL, BLKDIST, BLKPHAS, BLKNONE	BLKALL
1304	BLOCKZ1	Block all Zone 1 Functions	NO, YES	NO, YES	YES
1305	BLOCKZ2	Block all Zone 2 Functions	NO, YES	NO, YES	YES
1306	BLOCKZ3	Block all Zone 3 Functions	NO, YES	NO, YES	YES
1307	BLOCKZ4	Block all Zone 4 Functions	NO, YES	NO, YES	YES
OS TRIPPING					
1401	USE_OST	Select OST	NO, YES	NO, YES	NO
1402	NUMBRCHAR	Select Number of Characteristics	2, 3	2, 3	3
1403	TRIPIN_OUT	Trip Entering or Leaving Inner	IN, OUT	IN, OUT	OUT
1404	FWDREACH	OST Forward Reach	0.1 to 75.0 ohms step 0.1	0.5 to 375.0 ohms step 0.5	15.0Ω at 5A 75.0Ω at 1A

see TABLE NOTES on page 2–43 for footnote explanation

Table 2-7: PROTECTION SETTINGS GUIDE (Sheet 5 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
1405	REVREACH	OST Reverse Reach	0.1 to 75.0 ohms step 0.1	0.1 to 375.0 ohms step 0.5	5.0Ω at 5A 25.0Ω at 1A
1406	OUTER	Outer Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	90 deg.
1407	MIDDLE	Middle Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	105 deg.
1408	INNER	Inner Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	120 deg.
1409	TLOS1PU	Coordinating Timer 1 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	40 msec.
1410	TLOS1DO	Coordinating Timer 1 Dropout	1 to 500 msec. step 1	1 to 500 msec. step 1	40 msec.
1411	TLOS2PU	Coordinating Timer 2 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	40 msec.
1412	TLOS3PU	Coordinating Timer 3 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	40 msec.
1413	TLOS4PU	Coordinating Timer 4 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	40 msec.
NONCRIT_AL (IN ADDITION TO SELF-TEST ALARMS)					
1501	NCAIN1	Non-Critical Alarm Input #1 <i>These 8 inputs are ORed together and then outputted to the contact assigned to the Non-Critical Alarm</i>	0 to 256 step 1	0 to 256 step 1	48
1502	NCAIN2	Non-Critical Alarm Input #2	0 to 256 step 1	0 to 256 step 1	49
1503	NCAIN3	Non-Critical Alarm Input #3	0 to 256 step 1	0 to 256 step 1	50
1504	NCAIN4	Non-Critical Alarm Input #4	0 to 256 step 1	0 to 256 step 1	51
1505	NCAIN5	Non-Critical Alarm Input #5	0 to 256 step 1	0 to 256 step 1	0
1506	NCAIN6	Non-Critical Alarm Input #6	0 to 256 step 1	0 to 256 step 1	0
1507	NCAIN7	Non-Critical Alarm Input #7	0 to 256 step 1	0 to 256 step 1	0
1508	NCAIN8	Non-Critical Alarm Input #8	0 to 256 step 1	0 to 256 step 1	0

see TABLE NOTES on page 2-43 for footnote explanation

Table 2–7: PROTECTION SETTINGS GUIDE (Sheet 6 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
OUTPUTS					
1601	T1	T1 Contract	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1602	T2	T2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1603	T3	T3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1604	T4	T4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1605	T5	T5 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1606	T6	T6 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1607	A1 (configurable)	A1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	58 [‡]
1608	A2 (configurable)	A2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	59 [‡]
1609	A3 (configurable)	A3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1610	A4 (configurable)	A4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	33 [‡]
1611	A5 (configurable)	A5 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	37 [‡]
1612	A6 (configurable)	A6 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	37 [‡]
1613	A7 (configurable)	A7 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	38 [‡]
1614	A8 (configurable)	A8 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	45 [‡]
1615	A9 (configurable)	A9 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	77 [‡]
1616	A10 (configurable)	A10 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	132 [‡]
1617	A11 (configurable)	A11 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	120 [‡]
1618	A12 (configurable)	A12 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	121 [‡]
1619	C1 (configurable)	C1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	52 [‡]
1620	C2 (configurable)	C2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	115 [‡]

see TABLE NOTES on page 2–43 for footnote explanation

Table 2–7: PROTECTION SETTINGS GUIDE (Sheet 7 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	Default
1621	KT1 (configurable)	KT1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1622	KT2 (configurable)	KT2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1623	KT3 (configurable)	KT3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1624	KT4 (configurable)	KT4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0 [‡]
1625	CONFTRIP	Initiate Three phase Trip with Input from Xpression Builder	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0
1626	CONFOSC	Initiate Oscillography Capture with Xpression Builder Input	0 to 256 step 1 [†]	0 to 256 step 1 [†]	0

see TABLE NOTES on page 2–43 for footnote explanation

TABLE NOTES:

* The IPB and IPT settings are fixed as shown and are NOT adjustable by the user.

[†] Contact is normally open; add 1000 to number to close contact under normal conditions.

[‡] See Table 2–6 on page 2–33 for index assignments.

2.5.3 GENERAL SETTINGS GUIDE

Table 2–8: GENERAL SETTINGS GUIDE (Sheet 1 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	Default
CONFIGURE					
101	UNITID	Unit ID	0000 to 9999	1	0000
102	SYSFREQ	System Frequency	50 Hz, 60 Hz	none	60Hz
103	PHASROTATE	Phase Rotation	ABC, ACB	none	ABC
104	TIMESYNCH	Time Synch Source	INTERNAL, IRIG-B	none	INTERNAL
105	NUM_BKR	Number of Breakers	1, 2	none	1
106	NUM_TC	Number of Trip Circuits	1, 2	none	1
107	NUM_MON	Number of Trip Circuit Monitors	(T4→T1) format = <i>abcd</i>	a-d = 0 (on) or 1 (off)	0000 (0) T1 to T4 off
108	DISPLAYVAL	Value Display Mode	PRI, SEC	none	SEC
109	LANGUAGE	Language Option	ENGLISH, SPANISH	none	ENGLISH
COMMPORTS					
201	COMPORT1	Communications Port #1 Settings	Baud Rate (xx), Parity (y), Stop Bits (z) format = <i>xyz</i>	xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	9601
202	COMPORT2	Communications Port #2 Settings	Interface (i), Baud Rate (xx), Parity (y), Stop Bits (z) format = <i>ixyz</i>	i = 0 (RS232), 1 (RS485); xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	09601
203	COMPORT3	Communications Port #3 Settings	Interface (i), Baud Rate (xx), Parity (y), Stop bits (z) format = <i>ixyz</i>	i = 0 (RS232), 1 (RS485); xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	09601
204	PROTOCOL1	Communications Port #1 Protocol	GE-MODEM, ASCII	none	GE-MODEM
205	PROTOCOL2	Communications Port #2 Protocol	GE-MODEM, ASCII	none	GE-MODEM
206	PROTOCOL3	Communications Port #3 Protocol	GE-MODEM, ASCII	none	GE-MODEM

‡ Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

Table 2-8: GENERAL SETTINGS GUIDE (Sheet 2 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	Default
OSC_GRAPHY					
301	NUMFAULTS	Number of Fault Records (with expanded memory)	6, 12, 24, 36	none	N/A
302	PREFault	Number of Pre-fault Cycles	1 to 8	1	5
303	SPLITREC	Splits Fault Record and captures this percentage at end, with 1-SPLITREC captured at beginning	0 to 100%	1	0
BRKR DUTY					
401	EXPONENT	Exponent in I^2t calculation	1.0 to 2.0	0.1	2.0
402	MAX_OP	Maximum Number of Breaker Operations for a Breaker	0 to 9999	1	0
403	MAX_IXT	Maximum Breaker Duty for a Breaker	0 to 9999999 A ^x sec.	0.1K	0
404	IXTPHASEA	Accumulated Breaker Duty, Phase A	0 to 9999999 A ^x sec.	0.1K	0
405	IXTPHASEB	Accumulated Breaker Duty, Phase B	0 to 9999999 A ^x sec.	0.1K	0
406	IXTPHASEC	Accumulated Breaker Duty, Phase C	0 to 9999999 A ^x sec.	0.1K	0
407	NUM_OP	Present Number of Breaker Operations	0 to 9999	1	0
INPUTS					
501	CC1	Contact Converter 1	0 to 32 ‡	1	0
502	CC2	Contact Converter 2	0 to 32 ‡	1	0
503	CC3	Contact Converter 3	0 to 32 ‡	1	0
504	CC4	Contact Converter 4	0 to 32 ‡	1	0
505	CC5	Contact Converter 5	0 to 32 ‡	1	1
506	CC6	Contact Converter 6	0 to 32 ‡	1	4
507	CC7	Contact Converter 7	0 to 32 ‡	1	0
508	CC8	Contact Converter 8	0 to 32 ‡	1	0
509	CC9	Contact Converter 9	0 to 32 ‡	1	0

‡ Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

Table 2–8: GENERAL SETTINGS GUIDE (Sheet 3 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	Default
510	CC10	Contact Converter 10	0 to 32 ‡	1	0
511	CC11	Contact Converter 11	0 to 32 ‡	1	0
512	CC12	Contact Converter 12	0 to 32 ‡	1	0

‡ Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

2.5.4 PROTECTION SETTINGS DATA SHEET

Table 2–9: PROTECTION SETTINGS DATA SHEET (Sheet 1 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
Z1DISTANCE					
101	Z1PHASE	Z1 Phase Distance	NO, YES	NO, YES	
102	Z1PHREACH	Z1 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	
104	Z1P_TIME	Z1 Phase Timer	0.00 to 10. sec. step 0.01	0.00 to 10. sec. step 0.01	
Z2 DISTANCE					
201	Z2PHASE	Z2 Phase Distance	NO, YES	NO, YES	
202	Z2PHREACH	Z2 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	
203	Z2PCHARANG	Z2 Phase Characteristic Angle	90 to 120 deg. step 5	90 to 120 deg step 5	
204	Z2TIMER	Z2 Timer	NO, YES	NO, YES	
205	Z2P_TIME	Z2 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	
Z3DISTANCE					
301	Z3PHASE	Z3 Phase Distance	NO, YES	NO, YES	
302	Z3PHREACH	Z3 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	
303	Z3PCHARANG	Z3 Phase Characteristic Angle	90 to 120 deg. step 5	90 to 120 deg step 5	
304	Z3P_TIME	Z3 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	
Z4DISTANCE					
401	Z4PHASE	Z4 Phase Distance	NO, YES	NO, YES	
402	Z4PHREACH	Z4 Phase Reach	0.01 to 50.0 ohms step 0.01	0.05 to 250.0 ohms step 0.05	
403	Z4PCHARANG	Z4 Phase Characteristic Angle	80 to 120 deg. step 5	80 to 120 deg step 5	
404	Not Used				
405	Z4_TIMERS	Z4 Timers	NO, YES	NO, YES	
406	Z4P_TIME	Z4 Phase Timer	0.00 to 10.0 sec. step 0.01	0.00 to 10.0 sec. step 0.01	

see TABLE NOTES on page 2–53 for footnote explanations

Table 2-9: PROTECTION SETTINGS DATA SHEET (Sheet 2 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
CURVSUPVSN					
501	IT_PICKUP	Trip Supervision Current	0.20 to 4.0 amps step 0.01	0.04 to 0.8 amps step 0.01	
502	IB_PICKUP	Block Supervision Current	0.20 to 4.0 amps step 0.01	0.04 to 0.8 amps step 0.01	
503	IPT_PICKUP *	GDOC Trip Current	0.50 amps fixed	0.10 amps fixed	
504	IPB_PICKUP *	GDOC Block Current	0.25 amps fixed	0.05 amps fixed	
505	IPBKFACTOR *	IPB I1 Restraint	0.0 fixed	0.0 fixed	
506	NT_OFFSET	NT/NB Offset	0.0 to 20.0 ohms step 0.01	0.0 to 100 ohms step 0.01	
507	UNBALALARM	Unbalanced Current Alarm	NO, YES	NO, YES	
OVERCURRNT					
601	50	Phase Instantaneous Overcurrent	NO, YES	NO, YES	
602	50_DIRCNL	Directional Control of 50	NO, YES	NO, YES	
603	50PICKUP	50 Pickup Setting	2.0 to 160.0 amps step 0.1	0.4 to 32.0 amps step 0.1	
604	50PICKUPFF	50 Pickup during fuse failure	2.0 to 160.0 amps step 0.1	0.4 to 32.0 amps step 0.1	
605	50G	Ground Instantaneous Overcurrent	NO, YES	NO, YES	
606	50G_DIRCNL	Directional Control of 50G	NO, YES	NO, YES	
607	50GPICKUP	50G Pickup Setting	0.5 to 80.0 amps step 0.1	0.1 to 16.0 amps step 0.1	
608	50GPCKPFF	50G Pickup during fuse failure	0.5 to 80.0 amps step 0.1	0.1 to 16.0 amps step 0.1	
609	50GRESTNT	50G Restraint Setting	0.0, 0.3	0.0, 0.3	
610	51G	Ground Time Overcurrent	NO, YES	NO, YES	
611	51G_DIRCNL	Directional Control of 51G	NO, YES	NO, YES	
612	51GPICKUP	51G Pickup Setting	0.20 to 15.0 amps step 0.01	0.04 to 3.0 amps step 0.01	
613	51GPCKUPFF	51G Pickup during fuse failure	0.20 to 15.0 amps step 0.01	0.04 to 3.0 amps step 0.01	
614	51GCURVE	51G Curve	INV, V-INV, E-INV, CUSTOM, DEFT	INV, V-INV, E-INV, CUSTOM, DEFT	

see TABLE NOTES on page 2-53 for footnote explanations

Table 2-9: PROTECTION SETTINGS DATA SHEET (Sheet 3 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
615	51GTIMDIAL	51G Time Dial	0.5 to 10.0 step 0.1	0.5 to 10.0 step 0.1	
616	DEFTIMDELY	Definite Time Delay	0.5 to 30.0 sec. step 0.1	0.5 to 30.0 sec. step 0.1	
617	51G_RESET	51G Reset Characteristic	FAST, EM	FAST, EM	
VOLTAGE					
701	RATEDVOLTS	Rated Per Unit Voltage	100, 105, 110, 115, 120 volts	100, 105, 110, 115, 120 volts	
702	PHASEOVER	Select Phase Overvoltage	NO, YES	NO, YES	
703	PHOV PICKUP	Phase Overvoltage Pickup	0.0 to 1.4 p.u. volts step 0.01	0.0 to 1.4 p.u. volts step 0.01	
704	PHOVTMDLY	Phase Overvoltage Time Delay	0.0 to 10.0 sec. step 0.01	0.0 to 10.0 sec. step 0.01	
705	FUSEFAIL	Potential Fuse Failure Blocking	NO, YES	NO, YES	
LINE PICKUP					
801	LINEPICKUP	Select Line Pickup	NO, YES	NO, YES	
802	BYPASSTL3	Bypass Line Pickup Time Delay	NO, YES	NO, YES	
803	I1PICKUP	I1 Pickup	1.0 to 15.0 amps step 0.1	0.2 to 3.0 amps step 0.1	
REMOTE OPEN					
901	REMOTEOPEN	Select Remote Open Detector	NO, YES	NO, YES	
902	TL20PICKUP	Remote Open Detector Time Delay	10 to 100 msec. step 1	10 to 100 msec. step 1	
LINE OVERLOAD					
1001	LINEOVERLD	Select Line Overload Protection	NO, YES	NO, YES	
1002	LEVEL1PU	Level 1 pickup current	2.5 to 20 amps step 0.1	0.5 to 4.0 amps step 0.1	
1003	LEVEL2PU	Level 2 pickup current	5.0 to 40.0 amps step 0.1	1.0 to 8.0 amps step 0.1	
1004	LEVEL1TDLY	Level 1 time delay	10 to 200 sec. step 1	10 to 200 sec. step 1	
1005	LEVEL2TDLY	Level 2 time delay	10 to 99 sec. step 1	10 to 99 sec. step 1	

see TABLE NOTES on page 2-53 for footnote explanations

Table 2–9: PROTECTION SETTINGS DATA SHEET (Sheet 4 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
SCHEMETIMERS					
1101	TL5PICKUP	BKR1 b sw Coord Timer PU	0 to 200 msec. step 1	0 to 200 msec. step 1	
1102	TL5DROPOUT	BKR1 b sw Coord Timer DO	0 to 200 msec. step 1	0 to 200 msec. step 1	
1103	TL6PICKUP	BKR2 b sw Coord Timer PU	0 to 200 msec. step 1	0 to 200 msec. step 1	
1104	TL6DROPOUT	BKR2 b sw Coord Timer DO	0 to 200 msec. step 1	0 to 200 msec. step 1	
LINEINFO					
1201	POSSEQANG	Positive Sequence Impedance Angle	25 to 90 deg. step 1	25 to 90 deg. step 1	
1202	CTRATIO	CT Ratio	1 to 5000 step 1	1 to 5000 step 1	
1203	PTRATIO	PT Ratio	1 to 7000 step 1	1 to 7000 step 1	
1204	TRSFMRTYPE	Transformer Type	NONE, YD1, YD5, YD7, YD11	NONE, YD1, YD5, YD7, YD11	
OS BLOCKING					
1301	MOBZONE	Coordinating Zone	ZONE2, ZONE3, ZONE4	ZONE2, ZONE3, ZONE4	
1302	MOBCHARANG	MOB Characteristic Angle	30 to 130 deg. step 1	30 to 130 deg. step 1	
1303	BLOCKWHAT	Block during OS	BLKALL, BLKDIST, BLKPHAS, BLKNONE	BLKALL, BLKDIST, BLKPHAS, BLKNONE	
1304	BLOCKZ1	Block all Zone 1 Functions	NO, YES	NO, YES	
1305	BLOCKZ2	Block all Zone 2 Functions	NO, YES	NO, YES	
1306	BLOCKZ3	Block all Zone 3 Functions	NO, YES	NO, YES	
1307	BLOCKZ4	Block all Zone 4 Functions	NO, YES	NO, YES	
OS TRIPPING					
1401	USE_OST	Select OST	NO, YES	NO, YES	
1402	NUMBRCHAR	Select Number of Characteristics	2, 3	2, 3	
1403	TRIPIN_OUT	Trip Entering or Leaving Inner	IN, OUT	IN, OUT	

see TABLE NOTES on page 2–53 for footnote explanations

Table 2–9: PROTECTION SETTINGS DATA SHEET (Sheet 5 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
1404	FWDREACH	OST Forward Reach	0.1 to 75.0 ohms step 0.1	0.5 to 375.0 ohms step 0.5	
1405	REVREACH	OST Reverse Reach	0.1 to 75.0 ohms step 0.1	0.1 to 375.0 ohms step 0.5	
1406	OUTER	Outer Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	
1407	MIDDLE	Middle Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	
1408	INNER	Inner Characteristic Angle	40 to 165 deg. step 1	40 to 165 deg. step 1	
1409	TLOS1PU	Coordinating Timer 1 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	
1410	TLOS1DO	Coordinating Timer 1 Dropout	1 to 500 msec. step 1	1 to 500 msec. step 1	
1411	TLOS2PU	Coordinating Timer 2 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	
1412	TLOS3PU	Coordinating Timer 3 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	
1413	TLOS4PU	Coordinating Timer 4 Pickup	1 to 100 msec. step 1	1 to 100 msec. step 1	
NONCRIT_AL (IN ADDITION TO SELF-TEST ALARMS)					
1501	NCAIN1	Non-Critical Alarm Input #1 <i>These 8 inputs are ORed together and then outputted to the contact assigned to the Non-Critical Alarm</i>	0 to 256 step 1	0 to 256 step 1	
1502	NCAIN2	Non-Critical Alarm Input #2	0 to 256 step 1	0 to 256 step 1	
1503	NCAIN3	Non-Critical Alarm Input #3	0 to 256 step 1	0 to 256 step 1	
1504	NCAIN4	Non-Critical Alarm Input #4	0 to 256 step 1	0 to 256 step 1	
1505	NCAIN5	Non-Critical Alarm Input #5	0 to 256 step 1	0 to 256 step 1	
1506	NCAIN6	Non-Critical Alarm Input #6	0 to 256 step 1	0 to 256 step 1	
1507	NCAIN7	Non-Critical Alarm Input #7	0 to 256 step 1	0 to 256 step 1	

see TABLE NOTES on page 2–53 for footnote explanations

Table 2-9: PROTECTION SETTINGS DATA SHEET (Sheet 6 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
1506	NCAIN8	Non-Critical Alarm Input #8	0 to 256 step 1	0 to 256 step 1	
OUTPUTS					
1601	T1	T1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1602	T2	T2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1603	T3	T3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1604	T4	T4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1605	T5	T5 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1606	T6	T6 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1607	A1 (configurable)	A1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1608	A2 (configurable)	A2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1609	A3 (configurable)	A3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1610	A4 (configurable)	A4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1611	A5 (configurable)	A5 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1612	A6 (configurable)	A6 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1613	A7 (configurable)	A7 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1614	A8 (configurable)	A8 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1615	A9 (configurable)	A9 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1616	A10 (configurable)	A10 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1617	A11 (configurable)	A11 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1618	A12 (configurable)	A12 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1619	C1 (configurable)	C1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	

see TABLE NOTES on page 2-53 for footnote explanations

Table 2–9: PROTECTION SETTINGS DATA SHEET (Sheet 7 of 7)

No.	Mnemonic	Description	Range (5A)	Range (1A)	User Setting
1620	C2 (configurable)	C2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1621	KT1 (configurable)	KT1 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1622	KT2 (configurable)	KT2 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1623	KT3 (configurable)	KT3 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1624	KT4 (configurable)	KT4 Contact	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1625	CONFTRIP	Initiate Three phase Trip with Input from Xpression Builder	0 to 256 step 1 [†]	0 to 256 step 1 [†]	
1626	CONFOSC	Initiate Oscillography Capture with Xpression Builder Input	0 to 256 step 1 [†]	0 to 256 step 1 [†]	

see TABLE NOTES on page 2–53 for footnote explanations

TABLE NOTES:

* The IPB and IPT settings are fixed as shown and are NOT adjustable by the user.

[†] Contact is normally open; add 1000 to number to close contact under normal conditions

2.5.5 GENERAL SETTINGS DATA SHEET

Table 2–10: GENERAL SETTINGS DATA SHEET (Sheet 1 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	User Setting
CONFIGURE					
101	UNITID	Unit ID	0000 to 9999	1	
102	SYSFREQ	System Frequency	50 Hz, 60 Hz	none	
103	PHASROTATE	Phase Rotation	ABC, ACB	none	
104	TIMESYNCH	Time Synch Source	INTERNAL, IRIG-B	none	
105	NUM_BKR	Number of Breakers	1, 2	none	
106	NUM_TC	Number of Trip Circuits	1, 2	none	
107	NUM_MON	Number of Trip Circuit Monitors	(T4→T1) <i>format = abcd</i>	a-d = 0 (on) or 1 (off)	
108	DISPLAYVAL	Value Display Mode	PRI, SEC	none	
109	LANGUAGE	Language Option	ENGLISH, SPANISH	none	
COMMPORTS					
201	COMPORT1	Communications Port #1 Settings	Baud Rate (xx), Parity (y), Stop Bits (z) <i>format = xxyz</i>	xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	
202	COMPORT2	Communications Port #2 Settings	Interface (i), Baud Rate (xx), Parity (y), Stop Bits (z) <i>format = ixxyz</i>	i = 0 (RS232), 1 (RS485); xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	
203	COMPORT3	Communications Port #3 Settings	Interface (i), Baud Rate (xx), Parity (y), Stop bits (z) <i>format = ixxyz</i>	i = 0 (RS232), 1 (RS485); xx = 03, 12, 24, 48, 96, 19; y = 0 (none), 1 (odd), 2 (even); z = 1, 2	
204	PROTOCOL1	Communications Port #1 Protocol	GE-MODEM, ASCII	none	
205	PROTOCOL2	Communications Port #2 Protocol	GE-MODEM, ASCII	none	
206	PROTOCOL3	Communications Port #3 Protocol	GE-MODEM, ASCII	none	

‡ Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

Table 2–10: GENERAL SETTINGS DATA SHEET (Sheet 2 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	User Setting
OSC_GRAPHY					
301	NUMFAULTS	Number of Fault Records (with expanded memory)	6, 12, 24, 36	none	
302	PREFault	Number of Pre-fault Cycles	1 to 8	1	
303	SPLITREC	Splits Fault Record and captures this percentage at end, with 1-SPLITREC captured at beginning	0 to 100%	1	
BRKR DUTY					
401	EXPONENT	Exponent in I^2t calculation	1.0 to 2.0	0.1	
402	MAX_OP	Maximum Number of Breaker Operations for a Breaker	0 to 9999	1	
403	MAX_IKT	Maximum Breaker Duty for a Breaker	0 to 9999999 A ^x sec.	0.1K	
404	IKTPHASEA	Accumulated Breaker Duty, Phase A	0 to 9999999 A ^x sec.	0.1K	
405	IKTPHASEB	Accumulated Breaker Duty, Phase B	0 to 9999999 A ^x sec.	0.1K	
406	IKTPHASEC	Accumulated Breaker Duty, Phase C	0 to 9999999 A ^x sec.	0.1K	
407	NUM_OP	Present Number of Breaker Operations	0 to 9999	0.1	
INPUTS					
501	CC 1	Contact Converter 1	0 to 32 [‡]	1	
502	CC2	Contact Converter 2	0 to 32 [‡]	1	
503	CC3	Contact Converter 3	0 to 32 [‡]	1	
504	CC4	Contact Converter 4	0 to 32 [‡]	1	
505	CC5	Contact Converter 5	0 to 32 [‡]	1	
506	CC6	Contact Converter 6	0 to 32 [‡]	1	
507	CC7	Contact Converter 7	0 to 32 [‡]	1	
508	CC8	Contact Converter 8	0 to 32 [‡]	1	
509	CC9	Contact Converter 9	0 to 32 [‡]	1	

[‡] Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

Table 2–10: GENERAL SETTINGS DATA SHEET (Sheet 3 of 3)

No.	Mnemonic	Description	Range (5A & 1A)	Step	User Setting
510	CC10	Contact Converter 10	0 to 32 [‡]	1	
511	CC11	Contact Converter 11	0 to 32 [‡]	1	
512	CC12	Contact Converter 12	0 to 32 [‡]	1	

[‡] Contact Converter output normally appears as a Logic 1 with normally open contact connected; to invert output to Logic 0, add 1000 to the number

3.1.1 CONSTRUCTION



CAUTION: Power down the relay by turning off the front panel power switch and disconnecting power from the rear connector (A1–A17) before disassembling the unit. Failure to do so can permanently damage the relay.

The LPS-O case is constructed from an aluminum alloy. It consists of a main frame with mounting brackets and a front, top and rear cover. The relay may be mounted either vertically or horizontally, and mounting ears may be placed in 6 positions (see Figure 3–1: FRONT AND REAR VIEWS OF THE LPS-O).

The front cover attaches with four thumb screws. A hole in each of the screws permits a tamper proof installation when a sealing wire is passed through two or four thumbscrews. The Target Reset / Metering button is accessible via a hole in the front cover, place by restraining screws on the front of the module trays.

The rear of the case supports terminal blocks for external connections to the relay. The printed circuit boards are mounted horizontally inside the case and connected via a bus card behind the front panel. They also have rear edge connectors that electrically connect with the rear terminal blocks, and are firmly held in place by restraining screws on the front of the module trays.

Each board is mounted on an aluminum plate. Proper alignment of the boards to their sockets is maintained by card guides. The aluminum plate supporting each board fits into these guides. The magnetics module, due to its weight, is rigidly mounted to the bottom of the case.

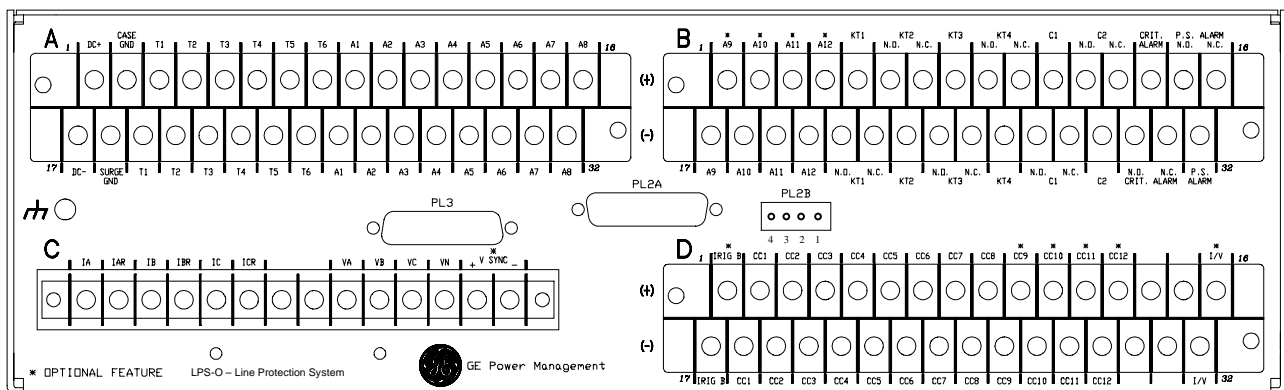
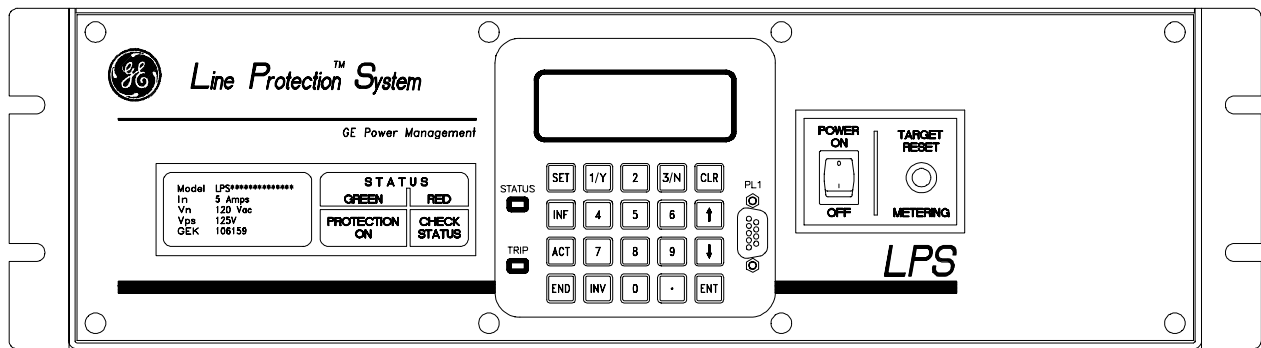
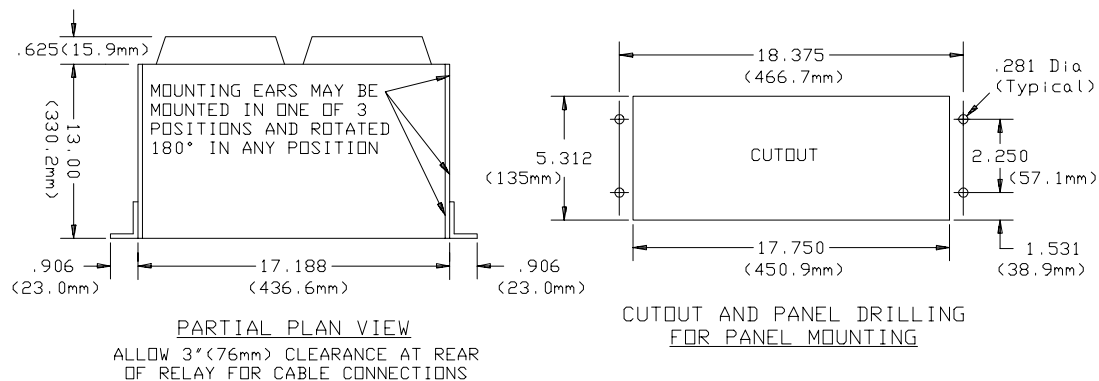


Figure 3–1: FRONT AND REAR VIEWS OF THE LPS-O



NOTES:

- 1) CASE MAY BE MOUNTED HORIZONTALLY OR VERTICALLY.
- 2) CASE MAY BE MOUNTED IN AN L2 RELAY CASE HOLE (20 × 5.687) USING 0158D7660P-1.
- 3) CASE MAY BE MOUNTED IN A W FT-42 RELAY CASE HOLE (17.875 × 5.875) USING 0158D7660P-2

Figure 3-2: LPS-O OUTLINE – HORIZONTAL

An outline drawing is shown in Figure 3-2: LPS-O OUTLINE – HORIZONTAL above, presenting the front, top, and rear views of the horizontal mount LPS-O. This figure provides a panel cutout and drill pattern for mounting the LPS-O.

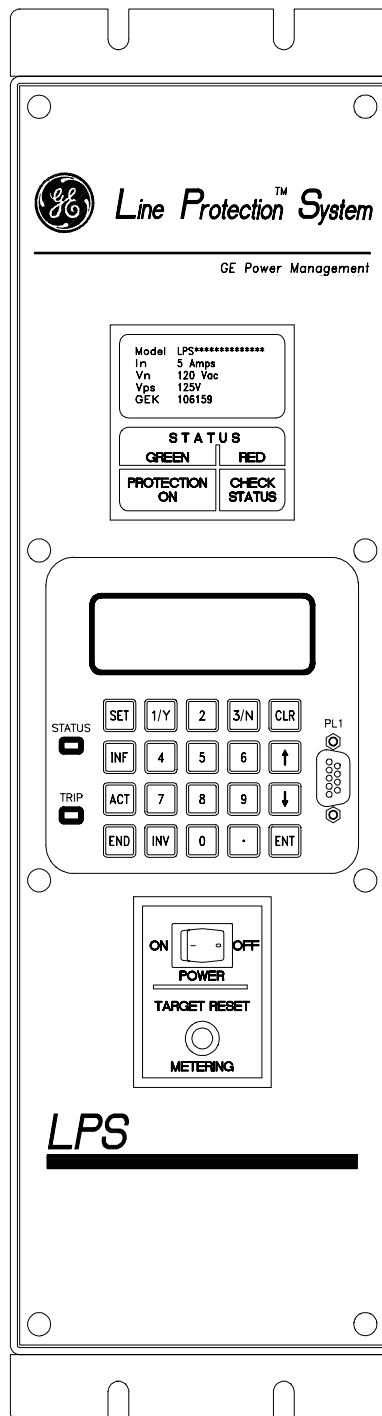


Figure 3–3: LPS-O VERTICAL FRONT VIEW

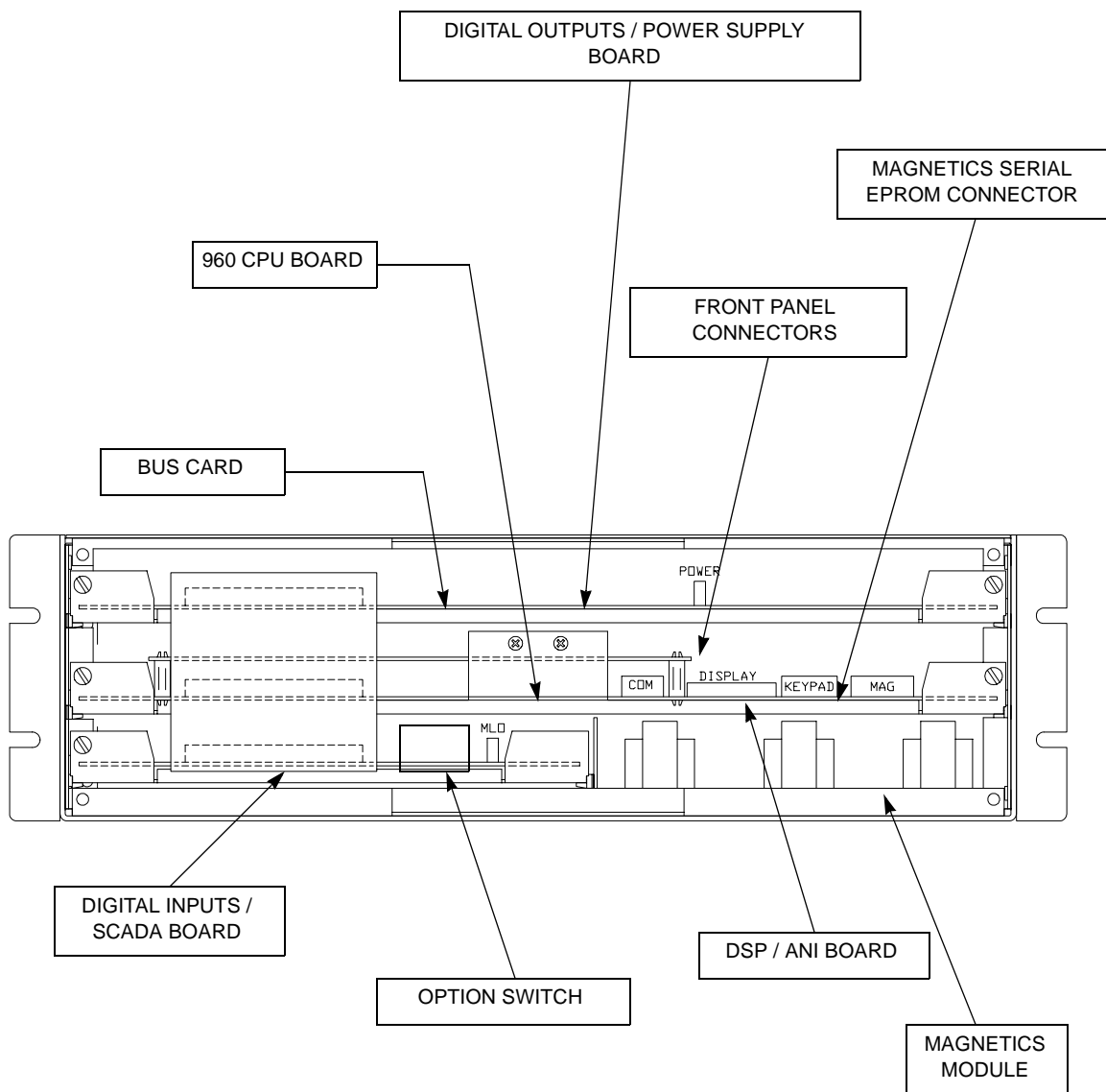


Figure 3-4: CIRCUIT BOARD LOCATIONS

3.1.2 ELECTRICAL CONNECTIONS AND WIRING

Electrical connections are made to the case through four terminal blocks (A, B, C, D) mounted on the rear cover plate. Terminal blocks A, B and C contain 32 terminal points, each consisting of a #6 screw threaded into a flat contact plate. Terminal D contains 14 terminal points, each consisting of a #6 screw threaded into a flat contact plate.

The top and bottom printed circuit boards connect directly to terminal blocks A, B and C via edge connectors along the rear of the boards. The magnetics module is wired directly to terminal block D.

The middle printed circuit board is connected to the top and bottom circuit boards via the Bus Card connected on the front side of the circuit boards. The magnetics module is connected via a card edge connector to the bottom circuit board (input board). The current block contacts are rated to handle current transformer (CT) secondary currents.

3.1.3 IDENTIFICATION

The LPS-O system model number label is located on the front cover.

The terminal blocks located on the rear cover plate are uniquely identified by a label that is found along the side of each terminal block. Each terminal is also identified.

Four connectors, PL1, PL2 (A & B), and PL3 are used for serial communication between the LPS-O and a PC or modem. All three communications ports work independently.

3.1.4 SYSTEM BLOCK DIAGRAM

Figure 3–5 is the LPS-O system block diagram, illustrating the external connections and the interconnections between the system modules.

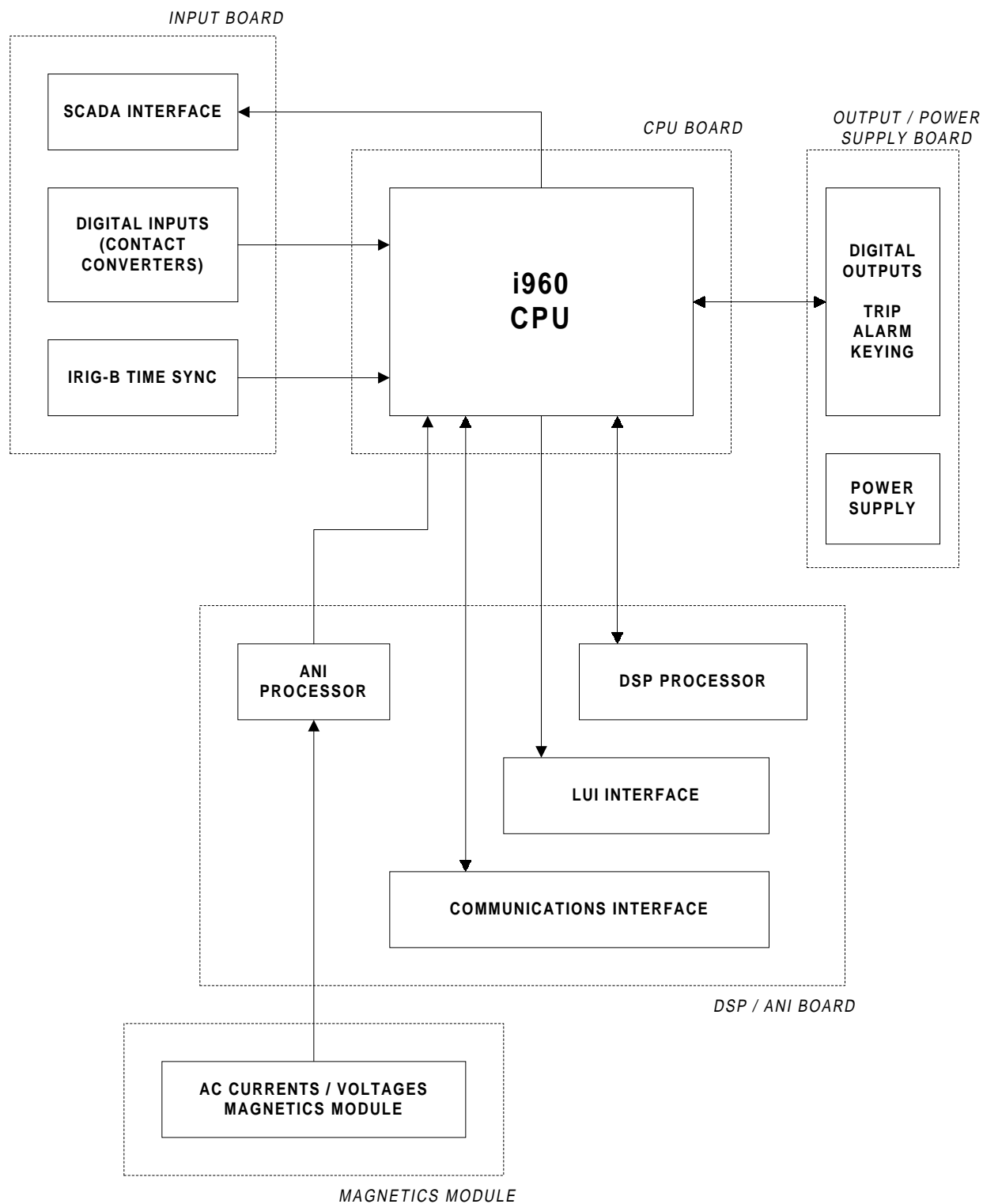


Figure 3-5: LPS-O SYSTEM BLOCK DIAGRAM

3.2.1 RECEIVING, HANDLING, & STORAGE

Immediately upon receipt, the equipment should be unpacked and examined for any damage sustained in transit. If damage resulting from rough handling is evident, file a damage claim at once with the transportation company and promptly notify the nearest GE Sales Office.

If the equipment is not to be installed immediately, it should be stored indoors in a location that is dry and protected from dust, metallic chips, and severe atmospheric conditions.

3.2.2 ENVIRONMENT

The LPS-O should be installed in a clean and dry location, free from dust and excessive vibration, and well lighted to facilitate inspection and testing.

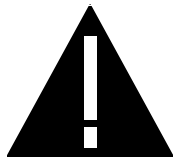
3.2.3 MOUNTING

The LPS-O case has been designed for standard rack mounting. The case is three Rack Units (3 RU) high. Figure 3–2: LPS-O OUTLINE – HORIZONTAL on page 3–2 shows the outline and mounting dimensions.

3.2.4 EXTERNAL CONNECTIONS

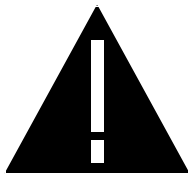
External connections are made according to the elementary diagram shown in Figure 1–11: ELEMENTARY DIAGRAM on page 1–25. These are default diagram incorporating all of the available options. Since the relay is programmable, some outputs and inputs may need to be re-programmed. Refer to Chapter 2: CALCULATION OF SETTINGS for more details.

3.2.5 SURGE GROUND CONNECTIONS



CAUTION: LPS-O Terminals A2 (case ground) and A18 (surge ground) must be tied together, with terminal A18 tied to station ground, as shown in the elementary diagram Figure 1–11: ELEMENTARY DIAGRAM on page 1–25. The connection to the ground bus must be made as short as possible, using #12 wire or larger.

3.3.1 WARNING



CAUTION: This relay contains electronic components that can be damaged by electrostatic discharge currents. The main source of electrostatic discharge currents is the human body, and low humidity, carpeted floors, and isolating shoes are conducive to the generation of electrostatic discharge currents. Care should be exercised when removing and handling the modules. Each person handling the printed circuit boards must ensure that their body through a grounding wrist strap or similar apparatus tied to ground potential *before* touching any of the components on the boards or the boards themselves.

The printed-circuit boards are located inside the case in the positions shown in Figure 3–3: LPS-O VERTICAL FRONT VIEW on page 3–3.

3

3.3.2 BASIC CONSTRUCTION

Each module consists of a printed-circuit board and aluminum plate. The printed circuit board is securely mounted to five stand-offs on the plate with five screws. There are two tabs on the front of the aluminum plate for removing and inserting the module. Electrical connection is made by an edge connector on the rear of the input and output boards and ribbon cables and the bus card connector on the front of the boards.

3.3.3 MODULE IDENTIFICATION

Each module is identified by a silk screen description on the printed circuit board.



CAUTION: Power down the relay by removing any DC voltage to the relay before removing or inserting modules. Failure to do so can permanently damage the relay.

3.3.4 LOCAL USER INTERFACE (LUI)

The Keypad / Display Interface contains a 4-line, 20-character LED display, a green/red status LED, a red trip LED, a 9-pin RS232 port, and the 20-character keypad. The interface logic is contained on two printed circuit boards (DSP/ANI and LUI).

- The LUI module board contains all of the items listed above except the keyboard decoding logic; it is on the DSP/ANI board.
- The Output board contains the LPS-O communications interface (RS232 / ASCII), a Critical Alarm Timer, various output relay drivers, and user-selectable switches to enable remote functions.

3.3.5 INPUT BOARD

The input board contains the input logic which includes the programmable contact converter optocouplers. The SCADA I/V (current/voltage) selection switch, SW1, is in the back, left corner on this board. The IRIG-B input is also on this board. Figure 3–6: INPUT BOARD DIAGRAM is the block diagram of the input board.

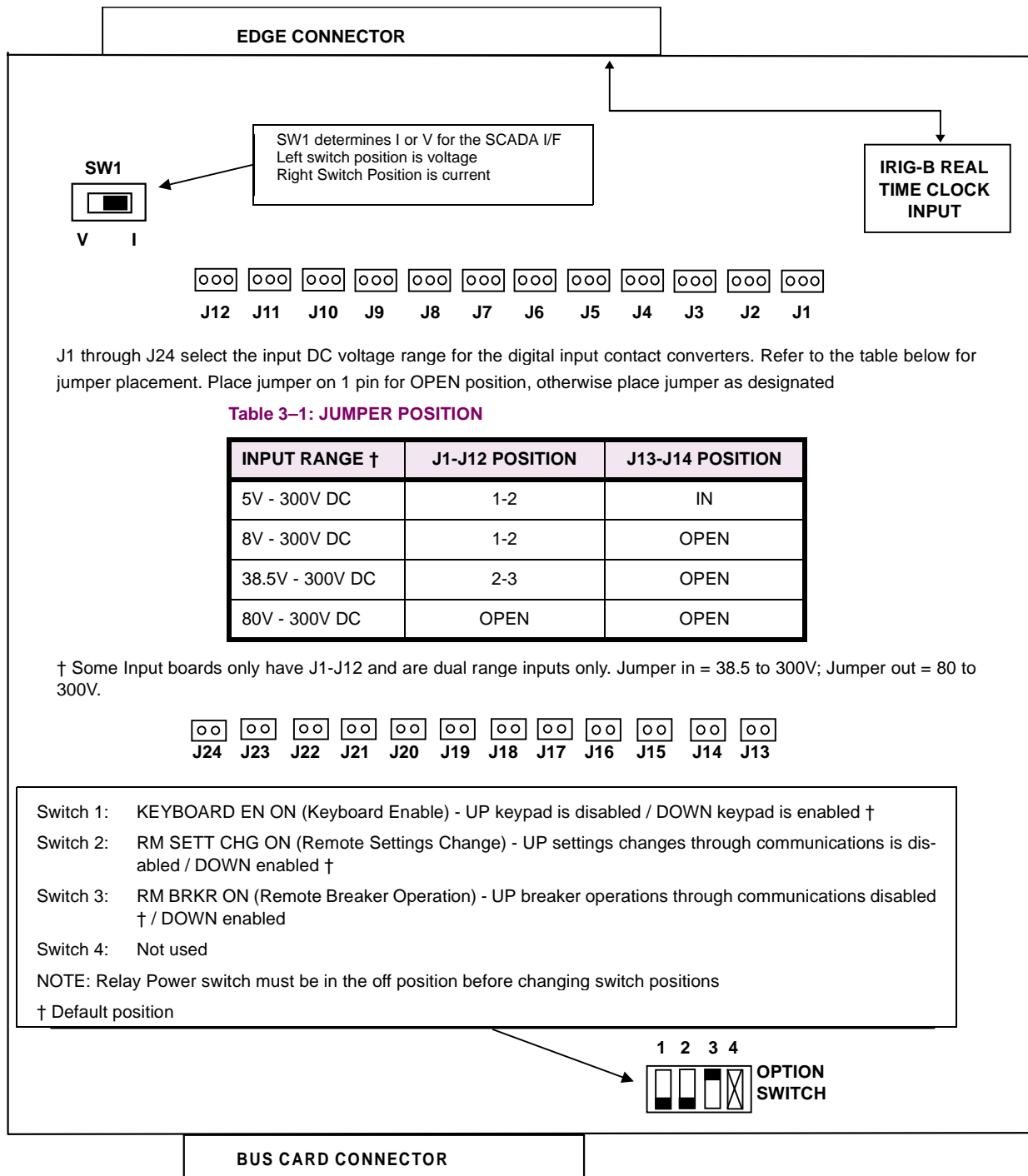


Figure 3-6: INPUT BOARD DIAGRAM

3.3.6 MAGNETICS MODULE

The magnetics module (MGM) contains the input current transformers and voltage transformers. The MGM also contains an EEPROM with factory-stored LPS-O model information (DC voltage rating, AC current rating) and gain-calibration information for the analog channels

The relay driver logic located on the output board contains the alarm, BFI, RI, RC, breaker close, key transmitter, and phase A tripping contacts (or SCRs). Figure 3–7 is a block diagram of the magnetics module and the relay driver.

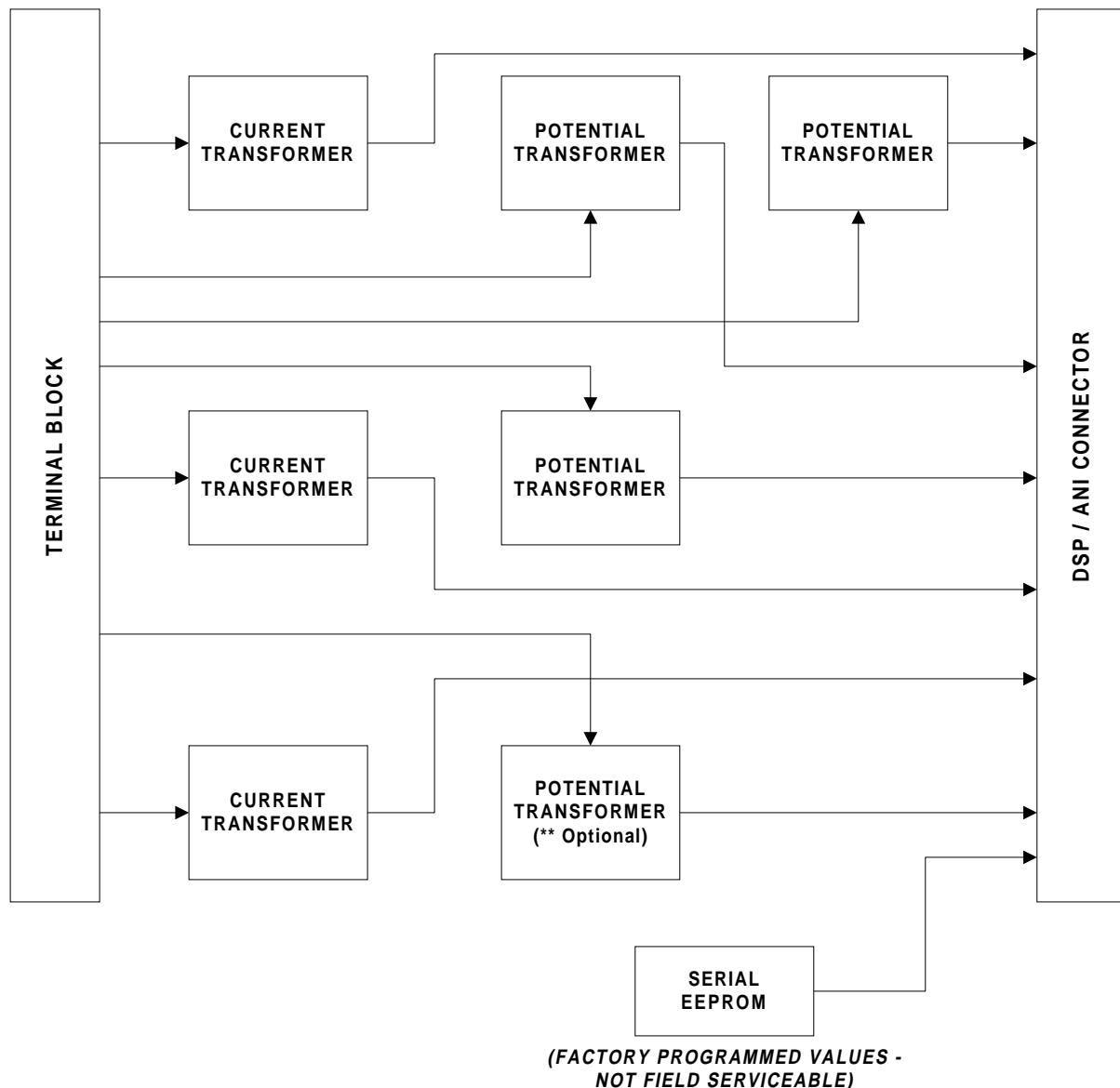


Figure 3–7: BLOCK DIAGRAM OF THE MAGNETICS MODULE

3.3.7 COMMUNICATIONS INTERFACE

The communications interface resides on plug-in modules with user selectable jumpers to configure the interface for the communications application. The two communications types that can be chosen are RS232 and RS485. See the description below for details. Figure 3–8 is the block diagram of the PC card for the communications interface.

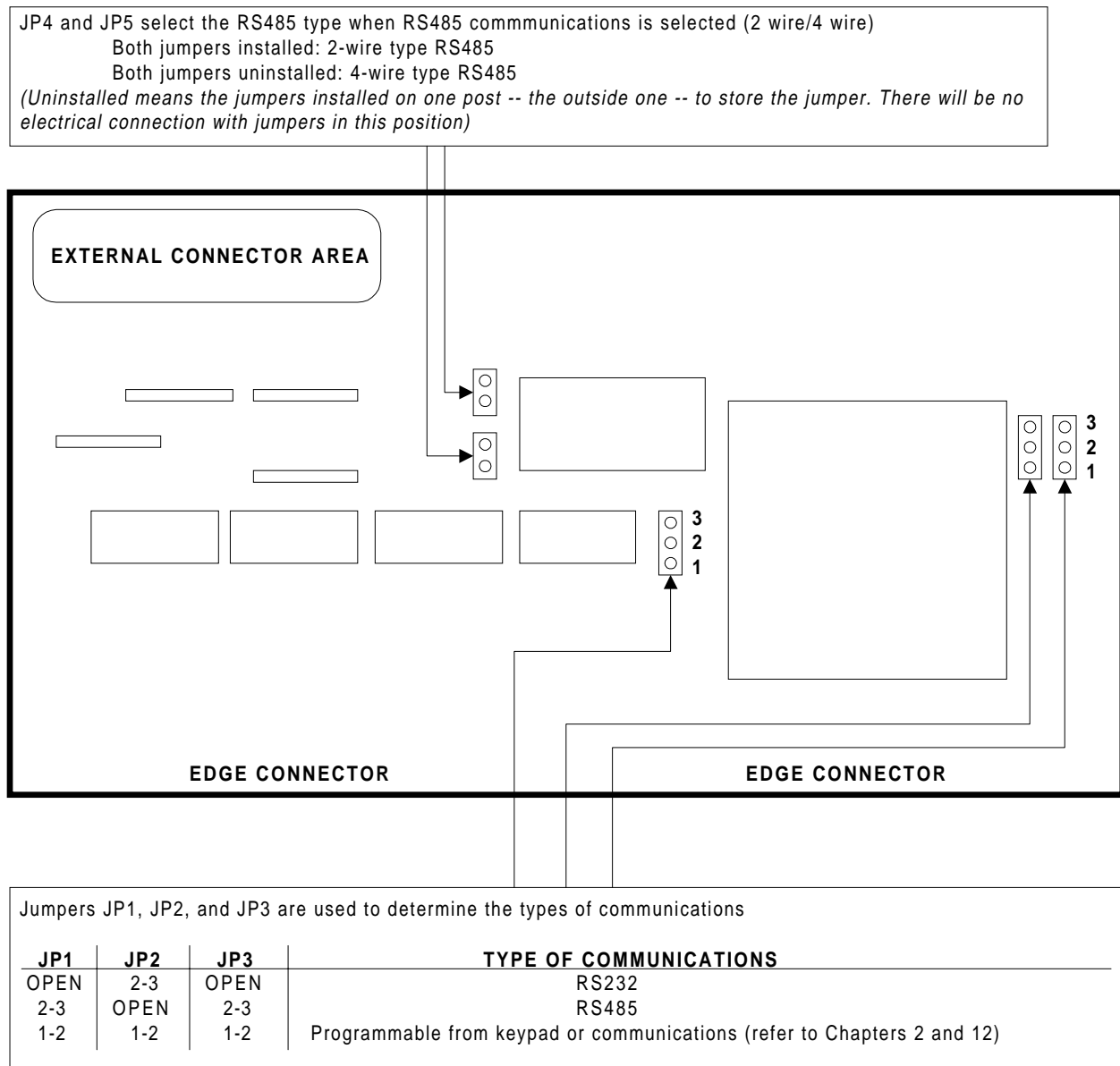


Figure 3–8: BLOCK DIAGRAM OF THE COMMUNICATIONS MODULE

3.3.8 DIGITAL OUTPUT / POWER SUPPLY BOARD

The Digital Outputs (which are programmable) and power supply circuitry are contained on this board. The logic to select and write a digital output is also located on this board.

Figure 3–9 is a block diagram of the Digital Output/Power Supply board.

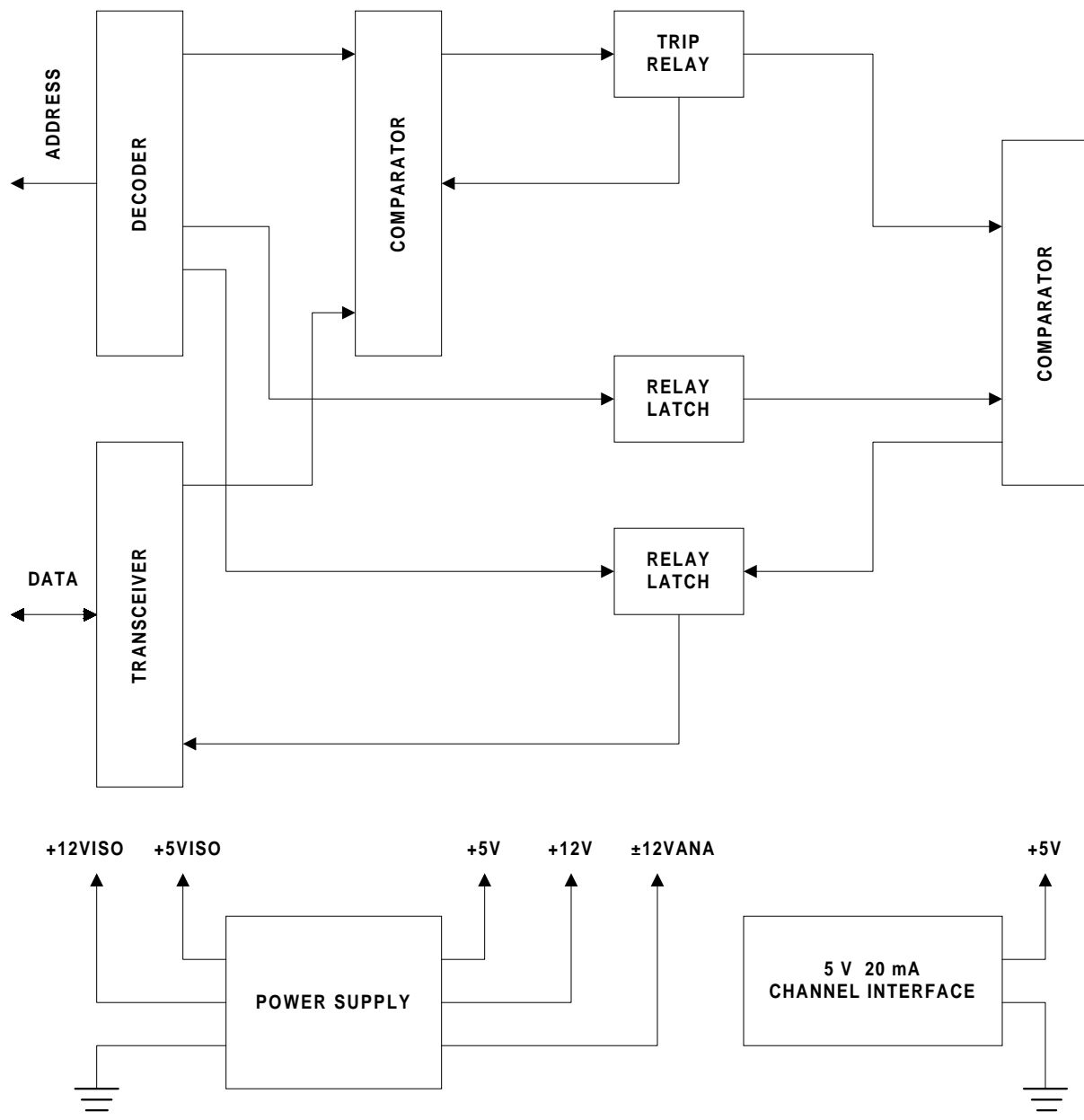


Figure 3–9: BLOCK DIAGRAM OF THE DIGITAL OUTPUT / POWER SUPPLY

3.3.9 DSP / ANI / COMM / LUI

The digital signal processor (DSP), located on the DSP/ANI board, contains the TMS320C52 digital signal processor chip and its required memory. The DSP is responsible for most of the numerical calculations in the LPS-O. It performs a recursive Fourier transform calculation to transform the digitized waveforms into phasor quantities. It also handles the data acquisition through the ANI section of the board. The keypad, display and communications interfaces are also on the DSP/ANI Board. Figure 3-10: BLOCK DIAGRAM OF THE DSP / COMM / LUI MODULE is the block diagram of the DSP/ANI Board.

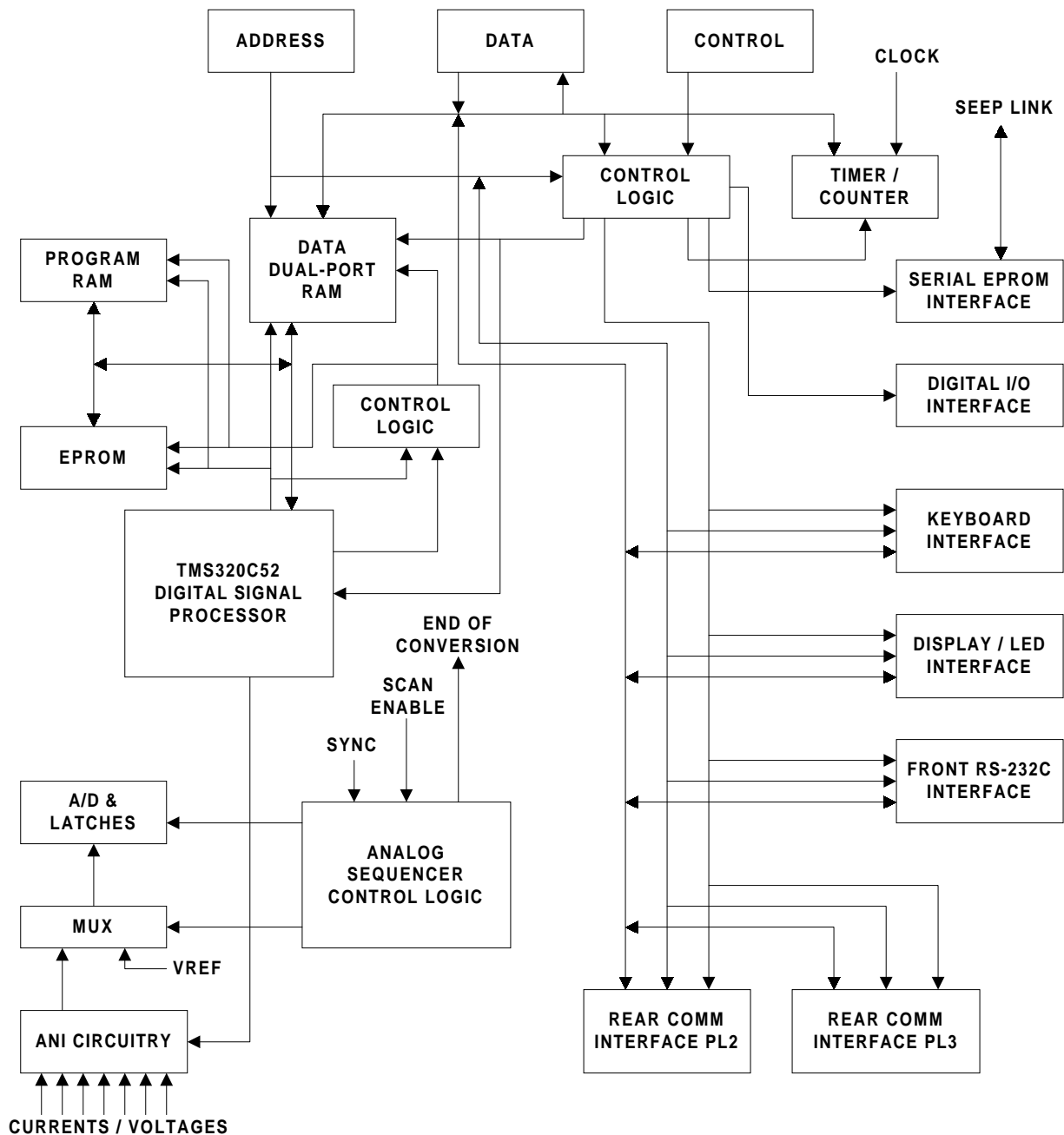


Figure 3–10: BLOCK DIAGRAM OF THE DSP / COMM / LUI MODULE

3.3.10 960 CPU BOARD

The 960 CPU board contains the 960 processor used in the LPS-O, EEPROM for storage of user settings, CAPRAM for storage of fault data and oscillography, and controls data transfer to other modules. The following functions are performed by the 960 CPU board:

- Scheme Logic
- Test Mode
- Peripheral Protection Trip Logic
- Digital Output Logic
- Fault Reporting
- Power System Alarming
- Communications and Printer Control

Figure 3–11: BLOCK DIAGRAM OF THE SYSTEM PROCESSOR (i960 CPU) contains the block diagram of the CPU logic.

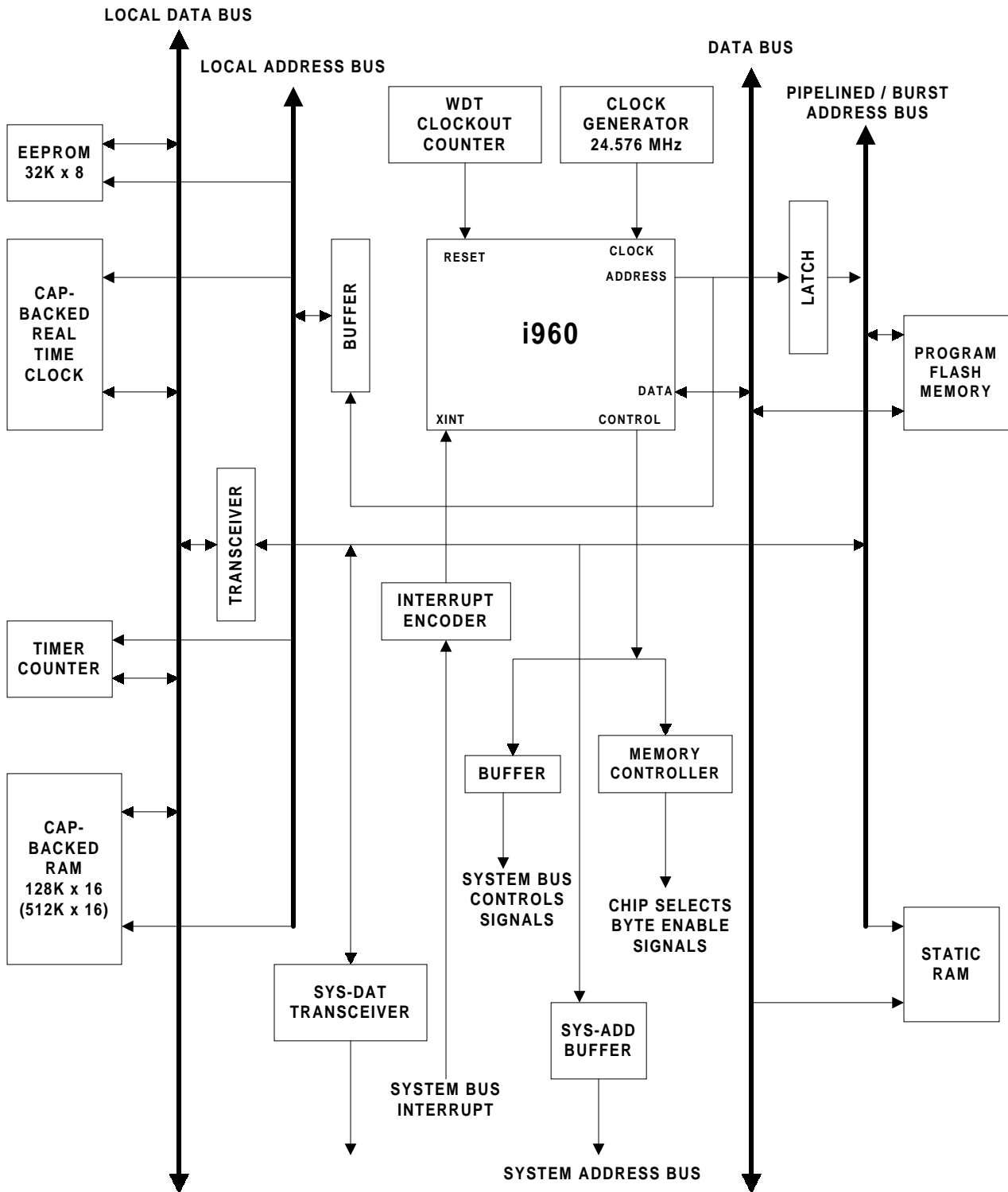


Figure 3-11: BLOCK DIAGRAM OF THE SYSTEM PROCESSOR (i960 CPU)

4.1.1 INTRODUCTION



WARNING: Remove all power from the relay by disconnecting the DC control power and removing all voltage inputs to the rear terminals prior to opening the unit. Dangerous or lethal voltages may be present inside the unit even if the power switch is OFF.

This section is a guide for testing the LPS-O. These tests are not necessary for incoming inspection as the relay was tested at the factory with automated test equipment. The LPS-O is controlled by self-checking software. If a system failure is detected, it is reported through the display and STATUS LED.

The tests in this section include self-tests of the relay status, display, and Keypad/Display Interface. Tests of backup protection functions, measuring units, and zone timers are also included and can be performed at the customer's discretion.

General Relay Tests:

- T1 – Relay Status and Display Tests
- T2 – Digital Output Tests
- T3 – Configurable Input and Output Tests
- T4 – AC System Input Test

4.1.2 TEST EQUIPMENT

The following test equipment is required:

- A three-phase source of voltage and current at rated frequency.
- A DC Control voltage source.
- Three AC voltmeters.
- Three AC ammeters.
- A continuity tester or ohmmeter.
- An IBM PC-compatible computer with a serial port and mouse.
- An RS232 null modem cable to connect the PC to the LPS-O.
- A precision timer for testing timed events.

The specific equipment requirements are listed in the instructions for each test and in the associated circuit diagrams.

The three-phase AC sinusoidal voltage must be balanced and undistorted. Similarly, the DC power should come from a “good” source with less than 5% ripple. A good source is within the voltage range listed in Chapter 7: SPECIFICATIONS.

Alternatively, a three-phase electronic test source may be used. In many cases, these devices allow simplification of the test circuits.

4.1.3 DRAWINGS AND REFERENCES

The following drawings should be used for reference during testing.

Elementary Diagrams

- Figure 1–11: ELEMENTARY DIAGRAM on page 1–25

Logic Diagrams:

- Figure 1–1: PTFE LOGIC DIAGRAM on page 1–8
- Figure 1–2: LINE PICKUP LOGIC DIAGRAM on page 1–9
- Figure 1–3: REMOTE-OPEN DETECTOR LOGIC on page 1–10
- Figure 1–4: OSB LOGIC DIAGRAM on page 1–10
- Figure 1–8: STEP DISTANCE LOGIC DIAGRAM on page 1–21

51G curves:

- Figure 2–14: INVERSE CURVE on page 2–29
- Figure 2–15: VERY INVERSE CURVE on page 2–30
- Figure 2–16: EXTREMELY INVERSE CURVE on page 2–31

The following Chapters should also be used for reference:

- Chapter 11: LPSO-LINK USER GUIDE
- Chapter 12: ASCII COMMUNICATIONS

4.1.4 EQUIPMENT GROUNDING

All equipment used in testing the relay should be connected to a common grounding point to provide noise immunity. This includes the voltage and current sources and the LPS-O itself.

The ground connection on the LPS-O is terminal A2. The common for surge protection is terminal A18.

NOTE: A2 should be connected to A18 with #12 wire or larger during test as well as operation (the separate surge ground is for Hi-Pot testing purposes).

4.1.5 REQUIRED SETTINGS

Most tests use the default settings. Any required setting changes are listed with the test procedure.

For details on performing the relay test with user-specific settings during periodic testing; see Chapter 6: FUNCTIONAL TESTS (USER SETTINGS).

4.1.6 GENERAL INSTRUCTIONS

1. Tests are performed using the test mode of the LPS-O which allows viewing of the internal measuring units and functions. The measuring units and functions are actually internal to the software. There are no individual hardware modules that are responsible for the specific measuring functions.

The test mode selects and isolates various relaying functions and measuring units, then routes their status to the A1 (Programmable Alarm 1) contact. When the particular function under test has picked up, the A1 contact closes. Target information is displayed for tests that cause tripping.

Testing can be performed with outputs disabled. The A1 contact still closes whenever a trip condition exists, however the tripping contacts do not operate. Disabling outputs can be accomplished from the ACTIONS menu or at the start of Relay Test mode.



CAUTION: Contact A1 will chatter when the unit under test is near its threshold. *Do not let it continue to chatter!* Remove the test current. A single contact closure is enough to determine that the unit picked up.

In tests that cause tripping, the trip target type may not match the unit being tested in the procedure. For example, if a Zone 1 phase fault is being tested, Zone 2 may pick up and trip the relay before the fault is in the Zone 1 characteristic. The target information will reflect the Zone 2 trip, not Zone 1. Keep this in mind during the tests.

Use a continuity tester with high input impedance, such as a digital ohmmeter, to monitor the A1 contact during relay testing.

NOTE: Tripping contacts will operate while the relay is in test mode unless the outputs are disabled.

2. Where appropriate, current levels are defined with two numbers as $xx(yy)$; xx is the value to be used for relays rated at 5 Amperes and (yy) is the value to be used for 1 Ampere relays.
3. One or more of the electronic current sources may not be used during a test. If the source is not used, it must be set to zero, in addition to being disabled. Also, the currents should always be set at or near zero whenever a current source is powered on or off.
4. The phase angles of the test sources are shown relative to phase A voltage. A positive phase angle indicates the referenced quantity is leading phase A voltage. A negative phase angle indicates the referenced quantity is lagging phase A voltage.
5. All test voltages are phase-to-ground measurements unless otherwise specified.
6. Entries at the keypad are shown as $[KEY]$, with the label of the key to be pressed enclosed in square brackets. For tests that require a setting change, the setting number is shown in parentheses next to the setting. This is performed by pressing the $[SET]$ key, choosing the setting type (Protection or General), the group (if necessary), the setting number ($nnnn$), and $[ENT]$. The new setting may then be entered.

NOTE: Operation of Potential Transformer Fuse Failure (PTFF) will cause the Critical Alarm to operate.

7. When testing the relay using the LPSO-Link software, the only time that information will automatically appear on the display is after the relay has tripped or to report a detected error. Relay status and test mode information will not appear.
8. At the end of testing, make sure that all settings are returned to their initial values. This can be done through LPSO-Link by uploading the settings to the PC before testing begins and then downloading them back to the relay when testing has been completed. If a PC is not available, scroll through all settings using the keypad and verify each one with the setting recorded in Table 2–9: PROTECTION SETTINGS DATA SHEET on page 2–47.

4.1.7 SETTING CHANGES

Setting changes required for a particular test are listed before the test. A sample setting change is shown below. Refer to Chapter 8: LOCAL USER INTERFACE for further details on making setting changes.

EXAMPLE SETTING CHANGE:

This example illustrates changing the reach of the Zone 1 Phase Unit to 5.6 Ohms.

1. Apply rated DC and wait for relay initialization to complete, indicated by a solid green status LED on the front of the relay.
2. Press the $[SET]$ key:

ENTER PASSWORD:

is displayed.

Enter the Master or Settings level password and press the $[ENT]$ key.

If this is the first time the Settings Level functions are used, the password has the factory value “123.” (make sure to include the period). This password must be changed before any setting functions can be accessed. See Section 8.1.20: CHANGE PASSWORD on page 8–17 for details on changing the password. The Master password gives the user setting and action control within the relay. The factory Master password is “789.” (make sure to include the period). The Master password must be changed before the relay can be used for the first time. See Section 1.1.2: PASSWORDS: FACTORY SET on page 1–1 for additional details on changing the password.

3. When the correct password is entered, the settings menu is displayed.
4. Press the [1/Y] and [ENT] keys to select **Edit Protection Settings**.
5. Press the [1/Y] and [ENT] keys to select **Group 1**.
6. Scroll with the arrow keys until the cursor is on

1. Z1DISTANCE

then press the [ENT] key.

7. Scroll through the Z1DISTANCE menu until

Z1PHREACH = #.#

appears on the display then press the [ENT] key.

8. Press [5] then [.] then [6] from the keypad. The inputs appear on the display and the equals sign (=) changes to a blinking colon (:) to indicate that a change has been made but not yet entered.
9. When the correct reach is entered, press the [ENT] key. The blinking colon (:) will change back to an equals sign (=). This indicates that the change is entered into the settings buffer, but not permanently changed in the relay.
10. To complete the setting change, press the [END] key followed by the [ENT] key (**Save Settings and Quit**). If these keys are not pressed after setting changes, the settings are *not* stored in the relay memory. The message:

SETTINGS SAVED SESSION ENDED

will be displayed when settings are stored into the relay's memory.

11. Restore the **Z1PHREACH** setting to its original value before beginning the test. The settings level or master level password must be entered again to complete this step.

4.1.8 ENTERING TEST MODE

Before a test can be performed, the LPS-O must be put in test mode and select the function to be tested. The test mode is set as follows:

1. Apply rated DC and wait for relay initialization to complete (if this has not already been done), indicated by the green status LED on the front of the relay.
2. Press the [ACT] key. The message

ENTER PASSWORD:

is displayed.

Enter the Master or Actions level password and press the [ENT] key.

If this is the first time the Actions Level functions are used, the password has the factory value “456.” (make sure to include the period). This password must be changed before any Control functions can be accessed. See Section 8.1.20: CHANGE PASSWORD on page 8–17 for details on changing the password.

word. The Master password gives the user setting and action control within the relay. The factory Master password is “789.” (make sure to include the period). The Master password must be changed before the relay can be used for the first time. See Section 1.1.2: PASSWORDS: FACTORY SET on page 1–1 for additional details on changing the password.

3. When the correct password is entered, the actions menu is displayed.
4. Scroll with the arrow keys until

5. RELAY TEST

is displayed, then press the [ENT] key. A complete list of the test numbers is shown in Table 4–1 below.

5. You will be prompted to **DISABLE OUTPUTS**. The test can be performed with or without the outputs disabled. To disable the outputs, press [1/Y] and the [ENT] key. When outputs have been disabled the status LED will turn red. If [3/N] is pressed rather than [1/Y], the outputs are not disabled and the status LED remains green.
6. Scroll through the different test mode functions or enter the number of the desired test, such as 22 for the Fault Detector. Press [ENT] and the cursor will be placed on the fault detector test. Press [ENT] again and the test is started. When the LPS-O picks up for the selected function it closes the A1 contacts.
7. To exit test mode, press the [ACT] key. Scroll with an arrow key until

5. RELAY TEST

is displayed, then press the [ENT] key. Scroll until the display indicates

1. END TEST MODE

and press the [ENT] key. If you previously disabled the outputs, you will be prompted to ENABLE OUTPUTS before the relay test mode will end. Press [1/Y] and [ENT] to enable the outputs. The status LED should return to green, indicating that normal operation has resumed.

Table 4–1: AVAILABLE RELAY TESTS

1: End Test Mode	10: ZONE 3 CA	19: IB DETECTOR	28: INST GND OVRC
2: ZONE 1 AB	11: ZONE 4 AB	20: GND DIR TRIP	29: GND TOC PICKUP
3: ZONE 1 BC	12: ZONE 4 BC	21: GND DIR BLK	30: LINE PICKUP
4: ZONE 1 CA	13: ZONE 4 CA	22: FAULT DETECTOR	31: OVER VOLTAGE
5: ZONE 2 AB	14: ANY Z1 PHASE	23: REM OP DETCT	32: UNDER VOLTAGE
6: ZONE 2 BC	15: ANY Z2 PHASE	24: OUT OF STEP BLK	33: OUT OF STEP TRIP
7: ZONE 2 CA	16: ANY Z3 PHASE	25: V1 DETECTOR	
8: ZONE 3 AB	17: ANY Z4 PHASE	26: LINE OVERLOAD	
9: ZONE 3 BC	18: IT DETECTOR	27: INST PHS OVRC	

4.1.9 USING COMMUNICATIONS (OPTIONAL)

The relay can be tested without using the keypad. A PC and a communications program, either LPSO-Link or an ASCII terminal emulator, are required to establish communications, change the passwords, change settings for the tests, and place the unit into test mode. The example used here is for LPSO-Link. Refer to Chapter 12: ASCII COMMUNICATIONS for details on using a terminal emulator. All the functions available at the keypad are also available through communications.

This section contains a step-by-step procedure to test the relay, from setting up communications to the application of the voltage and current inputs. You must be familiar with the LPSO-Link software. Refer to Chapter 11: LPSO-LINK USER GUIDE for more details on using LPSO-Link.

a) HARDWARE SETUP

The appropriate cable to connect the PC to the relay depends on the connections the PC and the LPS-O require. The LPS-O front port PL-1 accepts a 9-pin male D-connector. Ports PL-2 and PL-3 accept a 25-pin male D-connector. The PC used may require a 9- or 25-pin connector. A null modem cable is used to connect two communications ports without a modem. Null modem cables pinouts are shown in Section 8.4.5: NULL-MODEM CONNECTIONS on page 8–30 for connecting the LPS-O to a PC.

b) PC SOFTWARE SETUP

The software setup consists of starting Windows, loading the software into the PC, starting the program, and configuring the program to the port and baud rate of the PC and LPS-O. LPSO-Link is a Windows program. Refer to Chapter 11: LPSO-LINK USER GUIDE or computer documentation for directions on using a mouse, menu bars, dialog boxes and windows.

4

c) LOAD & START LPSO-LINK

1. Refer to Section 11.2: LPSO-LINK INSTALLATION on page 11–2 for directions on loading LPSO-Link into the PC.
2. Double-click on the group icon that contains LPSO-Link to open the window.
3. Start the program by double-clicking the LPSO-Link icon.

d) SET LOCAL PC CONFIGURATION

1. When you start LPSO-Link the main menu bar is displayed.
2. Click on the **SupportFunc > Host Setup > Ports** menu item.
3. Select the communication port number that matches the PC port connected to the LPS-O relay (typically it is COM1). Leave the Base I/O Port Address and Interrupt Request Line (IRQ) values at the default or change if necessary.
4. Select **OK** when the port is configured.

e) CREATE TEST UNIT DESCRIPTION

The next step is to create a new Unit Description that matches the baud rate, phone number, and switch code of the LPS-O. Usually, the LPS-O is accessed locally during testing; therefore, the **Phone Number** and **Switch Code** are left blank. The **Baud Rate** is set to the factory setting of 9600 baud with one stop bit and no parity; see General Setting 201: **COMPORT1**. A setting of **COMPORT1** = 9601 specifies 9600 baud, no parity, and 1 stop bit.

1. Select **Device > Device Setup** from the main menu and click the **Add** button to create a new device name.
2. In the text box for the **Device Name**, type TEST and press TAB. A new unit description called TEST is created and must now have parameters set for it. Note that the **Device Setup** dialog box contains spaces for **Unit ID**, **Data Bits**, **Phone Number**, **Switch Code**, **Baud Rate**, **Stop Bits**, and **Parity**.
3. In the **Unit ID** field, enter the Unit ID number of the LPS-O and press TAB. The factory default is 0000.
4. At the **Baud Rate** prompt, select 9600 and press TAB.
5. In the **Data Bits** field, select 8 and press TAB.
6. At the **Stop Bits** prompt, select 1 and press TAB.

7. At the **Parity** prompt, select None and press TAB.
8. At the **Phone Number** and **Auxiliary Phone** fields, press TAB and leave blank.
9. At the **Switch Code** prompt, press TAB.
10. The **Break Signal** feature should be de-selected and **Duration of Break** set to 0 seconds. Refer to Section 11.4: SETTING UP YOUR HOST MACHINE on page 11–11 for more details.

The Unit Description for TEST is complete. Select **OK** and **Close** to finish.

f) RELAY SETUP

Before shipment, the relay is set with factory default settings. These include the Unit ID, the Baud Rate, and the Factory Passwords. The default communications parameters are listed in Table 4–2: FACTORY DEFAULT COMMUNICATIONS PARAMETERS below.

Table 4–2: FACTORY DEFAULT COMMUNICATIONS PARAMETERS

Parameter	Setting
Unit ID	0
View Password	VIEW!
Control Password	CONTROL!
Settings Password	SETTING!
Master Password	MASTER!
Baud Rate	9600

g) LOGGING INTO THE RELAY

1. Select **Connect** from the **Device** menu.
2. Select the TEST device just created. LPSO-Link will prompt for a password. If this is the relay login, the passwords listed in Table 4–2: FACTORY DEFAULT COMMUNICATIONS PARAMETERS must be changed before any relay functions except CHANGE PASSWORD and LOGOUT will operate. See Section 11.7.4: CHANGE PASSWORD on page 11–21 for details on changing a password with LPSO-Link.
3. Type in the current Master password and click **OK**. If the password is not known, refer to Chapter 8.2.8: COMMUNICATION PASSWORDS on page 8–23 for details on displaying the current password.
4. At this point, LPSO-Link responds with a complete display of menus. If this was an initial login, you must first change the password and then log out and log in again in order to get a complete display of all the menus.
5. Select **Logout** from the **Device** menu.
6. Select **Yes** to logout.

h) SETTING CHANGES

Setting changes required for a particular test are listed before the test. A setting can be changed either by category or individually, by selecting either **Device > Settings** or **Device > Local Settings** from the LPSO-Link menu bar. A procedure for and example of how to change settings with LPSO-Link is provided in Section 11.6: SETTINGS on page 11–18.

It is important to remember to select **Send End** from the LPS-O Settings list menu after all settings changes for a particular test are complete. This is necessary because settings are stored in a buffer so that they can all be downloaded at once. Selecting **Send End** will complete the settings download to the relay.

i) ENTERING TEST MODE

Before most tests it is necessary to set the relay in test mode according to the function to be tested. The test mode is set as follows:

1. Select **Connect** from the **Device** menu.
2. Select the TEST device name and click **OK**. LPSO-Link will prompt for a password.
3. Enter the Master Level password created after initial login to the relay. If the password is not known, see Chapter 8: LOCAL USER INTERACE for details on viewing the current password.
4. Select **Relay Test** from the **Actions** menu. The **Relay Test** list box appears.
5. Select the test you wish to enter from the menu and then select **Do Test**.
6. The **Status LED** changes from green to red when the LPS-O is in test mode.

4

j) EXITING TEST MODE

To end test mode and turn relay protection on, select **End Test Mode** from the **Relay Test** list box and then select **Do Test**. The **Status LED** changes from red to green, indicating that normal operation has resumed.

k) INITIAL TEST SETUP

Before beginning a test, the relay settings should be checked for reference and verification. The factory default settings are listed in Sections 2.5.2 PROTECTION SETTINGS GUIDE and 2.5.3 GENERAL SETTINGS GUIDE on pages 2–44 to 2–54. You may use either the communications ports or scroll through the settings to ensure they all match the defaults.

For testing with LPSO-Link, the relay settings should be uploaded from the LPS-O and printed for reference and verification. Verify that each LPS-O setting matches the default setting listed. If no printer is available, use the **Device > Settings** command for verification.

Once uploaded, the current LPS-O settings can be saved to a disk file so that they can be downloaded to the LPS-O when testing is completed. Use the **Save** command after the device settings have been uploaded. LPSO-Link prompts for a name for the file, after which you should enter a valid MS-DOS filename (maximum of eight characters followed by the SET extension). More information on how to use this command can be found in Chapter 11: LPSO-LINK USER GUIDE.

4.2.1 T1 – RELAY STATUS AND DISPLAY TESTING

The LPS-O Status is reported through the Keypad/Display Interface, the noncritical alarm contact, and the critical alarm contact. If a system error causes relaying functions to cease, the status LED turns red and the critical alarm contact closes. A failure that does not interrupt relaying is indicated by closing the noncritical alarm contact and displaying a WARN message and green status LED.

a) STATUS CHECK

This test demonstrates the use of the Keypad/Display Interface to check relay status. See Chapter 11: LPSO-LINK USER GUIDE or Chapter 12: ASCII COMMUNICATIONS for further details.

1. Only the DC power supply voltage is required for this test. Apply the rated DC power and wait for initialization to complete (if this has not been done already), as indicated by the green LED.
2. Press the [INF] key, then use the arrow keys to scroll until the cursor is on

1. LPS STATUS

3. Press the [ENT] key. The display should contain the message

STATUS: OK

indicating that the relay is operational and there are no errors.

4. Verify the setting of the trip circuit monitor (General Setting 107: **NUM_MON**) is:

NUM_MON = 0011

Be sure to press the [END] and [ENT] keys after the setting is changed. When this is done, the relay expects wetting voltage across the trip contacts T1 and T2.

5. Press the [INF] key and scroll with arrow keys until the display contains the message:

1. LPS STATUS

6. Press the [ENT] key. The display should contain the message

STATUS: FAIL

**FAIL: TRIP CKT #1 CONTINUITY
ERROR**

This verifies that the relay detected the absence of wetting voltage across the trip contact.

7. Change the setting of the trip circuit monitor to

NUM_MON = 0000

to re-check the status. The display should read

STATUS: OK

8. Change the setting of the trip circuit monitor back to **NUM_MON = 0011** before starting the next test.

b) DISPLAY AND KEYPAD TESTS

The Keypad/Display Interface (LUI) Test is built into the software and allows testing the keypad and the display.

1. Apply rated DC power and wait for initialization to complete, as indicated by the green LED, if necessary.
2. Press the [ACT] key, then scroll with the arrow keys until the display contains the heading

7. LUI TEST

3. Press the [ENT] key. The display should contain three choices to test the display, LEDs and keypad.

4. Select

1. DISPLAY

and press the [ENT] key.

5. Check that the display has two rows filled completely with rectangles and press the [ENT] key. The display changes to the last two rows filled with rectangles. When the display has been checked press the [ACT] key. If any other key is pressed the display will not return to the LUI Test menu.

6. Use the arrow keys to select

2. LEDs

and press the [ENT] key. The selected LED will change. Press [ENT] after verifying each LED state. When the test is finished the LUI Test menu will be displayed.

7. Use the ARROW keys to select

3. KEYPAD

and press [ENT]. A map of the keypad will be displayed on the screen.

8. At this point the relay is in the keypad test. Press every key on the keypad except the [CLR] key. As each key is pressed, verify that the display correctly indicates the key. For example, pressing the ↑ key is indicated on the display by a flashing ↑. The display corresponding to the other keys is the legend that is on printed the key itself.
9. When all the keys have been checked, press the [CLR] key.
10. When the test is completed, press the [END] followed by the [ENT] key. Press the [CLR] key to clear the message. This ends the Keypad/Display Interface Test.

4.2.2 T2 – DIGITAL OUTPUT TEST

This test checks all outputs of the relay. It is a convenient way to determine proper system connections and verify the operation of all relay contacts, without having to apply currents and voltages to simulate faults. Protection must be disabled to perform the output tests.

NOTE: If this test is run remotely through LPSO-Link, then switch RM BRKR must be in the down position to allow the outputs to operate. Refer to Section 8.4.1: HARDWARE SWITCHES on page 8–27 for details on changing the switch position. Note that the relay is shipped from the factory with the switch in the down position *allowing* the outputs to operate.

Connect the relay as shown in Figure 4–1: DIGITAL OUTPUTS TEST CONNECTIONS on page 4–13. Either LPSO-Link or the keypad may be used to operate the relay's outputs. To use LPSO-Link follow the procedure below:

1. Press the [ACT] key, enter the Master level password, and press the [ENT] key. The ACTIONS menu will be displayed.
2. Use the arrow keys to select

8. DIG OUTPUT TEST

3. Press the [ENT] key. Before a contact is allowed to be tested, the display prompts

DISABLE PROTECT?

4. Press the [1/Y] key followed by the [ENT] key to turn protection off. Protection must be disabled to continue with the digital output tests. Protection remains off until the outputs are re-enabled.

5. Select the output to test by using the arrow keys to scroll to the desired output, such as T1, and press the [ENT] key. When the digital output is chosen, the selected relay output closes. Verify that the output under test has closed, using an ohmmeter or other suitable device.
6. After the output is tested, scroll to the next output to test, then press the [ENT] key. This output closes and the previously selected output opens. Continue in this fashion until all outputs are tested.
7. End the test mode by scrolling to the

END TEST MODE

selection, then press the [ENT] key. Press [1/Y] to enable protection followed by the [ENT] key. The status LED will turn green indicating that the relay is back into normal operation.

To use LPSO-Link to operate the relay outputs, follow the procedure below:

1. From the **Actions** menu, select **Digital Output Test**.
2. Select **Yes** to disable protection.
3. The output test selection box will be displayed.
4. Select an output and select **Do Test** to operate. The contact will operate momentarily and the status LED will turn red to indicate that protection is disabled.
5. Continue selecting each output. When finished with the test, select **End Test Mode** followed by **Do Test**.
6. Select **Yes** to turn protection on. The status LED will turn green indicating normal operation mode.

Table 4-3: DIGITAL OUTPUTS TEST CONNECTIONS

DIGITAL OUPUT	X	Y	DIGITAL OUTPUT	X	Y
T1	A3	A19	A12	B4	B20
T2	A4	A20	KT1 (no)	B5	B21
T3	A5	A21	KT1 (nc)	B5	B22
T4	A6	A22	KT2 (no)	B5	B21
T5	A7	A23	KT2 (nc)	B23	B7
T6	A8	A24	KT3 (no)	B8	B24
A1	A9	A25	KT3 (nc)	B8	B25
A2	A10	A26	KT4 (no)	B26	B9
A3	A11	A27	KT4 (nc)	B26	B10
A4	A12	A28	C1A (no)	B11	B27
A5	A13	A29	C1B (nc)	B11	B28
A6	A14	A30	C2A (no)	B29	B12
A7	A15	A31	C2B (nc)	B29	B13
A8	A16	A32	CA (nc)	B14	B30
A9	B1	B17	CA (no)	B14	B31
A10	B2	B18	PWR (nc)	B32	B15
A11	B3	B19	PWR (no)	B32	B16

Tx - TRIPPING contacts (programmable)

Ax - Alarm contacts (programmable)

KTx - Key Transmitter contacts (programmable)

Cxy - C Form contacts with one NO/NC contact pair (programmable)

CA - Critical Alarm

PWR - Power Supply Alarm

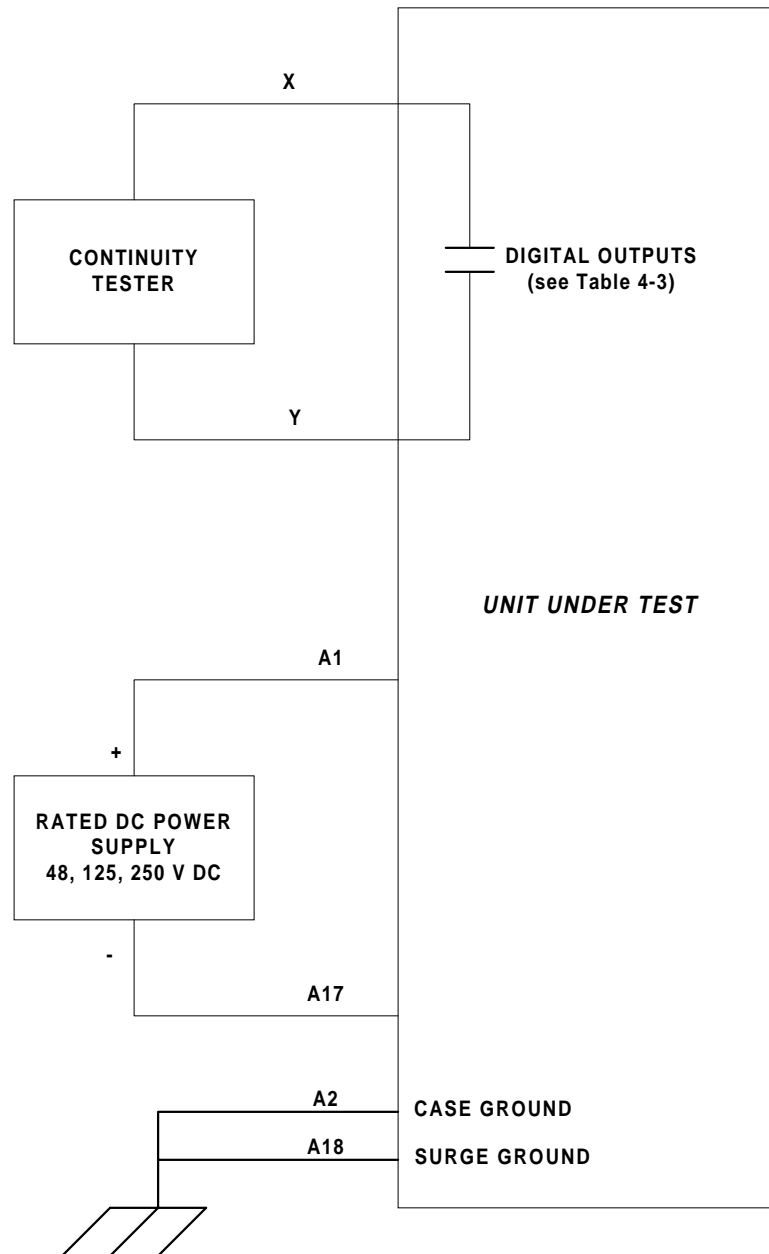


Figure 4–1: DIGITAL OUTPUTS TEST CONNECTIONS

4.2.3 T3 – CONFIGURABLE INPUT TEST

The LPS-O includes twelve configurable inputs and twenty configurable outputs. These provide great flexibility in applying and testing the relay. The configurable inputs are user-programmed to determine their use. For example, one input could trigger oscillography, while another could select a settings group.

TEST T3 PROCEDURE:

1. Connect the relay as shown in Figure 4–2: CONFIGURABLE INPUT/OUTPUT TEST CONNECTIONS on page 4–15 with default configurable logic installed.

2. Apply rated DC across CC1 (D2-D18). Using the keypad and the INF: "CC status" command, verify that CC1 is ON (indicated by a value of 1). Remove the DC from CC1.
3. Apply rated DC across CC2 (D3-D19). Using the keypad and the INF: "CC status" command, verify that CC2 is ON (indicated by a value of 1). Remove the DC from CC2.
4. Apply rated DC across CC3 (D4-D20). Using the keypad and the INF: "CC status" command, verify that CC3 is ON (indicated by a value of 1). Remove the DC from CC3.
5. Apply rated DC across CC4 (D5-D21). Using the keypad and the INF: "CC status" command, verify that CC4 is ON (indicated by a value of 1). Remove the DC from CC4.
6. Apply rated DC across CC5 (D6-D22). Using the keypad and the INF: "CC status" command, verify that CC5 is ON (indicated by a value of 1). Remove the DC from CC5.
7. Apply rated DC across CC6 (D7-D23). Using the keypad and the INF: "CC status" command, verify that CC6 is ON (indicated by a value of 1). Remove the DC from CC6.
8. Apply rated DC across CC7 (D8-D24). Using the keypad and the INF: "CC status" command, verify that CC7 is ON (indicated by a value of 1). Remove the DC from CC7.
9. Apply rated DC across CC8 (D9-D25). Using the keypad and the INF: "CC status" command, verify that CC8 is ON (indicated by a value of 1). Remove the DC from CC8.
10. Apply rated DC across CC9 (D10-D26). Using the keypad and the INF: "CC status" command, verify that CC9 is ON (indicated by a value of 1). Remove the DC from CC9.
11. Apply rated DC across CC10 (D11-D27). Using the keypad and the INF: "CC status" command, verify that CC10 is ON (indicated by a value of 1). Remove the DC from CC10.
12. Apply rated DC across CC11 (D12-D28). Using the keypad and the INF: "CC status" command, verify that CC11 is ON (indicated by a value of 1). Remove the DC from CC11.
13. Apply rated DC across CC12 (D13-D29). Using the keypad and the INF: "CC status" command, verify that CC12 is ON (indicated by a value of 1). Remove the DC from CC12.

4.2.4 T4 – AC SYSTEM INPUT TEST

This test uses the Present Values to determine that the voltages and currents are connected properly to the terminal strip. The front target reset button can be used at any time during the test to verify the relay voltages and currents. Use LPSO-Link and select **Report > New > Present Values**.

1. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
2. Set VA to 67 V rms $\angle 0^\circ$, VB to 57 V rms $\angle -120^\circ$, and VC to 47 V rms $\angle 120^\circ$.
3. Press the INF key on the keypad. Scroll, using the ARROW keys, to the heading:

1. PRESENT VALUES

and press the [ENT] key. The present values are now displayed. Alternately, the Target reset key can be pressed to view the metering values.

4. Scroll to the values of VA, VB, and VC and verify that the voltages are within ± 2 volts of the voltage source setting. This verifies the connections of the voltage sources.
5. Set I_{op} to 1.0 amp rms for phases IA, IB, or IC, as shown by the Y connection point in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
6. Verify the value of IA, IB, or IC depending on connection Y. Verify that the current reading is between 0.9 and 1.1 amps rms.
7. Reduce the test current to zero amps.

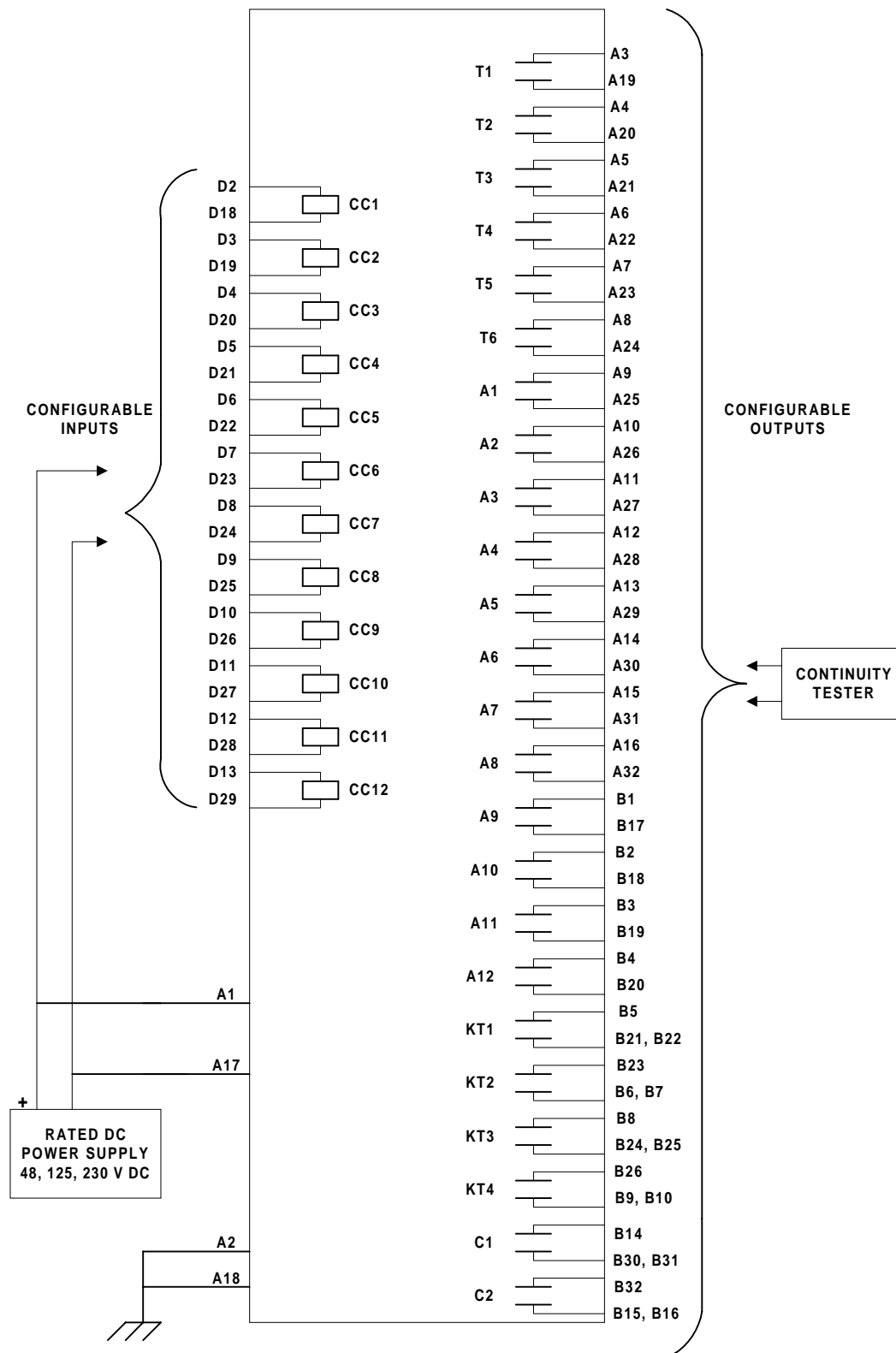


Figure 4-2: CONFIGURABLE INPUT/OUTPUT TEST CONNECTIONS

4

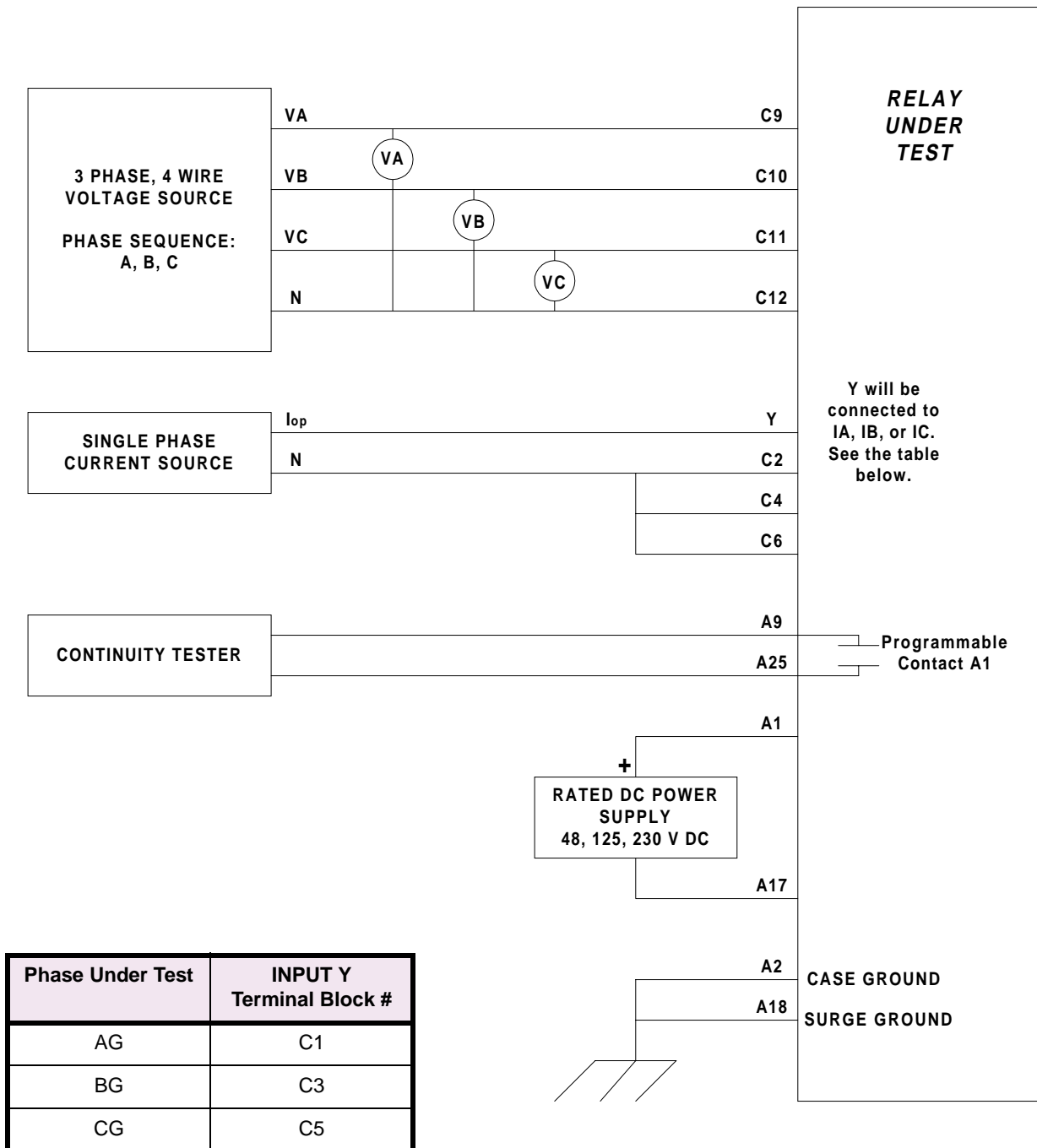


Figure 4–3: PHASE TO GROUND TEST CONNECTIONS

a) MEASURING UNIT TESTS

- T1 – FD Fault Detector
- T2 – IT Trip Supervision Test
- T3 – IB Blocking Supervision Test
- T4 – Ground Directional Trip Test
- T5 – Ground Directional Block Test
- T6 – Phase Instantaneous Overcurrent
- T7 – Ground Instantaneous Overcurrent
- T8 – Ground Time Overcurrent Test
- T9 – Undervoltage Test
- T10 – Overvoltage Test

b) ZONE PHASE REACH & TIMERS TESTS

- T11 – Zone1 Phase Reach without Transformer Compensation
- T12 – Zone2 Phase Reach without Transformer Compensation
- T13 – Zone3 Phase Reach without Transformer Compensation
- T14 – Zone4 Phase Reach without Transformer Compensation
- T15 – Three Phase Fault with Transformer Compensation
- T16 – Phase (Zone Backup) Timer Tests

c) OUT OF STEP TESTS

- T17 – Out of Step Block Test
- T18 – Out of Step Trip Tests

Refer to Section 4.1: OVERVIEW on page 4–1 for generic test instructions pertaining to the test equipment, equipment grounding, required settings and settings changes, general instructions, entering and exiting test mode, using communications, and PC software setup.



CAUTION: Contact A1 will chatter when the unit under test is near the threshold. *Do not allow this to continue!* Remove the test current. A single contact closure is enough to determine that the unit picked up.



CAUTION: Before starting to test the LPS-O relay, download all the relay settings to your PC using the LPSO-Link program

NOTE: Where appropriate, current levels are defined with two numbers as $xx(yy)$; xx is the value to be used for relays rated at 5 Amperes and (yy) is the value to be used for 1 Ampere rated relays.

5.1.2 T1 – FAULT DETECTOR TEST

The Fault Detector responds to sudden changes in current levels. Slow changes are not picked up.

1. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
2. Set the relay into test mode 22 (the fault detector). The LUI displays

FAULT DETECTOR ON

3. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

OVERCURRENT

(601) **50** = NO

(605) **50G** = NO

(610) **51G** = NO

4. Set the voltages to zero.
5. Slowly increase I_{op} to 1.2 (0.24) A rms, at approximately 0.1 (0.02) A per second. Slowly decrease the current to 0 A. The A1 contact should not close.
6. Immediately increase I_{op} to 1.5 (0.3) A rms. The A1 contact should close momentarily.
7. Immediately increase I_{op} to 2.5 (0.5) A rms. The A1 contact should close until current is removed.
8. Reduce I_{op} to 0.

5.1.3 T2 – IT TRIP SUPERVISION TEST

1. Protection Setting:

CURSUPVISN

(501) **IT_PICKUP** = 0.25 (0.05) Amps

2. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
3. Set the relay into test mode 18 (IT Detector). The LUI displays:

IT DETECTOR ON

4. Set the voltages to zero.
5. Set I_{op} to 0.35 (0.07) A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 0.15 (0.03) A rms, at which point the A1 contact should open.
6. Reduce I_{op} to 0.

5.1.4 T3 – IB BLOCKING SUPERVISION TEST

1. Protection Setting:

CURSUPVISN

(502) **IB_PICKUP** = 0.2 (0.04) amps

2. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.

3. Set the relay into test mode 19 (IB Detector). The LUI displays:

IB DETECTOR ON

4. Set the voltages to zero.
5. Set I_{op} to 0.30 (0.06) A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 0.10 (0.02) A rms, at which point the A1 contact should open.

$$I_{op} > \frac{IPT_PICKUP}{0.9} = 0.56 (0.11)$$

6. Reduce I_{op} to 0.

5.1.5 T4 – GROUND DIRECTIONAL TRIP TEST

1. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.

2. Set the voltages as follows:

$$V_A = 55 \text{ V rms } \angle 0^\circ$$

$$V_B = 67 \text{ V rms } \angle -120^\circ$$

$$V_C = 67 \text{ V rms } \angle +120^\circ.$$

3. Set the relay into test mode 20 (Ground Directional Trip). The LUI displays:

GRD DIR TRIP ON

4. Set I_A , the current of I_{op} , to 0.70 (0.14) $\angle -85^\circ$ A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 0.40 (0.08) A rms, at which point the A1 contact should open.

$$I_{op} > IPT_PICKUP = 0.50 (0.10) \text{ A}$$

The IPT operating quantity is given by:

$$3 \cdot |I_0| - 3 \cdot KT \cdot |I_1| \quad (\text{eq. 5-1})$$

where I_0 is equal to the zero-sequence current, I_1 is equal to the positive-sequence current, and KT or IPBKFACTOR is equal to 0.0.

Since the test current I_{op} is single phase, I_0 and I_1 are given by:

$$I_0 = \frac{I_{op}}{3} \quad (\text{eq. 5-2}) \quad \text{and} \quad I_1 = \frac{I_{op}}{3} \quad (\text{eq. 5-3})$$

Substituting Equations 5–2 and 5–3 into Equation 5–1 yields:

$$I_{op} = PUIPT$$

Therefore IPT will pick up when $I_{op} \geq \text{PUIPT}$.

5. Reduce I_{op} to 0.

5.1.6 T5 – GROUND DIRECTIONAL BLOCK TEST

1. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
2. Set the voltages as follows:

$$V_A = 55 \text{ V rms } \angle 0^\circ$$

$$V_B = 67 \text{ V rms } \angle -120^\circ$$

$$V_C = 67 \text{ V rms } \angle +120^\circ.$$

3. Set the relay into test mode 21 (Ground Directional Block). The LUI displays:

GRD DIR BLK ON

4. Set I_A , the current of I_{op} , to 0.40 (0.08) A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 0.15 (0.03) A rms, and the A1 contact should open.

$$I_{op} > \text{IPT_PICKUP} = 0.25 \text{ (0.05) A}$$

The IPT operating quantity is given by:

$$3 \cdot |I_0| - 3 \cdot \text{KB} \cdot |I_1| \quad (\text{eq. 5-4})$$

where I_0 is equal to the zero-sequence current, I_1 is equal to the positive-sequence current, and KB or IPBKFACTOR is equal to 0.0.

Since the test current I_{op} is single phase, I_0 and I_1 are given by:

$$I_0 = \frac{I_{op}}{3} \quad (\text{eq. 5-2}) \quad \text{and} \quad I_1 = \frac{I_{op}}{3} \quad (\text{eq. 5-3})$$

Substituting Equations 5–2 and 5–3 into Equation 5–4 yields:

$$I_{op} = \text{PUIPT}$$

Therefore IPT will pick up when $I_{op} \geq \text{PUIPT}$.

5. Reduce I_{op} to 0 A.

5.1.7 T6 – PHASE INSTANTANEOUS OVERCURRENT TEST

1. Protection settings:

OVERCURRNT

$$(601) \quad \mathbf{50} = \text{YES}$$

$$(602) \quad \mathbf{50_DIRCNL} = \text{NO}$$

$$(603) \quad \mathbf{50PICKUP} = 5.0 \text{ (1.0) Amps}$$

2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for a phase AB, BC, or CA fault. Note that the leading phase is 180 degrees out of Phase with the line to which it is shorted.

- Set the relay into test mode 27 (Phase Overcurrent). The LUI should display

INST PHS OVRC ON

- Set I_{op} to 2.8 (0.6) A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 2.0 (0.4) A rms, at which point the A1 contact should open.

$$I_{op} > 50\text{PICKUP} \times 0.5 = 2.5 \text{ (0.5) A}$$

See Chapter 6 for I_{op} description.

- Reduce I_{op} to 0 A.
- Restore the following Protection settings

OVERCUR

- (601) **50** = YES
- (602) **50_DIRCNL** = YES
- (603) **50PICKUP** = 20.0 (4.0) Amps

5.1.8 T7 – GROUND INSTANTANEOUS OVERCURRENT TEST

- Protection settings:

OVERCURRNT

- (605) **50G** = YES
- (606) **50G_DIRCNL** = NO
- (607) **50GPICKUP** = 2.5 (0.5) Amps

- Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
- Set the relay into test mode 28 (Ground Overcurrent). The LUI displays

INST GND OVRC ON

- Set I_{op} to 4.0 (0.80) A rms and apply to the relay. The A1 contact should close. Lower I_{op} to 2.4 (0.40) A rms, at which point the A1 contact should open.

$$I_{op} > \frac{50\text{GPICKUP}}{0.7} = 3.6 \text{ (0.72) A}$$

- Reduce I_{op} to zero.
- Restore the following settings

OVERCURRNT

- (606) **50G_DIRCNL** = YES
- (607) **50GPICKUP** = 10 (2.0) Amps

5.1.9 T8 – GROUND TIME OVERCURRENT TEST

1. Protection Settings:

OVERCURRENT

(610) **51G** = YES(611) **51G_DIRCNL** = NO(612) **51GPICKUP** = 1.0 (0.2) Amps(614) **51GCURVE** = V-INV(615) **51GTIMDIAL** = 5.0 sec.(617) **51G_RESET** = FAST

2. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.

NOTE: Start the timer when I_{op} is applied, and stop the timer when A1 closes (the relay trips).

3. For this test remove the relay from test mode and assign TOCTRP to A1.

(1607) **A1** = index 119; TOCTRP4. Apply I_{op} at 3.0 (0.6) A rms (this is 3 times the multiple of pickup) and start the timer. Leave the current on until the A1 contact closes and stops the timer. The **51G** should time out in 2.8 to 3.2 seconds.

$$I_{op} > 51GPICKUP$$

See Chapter 6 for I_{op} description.5. Reduce I_{op} to zero.6. Repeat steps 3 and 4 with the values for I_{op} from Table 5–1: TIME-OUT VALUES WHILE REPEATING T8 below. Verify that the **51G** times out within the specified time.**Table 5–1: TIME-OUT VALUES WHILE REPEATING T8**

I_{op} , A rms	51G time out, s
3	2.8 to 3.2
6	0.9 to 1.1
10	0.6 to 0.8

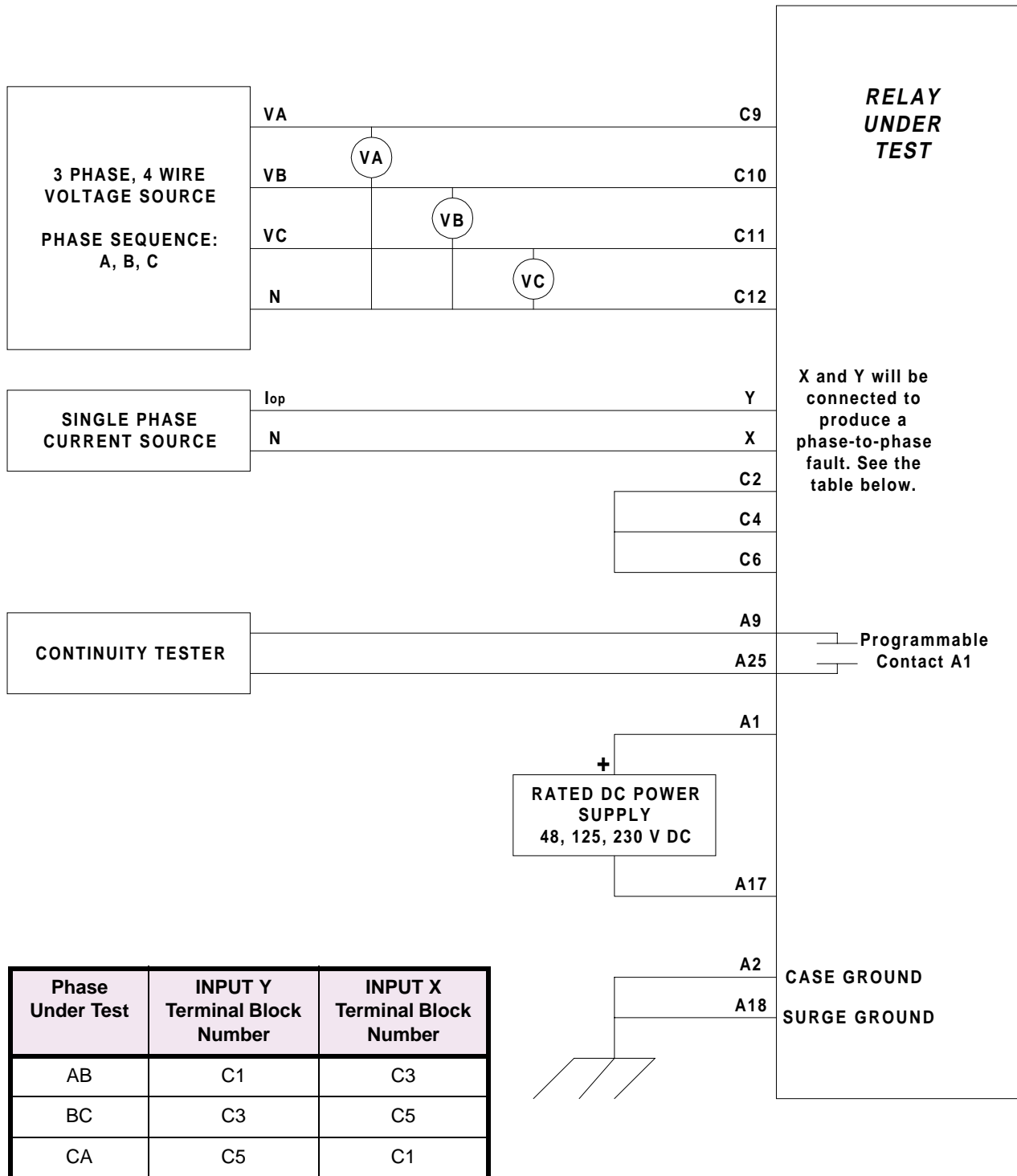


Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS

5.1.10 T9 – UNDERVOLTAGE TEST

1. The undervoltage function has a fixed pickup setting of 75% of nominal.
2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7.
3. Set the relay into test mode 32. The LUI displays

UNDERVOLTAGE ON

4. Set the voltage inputs to the following values:
 VA: 67 volts rms $\angle 0^\circ$
 VB: 67 volts rms $\angle -120^\circ$
 VC: 67 volts rms $\angle +120^\circ$
5. Set I_{op} to 0 Amps.
6. Set phase A voltage to 40 V and check that contact A1 closed. Set phase A voltage back to 67 V and check that contact A1 opens. Repeat for phase B and C.

$$V_{op} < V_{nominal} \cdot 0.75 = 50.0 \text{ V}$$

5.1.11 T10 – OVERVOLTAGE TEST

5

1. Record the pre-test values for Protection Settings 701, 702, 703, and 704.
2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7.
3. Protection settings:

VOLTAGE

- (701) **RATEDVOLTS** = 115 V rms
 (702) **PHASEOVER** = YES
 (703) **PHOV PICKUP** = 1.10 p.u. V
 (704) **PHOVTMDLY** = 0.5 sec.

4. Set the relay into test mode 31. The LUI displays

OVERVOLTAGE ON

5. Set the voltage inputs to the following values:

- VA: 67 volts rms $\angle 0^\circ$
 VB: 67 volts rms $\angle -120^\circ$
 VC: 67 volts rms $\angle +120^\circ$.

6. Set I_{op} to zero Amps.

The overvoltage function is a positive-sequence overvoltage detector with adjustable time delay such that:

$$V_{op} = \frac{\text{RATEDVOLTS}}{1.732} \times \text{PHOV PICKUP} = \frac{115 \text{ V}}{1.732} \times 1.10 \text{ p.u. V} = 73.0 \text{ V}$$

7. Set phase A voltage to 76 V and check that contact A1 is closed. Set phase A voltage back to 67 V and check that contact A1 opens. Repeat for phases B and C.
8. Restore these Protection Settings to the values recorded in Step 1.

5.2.1 GENERAL ZONE REACH TESTING CONSIDERATIONS

1. The Zone measuring units are checked in the test mode of operation. The A1 (programmable alarm) contact indicates when the unit has operated. It is the *only* measure of whether the test passes or fails. The displayed target information is for reference only. Different test equipment methods can alter the output from what is shown.

The display output is shown for reference only; it is not part of the test. The display includes the target information.

2. When a particular zone is under test, the other protection zones are disabled so that they do not time out and distort the results of the zone under test.

The backup protection functions will cause the relay to trip during zone testing, as they should. They must be disabled to isolate the zone reach unit under test. Before doing any of the reach tests make the following protection settings changes:

OVERCURRENT

(601) **50** = NO

(605) **50G** = NO

(610) **51G** = NO

OS BLOCKING

(1303) **BLOCKWHAT** = 3 (BLKNONE)

NOTE: After the zone reach testing is completed, restore these settings to their pretest values.

5.3.1 T11 – ZONE 1 PHASE REACH TEST

1. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = YES(104) **Z1P_TIME** = 0.0 sec.

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

LINEINFO

(1204) **TRSMFRTYPE** = NONE

2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phases under test. Set the relay to test mode 14 (Any Zone 1 Phase). The LUI displays:

ANY Z1 PHASE ON

3. Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,VB: 67 volts rms $\angle -120^\circ$,VC: 67 volts rms $\angle +120^\circ$.4. Set the phase angle of the fault current I_{op} to the phase-angle value listed in Table 5–2: FAULT CURRENT PHASE SETTINGS FOR TEST T11. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.

Table 5–2: FAULT CURRENT PHASE SETTINGS FOR TEST T11

$\angle I$ Degrees	Volts rms	Displayed Target [†]
–25	51 to 57	–
–55	59 to 66	82 to 88
–85	51 to 57	–

[†] Reference only

5. Set the fault current to 10.0 (2.0) amps rms. Reduce the voltage of the faulted phases and check that the A1 contact closes when the voltages are within the limits shown in Table 5–2: FAULT CURRENT PHASE SETTINGS FOR TEST T11.

6. Reduce the fault current to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as follows:

TRIP AB Z1 “DIST”

where “DIST” is the displayed target.

- Repeat the test for phase BC and CA faults.

5.3.2 T12 – ZONE 2 PHASE REACH TEST

- Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = YES

(204) **Z2TIMER** = YES

(205) **Z2P_TIME** = 1.0 sec.

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

- Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phases under test. Set the relay to test mode 15 (Any Zone 2 Phase). The LUI displays:

ANY Z2 PHASE ON

- Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,

VB: 67 volts rms $\angle -120^\circ$,

VC: 67 volts rms $\angle +120^\circ$.

- Set the fault current, I_{op} , to the phase-angle value listed in Table 5–3: FAULT CURRENT PHASE SETTINGS FOR TEST T12. Note that the leading phase angle is 180° out of phase with the line to which it is shorted (Increase VA, VB, and VC to 75 V when $\angle I_{op} = -55^\circ$).

Table 5–3: FAULT CURRENT PHASE SETTINGS FOR TEST T12

$\angle I$ Degrees	Volts rms	Displayed Target [†]
–25	57 to 64	–
–55	65 to 73	146 to 154
–85	57 to 64	–

[†] Reference only

- Set the fault current to 6.7 (1.4) amps rms. Reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within the limits shown in Table 5–3: FAULT CURRENT PHASE SETTINGS FOR TEST T12.

6. Reduce I_{op} of the faulted phase to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as follows:

TRIP AB Z2 "DIST"

where "DIST" is the displayed target.

7. Repeat the test for phase BC and CA faults.

5.3.3 T13 – ZONE 3 PHASE REACH TEST

1. Setting:

Z1DISTANCE

(101) **Z1PHASE = NO**

Z2DISTANCE

(201) **Z2PHASE = NO**

Z3DISTANCE

(301) **Z3PHASE = YES**

(304) **Z3P_TIME = 2.0 sec.**

Z4DISTANCE

(401) **Z4PHASE = NO**

LINEINFO

(1204) **TRSFMRTYPE = NONE**

2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phase under test. Set the relay to test mode 16 (Any Zone 3 Phase). The LUI displays:

ANY Z3 PHASE ON

3. Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,

VB: 67 volts rms $\angle -120^\circ$,

VC: 67 volts rms $\angle +120^\circ$.

4. Set the fault current, I_{op} , to the phase-angle value listed in Table 5–4: FAULT CURRENT PHASE SETTINGS FOR T13. Note that the leading phase angle is 180° out of phase with the line to which it is shorted (increase VA, VB, and VC to 75 V when $\angle I_{op} = -55^\circ$)

Table 5–4: FAULT CURRENT PHASE SETTINGS FOR T13

I Degrees	Volts rms	Displayed Target [†]
–25	56 to 63	–
–55	65 to 73	195 to 205
–85	56 to 63	–

[†] Reference only

5. Set the fault current to 5.0 (1.0) Amps rms. Simultaneously reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within the limits shown in Table 5–4: FAULT CURRENT PHASE SETTINGS FOR T13.
6. Reduce the fault current to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as:

TRIP: AB Z3 "DIST"

where "DIST" is the displayed target.

7. Repeat the test for phase BC and CA faults.

5.3.4 T14 – ZONE 4 PHASE REACH

1. Setting:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = YES

(405) **Z4_TIMERS** = YES

(406) **Z4P_TIME** = 0.05 sec.

LINEINFO

(1204) **TRSFMRTYPE** = NONE

2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phase under test. Set the relay to test mode 17 (Any Zone 4 Phase). The LUI displays:

ANY Z4 PHASE ON

3. Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,

VB: 67 volts rms $\angle -120^\circ$,

VC: 67 volts rms $\angle +120^\circ$.

4. Set the fault current, I_{op} , to the phase-angle value listed in Table 5–5: FAULT CURRENT PHASE SETTINGS FOR TEST T14. Note that the leading phase angle is 180° out of phase with the line to which it is shorted. (increase VA, VB, and VC to 75 V when $\angle I_{op} = -55^\circ$)

Table 5–5: FAULT CURRENT PHASE SETTINGS FOR TEST T14

I Degrees	Volts rms	Displayed Target [†]
–25	56 to 63	–
–55	64 to 72	290 to 310
–85	56 to 63	–

[†] Reference only

- Set the fault current to 10.0 (2.0) amps rms. Simultaneously reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within the limits shown in Table 5–5: FAULT CURRENT PHASE SETTINGS FOR TEST T14.
- Reduce the fault current to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as follows:

TRIP AB Z4 “DIST”

where “DIST” is the displayed target.

- Repeat the test for phase BC and CA faults.

5

5.3.5 T15 – 3 PHASE FAULT WITH TRANSFORMER COMPENSATION

- Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = YES

(102) **Z1PREACH** = 6.03 Ω

(104) **Z1P_TIME** = 0.0 sec.

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

LINEINFO

(1204) **TRSFMRTYPE** = YD1

- Connect the relay as shown in Figure 5–2: THREE PHASE TEST CONNECTIONS. Set the relay to test mode 14 (Any Zone 1 Phase). The LUI displays:

ANY Z1 PHASE ON

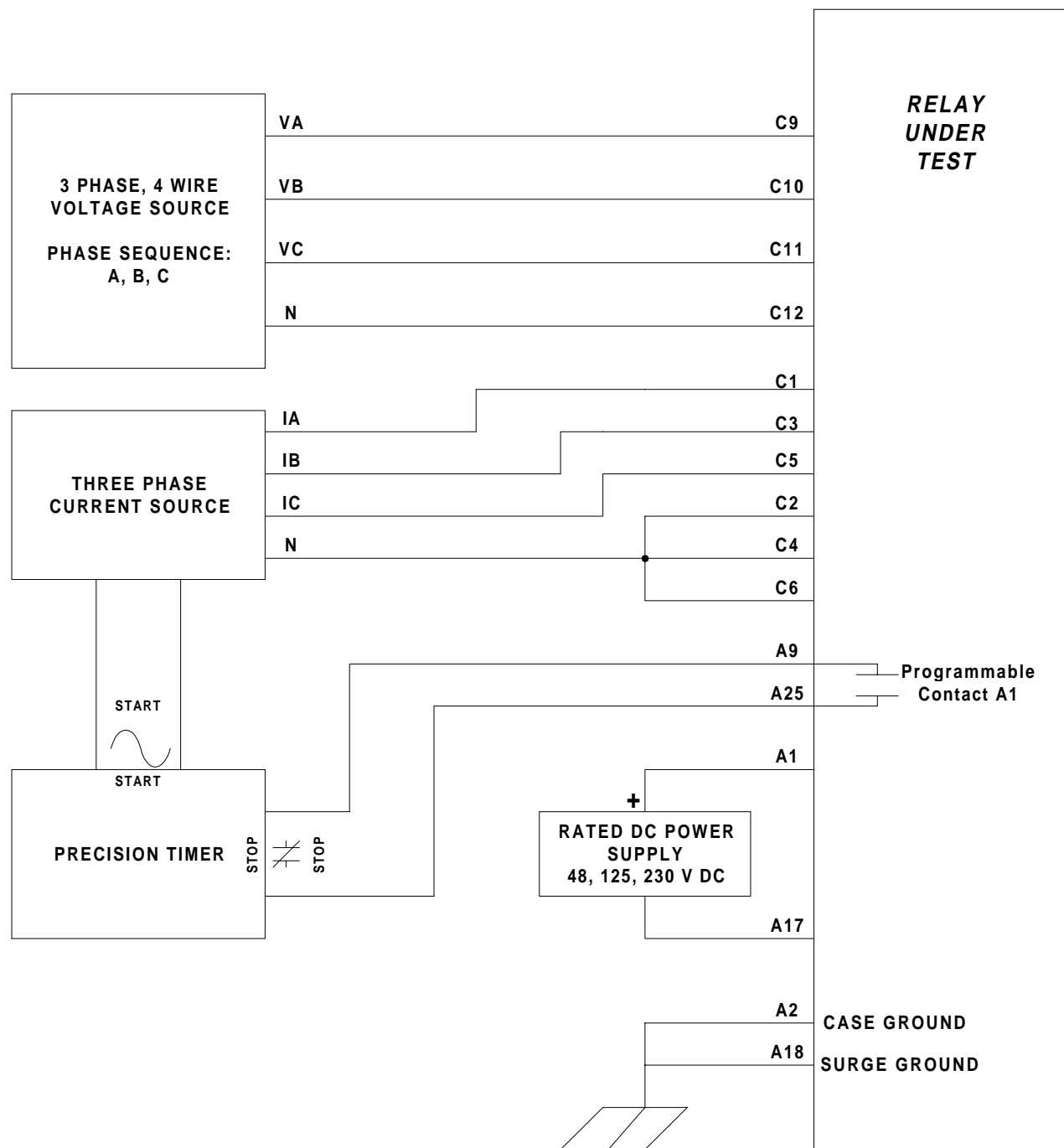


Figure 5–2: THREE PHASE TEST CONNECTIONS

3. Set the voltage inputs to the following values:
 - VA: 67 volts rms $\angle 0^\circ$,
 - VB: 67 volts rms $\angle -120^\circ$,
 - VC: 67 volts rms $\angle +120^\circ$.
4. Set the current inputs to the following values:
 - IA: 7.06 (1.41) amps rms $\angle -79.6^\circ$,
 - IB: 7.06 (1.41) amps rms $\angle 160.4^\circ$,
 - IC: 7.06 (1.41) amps rms $\angle 40.4^\circ$.
5. Reduce the voltage of all three phases simultaneously to 42.55 V rms and check that the A1 contact closes.
6. Reduce the fault current to zero. Note that the trip target indication concurs with the fault.
7. If desired, repeat the test for Zone 2, 3, or 4 by setting the specific zone reach to 6.03 Ω and disabling the zone elements not being tested.

5.3.6 T16 – PHASE (ZONE BACKUP) TIMER TEST

1. For this test, remove the relay from test mode.

2. Protection Settings:

Z1DISTANCE

- (101) **Z1PHASE** = NO
- (104) **Z1P_TIME** = 0.0 sec.

Z2DISTANCE

- (201) **Z2PHASE** = NO
- (204) **Z2TIMER** = YES
- (205) **Z2P_TIME** = 2.0 sec.

Z3DISTANCE

- (301) **Z3PHASE** = NO
- (304) **Z3P_TIME** = 3.0 sec.

Z4DISTANCE

- (401) **Z4PHASE** = NO
- (405) **Z4TIMERS** = YES
- (406) **Z4P_TIME** = 5.0 sec.

LINEINFO

- (1204) **TRSFMRTYPE** = NONE

OUTPUTS

- (2007) **A1** = Z1PH; Index 77

a) ZONE1 TIMER

3. Connect the relay as shown in Figure 5–3: PHASE-REACH TIMER TEST CONNECTIONS on page 5–19 for an AB fault.
4. Set the voltage inputs to the following values:
 - VA: 62 volts rms $\angle 0^\circ$,
 - VB: 62 volts rms $\angle -120^\circ$,
 - VC: 67 volts rms $\angle +120^\circ$.
5. Set the phase angle of the fault current, $\angle I_{op}$, to -55° .
6. Apply the fault current at 10.0 (2.0) Amps rms to the relay and start the Precision Timer (the fault current should not be ramped but applied at this level).
7. Stop the timer when the A1 contact closes, and reduce the fault current to zero. Verify that the trip target indication shows a ZONE1 trip, such as: **TRIP AB Z1**. This verifies that the first zone tripped. The time for the trip should be in the range 0.9 to 1.1 seconds.
8. Change the voltages of phases A and B to a magnitude of 70 V rms.

b) ZONE2 TIMER

9. Protection Settings:
 - Z1DISTANCE
 - (101) **Z1PHASE** = NO
 - OUTPUTS
 - (2007) **A1** = Z2PTMR; Index 132
10. Apply the fault current at 6.7 (1.4) Amps rms to the relay and start the Precision Timer (the fault current should not be ramped but applied at this level).
11. Stop the timer when the A1 contact closes, and reduce the fault current to zero. Verify that the trip target indication shows a ZONE2 trip, such as: **TRIP AB Z2**. This verifies that the first zone tripped. The time for the trip should be in the range 1.9 to 2.1 seconds.
12. Leave the voltages at the values indicated in Step 9.

c) ZONE3 TIMER

13. Protection Settings:
 - Z2DISTANCE
 - (201) **Z2PHASE** = NO
 - OUTPUTS
 - (2007) **A1** = Z3PTMR; Index 133
14. Apply the fault current at 5.0 (1.0) Amps rms to the relay and start the Precision Timer (the fault current should not be ramped but applied at that level). This is an AB fault that is within pickup of all four zones.
15. Stop the timer when the A1 contact closes, and reduce the fault current to zero. Verify that the trip target indication shows a ZONE3 trip, such as: **TRP AB Z3**. This verifies that the third zone tripped. The time for the trip should be in the range 2.9 to 3.1 seconds.
16. Change the voltages of phases A and B to a magnitude of 62 V rms.

d) ZONE4 TIMER

17. Settings:

Z3DISTANCE

(301) **Z3PHASE** = NO

OUTPUTS

(2007) **A1**= Z4PTMR; Index 134

18. Apply a fault current of 10.0 (2.0) Amps rms to the relay and start the Precision Timer. The fault current should not be ramped but applied at that level. This is an AG fault within pickup of all four zones.

19. Stop the timer when the A1 contact closes, and reduce the fault current to zero. Verify that the trip target indication shows a ZONE4 trip, such as: **TRIP AB Z4**. This verifies that the fourth zone tripped. The time for the trip should be in the range 4.8 to 5.2 seconds.

20. If not continuing with out-of-step block testing, return all settings to their pretest values.

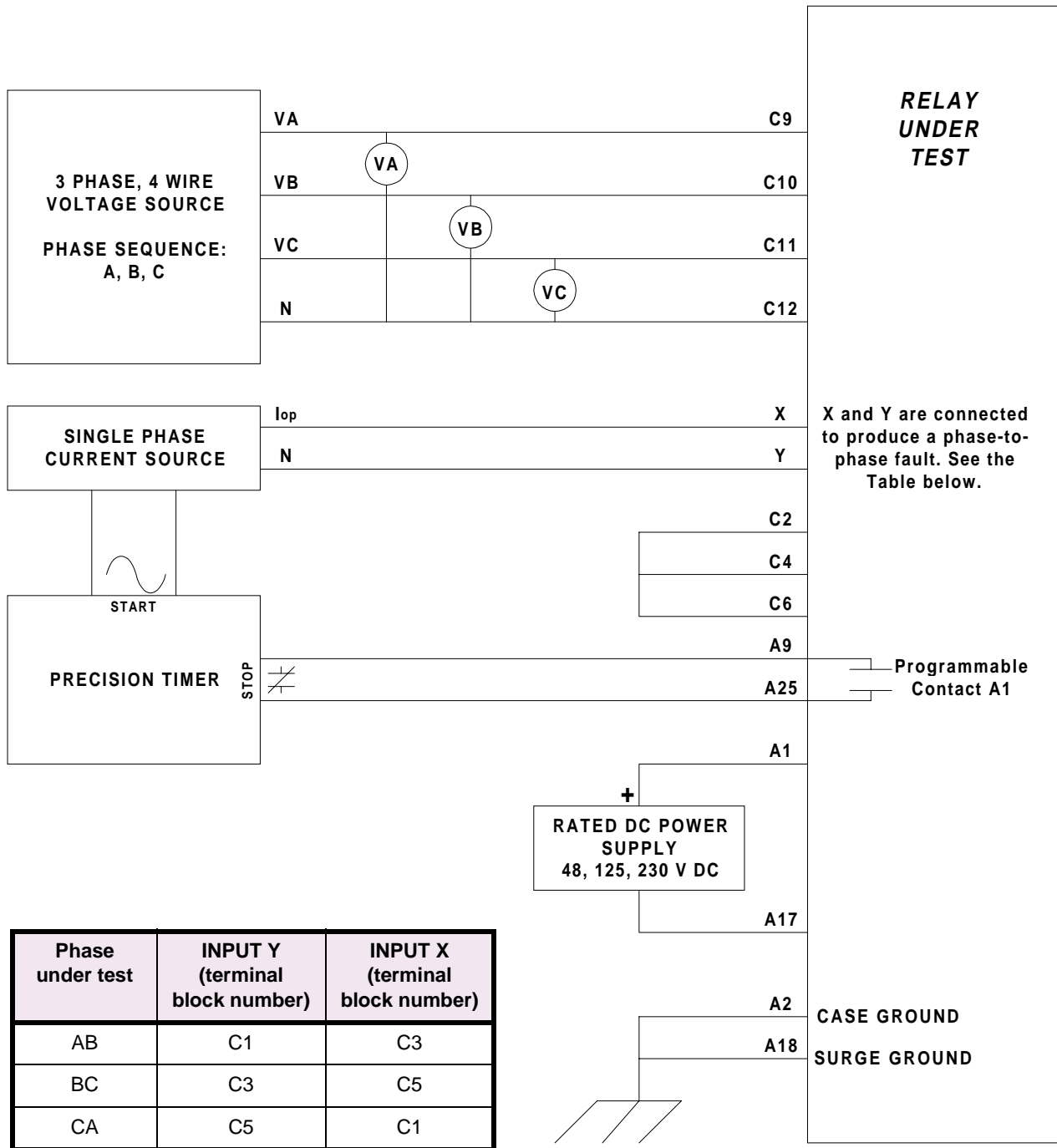


Figure 5-3: PHASE-REACH TIMER TEST CONNECTIONS

5.4.1 T17 – OUT-OF-STEP BLOCK

1. Record the pre-test values of the Protection Settings used for this test.
2. Settings:
 - OS BLOCKING
 - (1601) **MOBZONE** = 0 (Zone 2)
 - (1603) **BLOCKWHAT** = 0 (BLKALL)
 - Z1DISTANCE
 - (101) **Z1PHASE** = NO
 - Z2DISTANCE
 - (201) **Z2PHASE** = YES
 - (205) **Z2P_TIME** = 1.0 sec.
 - Z3DISTANCE
 - (301) **Z3PHASE** = NO
 - Z4DISTANCE
 - (401) **Z4PHASE** = NO
3. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phase under test.
4. Set the relay to test mode 24 (Out of Step Block). The LUI displays the following:

OUT OF STEP BLK ON
5. Set the voltage inputs to the following values:
 - VA: 75 volts rms $\angle 0^\circ$,
 - VB: 75 volts rms $\angle -120^\circ$,
 - VC: 75 volts rms $\angle +120^\circ$.
6. Set the fault current, I_{op} , to the phase-angle value listed in Table 5–6: FAULT CURRENT PHASE SETTINGS FOR TEST T17. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.

Table 5–6: FAULT CURRENT PHASE SETTINGS FOR TEST T17

$\angle I$ Degrees	Volts rms
–25	57 to 63
–85	57 to 63

7. Set the currents in the faulted phases to 6.7 (1.4) Amps rms. Reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within the limits shown in Table 5–6: FAULT CURRENT PHASE SETTINGS FOR TEST T17.
8. Reduce the current in the faulted phase to zero.
9. Repeat the test for phases BC and CA
10. If not continuing with out-of-step trip testing, return settings to their pretest values.

5.4.2 T18 – OUT-OF-STEP TRIP TEST

1. Record the pre-test values of the Protection Settings used for this test.
2. Protection settings:
 - OS BLOCKING
 - (1303) **BLOCKWHAT** = 0 (BLKALL)
 - OS TRIPPING
 - (1401) **USE_OST** = YES
 - (1402) **NUMBRCHAR** = 2
 - (1403) **TRIPIN_OUT** = IN
 - (1404) **FWDREACH** = 3.0 Ω
 - (1405) **REVREACH** = 3.0 Ω
 - (1406) **OUTER** = 70°
 - (1407) **MIDDLE** = 90°
 - (1408) **INNER** = 120°
3. Connect the relay as shown in Figure 5–2: THREE PHASE TEST CONNECTIONS on page 5–15.
4. Set the relay to test mode 33 (OUT OF STEP TRIP). The LUI displays:

OUT OF STEP TRIP ON
5. Set the current & voltage inputs to the following values:
 - IA: 5.0 (1.0) Amp rms $\angle 0^\circ$,
 - IB: 5.0 (1.0) Amps rms $\angle -120^\circ$,
 - IC: 5.0 (1.0) Amps rms $\angle -240^\circ$,
 - VB: 120 V rms $\angle -120^\circ$.
6. Decrease magnitude of VB to begin the swing from the Outer to the Inner characteristics.
7. Decrease VB below 65V and above 55V to enter Outer characteristic.
8. Decrease VB below 33V and above 28V to enter Inner characteristic. Check that A1 contact closes when “Entering” the “Inner” characteristic.
9. Reduce VB, IA, IB, IC to zero.
10. Protection settings:
 - OS TRIPPING
 - (1403) **TRIPIN_OUT** = OUT
11. Set VB, IA, IB, IC to the values in Step 4.
12. Decrease magnitude of VB to begin the swing from the Outer to Inner to Outer characteristics.
13. Decrease VB below 65V and above 55V to enter Outer characteristic.
14. Decrease VB below 33V and above 28V to enter Inner characteristic.
15. Increase VB above 55V and below 65V to leave Outer characteristic. Check that A1 contact closes when “Leaving” the “Outer” characteristic.
16. Return settings to their pretest values

5.5.1 ENDING TESTS

Make sure that the relay is no longer in test mode; select **END TEST MODE** from the test mode menu. Print out or scroll through all of the settings. Compare them with the initial settings of the relay, and change to initial values. If the initial settings were saved to a disk file with LPSO-Link before testing, download the file to the relay.

6.1.1 DESCRIPTION



CAUTION: Power down the relay, either with the power switch or by removing a connection plug, before removing or inserting modules. Failure to do so may permanently damage the relay.

This chapter contains formulas for the calculation of pickup currents and voltages for testing the LPS-O with settings specific to a particular application. The test circuits and procedures are the same as used and illustrated in Chapter 4: ACCEPTANCE/PERIODIC TESTS and Chapter 5: FUNCTIONAL TESTS (FACTORY SETTINGS).

The customer must determine the extent of the testing to be performed. These tests are intended as guides – they are not required for every periodic test of the relay. The desired test procedures can be incorporated into the standard test procedures. However, it is suggested that the relay's built-in self tests be incorporated into the test procedures, since they test the operational status of the unit.

Refer to Section 4.1: OVERVIEW on page 4–1 for generic test instructions pertaining to the required test equipment, equipment grounding, required settings and settings changes, general instructions, entering and exiting test mode, using communications, and PC software setup.

It is assumed in what follows that you are familiar with LPS-O testing. If not, refer to Chapter 4: ACCEPTANCE/PERIODIC TESTS for details. See Chapter 5: FUNCTIONAL TESTS (FACTORY SETTINGS) for tests T1, T4, T5, and T9 (these tests have fixed settings that are not user selectable). This chapter does not include user specific tests for Out-of-Step Block or Trip functions (tests T17 and T18) or Phase (Zone Backup) Timer tests (test T16) of the LPS-O relay. Refer to Chapter 5: FUNCTIONAL TESTS (FACTORY SETTINGS) for sample tests.

a) MEASURING UNIT TESTS

- T2 – IT Trip Supervision Test
- T3 – IB Blocking Supervision Test
- T6 – Phase Instantaneous Overcurrent Test
- T7 – Ground Instantaneous Overcurrent Test
- T8 – Ground Time Overcurrent Test
- T10 – Overvoltage Test

b) ZONE PHASE REACH TESTS

- T11 – Zone 1 Phase Reach without Transformer Compensation
- T12 – Zone 2 Phase Reach without Transformer Compensation
- T13 – Zone 3 Phase Reach without Transformer Compensation
- T14 – Zone 4 Phase Reach without Transformer Compensation
- T15 – Three Phase Fault with Transformer Compensation

6.1.2 DRAWINGS AND REFERENCES

a) DRAWINGS

The following drawings should be used for reference during testing:

Elementary Diagrams

- Figure 1–11: ELEMENTARY DIAGRAM on page 1–25

Logic Diagrams

- Figure 1–1: PTFF LOGIC DIAGRAM on page 1–8
- Figure 1–2: LINE PICKUP LOGIC DIAGRAM on page 1–9
- Figure 1–3: REMOTE-OPEN DETECTOR LOGIC on page 1–10
- Figure 1–4: OSB LOGIC DIAGRAM on page 1–10
- Figure 1–8: STEP DISTANCE LOGIC DIAGRAM on page 1–21

51G curves

- Figure 2–14: INVERSE CURVE on page 2–29
- Figure 2–15: VERY INVERSE CURVE on page 2–30
- Figure 2–16: EXTREMELY INVERSE CURVE on page 2–31

b) REFERENCE

- Chapter 11: LPSO-LINK USER GUIDE
- Chapter 12: ASCII COMMUNICATIONS

6.1.3 GENERAL INSTRUCTIONS

6

Tests are performed in test mode, which allows viewing of the internal measuring units and functions. The measuring units and functions are actually internal to the software. There are no individual hardware modules that are responsible for the specific measuring functions.

The test mode selects and isolates various test functions and measuring units, then routes their status to the A1 (A9–A25) contact. When the particular function under test has picked up, the A1 contact closes. Target information is displayed for tests that cause tripping.

Testing can be performed with outputs disabled. The A1 contact still closes whenever a trip condition exists, however the tripping contacts do not operate. Disabling outputs can be accomplished when test mode is entered.



CAUTION: The A1 contact will chatter when the unit under test is near its threshold. *Do not let it continue to chatter!* Remove the test current. A single contact closure is enough to determine that the unit picked up.

Use a continuity tester with high-input impedance, such as a digital ohmmeter, to monitor the A1 contact during relay testing.

NOTE: Where appropriate, current levels are defined with two numbers as *xx(yy)*; *xx* is the value to be used for relays rated at 5 Amperes and (*yy*) is the value to be used for 1 Ampere rated relays.

NOTE: Tripping contacts will operate while the LPS-O is in test mode unless the outputs were disabled by the user.

6.2.1 T1 – FAULT DETECTOR TEST

This test has fixed settings that are not user selectable. See Section 5.1.2: T1 – FAULT DETECTOR TEST on page 5–2 for testing with factory settings.

6.2.2 T2 – IT TRIP SUPERVISION TEST

1. Protection Settings:

CURSUPVISN

(501) **IT_PICKUP** = [] Amps

OVERCURRENT

(601) **50** = NO

(605) **50G** = NO

(610) **51G** = NO

LINEPICKUP

(801) **LINEPICKUP** = NO

where I_T is set as follows:

$$I_T = I_A, I_B, \text{ or } I_C$$

The test current, I_{op} , is single phase and applied to I_A . Thus, the LPS-O should pick up when I_{op} is greater than or equal to I_T .

2. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
3. Set the relay into test mode 18 (IT Detector). The LUI should display
IT DETECTOR ON
4. Set the voltages to zero.
5. Set the level of I_{op} to $I_T + 0.1 = []$ A rms and apply to the relay. The A1 contact should close. Lower I_{op} to $I_T - 0.1 = []$ A rms, at which point the A1 contact should open.
6. Reduce I_{op} to 0 A.

6.2.3 T3 – IB BLOCKING SUPERVISION TEST

1. Protection Settings:

CURSUPVIS

(502) **IB_PICKUP** = [] Amps

OVERCURRENT

(601) **50** = NO

(605) **50G** = NO

(610) **51G** = NO

LINEPICKUP

(801) **LINEPICKUP** = NO

where $I_{BPICKUP}$ is set as follows:

$$I_{BPICKUP} = I_A, I_B, \text{ or } I_C$$

The test current, I_{op} , is single phase and applied to I_A . Thus, the LPS-O should pick up when I_{op} is greater than or equal to $I_{BPICKUP}$.

2. Connect the relay as shown in Figure 4–3: PHASE TO GROUND TEST CONNECTIONS on page 4–16.
3. Set the relay into test mode 19 (IB Detector). The LUI should display

IB DETECTOR ON

4. Set the voltages to zero.
5. Set the level of I_{op} to $I_{BPICKUP} + 0.1 = [\quad]$ A rms and apply to the relay. The A1 contact should close. Lower I_{op} to $I_{BPICKUP} - 0.1 = [\quad]$ A rms, at which point the A1 contact should open.
6. Reduce I_{op} to 0 A.

6.2.4 T4 – GROUND DIRECTIONAL TRIP TEST

This test has fixed settings that are not user selectable. See Section 5.1.5: T4 – GROUND DIRECTIONAL TRIP TEST on page 5–3 for testing with factory settings.

6.2.5 T5 – GROUND DIRECTIONAL BLOCK TEST

This test has fixed settings that are not user selectable. See Section 5.1.6: T5 – GROUND DIRECTIONAL BLOCK TEST on page 5–4 for testing with factory settings.

6.2.6 T6 – PHASE INSTANTANEOUS OVERCURRENT TEST

6

1. Protection settings:

OVERCURRENT

- (601) **50** = YES
- (602) **50_DIRCNL** = NO
- (603) **50PICKUP** = $[\quad]$ Amps
- (605) **50G** = NO
- (610) **51G** = NO

LINEPICKUP

- (801) **LINEPICKUP** = NO

The **50** function is calculated with the following equation:

$$\mathbf{50} = (I_A - I_B) \text{ or } (I_B - I_C) \text{ or } (I_C - I_A)$$

where **50** is the difference in phase-to-phase current.

The test current, I_{op} , is connected to one phase and returned through another to simulate a phase-to-phase fault. When an AB fault is applied, the difference $(I_A - I_B)$ equals $(I_{op} - (-I_{op})) = 2I_{op}$. Therefore, **50** will pick up when I_{op} is greater than or equal to $0.5 \times \mathbf{50PICKUP}$.

2. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for a phase AB, BC, or CA fault. Note that the leading phase is 180° out of phase with the line to which it is shorted.

- Set the relay into test mode 27 (Phase Overcurrent). The LUI should display

INST PHS OVRC ON

- Set I_{op} to $0.55 \times 50\text{PICKUP} = [\text{_____}]$ A rms and apply to the relay. The A1 contact should close. Lower I_{op} to $0.45 \times 50\text{PICKUP} = [\text{_____}]$ A rms, at which point the A1 contact should open.
- Reduce I_{op} to 0 A.

6.2.7 T7 – GROUND INSTANTANEOUS OVERCURRENT TEST

- Protection settings:

OVERCURRENT

- (605) **50G** = YES
 (606) **50G_DIRCNL** = NO
 (607) **50GPICKUP** = $[\text{_____}]$ Amps
 (610) **51G** = NO

LINEPICKUP

- (801) **LINEPICKUP** = NO

The **50G** function is given by:

$$50G = 3I_0 + 0.9I_1 \quad (\text{eq. 6-1})$$

where I_0 is the zero-sequence current and I_1 is the positive-sequence current. Since the test current I_{op} is single phase, I_0 and I_1 are given by:

$$I_0 = \frac{I_{op}}{3} \quad (\text{eq. 6-2}) \quad \text{and} \quad I_1 = \frac{I_{op}}{3} \quad (\text{eq. 6-3})$$

Substituting Equations 6-2 and 6-3 into Equation 6-1 yields:

$$50G = I_{op} - 0.3I_{op} = 0.7I_{op} \quad (\text{eq. 6-4})$$

Therefore, I_{PT} will pick up when:

$$I_{PT} \geq \frac{50GPICKUP}{0.7}$$

- Connect the relay as shown in Figure 4-3: PHASE TO GROUND TEST CONNECTIONS on page 4-16.
- Set the relay into test mode 28 (Ground Overcurrent). The LUI displays

INST GND OVRC ON

- Set I_{op} to $(50GPICKUP / 0.7) + 0.5 = [\text{_____}]$ A rms and apply to the relay. The A1 contact should close. Lower I_{op} to $(50GPICKUP / 0.7) - 0.5 = [\text{_____}]$ A rms, at which point the A1 contact should open.
- Reduce I_{op} to 0 A.

6.2.8 T8 – GROUND TIME OVERCURRENT TEST

1. Protection Settings:

OVERCURRENT

- (601) **50** = YES
- (605) **50G** = YES
- (610) **51G** = YES
- (611) **51G_DIRCNL** = NO
- (612) **51GPICKUP** = [] Amps
- (614) **51GCURVE** = [] Curve
- (615) **51GTIMDIAL** = [] Time dial
- (617) **51G_RESET** = FAST

The **51G** function is calculated with the equation:

$$51G = 3I_0 \quad (\text{eq. 6-4})$$

where I_0 is equal to the zero-sequence current. Since I_{op} is single phase, I_0 is given by

$$I_0 = \frac{I_{op}}{3} \quad (\text{eq. 6-5})$$

Substituting Equation 6-5 into Equation 6-4 yields:

$$I_{op} = 51G$$

Therefore, 51G will pick up when $I_{op} \geq 51GPICKUP$. The time it takes for 51G to pick up is determined by the time-dial curves shown in Section 2.4: INVERSE CURVES on page 2-29.

CAUTION: If the test current exceeds $2I_n$ (where I_n is the rated current), then the current test should be applied with a 50% duty cycle. For instance, if the current is applied for 5 minutes, it should be left off for 5 minutes before it is reapplied.

2. Connect the relay as shown in Figure 4-3: PHASE TO GROUND TEST CONNECTIONS on page 4-16.

NOTE: Start the timer when I_{op} is applied, and stop the timer when A1 closes (the relay trips).

3. For this test remove the relay from test mode and assign TOCTRP to A1.

(2007) **A1** = index 119; TOCTRP

- 4. Apply I_{op} at $2 \times 51PICKUP = []$ A rms and start the timer. Leave the current on until the A1 contact close then stop the timer. The time should be within $\pm 7\%$ of the value found in the time current characteristic in use.
- 5. Reduce I_{op} to zero.
- 6. Repeat steps 4. and 5. for I_{op} at $6 \times 51PICKUP = []$ A rms and $10 \times 51PICKUP = []$ A rms. Verify that the times are within $\pm 7\%$ of the value found in the time current characteristic in use.

6.2.9 T9 – UNDERVOLTAGE TEST

This test has fixed settings that are not user selectable. See Section 5.1.10: T9 – UNDERVOLTAGE TEST on page 5-8 for testing with factory settings.

6.2.10 T10 – OVERVOLTAGE TEST

1. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7.
2. Protection settings:

VOLTAGE

(701) **RATEDVOLTS** = [] V rms

(702) **PHASEOVER** = YES

(703) **PHOV PICKUP** = [] p.u. V

(704) **PHOVTMDLY** = [] sec.

3. Set the relay into test mode 31. The LUI displays

OVERVOLTAGE ON

4. Set the voltage inputs to the following values:

$$V_A: \frac{\text{RATEDVOLTS}}{1.732} \text{ V rms } \angle 0^\circ$$

$$V_B: \frac{\text{RATEDVOLTS}}{1.732} \text{ V rms } \angle -120^\circ$$

$$V_C: \frac{\text{RATEDVOLTS}}{1.732} \text{ V rms } \angle -240^\circ$$

5. Set I_{op} to zero Amps.

The overvoltage function is a positive sequence overvoltage detector with adjustable time delay such that:

$$V_{op} = \left(\frac{\text{RATEDVOLTS}}{1.732} \right) \times \text{PHOV PICKUP}$$

6. Raise phase A voltage from nominal to $V_{op} + 5 \text{ V} = [] \text{ V}$ and check that contact A1 closes within $\pm 7\%$ of **PHOVTMDLY** = [] seconds. Set phase A voltage back to $(\text{RATEDVOLTS} / 1.732) = [] \text{ V}$ and check that contact A1 opens. Repeat for phases B and C.

6.3.1 WARNING



CAUTION: The A1 contact will chatter when the unit under test is near its threshold. *Do not allow this to continue!* Remove the test current. A single contact closure is enough to determine that the unit has picked up.

At the start of each test is an area to record your specific setting for the function under test.

6.3.2 GENERAL CONSIDERATIONS

Testing the reach of the relay requires a few organized steps:

1. Choosing a test current I_T for the impedance of the reach.
2. Calculating the voltage range in which the unit will pick up.
3. Applying the test voltage and currents in accordance with the test procedure.

Equations are given for calculating the pickup voltage for a chosen circuit magnitude and phase. If you wish to test the complete characteristic, the ALPS-Test software can be used to generate test currents and voltage pickups for the complete characteristic for zone elements without transformer compensation (Protection Setting 1204: **TRSFMRTYPE** = NONE).

6.3.3 ZONE 1 TO 4 PHASE-TO-PHASE REACH CALCULATIONS

This section describes how to determine the test currents and voltages for Z1PHREACH, Z2PHREACH, Z3PHREACH, and Z4PHREACH for Protection Setting 1204: **TRSFMRTYPE** = NONE. The same procedure is used for each zone to determine the test values.

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The test current, I_T , is determined from Table 6-1. The value of I_T is chosen according to the value of the reach of the zone. The nominal pickup voltage, V_{NOM} , is calculated with respect to I_T and to several settings of the relay.

V_{NOM} calculations are referenced to the leading phase-to-ground faulted voltage. When an AB fault is applied, the current angle is with respect to the phase angle of VA, not the phase-to-phase voltage. That is why the 1.732 (square root of three) factor and the added angle of 30° are included in Equations 6-6 and 6-7.

The nominal pickup voltage is given by

$$V_{NOM} = \frac{2}{1.732} \cdot \frac{Z_R \cdot I_T}{\cos(90^\circ - \angle T)} \cdot \cos((\angle I + 30^\circ) - \angle Z - \angle T + 90^\circ) \quad (\text{eq. 6-6})$$

for $(\angle Z - \angle T - 180^\circ) < \angle I < \angle Z$

or

$$V_{NOM} = \frac{2}{1.732} \cdot \frac{Z_R \cdot I_T}{\cos(90^\circ - \angle T)} \cdot \cos((\angle I + 30^\circ) - \angle Z + \angle T - 90^\circ) \quad (\text{eq. 6-7})$$

for $\angle Z < \angle I < (\angle Z - \angle I + 180^\circ)$

Definitions:

Z_R = relay reach for Z1PHREACH, Z2PHREACH, Z3PHREACH, or Z4PHREACH

$\angle Z$ = Angle of maximum reach.

I_T = Test current for I_{op} , chosen for the zone.

$\angle T$ = Characteristic timer of the zone.

$\angle I$ = Test current angle with respect to the faulted phase.

Settings and Calculations:

- Record the following relay settings:

(1201) **POSSEQANG** = []°
 (102) **Z1PHREACH** = [] Ω (Zone 1)
 (202) **Z2PHREACH** = [] Ω (Zone 2)
 (302) **Z3PHREACH** = [] Ω (Zone 3)
 (402) **Z4PHREACH** = [] Ω (Zone 4)
Z1PCHARANG = 90° (fixed for Zone 1)
 (203) **Z2PCHARANG** = []° (Zone 2)
 (303) **Z3PCHARANG** = []° (Zone 3)
 (403) **Z4PCHARANG** = []° (Zone 4)

- Determine the test current I_T for Zone 1, Zone 2, Zone 3, and Zone 4 from Table 6–1.

I_T (Z1R) = [] Amps rms
 I_T (Z2R) = [] Amps rms
 I_T (Z3R) = [] Amps rms
 I_T (Z4R) = [] Amps rms

Table 6–1: TEST CURRENT RANGES FOR PHASE-TO-PHASE REACH

Z_R REACH ($I_n = 5$ A)	I_T	Z_R REACH ($I_n = 1$ A)	I_T
0.1 to 2.5	10 A	0.5 to 12.5	2 A
2.5 to 6.0	8 A	12.5 to 30.0	2 A
6.0 to 12.0	5 A	30.0 to 60.0	1 A
12.0 to 20.0	3 A	60.0 to 100.0	0.6 A
20.0 to 30.0	2 A	100.0 to 150.0	0.4 A
30.0 to 40.0	1.5 A	150.0 to 200.0	0.3 A
40.0 to 50.0	1.0 A	200.0 to 250.0	0.2 A

- Choose $\angle I$ (the I_T angle). V_{NOM} is at maximum when $\angle I = \angle T - 30^\circ$.

$\angle I_1$ = []° (Zone 1)
 $\angle I_2$ = []° (Zone 2)
 $\angle I_3$ = []° (Zone 3)
 $\angle I_4$ = []° (Zone 4)

4. Calculate V_{NOM} for each zone by substituting the values of Z_R , $\angle Z$, **POSSEQANG**, I_T and $\angle I$ into Equations 6–6 and 6–7 for V_{NOM} according to zone. Alternately, ALPS-Test software can be used to calculate each value.

V_{NOM1} = [] Volts rms (nominal test voltage for Z1PHREACH)

V_{NOM2} = [] Volts rms (nominal test voltage for Z2PHREACH)

V_{NOM3} = [] Volts rms (nominal test voltage for Z3PHREACH)

V_{NOM4} = [] Volts rms (nominal test voltage for Z4PHREACH)

Zone 4 is reverse looking, so remember to add 180° to both the test current angle $\angle I_4$ and the impedance angle $\angle Z_4$. If Zone 4 has a nonzero offset, use the ALPS-Test software to calculate V_{NOM4} .

5. Record V_{NOMn} , I_T and $\angle I_n$ in the space provided in the appropriate Zone reach test.
6. Before doing any of the reach tests make the following protection setting changes:

OVERCURRENT

(601) **50** = NO

(605) **50G** = NO

(610) **51G** = NO

LINEPICKUP

(801) **LINEPICKUP** = NO

LINE INFO

(1204) **TRSFMRTYPE** = None

OS BLOCKING

(1303) **BLOCKWHAT** = 3 (BLKNONE)

6.3.4 T11 – ZONE 1 PHASE REACH TEST

1. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = YES

(102) **Z1PHREACH** = [] Ω

(104) **Z1P_TIME** = 0.0 sec.

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

2. Record the following values:

V_{NOM1} = [] V

$$I_T = [\text{_____}] \text{ A}$$

$$\angle I_1 = [\text{_____}]^\circ$$

3. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phases under test. Set the relay to test mode 14 (Any Zone 1 Phase). The LUI displays:

ANY Z1 PHASE ON

4. Set the voltage inputs to the following values:
 VA: 67 volts rms $\angle 0^\circ$,
 VB: 67 volts rms $\angle -120^\circ$,
 VC: 67 volts rms $\angle +120^\circ$.
5. Set the fault current phase angle to $\angle I_1 = [\text{_____}]^\circ$ lagging. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.
6. Set the fault current to $I_T = [\text{_____}]$ A rms. Simultaneously reduce the voltage of the faulted phases and check that the A1 contact closes when the voltages are within 7% of V_{NOM1} .
7. Repeat the test for phase BC and CA faults.

6.3.5 T12 – ZONE 2 PHASE REACH TEST

1. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = YES

(202) **Z2PHREACH** = $[\text{_____}] \Omega$

(204) **Z2TIMER** = YES

(205) **Z2P_TIME** = 1.0 sec.

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

LINEINFO

(1204) **TRSFMRTYPE** = NONE

2. Record the following values:

$$V_{NOM2} = [\text{_____}] \text{ V}$$

$$I_T = [\text{_____}] \text{ A}$$

$$\angle I_2 = [\text{_____}]^\circ$$

3. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phases under test. Set the relay to test mode 15 (Any Zone 2 Phase). The LUI displays:

ANY Z2 PHASE ON

- Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,

VB: 67 volts rms $\angle -120^\circ$,

VC: 67 volts rms $\angle +120^\circ$.

- Set the fault current, I_{op} , phase angle to $\angle I_2 = [\text{_____}]^\circ$ lagging. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.
- Set the fault current to $I_T = [\text{_____}]$ A rms. Simultaneously reduce the voltages of the faulted phases and verify that the A1 contact closes when the voltages are within 7% of V_{NOM2} .
- Reduce I_{op} of the faulted phase to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as follows:

TRIP AB Z2 "DIST"

where "DIST" is the displayed target.

- Repeat the test for phase BC and CA faults.

6.3.6 T13 – ZONE 3 PHASE REACH TEST

- Setting:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = YES

(302) **Z3PHREACH** = $[\text{_____}] \Omega$

(304) **Z3P_TIME** = 2.0 sec.

Z4DISTANCE

(401) **Z4PHASE** = NO

LINEINFO

(1204) **TRSFMRTYPE** = NONE

- Record the following values:

$V_{NOM3} = [\text{_____}]$ V

$I_T = [\text{_____}]$ A

$\angle I_3 = [\text{_____}]^\circ$

- Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phase under test. Set the relay to test mode 16 (Any Zone 3 Phase). The LUI displays:

ANY Z3 PHASE ON

4. Set the voltage inputs to the following values:
VA: 67 volts rms $\angle 0^\circ$,
VB: 67 volts rms $\angle -120^\circ$,
VC: 67 volts rms $\angle +120^\circ$.
5. Set the fault current, I_{op} , phase angle to $\angle I_3 = [\text{_____}]^\circ$ lagging. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.
6. Set the fault current to $I_T = [\text{_____}]$ A rms. Simultaneously reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within 7% of V_{NOM3} .
7. Reduce the fault current to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as:
TRIP: AB Z3 "DIST"
where "DIST" is the displayed target.
8. Repeat the test for phase BC and CA faults.

6.4.1 T14 – ZONE 4 PHASE REACH TEST

1. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE** = NO

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = YES(402) **Z4PHREACH** = [] Ω (405) **Z4_TIMERS** = YES(406) **Z4P_TIME** = 0.05 sec.

LINEINFO

(1204) **TRSFMRTYPE** = NONE

2. Record the following values:

 V_{NOM4} = [] V I_T = [] A $\angle I_4$ = []°

3. Connect the relay as shown in Figure 5–1: PHASE-TO-PHASE TEST CONNECTIONS on page 5–7 for the appropriate phase under test. Set the relay to test mode 17 (Any Zone 4 Phase). The LUI displays:

ANY Z4 PHASE ON

4. Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,VB: 67 volts rms $\angle -120^\circ$,VC: 67 volts rms $\angle +120^\circ$.5. Set the fault current, I_{OP} , phase angle to $\angle I_4$ = []° lagging. Note that the leading phase angle is 180° out of phase with the line to which it is shorted.6. Set the fault current to I_T = [] A rms. Simultaneously reduce the voltages of the faulted phases and check that the A1 contact closes when the voltages are within 7% of V_{NOM4} .

7. Reduce the fault current to zero. Note that the trip target indication concurs with the fault. For example, an AB fault is displayed as follows:

TRIP AB Z4 “DIST”

where “DIST” is the displayed target.

8. Repeat the test for phase BC and CA faults.

6.4.2 T15 – 3 PHASE FAULT WITH TRANSFORMER COMPENSATION

1. Protection Settings:

Z1DISTANCE

(101) **Z1PHASE**= YES(102) **Z1PREACH** = [] Ω (104) **Z1P_TIME** = 0.0 sec.

Z2DISTANCE

(201) **Z2PHASE** = NO

Z3DISTANCE

(301) **Z3PHASE** = NO

Z4DISTANCE

(401) **Z4PHASE** = NO

LINEINFO

(1204) **TRSFMRTYPE** = YD1

2. Connect the relay as shown in Figure 5–2: THREE PHASE TEST CONNECTIONS. Set the relay to test mode 14 (Any Zone 1 Phase). The LUI displays:

ANY Z1 PHASE ON

3. Set the voltage inputs to the following values:

VA: 67 volts rms $\angle 0^\circ$,VB: 67 volts rms $\angle -120^\circ$,VC: 67 volts rms $\angle +120^\circ$.

4. Select a value for V_{NOM} between 30 and 50 V rms: $V_{NOM} = []$ V rms

5. For a three phase fault, we have the following equation:

$$I = \frac{V}{Z} = \frac{V_{NOM}}{Z_R} \quad (\text{eq. 6-8})$$

6. Set the current inputs to the following values:

$$\text{IA: } \frac{V_{NOM}}{Z_R} = [] \text{ Amps rms } \angle -79.6^\circ$$

$$\text{IB: } \frac{V_{NOM}}{Z_R} = [] \text{ Amps rms } \angle 160.4^\circ$$

$$\text{IC: } \frac{V_{NOM}}{Z_R} = [] \text{ Amps rms } \angle 40.4^\circ$$

7. Reduce the voltage of all three phases simultaneously to V_{NOM} V rms and check that the A1 contact closes.
8. If desired, repeat the test for Zone 2, 3, or 4 by setting the specific zone reach and disabling the zone elements not being tested.

7.1.1 DESCRIPTION

ELECTRICAL RATINGS

Rated Frequency:	50 to 60 Hz
Rated Voltage:	100 to 120 V AC
Rated Current I_n :	1 A or 5 A
DC Control Voltage, operating range:	
48 V DC	38.5 to 60 V DC
110/125 V DC	88 to 150 V DC
220/250 V DC	176 to 300 V DC
Maximum Permissible AC voltage:	
Continuous	138 V AC (ph-n)
1 minute	208 V AC (ph-n)
Maximum Permissible current:	
Continuous	$3 \times I_n$
3 seconds	$50 \times I_n$
1 second	$100 \times I_n$
Sample Rate:	64 per cycle
Hi-Pot (DC Test):	ANSI C37.90 IEC 255-5
Surge Withstand Capability:	ANSI C37.90.1 IEC 255-22-1
Impulse Voltage Withstand Fast Transient:	5 kV peak, 1.2/50 ms, 0.5 J ANSI C37.90.1 IEC255-4
Radio Frequency Interference Withstand:	ANSI C37.90.1 IEC 255-22-1
Electrostatic Discharge:	IEC255-22-2
Humidity:	95% without condensation
Ambient Temperature Range	
Storage:	-30°C to 75°C
Operation:	-20°C to 65°C

BURDEN RATINGS

Current Circuit:	$I_n = 1 \text{ A: } 0.12 \Omega @ 30^\circ$ $I_n = 5 \text{ A: } 0.022 \Omega @ 5^\circ$
Voltage Circuit:	0.15 VA @ 60 Hz 0.20 VA @ 50 Hz
DC Battery (contact converters):	2.5 mA at rated DC input
(power supply):	< 20 W
Trip Circuit Motor:	150 mA for current-flow sensor

CONTACT RATINGS

Trip Outputs (T1 to T6)	
Continuous Rating:	5A
Make and Carry:	30 A (per ANSI C 37.90)
Interrupting:	25 VA
Pickup:	< 4 ms
SCR Outputs:	same as Trip Outputs
Auxiliary Outputs (A1 to A12, C1, C2)	
Continuous Rating:	5A
Make and Carry:	30 A (per ANSI C 37.90)
Interrupting:	25 VA
Pickup:	< 8 ms
High Speed (KT1 to KT4)	
Continuous Rating:	5A
Make and Carry:	30 A (per ANSI C 37.90)
Interrupting:	25 VA
Pickup:	< 8 ms
Contact Converter Inputs:	38.5 to 300 V DC
Protection Schemes:	Step Distance Programmable Logic
Directional Control:	Forward or Reverse
Time Synchronization:	by demodulated IRIG-B signal (5 V DC)
Out-of-Step Blocking	
Reach:	The reach of MOB is that of the zone it is coordinated with: Zone 2 or Zone 3.
Characteristic Angle:	30° to 130°

REACH SETTINGS

M1 (Zone 1 Phase Reach)	
Range:	$I_n = 1 \text{ A: } 0.05 \text{ to } 250 \Omega$ $I_n = 5 \text{ A: } 0.01 \text{ to } 50 \Omega$
Resolution:	$I_n = 1 \text{ A: } 0.01 \Omega$ $I_n = 5 \text{ A: } 0.01 \Omega$
MT (Zone 2 Phase Reach)	
Range:	$I_n = 1 \text{ A: } 0.05 \text{ to } 250 \Omega$ $I_n = 5 \text{ A: } 0.01 \text{ to } 50 \Omega$
Resolution:	$I_n = 1 \text{ A: } 0.01 \Omega$ $I_n = 5 \text{ A: } 0.01 \Omega$
M3 (Zone 3 Phase Reach)	
Range:	$I_n = 1 \text{ A: } 0.05 \text{ to } 250 \Omega$ $I_n = 5 \text{ A: } 0.01 \text{ to } 50 \Omega$
Resolution:	$I_n = 1 \text{ A: } 0.01 \Omega$ $I_n = 5 \text{ A: } 0.01 \Omega$
M4 (Zone 4 Phase Reach)	
Range:	$I_n = 1 \text{ A: } 0.05 \text{ to } 250 \Omega$ $I_n = 5 \text{ A: } 0.01 \text{ to } 50 \Omega$
Resolution:	$I_n = 1 \text{ A: } 0.01 \Omega$ $I_n = 5 \text{ A: } 0.01 \Omega$

CURRENT SUPERVISION FUNCTION

Function	Range A		Resolution A	
	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$
IPT	0.50 to 5.00	0.10 to 1.00	0.01	0.01
IPB	0.25 to 3.75	0.05 to 0.75	0.01	0.01
IT	0.20 to 4.00	0.20 to 4.00	0.01	0.01
IB	0.20 to 4.00	0.20 to 4.00	0.01	0.01

OVERCURRENT BACKUP

Function	Range A		Resolution A	
	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$
50	2.0 to 160.0	0.4 to 32.0	0.1	0.1
50G	0.5 to 80.0	0.1 to 16.0	0.1	0.1
51G	0.2 to 15.0	0.04 to 3.0	0.01	0.01

TOC TIME DIAL

Range: 0.5 to 10 times pickup setting

Steps: 0.1

LINE PICKUP

Function	Range A		Resolution A	
	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$
I1	1.0 to 15.0	0.2 to 3.0	0.1	0.1

REMOTE OPEN DETECTOR

Range: 10 to 100 ms

Step: 1 ms

LINE OVERLOAD

Overcurrent Settings:

Function	Range A		Resolution A	
	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$	$I_n = 5 \text{ A}$	$I_n = 1 \text{ A}$
Level 1 PU	2.5 to 20.0	0.5 to 4.0	0.1	0.1
Level 2 PU	5.0 to 40.0	1.0 to 8.0	0.1	0.1

Overload Settings

LV1 timer LEVEL1TDLY

Range: 10 to 99 seconds

Resolution 0.01 sec.

LV2 timer LEVEL2TDLY

Range: 10 to 99 seconds

Resolution 0.01 sec.

COMPENSATION FACTOR

Range: 1.0 to 7.0

Resolution: 0.01

PROTECTION SCHEME LOGIC TIMERS

Timer	Description	Range	Resolution
TL1PICKUP	Trip integrator pickup	1 to 50 ms	1 ms
Z2P_TIME	Zone 2 timer	0.1 to 3.0 s	0.01 s
Z3P_TIME	Zone 3 timer	0.1 to 10.0 s	0.01 s
Z4P_TIME	Zone 4 timer	0.1 to 10.0 s	0.01 s
TL4	POTT/PUTT coordination	0.1 to 50 s	0.01 s
(TL5) TL5PICKUP TL5DRPOUT	b contact coordination for Breaker 1 (pickup & dropout timers)	0 to 200 ms	1 ms
(TL6) TL6PICKUP TL6DRPOUT	b contact coordination for Breaker 2 (pickup & dropout timers)	0 to 200 ms	1 ms

SYSTEM CONFIGURATION

Communications baud

rate: 300, 1200, 2400, 4800, 9600, 19200

Number of breakers: 1 to 2

CT Ratios: 1 to 5000

PT Ratios: 1 to 7000

Distance Units: Miles or Kilometers

ACCURACIESDistance measuring units: Reach: $\pm 5\%$ of setting at angle of maximum reach and rated currentZone Timers: $\pm 2 \text{ ms}$ Fault Locator: $\pm 3\%$ (typical)RMS Values: $\pm 1\%$ of readingWatts and Vars: $\pm 3\%$ of full-scale reading from 1 A to MAX rated currentData Sample time tag resolution: $\pm 1 \text{ ms}$ **DIMENSIONS AND WEIGHT**Height: 5.31" (135 mm)
3 standard rack-unitsWidth: 19.00" with ears (3 standard rack-units)
16.90" without ears (430 mm)

Depth: 13.63" (347 mm)

Weight: The standard rack-mounted unit weighs 23 pounds.

SPECIFICATONS ARE SUBJECT TO CHANGE WITHOUT NOTICE

8.1.1 DESCRIPTION

The Local User Interface (LUI) for the Line Protection System (LPS-O) consists of a 4-line liquid crystal display (LCD), a keypad, and trip and status LEDs.

There are a few conventions used with the keypad and display that will be mentioned periodically in this section. However, to aid the user in using this section more effectively, they will be described briefly here.

- When a command key is pressed a menu will be displayed. There are several levels of choices and menus which will be needed to perform a certain task. To scroll back up through the different levels previously scrolled down, the same command key is used. For example, in the ACTIONS menu, the [ACT] key will go back up through the levels needed to perform that action. The [SET] and [INF] keys work the same way.
- If a mistake is made while entering data, press the [CLR] key once. Verify that the incorrect text has been deleted re-type the data or answer.
- Messages will be occasionally displayed. There may have been a mistake made in entering data or the relay may be informing the user of a state they have just put the relay in. These messages must be cleared before any other keypad input can be accepted. The [CLR] key will remove these messages and leave the user at the same level. Pressing the [ACT], [SET] or [INF] keys will let the user continue.
- If a message box or list of items is similar to one preceding it, the new one will not be shown.
- There are lists of items that have numbers next to them that appear on the display. If the number of an item is known the number can be pressed followed by the [ENT] key. This will position the cursor on the item. The user must press the [ENT] key one more time to actually enter the item the cursor is on.

8.1.2 DISPLAY & KEYPAD

a) DISPLAY

The LCD display consists of four 20-character lines. The LCD character contrast can be adjusted through the [ACT] key on the keypad. For more information see Section 8.1.11: ACTIONS on page 8–9.

b) KEYPAD

The keypad consists of twenty keys: 10 numeric keys, a decimal point, eight function keys and an [INV] key (as shown below):

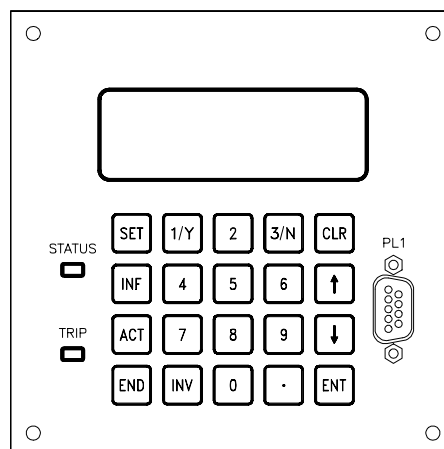


Figure 8–1: LPS-O KEYPAD

The keys are divided into three groups:

1. The **Command keys**: SETTINGS [SET], INFORMATION [INF], ACTIONS [ACT] and [END], begin or end a command sequence. These keys will be discussed in detail in this section.
2. The **Control keys**: ENTER [ENT], UP-ARROW (↑), DOWN-ARROW (↓) AND CLEAR [CLR] may cause the relay to take some action.
3. The **Data Entry keys**: all the numeric keys, the decimal point and the [INV] key enter data into the relay or answer prompts.

The keypad can be enabled or disabled by SW2 on the input board. If the switch is in the “ON” position, the keypad is enabled and if the switch is in the “OFF” position, the keypad is disabled. Only the [CLR] key functions when the keypad is disabled.

8.1.3 CONTROL KEYS

a) METERING/CLEAR KEY [CLR]

Depending on the current state of the display, the [CLR] key has the following uses: aborting a key sequence in progress; clearing an error message; and activating scrolling of metering and display recorded TRIP data.

If the [CLR] key is pressed while entering data, all or part of the display will be blanked. If there is user-entered data on the display, only the data will be blanked. For example, if the user is entering a Setting value or responding to an Action prompt when the [CLR] key is pressed, only the user's input will be blanked; the name of the setting or the prompt will remain on the display. If there is no user-entered data on the display when CLR key is pressed, the entire display will be blanked and the relay screen will be displayed.

When a keypad error message is displayed, the user must press the [CLR] key to remove the error message (all other keys will be ignored). When the error message is removed, the user will be returned to the current operation being performed.

Pressing the [CLR] key while a TRIP message is displayed will produce the TRIP information on the LCD. Only the target information (TRIP message) and date/time of the trip for each of the accumulated faults are displayed, starting from the most recent fault (that is, the one whose TRIP message was on display before pressing the [CLR] key). The trip time resolution is one millisecond as shown below:

#1
19:10:01.259
06/29/95
TRIP AB Z2 145.0MI

8

If the user presses the [CLR] key again, the target information and trip time and date for the next most recent fault is shown on the display. The user can scroll through all the accumulated TRIP information using the [CLR] key. The most recent TRIP message will flash. Pressing the [CLR] key after the last trip will display the relay screen. Scrolling through the TRIP information using arrow keys is not possible – as such, the trip information may only be viewed from the most recent to the oldest when using the [CLR] key.

Pressing the [CLR] key when the screen is blank or when the relay screen is displayed causes the Present Values/Metering screens to be displayed. Each screen of values is displayed for 4 seconds before proceeding to the next screen. Screens containing breaker health present values are not displayed. After automatically scrolling through all the screens, the display returns to the relay screen. The items displayed are described later in this section (see 8.2.4: REQUEST PRESENT VALUES on page 8–20). The user cannot use the arrow keys to scroll through the present values.

Both the fault data display and the Present Value display are stopped by one of the following: TRIP, FAIL/WARN message or a key being pressed.

b) ARROW KEYS

The arrow keys are used to scroll through the lists of commands and categories and adjust the contrast of the LCD display. By pressing the ↑ and ↓ keys, the user can select any item in the menu displayed. The LCD scrolls upward or downward when there are more items than can be displayed on four lines.

When the user reaches the desired category, pressing the [ENT] key will produce the name of the category on the top line and the first three items in that category on the following three lines. The user can use ↑ or ↓ keys to scroll through the items.

The ↑ key scrolls in a backward direction through a list of categories or items while the ↓ key scrolls forward through a list. The ↑ will select the item before it in a list (for example, from item 5 to item 4). The ↓ will select the item after it in a list (for example, from item 5 to item 6).

Both the ↑ and ↓ keys wrap. Wrapping happens when the top or bottom of a list is reached. The last item becomes the first and the first item becomes the last.

c) ENTER KEY [ENT]

The [ENT] key is used to enter data or make a selection. When a category name or command is selected on the display and the [ENT] key is pressed, the user is choosing to scroll through that category. After an item is selected to be edited using the [ENT] key, the numeric keys and decimal point are used to enter the value. When the correct value has been entered, the [ENT] key is used to accept the new value for the selected item.

d) DATA ENTRY KEYS

The numeric keys [1/Y] and [3/N] have two meanings, depending on the context. If the user is entering numeric values, the [1/Y] and [3/N] keys are used as the numbers 1 and 3. If the user is responding to a YES/NO prompt, the [1/Y] key is used and displayed as YES and the [3/N] key is used and displayed as NO.

The [INV] key is used to invert the values of logic signals used with the programmable outputs. For example, if the user needs to invert the value of the ZONE 1 AB logic signal (Index number 65) for input into programmable output A1, the key sequence [INV] followed by [6] then [5] is entered. The display will indicate: **!85**.

8.1.4 MESSAGES

All messages on the display are the result of some keypad action, with four exceptions: the Trip message when the relay has caused a protective trip; the Fail message when the relay has discovered a critical self-test failure; the Warning message when the relay has discovered a non-critical self-test failure; and the Initialization messages when the relay is initializing during a power-up.

If a protective trip occurs when there is no self-test message (Self-test Failure or Warning) on the display, the TRIP message will be displayed on four lines of the display. An example is shown below:

TRIP
AB
Z1
50.5 MI

The TRIP message will be displayed with the background flashing to indicate that the relay has caused a protective trip. The red TRIP LED will also be flashing to indicate the trip, and that the trip has not been acknowledged. Three fields of information form the TRIP message on display. They are: a two or three character fault type (e.g. AB), a two or three character trip type (see Section 8.2.3: REQUEST FAULT INFORMATION on page 8–19 for a list of the trip types), and distance to the fault (in user-specified units). The message will remain on the display until removed by a keypad operation or by the remote communications Target Reset command. If the relay restarts or is powered down and up, the trip indicator will be remembered and redis-

played. In either case, as soon as any key on the keypad is pressed or remote communications resets the target, the LED indicating protective tripping by the relay will stop flashing and the Trip message will be removed from display. The Trip information will be stored for later use.

When a system failure occurs, the Fail message is always shown on the bottom two lines of the display and has the following format:

```
BBB FAIL-XXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
```

where **BBB** stands for the sub-system name issuing the message, and **XXX...XXX** is the text which describes the critical self-test failure. The Fail message remains on the display until a key is pressed or until the relay restarts successfully (with no self-test failures).

If a TRIP message is already on display when a failure occurs, the TRIP message is displayed on a single line (top line) instead of on all the four lines. The fail message is still shown on the bottom two lines of the display, as shown below:

```
TRIP AB Z1 50.5MI

BBB FAIL-XXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXX
```

Since a trip has occurred, the LCD background for all four lines will be flashing.

The Warn message is always shown on the bottom two lines of the display in the same format as the failure message. The message remains on the display until a key is pressed or until the relay restarts successfully (with no self-test warnings). If a TRIP message is already on display when a warning occurs, the display format will be the same as the fail message. Since a trip has occurred the LCD background will be flashing.

The Initialization messages are displayed while the relay is initializing itself during a power up (and not during a warm restart).

All other messages, which are the result of keypad operations, remain on the display until another key is pressed or until no keys have been pressed for a period of 15 minutes. At the end of this time-out interval, the display is blanked.

Though there are some exceptions (the display of present values and events), for any user initiated interaction, the following applies:

- The top line of the display shows the current category. For example, if the user is editing a setting item, the top line shows the name of the current category, the setting group number and the setting item number. If the user is viewing the status of the Contact Converters, the top line shows **CC STATUS**.
- The fourth line usually displays the response to the actions initiated by the user. The response will be either a success or error message.

When a session is ended by pressing the [END] [ENT] sequence of keys, the display is cleared after 10 seconds. The KEYPAD/DISPLAY INTERFACE access privilege is then set to the View Level.

8.1.5 SETTINGS

The [SET] command key allows the user to view or edit protection and general settings, change the active settings group, and modify the date and time.

Pressing the [SET] key prompts the user for the Settings level password. If the password is not valid, the message **PASSWORD INVALID** will be displayed on the bottom line of the display. The [CLR] key deletes this error message and prompts for the password again.

If the password is valid, the privilege level is set to that associated with the entered password.

NOTE:

1. A password is required only when the user does not have SETTING or MASTER level access privilege at the time of pressing the [SET] key.
2. When the relay is first shipped, CONTROL, SETTING and MASTER passwords are loaded with factory values. The factory values for the passwords are: Settings (123.), Actions (456.) and Master (789.). Selecting these passwords will not increase the privilege level. All three passwords must first be changed to user-defined passwords. It is important to understand that the user does not obtain higher privilege levels until the passwords have been changed. See Chapter 9: SERVICING for details.

8.1.6 EDIT PROTECTION SETTINGS

```

EDIT PROT
GROUP (1-4): 4
Lose Chgs to Gn?
Act Grp= #

```

This option allows the user to modify the protection settings. Four different groups of settings are provided. SETTING or MASTER privilege level must be selected in order to change settings. The settings can only be viewed with CONTROL or default privilege level.

The **Edit Protection Settings** command is used to display or change protection settings. Each of the four groups contain the same list of settings, but they may have different values. Only one group of settings can be used at a time. However, any of the four groups may be viewed or changed at any time. The Protection Settings are divided into categories. By using the arrow keys, the user can scroll through the categories and the settings within each category. Each setting has been assigned a number so that it may be directly accessed.

If the user selects **Edit Protection Settings** by positioning the cursor on that line and pressing the [ENT] key, the display will change to allow the user to select a group of settings.

The cursor will be positioned after the colon (see figure above). If a group was previously edited but not saved then its number will be displayed after the colon and blink. If no group has been previously selected, there will be no number after the cursor. A number must be entered after the colon or an error message will displayed. The **Act Grp=** displayed on the bottom line indicates which group of settings is being used for protection. This group number is only informational.

After the group has been selected, press the [ENT] key. If the blinking digit appears (indicating that there are settings changes that have not been saved for that group), the display changes to indicate the changed settings that will be lost if the new group selection is confirmed. *Unless the settings changes are saved using the [END] key, the changes are not permanent and can be lost!*

In the above figure, **n** is the settings group which was modified but not saved. The user presses [1/Y] (YES) to indicate that changes to previously selected group should be dropped, or [3/N] (NO) to keep the changes and select another group. If the user has pressed NO, the group selection prompt is redisplayed. It is recommended the settings changes be saved in the EEPROM by pressing the [END] key. It is still possible to re-select a group number which is blinking by pressing the [ENT] key.

When a group is finally selected, the display will have **SETTINGS** on the first line and the first three categories on the next three lines. The cursor is positioned on the second line.

A few things should be noted at this point:

- First, the user has the ability to directly enter a setting number. If this is done, the setting number will be displayed in the upper right-hand corner. To select the setting after typing the setting number the [ENT] key must be pressed. If the number is valid, the setting is selected. The [ENT] key must be pressed again to change the setting. If the setting number is invalid, an error message will be displayed on the bottom line of the display and must be cleared with the [CLR] key before proceeding.
- Second, there is a blinking square cursor on the left side of the display. This indicates the currently selected item. To select a different item using the cursor, use the ↑ and ↓ keys. Pressing the [ENT] key will activate the item in the current cursor position.

The [SET] key has an additional function – it will return to the level above the current menu level each time it is pressed until the top SETTINGS menu is reached. For example, if the user is currently entering a new setting value, pressing the [SET] key will return to the list of settings in the current category. Pressing it again will return to the list of settings categories.

Once a category is selected and the [ENT] key is pressed, the first three items in that category are displayed as 10-character mnemonics of the settings and their values. For example, if the [ENT] key was pressed when the cursor is positioned on the line displaying **Z3DISTANCE**, the following will be displayed:

```
Z3DISTANCE Gn S0301
Z3PHASE = YES
Z3PHREACH = 20.32
Z3PCHARANG = 105
```

with the cursor positioned on the second line from the top. **Gn** indicates the group number currently being edited and **S#####** indicates the setting number on which the cursor is currently placed.

The setting number to be edited can be chosen by entering the number and pressing the [ENT] key. The entered number is echoed at the same place (right corner of the top line) where the current setting item number is displayed. After the [ENT] key is pressed, the number is checked for validity. If it is valid, the cursor will be positioned on the corresponding setting; if it is invalid, an error message is displayed.

To edit a setting, the item should be first be indicated with the cursor, then selected with the [ENT] key. The information related to the setting is displayed as follows.

- The cursor is positioned on the second line, at the first digit of the displayed value.
- When the first data entry key is pressed, the setting mnemonic will remain on the display but the equals sign (=) will be replaced by a blinking colon (:). Each data entry key will be displayed as it is pressed, and the colon (:) symbol will continue to blink. Remember that the [1/Y] key is also the YES key and the [3/N] is also the NO key. After the last digit of the new value is entered, the user presses the [ENT] key. If the new value is valid, then the blinking colon (:) will be replaced by the equals sign (=) and the relay will store and display the new setting. If the value is not valid, an error message will displayed on the fourth line and the old setting value will be retained, as shown below:

```
Z3DISTANCE Gn S0302
Z3PHREACH : 51.37
Zone 3 Ph reach(Ohm)
VALUE OUT OF RANGE
```

Two checks are made before accepting the user-entered value. When it is valid, the privilege level will be checked for either SETTING or MASTER level and communications must not be in the process of changing settings. If the check fails then an error message is displayed and the setting is not changed.

After changing a setting value, the setting name and value remain on the display. The arrow keys may be pressed to edit the next setting in the category or any Command key pressed to begin performing other operations. If the user presses the [SET] key, the next higher level menu consisting of the settings items in the present category is displayed with the cursor positioned on the last item edited. The arrow keys may then be used to select another setting item.

If the [SET] key is pressed again, the setting category screen with the cursor positioned on the latest edited category will be displayed. If the [SET] key is pressed for the third time, the group selection display, with the current group number blinking, will appear. If any of the other Command keys are pressed, the command menu associated with the Command key will be displayed.

It is important to note that the LPS-O continues its protection activities while setting values are being entered. Entered settings are stored in a temporary buffer until the user presses [END] and selects one of the save settings item. This will cause a transfer of settings from the buffer to EEPROM and the protection to re-initialize, if there is not a fault in progress at that time. If the settings are not saved and the relay is allowed to time out (15 minutes), all of the settings in temporary storage will be lost.

As soon as the user has made the first valid setting change, the LED which indicates LPS-O status starts blinking, to remind the user to save the settings after editing them. It continues to blink until the user saves the settings by pressing [END] or the relay times out (15 minutes). In order to safeguard changed settings the following message will be displayed whenever the [ACT] or [INF] keys are pressed after changing but not saving settings.

To Save Settings
Press END key

At this point the user can press the [END] key to save the changed settings in EEPROM. The user may also press the [ACT] or [INF] keys and proceed with the other operations. The setting changes will continue to reside in temporary memory until the user later presses the [END] key or the relay times out.

8.1.7 END KEY

END

- 1.Save settings & quit
- 2.Save settings
- 3.Quit

The [END] key has two purposes. The first is to transfer settings changes from the temporary area into the correct group. The other is to return the user to the VIEW or default privilege level. Each function can be accomplished without the other.

If no settings changes have been made, the only option when pressing [END] is **Quit**. This returns to the default privilege level. If settings changes were made, then three choices are available:

1. **Save set & quit** – The edited settings are saved and the privilege level is returned to default. The messages **SETTINGS SAVED** and **SESSION ENDED** are displayed, reporting the action taken (see below).
2. **Save settings** – The edited settings are saved and the current privilege level is retained. For this choice only **SETTINGS SAVED** is displayed.


```
END
Settings changed.
SETTINGS SAVED.
SESSION ENDED.
```

3. **Quit** – If the settings have not been saved, the relay prompts to save them. If [1/Y] (YES) and [ENT] are pressed, the settings are saved and the privilege level returns to default. Both **SETTINGS SAVED** and **SESSION ENDED** are displayed. If [3/N] (NO) and [ENT] are pressed, the settings are not saved and the privilege level returns to default.

After the session is finished, the display clears after 10 seconds and the default privilege level is restored.

If no setting changes are made prior to pressing the [END] key, the only choice will be **Quit**. If the [ENT] key is pressed, **SESSION ENDED** is displayed and the default privilege level is restored.

NOTE:

1. If the Digital Output Test was started, it will be terminated when a choice containing **Quit** is selected.
2. If the settings are saved, they are copied to the EEPROM. If the saved settings affect protection and no fault is currently in progress the settings change is complete. Otherwise, an error message is issued.

When settings are saved, protection is turned ON if it is currently OFF. The status LED turns GREEN if disabling protection was the only reason to turn it RED.

If the settings saved are from the active settings group, a Trip Bus Check is made to ensure that the new settings are legitimate. If the check fails, the protection is turned off and the status LED turns RED indicating that the relay is no longer protecting the line.

8.1.8 EDIT GENERAL SETTINGS

```
EDIT GEN
1.CONFIGURE
2.COMMPORTS
3.OSC_GRAPHY
```

This option allows for changes to the General Settings (for example: Configuration, Communications, Oscillography, etc.). Unlike the Protection Settings, there is only one group of general settings. SETTING or MASTER privilege level must be active in order to change general settings. It is possible, however, to view settings with CONTROL or default privilege level.

8

Viewing/Editing of General Settings and the LPS-O response to key selection is similar to that described in Section 8.1.6: EDIT PROTECTION SETTINGS on page 8–5.

8.1.9 SELECT ACTIVE SETTING GROUP

This command allows selection of setting groups to be used by protection functions. When selected, the currently active group is displayed as follows:

```
SELECT ACT SETT GRP
Act Grp= n

Range: 0 - 4
```


The cursor is positioned on the second line and 'n' indicates the current group number. If group number selection is controlled by Contact Converter inputs, the display will contain the word **EXTERNAL**.

When the active group number is changed, the equals sign (=) will be replaced by a blinking colon (:) until the [ENT] key is pressed. A value between 0 and 4 can be entered. Entering 1 to 4 followed by the [ENT] key selects Protection Settings group 1 to 4. Entering '0' informs the relay to read the active group number from Contact Converter inputs. If any number other than 0 to 4 is entered, an error message is displayed on the second line until the [CLR] key is pressed.

8.1.10 MODIFY DATE/TIME

This command is used to display or change the current date and/or time stored in the relay. SETTING or MASTER privilege level is required to make this change, however, users with any privilege level can view the date and time. When this item is selected, the display looks as shown below:

```
MODIFY DATE/TIME
Date    = 12/10/95
Time    = 10:00:00
```

The cursor will be located on the second line. To change the date or time, place the cursor on the desired line and press the [ENT] key.

```
MODIFY DATE/TIME
Date    = 12/13/95

FORMAT: MM/DD/YY
```

Enter the 6 digits corresponding to the correct date or time from the numeric keypad and press the [ENT] key.

When the first digit is entered, the 6 digits on the display are blanked and the equals sign (=) is replaced by a blinking colon (:) until the [ENT] key is pressed. If the entered digits do not compose a valid date or time, the old date or time is retained and an error message is displayed.

In both cases, two checks are performed: privilege level must be SETTING or MASTER and entered data must be in the correct format. If the checks fail then an error message is displayed and the change is not performed.

8.1.11 ACTIONS

```
ACTIONS
1.Disable outputs
2.Enable outputs
3.Trip breaker
```

The [ACT] key is used to select Action Commands. All Action Commands except **LUI Test** require either CONTROL or MASTER privilege level. The KEYPAD/DISPLAY INTERFACE Test can be performed with any privilege level. The PASSWORD ENABLE/DISABLE command and all relay tests require MASTER privilege level.

ACTIONS
Enter Password:

When the [ACT] key is pressed, the relay requests a password. The cursor is located at the beginning of the third line. A password may be entered just the [ENT] key pressed. If the [ENT] key is pressed without entering a password, the current privilege level is retained and the [ACT] command category menu is displayed. When a password is entered, each character of the password is echoed on the display as an asterisk (*). When the [ENT] key is pressed, the password is checked for validity. If the password is not valid, an error message is displayed which must be cleared with the [CLR] key. When the error message has been cleared, the password can be re-entered. If the password is valid, the privilege level is set accordingly.

NOTE:

1. The relay requests a password only if the privilege level is not CONTROL or MASTER when the [ACT] key is pressed.
2. When the relay is shipped from the factory, the CONTROL, SETTING and MASTER passwords are loaded with factory values. Selecting these passwords does not increase privilege level; it only allows them to be changed to custom passwords. Higher privilege levels can be obtained only after the factory passwords have been changed.

The following list describes the available LPS-O actions:

- | | |
|---|-----------------------------|
| 1. Disable Outputs | 8. Digital Output Test |
| 2. Enable Outputs | 9. Playback |
| 3. Trip Breaker | 10. Change Password |
| 4. Close Breaker | 11. Enable/Disable Password |
| 5. Relay Test | 12. Reset Data |
| 6. Channel Test (not applicable to LPS-O) | 13. N/A |
| 7. LUI Test | 14. Adjust Contrast |

The display will be similar to the settings display. The first line will display **ACTIONS** when in the Actions menu. The next three lines will contain the ACTIONS commands. Other menu items are selected by pressing the ↑ and ↓ keys. To go directly to a menu item, type the menu item number. The menu item number will appear in the right corner of the top line. If the number is valid when the [ENT] key is pressed, the cursor will be positioned on that action category. If the number is invalid when the [ENT] key is pressed, an error message will be displayed which must be cleared by the [CLR] key.

When an action category has been selected, press the [ENT] key. The first item in the selected category is displayed. The displayed list can be scrolled through with the arrow keys. To select another actions category, press the [ACT] key and repeat the previous steps.

8.1.12 DISABLE OUTPUTS

This command inhibits the relay from energizing any of the Digital Output contacts except for the critical alarm and power supply alarm outputs.

The relay will ask whether to disable the outputs. Press the [3/N] key for NO or the [1/Y] for YES followed by the [ENT] key. If NO is selected, **CANCELED** is displayed and no LPS-O action occurs. If YES is selected, two tests are performed: CONTROL or MASTER privilege level is verified and communication must not be in the

process of performing an action. If the test fails then an error message is displayed and the action is not performed. If the test passes, the action is performed, **OUTPUTS DISABLED** is displayed, and the status LED on the front of the relay will turn RED. If a key other than a [1/Y] or [3/N] is pressed, an error message is displayed and the outputs are not disabled. If this category is selected when outputs are already disabled, the following message is displayed and must be cleared with the [CLR] key.

DISABLE OUTPUTS
OUTPUTS CURRENTLY
DISABLED.

8.1.13 ENABLE OUTPUTS

This command is used to permit the relay to enable the digital outputs of the relay.

The relay will ask whether to enable the outputs. Press [3/N] for NO or [1/Y] for YES and then press the [ENT] key. If NO is selected, **CANCELED** is displayed and no LPS-O action occurs. If YES is selected, two checks are performed: for the CONTROL or MASTER privilege level and whether communication is in the process of performing an action. If the test fails, an error message is displayed and the action is not performed. If the test passes, the action is performed and **OUTPUTS ENABLED** is displayed. The status LED on the front of the relay will turn GREEN if there are no status problems with the relay. If a key other than [1/Y] or [3/N] is pressed, an error message is displayed and the outputs are not enabled.

If this category is selected when outputs are already enabled, the relay will display a message which must be cleared with the [CLR] key.

8.1.14 TRIP BREAKER

This command manually trips a breaker. Each breaker controlled by the relay must be tripped individually. If the relay is controlling two breakers when this category is selected, the relay will request which breaker to trip.

To indicate the breaker, press [1] or [2] followed by the [ENT] key (any other Data Entry key will cause an error message to be displayed). If the relay is set to control one breaker, this query will be skipped.

The relay will then ask whether to trip the selected breaker. Select [3/N] (NO) or [1/Y] (YES) followed by the [ENT] key. If NO is chosen, **CANCELED** appears on the display and no LPS-O action occurs. If YES is chosen, two checks are performed: for the CONTROL or MASTER privilege level and whether communication is in the process of performing an action. If the checks fail, then an error message is displayed and the action is not performed. If the checks pass, then the action is performed and either **BREAKER x TRIPPED** or **NOT TRIPPED** appears on the bottom line of display (depending on the status of the breaker). If a Data Entry key other than [3/N] or [1/Y] is pressed, an error message is displayed and the breaker is not tripped.

TRIP BREAKER
Trip Breaker 1/2?

The breakers are tripped as follows:

- For one breaker and one trip circuit, output contact T1 is energized.
- For one breaker and two trip circuits, output contact T1 and T2 are energized.
- For two breakers with one trip circuit each, output contacts T1 and T2 are energized.

- For two breakers with two trip circuits each, output contacts T1, T2, T3, and T4 are energized.

8.1.15 CLOSE BREAKER

This command is used to manually close the breaker. If two breakers are being controlled by the relay, each breaker must be closed individually. If the relay is controlling two breakers when this category is selected, the relay will request which breaker to close.

The user presses [1] or [2] (any other Data Entry key will cause an error message to be displayed) followed by the [ENT] key to indicate the breaker. If the relay is controlling only one breaker, this query is skipped.

The relay will ask whether to close the selected breaker. Press [3/N] (NO) or [1/Y] (YES) followed by the [ENT] key. If NO is selected, **CANCELED** appears on the display and no LPS-O action occurs. If YES is selected, the checks are performed for the control or master privilege level and whether Communication is in the process of performing an action. If the checks fail then an error message is displayed and the action is not performed. If the checks pass then the action is performed and either **BREAKER x CLOSED** or **NOT CLOSED** is displayed (depending on breaker status). If a key other than [3/N] or [1/Y] is pressed, an error message is displayed and the breaker is not closed.

8.1.16 RELAY TEST

This command tests the protection functions of the relay. MASTER password level privilege is required and protection must be enabled to perform this test. If protection has been turned off before entering this test, the relay will prompt to enable it. If the [3/N] (NO) key is pressed, **CANCELED** is displayed and the test is canceled. If the [1/Y] (YES) key is pressed, the user will be asked if the digital outputs should be disabled.

```

RELAY TEST
1.End Test Mode
2.Zone 1 AB
3.Zone 1 BC

```

Whether protection was just turned on or was already on when this test was selected, the relay asks to disable the digital outputs. If the answer is YES, all outputs except contact A1 are disabled and the status LED turns RED to indicate the digital outputs have been disabled. They may be enabled when **End Test Mode** is selected. If the answer is NO, all the digital outputs will stay active during the test.

NOTE: During relay test, all results from the tests will be output to contact A1 whether the digital outputs are enabled or disabled.

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When the relay test items are displayed, the cursor will be positioned on the second line. Additional tests can be displayed with the arrow keys or by entering the test number followed by the [ENT] key. The entered digits are echoed in the top right corner of the display. If the [ENT] key is pressed and the entered number is valid, the test item corresponding to that number is displayed. A test item can also be selected by moving the cursor to the item and pressing the [ENT] key. At this point a check is performed to make sure that communication is not in the process of performing an action. If the check fails then an error message is displayed and the test is not selected. When the test is selected, the word **ON** will be displayed to the right of the unit under test.

```

RELAY TEST
15.ANY Z2 PHASE  ON
16.ANY Z3 PHASE
17.ANY Z4 PHASE

```

One test may be performed at a time. When a new test is selected, the previous test will be deselected.

Other activities using the [SET], [ACT] or [INF] keys may be performed during the relay test. When the relay test category is re-selected, the test started earlier will be remembered only if the [END] key has not been used. If the digital outputs were enabled, the relay will again ask if they should be disabled. If protection was disabled, the relay will prompt to enable it before proceeding with the tests again.

NOTE: The Disable Output? screen may appear first.

To remove the relay from test mode, the select **1. End Test Mode** and press the [ENT] key. The cursor can be moved to the item in two ways: by using the arrow keys or by entering [1] followed by [ENT] key. If **1. End Test Mode** is selected, the message **ON** will be removed from the display line of the item under test and the relay test terminated.

If outputs have been disabled before the relay test, a prompt appears after the selection of **1. End Test Mode** option, as shown below:

```
RELAY TEST
Enable outputs?
```

If YES is chosen, the outputs are enabled, the status LED may turn GREEN (if disabling outputs or relay test was the cause to turn it RED), and the ACT command menu is displayed. If NO is chosen, the outputs remain disabled, the status LED stays RED and the ACT command menu is displayed. If any other key is pressed, an error message is generated and [CLR] key must be pressed to clear the message.

The available LPS-O tests and their corresponding numbers are:

1: End Test Mode	12: ZONE 4 BC	23: REM OP DETCT
2: ZONE 1 AB	13: ZONE 4 CA	24: OUT OF STEP BLK
3: ZONE 1 BC	14: ANY Z1 PHASE	25: V1 DETECTOR
4: ZONE 1 CA	15: ANY Z2 PHASE	26: LINE OVERLOAD
5: ZONE 2 AB	16: ANY Z3 PHASE	27: INST PHS OVRC
6: ZONE 2 BC	17: ANY Z4 PHASE	28: INST GND OVRC
7: ZONE 2 CA	18: IT DETECTOR	29: LINE PICKUP
8: ZONE 3 AB	19: IB DETECTOR	30: OVER VOLTAGE
9: ZONE 3 BC	20: GRD DIR TRIP	31: UNDER VOLTAGE
10: ZONE 3 CA	21: GRD DIR BLOCK	32:OUT OF STEP TRIP
11: ZONE 4 AB	22: FAULT DETECTOR	

8.1.17 KEYPAD/DISPLAY INTERFACE TEST

This command tests the display, keypad, and LEDs. This test does not require a specific privilege level.

```
LUI TEST
1.Display
2.LEDs
3.Keypad
```

A test is selected using the arrow keys followed by the [ENT] key.

If **Display** is chosen, the top two lines of the display will be filled to verify that all LCD dots are working. The display will prompt the user to press the [ENT] key. The bottom two lines of the display will now be filled. This is the end of the test. If the [CLR] key is pressed the relay screen is displayed. If the [ACT] key is pressed, the LUI TEST choices screen will be displayed.

If **LEDs** is chosen, both the STATUS and TRIP LEDs will be tested. The STATUS LED is tested first followed by the TRIP LED. The display will indicate the correct state of the LEDs. After each LED state the user will be prompted to press the [ENT] key and move to the next test. When the [ENT] key is pressed after the last test, the LEDs return to their pre-test state and the **LUI TEST** item menu is displayed.

If **Keypad** is chosen, the following screen appears:

```

SET 1/Y 2 3/N CLR
INF 4 5 6 UP
ACT 7 8 9 DN
END INV 0. ENT

```

When any key is pressed, the key label will blink on the display. If another key is pressed, the new key label will blink. Pressing the [CLR] key will terminate the keypad test and the test item menu is displayed.

8.1.18 DIGITAL OUTPUT TEST

This command tests the digital outputs of the relay. If the digital outputs are not enabled, the user is prompted to enable them. If the user enters [1/Y] (YES) and presses [ENT], the outputs are enabled. If the user presses [3/N] (NO), **CANCELED** is displayed and the test is terminated.

When the outputs are enabled, protection must be disabled (if it is currently enabled). If the user responds NO, **CANCELED** is displayed and the test is canceled. If user responds YES, protection is turned OFF, the status LED turns RED and the list of available tests is displayed.

To select a test item, scroll through the list using arrow keys or enter the test number. If the test pre-requisites are satisfied, the word **ON** will display to the right of test item. If the password privilege level is not MASTER or communications is performing an action, an error message is displayed and the test is not performed.

The contact being tested will close if it is normally open and it will open if it is normally closed. Only one output can be monitored at a time. When a new output is tested, the old output will be reset and the new output will either open or close.

Other activities using the [SET], [ACT] or [INF] keys may be performed at any time. When the user returns to the Digital Output tests, they are asked questions about Protection enable and then the selected test and its following tests are displayed, starting from the second line.

Press the arrow keys until **End Test Mode** is displayed or press the [1], [ENT] keys to stop the digital output test. Press [ENT] again. The digital output test is terminated and the following message will be displayed:

```

DO TEST
Enable Protection?

```

The cursor will be stationed on the third line. If [1/Y] (YES), [ENT] is entered, protection is turned ON. The LED indicating LPS-O status turns GREEN (if performing digital output test was the only cause for it being RED) and the ACT command menu is displayed with the cursor positioned on **Dig output test**. The above prompt will be also displayed when the user tries to exit the digital output test category without ending the test.

If [3/N] (NO) is entered followed by [ENT] key, protection is not enabled and the status LED remains RED. The ACT command menu is displayed with the cursor positioned on the item **Dig output test**.

The test may be stopped by pressing the [END] [ENT] key sequence, ending the relay session with protection turned ON.

The available digital output tests and their corresponding numbers are listed below.

1: End Test Mode	10: A3	19: A12
2: T1	11: A4	20: C1A/C1B
3: T2	12: A5	21: C2A/C2B
4: T3	13: A6	22: KT1
5: T4	14: A7	23: KT2
6: T5	15: A8	24: KT3
7: T6	16: A9	25: KT4
8: A1	17: A10	26:CA-A/B (Critical Alarm)
9: A2	18: A11	

8.1.19 PLAYBACK

This category checks the relay logic and outputs by replaying oscillography data. The oscillography data can be the embedded factory test case, uploaded oscillography data, or oscillography data stored in the relay.

After this command is selected, the following message appears (if protection is currently disabled):

PLAYBACK
Enable Protection?

The cursor is positioned at the beginning of the third line. If the user responds NO, **CANCELED** is displayed and the test is canceled. If the user presses any keys other than [1/Y] or [3/N] and presses the [ENT] key, an error message is displayed. It can be cleared and a valid input can be entered using the [CLR] key.

If the user responds YES, protection is enabled and the relay asks whether to disable the outputs, if they are currently enabled. The user presses [1/Y] or [3/N] followed by [ENT] key. These keys are echoed on the display as **YES** or **NO** respectively. If [1/Y] is pressed, the outputs are disabled and then the playback mode is continued. The outputs can be enabled after the playback is complete. If [3/N] is pressed, the outputs remain enabled. Any control actions issued by the relay take place in this case.

If the outputs are disabled, the status LED turns RED since the relay is currently not protecting the line. If they remain enabled during playback, the status LED turns RED only for the duration of the playback. In that case, after the playback is complete, the status LED turns GREEN again.

The cursor will be located on the second line. The option **Factory test case** is chosen by moving the cursor to that line and pressing the [ENT] key.

The user is prompted to select the settings which used during playback. If [1/Y] is pressed followed by [ENT] key, the relay settings currently in effect will be used during playback. If [2] is pressed followed by [ENT], the settings stored with the oscillography data will be used.

The factory test case is a phase to phase fault at 50% of the line determined by the default factory settings, except for the configurable outputs which are all assigned a value of 0 (no assignment). The contact converters will respond to the levels in the uploaded file. After the response described above, playback is started and the word **ON** will be displayed on the top line. The cursor will be positioned on the top line. After the playback is over, the word **ON** is removed.

If the second choice, **Uploaded data**, is selected, a check is made to verify whether any uploaded oscillography data exists in the relay. If the data does not exist, an error message is displayed. If the data exists, the user is asked to select the settings to be used during playback, as explained for the item **Factory test case**. An oscillography file may be uploaded by using LPSO-Link (refer to Chapter 11: LPSO-LINK USER GUIDE). The playback is started after all prompts are answered. The word **ON** will be displayed as long as playback lasts.

The only data files that can be uploaded to the relay are OSC files downloaded from another LPS-O, LPS-D, or ALPS model relay, or a binary or ASCII Commtrade file from another source (Commtrade details are explained below). These files contain the analog data, flags and settings to be uploaded to the relay.

Any file that meets the Commtrade format may be downloaded to the relay after it has been converted to OSC format using the `CTRD2OSC.exe` program provided with the LPS-O software suite. It will be installed into the same directory as LPSO-Link. This utility converts only the analog data from the file; all flag values are set to 0, and default settings will be added to the file. View the `CTRD2OSC.TXT` text file for complete instructions on using the conversion utility. The only data used from a Commtrade file is the analog channel data. All other data are discarded and replaced with dummy values. The data must be sampled at a rate of 64 samples per power cycle or 3840 samples/second at 60 Hz.

The values of the oscillography setting are obtained from the current settings, not the ones in the playback fault. Therefore, the new fault report will correspond to the current settings. For example, if the playback fault has 36 cycles of data, but the current **NUMFAULT** is set to 8, only 18 cycles of data will appear in the new fault report. Conversely, if the playback fault has only 12 cycles of data and the current setting will generate 36 cycles, then 24 cycles of zero data will be processed at the end of playback.

If the third choice, **Data in relay**, is selected, the user is asked to select the settings (current/fault) for playback. After the settings have been selected, the summary of faults to be selected is displayed. If fault settings is selected, the settings active at the time of the fault will be used. The settings file is attached to the oscillography and is always saved with the oscillography data.

The cursor will be located on the second line. To move cursor to an item, use the arrow keys or enter the fault number followed by the [ENT] key. If entering a number, the digits pressed are echoed at the top right corner of the display. Pressing the [ENT] key after moving the cursor to the desired item starts playback. The top line changes to indicate that playback has started. The word **ON** will be removed from the display as soon as the playback is complete.

Two checks are made before starting playback: the privilege level must be MASTER and communications must not be in the process of performing an action. If either of these checks fails, an error message is displayed to the user and the test is canceled.

If **End Playback** is chosen and the outputs are disabled, the relay prompts with the dialogue:

Enable Outputs?

If YES is chosen, the outputs are enabled, the status LED turns GREEN (if playback test was the only reason to turn it RED), and the ACT command category selection is displayed. If NO is chosen, the outputs remain disabled, the status LED remains RED, and the ACT command category selection is displayed.

8.1.20 CHANGE PASSWORD

This category is used to change the SETTINGS, CONTROL and MASTER passwords. The arrow keys may be used to scroll to the desired item. To select an item press the [ENT] key. Once a password has been selected to be changed, only the number keys can be used to enter the old password. The digits are echoed with an asterisk (*) for privacy. When the [ENT] key is pressed, the old password is checked for validity. If the password is valid, the relay will prompt for the new password.

Only the number keys can be used to enter the new password. Once the new password has been entered, the relay will prompt to re-enter the new password to ensure no mistakes were made while typing.

If the two password entries are identical then **PASSWD CHANGED** is displayed and the new password replaces the old one. Otherwise, **PASSWD NOT CHANGED** is displayed and the password is not changed.

No privilege level is needed to use this command and communications is not checked.

8.1.21 ENABLE/DISABLE PASSWORDS

This category is used to enable/disable LUI passwords. MASTER privilege level is required.

If passwords are currently enabled the relay will ask to disable the passwords; if passwords are currently disabled, the relay will ask to enable the passwords. In either case, if [3/N] (NO) is pressed, **CANCELED** is displayed and the command is terminated.

The [1/Y] (YES) is pressed, the current state for the operation of the passwords will be changed. If the current state is disabled, the relay will ask for the MASTER password. **PASSWORDS ENABLED** is displayed and passwords will be required to perform most of the relay commands through the keypad. When the passwords are enabled, the passwords in effect before disabling the passwords are restored. If the passwords are disabled when the command is executed, **PASSWORDS DISABLED** is displayed and no passwords will be required to perform most relay commands. Remember: a MASTER level password is required to perform this command whether or not passwords are enabled.

8.1.22 RESET DATA

This command is used to reset the fault, event, oscillography and breaker health data.

Use the arrow keys or choose the item number to select an item to be reset. Once an item has been selected, press the [ENT] key again. The user is prompted to reset the data. If [3/N] (NO), [ENT] is pressed, **CANCELED** is displayed and the data is not reset. If [1/Y] (YES), [ENT] is pressed, the data is reset and a message displayed which must be cleared with the [CLR] key. If a fault is in progress while attempting to reset fault data or equipment duty data, an error message is displayed and the data is not reset.

An event is logged for each successful reset operation. CONTROL or MASTER privilege is needed to perform this command and communications must not be executing an action command.

8.1.23 ADJUST CONTRAST

The contrast level of the LCD display can be adjusted using this command. The ↑ or ↓ keys are used to increase or decrease the contrast of the display, respectively. As the arrow keys are pressed, the contrast change will be visible on the display. Increasing the contrast will make the characters appear darker on the display; decreasing the contrast will make the characters lighter on the display.

If the minimum or maximum contrast limit has been reached, the relay will change the prompt to **INCREASE** or **DECREASE** only (depending on the limit reached). Pressing the other arrow will not affect the contrast.

An error message will be displayed if the data entry keys are used. CONTROL or MASTER privilege is required to use this command.

8.2.1 DESCRIPTION

The [INF] key is used to view information stored in the relay and can be used with any privilege level. Pressing the [INF] key on the keypad allows access to the following relay information.

1. LPS status information
2. Fault information
3. Present values
4. Contact Converter status
5. Digital output status
6. Events information
7. Communication Passwords
8. Station/Line ID
9. LPS-O Model/Version
10. Snaps hot oscillography

```

INFORMATION
1.LPS status
2.Faults
3.Present values
  
```

Use the arrow keys to select the desired category. Categories may also be selected by entering the category number followed by the [ENT] key.

The user can scroll through the list of categories by pressing the ↑ or ↓ keys. The user can select a category by entering its number as well. If the user enters a category number, it is echoed in the upper right-hand corner. When the user presses the [ENT] key after selecting a category, the first three items of information of the selected category are displayed. Use the arrow keys to display information that is not currently display. The cursor will be visible only when the user is making a choice to view information. It is not visible while the user is viewing the information. The user may return to the category list by pressing the [INF] key at any time. Another category can be selected by using the arrow keys or entering a new category number and pressing the [ENT] key as above. If the text on a line is longer than 20 characters (the maximum number per line), the text continues on the next line with the first character blank, as shown below.

8.2.2 REQUEST STATUS INFORMATION

```

LPS STATUS
Trip Bus Check Fail
Setting changes
  started
  
```

When the user requests the relay status, the overall relay status is displayed on the second line. If the relay is working properly and protecting the line, the relay will display **STATUS: OK**. If there is a critical failure detected by self-test, the display will be **STATUS: FAIL**. If there are no critical failures but there is a non-critical failure, the display will be **STATUS: WARN**. Even if there are no hardware failures, there may still be miscellaneous status in which case the display will be **STATUS: MISC**.

The detailed status information is presented starting from the third line. The user may use the arrow keys to scroll through the information. Each time the arrow key is pressed, a full screen of detailed status information is displayed. Status information is presented in the following order: critical failure information, non-critical failure information and miscellaneous status information.

8.2.3 REQUEST FAULT INFORMATION

This category is used to display fault information.

When this category is selected, a summary of the fault information for the stored faults is displayed to facilitate the user choose a fault for viewing more information about it. An example is shown below:

```

SELECT FAULT #1
XXX  YYY  MM/DD HH:MM
XXX  YYY  MM/DD HH:MM
XXX  YYY  MM/DD HH:MM

```

where: **XXX**: Fault type

YYY: Trip type

MM/DD HH:MM: Date and time of occurrence

The number in the top right-hand corner indicates the selected fault. When the category is entered, the number is #1 and the cursor is on the first fault. The arrow keys may be used to scroll through the list of accumulated faults. The number on the top line will change to match the currently selected fault. The user can also enter the fault number to view. If the number is valid when the user presses [ENT] key, the cursor will be placed on the selected fault description. An error message is displayed if the user enters an invalid number.

The user has to press [ENT] key to view all the fault information. An example is shown below:

```

FAULT    #1

Time: HH:MM:SS.XXX
Date: MM/DD/YY

```

Explanation of the information displayed for each fault is given below:

Time: **HH:MM:SS.XXX** (**XXX = msec**) – time of fault occurrence

Date: **MM/DD/YY** – date of fault occurrence

Fault Type: **XXX** – see the list below

Trip Type: **YYY** – see the list below

Distance: **zzz.z MI/KM** – distance to fault occurrence

Relay Op Time: **xxxxxx** – relay operating time in msec.

Brkr Op Time: **xxxxxx** – breaker opening time in msec.

Fault Types:

AB (phases A-B)

BC (phases B-C)

CA (phases C-A)

3PH (3-phase)

Trip Types:

Z1	(Zone 1)
Z2	(Zone 2)
Z3	(Zone 3)
Z4	(Zone 4)
50G	(Ground instantaneous overcurrent)
50P	(Phase instantaneous overcurrent)
51G	(Ground time delayed overcurrent)
LPU	(Line pick up)
REM	(Remote open)
OSC	(Oscillography Trigger)
CTB	(configurable trip bus trip)

8.2.4 REQUEST PRESENT VALUES

This category displays the present analog values. They are updated every 4 seconds while being displayed.

The present values information is displayed in six different screens. Each time the ↓ key is pressed, the next screen of information will be displayed. Using the ↑ key will display the information in reverse order.

The forward order of the information screens is: 1) RMS Values, 2) Power Factor, Frequency and Watts Vars, 3) Analog Values for Voltage, 4) Analog Values for Current, 5) Breaker Duty, and 6) Breaker Operations.

NOTE:

Currents and voltages are displayed in primary or secondary values depending on the value of General Setting 108. For secondary side values, the units of voltages will be V and the current units will be A. For primary side values, the voltage units will be KV and the current units will still be A. The RMS present values are always displayed in primary units, when primary display is selected. The asterisk symbol (*) used for Watts; Vars can be: blank, K (for 1000), or M (for 1,000,000). The breaker duty is calculated according to the values in the Equipment Duty General Settings. In general, the units of breaker duty are (Amps)^X(Seconds) where X is General Setting 401: **EXPONENT**. The breaker duty values are displayed with the units 'A' (A x sec.), 'K' (kA x sec., in thousands) or 'M' (MA x sec., in millions). In the LPSO-Link program, the voltages will be shown in secondary values only.

8.2.5 CONTACT CONVERTER STATUS

This category is used to display the state of each digital input monitored by the relay. They are updated every 4 seconds while they are displayed.

The number of the contact converter, the name of the digital input assigned to the contact converter and the status of the converter are displayed on the same line. Three contact converter status are displayed at a time.

```
CC STATUS
1.52B_1A : 0
2.52B_1B : 1
3.52B_1C : 0
```

NOTE:

1. The LPS-O has 12 contact converters.
2. The contact converter is OPEN if the status is a '0'. The contact converter is CLOSED if the status is a '1'.
3. If no digital input is assigned to a contact converter, its status information will still be displayed along with the contact converter number but the name will be blank.

8.2.6 DIGITAL OUTPUT STATUS

This command displays the definition and the state of each digital output in the relay. This information is displayed three lines at a time. Use the arrow keys to scroll through the digital outputs (displayed in groups).

The Trip Outputs have the letter T in front of the output contact number. Alarm Contacts have the letter A in front of the output contact number. The two Form C output contacts have the letter C in front of the number. The Critical Alarm is just labeled CA.

DO STATUS	
T1 - T4 :	1 0 1 1
T5 - T6 :	0 0
A1 - A4 :	0 1 0 0

NOTE: If the DO status is shown as '0' it means it is OPEN; if it is '1', then it is CLOSED.

8.2.7 EVENT INFORMATION

This category can be used to view event information logged when certain functions are performed by the relay. Information displayed for each event consists of: Event number and its time of occurrence on the top line; date of occurrence of event on the second line; detailed event description on the third and fourth lines. The user may use the arrow keys to view the event information. The user can also enter an event number followed by the [ENT] key to display the information for a specific event. An error message is displayed if the user enters an invalid event number. Listed below is a list of the possible event messages available:

EVENT LIST

- | | |
|---|--|
| • Fail: CPU board SRAM | • Fail: DSP PROM failure |
| • Fail: 960 access to DPRAM | • Fail: DSP internal RAM |
| • Fail: EEPROM | • Fail: DSP internal RAM checksum error |
| • Fail: Digital output test | • Fail: DSP access to DPRAM |
| • Fail: Interrupt test | • Fail: DSP interrupt |
| • Fail: ANI ADC Control logic | • Fail: Digital input test |
| • Fail: ANI ref. channel test | • Fail: Model number - critical in nature |
| • Fail: DMA interrupt failure | • Fail: MAG module configuration mismatch |
| • Fail: ANI board timer | • Fail: ANI module configuration mismatch |
| • Fail: ANI board serial EEPROM test | • Fail: Digital input module configuration mismatch |
| • Fail: MAG module serial EEPROM test | • Fail: Digital output module configuration mismatch |
| • Fail: Digital output serial EEPROM test | • Fail: Trip circuit continuity monitor #1 |
| • Fail: DTA serial EEPROM test | • Fail: Trip circuit continuity monitor #2 |

- Fail: Trip circuit continuity monitor #3
- Fail: Trip circuit continuity monitor #4
- Fail: Trip circuit continuity monitor #5
- Fail: Trip circuit continuity monitor #6
- Fail: Software version error
- Fail: DSP software version error
- Fail: More than 4 warm restarts occurred in an hour
- Fail: i960 DSP interface
- Fail: Runtime flash test CRC check
- i960 Instruction fault
- i960 Arithmetic fault
- Too many bogus interrupts
- Warning: CPU board timer test
- Warning: Zero crossing logic
- Warning: CAPRAM failure
- Warning: RTC test failure
- Warning: Comm front port failure
- Warning: Comm rear port 1 failure
- Warning: Comm rear port 2 failure
- Warning: Watch dog timer failure
- Warning: LCD display failure
- Warning: IRIGB failure
- Warning: Rear port 2 absent
- Warning: Non critical field in model number
- Warning: CAPRAM size mismatch
- Warning: Frequency error
- Warm restart
- ANI reference corrected
- Digital input error corrected
- MAG module error corrected
- ANI module error corrected
- LCD display error corrected
- Remote communication login failure
- Passwords changed
- Outputs enabled
- Outputs disabled
- Manual trip
- Manual close
- Manual trip failed
- Manual close failed
- Setting changes started
- Setting changes completed
- Protection OFF
- Protection ON
- Fault queue in CAPRAM re-initialized
- Event queue in CAPRAM re-initialized
- OST oscillography data area re-initialized
- Equipment duty is reset
- Active setting group changed
- Protection re-initialized
- Request for protection re-initialization not serviced
- Factory settings done
- Error in constants used by protection
- Error in code area of configurable logic
- LPS Initialized
- Trip signals ON
- Trip signals reset
- Trip A signal ON
- Trip A signal reset
- Trip B signal ON
- Trip B signal reset
- Trip C signal ON
- Trip C signal reset
- Out of step block ON
- Out of step block OFF
- Breaker #1 open
- Breaker #1 closed
- Breaker #2 open
- Breaker #2 closed
- Fuse failure alarm ON
- Fuse failure alarm OFF
- Key transmitter ON

- Key transmitter OFF
- Trip circuit #1 energized
- Trip circuit #2 energized
- Trip circuit #3 energized
- Trip circuit #4 energized
- Trip circuit #5 energized
- Trip circuit #6 energized
- Line overload alarm ON
- Line overload alarm OFF
- Trip circuit #1 monitor alarm ON
- Trip circuit #1 monitor alarm OFF
- Trip circuit #2 monitor alarm ON
- Trip circuit #2 monitor alarm OFF
- Trip circuit #3 monitor alarm ON
- Trip circuit #3 monitor alarm OFF
- Trip circuit #4 monitor alarm ON
- Trip circuit #4 monitor alarm OFF
- Trip circuit #5 monitor alarm ON
- Trip circuit #5 monitor alarm OFF
- Trip circuit #6 monitor alarm ON
- Trip circuit #6 monitor alarm OFF
- Pilot protection ON
- Pilot protection OFF
- Oscillography trigger
- Fail: Trip bus check
- Unbalanced system detection alarm ON
- Unbalanced system detection alarm OFF
- Zone measurement units alarm ON
- Zone measurement units alarm OFF
- Overcurrent monitor alarm ON
- Overcurrent monitor alarm OFF
- Trip circuit #1 not energized
- Trip circuit #2 not energized
- Trip circuit #3 not energized
- Trip circuit #4 not energized
- Trip circuit #5 not energized
- Trip circuit #6 not energized
- TOC curve changed
- Runtime NO DMA interrupt
- Out of step trip ON
- Out of step trip OFF
- Run time ANI controller error
- Run time ANI reference error
- Run time DSP H/W fail
- Run time DSP settings error
- Run time DSP table corrupted

An example of event information display is shown below:

```
13:45:21.240 Evt#100
09/12/88
LUI:MANUAL CLOSE
```

8.2.8 COMMUNICATION PASSWORDS

This category is used to view the communications passwords in encrypted form.

Viewing of encrypted passwords is determined by the user's current privilege level. With a default or factory password privilege level, the user will only see the VIEW password for communications. With settings privilege level, only the SETTINGS and VIEW passwords are displayed. With control privilege level, only the CONTROL and VIEW passwords are displayed. All passwords can be viewed with master privilege level.

If the relay is set for MASTER privilege level, use the arrow keys to view the second pair of passwords.

To change the privilege level in the relay, enter the SETTINGS or ACTIONS categories and enter the password. The [SET] key and the [ACT] key are the only two keys that allow you to set the privilege level. If only the SETTINGS privilege level is desired, the [SET] key must be used. The [ACT] key must be used only if CONTROL privilege level is desired. Either may be used for the MASTER privilege level. See the following table for decoding information.

Table 8-1: PASSWORD ENCRYPTION KEY TABLE

Displayed	Decoded	Displayed	Decoded	Displayed	Decoded
(space)	P	8	B	M	7
!	T	9	F	P	(space)
"	X	:	J	Q	\$
\$	Q	;	N	R	(
%	U	<	C	S	,
&	Y	=	G	T	!
(R	>	K	U	%
)	V	?	O	V)
*	Z	@	0	W	-
,	S	A	4	X	"
-	W	B	8	Y	&
1	D	D	1	Z	*
2	H	E	5	[.
3	L	F	9	\	#
4	A	H	2]	'
5	E	I	6	^	+
6	I	L	3	_	/
7	M				

8.2.9 REQUEST STATION/LINE ID

This category is used to view the Station and Line ID strings which are set by the remote communications. These IDs allow the user to easily identify each relay by name while logged in through communications. Use the arrow keys to display the ID not currently on the screen.

NOTE: If the Station/Line ID string is longer than 20 characters, a check is made to see if the string can be smoothly separated to fit on two lines. If it is not possible, the first 20 characters of the station ID are displayed on the third line and the rest are displayed on the fourth line.

8.2.10 REQUEST LPS-O MODEL/VERSION

This category is used to display the Model and Version numbers for the relay.

8.2.11 OSCILLOGRAPHY SNAPSHOT

This command can be used to trigger the immediate collection of oscillography data. Oscillography can be triggered without at any privilege level. The user will be prompted to start the trigger.

```
OSC SNAPSHOT
Trigger Osc?
```

Table 8–2: KEYPAD / DISPLAY INTERFACE ERROR MESSAGES

Error Message	Cause of Error
VAL OUT OF RANGE	The setting value is either greater than the upper limit or less than the lower limit.
SETT NUM INVALID	The setting number is not valid.
Y/N NOT ENTERED	A YES or NO response key was required, but the [1/Y] or [3/N] key was not pressed.
REQUEST INVALID	A key was pressed that is not valid for a sequence; for example: The [ENT] key is pressed to view events. The _ key is pressed during entry of a settings value.
CATEGORY INVALID	An incorrect category number was entered for an action or information item.
BKR NUM INVALID	A breaker number other than 1 or 2 was entered.
DATE INVALID	The day, month, or year entry is invalid.
TIME INVALID	The hour, minute, or seconds entry is invalid.
FAULT # INVALID	An out of range fault number was entered.
REMOTE LINK ACT	The remote communication link is in use for actions or settings; local settings or changes can't be done.
LUI KEY ERROR	The LUI received an invalid key code from the keyboard (hardware error).
ACT INVALID NOW	The current action is invalid because the setting's CRC code is in error.

8.3.1 DESCRIPTION

The pin-to-pin connections for the cable connecting the ASCII port to plug PL2 on the back of the LPS-O are shown in Figure 8–2: MODEM CABLE. Virtually any standard communications package on a PC with a serial interface may be used. The ASCII serial interface must be programmed to the same parameters as the remote communications ports. The ASCII port's handshaking mode must be set to either XON/XOFF or DTR ready. The LPS-O setting COMFORT affects both the baud rate of the RS232 port (plug PL1) and the ASCII port PL2. Figure 8–3: 25-PIN NULL MODEM CABLE shows a Null modem cable for the 9-pin front port PL-1.

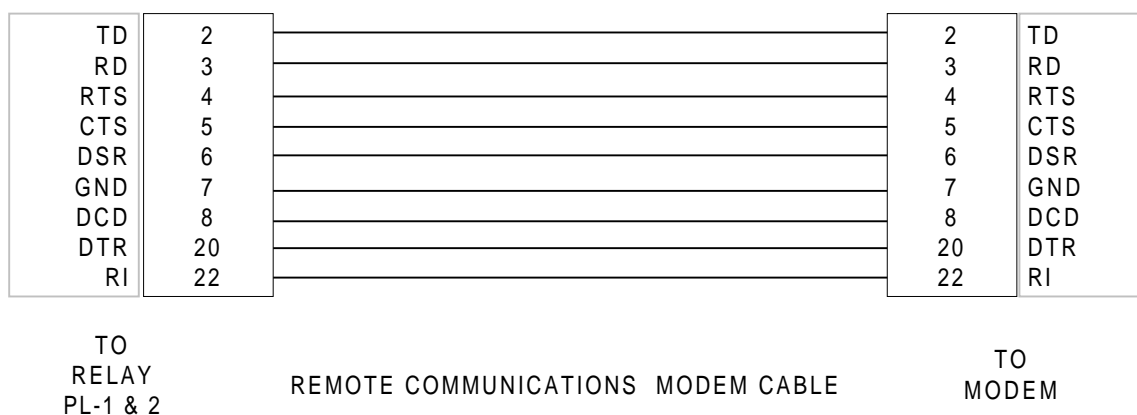


Figure 8–2: MODEM CABLE

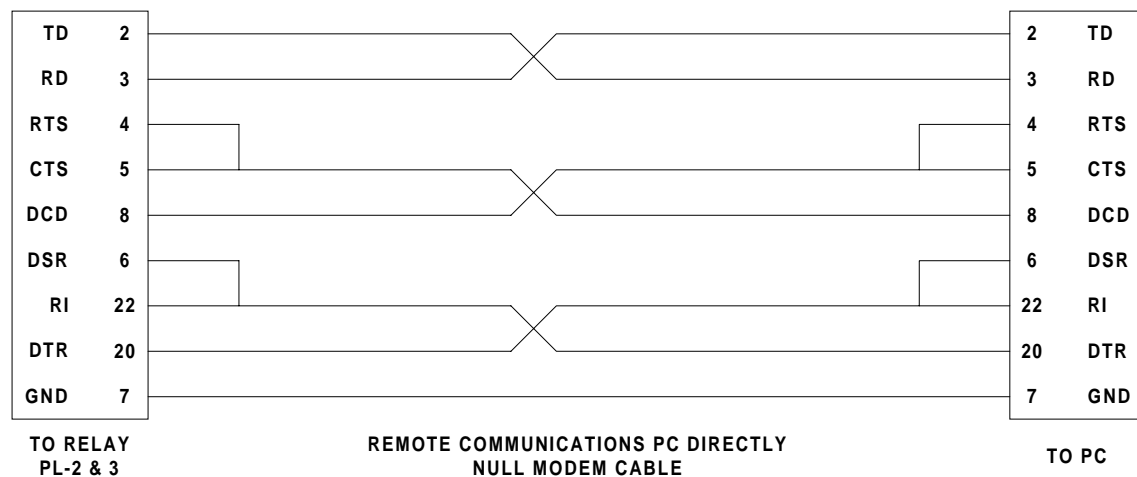


Figure 8–3: 25-PIN NULL MODEM CABLE

8.3.2 RECOMMENDED REMOTE COMMUNICATIONS PACKAGES

The following programs have been tested and known to support the ASCII interface on the LPS-O. Note that most any communications package that emulates a TTY type terminal should communicate successfully.

- Procomm Plus (vendor: Datastorm)
- Windows Terminal Program (vendor: Microsoft; included in Windows 3.1/95/98 system)

8.4.1 HARDWARE SWITCHES

There are hardware switches on the Input Board (see Section 3.3.5: INPUT BOARD on page 3–8) that inhibit the Remote Breaker Operations, the Remote Settings Change, and the Remote Enable/Disable Outputs functions. Please note that these switches are shipped from the factory in the down position and these functions are enabled.

1. The proper sequence for setting these switches is as follows:
2. Remove four thumbscrews holding the plastic cover in place and lay aside with plastic cover.
3. Turn the power switch off on the front panel.
4. Remove DC power from the LPS-O.



WARNING: Completely power down the relay by disconnecting the control DC power and by removing all voltage inputs to the rear terminals prior to opening the unit. Dangerous or lethal voltages may be present inside the unit even if the power switch is OFF.

5. Remove the four 1/4" hex nuts at the four corners of the front panel and carefully remove the front panel.
6. Disconnect the power and the ribbon cables from the front panel and lay the panel aside
7. The Switches are located in the middle on the front edge of the board. Move the switches up to turn a function off. Figure 3–6: INPUT BOARD DIAGRAM on page 3–9 indicates the location of the jumpers on the board.
8. Reinstall the PC board retainers with the four phillips head screws.
9. Reinstall the power cable and the bus card on the PC boards.
10. Reconnect the LUI ribbon cable and the power cable to the front panel and install the front panel with the four 1/4" hex nuts.
11. Turn on the front panel power switch.
12. Restore DC power to the relay.
13. Reinstall the plastic cover with the four thumbscrews.
14. The hardware switches are defined below in Table 8–3: HARDWARE SWITCH DESCRIPTIONS.

Table 8–3: HARDWARE SWITCH DESCRIPTIONS

Switch	Function
KBD EN ON	Down position enables keyboard operations. Up position disables.
RM CHG SET ON	Down position enables remote settings changes. Up disables.
RM BRKR ON	Down position enables remote breaker operations. Up disables.

8.4.2 MODEM CONNECTIONS AND SETTINGS

When establishing communication between the relay and a remote PC, two modems connected by a phone line are required. One modem is located at the relay and the other modem at the PC. The pin connections for the cable that connects the modem with either the relay or the PC is shown in Figure 8–3. Both modems must be "Hayes-compatible," meaning that they accept standardized modem configuration commands first developed by Hayes. This is necessary since the LPSO-Link communications software that runs on the PC sends a

Hayes-compatible command string to the modem located at the PC. The LPS-O does not send any configuration commands to its modem. Both the relay modem and the PC modem must be uniquely configured to permit logging into and communicating with the relay using LPSO-Link software.

The required configuration settings are presented as changes to the factory-default configuration settings for a Hayes V-Series 2400 SmartModem. The default settings are listed below.

B1	P	Y0	&K3	&S0	S7=30	S11=95	S26=1
E1	Q0	&C0	&L0	&T4	S8=2	S12=50	S36=1
L2	V1	&D0	&P0	&X0	S9=6	S18=0	S37=0
M1	W0	&G0	&Q5	S0=0	S10=14	S25=5	S38=20
N1	X4	&J0	&R0	S6=2			

Other "Hayes-compatible" modems may implement a subset of the full Hayes command set. It is the responsibility of the customer to determine the exact commands accepted by a particular modem. The proper syntax for entering the Hayes-compatible commands (sometimes referred to as the AT command set) is not described here. Refer to the modem manual for an explanation of this syntax.

8.4.3 PC MODEM

The PC modem must be configured for intelligent (command recognition enabled) operation. For the Hayes V-Series 2400 SmartModem, this setting is made with an internal jumper. The default settings listed in Section 8.4.2: MODEM CONNECTIONS AND SETTINGS are valid for LPSO-Link. The configuration settings critical to the operation of LPSO-Link are sent to the modem from the software:

+++

(delay 2 seconds)

ATE0L0Q0S7=60V0X4Y0

These commands are explained in Table 8–4: COMMAND SEQUENCE SENT BY LPSO-Link TO MODEM.

Table 8–4: COMMAND SEQUENCE SENT BY LPSO-Link TO MODEM

Command	Meaning
+++	Set modem to command mode
AT	Modem attention command
E0	disable command state echo
L0	Low speaker volume (desirable, not required)
Q0	Modem returns result codes
V0	Result codes returned in numeric form
X4	Enables result code features
Y0	Disable long-space disconnect
S7=60	Modem hangs up if no connection within 60 seconds

If any of the above commands are not recognized by the modem, then the modem will not operate properly. In addition to the required configuration settings listed in 8.4.2: MODEM CONNECTIONS AND SETTINGS on page 8–27, it is suggested that the following two settings also be made:

&D3: the modem resets on the ON-to-OFF transition of DTR (Data Terminal Ready).

&C1: DCD (Data Carrier Detect) tracks the received carrier signal.

The modem will operate properly without these two settings, but it will not hang up if the appropriate handshaking signal is lost.

An LPSO-Link setting establishes the baud rate which must match the baud rate setting of the LPS-O. LPSO-Link will then set the specified PC serial port (COM1, COM2) to the proper baud rate, parity, data bits, and stop bits. If the PC modem is capable of operating at more than one baud rate, then it must be able to automatically configure its baud rate, character length, and parity setting by examining the AT command prefix.

8.4.4 LPS-O MODEM

The LPS-O modem must be configured for "dumb" (command recognition disabled) operation. Since the relay sends no configuration commands to its modem, the required configuration settings must be made before connecting the modem to the relay. Additionally, the modem must be initialized to the required configuration settings each time modem power is turned OFF and then ON. Depending on the design of the modem this is accomplished with switch settings via switches or by saving the settings in nonvolatile memory.

The required configuration settings are listed in Table 8–5 below:

Table 8–5: CONFIGURATION SETTINGS FOR THE MODEM CONNECTED TO THE RELAY

Command	Description
E0	Disable command state echo
L0	Low speaker volume (desirable, not required)
Q1	Disable result code display
&C1	DCD (Data Carrier Detect) tracks the received signal
&D0	Modem resets on the ON-OFF transition of DTR (Data Terminal Ready)
&Q0	Asynchronous mode
S0=1	Enable auto-answer

If any of the settings in Table 8–5 cannot be implemented the modem may not answer, the relay may not connect properly, or you may not be able to log into the relay. With a Hayes V-Series 2400 SmartModem or equivalent, the relay modem performs a modulation handshake with the PC modem to set the baud rate of the relay modem. The default setting of N1 permits handshaking to occur at any baud rate supported by both modems. This is one reason why it is better to use identical modems at each end.

Note that auto-answering is controlled by register S0:

- S0=0: disables auto-answer.
- S0=1: the relay modem answers incoming calls after one ring. S0 can be set for any value between 1 and 255, if it is desirable to delay modem answering. Note that LPSO-Link configures the PC modem to wait 60 seconds for the relay modem to answer. If the relay modem register S0 is set higher than 12 (answer after 12 rings), the PC modem may time out and hang up before the relay modem can answer. S0=12 corre-

sponds approximately to the 60 second delay (S7=60) at the PC modem; however, you should verify the number of rings that correspond to 60 seconds for a particular application.

Table 8–6: MODEM COMMANDS FOR COMMUNICATION BETWEEN RELAY AND PC on page 8–31 lists the modem command set required to communicate to the relay from a remote PC.

8.4.5 NULL-MODEM CONNECTIONS

A PC can be connected directly to the relay without a modem through a null-modem cable. The required pin-to-pin connections for the PC null-modem cable are shown in Figure 8–4: 25-PIN NULL MODEM CABLE. The pin-to-pin connections for a null-modem cable to the 9-pin connector on the KEYPAD/DISPLAY INTERFACE are shown in Figure 8–5: NULL MODEM CABLE FOR PORT PL1. The null modem cable should be no more than 50 feet long.

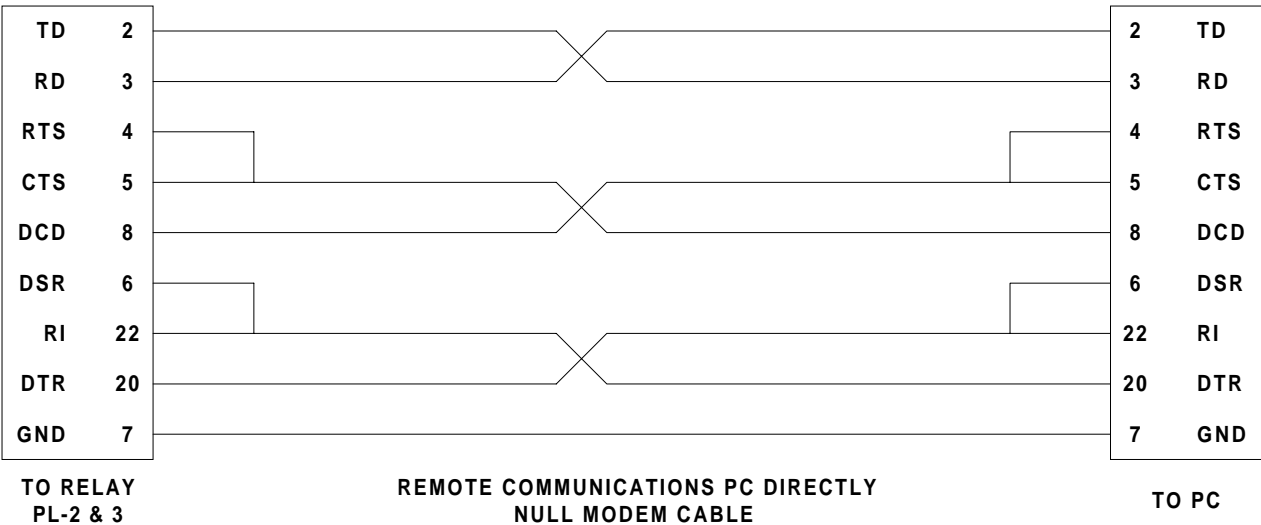


Figure 8–4: 25-PIN NULL MODEM CABLE

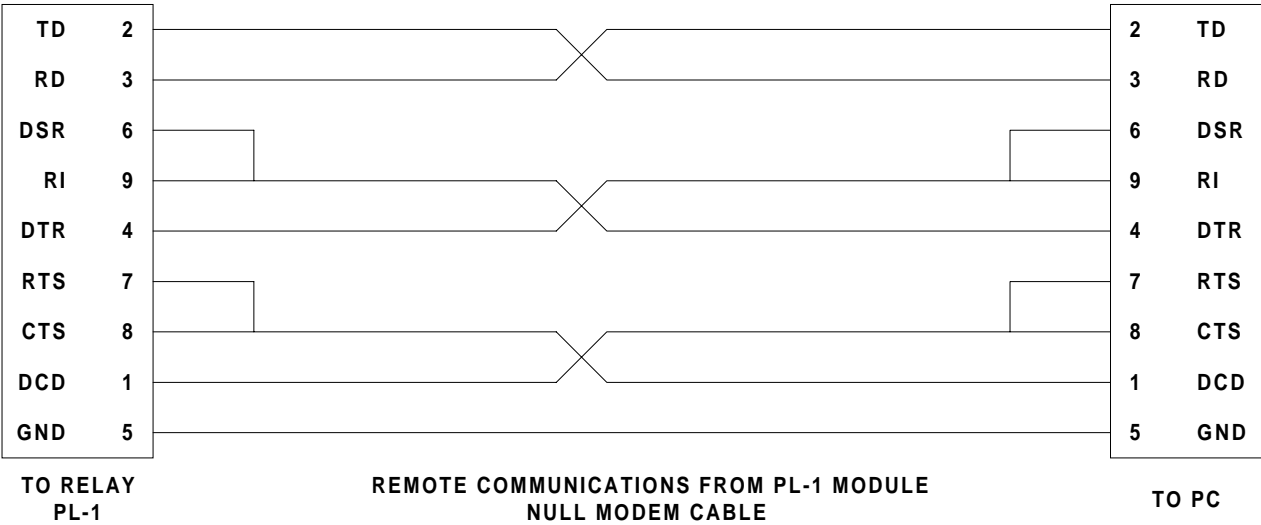


Figure 8–5: NULL MODEM CABLE FOR PORT PL1

Table 8–6: MODEM COMMANDS FOR COMMUNICATION BETWEEN RELAY AND PC

Function	LPS-O Modem (remote)	PC Modem (local)
DTR Status	Follow DTR (&D3)	Follow DTR (&D3)
Result Code Format	Numeric (V0)	Numeric (V0)
Result Code Display	Disable (Q1)	Disable (Q1)
Command State Echo	Disable (E0)	Disable (E0)
Auto-Answer	Enable (S0=1)	Disable (S0=0)
Carrier Detect	Follow CD (&C1)	Follow CD (&C1)
Jack Type	RJ-11, etc. (&J0)	RJ-11, etc. (&J0)
Command Recognition	Disable (Dumb)	Enable (Smart)
Comm. Std. (@1200 bps)	Bell 212A (B1)	Bell 212A (B1)
Response to DTR	Ignore DTR (&D0)	Ignore DTR (&D0)
Fall Back to 4800Bd	AT#F1	
Pulse Dial Ratio	39%Mk/61%Bk (&P0)	39%Mk/61%Bk (&P0)

9.1.1 DESCRIPTION

There are two servicing methods for the LPS-O:

- Spare board replacement.
- Component level repair.

The preferred method is board replacement using the LPS-O automatic self-tests to isolate failed boards. When the defective board is found, it can be replaced with a spare, and the system can be returned to service. This method typically yields the shortest system down-time. To further reduce down-time, we recommend keeping a complete set of spare boards at the maintenance center.

We do not recommend servicing the relay at the component level. This requires a substantial investment in test and repair equipment and in technical expertise, and usually results in longer down-time than board replacement. For those who do wish to troubleshoot to the component level, drawings can be requested from the factory. When you request drawings, you must supply the following information:

- The name of the board. This is found on the component side of the printed circuit board with the assembly number and revision.
- The assembly number of the LPS-O is an eight-digit number with a letter inserted between the fourth and fifth digit and with a group-identification suffix, such as 0215B8011G001.
- The revision number is found adjacent to the assembly number of the board.



CAUTION: Power down the relay by turning off the front panel power switch and disconnecting power from the rear connector before disassembling the unit. High voltage levels can be accessed at the power supply inputs.

9.2.1 DESCRIPTION

The LPS-O automatically performs tests of major functions and critical hardware components and reports their status via the LUI Display, status LED, and the non-critical and critical alarm contacts. The failure report is dependent on the type or level of failure. Some failures operate the critical alarm contact and the status LED, while others only operate the non-critical alarm contact.

There are three levels of self-test performed by the LPS-O:

1. The first level indicates severe relaying failures. These are indicated by a FAIL message on the display, the critical alarm contact opening, and the status LED turning red. These failures indicate that the relay is not providing protection.
2. The second level displays warning messages. They are indicated by a WARN message on the display and closure of the non-critical alarm contact. These failures indicate that the relay is still providing some degree of protection.
3. The third level indicates system status errors that are due to power system errors (Trip Circuit Open) or are caused by an LPS-O command that disables the relay (Disable Outputs). They are indicated by the closing of the non-critical alarm contact, a red status LED, or by the opening of the critical alarm contact. However, nothing is displayed until the Information Status command is issued.

The types of self-tests performed are described in Section 1.7: SELF-TEST FEATURES on page 1–18. The components tested during the start-up self-tests are listed in Table 9–1 below. The components tested during run-time background and foreground self-tests are listed in Tables 9–2 and 9–3 respectively

Table 9–1: COMPONENTS TESTED DURING START-UP TESTS

Component	Method	Processor	Nature
Flash Memory (PROM)	CRC-type check	960 CPU	Critical
EPROM	Checksum on DSP board	DSP	Critical
Local RAM	Patterns to check for stuck bits, stuck address lines, cross-talk between adjacent bits	960 CPU DSP	Critical
Shared RAM	Same as Local RAM	Both	Critical
Nonvolatile RAM CAPRAM Serial RAM	CRC-type check on settings area; checksum on fault storage area; duplicate locations on serial NVRAM	960 CPU	Critical if settings area or serial NVRAM
Timer Chip	Test all processor timers and their interrupts	960 CPU	Critical if ANI logic; non-critical if 960
Interrupt Controller	Test all 960 internal interrupts	960 CPU	Critical
Serial Chips	Wraparound and interrupt tests for serial interface	960 CPU	Non-critical
A/D Controller	DMA Interface	960 CPU	Critical
Digital Output Circuitry	Loop-back test	960 CPU	Critical
Digital Input Circuitry	Comparison of bits read via two separate optocouplers	960 CPU	Non-critical, turn off pilot protection
Real-Time Clock	Test of real-time clock operation and interrupts	960 CPU	Non-critical

Table 9–2: RUN-TIME BACKGROUND SELF-TESTS

Component	Method	Processor	Nature
Flash Memory (PROM)	CRC-type check	960 CPU	Critical, restart
EPROM	Checksum type check	DSP	Critical, restart
RAM	Protection values checked for correctness; Configurable logic checked for validity	960 CPU	Critical, restart
Nonvolatile RAM	CRC-type check on settings area	960 CPU	Non-critical
CAPRAM	Checksum on fault storage area	960 CPU	

Table 9–3: RUN-TIME FOREGROUND SELF-TESTS

Component	Method	Processor	Nature
A/D Controller	DMA interface	960 CPU	Critical
Digital Input Circuitry	Comparison of bits read via two separate optocouplers	960 CPU	Non-critical, turn off pilot protection
Digital Output Circuitry	Loop-back test	960 CPU	Critical, restart
Trip Circuit Continuity	Bit read via bus	960 CPU	Non-critical
LUI	Operator initiated, visual feedback	960 CPU	Non-critical

9.3.1 DESCRIPTION

Troubleshooting the LPS-O requires the following three steps:

1. Determine the relay status as either critical, non-critical, or miscellaneous.
2. Use the list of failure and warning codes or the Information Status command to determine the defective board(s).
3. Replace the defective board(s) in accordance with safety and static-discharge precautions.

NOTE: Refer to Chapter 4: ACCEPTANCE/PERIODIC TESTS for tests of the Local User Interface (LUI) display, keypad, and the measuring units.

9.3.2 THE INFORMATION STATUS COMMAND

Section 9.3.7: SERVICE SYSTEM STATUS FAILURES on page 9–6 contains the failure and warning codes that appear on the LCD display. The Information Status command should be used to obtain complete data about the relay status. The Information Status command can be used at the relay or remotely over a modem link.

The Information Status command is invoked as follows:

1. Apply rated DC power to the relay and wait for initialization to complete (if necessary).
2. Press the [INF] key, then scroll with the ↑ and ↓ keys until the LCD display indicates:

LPS status

3. Press the [ENT] key. The display indicates a failure with the words:

STATUS: FAIL

Press the ↑ key to get a detailed report of all the failures. A complete list of the possible errors is found in Section 9.3.7: SERVICE SYSTEM STATUS FAILURES on page 9–6. The FAIL and WARN messages are also included. Their descriptions may also be displayed with the Information Status command.

NOTE: After initial power up or a loss of power exceeding 24 hours, the time and date reset to 00:00:00 01/01/96. All event and fault data are reset.

Table 9–4: SYSTEM STATUS ERROR MESSAGES

Error	Indication	Description
WARN	NCA	Warn condition
FAIL	CA/LED	Fail condition
MISC	LED	Miscellaneous condition

LED: Red Status LED

CA: Critical alarm contacts close.

NCA: Non-critical alarm contacts close.

9.3.3 SERVICING A CRITICAL FAILURE

A critical failure denotes total interruption of protection. When a failure occurs on one of the boards (excluding the power supply), the critical alarm contact opens and the status LED turns red. Remove and re-apply DC power to display the fail message. If the LPS-O successfully restarts, the status LED turns green.

If the failure still exists, the status LED will be red and the critical alarm contact will be open. A FAIL message may also be on the display. The Fail message indicates the nature of the critical failure. It remains on the display until a key is pressed or until the LPS-O restarts successfully with no self-test failures. See Section 9.3.7: SERVICE SYSTEM STATUS FAILURES on page 9–6 for the list of mnemonic failure codes and their meanings.

NOTE: The Information–LPS Status command can be used to display all the current failures.

9.3.4 LOCATING THE DEFECTIVE BOARD

Use Section 9.3.7: SERVICE SYSTEM STATUS FAILURES on page 9–6 or the Information Status command to isolate the cause of the failure. Then refer to Figure 3–4: CIRCUIT BOARD LOCATIONS on page 3–4 to determine which board contains the defective logic module. When the suspected board is found, power down the LPS-O and replace the board.

The proper sequence for replacing a board is as follows:

1. Remove the four thumbscrews holding the plastic cover in place and lay aside with the plastic cover.
2. Turn the power switch off on the front panel.
3. Remove DC power from the LPS-O.



WARNING: Completely power down the relay by disconnecting the control DC power and by removing all voltage inputs to the rear terminals prior to opening the unit. Dangerous or lethal voltages may be present inside the unit *even if the power switch is OFF!*

4. Remove the four 3/16" hex nuts at the four corners of the front panel and carefully remove the front panel.
5. Disconnect the power and the ribbon cables from the front panel and lay the panel aside.
6. Remove the two ribbon cables and power cables from the front of the PC boards and lay aside.
7. Remove the PC board that connects the other PC board and lay aside in an anti-static bag.
8. Remove the defective PC board and place into an anti-static bag for storage or shipment.
9. Remove the replacement board from its anti-static container and insert into the LPS-O case.
10. Reinstall the connecting PC board.
11. Reinstall the ON/OFF switch cable and the two ribbon cables.
12. Reconnect the LCD display ribbon cable and the RESET/METERING cable to the front panel with the four 3/16" hex nuts.
13. Restore DC power to the LPS-O.
14. Turn on the front panel power switch.
15. Reinstall the plastic cover with the four thumbscrews.

If the FAIL message is gone, then the unit has been successfully repaired. If the message has changed, it is possible that another board requires replacement.

9.3.5 SERVICING A NON-CRITICAL FAILURE

A non-critical failure indicates an interruption potential in the LPS-O protection, but not a total loss. When a non-critical failure occurs, the LPS-O non-critical alarm contact closes but the LED remains green. Turn off the DC input power, then re-apply it. The **WARN xxx** message reappears if the failure still exists.

The non-critical failure message has the format **WARN xxx**. The **xxx** field is a numeric code that indicates the nature of the failure. The WARN message remains on the display until a key is pressed or until the LPS-O restarts successfully with no self-test failures. See Section 9.3.7 SERVICE SYSTEM STATUS FAILURES for the list of warning codes and their meanings.

NOTE: As an alternative, the Information Status command can be used to display the warning type directly on the LCD Display.

9.3.6 LOCATING THE DEFECTIVE BOARD

Use Section 9.3.7: SERVICE SYSTEM STATUS FAILURES or the Information Status command to isolate the cause of the failure. Power down the LPS-O and replace the suspected board, if appropriate. Reapply power. If the WARN message is gone the unit has been successfully repaired. If the message has changed, it is possible that another board requires replacement.

9.3.7 SERVICE SYSTEM STATUS FAILURES

A system failure indicates a failure of a power system input or that the relay has been disabled by a user command. It is indicated by the closing of the non-critical alarm contact, by a red LED, or by the closing of the critical alarm contact. However, no LCD display is provided until the Information Status command is invoked.

Turn off and reapply the DC input power. The non-critical alarm contact is closed if the failure still exists. Use the Information Status command to determine the cause of the trouble.

a) FAILURE MESSAGES: 960 CPU BOARD

- FAIL-FLASH MEMORY
- FAIL-STATIC RAM
- FAIL-STATIC RAM CRC
- FAIL-DPRAM 960 ACCESS
- FAIL-I960 INTRPT CONTROLLER
- FAIL-CPU TIMER
- FAIL-CPU EEPROM
- FAIL-CPU CAPRAM
- FAIL-CPU RTC
- FAIL-CPU WATCHDOG TIMER
- FAIL-S/W PROT CONSTANTS
- FAIL-S/W CONFIG. LOGIC
- FAIL-CONFIG S/W VERSION ERROR
- FAIL-CPU SYSTEM IN RESET
- FAIL-CPU SYSTEM SHUTDOWN
- FAIL-DO FEED BACK
- FAIL-LUI LCD DISPLAY
- FAIL-IRIGB
- FAIL-TRIP CKT #1 CONTINUITY ERROR
- FAIL-TRIP CKT #2 CONTINUITY ERROR
- FAIL-TRIP CKT #3 CONTINUITY ERROR
- FAIL-TRIP CKT #4 CONTINUITY ERROR
- FAIL-TRIP CKT #5 CONTINUITY ERROR*
- FAIL-TRIP CKT #6 CONTINUITY ERROR*
- FAIL-CONFIG H/W MISMATCH
- FAIL-NO DMA INTERRUPT
- FAIL-RUNTIME SETTINGS AREA
- FAIL-EEP CONTENTS ERROR
- STAT-DO DISABLED HARDWARE

b) FAILURE MESSAGES: MAGNETICS MODULE

- FAIL-MAG SEEPROM

c) FAILURE MESSAGES: COMMUNICATIONS WARNINGS

- FRONT PORT LOGIN FAILURE
- REAR PORT #1 LOGIN FAILURE
- REAR PORT #2 LOGIN FAILURE
- WARN-FRONT PORT FAIL
- WARN-REAR PORT #1 FAIL
- WARN-REAR PORT #2 FAIL
- WARN-REAR PORT 1 ABSENT
- WARN-REAR PORT 2 ABSENT

d) FAILURE MESSAGES: MISCELLANEOUS FAILURES

- CON MONITOR ALARM
- UNBALANCED SYS ALARM
- FUSE FAILURE
- TRIP BUS CHK FAIL
- TIME STROBE FAIL

e) FAILURE MESSAGES: MISCELLANEOUS MESSAGES

- WARN-LUI KEYPAD ERROR
- WARN--RTC
- WARN-DIGITAL INPUT LOGIC
- WARN-LCD DISPLAY
- ACTIVE GROUP SWITCH THROUGH CCs
- LUI PASSWORDS DISABLED
- DISABLED OUTPUTS
- DO DISABLED-SOFTWARE
- DO DISABLED-HARDWARE
- RELAY TEST
- DIGITAL OUTPUT TEST
- CHANNEL TEST
- PLAYBACK

f) FAILURE MESSAGES: ANI / DSP BOARD

- FAIL-ANI ADC CONTROLLER
- FAIL-ANI ADC SEEPROM
- FAIL-ANI REF. VOLTAGE
- FAIL-ANI ZERO CROSSING LOGIC
- FAIL-DMA NO INTERRUPT
- FAIL-DI INPUT LOGIC
- FAIL-SERIAL EEP READ
- FAIL-FREQUENCY OUT OF RANGE
- FAIL-DSP PROGRAM ROM
- FAIL-DSP INTERNAL RAM
- FAIL-DSP INTERNAL RAM CRC
- FAIL-DSP DPRAM DSP ACCESS
- FAIL-DSP 960-DSP INTERRUPT
- FAIL-RUN TIME DPRAM CHECKSUM
- FAIL-DI SERIAL EEPROM
- FAIL-DO SERIAL EEPROM
- FAIL-DSP SETTINGS
- FAIL-DSP TABLES
- FAIL DSP I960 HANDSHAKE
- FAIL-DSP IN RESET
- FAIL-DSP S/W VERSION
- FAIL-DSP IN SHUTDOWN
- FAIL - ANI VREF1
- FAIL - ANI VREF2
- FAIL - ANI VREF3
- WARN-COMM FRONT PORT FAIL
- WARN-COMM REAR PORT #1 FAIL
- WARN-COMM REAR PORT #2 FAIL
- WARN-COMM LUI KEYPAD ERROR
- STAT-DI ERROR CORRECTED

10.1.1 DESCRIPTION

The ALPS-Test program is designed to be used with both the ALPS and LPS series of relays. ALPS-Test is used to generate test data for the measuring units in the LPS-O relay for the settings specified by the user. This data can be used to validate your test data.

In order to run the program, the following files need to be installed in a directory of the tester's choice.

ALPS_TST.EXE
ALPS_TST.INI
ALPS_TST.HLP
PUSHHELP.VBX

10.1.2 STARTING THE PROGRAM FOR THE FIRST TIME

Install the program from the GE Power Management Products CD or from the GE Power Management Web site at www.ge.com/indsys/pm. See Section 11.2.4: SOFTWARE INSTALLATION on page 11–4 for instruction on installing the LPS-O software suite. This installation procedure will install ALPS-Test along with the LPSO-Link and Xpression Builder software packages.

When the program is started, the following screen is displayed.

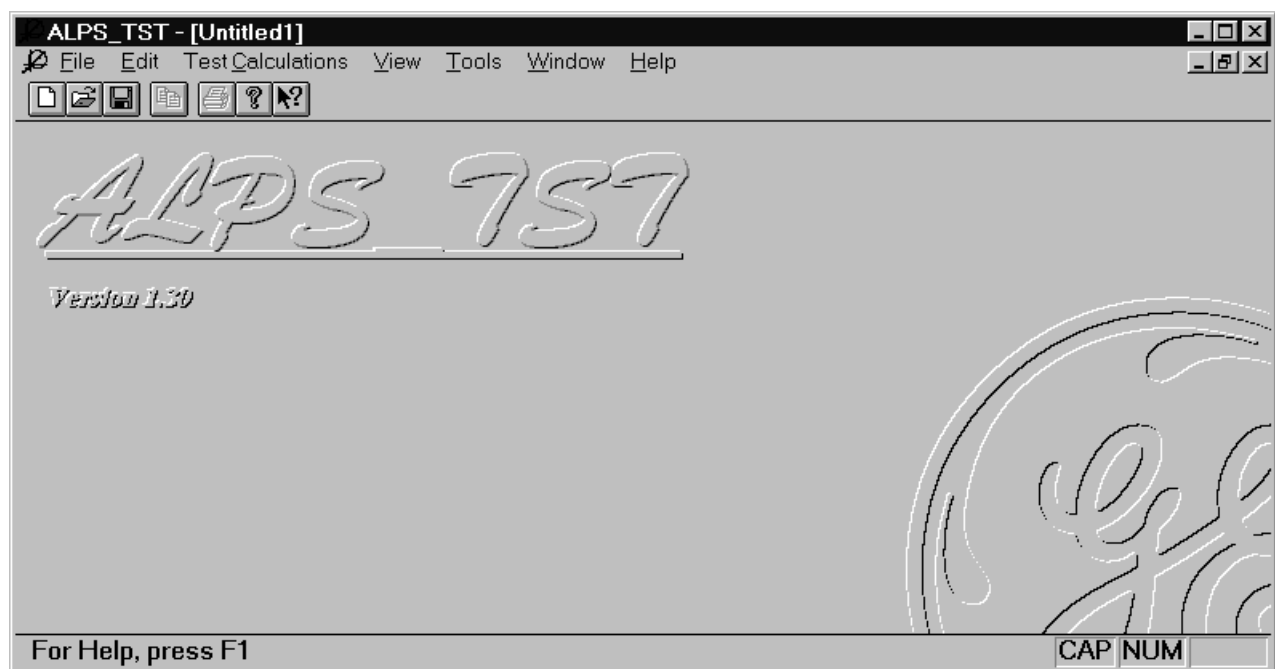


Figure 10–1: ALPS-TEST INITIAL SCREEN

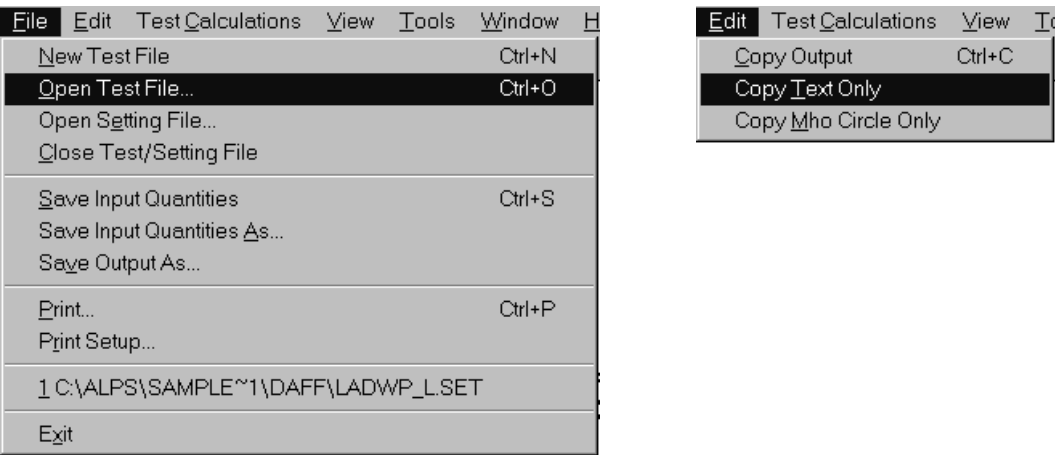


Figure 10-2: FILE AND EDIT MENUS

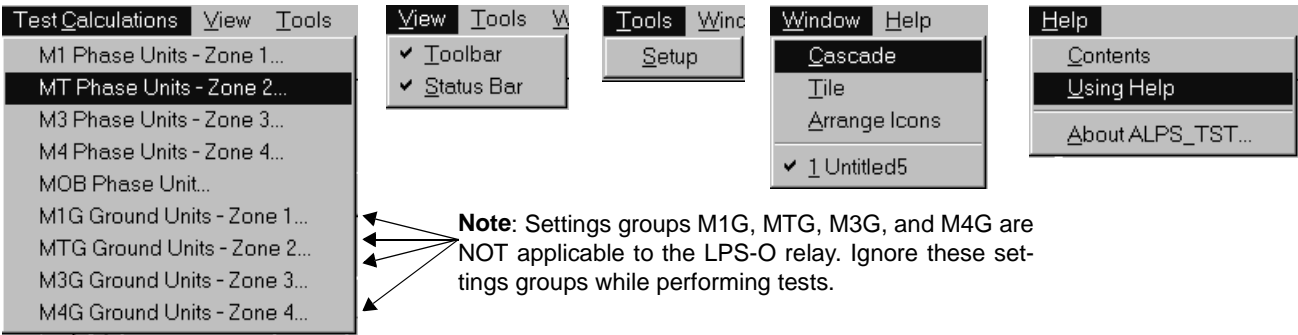


Figure 10-3: ADDITIONAL ALPS-TEST MENUS

10.1.3 STARTING PROGRAM AFTER THE FIRST TIME

Start the program as in the previous section. When the program is started, the opening screen is displayed as in Figure 10-1: ALPS-TEST INITIAL SCREEN on page 10-1.

- The title bar of the main window has the currently opened file name which is the file name the user selected
- Pull down the **File** menu. The most recent file is this same file name.

10.2.1 DESCRIPTION

The following is the user input quantities and their ranges. Each test does not use all the quantities. The default values are used for only the first test dialog box displayed for each new test.

Table 10-1: INPUT QUANTITIES

INPUT QUANTITY	RANGE	DEFAULT VALUES
Rated current	1 or 5 amp(s)	1 amp
Reach (Reach in forward / reverse direction)	1 amp: 0.01 to 250.00 5 amp: 0.01 to 50.00	0.01
Positive Sequence Reach Angle	45 to 90 degrees	45 degrees
Characteristic Timer	M1: 90 degrees MT: 90 to 120 degrees in steps of 5 M3: 90 to 120 degrees in steps of 5 M4: 80 to 120 degrees in steps of 5 MOB: 30 to 130 degrees	90 degrees for all
Test Current	calculated	high limit of range
Degrees to increment angle	5,10, 15	5
Phase angle reference	V[øG], V[øø]	V[øø]
Zero Sequence Reach Angle	45 to 90 degrees	45
I0 Compensation Factor, K0	1.0 to 7.0	1.0
Direction	forward, reverse	reverse
Offset Reach (times main reach)	0 to 0.4	0
Replica Impedance Angle	Calculated for output only	N/A
Effective Test Reach	Calculated for output only	N/A

10.2.2 ENTERING INPUT QUANTITIES

When the user clicks on a **Select** button from a **TestCalculations** dialog box, the **Enter Value** dialog box is displayed. This dialog box has two modes, one is to enter a value for a continuous range of values and the other is to select a value from a list of values. Select the **Help** button from the **Enter Value** dialog box. A help screen is displayed describing how to use this dialog box.

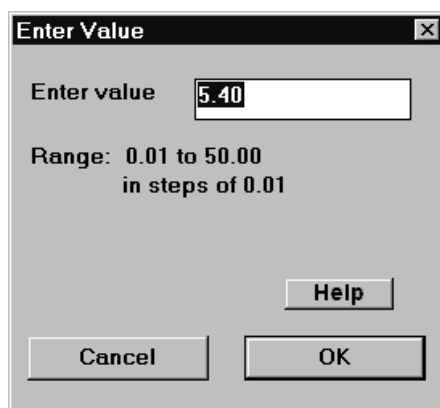


Figure 10-4: ENTER VALUE DIALOG BOX

10.2.3 ENTERING A VALUE

Click on a **Select** button from one of the test dialog boxes (**M1 Phase Units – Zone 1** is shown below) for an input quantity that has a continuous range.

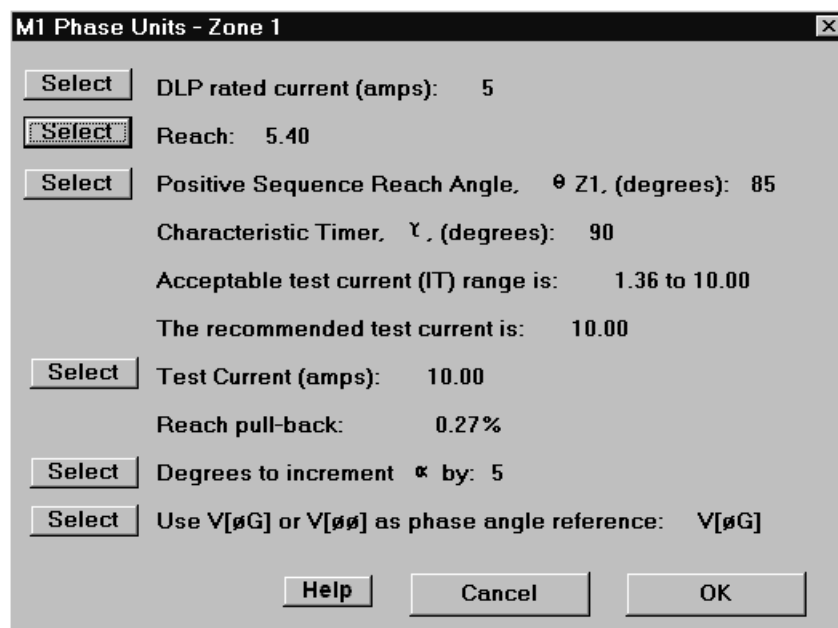


Figure 10-5: INPUT TEST DIALOG BOX: M1 PHASE UNITS – ZONE 1

For **Test Current (amps)**, the following dialog box is displayed:

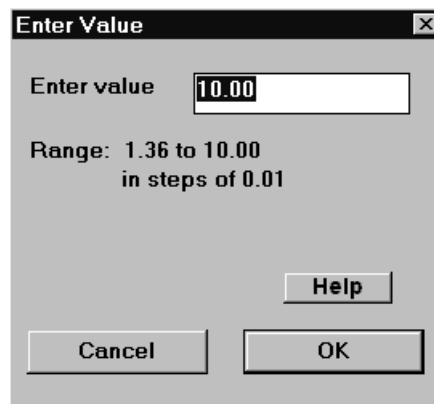


Figure 10-6: ENTER VALUE DIALOG BOX

Enter a valid new value and click on **OK**. The dialog box clears from the screen and the value in the test dialog box is changed to the value just entered.

10.2.4 SELECTING A VALUE

Click on a **Select** button from one of the test dialog boxes (see Figure 10-5: INPUT TEST DIALOG BOX: M1 PHASE UNITS – ZONE 1 on page 10-4 for an example) for an input quantity that has a list of values. An **Enter Value** dialog box appears.

Select a new value and click on **Cancel**. The dialog box clears from the screen and the value in the test dialog box remains unchanged.

Select a new value and click on **OK**. The dialog box clears from the screen and the value in the test dialog box is changed to the value just entered.

10.2.5 M1 PHASE UNITS – ZONE 1

The following dialog box is displayed for this test. The values are the default values used when the user selects **New Test File** from the **File** menu.

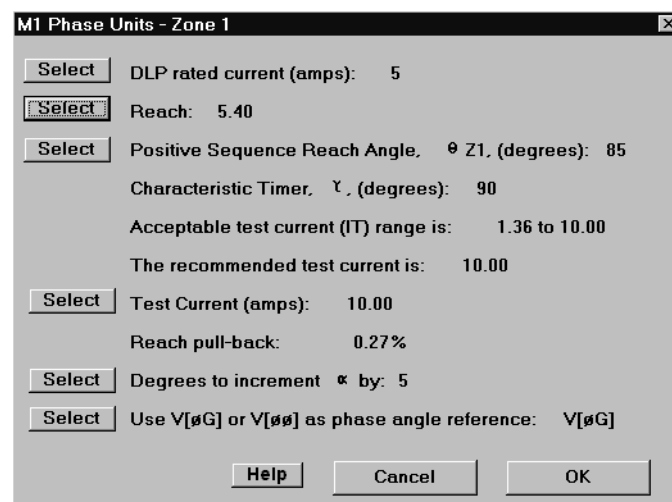


Figure 10-7: M1 PHASE UNITS – ZONE 1 DIALOG BOX

10.2.6 MT PHASE UNITS – ZONE 2

The following dialog box is displayed for this test. The values are the default values used when the user selects **New Test File** from the **File** menu.

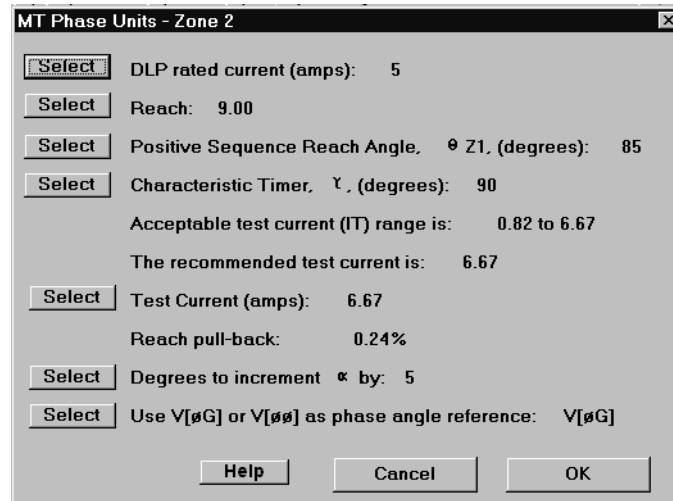


Figure 10–8: MT PHASE UNITS – ZONE 2 DIALOG BOX

10.2.7 M3 PHASE UNITS – ZONE 3

The following dialog box is displayed for this test. The values are the default values used when the user selects **New Test File** from the **File** menu.

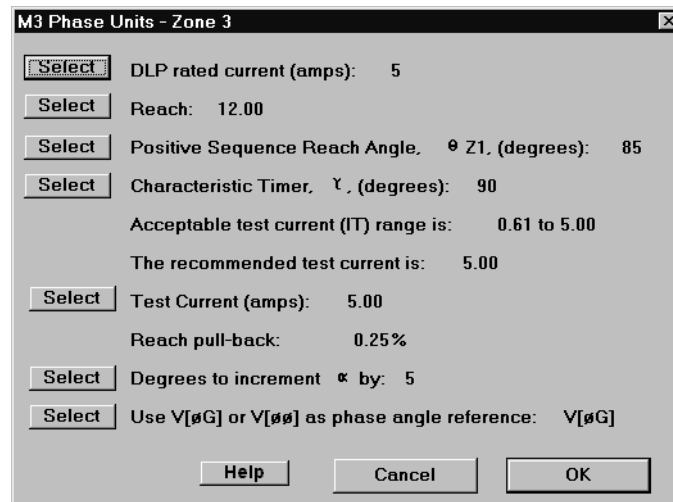


Figure 10–9: M3 PHASE UNITS – ZONE 3 DIALOG BOX

10.2.8 M4 PHASE UNITS – ZONE 4

The following dialog box is displayed for this test. The values are the default values used when the user selects **New Test File** from the **File** menu.

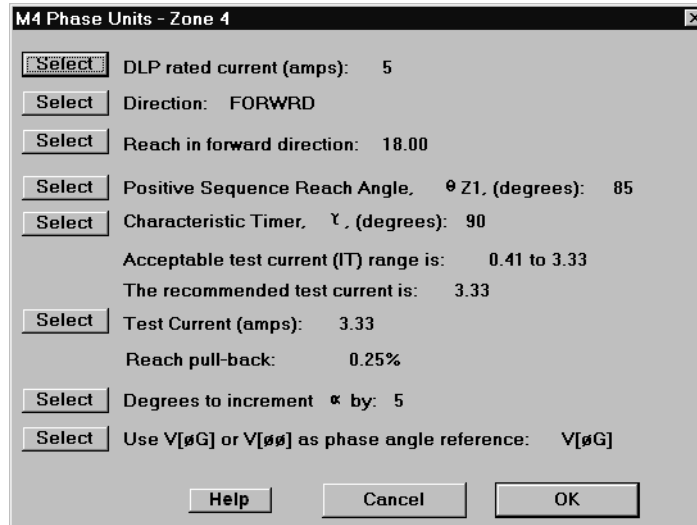


Figure 10–10: M4 PHASE UNITS – ZONE 4 DIALOG BOX

10.2.9 MOB PHASE UNIT

The following dialog box is displayed for this test. The values are the default values used when the user selects **New Test File** from the **File** menu.

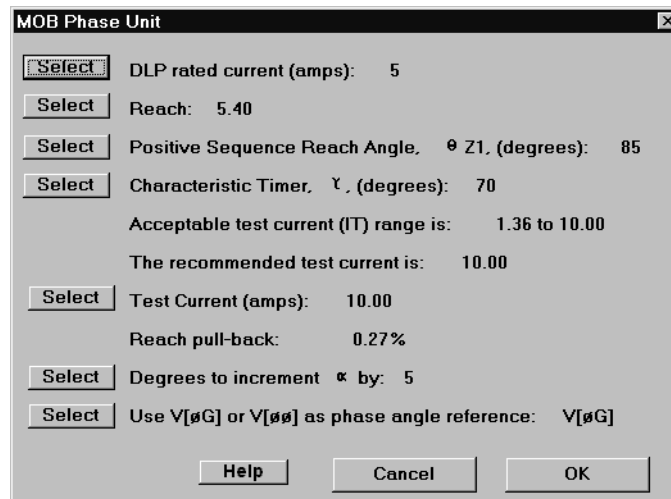


Figure 10–11: MOB PHASE UNIT DIALOG BOX

10.3.1 NEW TEST FILE

The **File** menu is shown below:

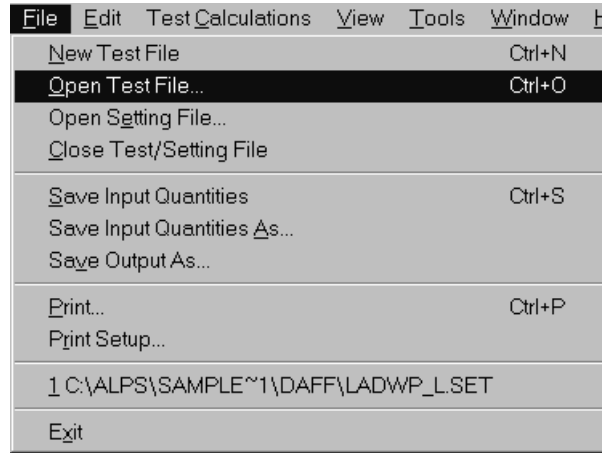


Figure 10–12: FILE MENU

Select **New Test File** from the **File** menu. This will create a new test which is indicated by the GE logo being displayed and the test name **Untitledx** in the title bar where **x** is a digit corresponding to the number of new documents created.

10.3.2 OPEN TEST FILE

This menu item results in a dialog box supplied by Microsoft. Therefore only the **OK** button of the dialog box is tested to make sure the file was properly opened.

Select **Open Test File** from the **File** menu. Select a file that is not a test file and not a setting file. A message box is displayed that explains the error. Verify that the currently active test has not changed from before the open command.

Edit an existing test file using a text editor. Add a line to the file. Select **Open Test File** from the **File** menu. Select the edited file. A message box is displayed that explains the error. Verify that the currently active test has not changed from before the open command.

Edit an existing test file using a text editor. Remove a line which contains a user entered value that is not a default value. Select **Open test File** from the **File** menu. Select the edited file. A message box is displayed explaining the error. Verify that the test file is still loaded and that the missing value has its default value.

Select **Open Test File** from the **File** menu. Select a test file containing no errors and click the **OK** button to open it. Select a test. Verify that the values in the dialog box are the same as those in the file (see the Save Input Quantities section).

10.3.3 OPEN SETTING FILE

The following is a list of protection setting numbers whose values are used by this test program.

102	Z1PREACH	Z1 Phase Reach
202	Z2PHREACH	Z2 Phase Reach
203	Z2PCHARANG	Z2 Phase Characteristic Angle

302	Z3PHREACH	Z3 Phase Reach
303	Z3PCHARANG	Z3 Phase Characteristic Angle
402	Z4PHREACH	Z4 Phase Reach
403	Z4PCHARANG	Z4 Phase Characteristic Angle
1401	POSSEQANG	Pos. Seq. Impedance Angle
1402	ZERSEQANG	Zero Seq. Impedance Angle
1404	ZEROSEQK0	Z0 / Z1 ratio
1601	MOBZONE	Coordinating Zone
1602	MOBCHARANG	MOB Characteristic Angle

This menu item results in a dialog box supplied by Microsoft. Therefore only the **OK** button of the dialog box is tested to make sure the file was properly opened.

Select **Open Setting File** from the **File** menu. Select a file that is not a setting file and not a test file.

Verify the following:

- A message box is displayed that explains the error.
- The currently active test has not changed from before the open command.

Select **Open Setting File** from the **File** menu. Select a setting file containing no errors and click the **OK** button to open it. Select each test.

Verify that the values in each dialog box which correspond to settings are the same as those in the setting file.

Edit an existing setting file using a text editor. Remove a setting line which contains a user entered value. Select **Open Setting File** from the **File** menu. Select the edited setting file. Select a test that uses the setting value that was deleted.

Verify the following:

- No error message is displayed.
- The corresponding test value is the default value.

10.3.4 CLOSE TEST FILE

Save the currently active test file. Select **Close Test File** from the **File** menu. Window is cleared from the screen thus closing the test.

Modify the currently active test file. Select **Close Test File** from the **File** menu. A message box will be displayed asking if you want to save the file. Click the **OK** button. The file is saved under the current name. The window is cleared from the screen thus closing the test.

- Verify that the file contains the modified values by looking at the file with a text editor.

Modify the currently active test file. Select **Close Test File** from the **File** menu. A message box will be displayed asking if you want to save the file. Click the **Cancel** button. The file is not closed.

Verify the window is not cleared from the screen and that the test file contains the modified inputs.

Modify the currently active test file. Select **Close Test File** from the **File** menu. A message box will be displayed asking if you want to save the file. Click the **No** button. The file is not saved. The window is cleared from the screen thus closing the test.

- Verify that the file does not contain the modified values by looking at the file with a text editor.

Open a new test file. Select **Close Test File** from the **File** menu. A message box will be displayed asking if you want to save the file. Click the **OK** button. The **Save Input Quantities As** dialog box will be displayed. Enter a name for the test and select the **OK** button. The test is saved. The window is cleared from the screen thus closing the test.

- Verify that the file contains the values displayed in the test dialog boxes by looking at the file with a text editor.

10.3.5 SAVE INPUT QUANTITIES

Select a test where the input quantities have been changed and not saved. Select **Save Input Quantities** from the **File** menu. The test is saved.

Verify the file format:

- Read the file using any text editor. The saved file is in ASCII format.
- There is a line for each input quantity listed in Table 1 regardless of whether a particular input quantity was used for the test.
- Each line contains the value's ID number, the value, and a brief description of the quantity. Each item on the line is separated by spaces.
- There is one section for each test.

Verify file can be re-opened:

- Close the test file that was just saved.
- Open the saved test file.
- Select the menu item for the test.
- Verify that the quantities in the dialog box are the same as in the test just saved.

Create a new test. Select **Save Input Quantities** from the **"File"** menu. The **Save Input Quantities As** dialog box will be displayed. Enter a name for the test and select the **OK** button. The test is saved.

Verify the saved test as above.

10.3.6 SAVE INPUT QUANTITIES AS

This menu item results in a dialog box supplied by Microsoft. Therefore only the "OK" button of the dialog box is tested.

Select **Save Input Quantities As** from the **File** menu. Select a drive, path, and file name to save the input quantities of test.

Verify that this item worked by following the same procedure as for the **Save Input Quantities** menu item.

10.3.7 SAVE OUTPUT AS

This menu item results in a dialog box supplied by Microsoft. Therefore only the "OK" button of the dialog box is tested.

Select **Save Output As** from the **File** menu. Select a drive, path, and file name from the dialog box to save the test output. Click on **OK** and the file is saved.

10.3.8 PRINT

This menu item results in a dialog box supplied by Microsoft. Therefore only the **OK** button of the dialog box is tested.

Select **Print** from the **File** menu. This is a standard MS-Windows dialog box. It behaves however Microsoft and MS-Windows determines it should behave. There is one exception, both the **Selection** and **Pages** buttons are disabled. Click on **OK**. The output is printed as it appears on the screen.

10.3.9 PRINT SETUP

This menu item results in a dialog box supplied by Microsoft. It can be tested only to the extent that it does get displayed and that it behaves in the same manner as other similar dialog boxes in other programs.

Select **Print Setup** from the **File** menu. This is a standard MS-Windows dialog box. It behaves however Microsoft and Windows determines it should behave.

10.3.10 LAST 4 OPENED SETTINGS FILES

The last 4 opened settings files are displayed in the File menu, and may be selected here.

10.3.11 EXIT

Save all open test files (windows). Select **Exit** from the **File** menu. The program exits.

If you have not saved the current file, select **Exit** from the **File** menu. A message box is displayed asking if you want to save the modified test. Click on **OK**. The program saves the file and exits.

10.4.1 COPY

The **Edit** menu is shown below.

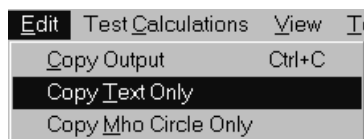


Figure 10–13: EDIT MENU

Select a test, set the input quantities to the desired values, and click the **OK** button.

Select **Copy** from the **Edit** menu.

10.4.2 COPY TEXT ONLY

Select a test, set the input quantities to the desired values, and click the “**OK**” button.

Select **Copy Text Only** from the **Edit** menu.

10.4.3 COPY MHO CIRCLE ONLY

Select a test, set the input quantities to the desired values, and click the **OK** button.

Select **Copy Mho Circle Only** from the **Edit** menu.

To use the output that is on the clipboard:

- Start Windows Application.
- Select **Paste Special** from the **Edit** menu. There is one item on the clipboard, a bitmap.
- Select the bitmap and paste into the current document.

10.5.1 DESCRIPTION

These menu items are supplied and manipulated by Microsoft. Therefore the testing will be brief as these items behave however Microsoft and the Windows operating system determines they should behave. The one exception is the items on the toolbar.

10.5.2 TOOLBAR

The items on the toolbar (shown below) are, from left to right:



Figure 10-14: ALPS-TEST TOOLBAR

- Create a new test file.
- Open an existing test file.
- Save the current test file.
- Copy the current test output to the clipboard
- Print the current test output.
- Display the “About” dialog box.
- Context Help command.

Select the **View > Toolbar** menu item. The toolbar is removed from the display.

Select the **View > Toolbar** menu item again. The toolbar is displayed.

10.5.3 STATUS BAR

Verify the items on the status bar (shown below):

For Help, press F1

NUM SCRL

Figure 10-15: ALPS-TEST STATUS BAR

- The left portion displays a short description of each menu item.
- The right most area displays **SCRL** if the scroll lock key has been selected and displays nothing if the scroll lock key has been de-selected.
- The area to the left of the scroll lock area displays **CAP** if the caps lock key has been selected and displays nothing if the caps lock key has been de-selected.
- The area to the left of the caps lock area displays **NUM** if the num lock key has been selected and displays nothing if the num lock key has been de-selected.

Select the **Status Bar** menu item. The status bar is removed from the display.

Select the **Status Bar** menu item again. The status bar is displayed.

10.6.1 DESCRIPTION

There is one menu item **Setup**. Click on **Setup** and the following dialog box is displayed.

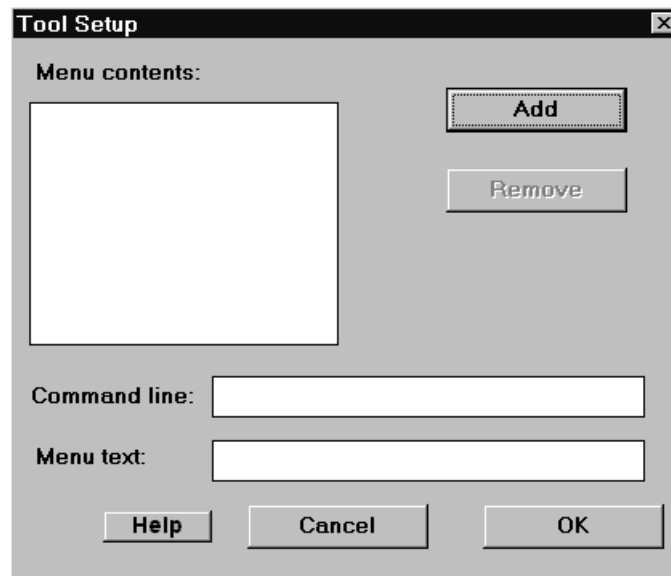


Figure 10-16: TOOL SETUP DIALOG BOX

The **Remove** button and the **Command line** and **Menu text** boxes are disabled, and that the focus is set to the **Add** button.

Type the **Enter** key or click on the **Add** button. The **Add Tool** dialog box is displayed. This is a standard MS-Windows dialog box. Select an executable windows program and click on the **OK** button.

- The full path and name is in the **Command line** text box
- The program name less the extension is in the **Menu text** box
- The program name less the extension is the **Menu contents** list box
- The **Remove** button is enabled
- The focus is set to the **Menu text** box.

Change the text in the **Menu text** box to text suitable for the tools menu. Click anywhere in the **Command line** text box.

- Verify that the new menu name is displayed in the **Menu contents** list box.

Change the command line so that it is invalid (for example, remove a character from the program name). Click on the **OK** button. Pull down the **Tools** menu.

Verify the following:

- There is one tool followed by a separator bar and the **Setup** menu item.
- The tool's name is correct.

Click on the tool.

- Verify that an error message is displayed indicating that the program couldn't be started.

Select the **Setup** menu item again.

- The focus is set to the first item in the **Menu contents** list box.
- The menu text is in the **Menu text** box.
- The **Command line** text box has the invalid path name.

Change the path name to the correct path. Click on the **OK** button. Pull down the **Tools** menu and click on the tool.

- Verify that the program started.

Select the **Setup** menu item again. Add a second tool.

- Verify that the tool gets added after the first tool.

Click on the **OK** button. Pull down the **Tools** menu.

Verify the following:

- There are two tools and they are in the correct order.
- The two tools are followed by a separator bar and the **Setup** menu item.

Select the **Setup** menu item again. Leave the first item in the **Menu contents** list box selected. Add a third tool.

Verify that the tool gets added after the first tool and before the second tool.

Click on the **OK** button. Pull down the **Tools** menu.

- There are three tools and they are in the correct order.
- The three tools are followed by a separator bar and the **Setup** menu item.

To Remove a tool, select the **Setup** menu item again. Select the second item in the **Menu contents** list box. Click on the **Remove** button.

- Verify that the selected item gets removed from the **Menu contents** list box and that the item immediately below the one removed is selected.

Click on the **OK** button. Pull down the **Tools** menu.

- Verify that there are two tools and they are in the correct order.
- The two tools are followed by a separator bar and the **Setup** menu item.

10.7.1 DESCRIPTION

These menu items are supplied and manipulated by Microsoft. Therefore the testing will be brief as these items behave however Microsoft and the Windows operating system determines they should.

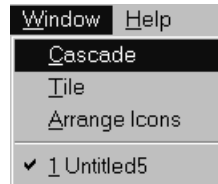


Figure 10–17: WINDOW MENU

10.7.2 CASCADE

Have more than one test file active in the program. Select the **Cascade** menu item. The windows are displayed in a cascaded style.

10.7.3 TILE

Have more than one test file active in the program. Select the **Tile** menu item. The windows are displayed in a tiled style.

10.7.4 ARRANGE ICONS

Select a test and click on its icon button (upper right corner of window). The window is reduced to an icon with its test name under it. Perform this action on several tests.

Move the icons around on the screen.

Select the **Arrange Icons** menu item. The icons are rearranged across the bottom of the screen.

10.7.5 VIEWING MULTIPLE TESTS

When more than one test file active in the program. Pull down the **Window** menu. The menu shows all the active test windows.

10.8.1 CONTENTS

The **Help** menu is shown below.

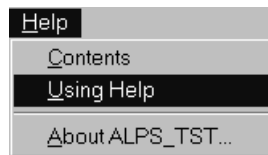


Figure 10–18: HELP MENU

Select **Contents** from the **Help** menu. A help screen is displayed that lists the contents of the help system. Any item that is green can be clicked on to view that topic.

10.8.2 ABOUT ALPS_TST

Select **About ALPS_TST** from the **Help** menu. The following dialog box indicating the installed version number is displayed.

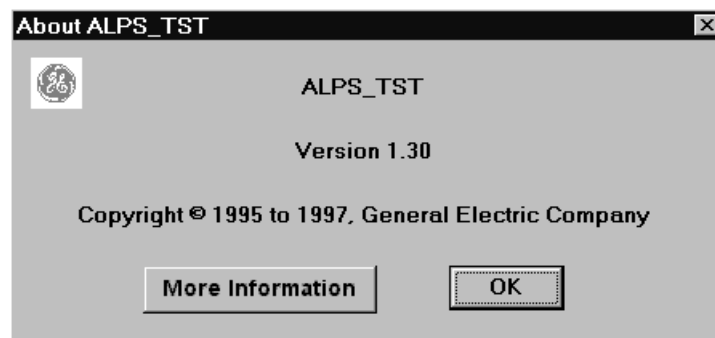


Figure 10–19: ABOUT ALPS_TST DIALOG BOX

Click on the **More Information** button. Information about who to contact is displayed.

Click on **OK**. The dialog box is cleared from the screen.

11.1.1 DESCRIPTION

The Line Protection System Link (LPSO-Link) User Guide contains detailed information about using LPSO-Link. This software is designed to be used with both the ALPS and LPS series of relays.

The LPSO-Link software facilitates various operations with the data from the relay formatted for easy viewing. The link software has the capability of opening a dialog session for a remote device through a dial-up modem or directly over a serial link. The software uses the GEModem communications protocol to operate the relay remotely. All the operations performed on a device will be initiated by a user command. The responses from the relay will be formatted for easy viewing.

11.1.2 WHAT'S INCLUDED IN YOUR LPSO-LINK USER GUIDE

This guide is organized as a comprehensive reference. In addition to the information needed to help you use the LPSO-Link to interact with the relay, this manual also includes some basic information for those users with little experience of working with Windows applications.

11.1.3 USING ON-LINE HELP

LPSO-Link software comes with on-line help for quick reference. It includes step-by-step procedures that you can follow as you work. You can view the LPSO-Link Contents window by choosing Contents from the Help menu. From this window, you can jump to more specific information. You can also press the F1 key on the keyboard to get the Help contents. Help information on any dialog box could be obtained by clicking the Help button in that dialog box.

11.2.1 DESCRIPTION

This section describes the required system hardware and software needed for installing LPSO-Link software on your machine.

11.2.2 SUPPORTED ARCHITECTURE

The minimum system configuration required to run LPSO-Link software is:

Personal Computer (PC) with an Intel 80386 or better processor with:

- 8 MB RAM
- minimum 200 MB of free Hard Disk space
- CD-ROM if using GE Products CD
- VGA / EGA or better display card and monitor
- PC/AT keyboard
- One or more RS-232 serial ports
- One parallel port for printer
- Mouse
- Any printer supported by Microsoft Windows
- Windows 95, Windows 98, Windows NT, Windows 3.1

The LPS-O relays can be connected to the host machine directly or through a dial-up modem. The LPS-O may be connected directly to the hosts RS232 port; for connection via the LPS-O RS485 port, an RS485/RS232 converter is required. If you wish to connect to your LPS-O over a dial-up modem, the relays should be connected as follows:

- Each device must have its own modem.
- A Code Operated Switch (COS) is attached to the modem and a number of devices are connected to the multiplexor. If a device is on an RS485 line, a converter can be used between the device and the COS.

The printer is connected to the parallel port of the PC.

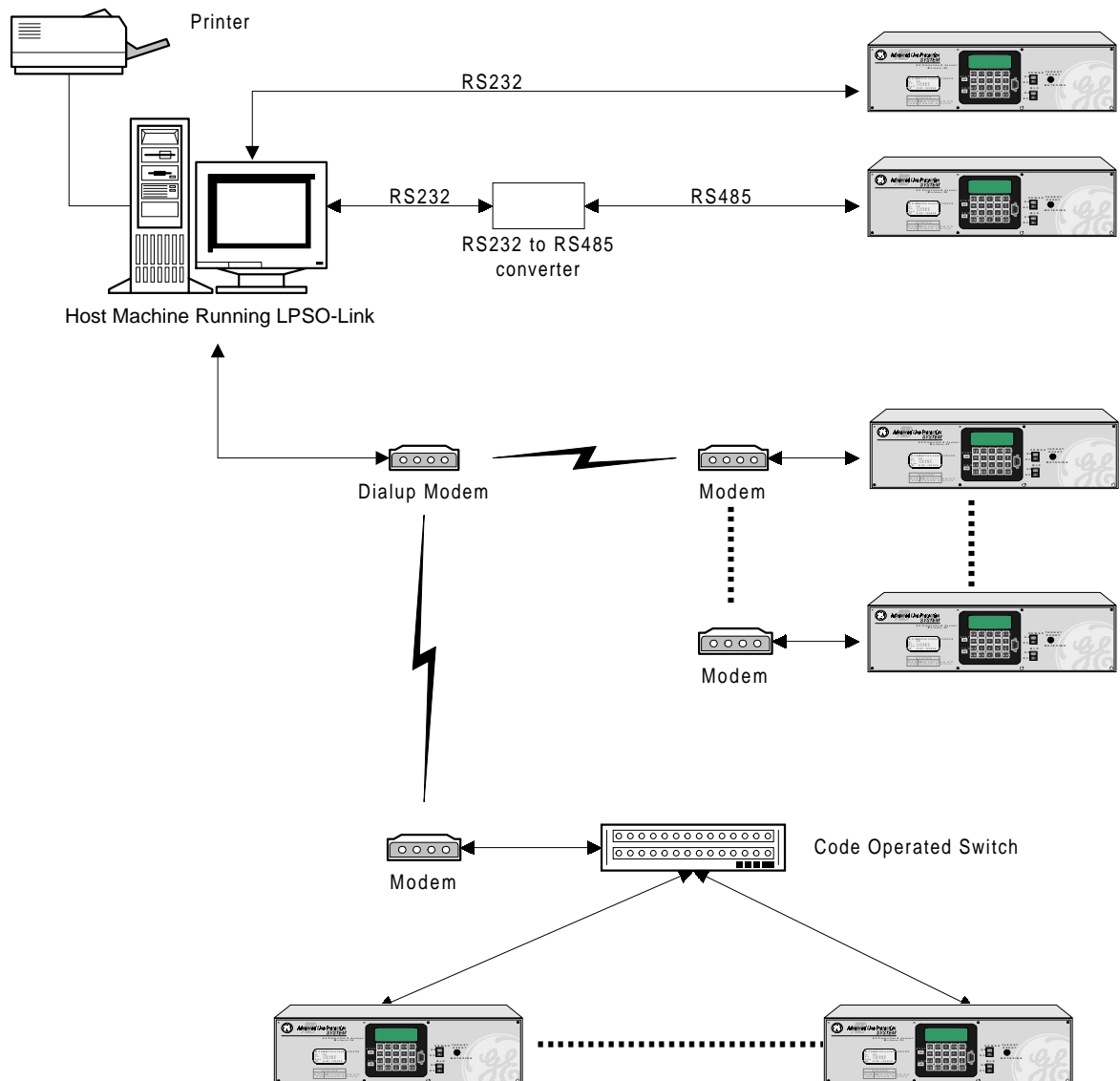


Figure 11-1: SUPPORTED ARCHITECTURE

11.2.3 HARDWARE INSTALLATION

Before proceeding verify that your computer is working well and meets the requirements above.

Connect the printer to the parallel port of the PC. You may have to choose an appropriate printer driver using the Windows Print Manager. For more details refer to the printer's installation manual.

It is assumed that the relay is installed and configured according to the Interface section of this instruction book.

11.2.4 SOFTWARE INSTALLATION

Microsoft Windows must be installed on your PC before proceeding with LPSO-Link Installation. Installation of the LPS-O software suite will install **all** of the following software packages: LPSO-Link, ALPS-Test, and Xpression Builder.

a) INSTALLING FROM PRODUCTS CD

To install LPSO-Link from the Products CD:

1. Start Windows.
2. Insert the GE Power Management Products CD into your local CD-ROM drive. The CD-ROM autorun utility will automatically load the page shown in Figure 11–2: GEPM PRODUCTS CD PRIMARY SCREEN into your default web browser.



Figure 11–2: GEPM PRODUCTS CD PRIMARY SCREEN

3. From the menu on the left of the page, click **Software**. This will display a list of software indexed alphabetically by product. Click **LPS Line Protection System** from the list.
4. The Software page for the LPS-O relay will be displayed as shown in Figure 11–3: LPS-O SOFTWARE PAGE below.

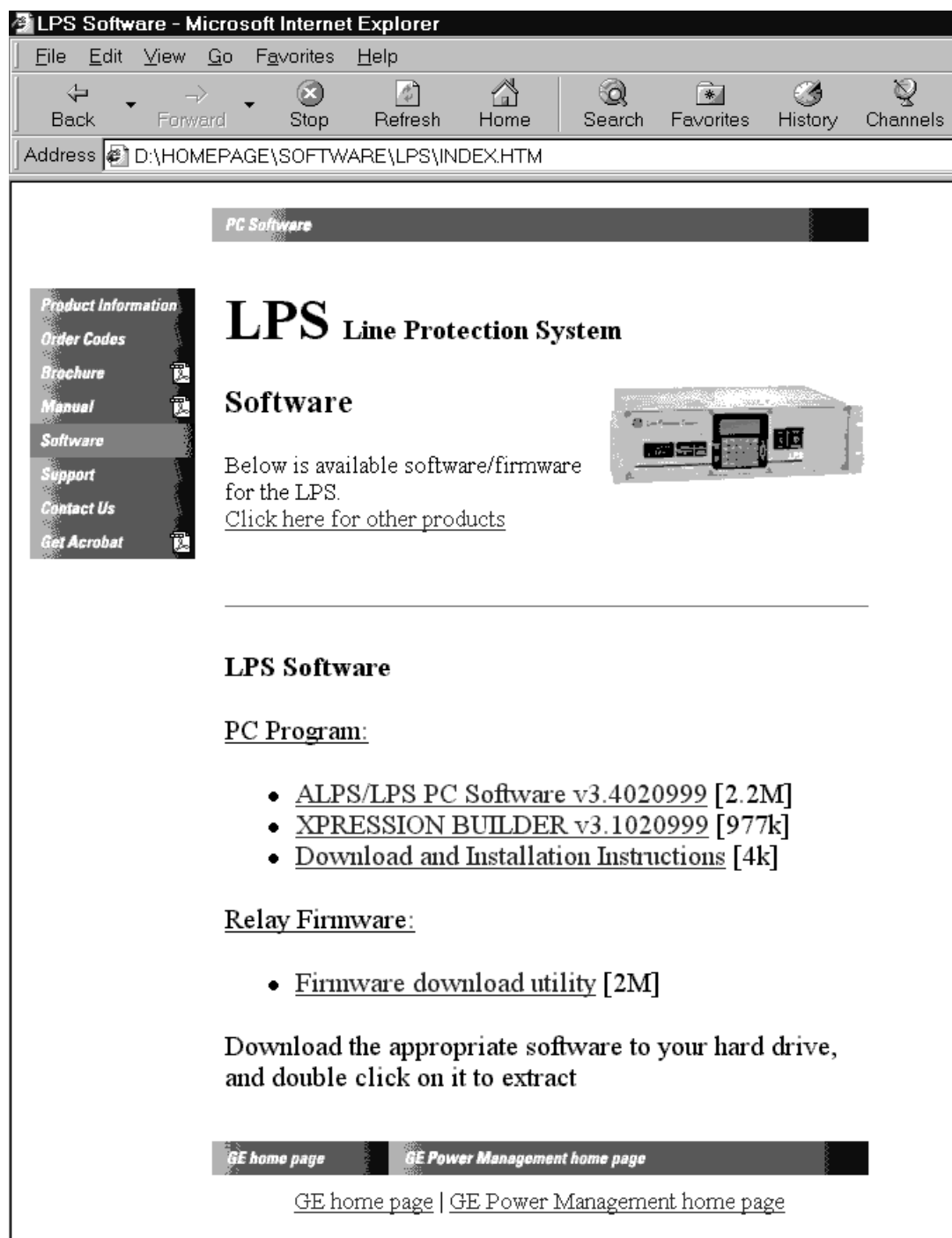


Figure 11-3: LPS-O SOFTWARE PAGE

5. Click on **ALPS/LPS PC Software**. A File Download dialog box will appear. Choose the **Save This Program to Disk** option and choose or create an appropriate directory to load the LPS-O software. The file ALPSPC.EXE will be placed in this directory.
6. Close down all applications that are running on the PC. Start the ALPSPC.EXE program by double-clicking its icon. The following dialog box is displayed:

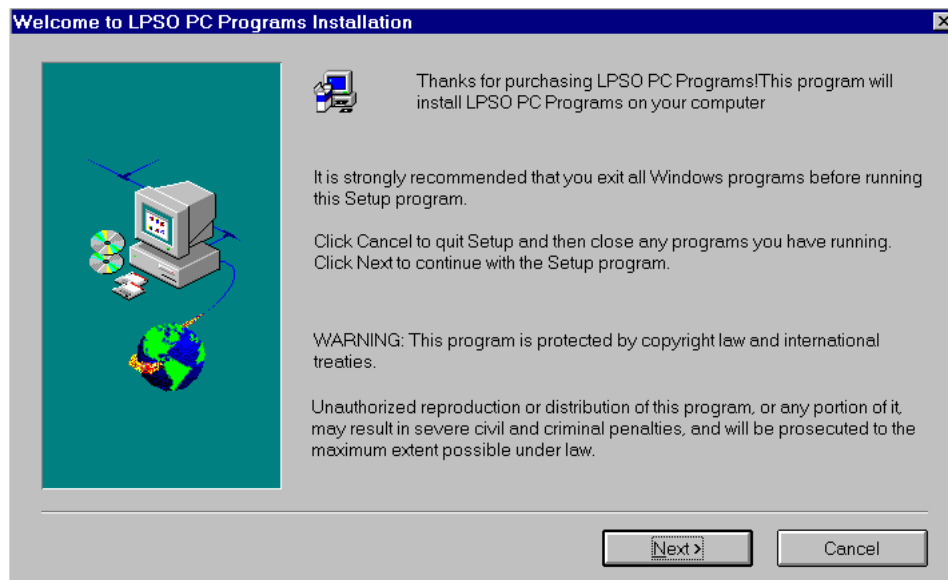


Figure 11-4: LPS SOFTWARE INSTALLATION WELCOME SCREEN

7. Click on the **Next** button to begin the installation.
8. The Software License dialog box will appear. Carefully read the Software license agreement. Click **Yes** if you agree with the terms of license; clicking **No** will terminate the Setup program.
9. The Setup Options dialog box will appear. Choose **Complete** or **Custom** installation. **Complete** is recommended. See Figure 11-5: SETUP OPTIONS DIALOG BOX below.

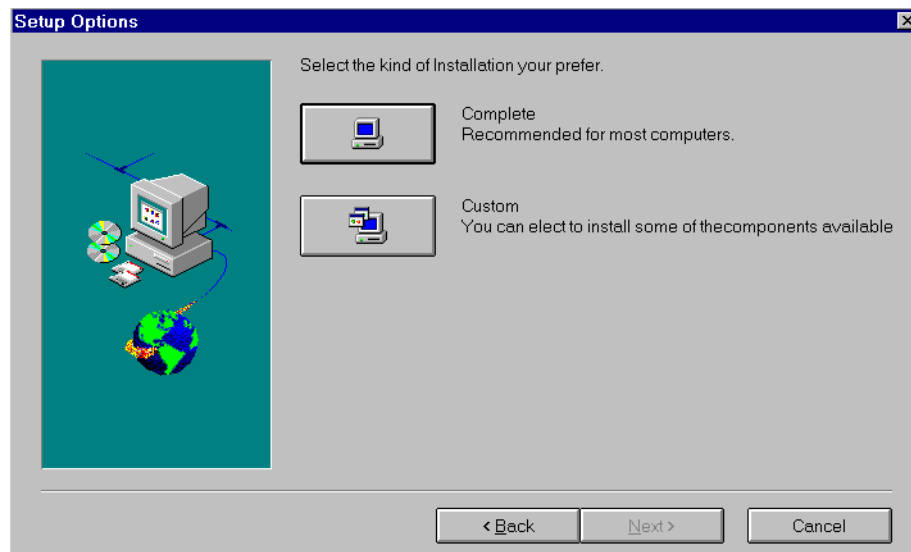


Figure 11-5: SETUP OPTIONS DIALOG BOX

10. Setup will prompt for a directory to install the LPS-O software. Click **Browse** to choose an appropriate directory or **Next** to accept the default directory C:\LPSO.
11. Setup will then prompt for a Program Folder for the LPS-O software. Enter a folder or choose the default ALPS PC Programs and click **Next**.

12. LPSO-Link Setup will now install the software and prompt for an appropriate directory for the Xpression Builder software. It is highly recommended to install Xpression Builder now. Choose an appropriate directory and click **Next**.
13. The Installation Complete dialog box will appear. Check **Yes, I want to view the ReadMe file** to view the latest software information and click **Finish**. The software is now installed.

Once the LPSO-Link software is installed, set-up must be chosen from the Device menu to set-up to communicate to the relay.

NOTE: LPSO-Link may have difficulty operating with some Windows applications running; therefore, it is recommended that before starting the application make sure there are no other programs or TSRs loaded on the system as this might affect the performance of LPSO-Link and related applications.

b) INSTALLING FROM THE INTERNET

To install the software from the GE Power Management web site enter the following URL in your Web browser:

www.ge.com/indsys/pm

The home page is the same as the Products CD shown in Figure 11–2: GEPM PRODUCTS CD PRIMARY SCREEN on page 11–5. Follow the above procedure from Step 3 to continue the installation.

11.3.1 STARTUP

11

This sub-section describes the Startup procedure and explains the main screen details.

After a successful installation of LPSO-Link, the group window appears on the screen. This window consists of the LPSO-Link icon and the Help icon. Choose the LPSO-Link icon to start the LPSO-Link.

The LPSO-Link application starts and the LPSO-Link application window appears. The main window has a title bar with LPSO-Link, a menu bar, a tool bar and a status bar.

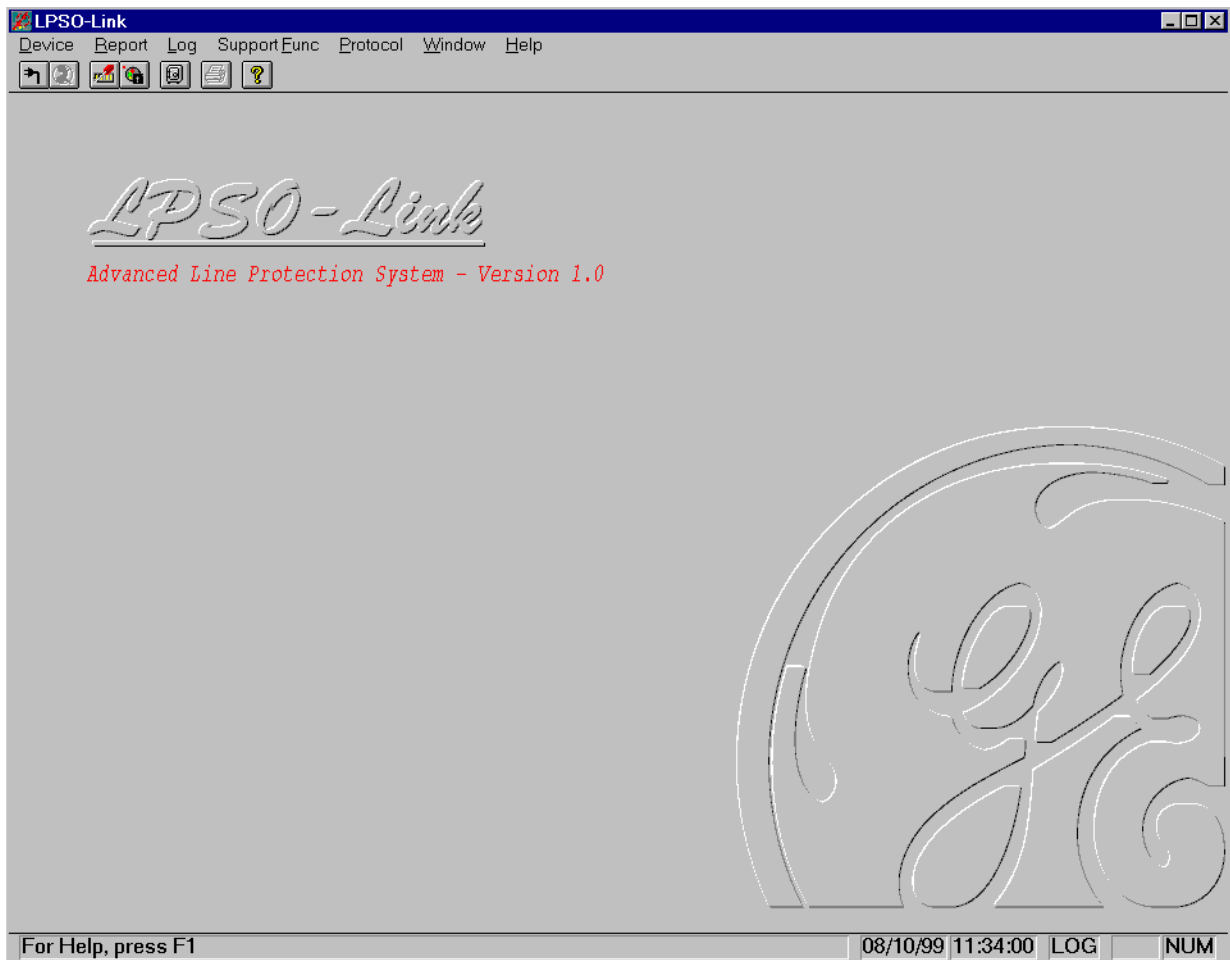


Figure 11–6: LPSO-LINK APPLICATION WINDOW

11.3.2 MENU BAR

The items in the LPSO-Link application window menu bar are: **Device**, **Report**, **Log**, **Support Func**, **Protocol**, **Window** and **Help**. The items in each menu change when a device is connected. For example, Log will not have the current item now but will display it when the device is connected.



Figure 11–7: LPSO-LINK TOOL BAR

The tool bar consists of icons which help choose some of the LPSO-Link activities quickly. The active icons at this time in the tool bar are, from left to right, **Connect**, **Hang-up** (if a telephone line is used), **Device Setup**, **Local Settings**, **archive**, **printer**, **Help** and **Context Sensitive Help**.

11.3.4 STATUS BAR

The status bar is divided in six parts. It is the bottom most row in the picture as shown in the LPSO-Link application window. Starting from the left, part one displays the information regarding any command selected, part two and three display the date and time respectively, part four indicates if Log is on or off, part five and six indicate the Caps Lock and Num Lock respectively.



Figure 11–8: LPSO-LINK STATUS BAR

11.4.1 DESCRIPTION

This is the preparation of the LPSO-Link software and the host machine for a trouble free and satisfactory operation with the LPS-O devices. Certain parameters of the serial (COM) port to which you wish to connect the device, the modem used for communication and the printer connected to the host machine are to be configured for LPSO-Link. LPSO-Link provides all the necessary user interface to set these parameters.

Keep the User's manuals for the serial port of your host machine, the modem and the printer handy for a quick reference.

11.4.2 COM PORT SETUP

For any operation with the LPS-O device, it is essential that the PC and the device have a physical link established between them. This physical link could be an RS232 line or an RS485 line. If required, dial-up modems can be used for this connection. On the host side, this can be connected to any of the serial (COM) ports of the host machine. To setup the serial (COM) port choose the **SupportFunc > Host setup > Ports** menu item. The **Port Setup** dialog box will appear.

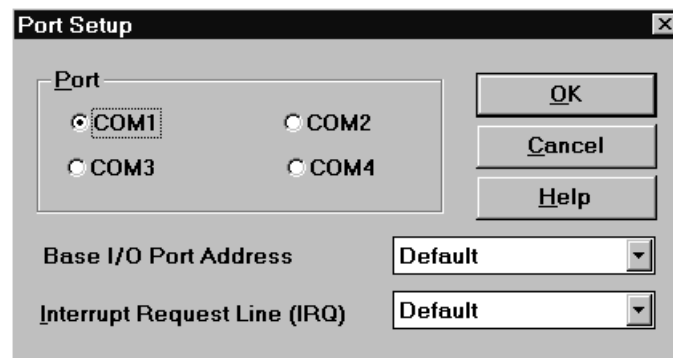


Figure 11-9: PORT SETUP DIALOG BOX

Change the **Base I/O Port Address** only if the device connected to your serial is not COM1 or COM2. Open the list to select an address.

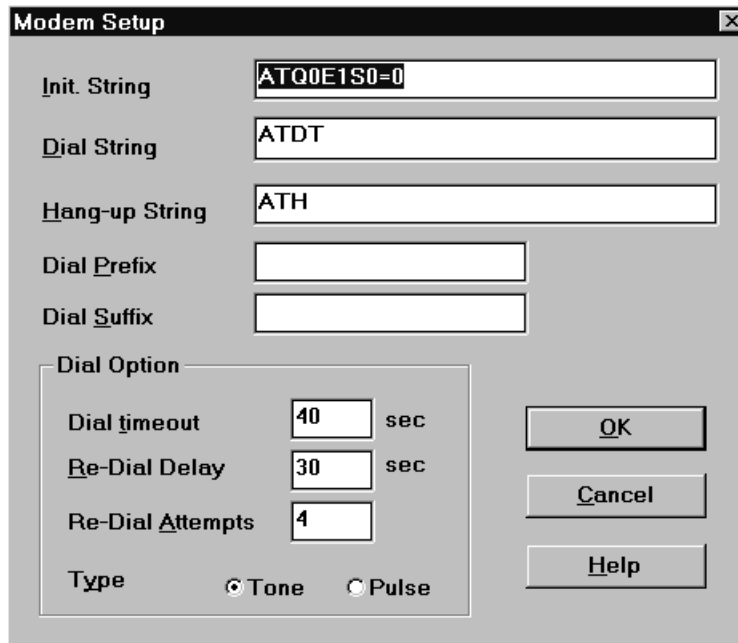
Before assigning IRQ numbers to serial ports, determine which interrupts are used by the devices connected to the serial ports and which ones are not being used by other cards or boards installed in your computer. You may need to adjust your serial card to use available interrupts. For information, see your serial card or computer documentation.

If you change the parameters of any port in this dialog box, these changes take effect only when you restart Windows. Choose the **OK** button to proceed with the selection or **Cancel** to quit without updating the selection.

11.4.3 MODEM SETUP

When the device is connected to LPSO-Link through a dial-up modem, it is essential that LPSO-Link is supplied with information about the modem characteristics. This can be done using the Modem setup.

To setup the modem, select the **Support Functions > Host Setup > Modem** menu item. The **Modem Setup** dialog box will appear.



The image shows a 'Modem Setup' dialog box with the following fields and options:

- Init. String:** ATQ0E1S0=0
- Dial String:** ATDT
- Hang-up String:** ATH
- Dial Prefix:** (empty text box)
- Dial Suffix:** (empty text box)
- Dial Option:**
 - Dial timeout:** 40 sec
 - Re-Dial Delay:** 30 sec
 - Re-Dial Attempts:** 4
 - Type:** ☒ Tone ☐ Pulse
- Buttons:** OK, Cancel, Help

Figure 11–10: MODEM SETUP DIALOG BOX

The **Init. String**, **Dial String** and the **Hang-up String** text boxes are all modem dependent. Refer to your modem manual for the suitable strings. Up to 40 characters are accepted for each of these fields.

If any number or string is to be dialed or sent on the port before dialing the phone number, specify it as the **Dial Prefix**. Similarly any strings to be appended at the end of the phone number are to be entered in the **Dial Suffix** field. These are modem independent and can be left blank if not needed.

The amount of time for which the system has to wait before deciding the non-availability of the telephone line is the **Dial timeout**. A maximum of 99 seconds can be specified here. The host will re-dial if the maximum number of valid re-dials are not yet completed.

The **Re-dial Delay** is in addition to the timeout delay. This is the amount of time the host machine waits before a re-dial. A maximum of 99 seconds can be specified here.

Specify the number of **Re-dial Attempts** the host machine has to do before declaring the dialing operation a failure. A maximum of 9 re-dials can be specified.

Any modifications done in the modem setup actually take effect the next time you make a connection request with a device.

11.4.4 PRINTER SETUP

The hard copies for reports, logs and settings are made through the printer connected to the host machine. The host machine need to be configured with the printer setup.

The Printer setup is performed from the **SupportFunc** menu. Choose the **Host Setup > Printer** item from the **Support Func** pull down menu.

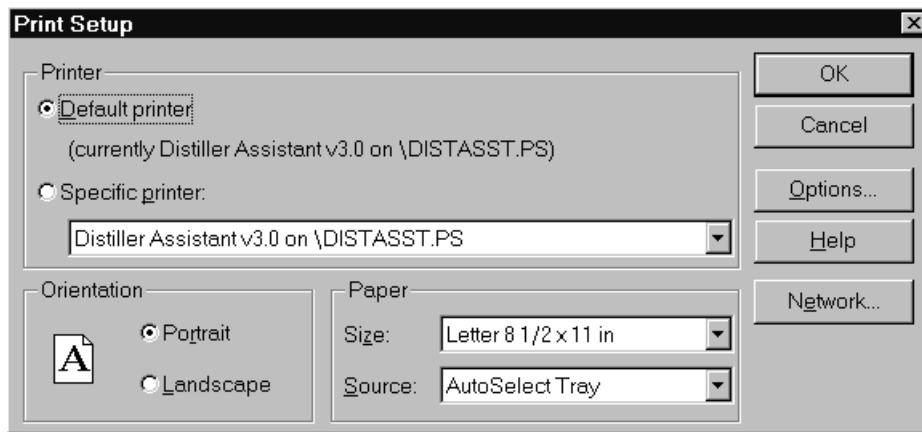


Figure 11–11: PRINTER SETUP DIALOG BOX

Select the printer you want to use. You can select the **Default Printer** by clicking that radio button or choose the **Specific Printer** option by clicking on that radio button and select one of the current installed printers shown in the box. Click on the **Options** button to get additional choices about printing, specific to the type of printer you have selected.

11.4.5 DEVICE SETUP

More than one LPS-O device could be connected to the host machine on the physical link. But, at any given time, LPSO-Link can communicate with a single device. It is possible that each of these devices are configured with various communication parameters: for example, telephone number, baud rate, etc. LPSO-Link should be setup with these details so that it can make proper connections with the devices. The Device Setup facilitates updating LPSO-Link with this information. If you need to add a device or modify the existing communication parameters of a device, Device Setup provides you the necessary interface.

11.4.6 HOW TO ADD A DEVICE

You can introduce a new device to LPSO-Link system or modify the setup of an existing device using the device setup feature.

Choose the **Device Setup** item in the **Device** menu. A **Device Directory** dialog box appears. This has the list of the devices already known to LPSO-Link. Click on the scroll button of the device name field to see this list.

To add a new device click the **Add** button. The **Device Setup** dialog box appears with the default parameters.

The 'Device Setup' dialog box is shown with the following fields and controls:

- Device Name :** A text input field.
- Unit ID:** A text input field containing '0000'.
- Baud Rate :** A dropdown menu showing '9600'.
- Data Bits :** A dropdown menu showing '8'.
- Stop Bits :** A dropdown menu showing '1'.
- Parity :** A dropdown menu showing 'NONE'.
- Break Signal :** An unchecked checkbox.
- Duration of Break :** A text input field containing '0' followed by 'secs. (0-50)'.
- Phone No :** A text input field.
- Auxiliary Phone :** A text input field with a '>>' button to its right.
- Connection :** Two radio buttons, 'RS-232' (selected) and 'RS-485'.
- Switch Code :** A large text input field.
- Buttons:** 'Copy From ...', 'Use As Default', 'OK', 'Cancel', and 'Help'.

Figure 11-12: DEVICE SETUP DIALOG BOX

Click in the **Device Name** text box and enter the name for the relay. Do the same for the **Unit ID** text box.

From the **Baud rate** list, select the communication speed that matches the relay Name (Device Name).

Specify the number of **Data Bits**, **Stop Bits** and the **Parity** in the specified fields for communication with this device.

The **Break Signal** is needed for communication with certain Code Operated Switches (COS) used on the other side of the communication line. Click this if the COS you are using needs this.

Duration of Break refers to the time gap required to specify a certain message is for the COS. This may be needed with or without the break signal.

The **Phone No.** text box is the phone number the host machine must dial to get connected to this device. A maximum of 60 characters can be entered in this field.

The **Auxiliary Phone** number specified is dialed before dialing the actual phone number. The Browse button (>>) will display a dialog box with a list of the existing auxiliary phone numbers. In this dialog box, you can add, delete and modify auxiliary phone numbers. For **Modify** and **Delete**, first select a number from the list and then choose the appropriate button. When you select **Add** and **Modify**, a dialog box appears with fields for the number and description. If no auxiliary phone number is necessary, leave this field blank.

A maximum of 60 characters can be entered in each of these field.

In the Device Setup dialog box, click on one of the radio buttons to indicate the mode of communication as the RS-232 or **RS-485**.

The **Switch Code** text box is a string of characters sent to the code operated switch. It accepts a maximum of six characters in Hexadecimal format.

These parameters take effect from the next time you make a connect request to the device specified. Choose the **OK** button to save these parameters for the specified device. Alternatively, choose the **Cancel** button to quit the dialog box without updating the device setup.

Clicking on **Use As Default** button will save the parameters for the device and also makes them as the default values. By selecting the most common device parameters as default will simplify the addition of a device to the system. So, next time you want to add a device, the device setup dialog box appears with these default parameters.

If you want to setup a new device by copying information from an existing device setup to a new one, you can use the **Copy From** option. Choose this button to display a list box with the existing devices. Select a device and choose the **OK** button to proceed. All the device setup parameters of that device are displayed under the device currently being edited. If any modifications are required, you can do them. You can save the new device with these parameters or **Cancel** to quit without saving.

To modify the parameters for an already existing device, select the device from the Device Directory dialog box and choose the **Modify** button. The device setup dialog box appears with all the parameters of that device. Do the necessary modifications and save or quit.

To delete a device from the system, select the device from the **Device Directory** dialog box and choose the **Delete** button. A message box requesting the confirmation for the deletion appears. Choose the **Yes** button to proceed with the deletion. Choose the **No** button to quit deleting the device from the list.

11.5.1 DESCRIPTION

Once the host setup and device setup is completed, operations with the device may be performed. To start with, a connection has to be established with a device to perform any kind of operation on that device. Select the device you want to connect to from the user interface provided and LPSO-Link will provide the connection for you, taking care of parameters like the phone number, speed of communication, etc.

11.5.2 CONNECT TO A DEVICE

To connect to a device, choose the **Connect** item in the **Device** menu.

A **Connect Device** dialog box appears. If there are more than one device configured in the LPSO-Link, the **Device Name** field will appear with a scroll button. Click this button to get the list of configured devices. From the list, select the device you desire a connection with and choose **OK** to proceed with the connection. Choose the **Cancel** button to quit the connection process.

Once the connection is established with the device, you are requested to enter a password to the device. The password determines the level of your privilege with the device. Enter password to the privilege at which you wish to interact with the device. Choose the **OK** button to proceed with the password entered or choose the **Cancel** button to quit the connection process.

The password you enter is sent to the device and if the login is successful, the menu bar and the tool bar change to incorporate the additional functions. **Reports**, **Settings** and **Actions** items will be added to the existing items in the menu bar.

Logging into the device is the start of a session. A session log starts and logs all the operations performed. The current item in the log menu is enabled and can be used to view the current session log. The tool bar also changes to display the Logout symbol in place of the connect symbol.

11.5.3 LOGOUT FROM A DEVICE

If the communication line is using a dial-up modem, the logout option will not hang-up the communication line.

To logout from a device, choose the **Logout** item from the **Device** menu. After a confirmation from the user, the device will be logged out. From the tool bar, the Logout icon also can be used.

The following conditions will be checked before the request for logout confirmation.

- If any settings were downloaded, was an END message sent?
- Are the outputs in disabled condition?
- Is the device in Test mode?

If any of the above conditions are true, LPSO-Link will display an appropriate message in the confirmation box. If you still want to proceed with the logout, choose the Yes button in the message box, or, if the END message is not sent, choose No, get back to the settings, send the END message. There is no need to download the settings again.

If the outputs are left in the disabled condition, choose the **Enable Outputs** item from the **Actions** menu.

If the device is in the Test mode, choose the **End Test** item from the **Actions** menu.

If you logout from a device when a dial-up modem is being used, a hang-up request need to be explicitly made. In fact, you can directly ask for hang-up without logging out of a device. LPSO-Link will do the necessary logout before hang-up.

a) WHY THIS EXPLICIT HANG-UP?

When you have more than one device connected to the other end of the telephone line using a code operated switch, you need not hang-up the line to logout from one device and login to another on the same line.

Even if the other device is not on the same line, LPSO-Link will automatically hang-up this line and dial the new number to connect to the new device you selected.

11.6.1 DESCRIPTION

The LPS-O device performs protection functions in a power system according to the device settings values. The settings are grouped into categories. The LPS-O has four settings groups. LPSO-Link provides for uploading the settings from the device, modifying and these modified settings can either be downloaded to the device or stored in a local file. The settings can also be loaded from these local files for download, etc.

11.6.2 UPLOAD SETTINGS

The settings can be uploaded from a connected device for viewing and modifying. An upload command will get all the settings of all the categories from the connected device.

To upload settings, connect to the desired device. From the **Device** menu, choose the **Settings** item. From the drop down menu, choose the **Get Settings** item. Choose the **Upload** item in the pop up menu. The **Settings** dialog box with the uploaded settings will appear.

For an upload command, the device sends the latest settings available with it. That means, if you download settings to the device and request an upload before sending the END message, the device will send those downloaded settings.

In the **Settings** dialog box, you can modify the settings of a category you desire, save them locally, print them and/or download them to the device.

From the **Protection Category** field, you can select a particular category. Click the scroll button to see the list of available categories. Selecting a particular category will display only the settings of that category. You can view and modify the values of the settings in that category only. If you want to view and modify all the settings of all the categories, select **All** in the category field. See Figure 11–13: PROTECTION CATEGORY SCROLL LIST.

The dialog box has two parts, one has the list of all the settings selected in a category. This is more like a table with the setting number, setting name, the setting value, the units of that setting and the new value if entered.

Once a setting is selected from the list, the second part of the dialog box displays the description of the setting and the value(s) in that setting. You can change the value of a setting by entering the new value in the Change to field. For some settings you can only choose one of the available values. If the text box is a combo box, select the value from the list.

If the (?) button is displayed next to the field, the value is to be entered by you. Clicking on this button will display the valid ranges for that setting.

You can download the settings to the device by clicking the **Download** button. It is possible to download either all the settings of all categories or only the changed values. When you choose the **Download** button, a dialog box appears so that you can select between **All** and **Changed Values** only. Choose the **Cancel** button to quit the download operation. You can also download **Protection Settings**, **General Settings**, or both categories.

After a successful download, a dialog box displaying the download status of the settings and requesting confirmation for sending an END message will appear. If you want to send the END message immediately, choose the **Yes** button. If you do not want to send the END message immediately, choose the **No** button.

The END message can be sent explicitly by clicking on the END button in the settings dialog box.

The settings can be saved locally in a file. Choose the **Save Locally** button in the **Settings** dialog box. A **File Save** dialog box appears where you can select the name and location of the file in which you want the settings to be saved.

The **Close** button will close the dialog box. Any modifications to the settings (downloaded or not) will be lost if not saved explicitly using the **Save Locally** button. If the settings are changed, a message box appears asking if you wish to save the changes. Choose **Yes** to save the changes and a **File Save** dialog box appears. You can choose **No** to quit without saving or choose **Cancel** to get back to the settings dialog box.

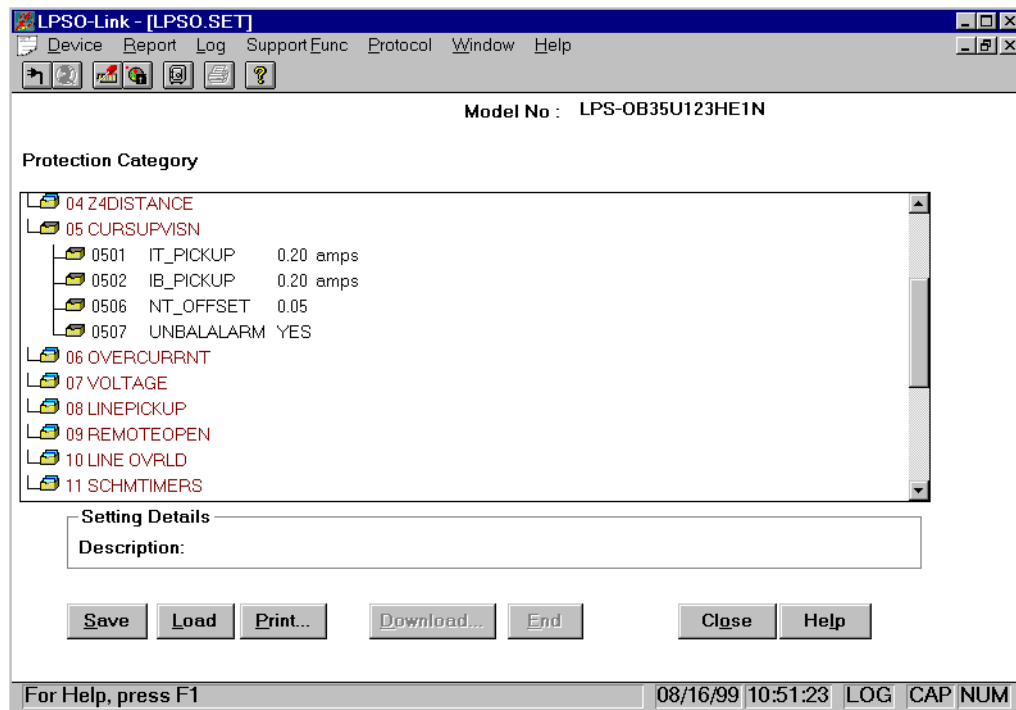


Figure 11–13: PROTECTION CATEGORY SCROLL LIST

A hard copy of the settings can be obtained by choosing the **Print** button in the **Settings** dialog box.

While you are working on a set of settings uploaded from the device, if you wish to load the settings from a file and use them for modifications and download, choose the **Load** button. A **File Open** dialog box appears for you to choose the file.

NOTE: If more than one user is logged in to the relay, it may be possible to have more than one set of settings group being edited locally. However, only one user may download and end settings changes at a time.

11.6.3 LOAD LOCAL SETTINGS

You can view, modify and print settings loaded from a local file. It is not essential to connect to the device for loading local settings. The file from which the settings are to be loaded is user selectable. A file open dialog box helps in locating the necessary file.

The download and END options in the settings dialog box will be disabled in this option.

To load local settings when not connected to a device:

- From the **Device** menu, choose the **Local Settings** item.

If you are already connected to a device,

- From the **Device** menu, choose **Settings**.
- From the drop down menu, choose **Get Settings**
- Choose **Load Local settings** from the pop up menu.

In both cases, a file open dialog box appears where you can select the file to load from, and the settings dialog box with the settings will appear. Multiple files can be opened simultaneously for viewing, modifying and printing.

Refer to Section 11.6.2: UPLOAD SETTINGS on page 11–18 for an explanation on the **Settings** dialog box features.

11.6.4 GET LOGIC

This command allows you to get configurable logic from the relay. This command automatically runs the Xpression Builder program installed on your hard drive from the Xpression Builder install disk located in this instruction book. See Chapter 13: XPRESSION BUILDER.

After configurable logic is downloaded from Xpression Builder, the program returns to LPSO-Link, but does not close Xpression Builder. Since Xpression Builder is still open, LPSO-Link will not let the user upload the configurable logic again. The uploaded logic window in Xpression Builder should be closed after the download by switching to the Xpression Builder application and closing the window corresponding to the uploaded logic. The same is true between any two consecutive logic upload operations.

11.6.5 SET DATE AND TIME

This feature helps you update the date and time in the device. Choose the **Set Date/Time** item from the **Settings** menu. The **Set Date/Time** dialog box will appear with the date and time of the host computer.

Modify the date and time as required. Choose **OK** to proceed with the downloading to the device.

The **Cancel** button ignores the modifications done and quits the dialog box. Any modification done here is only downloaded to the device and is not updated in the host computer.

11.6.6 CHANGE BUS/STATION ID

You can change the Bus and Station ID of a device. Choose the **Change Bus/Station ID** item from the **Settings** menu. A **Change Bus/Station ID** dialog box will appear.

This dialog box will display the current identifiers of the device. You can modify these strings. A maximum of 32 characters are accepted for each of them.

Choose **OK** to proceed with the download of these strings to the device or choose **Cancel** to quit.

11.6.7 TOC CURVES

LPSO-Link will facilitate uploading/downloading the TOC curves to/from the device. A separate software package will be used to view and edit the TOC curves. This package will not be a part of LPSO-Link. The interface between this package and LPSO-Link will be TOC curve files stored on the disk.

11.6.8 CALIBRATION

LPSO-Link will provide a facility to view the Calibration parameters in the device. User will also be able to modify these parameters and download them to the device. Selecting the **Calibrate** item from the **Settings** menu will post the following dialog box.

11.7.1 DESCRIPTION

LPSO-Link provides a mechanism to perform certain actions on a connected device. When necessary, the commands sent to a device to carry out these actions will follow 'Arm' and 'Execute' sequence defined in GEMODEM protocol. After a user confirmation for an action request, Arm and Execute sequence will be transparent to the user. You can not perform any of the actions before logging in to a device. It is also essential that you are logged in to the device with the appropriate privilege for performing actions.

11.7.2 ENABLE OUTPUTS

You can enable the device outputs by sending this request. This is an action that follows the Arm and Execute scheme. This scheme needs a user confirmation before executing the command.

To enable device outputs, click the **Enable Output** item in the **Actions** menu. A message box will be posted for your confirmation. Choose **OK** to proceed with enabling the outputs of the device. Choose **Cancel** if you wish to quit from enabling the outputs of the device.

Before logging out of the device, make sure the outputs are enabled.

11.7.3 DISABLE OUTPUTS

You can disable the outputs of a device by sending this request. This action follows the Arm and Execute Scheme. This needs a user confirmation before executing the command.

To disable device outputs, click the **Disable Output** item in the **Actions** menu. A message box will be posted for your confirmation. Choose **OK** to proceed with disabling the outputs of the device. Choose the **Cancel** button if you wish to quit from disabling the outputs of the device.

If the outputs are in disabled position, the LPSO-Link will inform you during logout.

11.7.4 CHANGE PASSWORD

You can change the password you use to log in to a device from LPSO-Link. Choose the **Change Password** item in the **Actions** menu. A **Change Password** dialog box appears.

Changing the password happens in three steps.

1. First you are asked to enter the old password. That is the password you are currently logged with. Enter the password and choose the **OK** button. Choose the **Cancel** button to quit the **Change Password** operation.
2. When you choose **OK** to proceed with changing password, LPSO-Link will post another dialog box asking you to enter the new password. Enter the new password and choose the **OK** button. Only alphanumeric characters are accepted for the password. Since the device accepts only upper case letters, all the characters are changed to upper case before sending to the device. The maximum length of the acceptable password is 16 characters.
3. For validation purpose, you are prompted to re-enter the new password. This is to take care of any typographical errors in your entering the password. Enter the new password again and choose the **OK** button.

The passwords are downloaded to the device for change. Any error from the device will be notified to you.

11.7.5 RESET DATA

This item helps you to reset specific data in an LPS-O relay.

To reset any of the data, choose the **Reset Data** item in the **Actions** menu. A dialog box will appear with various data items which can be reset. Check the associated check boxes, for all the data items which you want to reset. Choose **OK** to proceed with resetting of selected items or choose **Cancel** to abort the reset operation. While you choose **OK** if the **Breaker Health Data** item is checked, another dialog box appears asking you to enter new breaker health values. If you choose **OK**, the LPSO-Link will send an appropriate message to the device. If you choose **Cancel** then LPSO-Link will uncheck the Breaker Health Data item and brings you back to the **Reset Data** dialog box.

11.7.6 DIGITAL OUTPUT TEST

When you choose this item from the **Actions** menu, a dialog box appears with the list of output types.

Select an output test from the list and choose **OK** to proceed or choose **Cancel** to quit. If you choose **OK**, LPSO-Link will send an appropriate command to the device.

11.7.7 RELAY TEST

When you choose **Relay Test** item from the **Actions** menu, a dialog box with a list of available test modes will appear. Select a test mode you want and choose **OK** to proceed with the test. Choose the **Cancel** button to quit the testing.

Select the **End Of Relay Test** item from the list to bring the device out of the test mode. If you leave the device in a test mode, during the logout from the device, LPSO-Link will remind you that you have left the device in the test mode.

NOTE: The error message *OTHER USER IS ACCESSING THIS RESOURCE* will appear if the relay is in test mode from another port, or the keypad.

11.7.8 OPEN BREAKER

Choose this menu item to open the breaker, this will prompt you with the confirmation message box. Click **Yes** to open the breaker. The LPS-O will send command to the device to open the breaker.

11.7.9 CLOSE BREAKER

Choose this menu item to close the breaker. This will prompt you with the confirmation message box. Click **Yes** to close breaker. The LPS-O will send command to the device to close the Breaker.

11.8.1 DESCRIPTION

Different types of information stored in a LPS-O device can be fetched and viewed in a desired report format. LPSO-Link facilitates the acquisition of the information and presents it to you. You have the facility to view the reports, print the reports, or to store them for viewing or printing later. You can select the report you want from the **Reports** menu. A list of available reports will be displayed when you choose the **Reports** item. You can also view an existing report from a local file. You ought to have logged into a device before you deal with any of the information.

11.8.2 OPEN REPORT

The reports item is not visible in the menu bar until you are logged into a device. LPSO-Link provides you with facilities to fetch a new report from the device, store the report, view a report acquired earlier and stored in a file and print the reports.

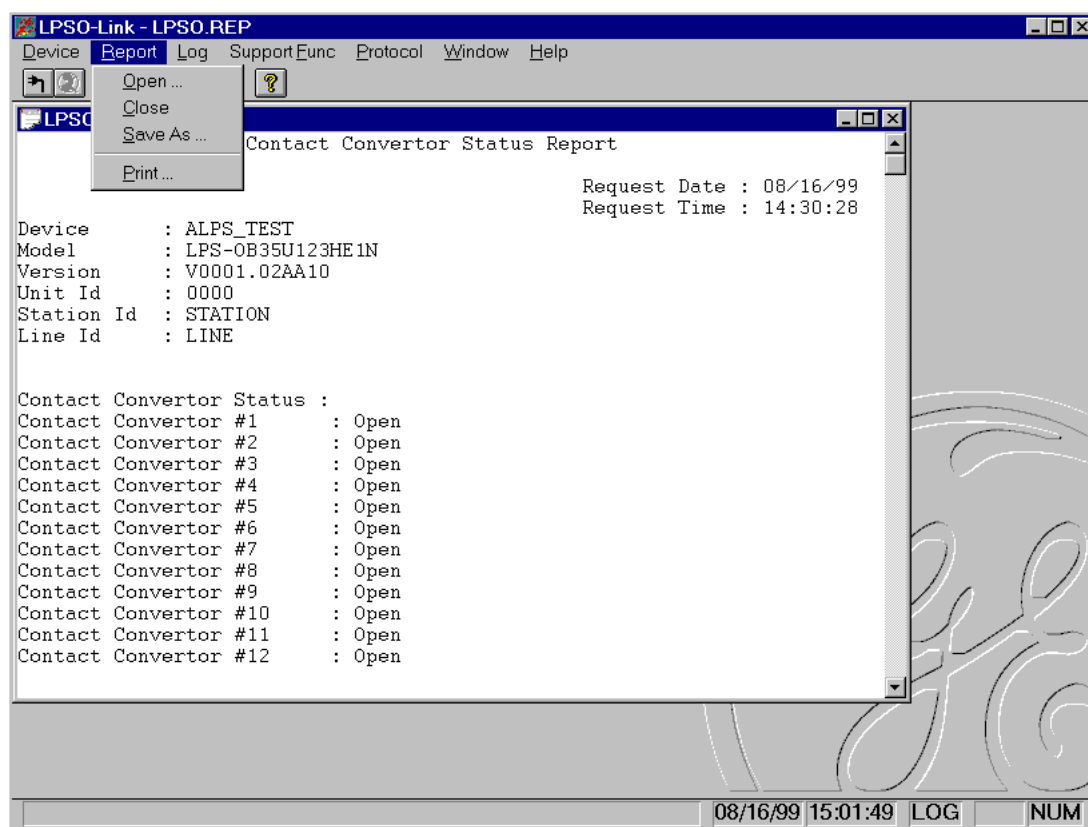


Figure 11–14: REPORT MENU WITH OPEN REPORT

11.8.3 NEW REPORT

Reports are the means of acquiring the current data from the device. For easy comprehensibility, the data is made available in various reports. The list of reports you can fetch from the device are displayed in the menu. Selecting **More** from the menu will post a dialog box from which you can select your choice including those which are not displayed in the above report menu.

When you select the **New** item in the **Reports** menu, this list will be displayed. Select the report you want and LPSO-Link will get that report data from the device and display it for you. You can view the sample reports in Appendix A.

You cannot modify the contents of a report. You can save the report acquired from the device in a local file for viewing or printing later. To save a report, choose the **Save As** item in the **Reports** menu. A **File Save** dialog box appears where you can select the name and destination of the file in which you want to store the report.

You can also print the report by choosing the **Print** item in the **Reports** menu.

You can acquire and view more than one report at a time. To do this, go through the same steps of getting a new report. You can also view some stored report by selecting the **Open** item. These multiple reports are displayed to you in multiple windows.

If you wish to print or save a report when multiple reports are in view, LPSO-Link will save or print the report in the active window. So, make sure that the report you want to print or save is in the active window before choosing the item.

Some reports need further input from the user. In all such cases data is acquired from user through a dialog and LPSO-Link validates this data wherever it is possible, before it proceed with the report. All of the reports and their associated dialog boxes (if any) are explained in the following sub-sections.

11.8.4 FAULT REPORT

When you choose the **Faults** report, a dialog box with the list of faults available with the device is displayed.

Select the fault for which you want the report and choose **OK**. LPSO-Link will fetch relevant data from the device.

11.8.5 OSCILLOGRAPHY REPORT

To retrieve an oscillography report from the relay, select **Report** from the menu bar then select **Regular Oscillography**. A list of available faults will appear. Select the fault to be downloaded. Enter the starting cycle and number of cycles required to be downloaded in the next window. A choice of DAF or COMTRADE file formats is available.

The .DAF file is formatted for use with the GE-DATA oscillography program. The .OSC format creates a binary COMTRADE file that can be viewed with any binary COMTRADE reader. You will be prompted for a name of this report when you close the fault report window, or, choose **Report** from the menu bar and select **Save** or **Save As**. Type in a descriptive file name, but do not add an extension. Five files will be saved and three files will be created to fit the COMTRADE standard. They are *.hdr (contains fault settings, fault report, and events), *.cfg (ASCII file containing definition of the data channels), *.dat (contains binary data). A *.osc file is also created that can be used for playback. See Section 8.1.19: PLAYBACK on page 8–15 for complete description of the PLAYBACK function.

A *.rep is also created, the user may delete this file as it does not contain any useful information for the user. It is used by the LINK program during generation of the oscillography file.

11.8.6 BREAKER HEALTH REPORT

Select **Breaker Health** from **Report** menu to see the current breaker health values. User input is not required for this report.

11.8.7 DEMAND REPORT

With **Demand Report** it is necessary to select the demand number (or range) for which you want demand data. Normally the allowed range is 1 to 192. If **Extended Demand Option** is set, then the valid range is 1 to 3360. If you want to see the report for a particular number and not the range, enter the same value in both the **Start Interval** and **End Interval** entries.

11.8.8 DIAGNOSTICS REPORT

Select **Diagnostics** from the **Report** menu to see a listing of all the diagnostic events occurred at the device.

11.8.9 EVENT REPORT

Select **Event** from the **Report** menu to see the events data fetched from a connected device.

11.8.10 PRESENT VALUES REPORT

When you select **Present Values** from the **Report** menu, LPSO-Link will pop-up a dialog box asking you to enter the period value in seconds. LPSO-Link will monitor the present values and update these values at the end of specified period continuously. These updated values are displayed through a special dialog box where you can monitor these as long as you want. You can get a report of these values at any moment by selecting the **Generate Report** option or stop monitoring by selecting **Close** option on the special dialog box monitoring these values.

NOTE: When General Setting 108: DISPLAYVAL= PRI (set to primary), the current values are in amps and the voltage values are in kV. The LPSO-Link Present Value display will show the units as V.

11.8.11 STATUS REPORT

Select **Status** from the **Report** menu to get the status report of various system components.

11.8.12 CONTACT STATUS REPORT

Select **Contact Status** from the **Report** menu to get the status of various contacts associated with the device. The status is conveyed in the On/Off or Open/Close terminology.

11.8.13 LUI PASSWORD REPORT

Select **LUI Password** to get a report on passwords of all the three levels namely settings level, control level and master level.

11.8.14 OPEN REPORT

This helps you view and/or print a report stored in a file. The report must have been fetched earlier from the device and stored in the file. When you choose the **Open** item in the **Report** menu, a **File Open** dialog box appears.

In the **File Open** dialog box, the **File** header part displays some information about the report file you are opening. This helps you in picking the right report file. Select the file name, directory and the source from where you want to read the report. The report will be displayed and you can print the report.

You can open multiple reports from multiple files and also can get new reports from the device for viewing simultaneously.

11.8.15 SAVE REPORT

Any report fetched from the device can be saved in a file. You can choose the name and location of the file in which you want to store the report. When you are in the report view, choose the **Save As** item from the **Report** menu. A **File Save** dialog box appears for the selection of the file name and path. If you wish to save a report when multiple reports are in view, LPSO-Link will save the report in the active window. So, make sure that the report you want to save is in the active window before choosing the item.

11.8.16 PRINT REPORT

You can take a hard copy of any of the report fetched from the device. You can do this before storing the report in a file or a report read from a file. When you are viewing multiple reports and choose the print item, LPSO-Link will print the report in the active window. So, make sure the report you want a hard copy of is in the active window.

11.9.1 SESSION LOG

LPSO-Link logs all the transactions done with a device. These logs are stored in disk files so that you can view them later. All the transactions in a session are stored in one log file. A session is defined as the time between logging into a device and logging out of a device. Up to 100 logs are stored in a cyclic manner, that is, after the 100th log, the overwriting re-starts from the first.

Each session log is stored in a different file. The log item is displayed in the menu bar before and after you are logged in to a device. To view the logs from the disk, you need not be logged in to a device. The current session log in the log menu is visible only when you are logged into a device. The LOG field in the status bar displays if the session log is on or off.

11.9.2 TURN OFF

By default, LPSO-Link has the session log on. If you wish to turn the log off, choose the **Turn Off** item in the **Log** menu. You can do this before and after logging in to a device. From the moment you turn the log off, LPSO-Link will not create any session log for any device until you turn it on.

If you choose **Turn Off**, a select mark will be displayed with that item in the menu. The LOG field in the Status bar will be empty. When you wish to turn the log on again, all you need to do is to choose this item again.

11.9.3 CURRENT SESSION LOG

This can be viewed only when you are connected to a device. This log contains all the transactions you have had with the device till this moment. You can add comments about your operations in the current log. This feature is only limited to the current log and you can not add comments to any previous logs.

As soon as you log out of a device, LPSO-Link automatically closes the log and stores it in the appropriate file.

You can print the current session log by choosing the print item in the Log menu.

To close the current log, choose the **Close** item in the **Log** menu. This will appear in the **Log** menu when you are in an active log window.

11.9.4 OPEN SESSION LOG

You can open a previous log for viewing and printing. You need not be logged into a device to invoke this option. Choose the **Open** item in the **Log** menu and a list box with all the available logs will appear.

The display consists of the log name, the date and time of occurrence and the device logged in during that session. You can scroll through the window and see the entire list. Select the log you wish to open and choose the **OK** button to view it. The session log will be displayed. Choose **Cancel** to quit the selection.

You can not add comments in any log opened from the list, but you can take a hard copy of the log by choosing the **Print** item in the **Log** menu.

You can view as many logs as you want using the **Open** option. If you choose the print item when you are viewing multiple logs, LPSO-Link will print the log that is in the active window.

To close a log, make sure that window is active and choose the **Close** item in the **Log** menu.

11.9.5 ARCHIVAL

Reports and Settings can be stored on the secondary storage by you, where as up to 100 log files are stored by LPSO-Link. It might be necessary to make an archival of some of these files. LPSO-Link supports this through the **Archival** option. The same option can be used to retrieve these backups.

11.9.6 ARCHIVE

When you want to take a backup of one of the Report, Settings or log files stored on the disk, use this option. Choose the **Archive** item in the **Support Functions** menu. An archives dialog box appears.

Enter the name of the source file along with the path and the destination file. Choose **OK** to proceed with the archival. You can also click the browse (>>) button to get a file common dialog box where you can select the file name. This browse button is available for both the source and destination.

11.9.7 RETREIVE

You can retrieve the archived files using the same dialog box. If you wish to retrieve any of the files, choose the Archive item in the support functions menu. The same archive menu will appear. You can select the source from where you want to retrieve (for example, floppy disk) and give the destination name and path.

If you are retrieving any log files, make sure you copy the file in to the directory C:\ge_relay\ALPS\link\data\log. Since you would not want to destroy the log existing with the same name, you can give a name of your choice, but with an extension of .log, that is, you can name it test.log.

For **Report** and **Settings**, you can select the directory and name of your choice.

12.1.1 DESCRIPTION

The LPS-O has a built-in ASCII interface which will communicate using any terminal emulator, such as Pro-comm Plus or Microsoft Windows Terminal. The user must initiate all commands by typing them. Some of the commands have abbreviations which are represented by the capital letters in a command. If there are no lower case letters in a command, the command does not have an abbreviation and the whole command must be typed.

Any operation that can be performed at the keypad can also be performed through the ASCII communications interface. The communications passwords apply to the ASCII interface and must be used to gain the necessary privilege level. If the passwords are not known or forgotten, they are available from the Keypad using the INF key.

Once the terminal emulator has been started, the COM port the relay or modem is connected to must be setup to match the relay for bits (8), parity (none), stop bits (1) and Xon/Xoff flow control.

Once the terminal emulator is ready and the relay is connected, press the ENTER key. The standard error message should appear. If it does not check the connections and settings. All the commands that follow can then be used. Use the **Save to File** command (or its equivalent) from your ASCII communications program to save relay responses in a file.

12.1.2 ASCII INTERFACE

1. When a prompt says "Press", this indicates that as soon as that key is pressed the relay will respond without the user pressing the ENTER key. When a prompt says "Enter", the entered keystrokes will not be processed until the ENTER key is pressed.
2. The CAPITAL letters in a command name must be typed to execute the command. The lowercase letters that continue the command are optional. For any command to be executed the ENTER must be pressed.
3. If a mistake is made while entering commands, a message will be displayed and the correct information can be entered after the prompt at the end of the error message. No action that will cause the relay to change settings, operate a breaker, or change the relay operation in any way will be done without user verification (for example: TRIP BREAKER 1, are you sure (Y/N): ?).
4. The relay responses below are in order of appearance. Where there is a user choice, all possible responses may not be listed. However, any unlisted responses will be similar to others listed.
5. Help is available before typing a command by typing HELP at the LPS_> prompt and pressing the ENTER key. Some commands have built-in help as well.
6. There are two kinds of command prompts. The colon (:) is used to indicate the relay is not logged in and is waiting for the LOGIN command. After a successful login, the prompt changes to depending on the privilege level. See Table 12-1: ASCII PROMPTS.

Table 12-1: ASCII PROMPTS

Privilege Level	Prompt
VIEW	LPS_INF>
ACTIONS	LPS_ACT>
SETTINGS	LPS_SET>
MASTER	LPS_MST>

Communication using the ASCII protocol presents oscillography data as directly readable ASCII characters. Oscillography data may contain 12 to 72 power cycles of data. Each power cycle contains 64 samples of data. The data structure of a sample is as shown in Table 12–2: OSCILLOGRAPHY DATA STRUCTURE. Each sample appears on a separate line.

Table 12–2: OSCILLOGRAPHY DATA STRUCTURE

Item	Data Format (ASCII characters)	Description
Sample No	decimal integer	Sample number within the cycle
Ia	signed decimal (resolution of 0.01 units)	Inst. current in Phase A
Ib	signed decimal	Inst. current in Phase B
Ic	signed decimal	Inst. current in Phase C
Va	signed decimal (resolution of 0.1 units)	Inst. voltage in Phase A
Vb	signed decimal	Inst. voltage in Phase B
Vc	signed decimal	Inst. voltage in Phase C
Digital Flags	Eight 4 byte hexadecimal integers	The 252 digital flags represent system status

Table 12–3: ASCII COMMAND LIST (Sheet 1 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
LOGIN	Login to the relay	NONE	Unit ID? Password? Reports the access level granted or that the password entered is INVALID	Relay ID number; up to 10 character password
QUIT	Logs out from the relay, displays the relay status, and returns the privilege level to VIEW for the relay port used.	VIEW	Press ENTER to continue Do you want to logout? You have logged out from the relay	Press the enter key; Y or N
PASSword	Change the passwords used by LPSO-Link and ASCII; MMI passwords are not affected by this command	Level equal to the password being changed	Enter Current Password Enter New Password Re-enter New Password Password changed or INVALID; password not changed	old password; new password; new password

Table 12–3: ASCII COMMAND LIST (Sheet 2 of 7)

[illegible]

Table 12–3: ASCII COMMAND LIST (Sheet 3 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
EVEnts	Display events	VIEW	List of events with date and time. Example: 06/30/98 16:26:29.7562 Host Logoff on MMI 06/30/98 16:24:37.5944 Host Logon OK on Port 2 06/30/98 16:10:45.6505 Recloser in RESET state 06/30/98 16:10:40.0000 Settings File 0 in Use 06/30/98 16:10:40.0000 System booted Press ENTER to continue, B to go back a screen, or ESC to quit	None
TRIP	Open Breaker command; issues the command to open breaker; breaker will be determined by settings NUM_BRKR and NUM_TC	CONTROL	Enter Breaker No. (1 / 2 / BOTH) TRIP BREAKER 1,! Are you sure? (Y/N) Breaker open command sent	1, 2, or BOTH; Y to trip, N to cancel
CLOSe	Close Breaker command; issues the command to close breaker; breaker will be determined by settings NUM_BRKR and NUM_TC	CONTROL	Enter Breaker No. (1 / 2 / BOTH) CLOSE BREAKER 1,! Are you sure? (Y/N) Breaker close command sent	1, 2, or BOTH; Y to trip, N to cancel
ENOUT	Enable outputs	CONTROL	Enable Outputs, Are you sure? (Y/N) Outputs are disabled or Outputs cannot be disabled	Y for OK, N to cancel; command
DISABLe outputs	Disable outputs	CONTROL	Disable Outputs, Are you sure? (Y/N) Outputs are disabled or Outputs cannot be disabled	Y for OK, N to cancel; command
STATUs	Display status of the relay	VIEW	RELAY STATUS Refer to the servicing section for status messages for the LPS-O Press ENTER to continue	None
DATAReset	Clear various data logs maintained in the relay	SETTING	To clear FAULT REPORT and OSCILLOGRAPHY enter F To clear OST REPORT enter S To clear EVENT DATA enter E To reset target LED and clear warn, failure, and trip messages enter L To clear BREAKER HEALTH enter B To quit press ESC Enter your choice:	Enter letter, press ENTER
DIGTest	Perform Digital Output tests; the test energizes the selected output until END is chosen or another output is tested	MASTER	Turn Protection off (Y/N): Enter the number of the Digital Output to be tested (1 to 18) Enter END to end test To see list of Digital Outputs enter H To quit press ESC Enter your choice: 4 Digital Output #4 is Activated Turn Protection on? (Y/N):	Enter letter; Enter digit form 1 to 18; enter letter

Table 12–3: ASCII COMMAND LIST (Sheet 4 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
GROUP		SETTING	<p>The active Protectioning Setting Group number is 1</p> <p>To select a Setting Group enter Setting Group Number ('1' - '4')</p> <p>To select active setting group through Contact Converter Inputs enter '0'</p> <p>To quit press ESC</p> <p>Enter your choice:</p> <p>Are you sure (Y/N):? y</p> <p>New Active Group = 3</p>	Enter digit from 0 to 4; enter letter
INPutS	Request contact converter status	VIEW	<p>Contact Converter #0=0 (SETTING GROUP BIT 0)</p> <p>Contact Converter #1=1 (SETTING GROUP BIT 1)</p> <p>Contact Converter #2=1 (not assigned)</p> <p>Contact Converter #3=0 (not assigned)</p> <p>Contact Converter #4=0 (not assigned)</p> <p>Contact Converter #5=1 (not assigned)</p> <p>Contact Converter #6=0 (not assigned)</p> <p>Contact Converter #7=1 (not assigned)</p>	None
MODEL	Retrieve the model number, serial number, and version of the relay	VIEW	<p>MODEL: LP3DA35U143VE3S</p> <p>VERSION: V0001.11</p>	None
CRCcalc	Recalculates the CRC of various settings groups (this is primarily a troubleshooting command - it is used only where a relay may have gone through a loss power during a settings change, and the settings are corrupted beyond the ability of the relay to correct).	SETTINGS	CRCs are recalculated	None
STLINID	Allows the station and line IDs to be changed	SETTINGS	<p>Station ID: Current Station ID</p> <p>Line ID: Current Line ID</p> <p>Do you want to change Station and/or Line ID? (Y/N): y</p> <p>Enter new Station ID (max. 32 characters): NEW STATION ID</p> <p>Enter new Line ID (max. 32 characters): NEW FEEDER ID</p> <p>Are you sure? (Y/N): y</p>	Y to change, N to exit; NEW STATION ID or ENTER to keep current ID; NEW FEEDER ID or ENTER to keep current ID; enter letter

Table 12–3: ASCII COMMAND LIST (Sheet 5 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
RELTest	Selects and runs a given relay test. Puts the relay in test mode (Contact A! Reports test function operation).	MASTER	<p>Disable Outputs? (Y/N):</p> <p>Select the function to be tested (2 to 49)</p> <p>To stop the test in progress enter I</p> <p>To see the list of functions enter H</p> <p>To quit without suspending the test enter Q</p> <p>To quit press ESC</p> <p>Enter your choice: 2</p> <p>Z1 AG test function is routed to contact A!</p>	Enter letter Y or N; one to two digit number, 1 to 49; enter letter H or Q
ACCESS	Allows the user to change privilege level	VIEW	Enter Password:?	User-defined password
OSCtrg	Start oscillography recording	VIEW	<p>Are you sure? (Y/N): y</p> <p>Oscillography is triggered</p>	Enter letter Y or N
CHNLtest	Test PLC channel. The test starts when a B is entered and ends only when an E is entered.	MASTER	To begin Channel Test enter B, To end Channel Test enter E	Enter letter B or E
PLAYBack	Re-run a fault produced earlier or test case for relay. There are three choices for running a fault: 1) re-run a fault saved in the relay; 2) with factory test data; 3) download oscillography into relay and run fault	ACTION	<p>To run the relay on Fault Data enter Fault Number</p> <p>To run the relay on factory test case enter F</p> <p>To run the relay on downloaded test data enter D</p> <p>To quit press ESC</p> <p>Enter your choice: 5</p> <p>The fault is absent</p> <p>There is no factory test data in the relay</p> <p>There is no downloaded data in the relay</p>	Fault number, F, D, or ESC
LUIPass	Display coded LUI passwords. See decoding table in Chapter 8	VIEW	<p>MMI PASSWORDS</p> <p>Settings Password: [DHLPPPPPPPPPPPP</p> <p>Control Password: [AEIPPPPPPPPPPP</p> <p>Master Password: [MBFPPPPPPPPPPPP</p>	None
HELP	Displays the ASCII command mnemonics as well as descriptions of each command	VIEW		None
OUTPuts	Displays the current state of the digital outputs	VIEW	<p>Output Contact #1, T1=0 Output Contact #2, T2=0</p> <p>Output Contact #3, T3=0 Output Contact #4, T4=0</p> <p>Output Contact #5, A1=0 Output Contact #6, A2=0</p> <p>Output Contact #7, A3=0 Output Contact #8, A4=0</p> <p>Output Contact #9, A5=0 Output Contact #10, A6=0</p> <p>Output Contact #11, A7=0 Output Contact #12, A8=0</p> <p>Output Contact #13, KT1=0 Output Contact #14, KT2=0</p> <p>Output Contact #15, KT3=0 Output Contact #16, KT4=0</p> <p>Output Contact #17, C1=0 Output Contact #18, C2=0</p>	None
DATE	Displays the current LPS-O date	SETTINGS	<p>Do you want to change date? (Y/N):</p> <p>Enter new date (mm/dd/yy):</p> <p>Command is executed</p>	Enter letter Y or N; 6 digit date code

Table 12–3: ASCII COMMAND LIST (Sheet 6 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
TIME	Displays the current LPS-O time	SETTINGS	Do you want to change time? (Y/N): Enter new time (hh:mm:ss): Command is executed	Enter letter Y or N; 6 digit time code
LINEs	Changes the number of lines the relay will display before pausing for the user to read	VIEW	Enter the number of LINES PER PAGE (24/25/48/50):	Enter 24, 25, 48, or 50
GEModem	Changes communications type to GE-Modem after user has logged out	SETTINGS		None
ECHO	Toggles the echo state and reports its status	VIEW	Echo is turned ON (OFF)	None
PORTparam	Changes and displays the current port parameters for the LPS-O serial communications port	SETTINGS	Do you want to change communication port parameters? (Y/N): Interface is (0 - RS232, 1 - RS485): 0 Enter Interface Type (0 - RS232, 1 - RS485): Baud rate is 9600 Enter baud rate (19200, 9600, 4800, 2400, 1200, 300): Parity check type is (0 -none, 1 - odd, 2 - even): 0 Enter parity check type (0 -none, 1 - odd, 2 - even): Number of stop bits is 1 Enter number of stop bits (1 or 2): Save changes? (Y/N):	Y displays parameter to be changed, N exits; 0 for RS232, 1 for RS485; press ENTER for no change; choose baud rate matching PC port; Enter 0, 1, or 2; Enter 0, 1, or 2; Enter Y or N
END	Ends the session	VIEW		None

Table 12–3: ASCII COMMAND LIST (Sheet 7 of 7)

ASCII Command Mnemonic	Command Description	Lowest Level Password Needed	Relay Prompt	User Response
SHOWSET	Displays the current values of selected settings	VIEW	<p>To see PROTECTION GROUP Settings press Setting Group no 1 to 4 To see GENERAL Settings press G To quit press ESC</p> <p>Enter your choice:2</p> <p>To view Category of Settings press C To view ALL Settings press A To go back to previous menu press B To quit press ESC</p> <p>Enter your choice: C</p> <p>To view protection SETTINGS in a category enter category number 1 to 20 To view protection settings CATEGORY names enter C To go back to previous menu press B To quit press ESC</p> <p>Enter your choice: 5</p> <p>Press ENTER to continue or ESC to quit</p>	<p>Enter 1, 2, 3, 4, G, or press ESC</p> <p>Enter C, A, B, or press ESC</p> <p>Enter numbers between 1 to 20, the letters C and B, or press ESC</p> <p>Press ENTER or ESC</p>
SET	Allows the user to change settings	SETTINGS	<p>To view/change PROTECTION GROUP Settings press Setting Group no 1 to 4 To view/change GENERAL Settings press G To quit press ESC</p> <p>Enter your choice:2</p> <p>To view/change Category of Settings press C To view/change ALL Settings press A To go back to previous menu press B To quit press ESC</p> <p>Enter your choice: C</p> <p>To view/change protection SETTINGS in a category enter category number 1 to 20 To view/change protection settings CATEGORY names enter C To go back to previous menu press B To quit press ESC</p> <p>Enter your choice: 1</p> <p>Press ENTER to continue or ESC to quit</p>	<p>Enter 1, 2, 3, 4, G, or press ESC</p> <p>Enter C, A, B, or press ESC</p> <p>Enter numbers between 1 to 20, the letters C and B, or press ESC</p> <p>Press ENTER or ESC</p>

13.1.1 OVERVIEW

The LPS-O relay has been designed to allow flexibility in the operation of contact converter inputs and contact outputs. The inputs and outputs are not hard-wired to any function; the functions of each input and output are defined by a software file which is downloaded to the relay as a part of each setting group.

The software file represents the linkage between the contact converters, internally generated protection flags, and contact outputs; it contains information regarding the logical relationships among each entity. This file is built using a windows based application called Xpression Builder.

Xpression Builder allows the utility engineer to design the interconnection of the inputs and outputs with Boolean operators, latches, timers, and counters in a graphical environment. The application performs the task of compiling the design from a graphical format, and allows the engineer to download the file to a relay setting group with LPSO-Link. Each setting group can contain different Xpression Builder logic. The LPS-O comes with a default Configurable Logic implementation.

13.1.2 INSTALLATION

If the LPS-O software suite has been installed from the Products CD or Web page, Xpression Builder may already be installed. To install Xpression Builder by itself, consult the following procedure. Note that Microsoft Windows must be installed on your PC before proceeding with the Xpression Builder Installation.

a) INSTALLING FROM PRODUCTS CD

To install Xpression Builder from the Products CD:

1. Start Windows.
2. Insert the GE Power Management Products CD into your local CD-ROM drive. The CD-ROM autorun utility will automatically load the page shown in Figure 13–1: GEPM PRODUCTS CD PRIMARY SCREEN into your default web browser.

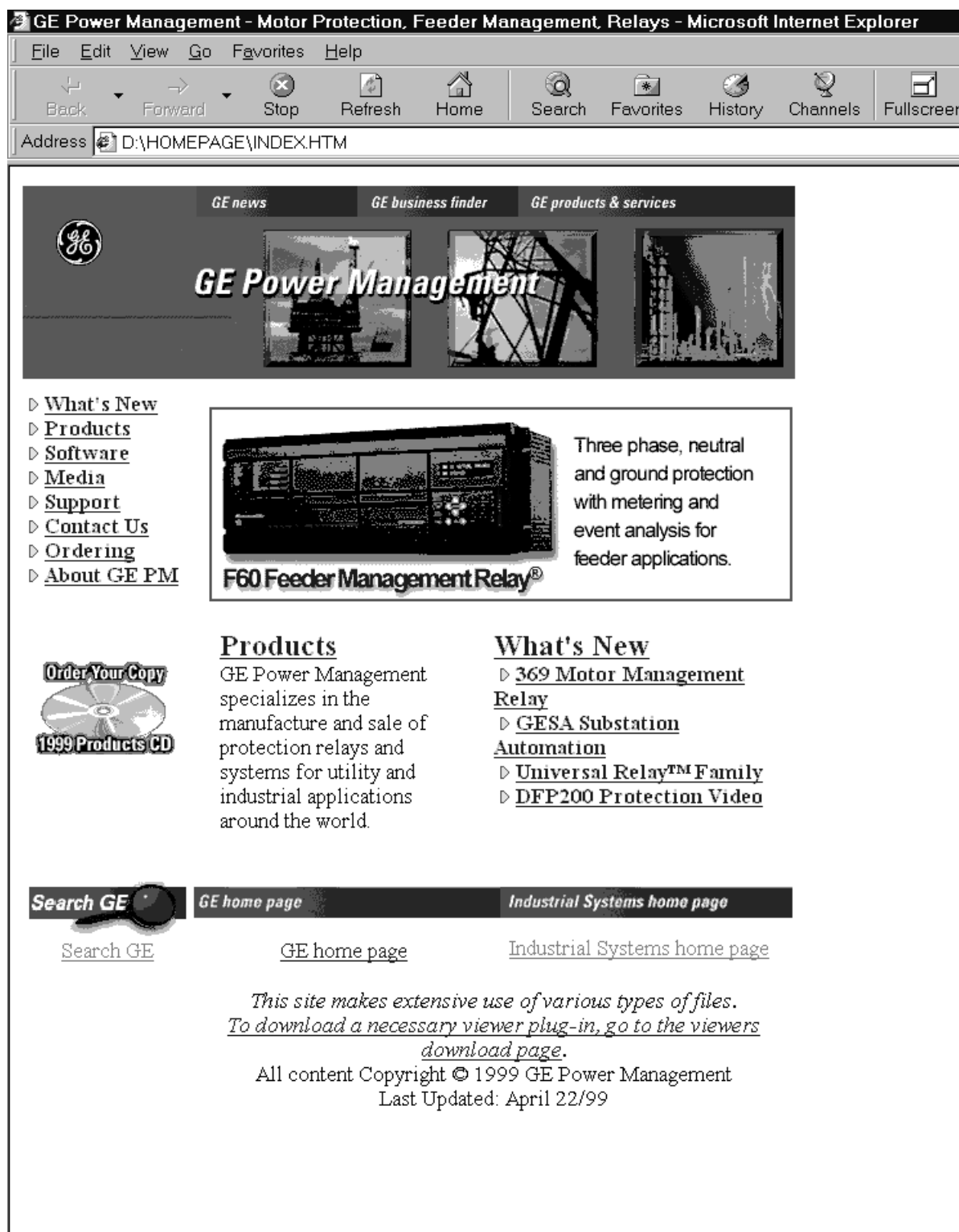


Figure 13–1: GEPM PRODUCTS CD PRIMARY SCREEN

- From the menu on the left of the page, click **Software**. This will display a list of software indexed alphabetically by product. Click on **LPS Line Protection System** from the list.
- The Software page for the LPS-O relay will be displayed as shown in Figure 13–2: LPS-O SOFTWARE PAGE below.

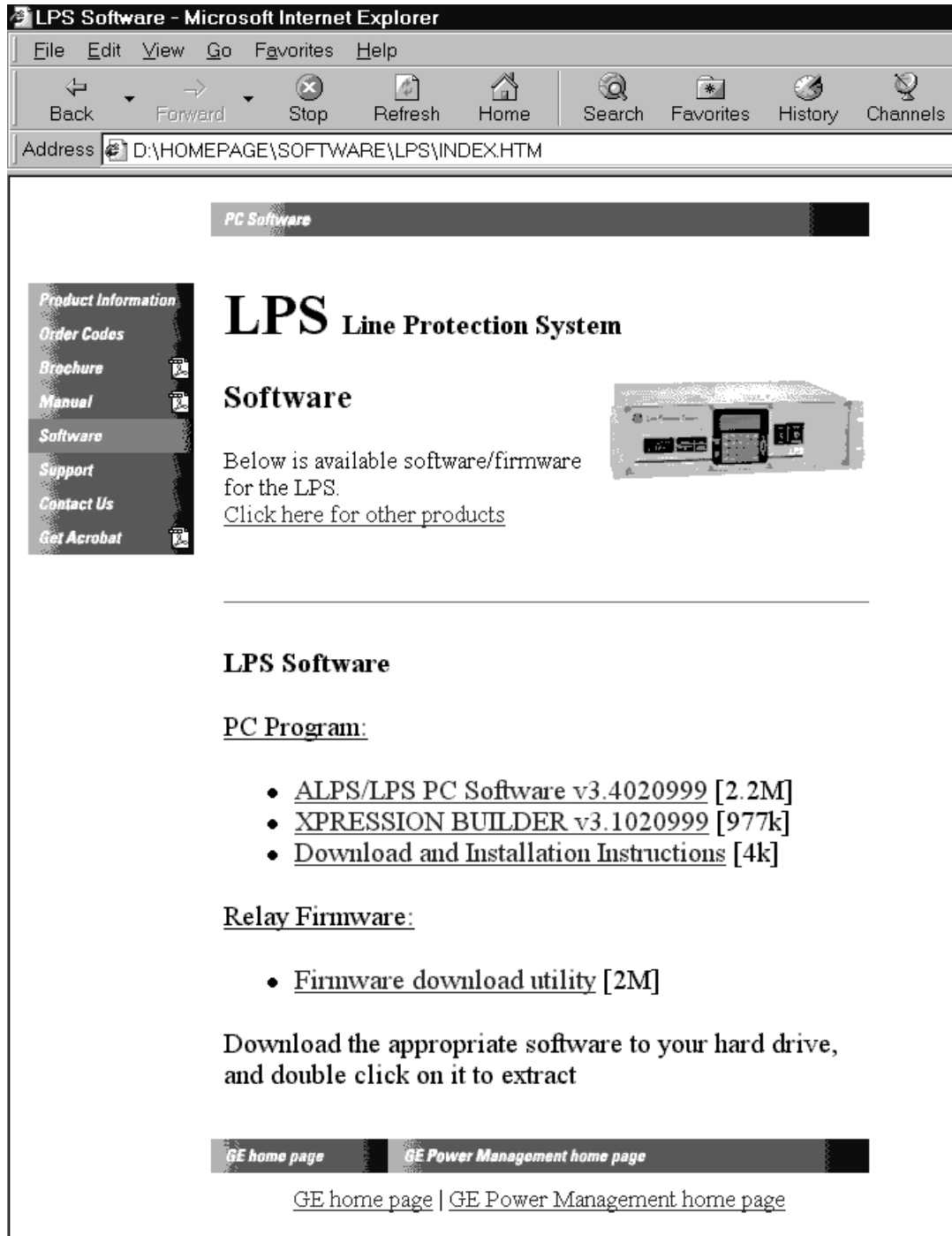


Figure 13–2: LPS-O SOFTWARE PAGE

5. Click on **XPRESS BUILDER**. A File Download dialog box will appear. Choose the **Save This Program to Disk** option and choose or create an appropriate directory to load the Xpression Builder installation program. The file XPRESS.EXE will be placed in this directory.
6. Close down all applications that are running on the PC. Start the XPRESS.EXE program by double-clicking its icon. The following dialog box is displayed:

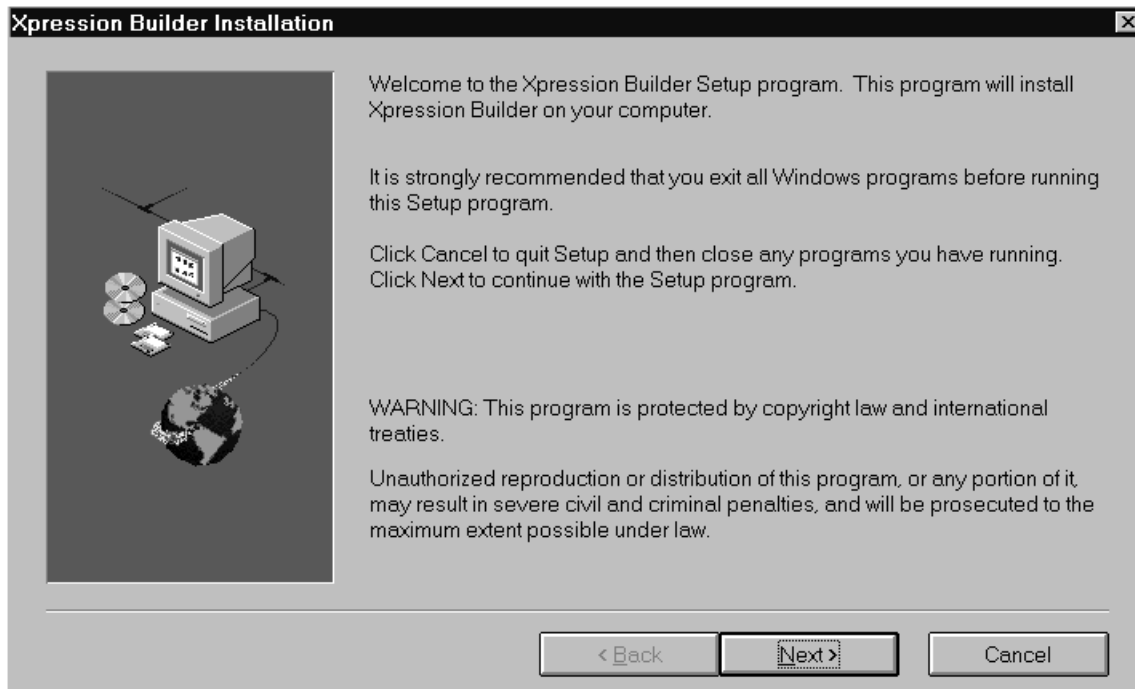


Figure 13-3: XPRESSION BUILDER INSTALLATION WELCOME SCREEN

7. Click on the **Next** button to begin the installation.
8. The Software License dialog box will appear. Carefully read the Software license agreement. Click **Yes** if you agree with the terms of license; clicking **No** will terminate the Setup program.
9. Setup will prompt for a directory to install the Xpression Builder software. Click **Browse** to choose an appropriate directory or **Next** to accept the default directory C:\XPRESS.
10. Xpression Builder Setup will now install the software. When the installation process is finished, the Installation Complete dialog box will appear. Check **Yes, I want to view the ReadMe file** to view the latest software information and click **Finish**. The software is now installed.

b) INSTALLING FROM THE INTERNET

To install the software from the GE Power Management web site enter the following URL in your Web browser:

www.ge.com/indsys/pm

The home page is the same as that shown in Figure 13-1: GEPM PRODUCTS CD PRIMARY SCREEN on page 13-2. Follow the above procedure from step 3 to continue the installation.

13.2.1 OVERVIEW

Xpression Builder logic is processed every other millisecond. This should be considered when designing logic to implement in the relay. The more gates that are connected in series, the longer the time delay from the initial logic input to the final logic output (roughly 2 ms per gate) of the expected result. This delay applies to the Xpression Builder logic only. The scheme logic outputs of the relay will not be delayed with the use of configurable logic.

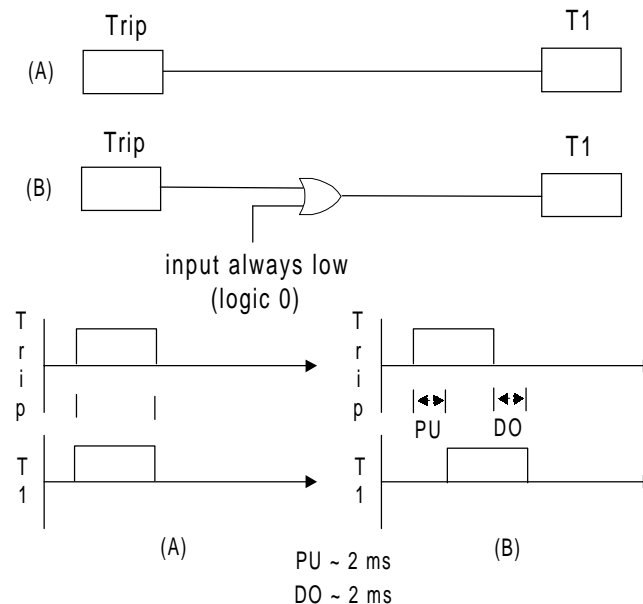


Figure 13-4: LOGIC PROCESSING DELAY

For example, the TRIP (flag #33) output of the scheme logic when directly connected to an output contact will close that contact when it becomes high (logic 1) with no additional processing delay as shown in Figure 13-4: LOGIC PROCESSING DELAY part A. If the TRIP flag is first connected to a Boolean gate before it reaches an output contact, a gate processing delay of 2 ms should be added to the expected function operating time as shown in Figure 13-4: LOGIC PROCESSING DELAY part B. This should be taken into consideration in the design of the relay configurable logic. This is why it is recommended all user defined logic be tested in a laboratory environment before installation in the field. This will ensure user confidence and expected performance of the configurable logic developed with the relay internal flags.

13.2.2 BOOLEAN OPERATORS, LATCHES, TIMERS, & COUNTERS

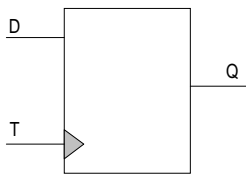
a) BOOLEAN OPERATORS

The operation of the Boolean operators (AND, OR, and NOT) are self explanatory. Each gate may have up to four (4) inputs. Each of the inputs may be logically inverted by clicking the right mouse button when the cursor is at the input of the gate. A small circle at the gate input will indicate the inversion of the input signal. The output can also be inverted by clicking the right mouse button when the cursor is at the output of the gate. A small circle at the gate output will indicate the inversion of the output signal.

b) LATCHES

A “D” flip-flop is used in the Xpression Builder logic as shown in Figure 13-5: LATCH AND TRUTH TABLE. The D input is where the data bit to be stored is applied. The T or clock input controls the flip-flop. It determines whether the data on the D input line is recognized (clocked) or ignored. If the T input line is high (binary 1), the

data on the D input line is stored in the flip-flop. If the T input line is low (binary 0), the D input line is not recognized. The Q output line directly reflects the state of the flip-flop. If the flip-flop is set, then Q equals a high (binary 1). If Q equals a low (binary 0), then the flip-flop is reset.



T	D	Q
L	X	Q_0
H	L	L
H	H	H

Figure 13–5: LATCH AND TRUTH TABLE

13

c) TIMERS

There are two types of timers used in the Xpression Builder program, the Pickup/Dropout Timer and the Pickup Relay Timer.

The simplest type is the Pickup/Dropout timer. Shown in Figure 13–6: PICKUP/DROPOUT TIMER, the 300 indicates the pickup delay and 250 indicates the dropout delay, both in milliseconds. In both parts A and B of Figure 13–6: PICKUP/DROPOUT TIMER, the IN/OUT time charts describe how the timer functions. If the input is high (binary 1) for a time equal to the pickup delay, the output becomes high (binary 1). Any reset of the input (high to low) causes the accumulated pickup time to reset immediately to zero. Once the output occurs, it remains high as long as the input remains high, and when the input subsequently goes low the output stays high for a time equal to the dropout delay. Once the dropout timer has started, it will continue to time out even if the input goes high during the reset time. Time chart A shows a second input pulse occurring after the output goes low. Since this pulse length is less than the 300 ms pickup delay, the output stays low. Time chart B shows a second input pulse occurring 100 ms after the first input pulse goes low. The output goes low as shown in time chart B, but the output then goes high 300 ms after the leading edge of the second input pulse or 150 ms after the trailing edge of the first output pulse. The pickup and dropout timers are independent of each other.

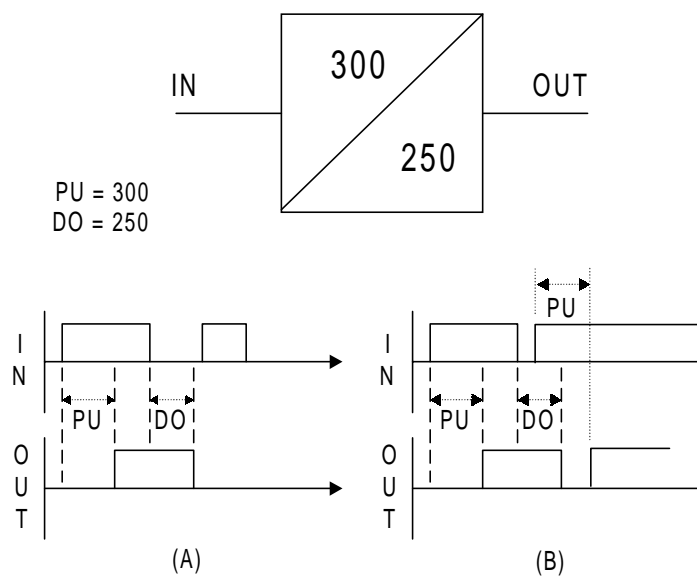


Figure 13–6: PICKUP/DROPOUT TIMER

The second type of timer is basically a pickup delay timer with a reset input/output feature. As shown in Figure 13–7: PICKUP DELAY TIMER, there are two inputs, two outputs, and a user selected pickup delay (in milliseconds). In its “initial” state with no inputs applied, both R and S are low (binary 0), the timer outputs RO and SO are both low (binary 0). The timer starts counting when the S input is high (binary 1). When the count becomes equal to the set time delay (1000 ms for our example), the SO output is set high (binary 1) and the RO output is set low (binary 0). If the R input becomes high (binary 1) while the timer IS NOT counting, then both outputs RO and SO are set low (binary 0) which returns the timer to its “initial state”. See Table 13–1: PICKUP DELAY TIMER TRUTH TABLE for a summary of the pickup delay timer function.

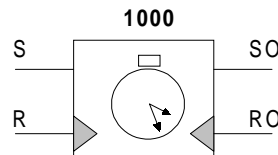


Figure 13–7: PICKUP DELAY TIMER

Table 13–1: PICKUP DELAY TIMER TRUTH TABLE

S	R	PREVIOUS TIMER STATE	CURRENT TIMER STATE	RO	SO
L	L	NOT TIMING	NOT TIMING	RO _{n-1}	L
↑	L	NOT TIMING	TIMING DOWN	L	L
X	L	TIMING DOWN	TIMER EXPIRED	L	H
X	H	TIMING DOWN	TIMER RESET	H	L
X	↑	NOT TIMING	NOT TIMING	L	L

d) COUNTERS

The counter has two input line, one output line, and a user selected count threshold (in milliseconds) as shown in Figure 13–8: COUNTER. A transition from low (binary 0) to high (binary 1) on the S input line increments the counter by a value of one. The O output line is high (binary 1) when the accumulated count is equal to or greater than the count threshold. If the O output line is low (binary 0), then the accumulated count is less than the set value. A transition from low (binary 0) to high (binary 1) on the R input line resets the counter to zero.

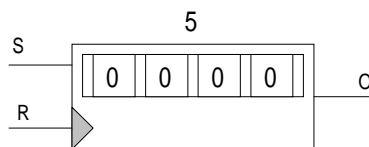


Figure 13–8: COUNTER

13.3.1 CONTACT CONVERTER INPUTS

Table 13–2: CONTACT CONVERTER INPUT FLAGS

Index	Description	Mnemonic
0	No Assignment to Input	NONE
1	Breaker #1 52b Contact Input	52B_1
4	Breaker #2 52b Contact Input	52B_2
8	Change Setting Group Input Bit 0	CGST1
9	Change Setting Group Input Bit 1	CGST2
10	External Contact Input to Stop Carrier	STCR
11	External Contact Input to Block Pilot Tripping	BPLTRP
12	Receiver 1 Input	RCVR1
13	Receiver 2 Input	RCVR2
15	External Reclose Initiate 3-Pole	EXRI3P
16	External Reclose Inhibit	EXRINH
17	External Reclose Cancel	EXRCNL
18	Reclose Reset	RCLRST
19	External Manual Close	EMNCLS
22	External Contact Input to Disable Outputs	DISOUT
23	External Contact to Trigger Oscillography	OSCTRG
24	Manual Lock-Out	MANLKT
25	Configurable Input 1	CNFDI1
26	Configurable Input 2	CNFDI2
27	Configurable Input 3	CNFDI3
28	Configurable Input 4	CNFDI4
29	Configurable Input 5	CNFDI5
30	Configurable Input 6	CNFDI6
31	Configurable Input 7	CNFDI7
32	Configurable Input 8	CNFDI8

13.3.2 INPUT FLAGS

The input flags available for assignment to user defined logic are shown in the following tables. Note that Xpression Builder may offer a number of choices that are not available with the LPS-O relay. Use only the inputs listed in the tables in this section.

Table 13–3: CONFIGURABLE INPUTS

INDEX	DESCRIPTION	MNEMONIC
25	Configurable Input 1	CNFDI1
26	Configurable Input 2	CNFDI2
27	Configurable Input 3	CNFDI3
28	Configurable Input 4	CNFDI4
29	Configurable Input 5	CNFDI5
30	Configurable Input 6	CNFDI6
31	Configurable Input 7	CNFDI7
32	Configurable Input 8	CNFDI8

Table 13–4: SCHEME LOGIC INPUTS

INDEX	DESCRIPTION	MNEMONIC
1	Breaker #1 52b Contact Input	52B_1
4	Breaker #2 52b Contact Input	52B_2
8	Change Setting Group Input Bit 0	CGST1
9	Change Setting Group Input Bit 1	CGST2
22	External Contact Input to Disable Outputs	DISOUT
23	External Contact to Trigger Oscillography	OSCTRG

Table 13–5: CURRENT AND VOLTAGE UNITS

INDEX	DESCRIPTION	MNEMONIC
103	Any Phase Undervoltage	ANYUVT
104	All Voltage High (No Phase Undervoltage)	ALLVLT
105	Fault Detector (FD)	FLTDET
107	IT Detector	IT
108	IB Detector	IB
109	IPT Detector	IPT
110	IPB Detector	IPB
111	Remote Breaker Open Detector	REMOPN
116	Instantaneous Phase Overcurrent (50P/PH4)	50
117	Instantaneous Ground Overcurrent (50G/IDT)	50G
118	Ground Time Overcurrent Pick-Up	TOCACT
119	Ground Time Overcurrent Trip (51G/TOC)	TOCTRP

Table 13–6: SCHEME LOGIC OUTPUTS

INDEX	DESCRIPTION	MNEMONIC
33	Trip	TRIP
37	Reclose Initiate	RI
38	Reclose Cancel Output from Scheme Output	RC
43	Warm Restart	WARMST
45	Line Overload Alarm Output	LNOVLD
46	Critical Alarm Output	CRTALM
48	Trip Circuit Monitor Alarm	TCMALM
49	Zone Flags On Alarm	ZNALM
50	Overcurrent Alarm	OVRALM
51	Unbalanced Current Detector Alarm Output	UNBAL
52	Non-Critical Alarm Output	NCALM
56	Manual Open Breaker # 1	MNOPN1
57	Manual Open Breaker # 2	MNOPN2
58	Manual Close Breaker # 1	MNCLS1
59	Manual Close Breaker # 2	MNCLS2
100	All Phases Open	OPEN
114	Line Pick-Up	LPU
115	Fuse Failure Alarm	FF
120	Out-of-Step Blocking	OSB
121	Out-of-Step Tripping	OST
122	Configurable Trip Bus	CNFTRP
123	Configurable Oscillography Trigger	CNFOSC
135	Any Trip Bus	TRPBUS
140	Any Phase Overvoltage Pickup	OVRVPU
144	Block Reclose Initiate	BLK-RI
145	Manual Close In Progress	CLS IP
146	Breaker Close	BKRCLS
153	Phase A Overvoltage	AVOVR
154	Phase B Overvoltage	BVOVR
155	Phase C Overvoltage	CVOVR

Table 13–7: DISTANCE UNITS

INDEX	DESCRIPTION	MNEMONIC
65	Zone 1 AB Distance Function	Z1AB
66	Zone 1 BC Distance Function	Z1BC
67	Zone 1 CA Distance Function	Z1CA
68	Zone 2 AB Distance Function	Z2AB
69	Zone 2 BC Distance Function	Z2BC
70	Zone 2 CA Distance Function	Z2CA
71	Zone 3 AB Distance Function	Z3AB
72	Zone 3 BC Distance Function	Z3BC
73	Zone 3 CA Distance Function	Z3CA
74	Zone 4 AB Distance Function	Z4AB
75	Zone 4 BC Distance Function	Z4BC
76	Zone 4 CA Distance Function	Z4CA
77	Any Zone 1 Phase Distance Function	Z1PH
78	Any Zone 2 Phase Distance Function	Z2PH
79	Any Zone 3 Phase Distance Function	Z3PH
80	Any Zone 4 Phase Distance Function	Z4PH
132	Zone 2 Phase Timer	Z2PTMR
133	Zone 3 Phase Timer	Z3PTMR
134	Zone 4 Phase Timer	Z4PTMR
106	TL1 Timer Output	TL1
126	Ground Forward Flag (NT)	GRDFWD
127	Ground Reverse Flag (NB)	GRDREV

Table 13–8: MISCELLANEOUS

Index	Description	Mnemonic
138	Number of Breaker Operation Alarm	BRMNOP
139	Breaker Equipment Duty Alarm	BRMNDT
60	Fault ID: Phase A Involved	DAFLTA
61	Fault ID: Phase B Involved	DAFLTB
62	Fault ID: Phase C Involved	DAFLTC
63	Fault ID: Neutral Involved	DAFLTN
64	DMA Overrun	DMAOVR
147	Trip Circuit #1 Voltage Monitor Status	T1TC
148	Trip Circuit #2 Voltage Monitor Status	T2TC
149	Trip Circuit #3 Voltage Monitor Status	T3TC
150	Trip Circuit #4 Voltage Monitor Status	T4TC

13.3.3 OUTPUT FLAGS

The output flags available for assignment to user defined logic are as follows:

Table 13–9: USER DEFINABLE OUTPUT FLAGS

INDEX	DESCRIPTION	MNEMONIC
-	Trip Contacts	T1 to T6
-	Auxiliary Contacts	A1 to A12
-	Control Contacts	C1 to C2
-	High Speed Channel Contacts	KT1 to KT4
-	User Defined Trip	CONFTRIP
-	User Defined Oscillography Capture	CONFOSC
-	User Defined Non-Critical Alarm	NC Alarm

13.4.1 DESCRIPTION

Configurable logic can be quickly created and downloaded to the relay using the following three steps:

1. Using LPSO-Link, upload the Configurable Logic file for the desired settings groups. This action will shift you to the Xpression Builder application.
2. Execute the required changes in Xpression Builder as described in Section 13.4.3: DESIGNING XPRESSION BUILDER LOGIC
3. Compile and download the expression using the utility in Xpression Builder.

13.4.2 UPLOADING RELAY CONFIGURABLE LOGIC

The first step in changing the relay logic is to upload the existing logic. This is done from the LPSO-Link **Settings** menu. Ensure that you are logged on with at least the settings password at this point. Clicking Configurable Logic with the mouse will lead to a group selection dialog box. Select OK for the active settings group or enter the desired group number and select OK. This will lead to the LPSO-Link application opening the Xpression Builder routine and making it the active application. The resultant screen will appear similar to Figure 13–10: CONTACT CONVERTER INPUTS (CC) on page 13–14. You are now ready to begin configurable logic design.

13.4.3 DESIGNING XPRESSION BUILDER LOGIC

In the Xpression Builder program, Select **File** followed by **New**. A menu window for ALPS / LPS / DFP200 options will be displayed as shown in Figure 13–9: CREATING A NEW FILE. For examination purposes, select **LPS 3-Pole Configurable Logic**. A working screen will be displayed for an LPS-O three-phase tripping unit.

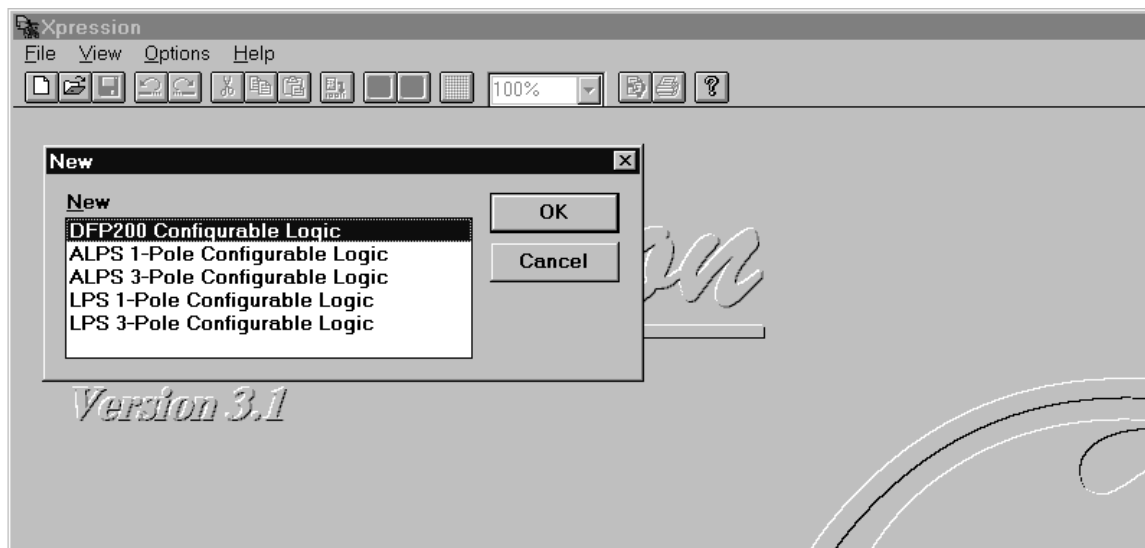


Figure 13–9: CREATING A NEW FILE

The next step in the design of configurable logic is to determine the need for digital inputs. Typical inputs assigned to contact converters are channel receivers and 52_b contacts. Other inputs can come from external contacts, other relay outputs, or the feedback of one of the LPS-O outputs to an input. The list of available contact converter input assignments can be found in Table 13–2: CONTACT CONVERTER INPUT FLAGS on page 13–8. In effect, this process does nothing more than associate a given digital input with a name that Xpression Builder can use. Selection of the contact converter (CC) box, for example CC1, with the left mouse

button will activate a pull down menu from where flags can be assigned to the respective input as shown in Figure 13–10: CONTACT CONVERTER INPUTS (CC). Double clicking on the CC box near the input bar with the right mouse button will give the input an inverted sense and a NOT logical gate will appear on the input bar as shown in Figure 13–11: INVERTED CC INPUTS. A straight input will require a pickup voltage presence to be considered a high input (logic 1). An inverted input will require a pickup voltage presence to be considered a low input (logic 0).

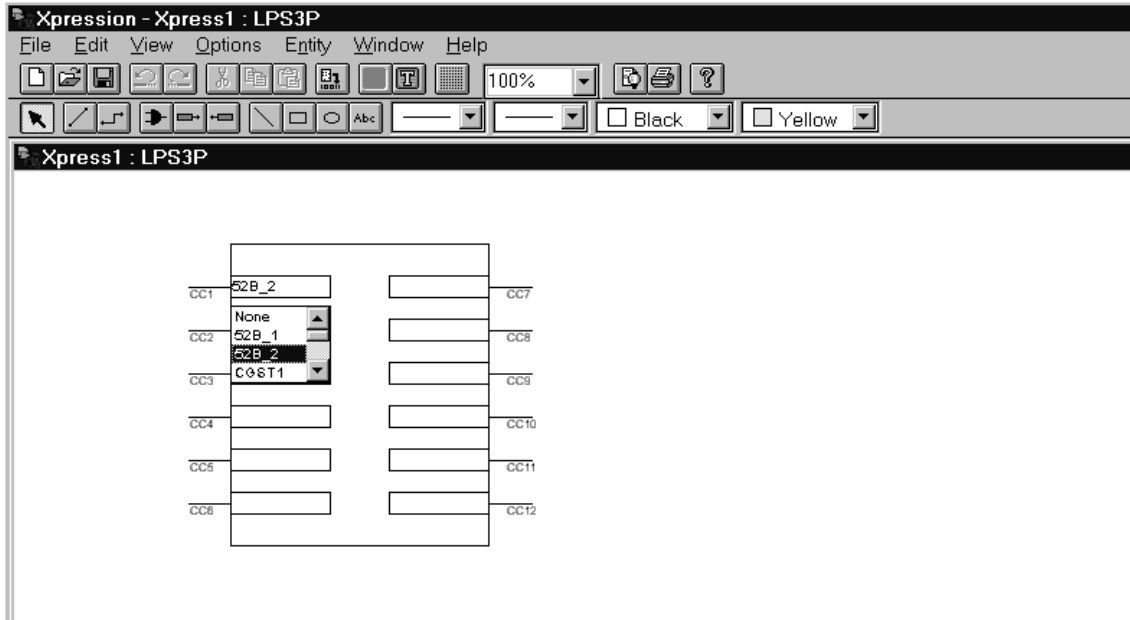


Figure 13–10: CONTACT CONVERTER INPUTS (CC)

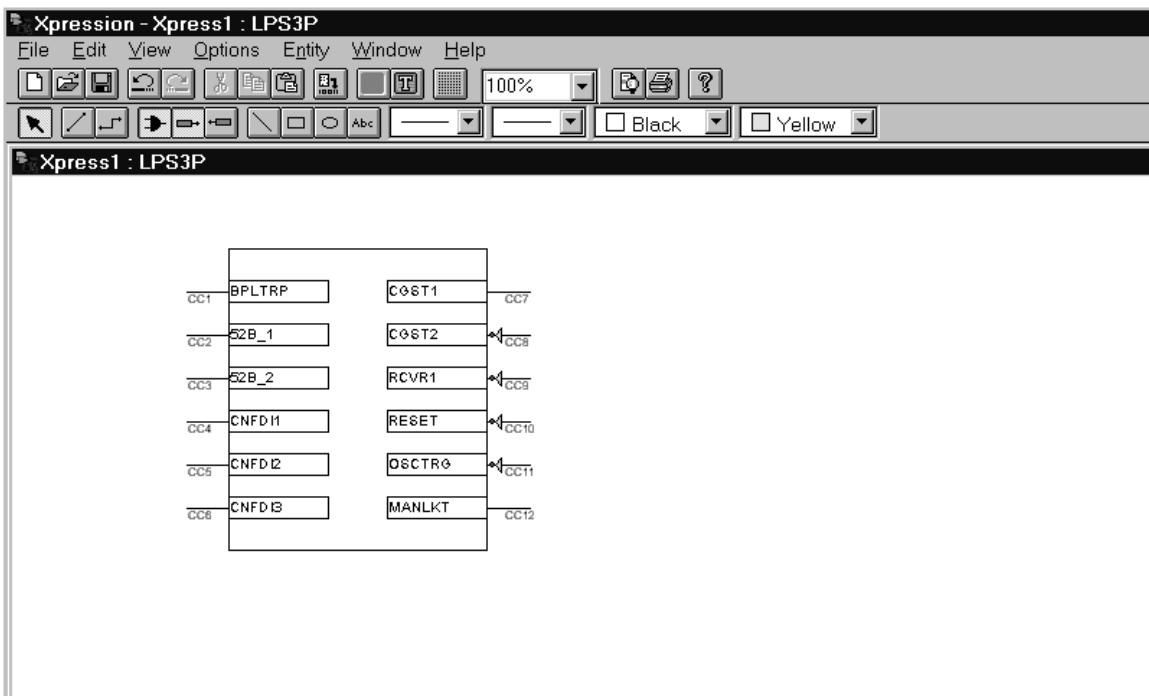


Figure 13–11: INVERTED CC INPUTS

The next step is to take advantage of the internal protection flags in the relay, and put them to work in logical combinations necessary to your specific application. Select the **Input** flags icon as shown in Figure 13–12: INPUT ICON. The input flags are listed by group beginning with Table 13–3: CONFIGURABLE INPUTS on page 13–9. You can move between groups by using the mouse to scroll through the pull-down menu. Simply select the flag by clicking the left mouse button. Move the cursor to the location where the flag is going to be used and click the left mouse button again. This action will place the flag at the desired location.

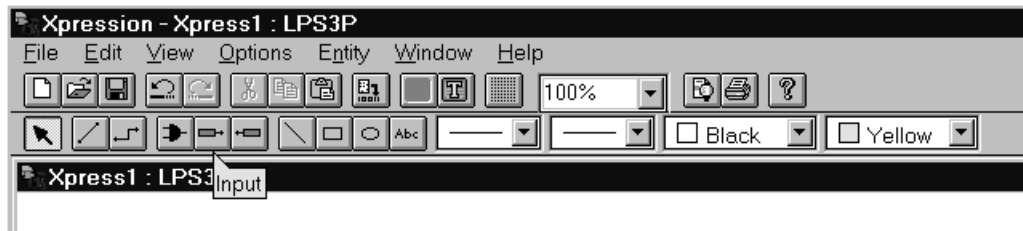


Figure 13–12: INPUT ICON

The next step is to use the Xpression Builder Boolean operators. Select the **Operator** icon as shown in Figure 13–13: OPERATOR ICON. The available operators are AND, OR, NOT, Latches, Counters, PD Timers, and Timers. Simply select the operator by clicking the left mouse button. Move the cursor to the location where the operator is going to be used and click the left mouse button again. This action will place the operator at the desired location.

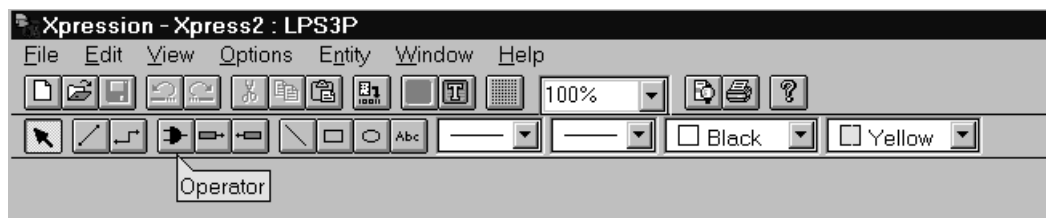


Figure 13–13: OPERATOR ICON

The next step is to select the output contacts which will be used in the relay application. Select the **Output** flag icon as shown in Figure 13–14: OUTPUT ICON. The output contacts are listed in Table 13–9: USER DEFINABLE OUTPUT FLAGS. Simply select the output flag by clicking the left mouse button. Move the cursor to the location where the flag is going to be used and click the left mouse button again. This action will place the flag at the desired location.

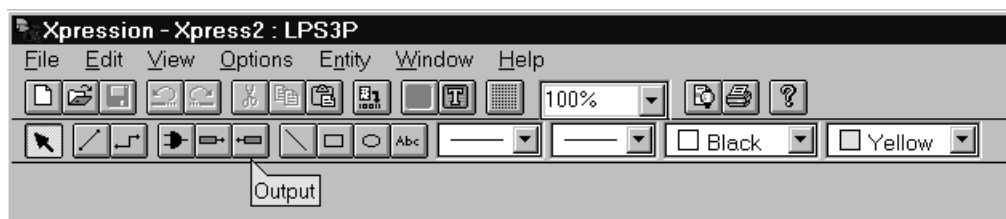


Figure 13–14: OUTPUT ICON

The next step is to start connecting the inputs to the Boolean operators and to the output gates. To use straight line connections, select the **Connection** icon as shown in Figure 13–15: STRAIGHT CONNECTION ICON. To use orthogonal line connections, select the **Orthoconnection** icon as shown in Figure 13–16: ORTHO-CON-

NECTION ICON. Once the type of connection is decided and selected, click the left mouse button on an input or Boolean operator output connection stud. Move the mouse and click the left button on the connection stud of an output or the input of a Boolean operator.

If all the inputs are connected to logic gates and/or output contacts, you are ready to compile the logic.

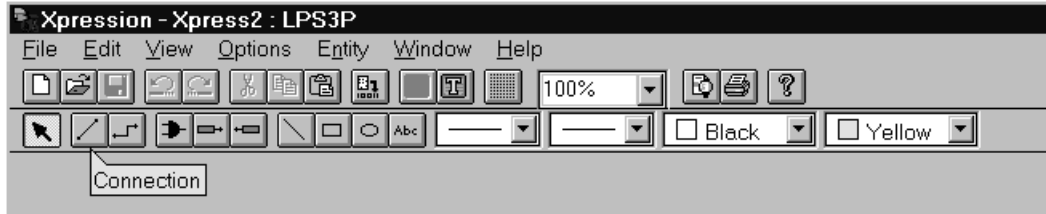


Figure 13–15: STRAIGHT CONNECTION ICON

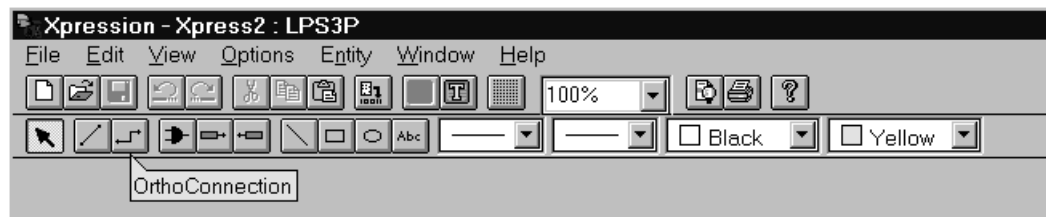


Figure 13–16: ORTHO-CONNECTION ICON

13.4.4 COMPILING AND DOWNLOADING XPRESSION BUILDER LOGIC

Once the logic has been created you are ready to compile. Under the **File** header, select **Compile**. If you are connected to the relay at the time you can download the logic to the relay by selecting the **Download** command under the **File** header. After you compile the logic, under the **File** header, select **Save_As** and give the file a name with a .BIN extension. The BIN file is a binary formatted file which is downloaded to the relay. A user should also save the logic with an .EXP extension. The EXP file saves the graphical layout of the logic. When both formats are saved, the logic uploaded from the relay can be matched to the graphical layout saved for the configurable logic file (Note: when Xpression Builder is launched, it prompts the user for the location of the EXP file; if the EXP file was not created, select **Cancel** and Xpression Builder will give the relay logic a graphical layout which is logically correct, but may have a poor layout).

13.4.5 BREAKER FAILURE EXAMPLE

Figure 13–17: SAMPLE BREAKER FAILURE LOGIC is an example of a simple breaker failure scheme which can be implemented in the relay using Xpression Builder logic. Use the description in the previous sections to select the external contact input to block pilot tripping (BPLTRIP), the external configurable input (CNFDI1), the internal block supervision current flag (IB), the Boolean operators (OR, AND, and P/D Timer), and the output contact (A1).

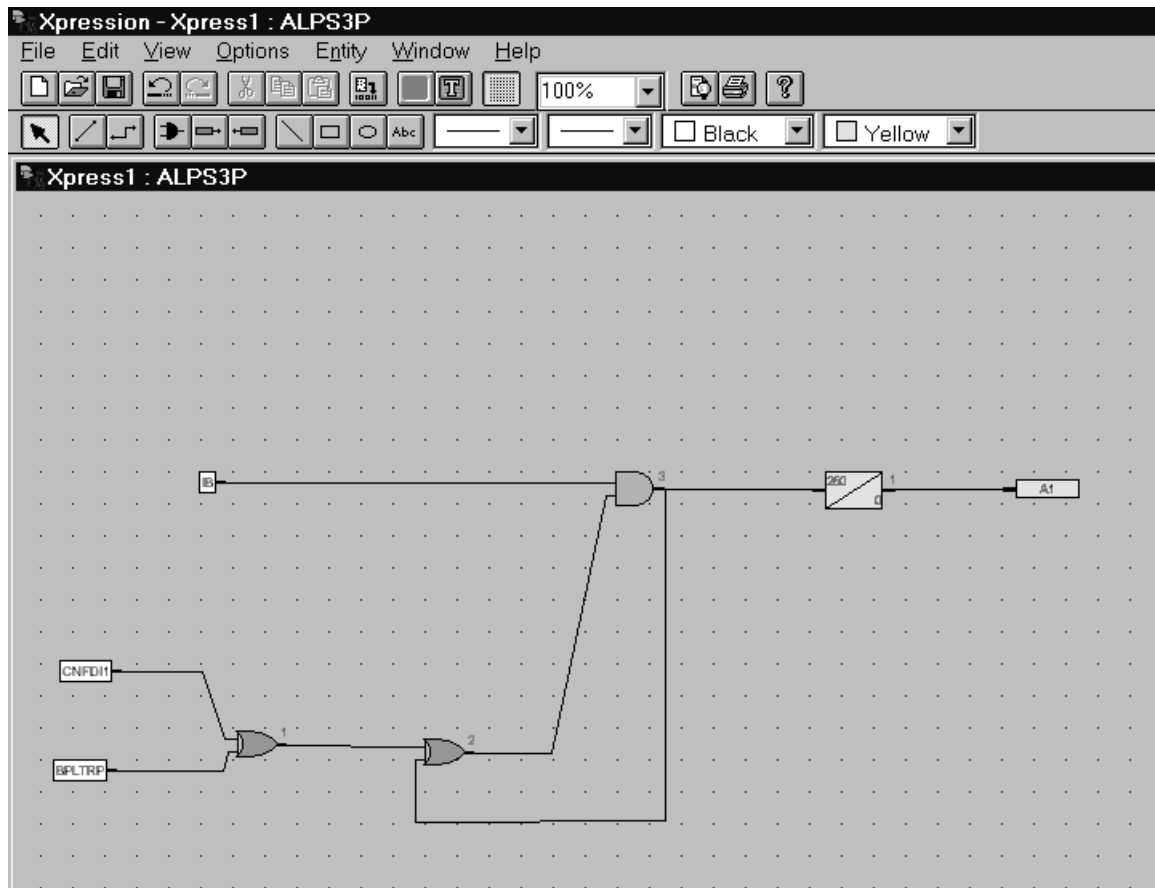


Figure 13–17: SAMPLE BREAKER FAILURE LOGIC

Q

Why doesn't the relay accept the default LUI passwords?

A

A new relay comes with LUI (Local User Interface) and remote factory setting passwords. The master factory setting password must be changed in order to login and perform actions with the relay through the keypad. To change a factory setting password, perform the following steps:

1. Press the action key [ACT].
2. Press the enter key [ENT]; no password is required.
3. Scroll down the menu to item: **10. CHANGE PASSWORD**.
4. Press the [ENT] key.
5. Select the password to be changed.
6. Enter the factory password.
7. Enter your new password.
8. Re-enter your new password.
9. Logout by pressing the [END] key followed by the [ENT] key.
10. The factory setting password has now been successfully changed.

Q

What are the LUI and remote factory setting passwords?

A

The LUI factory passwords for the different privilege levels are:

- 789.** (master)
- 456.** (actions)
- 123.** (settings)

Note: the period is part of the password!

The LUI passwords stored in the relay may be viewed, in encoded format, via remote communications. The remote factory passwords for the different privilege levels are

- master!** (master)
- actions!** (actions)
- setting!** (setting)
- view!** (view)

The remote passwords stored in the relay may be viewed, in encoded format, via the LUI.

A

Q Why can't I communicate with the relay using LPSO-Link?

A If you are unable to communicate with the LPS-O relay using LPSO-Link, perform the following checks:

- Verify the LPSO-Link program is selected for the comm port you are using on your PC or laptop
- Verify the cable you are using is a null modem cable
- Verify the protocol of the relay comm port you are using is set for GE-Modem. Note: rear port PL2A is factory set for ASCII.
- Verify the unit ID, baud rate, stop bits, and parity settings of the relay comm port you are using to match with the settings in the device setup for the LPSO-Link session.

Q What would I do if the LPS-O gives a red LED status indication?

A If the LPS-O relay displays a red LED status, prompt the relay for failure messages. Press the information key [INF] and select Status. Scroll down the list and write the failure messages of the relay. Protection is not active when the Status LED is red. This condition could indicate a critical failure: contact GE.

Q In which format should I save Xpression Builder configurable logic?

A When configurable logic is created with Xpression Builder, it must be saved with a .BIN extension. The BIN file is a binary formatted file which is downloaded to the relay. The user should *also* save the logic with an .EXP extension. The EXP file saves the graphical layout of the logic. When both formats are saved, the logic uploaded from the relay can be matched to the graphical layout saved for the configurable logic file. If an EXP file is not created, Xpression Builder will give the relay logic a graphical layout which is logically correct, but may have a poor layout.

Q Which do I download first: Xpression Builder configurable logic or relay settings?

A First, download protection and general settings using the LPSO-Link program. Secondly, download the configurable logic into the relay. The order of these two steps is important because downloading configurable logic or settings change the inputs and outputs of the relay. The last settings downloaded are saved in the relay.

Q Does LPSO-Link work with Windows NT?

A Yes. LPSO-Link works on Windows 3.1, Windows 95, and Windows NT platforms. The install program will look to see what operating system the user is running and will install the correct executable.

Q Are the Trip Output Contacts (T1 to T6) polarity sensitive?

A Yes. The Trip Output Contacts are polarity sensitive even if the user does not have an SCR model. The internal circuitry requires the correct polarity for the trip circuit monitor function to operate properly. The contact polarities are shown in Figure 1–11: ELEMENTARY DIAGRAM.

Q Can I plot the phase and ground characteristics of my settings for the relay?

A Yes. The LPS-O PC software package includes a program called ALPS-Test which allows you to plot the phase and ground characteristics from your settings file. See Chapter 10: ALPS-TEST PROGRAM.

Q What format should I choose when saving oscillography data?

A If you use the GE-DATA program to view oscillography, save the data in DAFF format. For other comtrade compatible viewers, save the data in the COMTRADE format. Note: a readme file in the LPS/UTIL directory describes the procedure to convert LPS-O oscillography for use with the DL-DATA program.

Q Why are so many files created when I save oscillography data?

A Several files are created when oscillography data is retrieved from the relay because they each serve different purposes.

Saving data in the DAFF format creates an OSC, DAF, and REP file. The OSC file is used to playback a waveform to the relay. The DAF file is used by the GE-DATA program to view the waveforms and flags within the relay. The REP file contains the fault report and settings in the relay at the time of the fault.

Saving data in the COMTRADE format creates an OSC, HDR, CFG, DAT, ASC, and REP file. The OSC file is used to playback a waveform to the relay. The HDR file contains the fault report and the settings in the relay at the time of the fault. The CFG file contains the configuration of the data such as sample rate and description of channels. The DAT file contains the actual oscillography data in a binary format. The ASC file contains the oscillography data in an ASCII format. The REP file contains instructions on saving the oscillography data.

To view the latest version of this FAQ and other documents, visit the GE Power Management Home page at www.ge.com/indsys/pm.

A

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C.1.1 SET MENU

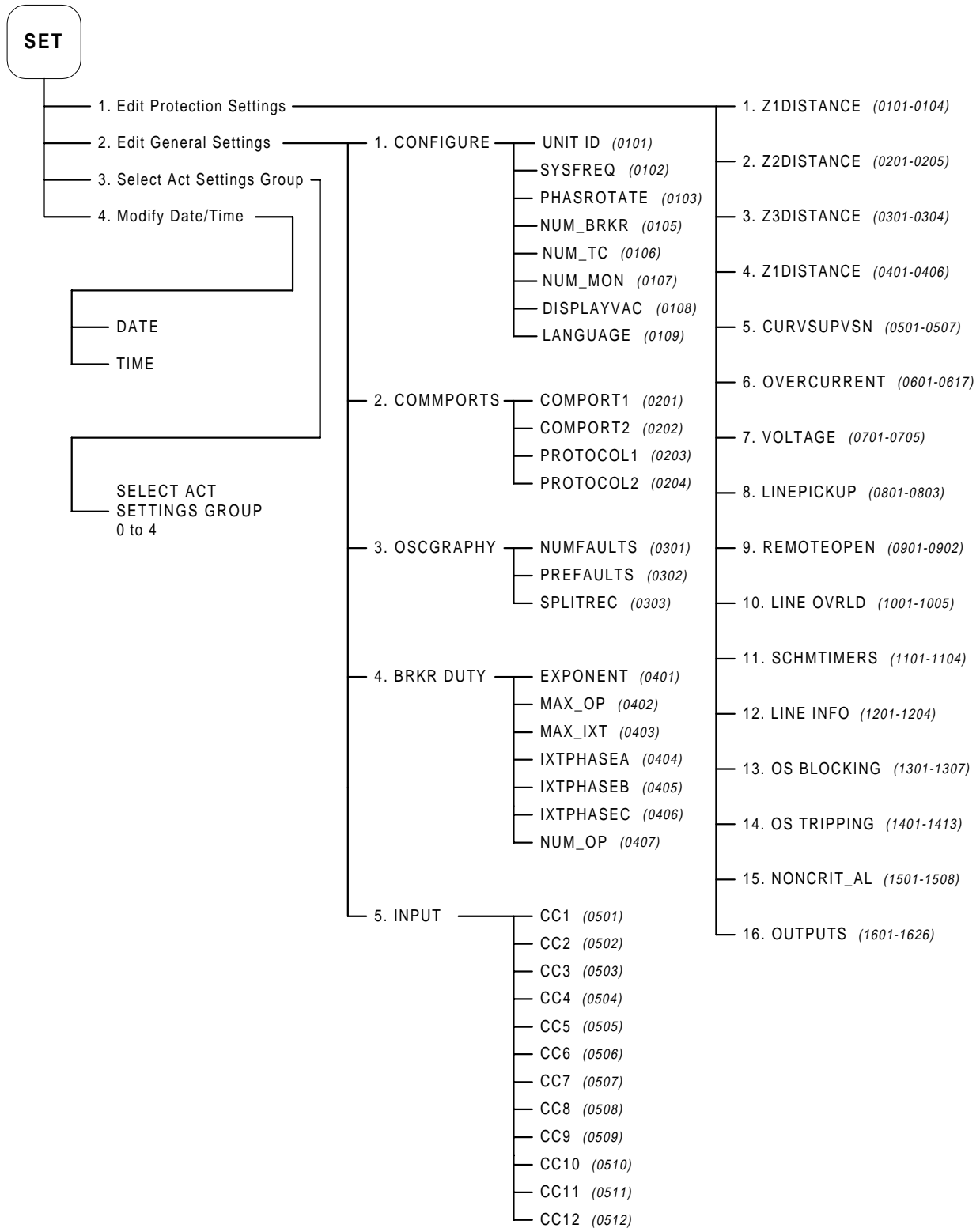


Figure C-1: SET KEYPAD MENU

C.1.2 ACT KEYPAD MENU

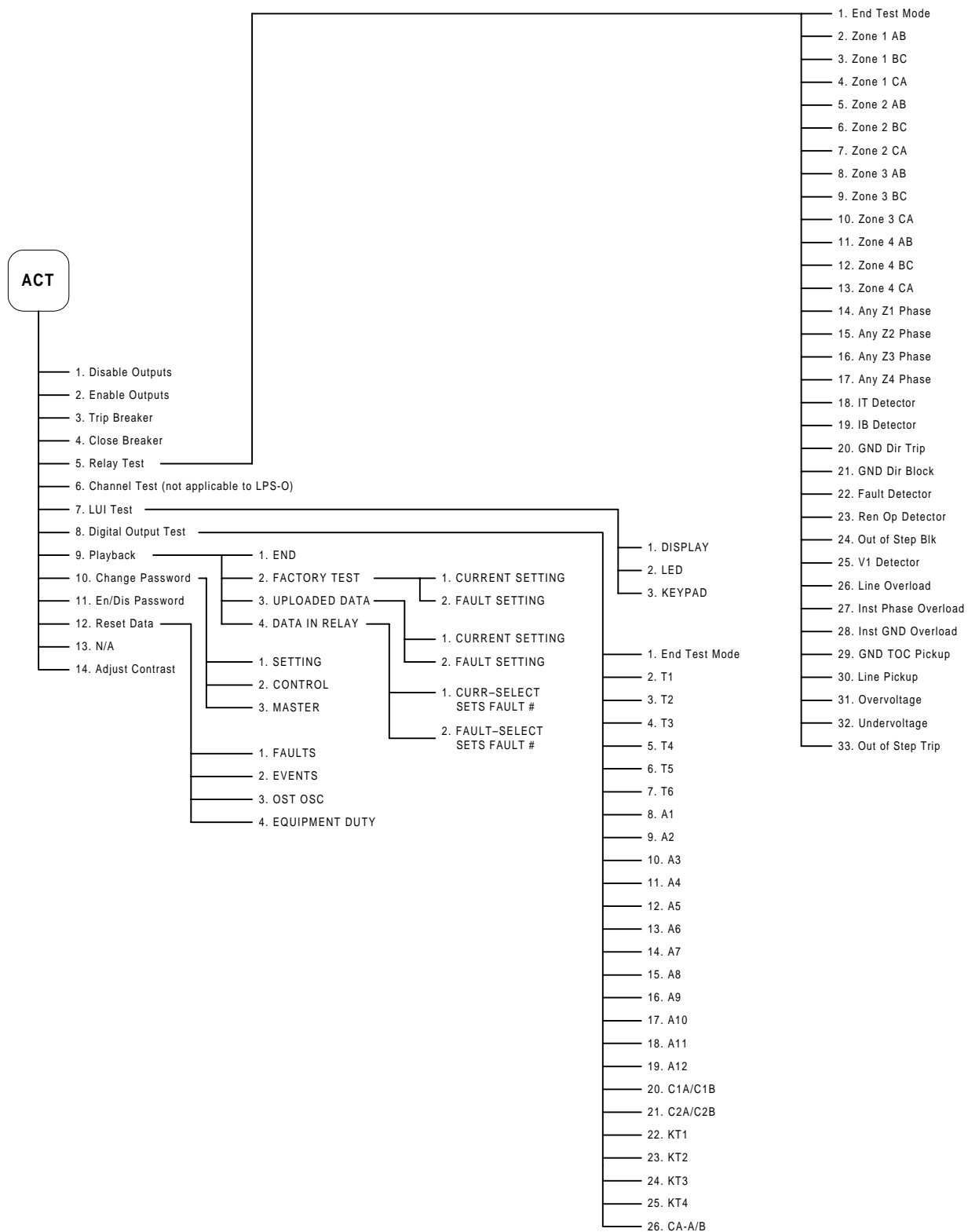


Figure C-2: ACT KEYPAD MENU

C.1.3 INF KEYPAD MENU

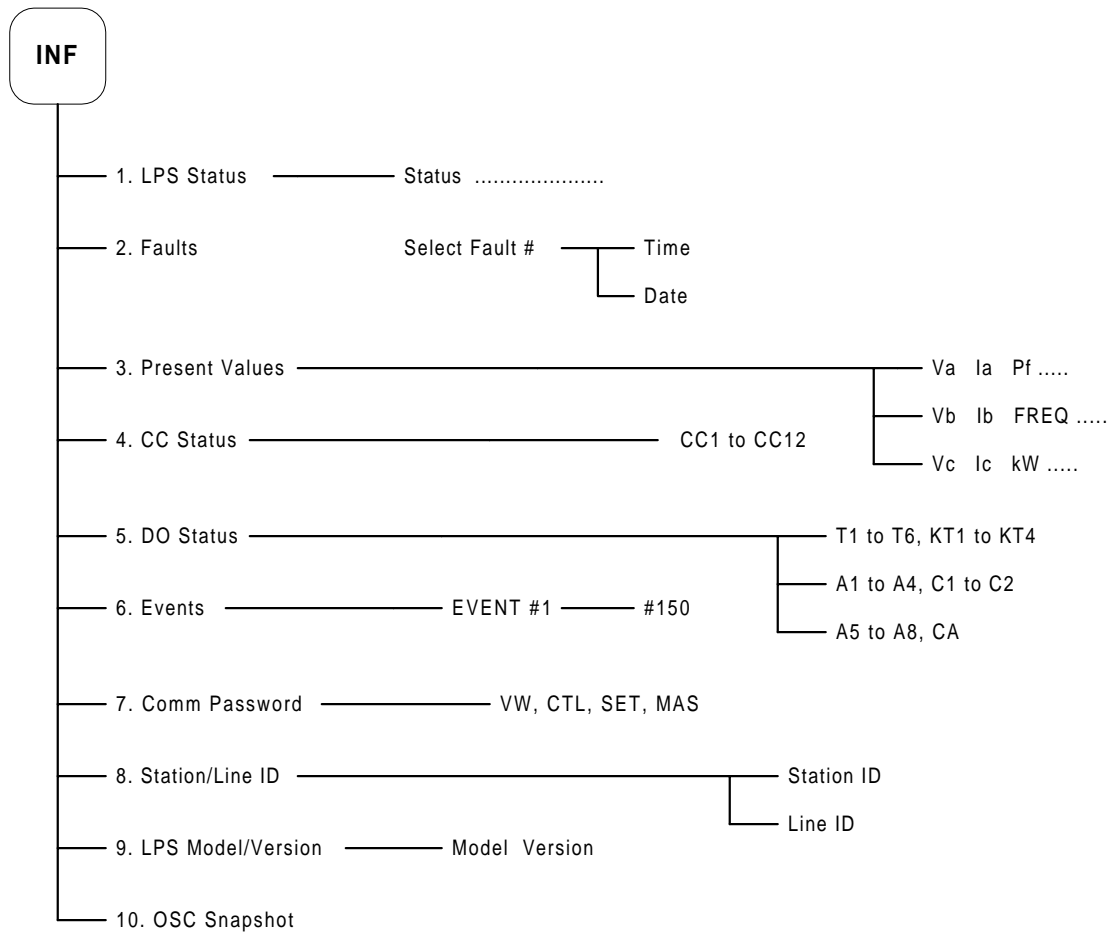


Figure C-3: INF KEYPAD MENU

D.1.1 GE MULTILIN WARRANTY

GE MULTILIN RELAY WARRANTY

General Electric Multilin Inc. (GE Multilin) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Multilin will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Multilin authorized factory outlet.

GE Multilin is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers), refer to GE Multilin Standard Conditions of Sale.

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