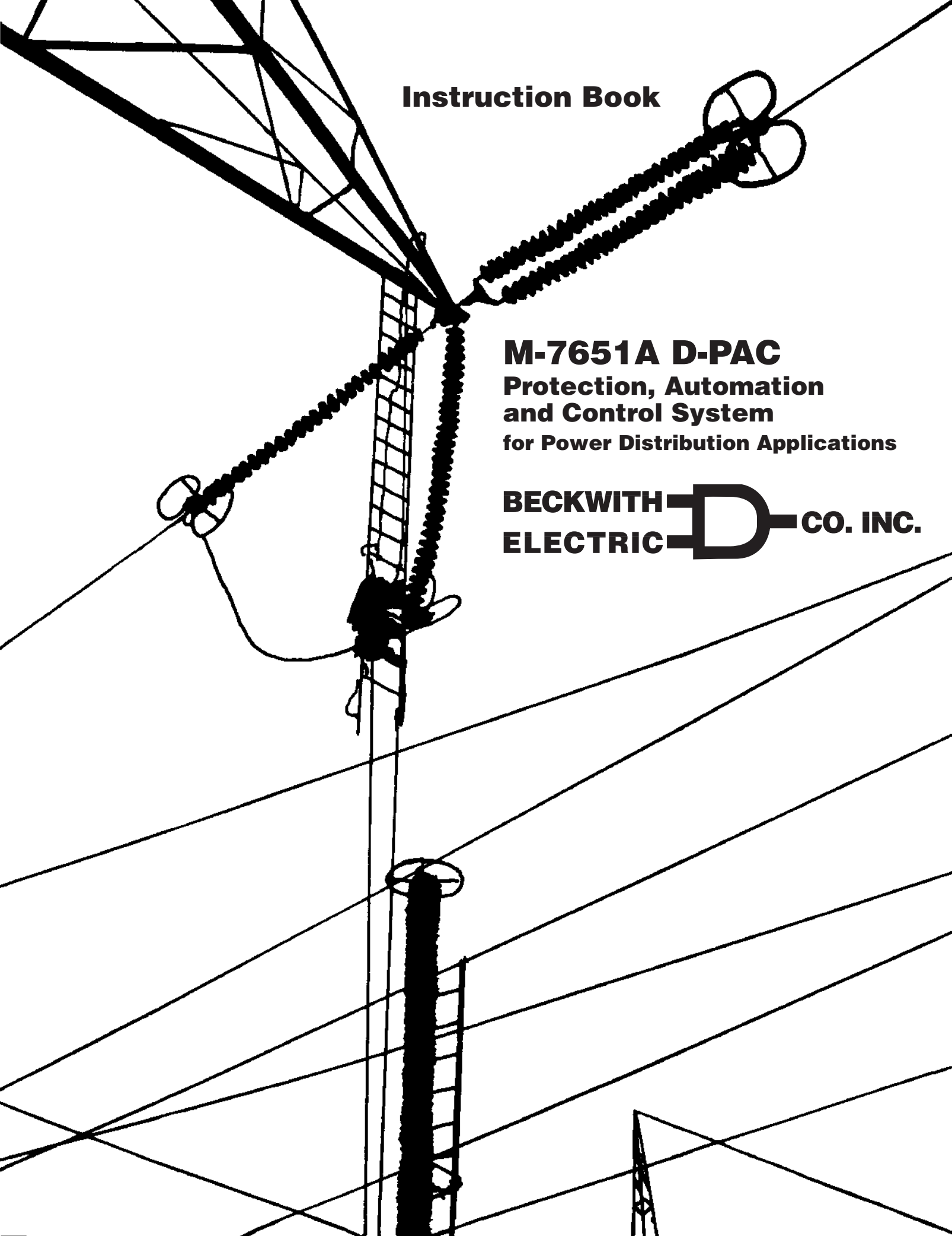

Instruction Book

M-7651A D-PAC

Protection, Automation and Control System

for Power Distribution Applications

BECKWITH ELECTRIC CO. INC.

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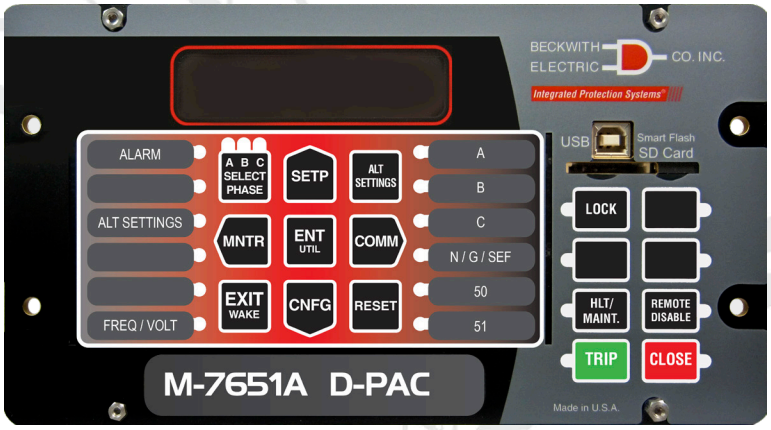
BECKWITH ELECTRIC CO. INC.

PROTECTION



M-7651A D-PAC

Protection, Automation and Control System for Power Distribution Applications

Protection

- Over 30 Protection Elements for optimal protection of Power Distribution Systems
- Ready to use advanced Protection Schemes for applications including Feeder Protection, Bay Control and DG Interconnection Protection
- 8 Setting Profiles
- Comprehensive I/O Matrix provides visual confirmation of enabled functions and selected outputs improving security

Automation/Communications

- Front panel USB and SD Card ports for local programming and data transfer
- One or two optional serial ports (TIA-232, TIA-485 or Serial Fiber)
- Optional single or dual Ethernet ports (copper or fiber) with simultaneous multi-user and multi-protocol support
- Protocols supported include:
  - MODBUS, DNP3.0
  - Optional: IEC61850
- Comprehensive Cyber Security tools for NERC CIP Compliance
- IEEE 1686 Compliant

Control

- Four user programmable Inputs and Outputs, expandable to twelve Inputs and twelve Outputs, plus three Virtual Inputs
- User programmable front-panel LEDs and pushbuttons

Monitoring

- Power Quality Monitoring up to the 63rd Harmonic including THD and TDD
- PQ Viewer (ITIC Curve)
- Sags, Swell and Sub-Synchronous Transient Detection
- Advanced Data Logging and Load Profile Recorder
- 3500 Event Sequence of Events (SOE) Recorder
- 100 DFR quality records of up to 480 cycles each with an adjustable sampling rate up to 128 s/c

IPScom® – *Uncomplicated Software for Complex Power System Applications*

- Integrated Metering, DFR and PQ Visualization Tools
- Search and filtering tools for analysis of SOE, DFR and PQ records
- IPSlogic Programmable Logic

Flexibility

- Fast and easy retrofitting for most popular relays in existing cutouts using Beckwith's Adapter Panel Technology™

Industry Leader Since 1969
Made in the USA

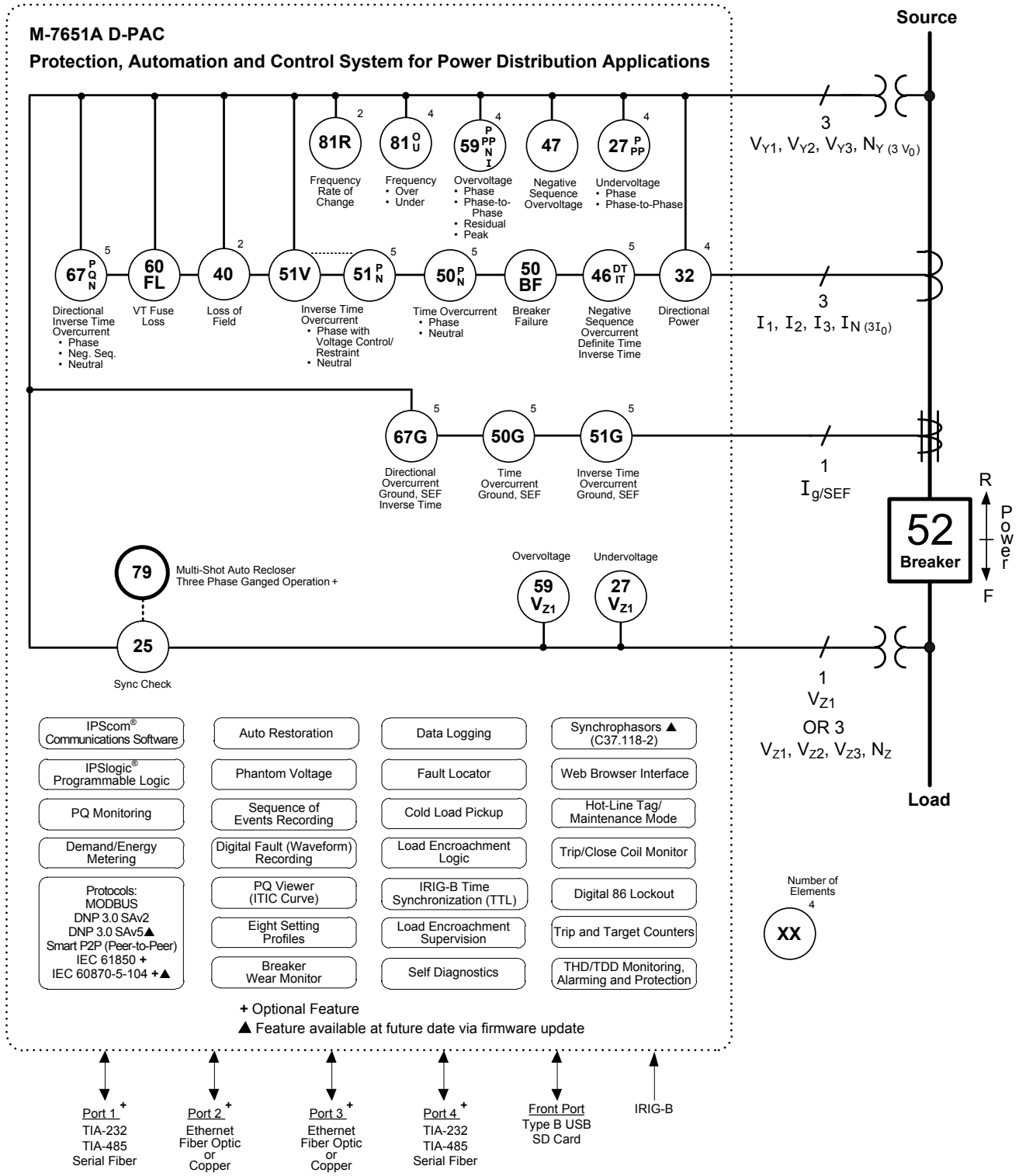


Figure 1 M-7651A D-PAC Typical Connections

Standard Control Features

- Over 30 protection functions
- Horizontal or Vertical Mounting
- 50 Hz or 60 Hz Frequency
- High (90 to 315 Vac/Vdc) or Low (18 to 60 Vdc) Power Supply
- IPScom Communications Software
- IPSlogic Programmable Logic
- Synchrophasors (IEEE C37.118-2)▲
- Load Encroachment Supervision
- Phantom Voltage
- Digital 86 Lockout▲
- I/O Map
- Smart Fuse Coordination▲
- Custom Curve Designer
- Hot-Line Tag/Maintenance Mode
- Fault Locator
- Eight Setting Profiles
- Compare Settings Tool
- Cold Load Pickup
- Auto Restoration
- Breaker Wear Monitor
- Power Quality Monitoring
- THD/TDD Monitoring, Alarming and Protection
- ITIC Curve Violation Counters and Recording
- Demand and Energy Metering
- Power Supply Monitor
- Trip/Close Coil Monitor
- Data Logging
- Sequence of Events Recording
- Trip and Target Counters
- Digital Fault (Waveform) Recording
- Fault Event Records
- Self-Diagnostics
- Three Phase Current Inputs plus one Ground or Sensitive Earth Current Input
- Three Phase Voltage Inputs plus one Sync Check Voltage Input
- IRIG-B Time Synchronization (TTL)
- Front Panel USB and SD Card ports
- Protocols Included:
  - MODBUS®
  - DNP3.0 SAv2
  - Smart P2P (Peer-To-Peer)▲
- Four User Programmable Digital Inputs
- Four User Programmable Digital Outputs
- Conformal coated circuit boards
- Configurable Front HMI LEDs and Pushbuttons
- 12 Vdc Backup Power Input
- SMTP E-mail server▲
- Web Browser Interface
- IEEE 1686 Standard Compliant Cyber Security
- IPsec (Internet Protocol Security)
- RADIUS Client Capability to manage local and remote access to the control
- Wide Variety of Communications Accessories

Optional Features

- Multi-Shot Auto Recloser, Three-Phase Ganged Reclose Operation
- PORT 1: TIA-232, TIA-485, or Fiber Optic
- PORT 2 – Rear Ethernet Fiber Optic or Copper
- PORT 3 – Rear Ethernet Fiber Optic or Copper
- PORT 4 – TIA-232, TIA-485, or Fiber Optic
- Optional Protocols in addition to standard MODBUS and DNP3.0 (requires at least one Ethernet Port):
  - Add IEC 61850
  - Add IEC 60870-5-104/101▲
  - Add Combination IEC 61850 and IEC 60870-05-104/101▲
- Expanded I/O – Additional eight digital Inputs and eight digital Outputs for a total of 12 each
- Low Energy Analog (LEA) Inputs per C37.92. Configurations available: 4 LEA, 3LEA + 1VT, or 6LEA.
- ArcFlash detection▲
- M-2032A Battery Charger/Power Supply – please refer to the M-2032A Specification for additional information and ordering options.

M-7651A Mounting Options

- 19" Rack Mount Adapter Panel
- Adapter Frames to mount the M-7651A into existing cutouts

▲ Feature available at future date via firmware update / IPScom update

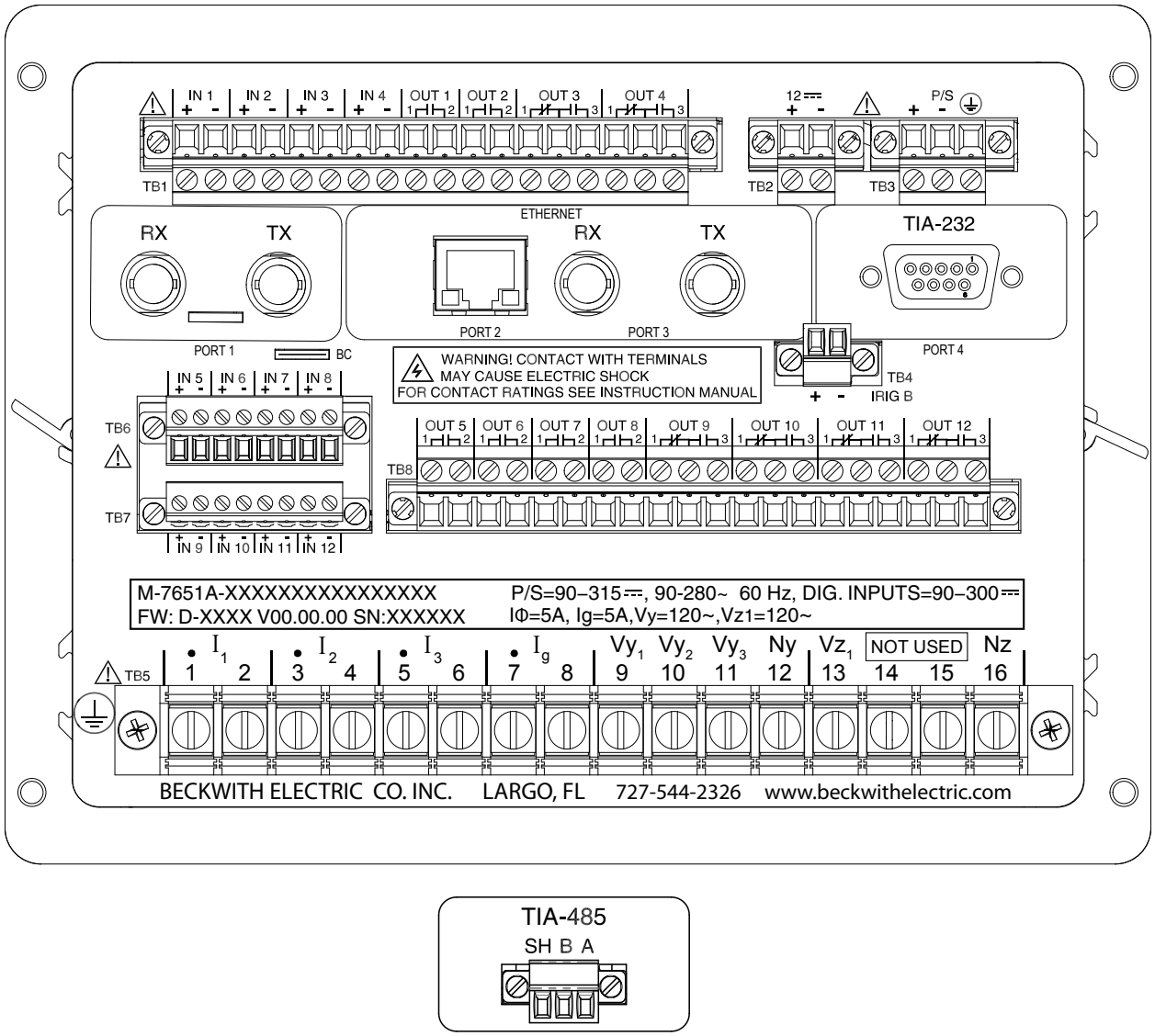


Figure 2 M-7651A External Connections (Typical configuration, other options are available)

PROTECTIVE FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Sync Check			
25	Reference Phase	A/B/C	_	_
	Undervoltage Permission			
	Dead Line/Dead Bus	Yes/No	_	_
	Dead Line/Live Bus	Yes/No	_	_
	Live Line/Dead Bus	Yes/No	_	_
	Live Line Minimum Voltage	0.0 to 200.0 V	0.1 V	± 0.2 V or ± 0.5%
	Live Bus Minimum Voltage	0.0 to 200.0 V	0.1 V	± 0.2 V or ± 0.5%
	Sync Check Permission			
	Max/Minimum Time Delay	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Voltage	10.0 to 300.0 V	0.01 V	± 0.2 V or ± 0.5%
	Maximum Voltage	10.0 to 300.0 V	0.01 V	± 0.2 V or ± 0.5%
	Angle Difference	0.00° to 90.00°	0.01°	± 0.3°
	Magnitude Difference	0.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Frequency Difference	0.00 to 5.00 Hz	0.01 Hz	± 0.02 Hz or ± 2%
	Undervoltage			
27	**Phase Undervoltage (#1 to #4 Steps)**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Auto Restoration	Enable/Disable		
27 PP	**Phase-to-Phase Undervoltage**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
27 Vz1	**Vz1 Undervoltage**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Bus Side Voltage Supervision			
27B	**Bus Side Voltage Supervision**			
	Minimum Closing Voltage	0.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Supervision Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Directional Power (#1 to #4 Steps)			
32	Pickup	-3.00 to +3.00 PU	0.01 PU	± 0.02 PU or 3% @ PF = 0.2 to 1.0
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Power	Real/Reactive		

Each directional power element can be set as overpower or underpower.
The per unit pickup is based on the nominal secondary VT voltage and CT current settings.

	Loss of Field - Dual-zone Offset-mho Characteristic (#1 to #2 Steps)			
40	Circle Diameter			
	1 A CT	0.5 to 500.0 Ω	0.1 Ω	± 0.5 Ω or ± 5%
	5 A CT	0.1 to 100.0 Ω	0.1 Ω	± 0.1 Ω or ± 5%
	Offset			
	1 A CT	-250.0 to 250.0 Ω	0.1 Ω	± 0.5 Ω or ± 5%
	5 A CT	-50.0 to 50.0 Ω	0.1 Ω	± 0.1 Ω or ± 5%
	Time Delay	0.01 to 300.00 s	0.01 s	± 1 Cycle or ± 1%
	Time Delay with Volt. Ctrl.	0.01 to 300.00 s	0.01 s	± 1 Cycle or ± 1%
	Time delay with Voltage Control for each zone can be individually enabled.			
	Voltage Control	5 to 180 V	1 V	± 0.5 V or ± 0.5%
	Directional Element	0° to 20°	1°	–

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Negative Sequence Overcurrent (#1 to #5 Steps)			
46 DT	**Definite Time**			
	Pickup			
	1 A CT	0.02 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
46 IT	**Inverse Time**			
	Pickup			
	1 A CT	0.02 to 3.20 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 16.00 A	0.01 A	± 0.1 A or ± 3%
	Electromechanical Reset Delay	Yes/No		
	Reset Coefficient	0.001 to 30.000 s	0.001 s	± 0.01 s or ± 1%
	TCC Modifiers			
	Time Adder	0.00 to 30.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Response Time Adder	0.00 to 1.00 s	0.01 s	± 0.01 s or ± 1%
	IEC Curves Family (IEC 60255-151)	Inverse, Very Inverse Extremely Inverse		
	Time Multiplier	0.05 to 1.00	0.01	± 2 cycles or ± 5%
	IEEE Curves (C37.112)	Moderately Inverse Very Inverse Extremely Inverse		
	Time Multiplier	0.10 to 25.00	0.01	± 2 cycles or ± 5%
	US Curves	Moderately Inverse Standard Inverse Very Inverse Extremely Inverse Short Time Inverse		
	Time Multiplier	0.05 to 15.00	0.01	± 2 cycles or ± 5%
	Traditional Recloser Curves	101; 102; 103; 104; 105; 106; 107; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 131; 132; 133; 134; 135; 136; 137; 138; 139; 140; 141; 142; 151; 152; 161; 162; 163; 164; 165; 200; 201; 202		
	Time Multiplier	0.10 to 2.00	0.01	± 2 cycles or ± 5%
	Definite Time			
	Time Multiplier	0.10 to 100.00	0.01	± 2 cycles or ± 5%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Negative Sequence Overvoltage			
47	Pickup	0.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Breaker Failure			
50 BF	Pickup			
	Phase Current			
	1 A CT	0.02 to 2.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 10.00 A	0.01 A	± 0.1 A or ± 3%
	Residual/ Ground (Sensitive Ground) Current			
	1 A CT	0.02 to 2.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 10.00 A	0.01 A	± 0.1 A or ± 3%
	10 mA CT	0.001 to 0.160 A	0.001 A	TBD
	50 mA CT	0.005 to 0.800 A	0.001 A	TBD
	200 mA CT	0.020 to 3.200 A	0.001 A	TBD
	Time Delay	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Retrip Delay	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Instantaneous/Definite Time Overcurrent (#1 to #5 Steps)			
50P	**Phase Instantaneous/Definite Time Overcurrent**			
	Pickup			
	1 A CT	0.02 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
50 HCL	**High Current Lockout (#1 to #5 Steps)**			
	Phase	Enable/Disable		
	Reference Current			
	1 A CT	0.10 to 100.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.50 to 500.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
50N	**Residual Instantaneous/Definite Time Overcurrent**			
	Pickup			
	1 A CT	0.02 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
50 HCL	**High Current Lockout (#1 to #5 Steps) with "$3I_0$" HCL Operating Current Reference**			
	Residual/Ground	Enable/Disable		
	Reference Current			
	1 A CT	0.03 to 100.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.15 to 500.00 A	0.01 A	± 0.02 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
50G	**Ground Instantaneous/Definite Time Overcurrent**			
	Pickup			
	1 A Gnd CT	0.02 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A Gnd CT	0.10 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
50 HCL	**High Current Lockout (#1 to #5 Steps) with "G" HCL Operating Current Reference**			
	Residual/Ground	Enable/Disable		
	Reference Current			
	1 A Gnd CT	0.03 to 100.00 A	0.01 A	± 0.02 A or ± 3%
	5 A Gnd CT	0.15 to 500.00 A	0.01 A	± 0.1 A or ± 3%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Inverse Time Overcurrent (#1 to #5 Steps)			
51P	**Phase Inverse Time Overcurrent with Voltage Control/Restraint**			
	Pickup			
	1 A CT	0.02 to 3.20 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 16.00 A	0.01 A	± 0.1 A or ± 3%
	Load Encroachment Logic	Use/Do Not Use	–	–
	Voltage Control or Voltage Restraint	4.0 to 150.0 %	0.1 %	
51N	**Residual Inverse Time Overcurrent**			
	Pickup			
	1 A CT	0.02 to 3.20 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.10 to 16.00 A	0.01 A	± 0.1 A or ± 3%
51G	**Ground Inverse Time Overcurrent**			
	Pickup			
	1 A Gnd CT	0.02 to 3.20 A	0.01 A	± 0.02 A or ± 3%
	5 A Gnd CT	0.10 to 16.00 A	0.01 A	± 0.1 A or ± 3%
	Electromechanical Reset Delay	Yes/No		
	Reset Coefficient	0.001 to 30.000 s	0.001 s	± 0.01 s or ± 1%
	TCC Modifiers			
	Time Adder	0.00 to 30.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Response Time Adder	0.00 to 1.00 s	0.01 s	± 0.01 s or ± 1%
	IEC Curves Family (IEC 60255-151)	Inverse, Very Inverse Extremely Inverse		
	Time Multiplier	0.05 to 1.00	0.01	± 2 cycles or ± 5%
	IEEE Curves (C37.112)	Moderately Inverse Very Inverse Extremely Inverse		
	Time Multiplier	0.10 to 25.00	0.01	± 2 cycles or ± 5%
	US Curves	Moderately Inverse Standard Inverse Very Inverse Extremely Inverse Short Time Inverse		
	Time Multiplier	0.05 to 15.00	0.01	± 2 cycles or ± 5%
	Traditional Recloser Curves	101; 102; 103; 104; 105; 106; 107; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 131; 132; 133; 134; 135; 136; 137; 138; 139; 140; 141; 142; 151; 152; 161; 162; 163; 164; 165; 200; 201; 202		
	Time Multiplier	0.10 to 2.00	0.01	± 2 cycles or ± 5%
	Definite Time			
	Time Multiplier	0.10 to 100.00	0.01	± 2 cycles or ± 5%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Overvoltage			
59	**Phase Overvoltage (#1 to #4 Steps)**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Auto Restoration	Enable/Disable		
59I	**Peak Overvoltage**			
	Pickup	100 to 150 %	1%	± 3%
	Definite Time	0.01 to 140.00 s	0.01 s	± 0.05 s
59N	**Residual Overvoltage**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
59 PP	**Phase-to-Phase Overvoltage**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
59 Vz1	**Vz1 Overvoltage**			
	Pickup	10.00 to 300.00 V	0.01 V	± 0.2 V or ± 0.5%
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	VT Fuse-Loss Detection			
60 FL	**A VT fuse-loss condition is detected by using the positive and negative sequence components of the voltages and currents.**			
	Time Delay	0.03 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Three Phase VT Fuse Loss Detection	Enable/Disable		

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Directional Overcurrent (#1 to #5 Steps)			
67P	**Phase Directional Overcurrent**			
	Operating Current	Phase Current		
	Phase Polarization Voltage	V_1		
67N	**Residual Directional Overcurrent**			
	Operating Current	$3I_O$		
	Phase Polarization Voltage	Vz_1, V_1, V_2, V_O		
67G	**Ground Directional Overcurrent**			
	Operating Current	I_g		
	Phase Polarization Voltage	Vz_1, V_1, V_2, V_O		
67Q	**Negative Sequence Directional Overcurrent**			
	Operating Current	Negative Sequence Current		
	Phase Polarization Voltage	V_2		
	Enabled Direction	No-Direction/Directional		
	Minimum Polarization Voltage (% of nominal voltage)	2.0 to 10.0 %	0.1%	± 3%
	Action if below	Trip/Block Trip		
	Maximum Sensitivity Angle 1	0° to 359°	1°	± 1°
	Maximum Sensitivity Angle 2	5° to 90°	1°	± 1°
	Time Delay	Definite/Inverse	–	–
	Definite Time: Pickup			
	1 A CT/Gnd CT	0.05 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT/Gnd CT	0.25 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Delay	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%

■ **NOTE:** Function 67 Inverse Time Delay Specifications continued on next page.

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Directional Instantaneous/Definite Time Overcurrent (Cont'd.)			
	Inverse Time:			
	Pickup			
	1 A CT/Gnd CT	0.02 to 3.20 A	0.01 A	± 0.02 A or ± 3%
	5 A CT/Gnd CT	0.10 to 16.00 A	0.01 A	± 0.1 A or ± 3%
	Electromechanical Reset Delay	Yes/No		
	Reset Coefficient	0.001 to 30.000 s	0.001 s	± 0.01 s or ± 1%
	TCC Modifiers			
	Time Adder	0.00 to 30.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Response Time Adder	0.00 to 1.00 s	0.01 s	± 0.01 s or ± 1%
	IEC Curves Family (IEC 60255-151)	Inverse, Very Inverse Extremely Inverse		
	Time Multiplier	0.05 to 1.00	0.01	± 2 cycles or ± 5%
	IEEE Curves (C37.112)	Moderately Inverse Very Inverse Extremely Inverse		
	Time Multiplier	0.10 to 25.00	0.01	± 2 cycles or ± 5%
	US Curves	Moderately Inverse Standard Inverse Very Inverse Extremely Inverse Short Time Inverse		
	Time Multiplier	0.05 to 15.00	0.01	± 2 cycles or ± 5%
	Traditional Recloser Curves	101; 102; 103; 104; 105; 106; 107; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 131; 132; 133; 134; 135; 136; 137; 138; 139; 140; 141; 142; 151; 152; 161; 162; 163; 164; 165; 200; 201; 202		
	Time Multiplier	0.10 to 2.00	0.01	± 2 cycles or ± 5%
	Definite Time			
	Time Multiplier	0.10 to 100.00	0.01	± 2 cycles or ± 5%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Frequency (#1 to #4 Steps)			
81	Pickup	40.00 to 65.00 Hz	0.01 Hz	± 0.02 Hz
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Hysteresis	0.0 to 1.0 Hz	0.1 Hz	
	Undervoltage Block	Enable/Disable		
	Minimum Voltage	1.00 to 180.00 V	0.01 V	
	Minimum Load	Enable/Disable		
	1 A CT	0.00 to 40.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.00 to 200.00 A	0.01 A	± 0.1 A or ± 3%
	The pickup accuracy applies at a range of 57 to 63 Hz. Beyond this range the accuracy is ± 0.1 Hz.			
	Auto Restoration	Enable/Disable		
	Rate of Change of Frequency (#1 to #2 Steps)			
81R	Pickup	0.20 to 5.00 Hz/s	0.01 Hz/s	± 0.02 Hz/s
	Definite Time	0.00 to 2.00 s	0.01 s	± 0.01 s or ± 1%
	Maximum Frequency	40.00 to 70.00 Hz	0.01 Hz	
	Minimum Current			
	1 A CT	0.00 to 20.00 A	0.01 A	± 0.02 A or ± 3%
	5 A CT	0.00 to 100.00 A	0.01 A	± 0.1 A or ± 3%
	Minimum Voltage	0.00 to 300.00 V	0.01 V	
	Pickup Cycle Number	3 to 15	1	
	Breaker Monitor			
BM	Pickup	1 to 60000 kA* Cycles	1 kA* Cycles	± 1 kA* Cycles
	Time Delay	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Breaker Open Arc Current Delay	0 to 2000 ms	1 ms	
	Arc Current Cycle	0 to 20 Cycles	1 Cycle	
	Preset Accumulators	0 to 60000 kA* Cycles	1 kA* Cycle	
	Timing Selection Method*	$I^{1.5}T$, IT or I^2T		
	(*Timing Selection Method determines unit: kA, $kA^{1.5}$ or kA^2)			

The Breaker Monitor feature calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current through the breaker contacts as an arc.

The per-phase values are added to an accumulated total for each phase, and then compared to a user-programmed threshold value. When the threshold is exceeded in any phase, the relay can set a programmable output contact.

The accumulated value for each phase can be displayed.

The Breaker Monitoring feature requires an initiating contact to begin accumulation, and the accumulation begins after the set time delay.

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Trip/Close Circuit Monitoring			
TCM	Time Delay	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%
CCM	Time Delay	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Trip Coil and Close Coil input voltages are limited to the specifications in Table 5.			
	Total Harmonic Distortion / Total Demand Distortion			
THD	Operating Quantity	Current/Voltage		
	Limit	3.0 to 10.0 %	0.1%	± 2%
	Time Delay	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
TDD	Operating Quantity	Current		
	Limit	3.0 to 10.0 %	0.1%	± 2%
	Time Delay	0.00 to 600.00 s	0.01 s	± 0.05 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

OPTIONAL PROTECTIVE FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Sensitive Ground Instantaneous/Definite Time Overcurrent (#1 to #5 Steps)			
50 GS	Sensitive Ground Pickup			
	10 mA Gnd CT	0.001 to 0.160 A	0.001 A	(TBD)
	50 mA Gnd CT	0.005 to 0.800 A	0.001 A	0.0015 A or ± 3%
	200 mA Gnd CT	0.020 to 2.500 A	0.001 A	(TBD)
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Replaces Standard 50G Ground			
50 HCL	**High Current Lockout (#1 to #5 Steps) with "G" HCL Operating Current Reference**			
	Residual/Ground	Enable/Disable		
	Reference Current			
	10 mA Gnd CT	0.001 to 0.160 A	0.001 A	(TBD)
	50 mA Gnd CT	0.005 to 0.800 A	0.001 A	0.0015 A or ± 3%
	200 mA Gnd CT	0.020 to 2.500 A	0.001 A	(TBD)
	Definite Time	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

OPTIONAL PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Sensitive Ground Inverse Time Overcurrent (#1 to #5 Steps)			
51 GS	Sensitive Ground Pickup			
	10 mA Gnd CT	0.001 to 0.160 A	0.001 A	(TBD)
	50 mA Gnd CT	0.005 to 0.800 A	0.001 A	0.0015 A or ± 3%
	200 mA Gnd CT	0.020 to 2.500 A	0.001 A	(TBD)
	Electromechanical Reset Delay	Yes/No		
	Reset Coefficient	0.001 to 30.000 s	0.001 s	± 0.01 s or ± 1%
	TCC Modifiers			
	Time Adder	0.00 to 30.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Response Time Adder	0.00 to 1.00 s	0.01 s	± 0.01 s or ± 1%
	IEC Curves Family (IEC 60255-151)	Inverse, Very Inverse Extremely Inverse		
	Time Multiplier	0.05 to 1.00	0.01	± 2 cycles or ± 5%
	IEEE Curves (C37.112)	Moderately Inverse Very Inverse Extremely Inverse		
	Time Multiplier	0.10 to 25.00	0.01	± 2 cycles or ± 5%
	US Curves	Moderately Inverse Standard Inverse Very Inverse Extremely Inverse Short Time Inverse		
	Time Multiplier	0.05 to 15.00	0.01	± 2 cycles or ± 5%
	Traditional Recloser Curves	101; 102; 103; 104; 105; 106; 107; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 131; 132; 133; 134; 135; 136; 137; 138; 139; 140; 141; 142; 151; 152; 161; 162; 163; 164; 165; 200; 201; 202		
	Time Multiplier	0.10 to 2.00	0.01	± 2 cycles or ± 5%
	Definite Time			
	Time Multiplier	0.10 to 100.00	0.01	± 2 cycles or ± 5%

Replaces Standard 51G Ground

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

OPTIONAL PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Sensitive Ground Directional Overcurrent (#1 to #5 Steps)			
67 GS	Phase Polarization Voltage	Vz_1, V_1, V_2, V_O	–	–
	Enabled Direction	No-Direction/Directional	–	–
	Minimum Polarization Voltage (% of nominal voltage)	2.0 to 10.0 %	0.1%	± 3%
	Action if below	Trip/Block Trip	–	–
	Maximum Sensitivity Angle 1	0° to 359°	1°	± 4°
	Maximum Sensitivity Angle 2	5° to 90°	1°	± 4°
	Time Delay	Definite/Inverse	–	–
	Definite Time:			
	Pickup 10 mA Gnd CT	0.001 to 0.160 A	0.001 A	(TBD)
	Pickup 50 mA Gnd CT	0.005 to 0.800 A	0.001 A	0.0015 A or ± 3%
	Pickup 200 mA Gnd CT	0.020 to 2.500 A	0.001 A	(TBD)
	Delay	0.00 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Inverse Time:			
	Electromechanical Reset Delay	Yes/No		
	Reset Coefficient	0.001 to 30.000 s	0.001 s	± 0.01 s or ± 1%
	TCC Modifiers Time Adder	0.00 to 30.00 s	0.01 s	± 0.01 s or ± 1%
	Minimum Response Time Adder	0.00 to 1.00 s	0.01 s	± 0.01 s or ± 1%
	IEC Curves Family (IEC 60255-151)	Inverse, Very Inverse Extremely Inverse		
	Time Multiplier	0.05 to 1.00	0.01	± 2 cycles or ± 5%
	IEEE Curves (C37.112)	Moderately Inverse Very Inverse Extremely Inverse		
	Time Multiplier	0.10 to 25.00	0.01	± 2 cycles or ± 5%
	US Curves	Moderately Inverse Standard Inverse Very Inverse Extremely Inverse Short Time Inverse		
	Time Multiplier	0.05 to 15.00	0.01	± 2 cycles or ± 5%
	Traditional Recloser Curves	101; 102; 103; 104; 105; 106; 107; 111; 112; 113; 114; 115; 116; 117; 118; 119; 120; 121; 122; 131; 132; 133; 134; 135; 136; 137; 138; 139; 140; 141; 142; 151; 152; 161; 162; 163; 164; 165; 200; 201; 202		
	Time Multiplier	0.10 to 2.00	0.01	± 2 cycles or ± 5%
	Definite Time Time Multiplier	0.10 to 100.00	0.01	± 2 cycles or ± 5%

Replaces Standard 67G Function

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

OPTIONAL PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Recloser Relay			
79	**Three-Phase Ganged Operation:**			
	Ground Precedence	Yes/No		
	Sequence Coordination Active For Trips	None/1/2/3	–	–
	Maximum Number of Phase Trips	1/2/3/4/5	1	–
	Maximum Number of Ground/Residual Trips	1/2/3/4/5	1	–
	Reset Time after Auto Reclose	1 to 1800 s	1 s	± 0.01 s or ± 1%
	Reset Time from Lockout	0 to 1800 s	1 s	± 0.01 s or ± 1%
	Reclose #1, #2, #3, #4 Time Delay for Phase Fault	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%
	Time Delay for Ground Fault	0.01 to 600.00 s	0.01 s	± 0.01 s or ± 1%

†Select the greater of these accuracy values. For voltage accuracy specified, the range is (20 – 180 V).

Introduction

The M-7651A D-PAC is a digital, Smart Grid ready, advanced Protection, Automation and Control System for Power Distribution Applications that is compatible with most manufacturer's switchgear and suitable for new installations or as a direct, easy-to-install, replacement for older protection, automation and control systems. It offers a comprehensive protection package with over 30 individual protection functions and up to eight setting groups. The M-7651A D-PAC features a high accuracy metering system with advanced recording and reporting functions as well as continuous data sampling at 128 samples per cycle.

By configuring various combinations of the slow-, fast-, and time-delay curve elements, the M-7651A D-PAC can allow as many as five Phase-to-Phase or Phase-to-Ground trips and four total reclosing operations. If required, individual phase or ground reclose intervals are user-settable with time-delays of up to 600 seconds. The settings for the different functions can be accomplished by using the IPScom S-7600 Communications Software or the front panel pushbuttons. For convenience and security, the M-7651A D-PAC offers an SD card reader. Programming can be done in the office and settings can be loaded using an SD card thus minimizing the time a user needs to spend in front of the relay.

Overcurrent Protection

Up to five cumulative fast- and delay-curve operations provide phase and ground overcurrent protection. With a recloser CT ratio of 1000:1, for example, the phase overcurrent protection can have primary currents set as sensitive as 20 A for phase overcurrent and 5 A for ground overcurrent protection.

The M-7651A D-PAC offers over 50 different time curves plus four user programmable curves to facilitate coordination with other elements in the network. The phase or ground fast- and delay-curves can be set either with the user-designed curves or with the curve selection choices listed in Table 1.

Use traditional Recloser Control curve modifiers to alter fast- and delay-curves (including US or IEC curves):

- Constant Time Adder – adds time to curve
- Vertical Multiplier (time dial) – shifts entire curve up or down in time
- Minimum Response Time – delays curve tripping for minimum time
- High Current Lockout – high set lockout maximum
- High Current Trip – closes on bolted fault

Custom Overcurrent Protection

IPSlogic includes algorithms that allow user programmable customization of the overcurrent protection.

The M-7651A D-PAC supports the following curve selections:

Curve Category	Curve Selection
IEC Curves (IEC 60255-151)	Inverse, Very Inverse, Extremely Inverse
IEEE Curves (IEEE C37.112)	Moderately Inverse, Very Inverse, Extremely Inverse
Traditional Recloser Curves ■NOTE: (Newer curves are shown with the older curve designations in parentheses)	101 (A); 102 (1); 103 (17); 104 (N); 105 (R); 106 (4); 107 (L); 111 (8*); 112 (15); 113 (8); 114 (5); 115 (P); 116 (D); 117 (B); 118 (M); 119 (14); 120 (Y); 121 (G); 122 (H); 131 (9); 132 (E); 133 (C); 134 (Z); 135 (2); 136 (6); 137 (V); 138 (W); 139 (16); 140 (3); 141 (11); 142 (13); 151 (18); 152 (7); 161 (T); 162 (KP); 163 (F); 164 (J); 165 (KG); 200; 201; 202
US Curves	Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse
Definite Time	Definite Time
User-Designed Programmable Curves	Four Programmable Curves

Table 1 M-7651A D-PAC Curve Selection

Reclosing Operation

When there is any breaker open operation due to a fault, the relay will close the breaker automatically without user intervention. The Reclosing Operation is achieved using the 79 function in conjunction with overcurrent functions (i.e. 50P, 50G/50GS, 50N, 46DT, 51P, 51G/51GS, 51N, 46IT, 67P, 67N, 67G/GS, 67Q).

The **Reclosing Sequence** is an extension of the single Reclosing Operation. In this instance, when a breaker opens and closes automatically, it will continue until a specified count is reached. Any overcurrent fault will cause a trip after the trip time expires, at which time the 79 function will start the **Reclose Interval**. Both the trip time and Reclose Interval are user settable.

At the end of the Reclose Interval the control will automatically send a close command to the breaker. This process will continue until the maximum number of trips is reached or until the fault clears, whichever occurs first. Once the maximum number of trips is reached, the control will automatically be placed in Lockout and prevent further operation until the unit is reset. The maximum number of trips is user settable. See the Instruction Book Setpoints Chapter for a detailed explanation of the Reclosing function.

Power Quality Monitoring

Power Quality (PQ) events: sags, swells, voltage and current unbalances; real-time harmonic analysis of current and voltage for each phase, THD, phase voltage loss and variations, and ITIC excursion detection.

Monitoring/Metering

Real-Time Metering – the following measured and calculated values are available in real-time:

- Instantaneous values of the current for three phases, ground or sensitive ground
- Line and phase voltages
- Active, reactive, apparent single- and three-phase power, including directional*
- Active energy received and delivered
- Demand metering on per-phase basis
- Reactive energy in quadrants I and III
- Single-phase and three-phase power factor*
- Frequency and phase sequence
- Sequence current and voltage magnitudes

*When the VT Configuration is set to any Delta Connection, only three phase power metering is displayed in the Primary and Secondary Metering screens. Individual phase power metering is grayed out, and the value displayed is "0".

METERING ACCURACIES

Analog sources used for measurement traceable to NIST Standards, with certifications on file.

VOLTAGE ACCURACY

Fundamental Metering		Magnitude	Phase Angle
Voltage Range (0.167-10.0)	WYE	±0.04%	±0.3°
Voltage Range (5.0-300.0)	WYE	±0.04%	±0.7°
	OPEN DELTA	±0.04%	±0.7°
RMS Metering		Magnitude	Phase Angle
Voltage Range (0.167-10.0)	WYE	±0.08%	±0.7°
Voltage Range (5.0-300.0)	WYE	±0.05%	±0.7°
	OPEN DELTA	±0.05%	±0.7°
Fundamental Sequence Voltage Accuracy		Magnitude	Phase Angle
Voltage Range (0.167-10.0)	WYE 3V0Y, 3V0Z	±0.02%	±0.3°
	WYE V1Y, V1Z	±0.10%	±0.3°
	WYE V2Y, V2Z	±0.06%	±0.3°
Voltage Range (5.0-300.0)	WYE 3V0Y, 3V0Z	±0.03%	±0.7°
	WYE V1Y, V1Z	±0.09%	±0.7°
	WYE V2Y, V2Z	±0.09%	±0.7°
	OPEN DELTA 3V0Y, 3V0Z	±0.02%	±0.7°
	OPEN DELTA V1Y, V1Z	±0.07%	±0.7°
	OPEN DELTA V2Y, V2Z	±0.04%	±0.7°
RMS Sequence Voltage Accuracy		Magnitude	Phase Angle
Voltage Range (0.167-10.0)	WYE 3V0Y, 3V0Z	±0.12%	±0.7°
	WYE V1Y, V1Z	±0.14%	±0.7°
	WYE V2Y, V2Z	±0.08%	±0.7°
Voltage Range (5.0-300.0)	WYE 3V0Y, 3V0Z	±0.01%	±0.7°
	WYE V1Y, V1Z	±0.09%	±0.7°
	WYE V2Y, V2Z	±0.09%	±0.7°
	OPEN DELTA 3V0Y, 3V0Z	±0.02%	±0.7°
	OPEN DELTA V1Y, V1Z	±0.07%	±0.7°
	OPEN DELTA V2Y, V2Z	±0.04%	±0.7°

■**NOTE:** Voltage accuracy:
<0.3 % with temperature between -5° C and +50° C
<1.0 % with temperature below -5° C or above +50° C

Table 2 Metering Accuracies – Voltage

METERING ACCURACIES Analog sources used for measurement traceable to NIST Standards, with certifications on file.			
CURRENT ACCURACY			
Fundamental Metering		Magnitude	Phase Angle
CT Rating and Range	5 A (IA, IB, IC) (0.01-20.0 A)	±0.02%	±0.7°
	1 A (IA, IB, IC) (0.01-15.0 A)	±0.03%	±0.7°
	200 mA (IN) (0.01-3.0 A)	±0.27%	±2.0°
	50 mA (IN) (0.001-1.00 A)	±1.1%	±2.0°
	10 mA (IN) (0.001-0.200 A)	±1.5%	±2.0°
RMS Metering		Magnitude	Phase Angle
CT Rating and Range	5 A (IA, IB, IC) (0.04-12.0 A)	±0.02%	±0.7°
	1A (IA, IB, IC) (0.01-12.0 A)	±0.15%	±0.7°
	200 mA (IN) (0.01-2.5 A)	±0.5%	±3.0°
	50 mA (IN) (0.005-1.00 A)	±1.1%	±3.0°
	10 mA (IN) (0.001-0.200 A)	±1.6%	±3.0°
Fundamental Sequence Current Accuracy		Magnitude	Phase Angle
Sequence Component & Current Range	3I0 (0.010-10.0 A)	±0.5%	±0.7°
	3I1 (0.010-10.0 A)	±0.5%	±0.7°
	3I2 (0.010-10.0 A)	±0.5%	±0.7°

Table 3 Metering Accuracies – Current

METERING ACCURACIES Analog sources used for measurement traceable to NIST Standards, with certifications on file.		
FREQUENCY ACCURACY		
Frequency Range (50 Hz & 60 Hz)	15 Hz – 100 Hz	±0.02 Hz
POWER ACCURACY		
Fundamental Metering	Phase (Real W)	±0.3 % @PF = 1.0, 0.87, 0.5
	Phase (Reactive var)	±0.5 % @PF = 0.0, 0.87, 0.5
	Phase (Apparent va)	±0.25 %
	Phase to Phase (Real W)	±0.3% @PF = 1.0, 0.87, 0.5
	Phase to Phase (Reactive var)	±0.5% @PF = 0.0, 0.87, 0.5
	Phase to Phase (Apparent va)	±0.25%
RMS Metering	Phase (Real W)	±0.3 % @PF = 1.0, 0.87, 0.5
	Phase (Reactive var)	±0.5 % @PF = 0.0, 0.87, 0.5
	Phase (Apparent va)	±0.25 %
	Phase to Phase (Real W)	±0.3% @PF = 1.0, 0.87, 0.5
	Phase to Phase (Reactive var)	±0.5% @PF = 0.0, 0.87, 0.5
	Phase to Phase (Apparent va)	±0.25%

Table 4 Metering Accuracies – Frequency and Power

Settings Groups

The M-7651A D-PAC has eight setting groups. Switch setting groups to properly account for prevailing power system conditions. For example if one breaker is dedicated for maintenance you can store the settings for all the feeders and use the appropriate group when that breaker is out of service for maintenance. All the functions shown in Figure 1 (Single Line diagram) are available in each settings group.

Oscillographic Recording

The Oscillograph Recorder provides comprehensive data recording of voltages, currents, and status input/output signals for all monitored waveforms. The Oscillograph recorder stores 100 records of up to 480 cycles each regardless of the sampling rate (at 16, 32, 64, or 128 samples per cycle). Oscillograph data can be downloaded using any communications ports to any Windows® compatible computer running the IPScom S-7600 Communications Software. Once downloaded, the waveform data can be examined, printed or used in generating reports. The waveform data is also available in COMTRADE file format.

The recorder may be triggered using either the designated protective function element or logic equations. When triggered, the recorder stores pre-trigger data, and then continues to store data for a user-defined post-trigger delay period. The post-trigger delay will range from 5 to 95% of the total record length.

Live Oscillograph

The Live Oscillograph feature allows the user to view in real time the eight channels of oscillography with Power, Power Quality, Phasors and Harmonics.

Sequence of Events

The M-7651A D-PAC keeps records of the last 3500 Sequence of Events with the following information:

- Pickup, trip, and extinction date and time, and fault duration
- Voltage and current signals for each phase, neutral and sensitive neutral during pre fault, trip and maximum or minimum depending on each case
- Trip cause
- Protection pickup elements that were activated
- Active group
- Fault directionality

Fault Locator

The M-7651A D-PAC Fault Locator feature can reduce the time required to restore service due to a distribution system fault by providing an accurate estimate of the fault's location, even during periods of high customer load. The control integrates line impedance settings, fault type and fault conditions to calculate the fault location estimation. This feature works without requiring special instrument transformers, pre fault data, or communication to other devices.

Fault Event Records

The M-7651A D-PAC can record and store up to 3,500 events related to the operation of protection functions, changes in configuration, states of the digital inputs and outputs, pickup and/or operation of protection functions, automated mechanism, statistics, etc.

Front Panel

- LCD display, 2 rows, 20 characters per row, with configurable contrast
- Twelve programmable tricolor front panel LEDs
- Keyboard – 17 pushbuttons (Two dedicated for Trip and Close):
  - Six programmable pushbuttons with programmable LEDs
  - Nine function pushbuttons

M-7651A D-PAC includes Programmable Alarm LEDs to indicate any general overcurrent trip (TRIP), plus additional LEDs to indicate the type of overcurrent trip. The Fast-Curve LED indicates a Fast-Curve Trip.

Recloser/Breaker Wear Monitor

The M-7651A D-PAC control records the amount of current carried in each phase each time the recloser trips. The control's operational logic employs an algorithm integrating the amount of unfiltered AC current at the time of each trip and the number of operations (close to open) as a method of calculating wear. The control uses this information to establish wear setpoints derived in accordance with IEEE C37.61-1973, and initiates a signal to assert an alarm or modify the breaker operation parameters, such as reducing the total number of breaker operations.

Load Profile Trending (Extended Data Logging Feature)

The M-7651A D-PAC can store up to 25 parameters in non-volatile memory (instantaneous, maximum, and minimum with date and time stamping). These parameters include the instantaneous values and energy accumulator groups in time intervals between 0 and 3600 seconds, with 60 second steps. The M-7651A D-PAC has a storage capacity of up to 210,000 records.

Synchrophasors▲

Synchrophasors improve system operation and reliability allowing operators to closely monitor the distribution network in real time to detect potential cascading voltage collapses before they occur. The M-7651A D-PAC supports the transmission of synchrophasors acting as a Phasor Measurement Unit (PMU) in compliance with IEEE C37.118-2. Phasor measurements taken at a selectable rate of up to 60 messages or frames per second can be transmitted to a Phasor Data Concentrator for user analysis in a wide-area monitoring and control system.

▲ Feature available at future date via firmware update

Phantom Voltage

The M-7651A has the capability to calculate and provide three-phase voltage that is measured without having three voltages physically connected to the terminals of the M-7651A. The following VT configurations are supported:

- Phantom Wye
- Phantom Delta
- Open Delta

Phantom WYE is supported for VT connection ONLY. The M-7651A will measure one analog voltage signal on any of the voltage terminals and will then calculate the two remaining corresponding balanced phase voltages.

Example: A voltage signal is applied to the terminal defined as Phase A. The M-7651A will calculate and provide all three balanced Line to Ground phase voltages.

Phantom Delta is also supported in the VT connection ONLY. The measured signal applied to one of the voltage terminals is assumed to be a Line to Line quantity. The M-7651A will then calculate the remaining two corresponding balanced Line to Line voltages.

Example: Line to Line voltage AB is applied to the Phase A terminal of the unit. The M-7651A will then calculate BC and CA and will provide all voltages.

Open Delta configuration is also supported in the VT connection ONLY. For example, if two voltage signals with a phase differential of 60 degrees are applied to 2 voltage terminals, with the remaining terminal grounded, the M-7651A will calculate and provide balanced Line to Line voltages AB, BC and CA derived from the two measured voltage signals. The M-7651A assumes proper polarity has been observed. The two measured signals come from Open Delta connected PTs.

Example of Open Delta CA:

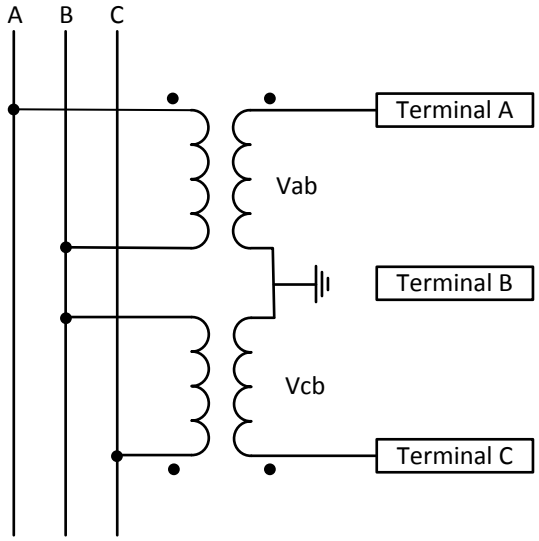


Figure 3 Open Delta CA Example Diagram

Cyber Security

The M-7651A D-PAC was designed from the ground up to help customers be NERC and cyber security compliant. The M-7651A D-PAC meets or exceeds the following standards:

IEEE 1686 Compliant

FIPS180-2, 186-2

ISO/IEC 9798-4

RFC 2104, 3174, 3394

IPsec using Internet Key Exchange (IKE) Version 2, compliant with: RFC 2401, 2402, 2406, 2407, 2408, 2409, 2411, 2412, 3706.

RADIUS Server Support (optional), compliant with: RFC 2865 and 2866

Smart Peer-to-Peer (P2P) Communications▲

Smart P2P Communications is a peer-to-peer communication feature provided that shares operational status among peer devices within its local network. P2P communication can be done via Ethernet communications including multi mode fiber optic link. The transmission distance for fiber optic is dependent on the type of fiber optic used, "Single Mode" or "Multi Mode", and can transmit up to 2,000 meters. Smart P2P Communication can be used to implement pilot transfer schemes or advanced network reconfiguration algorithms.

S-7600 IPScom Communications Software

The S-7600 IPScom Communications Software enables local or remote communication between a Windows® based computer and the M-7651A D-PAC. It is a Windows application, which allows the user to interact with software modules in different languages. The S-7600 IPScom Communications Software makes efficient use of object-oriented programming, achieving a smooth and scalable design, and has an open data structure that allows maintenance and the incorporation of new functions.

The S-7600 IPScom Communications Software is a Windows application that provides an easy graphical interface to program and monitor the M-7651A D-PAC. The S-7600 Software interface provides simple, easy function programming.

Smart Flash SD Card Slot

Allows the user to perform the following functions locally without needing a laptop in field.

- Load Setpoints
- Save Setpoints
- Save Data Log
- Save Sequence of Events
- Save Oscillograph Records
- Clone Save
- Clone Load
- Firmware Update
- Save Metering Data
- Save Wake Screen Data
- Physical Security Key
- Bootloader Update

Cold Load Pickup

The M-7651A D-PAC Cold Load Pickup feature provides the user with the ability to automatically adjust the M-7651A D-PAC Overcurrent protection elements to consider the duration of a loss of load and the recloser response to the loss of load. The Cold Load Pickup feature can tailor the recloser settings to allow the return of the load without tripping. The Cold Load Pickup feature continuously monitors recloser parameters to ascertain when the non-Cold Load Pickup settings can be restored.

Selective Load Shedding Provides Improved System Response and Service Reliability

Modernizing existing feeder protection apparatus by retrofitting with the M-7651A D-PAC provides improvements to system response and service reliability. The Protection, Automation and Control System can be set up to recognize critical loads and help stabilize system loading. Including underfrequency elements as components of the recloser feature scheme allows segmenting the feeder to sustain maximum load and respond to system conditions during power transients. Recloser programming allow as much as six levels of frequency and time settings to coordinate with other devices during a power loss.

▲ Feature available at future date via firmware update

General Specifications

Power Supplies

The M-7651A D-PAC provides a choice of two main power supply input ranges: a low voltage range of 18 to 60 Vdc and a high range of 90 to 280 Vac or 90 to 315 Vdc.

The M-7651A D-PAC also features a backup power supply input of 11 to 14 Vdc, that allows continued operation in case of main power supply loss.

▲**CAUTION:** An orange TB3 receptacle indicates that a Low Voltage Power Supply is installed in the unit.

Power Supply	Range	Burden
24/48 Vdc	18-60 Vdc	12 VA
125/220 Vdc/Vac (Optional)	90-280 Vac 90-315 Vdc	15 VA

Table 5 Power Supply Specifications

AC Voltage Inputs

Voltage	Nominal	Maximum Continuous	Max Short Duration	Burden
Line to Neutral	120 Vac	300 Vac	600 Vac for 10 s	1MΩ
Low Energy Analog	4 Vac	12 Vac	300 Vac for 10 s	1MΩ

Table 6 AC Voltage Input Specifications

AC Current Inputs

AC Current	I Nominal	I Continuous	I Short duration	Burden
Phase Current	1 A 5 A	3 A 15 A	100 A for 1 second 500 A for 1 second	< 0.021 VA < 0.20 VA
Ground Current	1 A 5 A	3 A 15 A	100 A for 1 second 500 A for 1 second	< 0.021 VA < 0.20 VA
Sensitive Earth Fault (SEF)	10 mA 50 mA 200 mA	0.3 A 1.5 A 6 A	100 A for 1 second 100 A for 1 second 100 A for 1 second	< 0.001 VA < 0.002 VA < 0.01 VA

Table 7 AC Current Input Specifications

Digital Inputs (Opto-Isolated)

The M-7651A D-PAC includes four programmable inputs with capability for expansion up to twelve. These inputs must be externally wetted. The M-7651A D-PAC offers two voltage ranges. The wetting voltage can be AC or DC. Set the debounce timer to 200 milliseconds to select AC.

■**NOTE:** Hardware prior to Serial Number 500 only supports a low voltage range of 24–48 Vdc with a minimum Turn-on Voltage of 18 Vdc. Please refer to the unit label "DIG. INPUTS" for the applicable range.

Wetting Voltage	
Input	**DC Pickup Range**
Low	9 – 60 Vdc
High	90 – 300 Vdc

Table 8 Digital Input Specifications

Output Contacts

The M-7651A D-PAC includes four output contacts expandable to twelve. Any of the protective functions can be individually programmed to activate any one or more of the four Programmable Output Contacts (OUT1 through OUT4). Any output contact can also be selected as pulsed or latched. IPSlogic can also be used to activate output relay contact.

The optional expanded I/O includes an additional eight Programmable Output Contacts (OUT5 through OUT12). These contacts are configurable only using IPScom Communications Software.

The output contacts are all rated per IEEE C37.90 (See Tests and Standards section for details).

Operation Frequency and Phase Rotation

Frequency:	60 Hz or 50 Hz
Tracking:	42 to 65 Hz
Phase Rotation:	ABC or ACB

Communications Ports

The unused communications ports can be disabled through software to comply with cyber security requirements.

Front – USB Port – Type B, Version 1.1 (Local Programming), SD Card

Rear – Communication Ports:

- Port 1 (optional) – Serial TIA-232, TIA-485, Fiber, or none
- Port 2/Port 3 (optional) – One or two Ethernet Ports, RJ45 10/100 BASE-T or Fiber 100 BASE-FX
- Port 4 (optional) – Serial TIA-232, TIA-485, Fiber, or none
- Ethernet Ports are auto-detect, auto-negotiable 10/100 Mbps, with support for multi-user rights for up to six concurrent users

Time Synchronization Port:

- IRIG - B (B000)
- Input – Demodulated
- Input level – TTL
- Isolation – 1,500 Vdc

Protocols

Serial Ports – MODBUS®, DNP3.0

Ethernet Ports – MODBUS over TCP/IP and UDP, DNP3.0 over TCP/IP and UDP; IEC 61850, SmartP2P (Peer to Peer)▲, IEC 60870-5-104/101▲ (optional)

Self-Diagnostics

The M-7651A D-PAC includes several self-diagnostic functions and routines that detect possible hardware failures. It also includes a manual test mode that is used to check if the LEDs, Inputs, Outputs, Display, and Keyboard are working properly.

▲ Feature available at future date via firmware update

IPScom System Setup

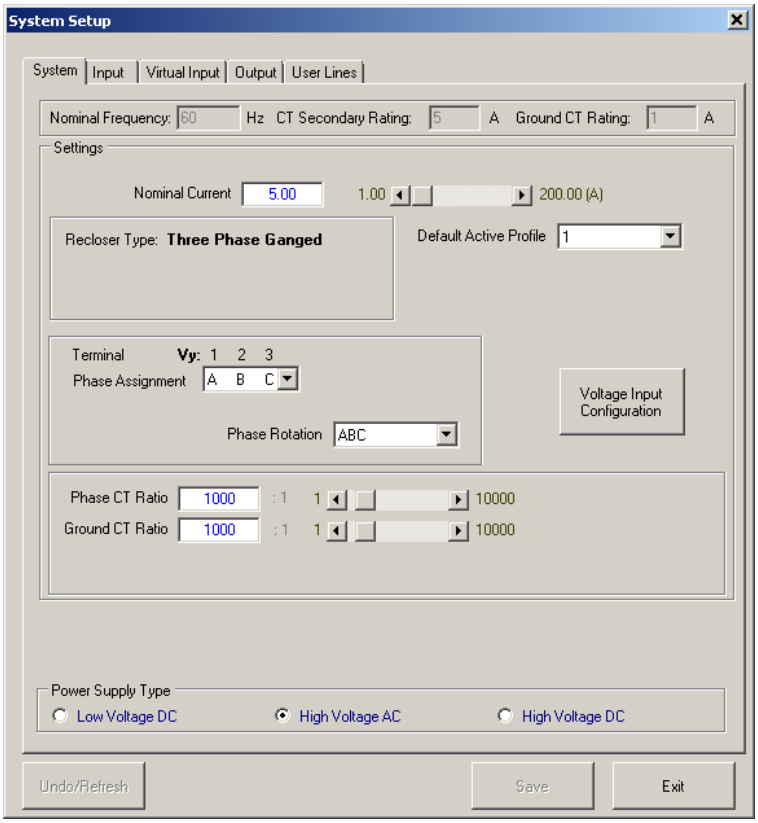


Figure 4 System Setup Screen (Shown: Voltage Input H4)

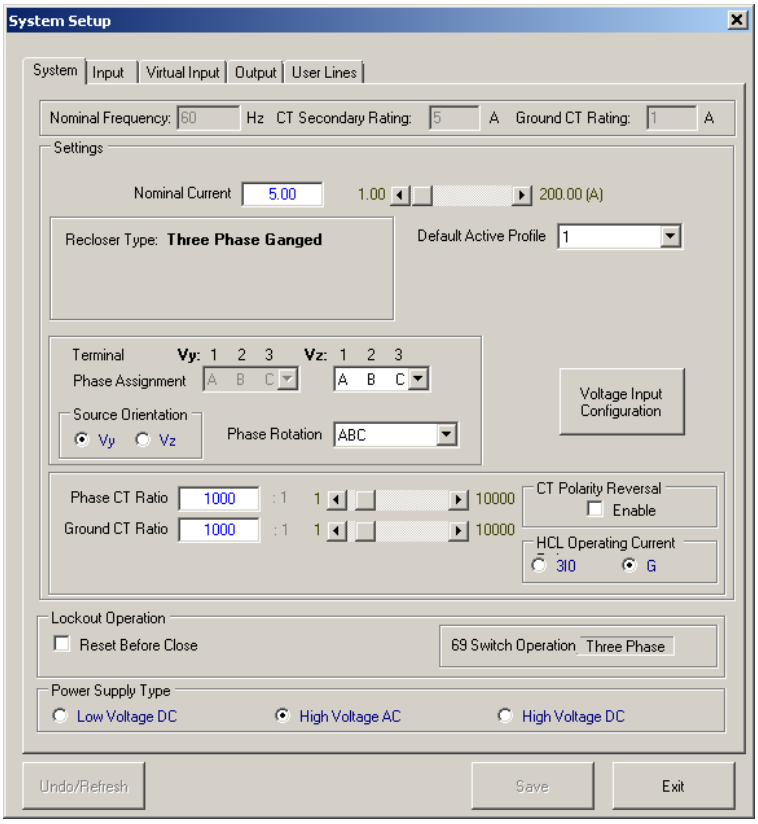


Figure 5 System Setup Screen (Shown: Voltage Input H6, Autoreclose Option)

IPScom System Setup (Cont'd.)

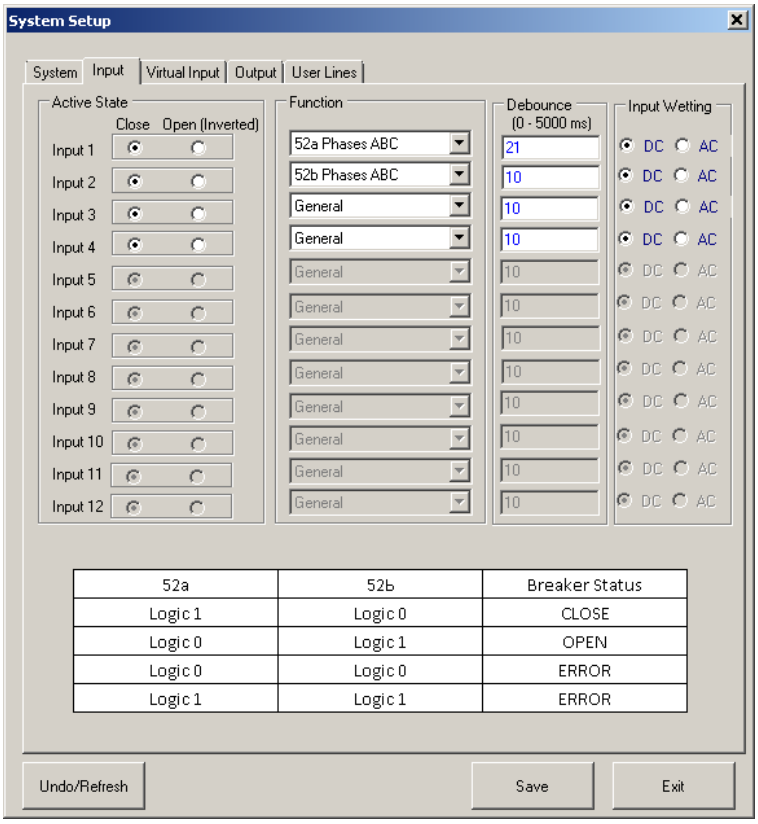


Figure 6 System Setup – Input Tab Dialog Screen (without Extended I/O)

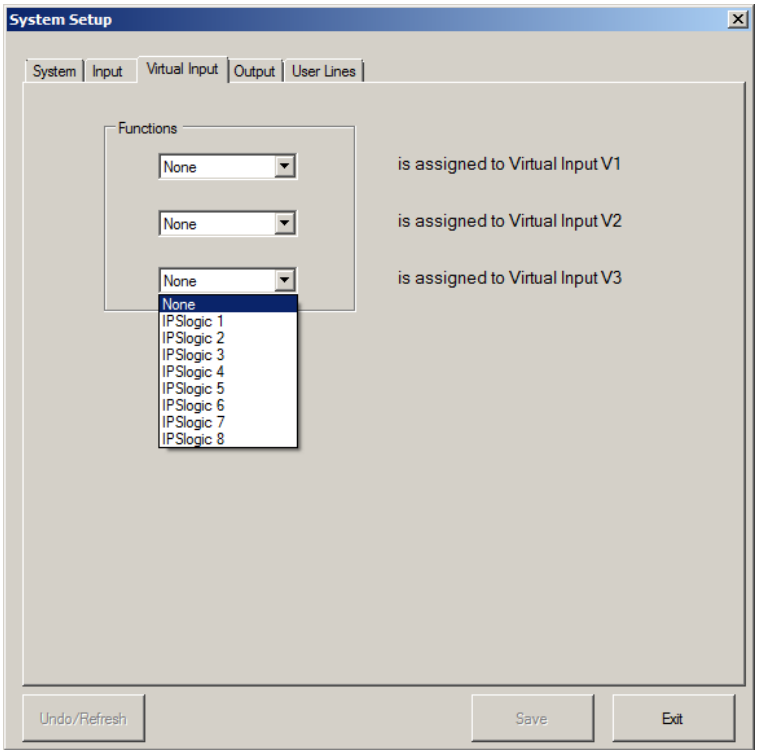


Figure 7 IPScom System Setup – Virtual Inputs Screen

IPScom System Setup (Cont'd.)

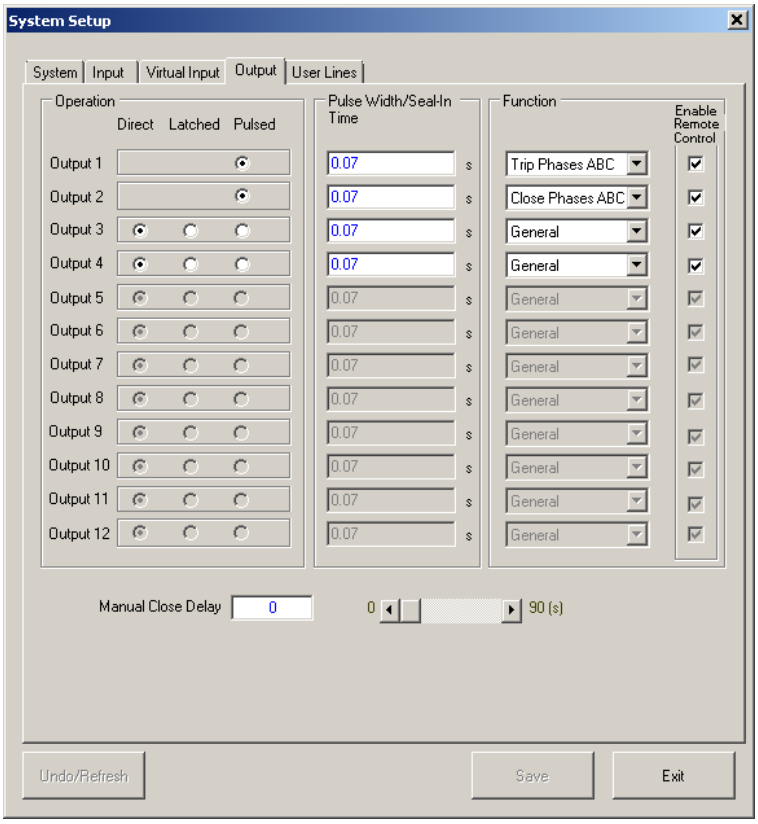


Figure 8 System Setup – Output Tab Dialog Screen (without Extended I/O)

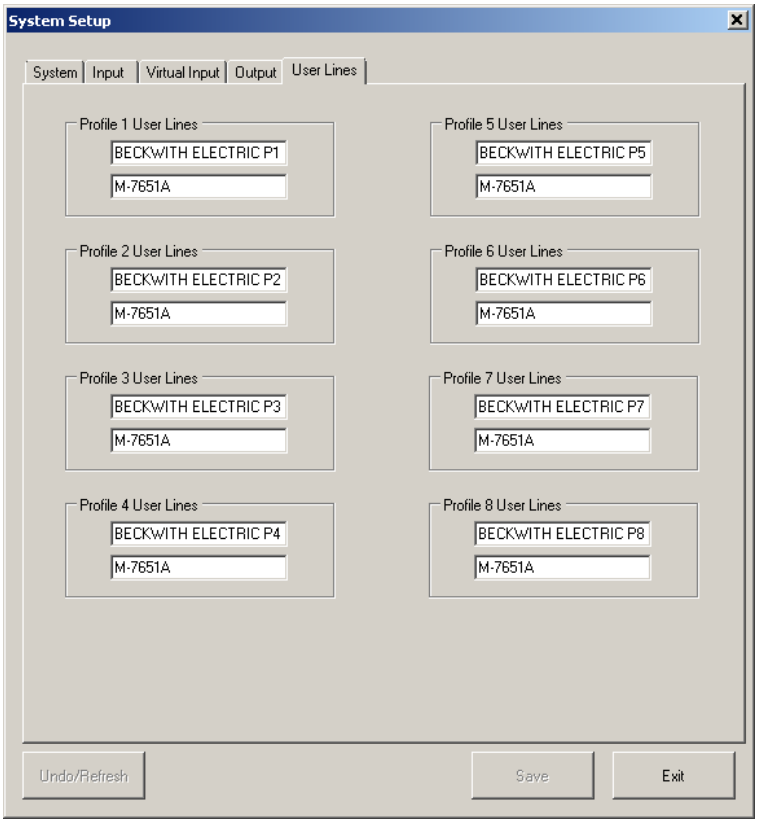
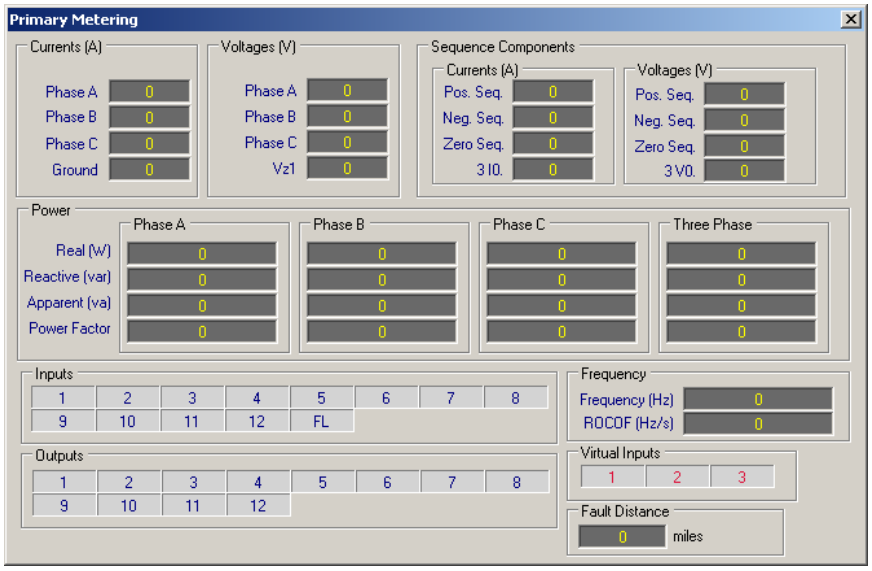
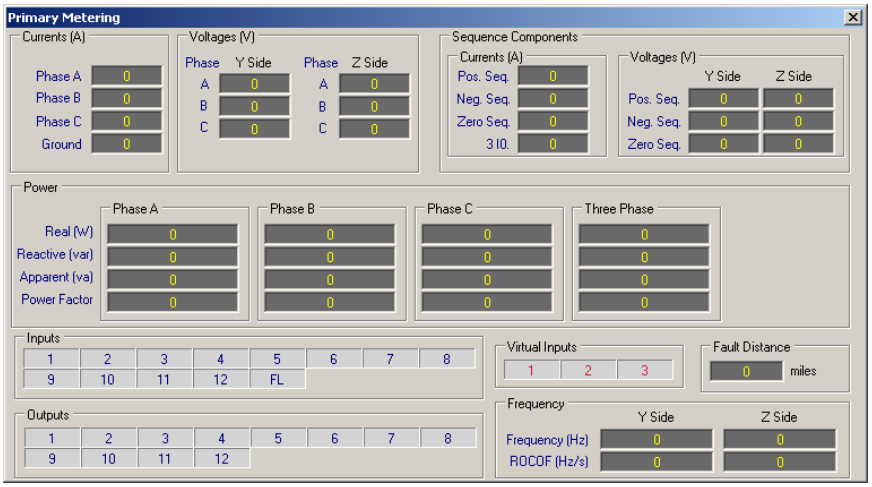


Figure 9 System Setup – User Lines Tab Dialog Screen



■**NOTE:** Secondary Metering Screen parameters are identical.

Figure 10 IPScom Primary Metering Screen (Voltage Input Option X4, L4, H4 or VT)



■**NOTE:** Secondary Metering Screen parameters are identical.

Figure 11 IPScom Primary Metering Screen (Voltage Input Option X6, L6 or H6)

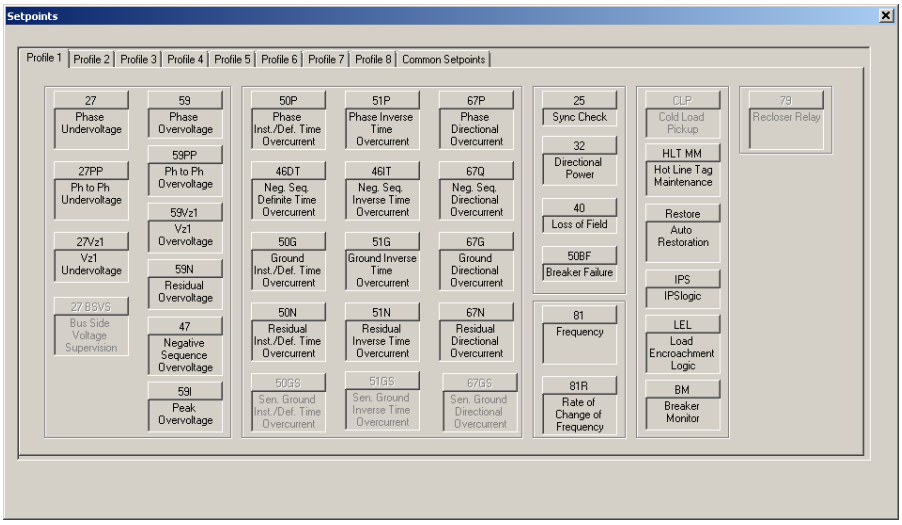


Figure 12 Typical Setpoints Dialog Screen

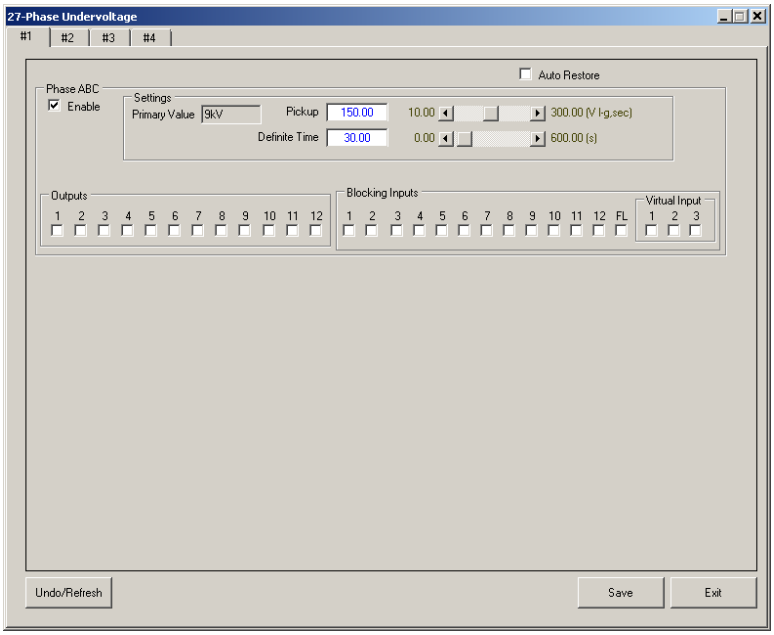


Figure 13 IPScom Example Setpoint Screen: 27 Phase Undervoltage

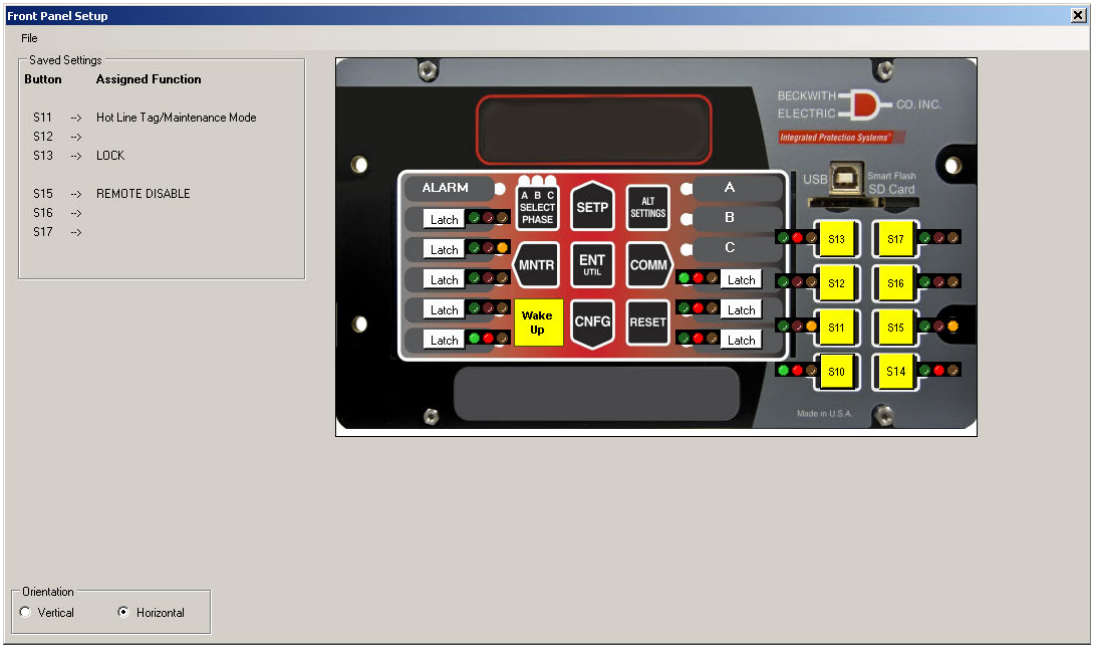


Figure 14 IPScom Smart Button Programming Screen

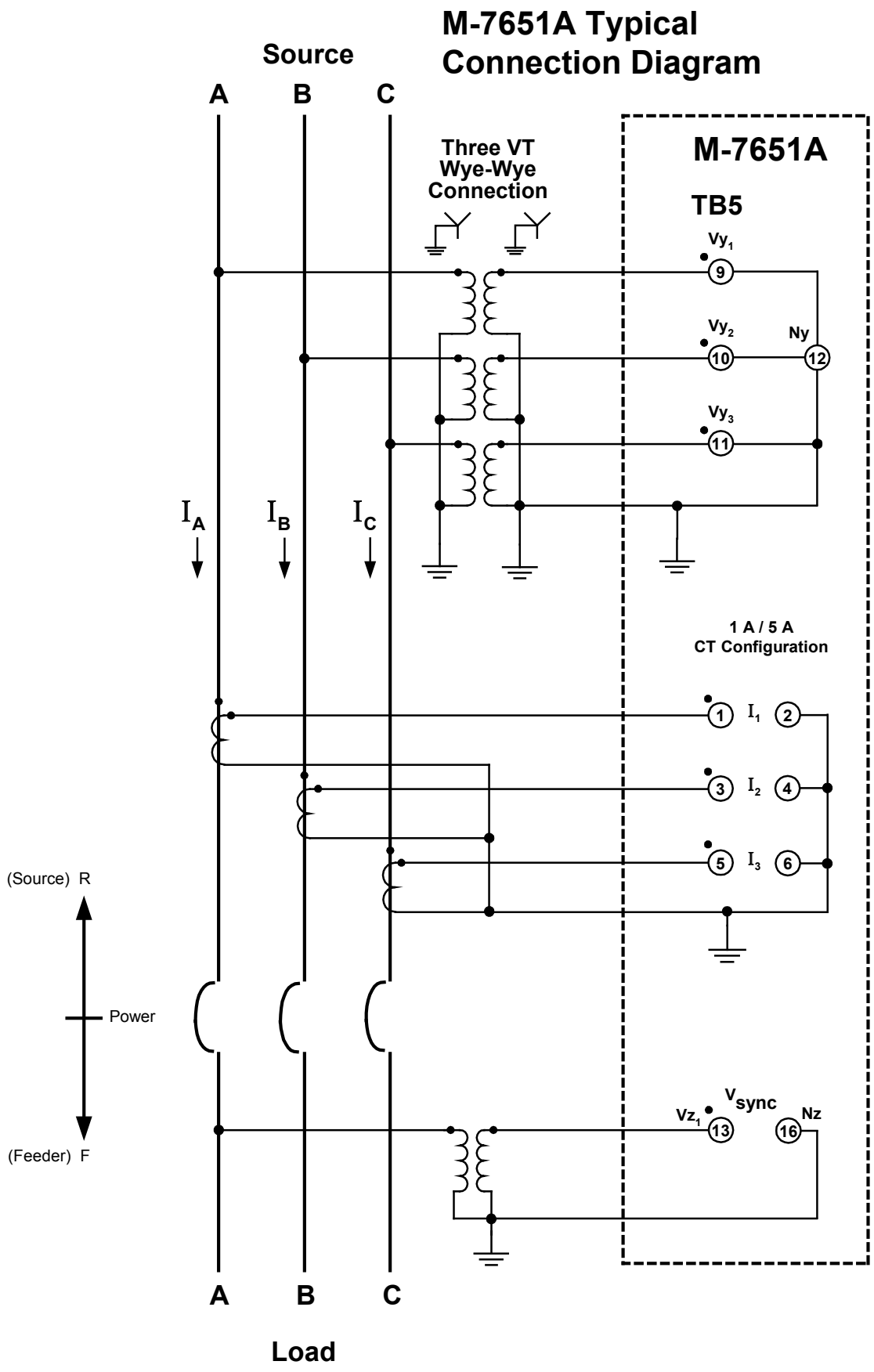


Figure 15 M-7651A D-PAC Three-Line Connection Diagram

Tests and Standards

The M-7651A D-PAC Protection, Automation and Control System for Power Distribution Applications complies with the following tests and standards:

Voltage Withstand

Dielectric Withstand

IEC 60255-27	2,000 Vac

Impulse Voltage

IEC 60255-27	+/- 5,000 V-pk

Insulation Resistance

IEC 60255-27	> 5 G Ω

Electrical Environment

Surge Withstand Capability

IEEE C37.90.1	+/- 2.5 kV Oscillatory
IEEE C37.90.1	+/- 4 kV Fast Transient Burst

1 MHz Oscillatory Immunity

IEC 61000-4-18	+/- 2.5 kV Common Mode
IEC 61000-4-18	+/- 2.5 kV Differential Mode

Electrostatic Discharge Test

IEEE C37.90.3	(+/- 8 kV) - Point Contact Discharge
IEEE C37.90.3	(+/- 15 kV) - Air Discharge
IEC 61000-4-2	(+/- 8 kV) - Point Contact Discharge
IEC 61000-4-2	(+/- 15 kV) - Air Discharge

Radiated Field Immunity

IEEE C37.90.2	35 V/m - 80 to 1000 MHz
IEC 61000-4-3	35 V/m - 80 to 1000 MHz

Fast Transient Disturbance Test

IEC 61000-4-4	+/-4 kV, 5 kHz

Surge Immunity

IEC 61000-4-5	+/- 4 kV Common Mode
IEC 61000-4-5	+/- 2 kV Differential Mode

Voltage Interruption Immunity

IEC 61000-4-11	(5 cycles AC / 50 ms DC)

Output Contacts

IEEE C37.90	30 A make for 0.2 seconds at 250 Vdc Resistive
	8 A carry at 120 Vac, 50/60 Hz
	6 A break at 120 Vac, 50/60 Hz
	0.5 A break at 48 Vdc, 24 VA
	0.3 A break at 125 Vdc, 37.5 VA
	0.2 A break at 250 Vdc, 50 VA

Atmospheric Environment

Temperature

■ **NOTE**: The LCD display's visible temperature range is –20° C to +70° C.

IEC 60068-2-1	Cold, -40° C (-40° F) (operating)
IEC 60068-2-2	Dry Heat, +85° C (+185° F) (operating)
IEC 60068-2-78	Damp Heat, +40° C (+104° F) @ 95% $_{RH}$ (operating)
IEC 60068-2-30	Damp Heat condensation cycle, +25° C, +55° C (+131° F) @ 95% $_{RH}$ (operating)

Mechanical Environment

IEC 60255-21-1	Vibration response Class 1 (0.5 g)
	Vibration endurance Class 1 (1 g)
IEC 60255-21-2	Shock response Class 1 (5 g)
	Shock Withstand Class 1 (15 g)
	Bump Endurance Class 1 (10 g)

IP Protection Degree

IEC 60529	IP 50, Dust Protected

External Connections

The possible connections for the M-7651A D-PAC are shown in Figure 2.

Physical

Mounting: The unit is a semi flush, 3 unit high design that can be panel mounted or mounted in a standard 19" rack mount with the optional Rack Mount Adapter Frame (Figure 20). Vertical mount units are also available.

Size: Horizontal: 9.47" wide x 5.20" high x 6.22" deep (24.1 cm x 13.21 cm x 15.8 cm)
Vertical: 6.0" wide x 8.0" high x 6.22" deep (15.2 cm x 20.3 cm x 15.8 cm)

Approximate Weight: 3.5 lbs (1.6 kg)

Approximate Shipping Weight: 5 lbs (2.27 kg)

Recommended Storage Parameters

Temperature: 5° C to 40° C

Humidity: Maximum relative humidity 80% for temperatures up to 31° C, decreasing to 31° C linearly to 50% relative humidity at 40°C.

Environment: Storage area to be free of dust, corrosive gases, flammable materials, dew, percolating water, rain and solar radiation.

Disposal and Recycling

Disposal of E-Waste for Beckwith Electric Co. Inc. Products

The customer shall be responsible for and bear the cost of ensuring all governmental regulations within their jurisdiction are followed when disposing or recycling electronic equipment removed from a fixed installation.

Equipment may also be shipped back to Beckwith Electric Co. Inc. for recycling or disposal. The customer is responsible for the shipping cost, and Beckwith Electric Co. Inc. shall cover the recycling cost. Contact Beckwith Electric Co. Inc. for an RMA # to return equipment for recycling.

Warranty

The M-7651A D-PAC Protection, Automation and Control System for Power Distribution Applications is covered by a ten-year warranty from date of shipment.

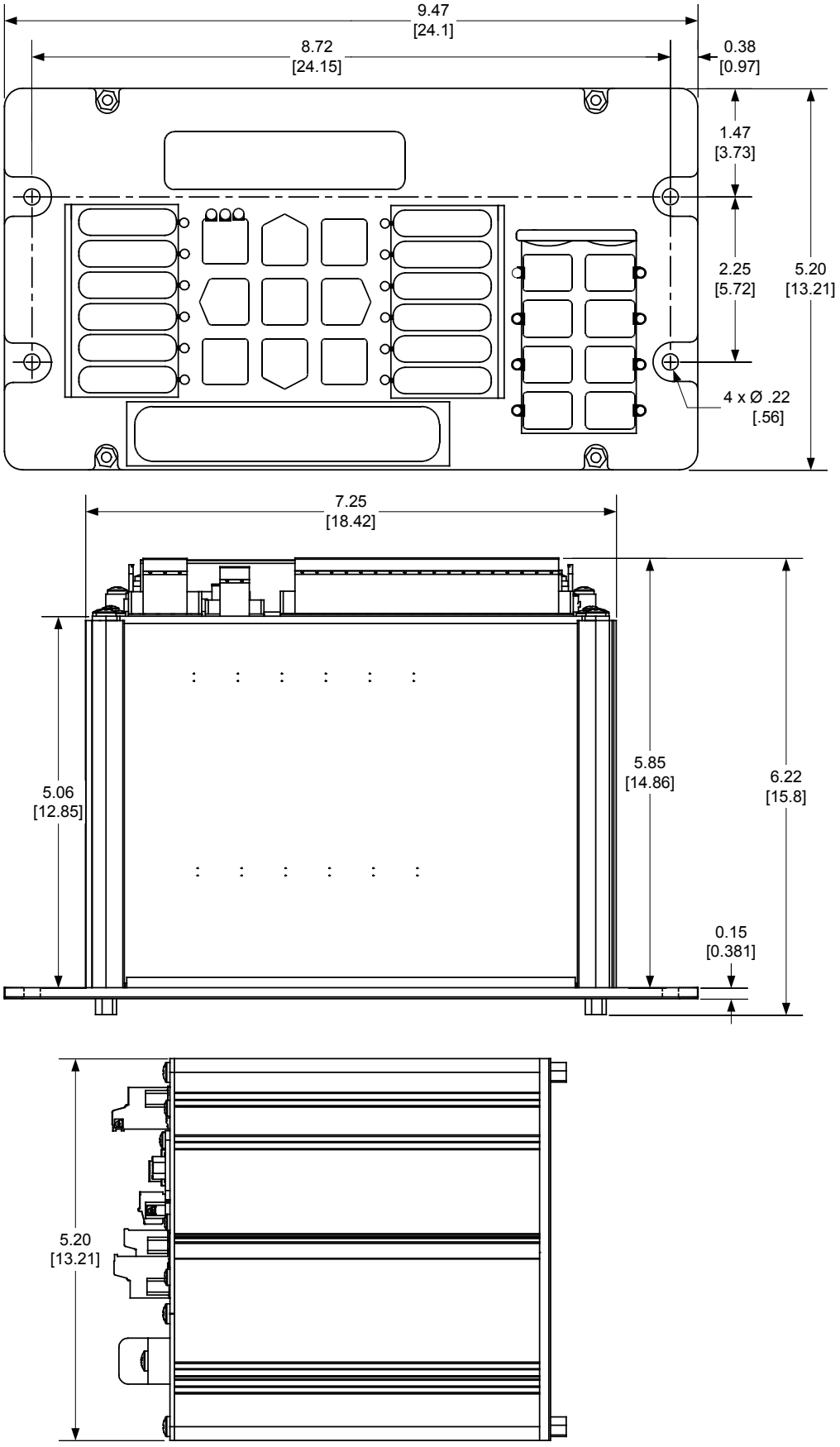


Figure 16 M-7651A D-PAC Horizontal Model Mounting Dimensions

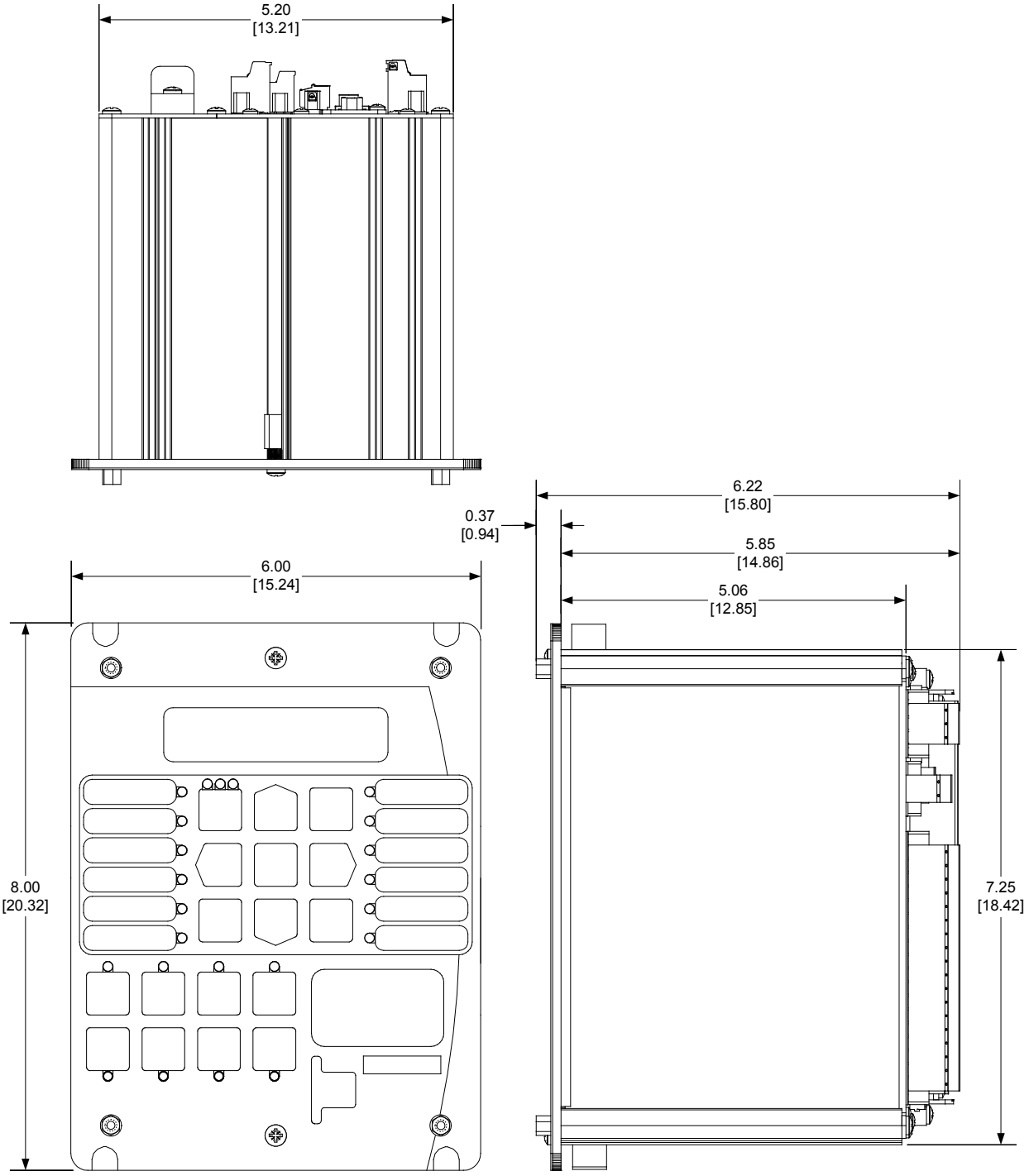


Figure 17 M-7651A D-PAC Vertical Model Mounting Dimensions

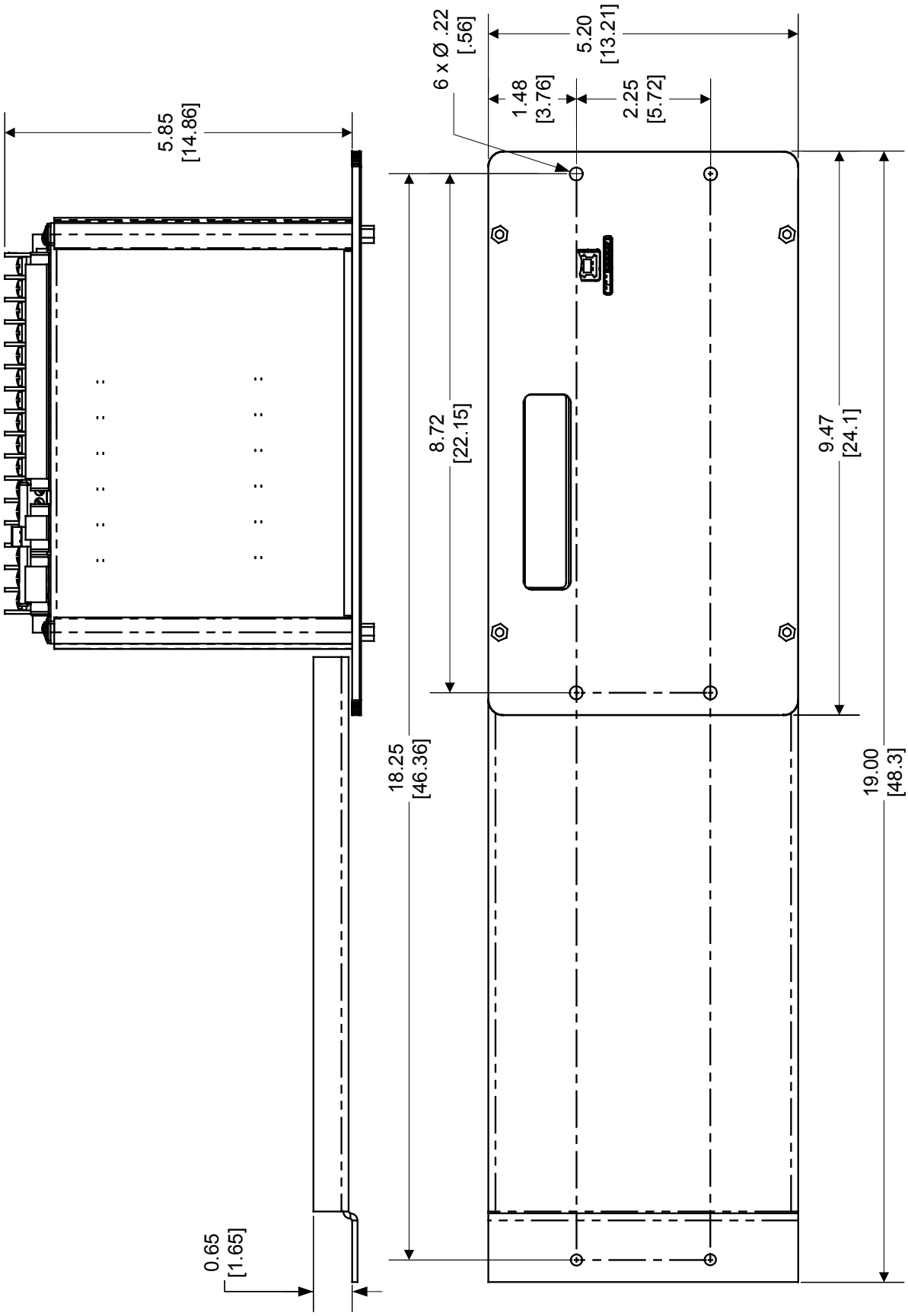


Figure 18 M-7651A D-PAC 19 Inch Rack Mount Adapter Frame Dimensions

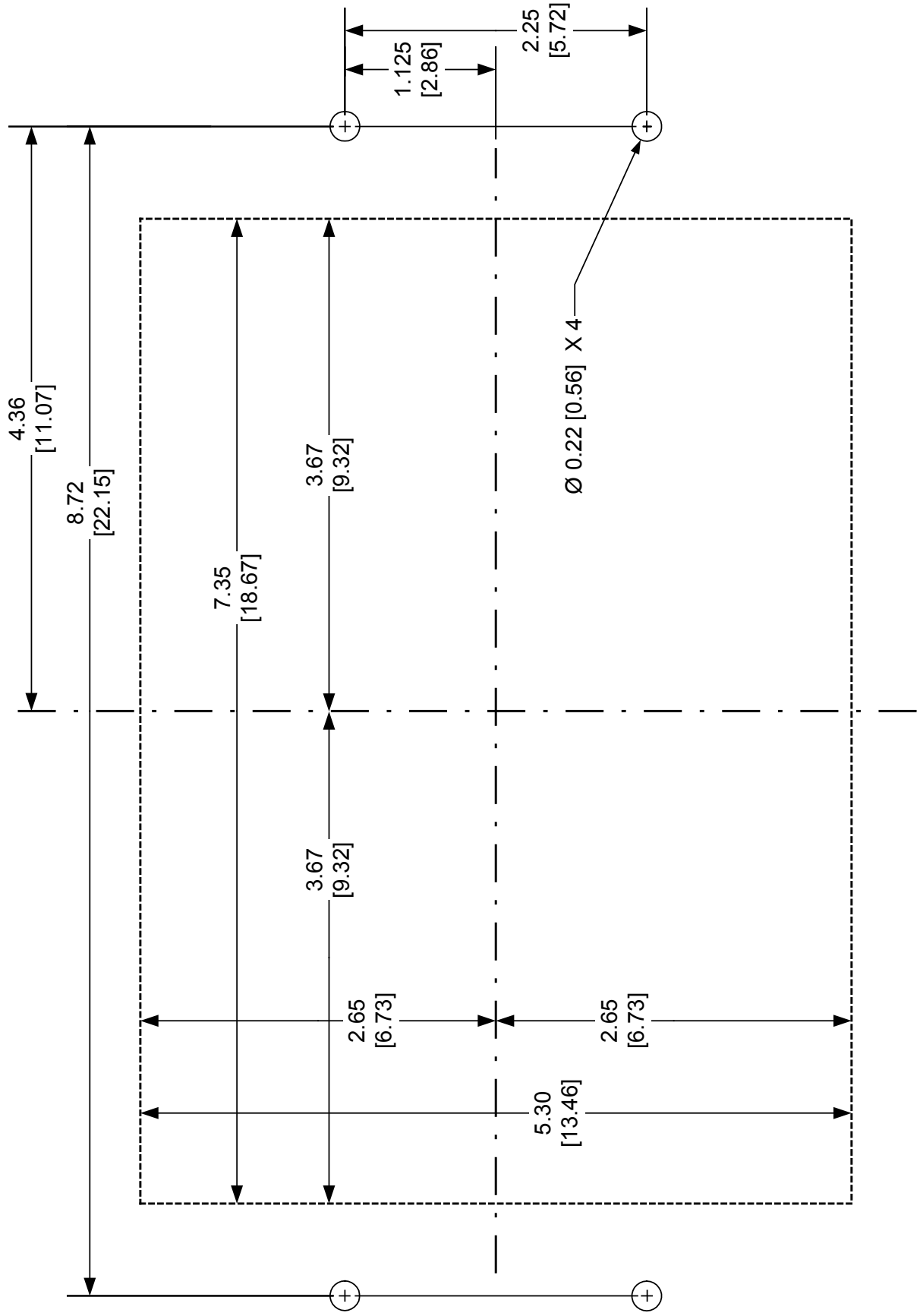


Figure 19 Horizontal Panel Mount Cutout Dimensions

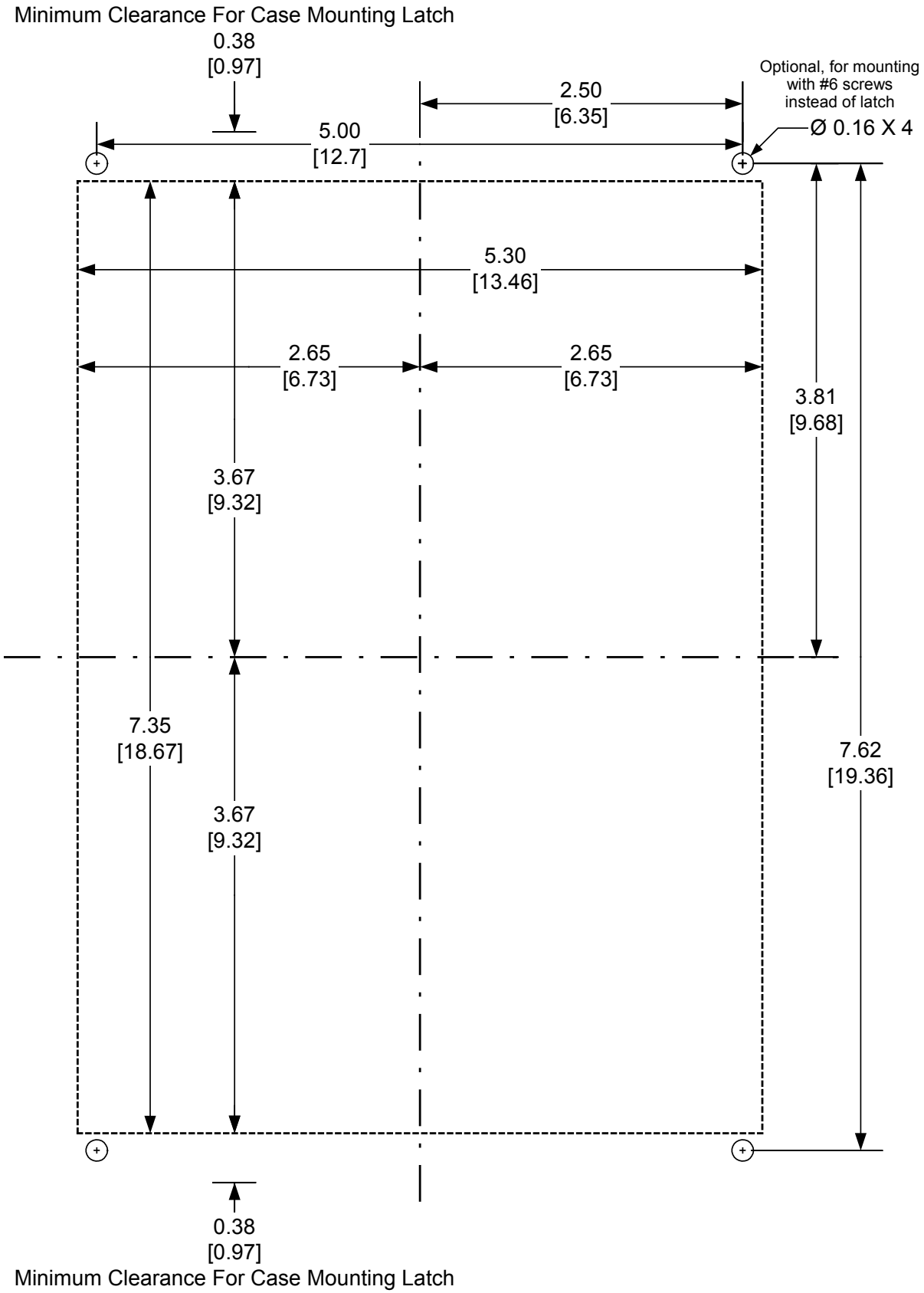


Figure 20 Vertical Panel Mount Cutout Dimensions

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Specification subject to change without notice. Beckwith Electric Co., Inc. has approved only the English version of this document.

BECKWITH ELECTRIC CO., INC.
6190 - 118th Avenue North • Largo, Florida 33773-3724 U.S.A.
PHONE (727) 544-2326 • FAX (727) 546-0121
marketing@beckwithelectric.com
www.beckwithelectric.com
ISO 9001:2008

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800-7651A-SP-07 04/18
Printed in U.S.A.

WARNING

DANGEROUS VOLTAGES, capable of causing death or serious injury, are present on the external terminals and inside the equipment. Use extreme caution and follow all safety rules when handling, testing or adjusting the equipment. However, these internal voltage levels are no greater than the voltages applied to the external terminals.

DANGER! HIGH VOLTAGE

– This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

PERSONNEL SAFETY PRECAUTIONS

The following general rules and other specific warnings throughout the manual must be followed during application, test or repair of this equipment. Failure to do so will violate standards for safety in the design, manufacture, and intended use of the product. Qualified personnel should be the only ones who operate and maintain this equipment. Beckwith Electric Co., Inc. assumes no liability for the customer's failure to comply with these requirements.

– This sign means that you should refer to the corresponding section of the operation manual for important information before proceeding.

Always Ground the Equipment

To avoid possible shock hazard, the chassis must be connected to an electrical ground. When servicing equipment in a test area, the Protective Earth Terminal must be attached to a separate ground securely by use of a tool, since it is not grounded by external connectors.

Do NOT operate in an explosive environment

Do not operate this equipment in the presence of flammable or explosive gases or fumes. To do so would risk a possible fire or explosion.

Keep away from live circuits

Operating personnel must not remove the cover or expose the printed circuit board while power is applied. In no case may components be replaced with power applied. In some instances, dangerous voltages may exist even when power is disconnected. To avoid electrical shock, always disconnect power and discharge circuits before working on the unit.

Exercise care during installation, operation, & maintenance procedures

The equipment described in this manual contains voltages high enough to cause serious injury or death. Only qualified personnel should install, operate, test, and maintain this equipment. Be sure that all personnel safety procedures are carefully followed. Exercise due care when operating or servicing alone.

Do not modify equipment

Do not perform any unauthorized modifications on this instrument. Return of the unit to a Beckwith Electric repair facility is preferred. If authorized modifications are to be attempted, be sure to follow replacement procedures carefully to assure that safety features are maintained.

PRODUCT CAUTIONS

Before attempting any test, calibration, or maintenance procedure, personnel must be completely familiar with the particular circuitry of this unit, and have an adequate understanding of field effect devices. If a component is found to be defective, always follow replacement procedures carefully to that assure safety features are maintained. Always replace components with those of equal or better quality as shown in the Parts List of the Instruction Book.

Avoid static charge

This unit contains MOS circuitry, which can be damaged by improper test or rework procedures. Care should be taken to avoid static charge on work surfaces and service personnel.

Use caution when measuring resistances

Any attempt to measure resistances between points on the printed circuit board, unless otherwise noted in the Instruction Book, is likely to cause damage to the unit.

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Appendix G Index

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800-7651A-IB-06 06/18

1 Introduction

1.1 Instruction Book Contents 1–1

1.2 General Overview of M-7651A D-PAC System 1–2

1.1 Instruction Book Contents

Chapter 1: Introduction

Chapter One summarizes the devices' capabilities, introduces the instruction book contents and provides an overview of the M-7651A D-PAC System.

Chapter 2: Operation

Chapter Two provides the necessary instructions regarding operation of the M-7651A D-PAC. Manual operation of the M-7651A D-PAC is accomplished by utilizing the relay's front panel controls and indicators, or through the S-7600 IPScom Communications and Oscillographic Analysis Software.

Chapter 3: IPScom

Chapter Three provides a description of each element of the S-7600 IPScom Communications Software. The IPScom menu structure and commands are described in detail for each feature and function.

Chapter 4: System Setup

Chapter Four is designed for the person(s) responsible for the direct setting and configuration of the system. It describes the procedures for entering all required data into the M-7651A D-PAC. Included in this chapter are functional and connection diagrams for a typical application for the system. It also illustrates the definition of system quantities and equipment characteristics required by the M-7651A D-PAC.

Chapter 5: Setpoints

Describes the individual function settings and the Setpoint configuration process for the relay (choosing active functions), output contact assignment and input blocking designation.

Chapter 6: Testing

This chapter provides step-by-step test procedures for each function, as well as diagnostic mode and auto-calibration procedures.

Appendix A: HMI Menu Flow

This Appendix includes the M-7651A D-PAC HMI Flow diagrams to aid the user in navigating the menu system.

Appendix B: Relay Configuration Worksheet

This Appendix contains a copy of the Relay Input/Output Configuration Table and is provided to define and record the blocking inputs and output configuration for the relay.

Appendix C: Self-Test Error Codes

This Appendix lists all the error codes and their definitions.

Appendix D: Battery Charger

This Appendix includes the M-2032A Battery Charger features and functions.

Appendix E: Inverse Time Curves

This Appendix contains the equations and graph representations of the supported Inverse Time Curves: IEC, IEEE, Traditional Recloser Curves, US Curves, and Definite Time Curve.

Appendix F: Index

This Appendix includes the Index for the M-7651A D-PAC Instruction Book.

1.2 General Overview of M-7651A D-PAC System

The M-7651A D-PAC is a digital, Smart Grid ready, advanced Protection, Automation and Control System for Power Distribution Applications that is compatible with most manufacturer's switchgear and suitable for new installations or as a direct, easy-to-install, replacement for older protection systems. It offers a comprehensive protection package with individual protection functions as shown in Table 1-1, with up to eight setting groups.

The M-7651A D-PAC Front Panel includes the following features:

- LCD display, 2 rows, 20 characters per row, with configurable contrast
- Twelve programmable tricolor front panel LEDs
- Keyboard – 17 pushbuttons (Two dedicated for Trip and Close)
- Six programmable pushbuttons with programmable LEDs
- Nine function pushbuttons

The M-7651A D-PAC features a high accuracy metering system with advanced recording and reporting functions as well as continuous data sampling at 128 samples per cycle.

By configuring various combinations of the slow–, fast–, and time-delay curve elements, the M-7651A D-PAC System can allow as many as five trips and four total reclosing operations. If required, individual reclose intervals are user-settable with time-delays of up to 600 seconds. The settings for the different functions can be accomplished by using the IPScom S-7600 Communication Software or the front panel pushbuttons.

The M-7651A D-PAC includes Programmable Alarm LEDs to indicate any general overcurrent trip (TRIP), plus additional LEDs to indicate the type of overcurrent trip. The Fast-Curve LED indicates a Fast-Curve Trip.

For convenience and safety, the M-7651A D-PAC System offers an SD card reader. Programming can be done in the office and settings can be loaded using an SD card thus minimizing the time a user needs to spend in front of the relay.

FUNCTION	DESCRIPTION
25	Sync Check
27	Phase Undervoltage
27PP	Phase-to-Phase Undervoltage
27Vz1	Vz1 Undervoltage
27BSVS	Bus Side Voltage Supervision
32	Directional Power
40	Loss of Field
46DT	Negative-Sequence Definite Time Overcurrent
46IT	Negative-Sequence Inverse Time Overcurrent
47	Negative-Sequence Overvoltage
50BF	Breaker Failure
50P	Phase Instantaneous/Definite Time Overcurrent
50G	Ground Instantaneous/Definite Time Overcurrent
50N	Residual Instantaneous/Definite Time Overcurrent
51P/51V	Phase Inverse Time Overcurrent with Voltage Control/Restraint
51N	Residual Inverse Time Overcurrent
51G	Ground Inverse Time Overcurrent
59	Phase Overvoltage
59PP	Phase-to-Phase Overvoltage
59I	Peak Overvoltage
59N	Residual Overvoltage
59Vz1	Vz1 Overvoltage
60FL	VT Fuse Loss Detection

FUNCTION	DESCRIPTION
67P	Phase Directional Overcurrent
67N	Residual Directional Overcurrent
67G	Ground Directional Overcurrent
67Q	Negative-Sequence Directional Overcurrent
81	Frequency
81R	Rate-of-Change of Frequency
BM	Breaker Monitor
CLP	Cold Load Pickup
HLT	Hot Line Tag
Restore	Auto Restoration
PSBC	IED Power Supply/Battery Charger Monitor
TCM/CCM	Trip/Close Circuit Monitoring
THD/TDD	Total Harmonic Distortion/ Total Demand Distortion
Optional Protective Functions (with 200 mA, 50 mA or 10 mA Ground CT option)	
50GS	Sensitive Ground Instantaneous/ Definite Time Overcurrent
51GS	Sensitive Ground Inverse Time Overcurrent
67GS	Sensitive Ground Directional Overcurrent
Optional Reclose Functions	
79	Auto Reclose
79 Sequence	Trip Reclose Sequence
79 Lockout	Drive to Lockout
Supervision	Supervision Functions

Table 1-1 M-7651A D-PAC Device Functions

Communication Ports

The M-7651A D-PAC includes five physical communication ports. The unused communications ports can be disabled through software to comply with cyber security requirements.

- Front – USB Port, Type B, Version 1.1. This port is used to locally set and interrogate the relay using a portable computer.
- Port 1, (optional) located on the rear of the relay can be either a Serial TIA-232, TIA-485, Fiber, or none.
- Port 2/Port 3, (optional) located on the rear of the relay can be either a RJ45 Ethernet 10/100 BASE-T or Fiber Ethernet 100 BASE-FX.

  Ethernet Ports are auto-detect, auto-negotiable 10/100Mbps, with support for multi-user rights for up to six concurrent users.
- Port 4, (optional) located on the rear of the relay can be either a Serial TIA-232, TIA-485, Fiber, or none.

Time Synchronization Port:

- IRIG - B (B000)
- Input – Demodulated
- Input level – TTL
- Isolation – 1,500 Vdc

Communications Protocols

USB Port – MODBUS RTU

Rear Serial Ports – DNP 3.0 level 2 slave, MODBUS RTU and Smart P2P (Peer-to-Peer)

Optional Ethernet Ports – DNP 3.0 over TCP/IP and UDP, and MODBUS over TCP, IEC 61850 (optional) plus Smart P2P

Time Sync: SNTP

Detailed information regarding the use of the relay communications ports is provided in **Chapter 3, IPScom**.

S-7600 IPScom Communications Software

The S-7600 IPScom Communications Software enables local or remote communication between a Windows® based computer and the M-7651A D-PAC System. The S-7600 IPScom Communications Software makes efficient use of object-oriented programming, achieving a smooth and scalable design, and has an open data structure that allows maintenance and the incorporation of new functions.

The S-7600 IPScom Communications Software is a Windows application that provides a graphical interface to program and monitor the M-7651A D-PAC. The S-7600 Software includes the step-by-step Recloser Wizard, for simple setup programming.

See **Chapter 3, IPScom** for an overview of IPScom features.

2 Operation

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■ **CYBER SECURITY NOTE:**
When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

The purpose of this chapter is to describe the steps that are necessary to interrogate the M-7651A D-PAC utilizing either the front panel HMI or a Windows® based computer running IPScom S-7600 Communications Software through any of the available communications ports. These instructions assume that the following conditions exist:

- The unit is energized from an appropriate power supply (Green Alarm LED is illuminated).
- For Windows based computer communications, IPScom is installed on the host computer.

  See **Chapter 3**, **IPScom S-7600**, Section 3.2 Installing IPScom, if IPScom is not installed.
- Initial computer communication has been established with the unit.

  If this is the first attempt to establish communications with the unit, then see **Chapter 3**, **IPScom S-7600**, Section 3.3 Communications Using Direct USB Connection.

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2.1 Front Panel Controls and Indicators Overview

The front-panel user interface consists of an LCD display, dedicated/programmable pushbuttons, and dedicated/programmable tri-color LEDs.

DISPLAY

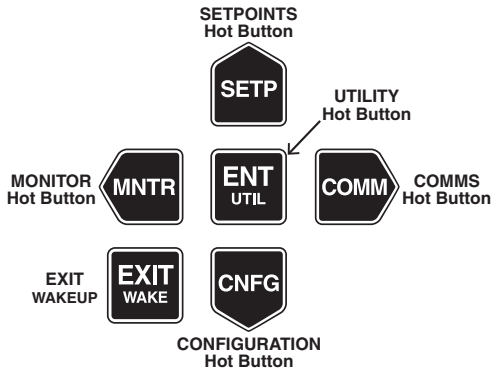
A two row, by 20 character per row Liquid Crystal Display (LCD) with configurable contrast is provided on the M-7651A D-PAC front panel (Figure 2-1). The display normally displays the user lines and remains so until the SETP, CNFG, MNTR, COMM, or ENT UTIL pushbutton is depressed or a relay cycling message is displayed.

NAVIGATION PUSHBUTTONS

The Navigation pushbuttons provide the means to navigate through the HMI menu screens and also to effect changes to settings.

They are used to enter new values by incrementing or decrementing the displayed value. The new value is not stored until the **ENT** pushbutton is pressed a second time. The navigation pushbuttons also provide direct access "Hot Buttons" to HMI menu headers.

Pressing the applicable pushbutton will display the heading corresponding to the "Hot Button" label contained in the pushbutton (Figure 2-1).



The "Hot Buttons" directly access the menu headers and can only be selected from either the user lines or the cycling display. While the **EXIT** pushbutton is not a Hot Button, it provides the means to navigate back to upper level menus and also "Wakes" the relay.

OPERATION PUSHBUTTONS

In addition to the navigation/hot buttons the M-7651A D-PAC front panel also includes dedicated pushbuttons that activate relay features. The pushbutton locations are stated as a function of the front panel index presented in Figure 2-2.

The dedicated pushbuttons (non programmable) include:

- Select Phase (S1) is not operable or programmable
- Alt Settings (S3)
- RESET (S9)

Default/preassigned programmable pushbuttons include:

- TRIP (S10)
- HLT/MAINT. (S11)
- CLOSE (S14)
- LOCK (S13)
- REMOTE DISABLE (S15)

The listed default/preassigned pushbuttons, and pushbuttons S12, S16 and S17 can be programmed by the user subject to the programming limitations stated in the IPScom, Setup/Configuration/Front Panel Functions feature.

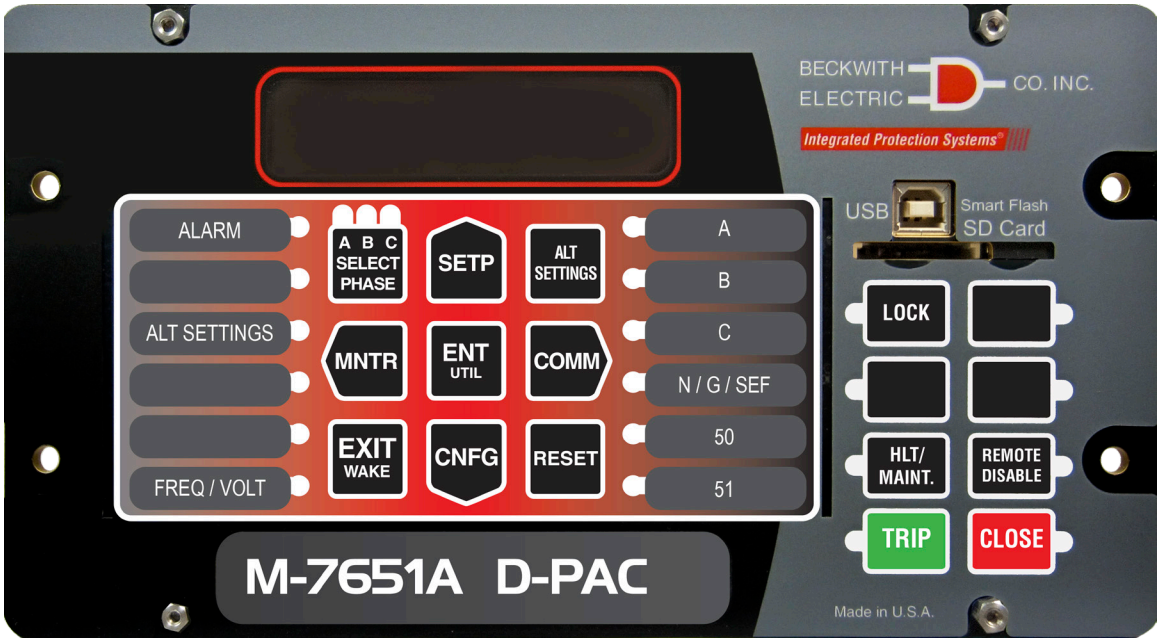


Figure 2-1 M-7651A D-PAC Front Panel

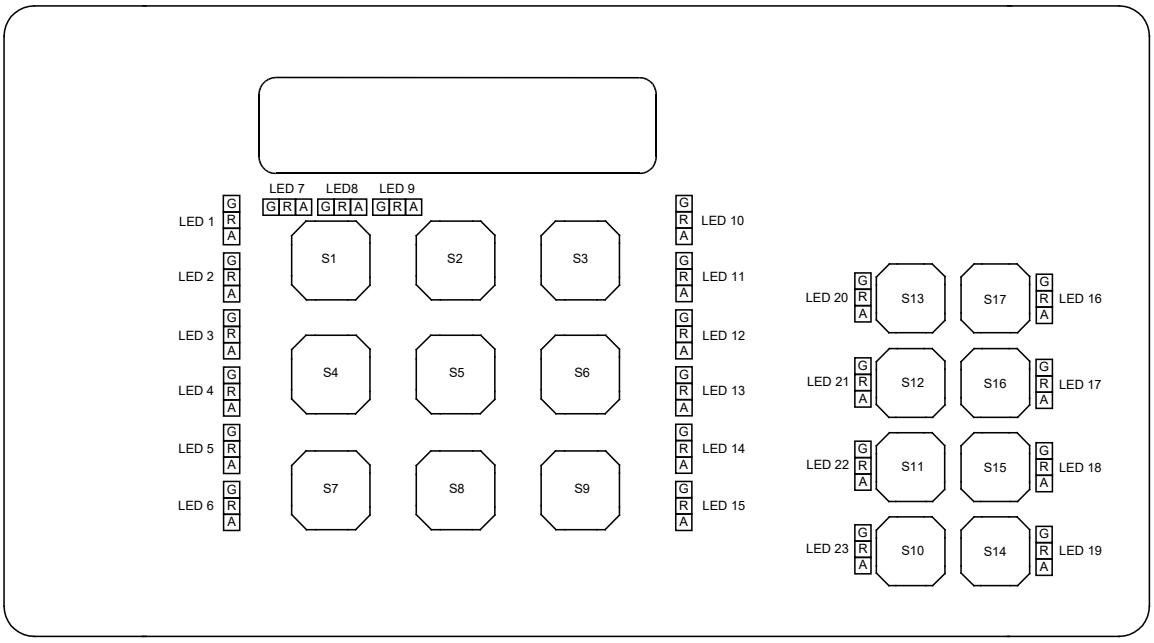


Figure 2-2 Pushbutton and LED Location Index

SELECT PHASE Pushbutton (S1)

The "Select Phase" pushbutton (S1) is not operable and is not programmable.

TRIP (S10)

The **TRIP** pushbutton is a pre-programmed pushbutton that retains its ability to be reprogrammed. When it is pressed, a trip command is initiated which activates the dedicated TRIP Output contact based on its configuration and the Lockout condition is set. If there is a time delay enabled on the TRIP output, then LED 16 will flash green. The flash rate is once per second. LED 16 will remain illuminated (solid) green once the contact is fired, only if the 52b contact is energized. LED 16 will flash amber when an Overcurrent Element 50/51 is picked up and timing to trip. LED 16 will extinguish when a Trip Close Error is detected.

When the relay is powered down when it is in a Lockout condition, the relay will remember the Lockout condition when power is restored to the relay and will also send a TRIP command to the breaker.

CLOSE (S14)

■**NOTE:** If a Trip Close Error is active, then both Local Manual and Remote Manual Close operations are blocked.

The **CLOSE** pushbutton is a pre-programmed pushbutton that retains its ability to be reprogrammed. When it is pressed it initiates a Close command which activates the dedicated Close Output contact based on its configuration. If there is a time delay enabled on the Close output, then LED 20 will flash red. The flash rate is once per second. LED 20 will remain illuminated (solid) red once the contact is fired, only if the 52a contact is energized. LED 20 will extinguish when a Trip Close Error is detected.

REMOTE DISABLE (S15)

The **REMOTE DISABLE** pushbutton is a pre-programmed pushbutton that retains its ability to be reprogrammed. When pressed, this pushbutton disables the remote operation of Outputs, and LED 21 illuminates amber. Outputs will not be operational in the following conditions:

- The user is attempting to send a Remote Trip/Close command
- The user is attempting to activate Outputs by sending a trigger signal (see "Remote Control" on page 2–28)
- When an Output is configured for Alarm, Battery Test, or Smart Button

■**NOTE:** Outputs assigned to functions are not affected. Any function timing out will trigger the assigned output, regardless of the state of the REMOTE DISABLE pushbutton.

When the unit is powered up, the state of this pushbutton is that the REMOTE DISABLE feature is not active, and remote operations are enabled. LED 21 is extinguished.

HOT LINE TAG/MAINTENANCE (S11)

The **HLT/MAINT** pushbutton is a pre-programmed pushbutton that retains its ability to be reprogrammed.

When the HLT/MAINT pushbutton is pressed, the HLT/MAINT feature will become active and inhibit all Close operations, regardless of the source of the Close command. LED 17 will illuminate amber indicating HLT/MAINT is active. With the Autoreclose option, when Hot Line Tag is active, and a TRIP is initiated, the relay will drive to LOCKOUT.

The state of the HLT/MAINT pushbutton is non-volatile. If a main power interruption to the relay occurs, the relay will remember the HLT/MAINT state at the time of the power interruption. When power is reinstated, the HLT/MAINT status prior to the power interruption will be reinstated.

Hot Line Tagging/Maintenance Mode can only be disabled by the same source that enabled it, either from the relay front panel or remotely.

LOCK (S13)

The LOCK pushbutton is a pre-programmed pushbutton that retains its ability to be reprogrammed.

The LOCK pushbutton toggles the Lock/Unlock state of the front panel pushbuttons S11 through S17. The S10 TRIP pushbutton remains accessible when the LOCK state is activated.

ALTERNATE SETTINGS (S3)

When the Alternate Settings pushbutton is pressed for greater than 0.5 seconds the relay will display the Profile Switching menu. The user can then switch the active profile to any of the 8 available profiles. LED 4 will illuminate amber indicating Alternate Settings are active.

RESET/LAMP TEST (S9)

The **RESET/LAMP TEST** pushbutton is a dedicated pushbutton and can not be programmed to actuate another feature or function. When pressed (for at least 3 seconds) it Resets the latched signals and LEDs. This pushbutton also performs a test of the LEDs by turning them all on simultaneously for 2 seconds after the pushbutton is depressed. All LEDs will illuminate amber for these 2 seconds.

LEDS

LED locations are presented in Figure 2-2. LEDs can be illuminated as Red, Green or Amber. The LEDs can be selected to latch (illuminate) on a particular color: Red, Green or Amber. This selection is available through IPScom's LED configuration utility. By default LEDs 10, 11, 12 are latched on RED. RED indicates overcurrent function timeout. Only LEDs 2, 3, 4, 5, 6, 13, 14, and 15 are programmable for latching. The latch condition is resettable by using the reset command either on the front panel, or remotely through communications. The latch condition is non-volatile and in case of a main power interruption to the relay, the relay will remember the latch state at the time the power interruption occurred.

■**NOTE:** Functions 32 and 67 do not have LEDs configured by default. These can be programmed through IPScom's Custom LED configuration utility.

ALARM LED (LED 1)

The ALARM LED will illuminate green at power up when all the self-diagnostic tests have passed. If any of the tests fails, the led flashes red. The LED will illuminate green to indicate that the health of the relay is good. Any anomaly causes the LED to flash red. Any conditions that trigger the alarm condition will be displayed on the LCD display. This LED configuration is fixed except for limited customization of the alarm list.

Alarm conditions that will cause the Alarm LED to illuminate and flash red include:

- Battery Charger comm failure
- DSP setpoint checksum error
- DSP calibration checksum error
- Flash format error
- AC power error
- Gas pressure error
- Trip-Close error
- Maximum operation error
- Internal battery fail error
- DSP watchdog error
- EEPROM setpoint checksum error
- EEPROM calibration checksum error
- DSP comm error

When the ALARM LED is flashing red, relay protection will be disabled when any of the following conditions are met:

- EEPROM setpoint checksum error
- DSP watchdog error
- EEPROM calibration checksum error

ALT SETTINGS (LED 3)

When any settings group is active other than the primary group, the LED will illuminate amber, otherwise it will be extinguished.

Unassigned (LEDs 2, 4 and 5)

LEDs 2, 4 and 5 are unassigned and can be user programmed utilizing the LEDs Utility found under the Setup/Configuration menu drop down in IPScom. See Chapter 3 for more information.

FREQ/VOLT (LED 6)

The FREQ/VOLT LED illuminates green when a 81 Element (not 81R) has caused a trip signal. The FREQ/VOLT LED will illuminate red when a 27 or 59 Element has caused a trip signal.

SELECT PHASE (LED 7, 8, 9)

Indicates status of breaker.

PHASE A, B, C (LED 10, 11, 12)

When a phase element is timing to trip, the respective LED will illuminate amber. If the element resets before tripping, the respective LED will extinguish. Each PHASE LED illuminates red when a trip signal is issued when the respective phase current exceeds its minimum trip setting. The PHASE LEDs are fixed and can not be reprogrammed.

N/G/SEF (LED 13)

When a Ground or Sensitive Earth Fault or Neutral current element is timing to trip, the LED will illuminate amber. If the element resets before tripping, the respective LED will extinguish. The N/G/SEF LED illuminates red when a trip signal is issued when the Ground or Sensitive Earth Fault or Neutral current exceeds its minimum trip setting. The N/G/SEF LED is fixed and can not be reprogrammed.

50 (LED 14)

The 50 LED will illuminate red when a 50 Element has caused a trip signal.

51 (LED 15)

The 51 LED will illuminate red when a 51 Element has caused a trip signal.

HMI MENU STRUCTURE

The HMI menu structure (Appendix A) consists of three levels; Header, Sub-Header and Data/Data Entry. From the header level the user can navigate to the adjacent headers with the **LEFT** or **RIGHT** pushbuttons (Figure 2-3), go to the sub-header level by pressing **ENT** or **DOWN** pushbutton, or clear the screen by pressing the **EXIT** pushbutton.

From the sub-header level, the user can navigate to the adjacent sub-headers with the **LEFT** or **RIGHT** pushbuttons, return to the header level by pressing the **EXIT** or **UP** pushbuttons, or enter the data/data entry level by pressing **ENT** or **DOWN**. Once in the data/data entry screens, the user can navigate through the list with the **UP** and **DOWN** pushbuttons. In this level the list wraps around. To exit the level, the user can press **EXIT** to return to the corresponding sub-header, or use the **LEFT** or **RIGHT** pushbuttons to go to the adjacent sub-header level. To enter data, reset parameters or access data screens, press **ENT**.

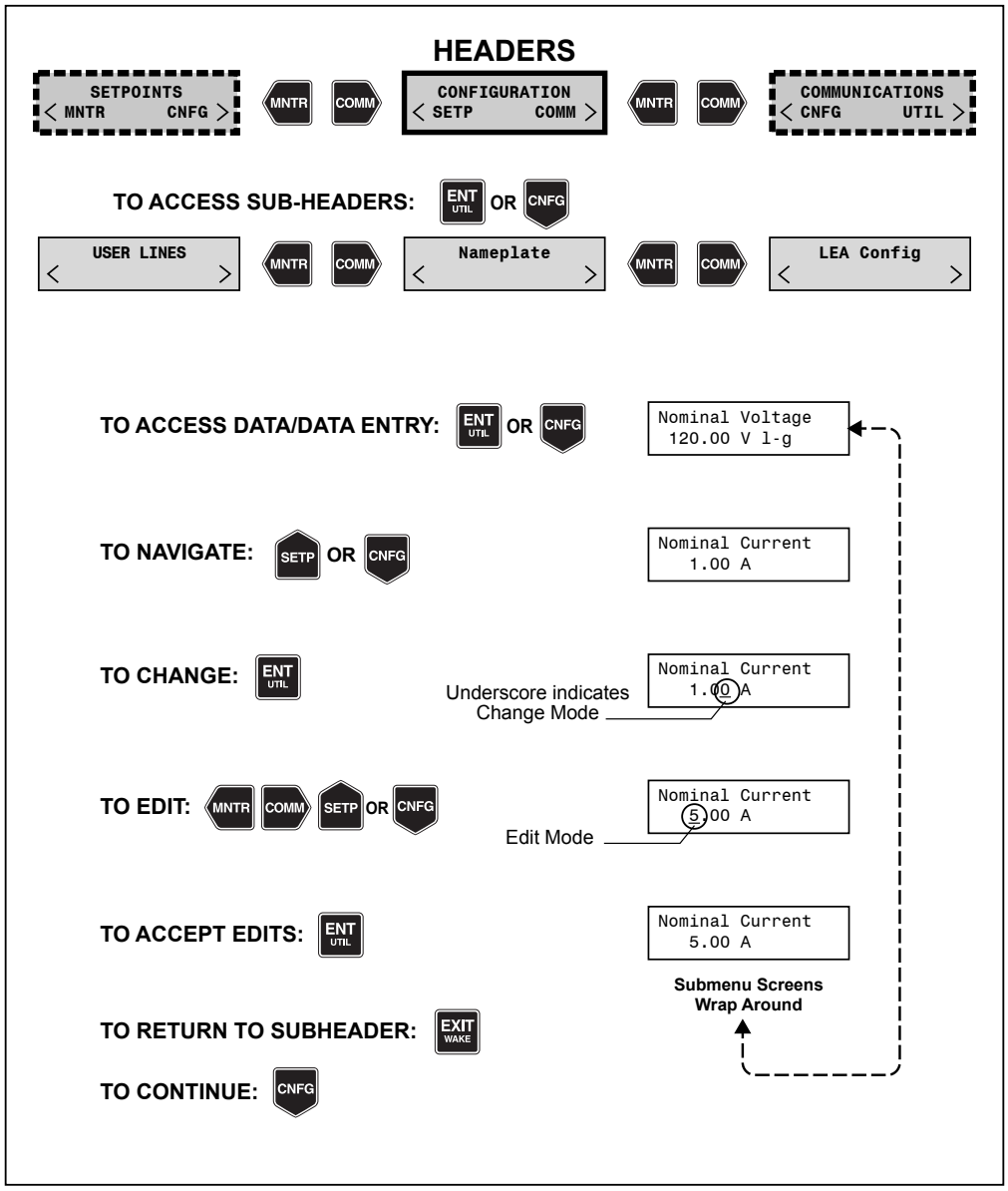


Figure 2-3 HMI Menu Structure and Navigation Example

ENT Pushbutton

The **ENT** pushbutton is a hot button for the "Utility Menu". It is also used to perform the following functions:

- Enter the "edit" mode of a screen
- Store a setpoint or condition in memory
- Enter the sub-header or data level
- Reset certain monitoring screens

EXIT Pushbutton

The **EXIT** pushbutton is a hot button for a unit "wakeup", which starts cycling through a series of user selectable metering information screens. The user can move up and down the automatic cycling using the **UP** and **DOWN** pushbuttons. The screens for the wakeup sequence can be enabled or disabled from the IPScom S-7600 Communications Software (See Section 4.1 Unit Setup).

The **EXIT** pushbutton is also used to perform the following functions:

- Exit a level to the next higher level
- Cancel data entry
- Clear the screen when at the header level

Data Entry Screens

Data entry screens are of three types:

- Alphanumeric – the **LEFT** and **RIGHT** pushbuttons advance the cursor to the digit to be edited and the **UP** and **DOWN** pushbuttons change the value
- List – the **UP** and **DOWN** pushbuttons change the data
- Bit Mask – the **LEFT** and **RIGHT** pushbuttons move the cursor to the bit and the up and down pushbuttons change the value

For all screens the **ENT** pushbutton saves the value and **EXIT** pushbutton cancels the operation. An "underscore" beneath the far left or far right character or digit indicates the user is in the **EDIT** mode.

Power Up Screens

Each time the unit is powered up, it will briefly display a series of screens that include:

- Initializing
- Loading Configuration
- Loading DSP
- User Lines

LCD Screen Contrast

The LCD screen contrast can be set/reset from the front panel through the HMI menu item at any time. The LCD Screen Contrast adjustment menu item is located in the Communication/ HMI menu.

"EDIT" Mode Prompt

An underscore beneath the far left or far right character or digit is enabled by initially pressing **ENT**. This prompt indicates that the user can change a setting using the **UP** or **DOWN** pushbuttons to increment or decrement the settings. Values have factory preset increments, such as 0.1 volt or 1 second. Press **ENT** the second time to execute the setting change.

Smart Flash SD Card Slot

The Smart Flash SD Card Slot allows the user to:

- Load and Save Setpoints
- Save Datalog/Datalog Range
- Save Sequence of Events Record/Range
- Save Oscillograph
- Save Trip Sequence Events Record
- Clone Save/Clone Load
- Save Metering Data
- Update Firmware
- Update Bootloader
- Record Datalog directly to SD Card
- Record IPsec Log directly to SD Card

2.2 Operation (HMI/IPScom)

HMI MESSAGE SCREENS

Default Message Screen

When the M-7651A D-PAC is energized and unattended, the User Logo lines are displayed along with any System Alarm messages.

Wakeup Message Screens

If **EXIT** is selected, the display will initiate a cycling display of any parameters selected in the IPScom Wakeup Dialog screen (Figure 3-76).

The Wakeup cycling can be frozen by selecting either the **UP** or **DOWN** pushbutton once, which will continuously display the wakeup screen being displayed at that moment. Utilize the **UP**/**DOWN** arrow pushbuttons to advance to the next parameter. Press the **EXIT** pushbutton to return to the User Lines screen.

Fault Recorder Event Message

In the event of a fault, the HMI will display a message alert that a fault has occurred with the timestamp of the most recent event, similar to the following:

```
Fault occurred
01/20/16  08:36:19.54
```

The screen will then cycle through the following parameters:

- Fault occurred/Time Stamp
- Input Status
- Output Status
- Function Pickup
- Function Timeout
- Voltages
- Currents

To clear the cycling display, press the **RESET** pushbutton.

Custom Messages

The user has the option to display up to eight custom messages in the HMI top menu main screen. The messages are enabled utilizing the IPSlogic feature of IPScom (see Chapter 5 Setpoints). Once enabled, the user may edit the message text from the IPScom Setup/ Setpoints/IPSlogic dialog screen.

CYBER SECURITY

NERC/CIP Compliant Cyber Security

To provide NERC/CIP compliance, the M-7651A offers enhanced Cyber Security utilizing User Name/Password authorization. When this cyber security is enabled, access to the control is restricted to authorized users. Access to specific HMI menus is determined by the User Permissions assigned by the Security Administrator.

OSCILLOGRAPH RECORDER

Trigger Oscillograph Recorder

To manually trigger the Oscillograph recorder from IPScom perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Oscillograph/Trigger** from the IPScom toolbar. IPScom will display an Oscillograph Trigger confirmation screen (Figure 2-4).

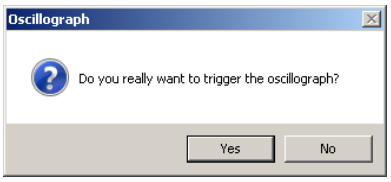


Figure 2-4 Manual Oscillograph Trigger Confirmation Screen

3. Select **YES**. IPScom will display an "Oscillograph was triggered successfully" confirmation screen (Figure 2-5).

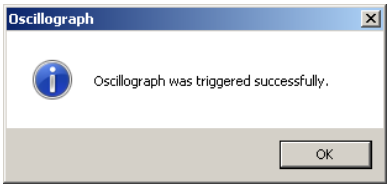


Figure 2-5 Oscillograph Recorder Successfully Triggered Confirmation Screen

4. Select **OK**. IPScom will return to the Main screen.

Retrieve Oscillograph Record

Oscillograph data must be retrieved from the relay in a Comtrade file (*.cfg) in order to be viewed. The included BecoPlot Oscillograph Analysis Software program (Utility/Data Analysis/BecoPlot) or any Comtrade reader is required to view the downloaded oscillograph files.

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Oscillograph/Retrieve** from the IPScom toolbar. IPScom will display a "Retrieve Oscillograph Record" dialog screen (Figure 2-6).

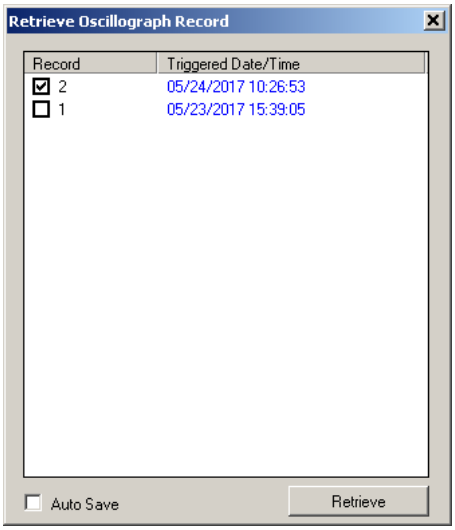


Figure 2-6 Retrieve Oscillograph Record Dialog Screen

3. Select the desired oscillograph record(s), then select "Retrieve". IPScom will display a Retrieve Oscillograph Record "Save As" dialog screen (Figure 2-8).

   Selecting "Auto Save" displays a popup window allowing all available records to be selected (Figure 2-7). Select **Yes** to allow IPScom to automatically select and save all records to the same location, rather than displaying the "Save As" screen for each selected record.

Figure 2-7 Retrieve Oscillograph Record Auto Save Popup Screen

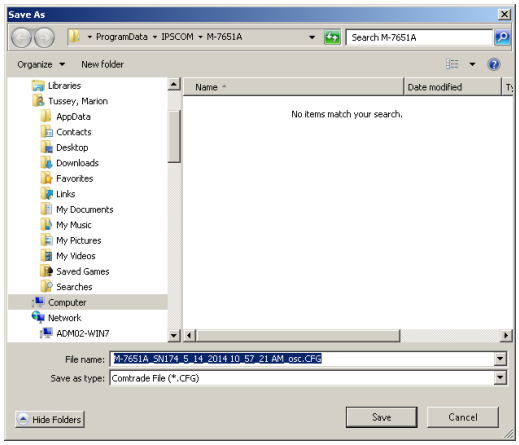


Figure 2-8 Retrieve Oscillograph Record (Save As) Dialog Screen

4. Select the desired location for the downloaded record(s). Select **Save**. IPScom will display a Download Oscillograph Record status screen (Figure 2-9).

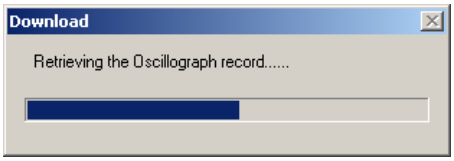


Figure 2-9 Download Oscillograph Record Status Screen

When the oscillograph record has been downloaded, IPScom will display the following confirmation screen.

Figure 2-10 Oscillograph Data Records Were Retrieved Confirmation Screen

5. Select **OK**. IPScom will return to the Main screen.

Clear Oscillograph Records from IPScom

To Clear all Oscillograph records in the relay perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Oscillograph/Clear** from the IPScom toolbar. IPScom will display a Clear Oscillograph Record confirmation screen (Figure 2-11).

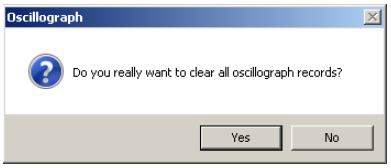


Figure 2-11 Clear Oscillograph Record Confirmation Screen

3. Select **Yes**, IPScom will display a confirmation dialog screen (Figure 2-12).

Figure 2-12 Oscillograph Records Cleared Successfully Confirmation Screen

4. Select **OK**. IPScom will return to the Main screen.

SEQUENCE OF EVENTS

Retrieve Sequence of Events Record

IPScom can be utilized to download and view the Sequence of Events (*.soe) file contents.

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Sequence of Events/Retrieve** from the IPScom toolbar. IPScom will display a Retrieve Sequence of Events Record "Save As" dialog screen (Figure 2-13).

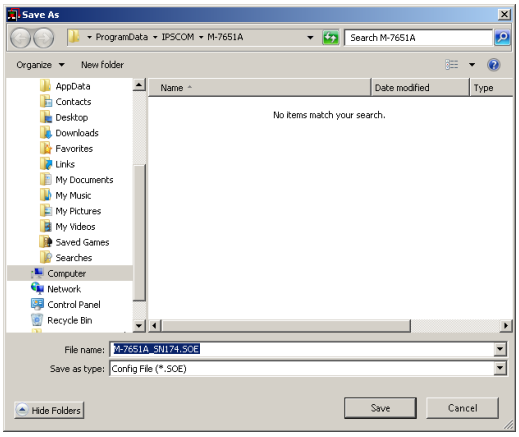


Figure 2-13 Retrieve Sequence of Events Record (Save As) Dialog Screen

3. Select a folder to save the file to and the desired file name, then select **Save**. IPScom will display a Download SOE Record status screen (Figure 2-14).

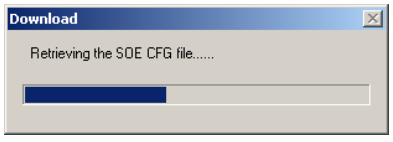


Figure 2-14 Download Sequence of Events Record Status Screen

When the Sequence of Events record has been downloaded, IPScom will briefly display a confirmation screen (Figure 2-15), followed by the Open Viewer prompt screen (Figure 2-16).

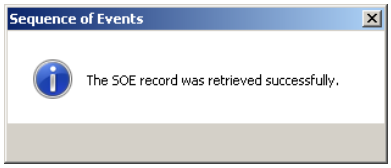


Figure 2-15 Sequence of Events Records Retrieved Successfully

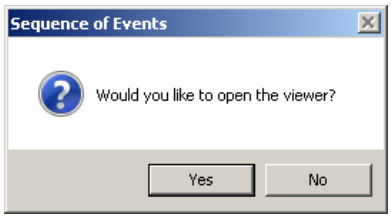


Figure 2-16 Sequence of Events Open Viewer Prompt Screen

4. Select **Yes** to open the file in the Sequence of Events Viewer. Select **No** to return to the main screen.

View Sequence of Events from IPScom

The Sequence of Events Viewer allows the user to view detailed Sequence of Events Record parameters.

■**NOTE:** Sequence of Events is monitored at a fixed period of 1 cycle.

1. Start IPScom, then select **Utility/Data Analysis/SOE Viewer/Sequence of Events Viewer** from the IPScom toolbar. IPScom will display a "Sequence of Events Viewer" dialog screen (Figure 2-17).
2. Select **Open** and navigate to the folder containing the desired Sequence of Events file(s).
3. The viewer displays all events in the selected file. Double-click any event to display the "Sequence of Events Detailed Record" (Figure 2-18) with the following captured basic parameters:

- Active Profile
- Current (A, B, C, N)
- Voltage (A, B, C, N)
- Voltage (Pos., Neg., Zero)
- Current (Pos., Neg., Zero)
- Real Power (A, B, C, 3Ph)
- Reactive Power (A, B, C, 3Ph)
- Power Factor (A, B, C, 3Ph)
- Apparent Power (A, B, C, 3Ph)
- Frequency/Frequency Change
- ITIC Events (VA, VB, VC)*
- Operation Counters
- THD/TDD
- Fault Distance/Fault Type
- Control Status
- Pickup Status
- Timeout Status
- Voltage & Current Harmonics

*A more detailed view of the ITIC data is available in the Power Quality Viewer (Figure 2-19).

■**NOTE:** Up to four Sequence of Events Detailed Record Screens can be opened at one time.

The Sequence of Events Detailed Record screen includes the following information:

- **Control Status –** Control features that were active at the time the Sequence of Event capture was initiated.
- **Pickup Status –** Pickup signal(s) that triggered the SOE Recorder.
- **Timeout Status –** Timeout signal(s) that triggered the SOE Recorder.

If a Sequence of Events record has an associated Oscillograph record, it will be highlighted in red, and the Oscillograph record will be displayed in the bottom window of the screen "Oscillograph files (File ID)". Double-click on the Oscillograph file in this window to retrieve and view the Oscillograph record.

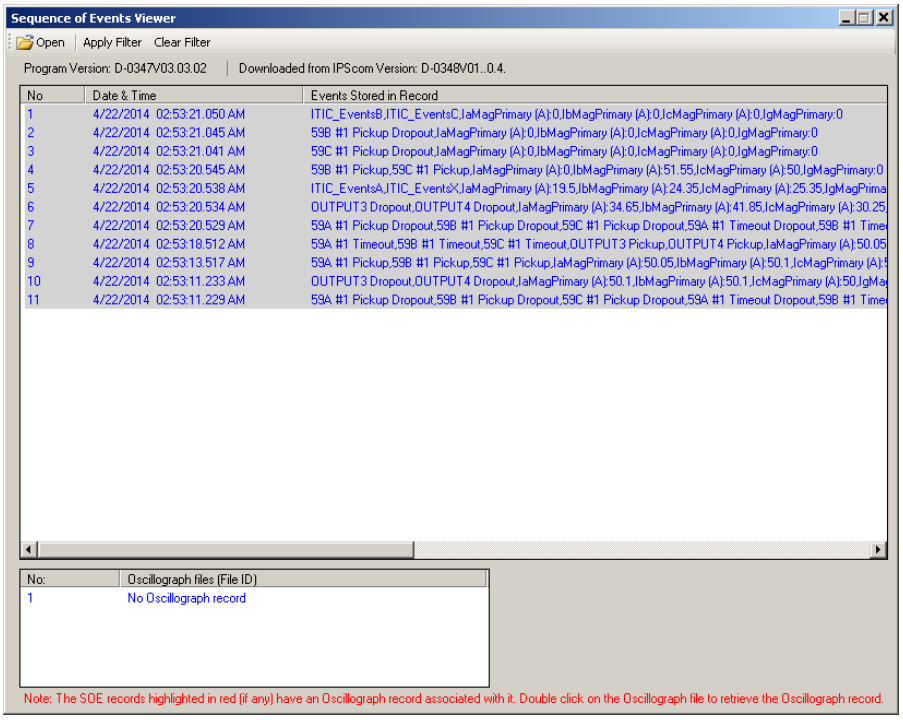


Figure 2-17 Sequence of Events Viewer Dialog Screen

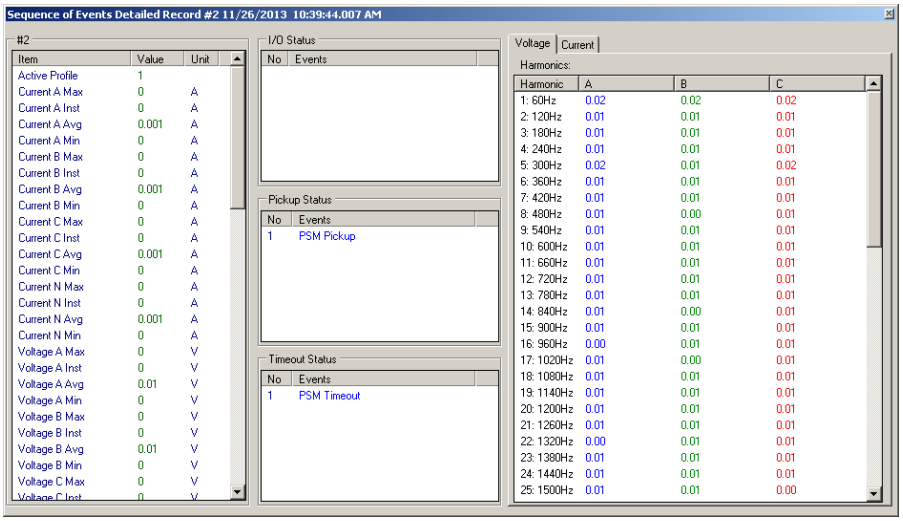


Figure 2-18 Sequence of Events Detailed Record Dialog Screen

View Power Quality Events from IPScom

The PQ Events Viewer allows the user to view detailed ITIC Event parameters from the Sequence of Events Record.

To view ITIC Events records perform the following:

1. Start IPScom, then select **Utility/Data Analysis/SOE Viewer/PQ Viewer** from the IPScom toolbar. IPScom will display the "PQ Events Viewer" dialog screen (Figure 2-19).
2. Select **Open** and navigate to the folder containing the Sequence of Events file.
3. Select the Sequence of Events record to display the captured ITIC parameters. Hovering over a plotted point will display the details of the event in the "Event Data" portion of the screen. Select the "PQ Table Form" tab to view the ITIC event parameters in a Table format (Figure 2-20).

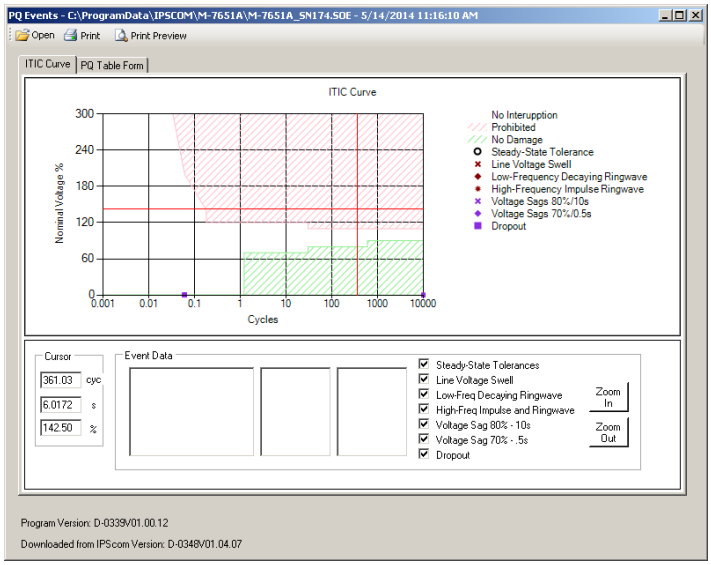


Figure 2-19 PQ Events Viewer Graphic Format Screen

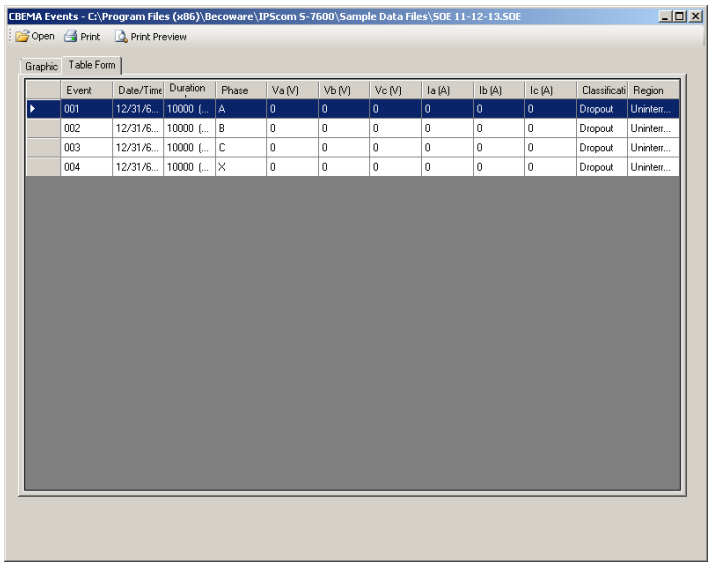


Figure 2-20 PQ Events Viewer Table Format Screen

Clear Sequence of Events Records

To Clear Sequence of Events records from the relay perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Sequence of Events/Clear** from the IPScom toolbar. IPScom will display a Clear Sequence of Events Record confirmation screen (Figure 2-21).

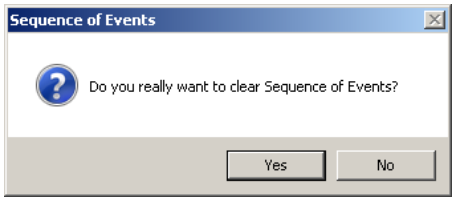


Figure 2-21 Clear Sequence of Events Record Confirmation Screen

3. Select **Yes**. IPScom will display a "Sequence of Events records cleared successfully" confirmation screen (Figure 2-22).

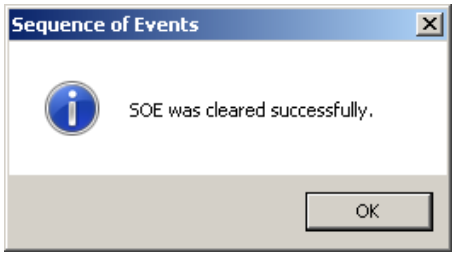


Figure 2-22 Sequence of Events Record Cleared Successfully Confirmation Screen

4. Select **OK**. IPScom will return to the Main screen.

DATA LOGGING

See "Data Logging" on page 4–21 for more information on the Data Logging feature.

Retrieve Data Logging Data from IPScom

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Data Logging/Retrieve** from the IPScom toolbar. IPScom will display the Data Log Download Option dialog screen (Figure 2-23).

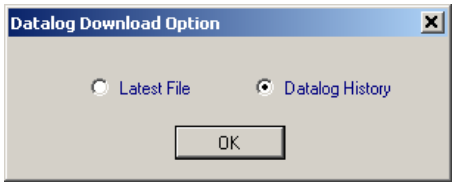


Figure 2-23 Datalog Download Options Dialog Screen

3. When **Latest File** is selected, IPScom will display the "Data Logging Record Save As" Dialog Screen.
4. Enter a filename and location for the retrieved Data Log file and select **Save**.
5. IPScom will display a download status screen followed by a confirmation screen (Figure 2-24). Select **OK**. IPScom will automatically open the file in BecoPlot.

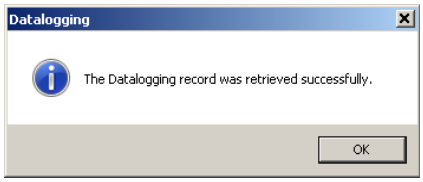


Figure 2-24 Data Log "Latest File" Retrieved Successfully Confirmation Screen

6. When **Datalog History** is selected, IPScom will display the "Datalog Range Download" Dialog Screen (Figure 2-25).

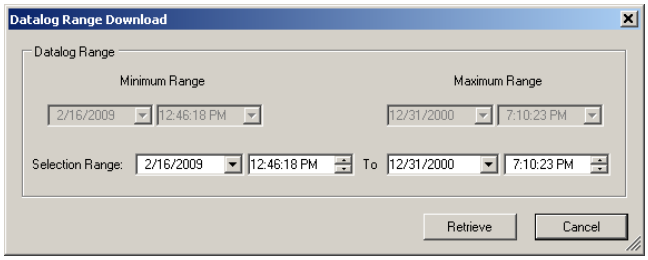


Figure 2-25 Datalog History Datalog Range Download Dialog Screen

7. Select the date range, and then select **Retrieve**.
8. IPScom will display the download status screen, followed by the "Datalogging Records Retrieved Successfully" Confirmation Screen which displays the default download location (Figure 2-26).

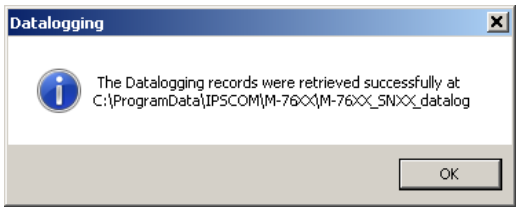


Figure 2-26 Datalogging History Records Downloaded Successfully Confirmation Screen

Clear All Data Log Records from IPScom

1. Start IPScom, then establish communications with the target relay.
2. Select **Setup/Data Logging/Clear** from the IPScom toolbar. IPScom will display a Clear Data Log Record confirmation screen (Figure 2-27).

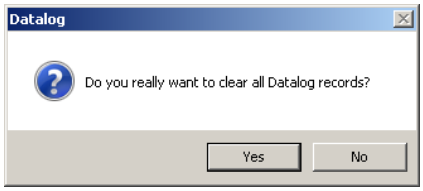


Figure 2-27 Clear All Data Log Records Confirmation Screen

3. Select **Yes**. IPScom will display a "Data Log records were cleared" confirmation screen (Figure 2-28).

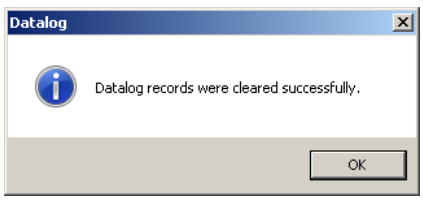
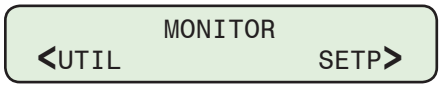


Figure 2-28 Data Log Records Cleared Successfully Confirmation Screen

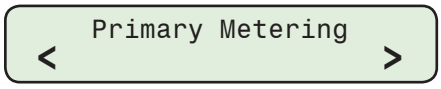
MONITOR

Accessing the HMI Monitor Screens

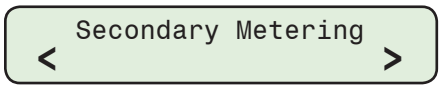
1. Press **MNTR**. The menu will advance to "MONITOR".

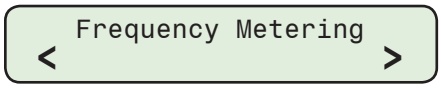


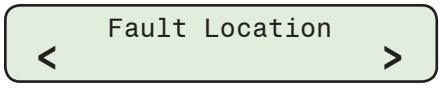
2. Press **ENT** or **CNFG** once. The unit will display the following:

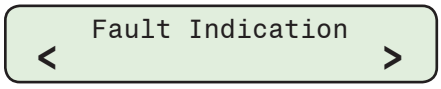


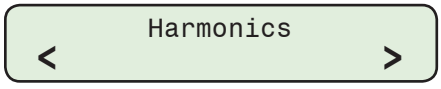
3. Press **MNTR** or **COMM** as necessary to navigate to the desired Monitor Sub-Header screen:

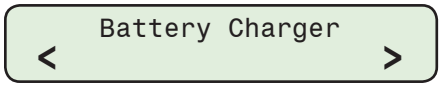












4. Press **CNFG** as necessary to view specific parameters within the selected Monitor Sub-Header as shown in the following list.

Relay Front Panel Monitor Screens

The HMI categories/parameters for Monitoring are:

PRIMARY METERING

Current and Voltages
Va, Vb, Vc, Vz1 Volts
Ia, Ib, Ic Amps
In/Ig Amps

Seq Components
V1, V2, Vo Volts
I1, I2, Io Amps

Power
Watts (A, B, C, 3 Phase)
VArs (A, B, C, 3 Phase)
VA (A, B, C, 3 Phase)

Energy Metering
KWatt Hours Forward (A, B, C)
Lagging KVAr Hours (A, B, C)
KWatt Hours Reverse (A, B, C)
Leading KVAr Hours (A, B, C)

SECONDARY METERING

Current and Voltages
– Magnitude
Va, Vb, Vc, Vz1 Volts
Ia, Ib, Ic Amps
In/Ig Amps
– Phase
Va, Vb, Vc, Vz1 Degrees
Ia, Ib, Ic Degrees
In/Ig Degrees

Seq Components
V1, V2, Vo Volts
I1,I2, Io Amps

Power and Demand
Demand Voltage (A, B, C, S)
Demand Current (A, B, C, G)
Present Watts (A, B, C)
Present VArs (A, B, C)
Present VA (A, B, C)
Present Power (3 phase)
Present Power Factor (A, B, C, 3PH)

Demand History
– Phase A, B, C
Min/Max Va (Vb, Vc)
Min/Max Ia (Ib, Ic)
Min/Max Pa (Pb, Pc)
Min/Max Qa (Qb, Qc)
Min/Max Sa (Sb, Sc)

Demand History (Cont.'d)
– Three Phase
Min/Max P
Min/Max Q
Min/Max S
Demand History Reset
– Ground/Neutral
Min/Max Vz1
Min/Max Ig

Energy Metering
KWatt Hours Forward (A, B, C)
Lagging KVAr Hours (A, B, C)
KWatt Hours Reverse (A, B, C)
Leading KVAr Hours (A, B, C)
Energy Meter Reset

FREQUENCY METERING
Frequency (Hz)
Rate of Change of Frequency (Hz/s)

FAULT LOCATION
Fault Distance (miles)
Fault Type

STATUS
Input Status
Output Status
Power Supply Voltage
Counters

FAULT INDICATION
View Fault Records

HARMONICS
Voltage % THD (A, B, C)
Current % THD (A, B, C)
Current % TDD (A, B, C)
Voltage Harmonics (A, B, C)
Current Harmonics (A, B, C)

BATTERY CHARGER
Battery Status
Battery Voltage (V)
Charging Current (A)
Pressure (if enabled)

Accessing the IPScom Monitor Screens

The Monitor sub-menu screens, when connected to a relay, display parameter values consistent with the capabilities of the communication system.

Monitor/Primary and Secondary Metering

To access the Primary or Secondary Metering parameters utilizing IPScom, select **Monitor/Primary (or Secondary) Metering** from the IPScom Main Screen drop down menu. IPScom will display the applicable Metering screen based on the Voltage Input option (Figure 2-29 or Figure 2-30) which includes Metering data for Currents, Voltages, Sequence Components, Power and Frequency. Also included is the Status of Inputs, Outputs, Virtual Inputs and Fault Distance.

■**NOTE:** When the VT Configuration is set to any Delta Connection, only three phase power metering is displayed in the Primary and Secondary Metering screens. Individual phase power metering is grayed out, and the value displayed is "0".

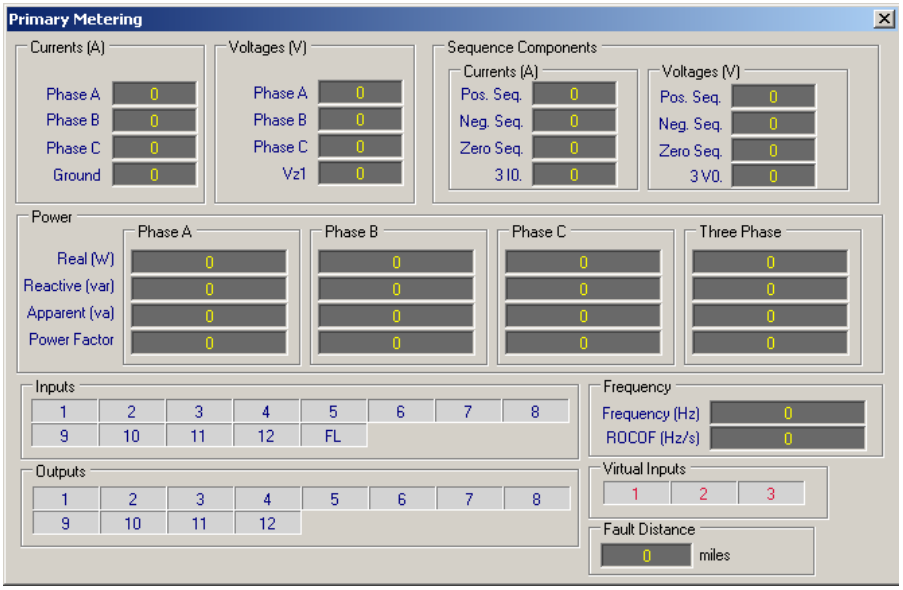


Figure 2-29 IPScom Primary Metering Screen (Voltage Input Option X4, L4, H4 or VT)

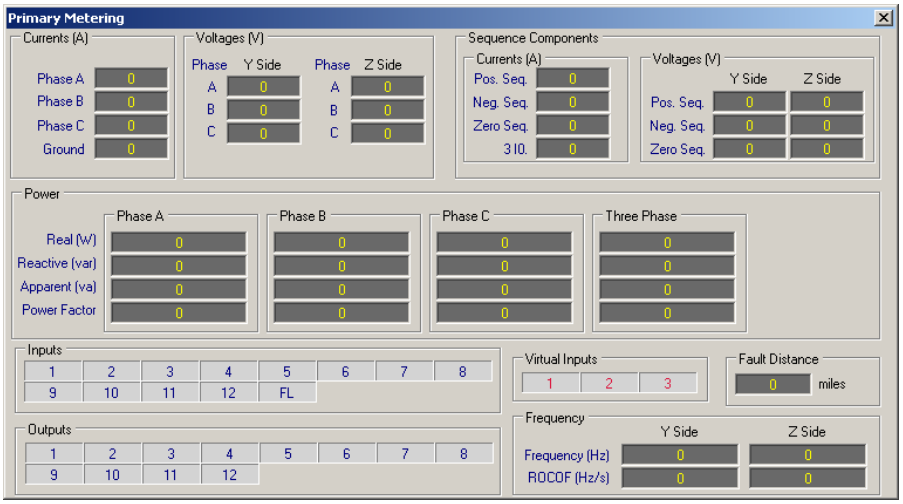


Figure 2-30 IPScom Primary Metering Screen (Voltage Input Option X6, L6 or H6)

Monitor/Function Status

Function Status Monitoring is available to the user from the IPScom Monitor/Function status drop down menu on the Main Menu Bar. The Function Status screen (Figure 2-31) presents a real-time graphic representation of the M-7651A D-PAC Protective Function pickup and trip status as well as those Inputs and Outputs that are activated.

Target – When checked, will indicate the last triggered Timeout Status. This lets the user know which function(s) operated last, prior to the normal conditions.

Reset – Resets all the latches if the conditions do not exist.

Remote Disable – This text is updated dynamically to indicate if remote operation is disabled from the front panel or through any other communication channel.

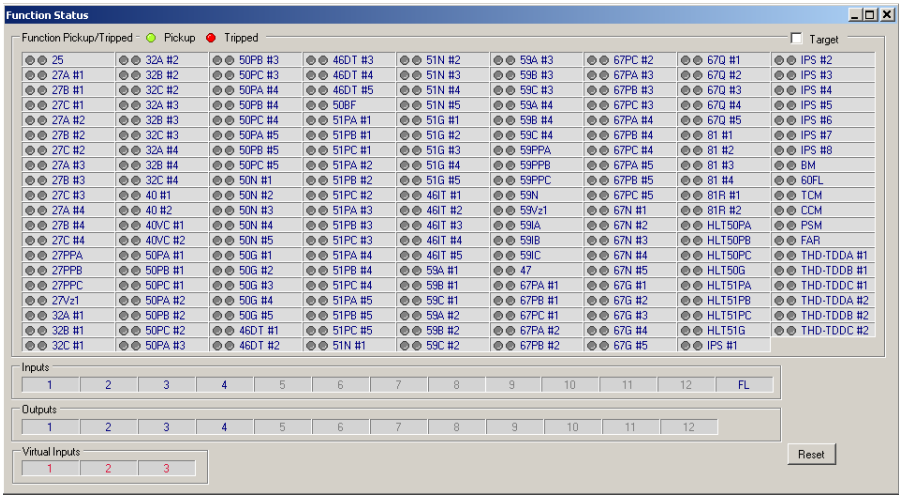


Figure 2-31 Function Status Screen

Monitor/Recloser Status Monitoring

Reclose Status Function 79 (Figure 2-32) can be monitored in real time. Breaker Status Phase A, B, and C, Reclose Settings and Reclose Status Phase A, B, and C are displayed.

- Breaker Status (Phase A, B, C)
- Settings
- Reclose Status (Phase A, B, C)
- Fault Type
- Supervision
- Reset from Lockout Timer
- Timing Status (Trips 1 through 5)

The screen contains a Breaker Status/Time Graph which displays real time Breaker Status relative to Time since a fault has occurred (Ground or Phase). Trip Time, Reclose Time, and Reset Time are displayed as a function of the Timing Option selection.

The Recloser Status screen also includes a "Refresh" Selection. The Refresh selection refreshes the "Settings" and "Reclose Status" displays to reflect the current 79 Function settings in the event that the Active Settings Profile has changed.

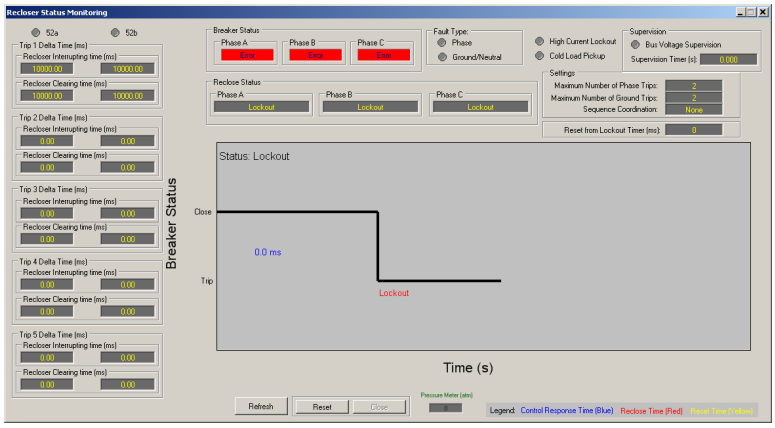


Figure 2-32 Recloser Status Monitoring Screen

Monitor/Demand Metering

To access the Demand Metering screen from IPScom, select **Monitor/Demand Metering**. IPScom will display the Demand Metering screen (Figure 2-33). The Demand Metering screen, when connected to a relay, displays parameter values consistent with the capabilities of the communication system. All Demand History and Energy Metering Values include the date and time at which each occurred.

The **Demand Interval** applies to the Demand Present and the Demand History parameters. The Demand Interval can be set to 15, 30, and 60 minutes.

The **Max Demand Load Current (I_L)** setting is an element of the Total Demand Distortion calculation and is applied when the Total Demand Distortion function is enabled.

■**NOTE:** Selecting "**UTC**" at the bottom of the screen displays the Date/Time in Universal Time Code format. Display either Primary or Secondary values using the "**Toggle**" selection.

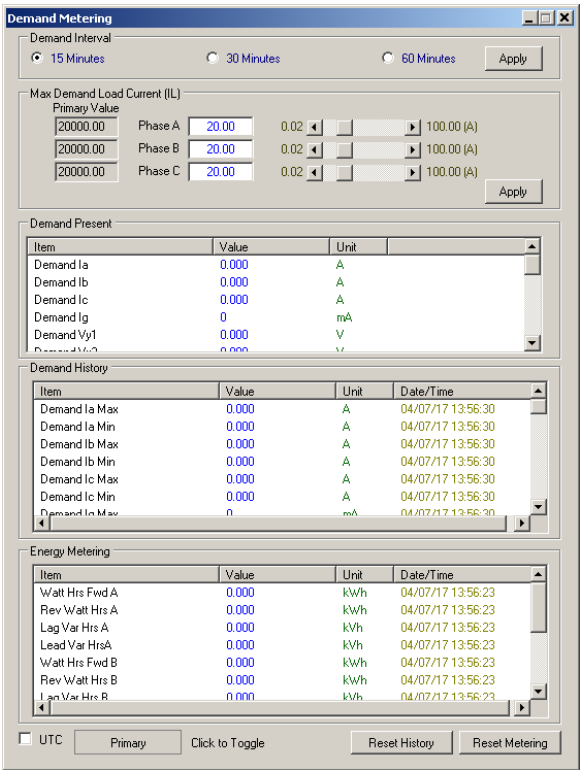


Figure 2-33 Demand Metering Screen

Monitor/Harmonics

To access the Harmonic Analysis screen from IPScom, select **Monitor/Harmonics**. IPScom will display the Harmonic Analysis screen (Figure 2-34).

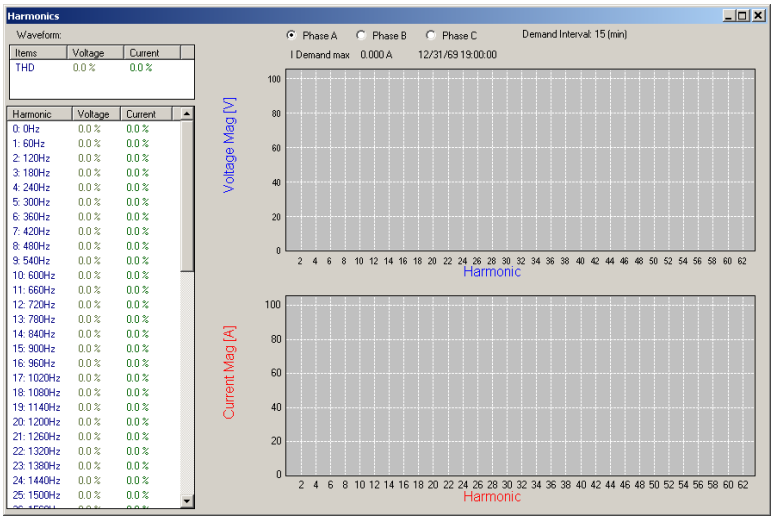


Figure 2-34 Harmonic Analysis Screen

WEB BROWSER INTERFACE

This feature allows the user to monitor the M-7651Afrom a web browser. The HTTP protocol must be enabled to use this feature. The HTTP protocol can be enabled from either the HMI (COMM/Comm Ports Security/Protocol Access/HTTP) or IPScom (Communication/Setup/Comm Port Security/Protocol Access) as shown below.

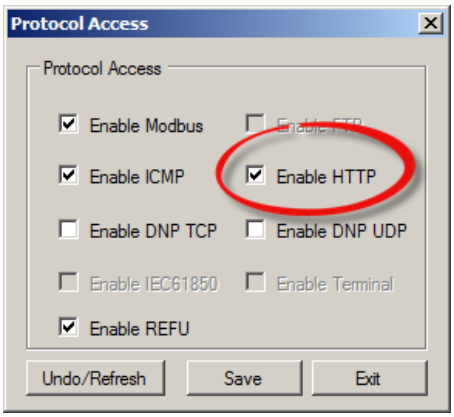


Figure 2-35 Communication, Comm Port Security, Protocol Access Dialog Screen

Accessing the M-7651A utilizing a Web Browser

Enter the IP address of the target unit to display the M-7651A landing page (Figure 2-36).

Figure 2-36 M-7651A Web Browser Landing Page

Select the "M-7679 Monitor" link from the top black toolbar to display the available monitoring selections (Figure 2-37).

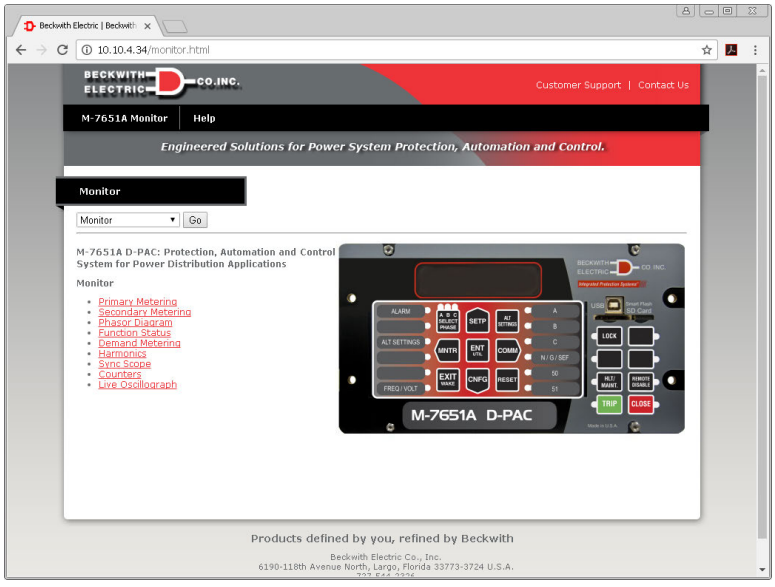


Figure 2-37 M-7651A Web Browser Monitor Page

Select the Monitoring screen to be displayed from either the red link or the dropdown menu. An example of the Primary Metering screen is shown in Figure 2-38.

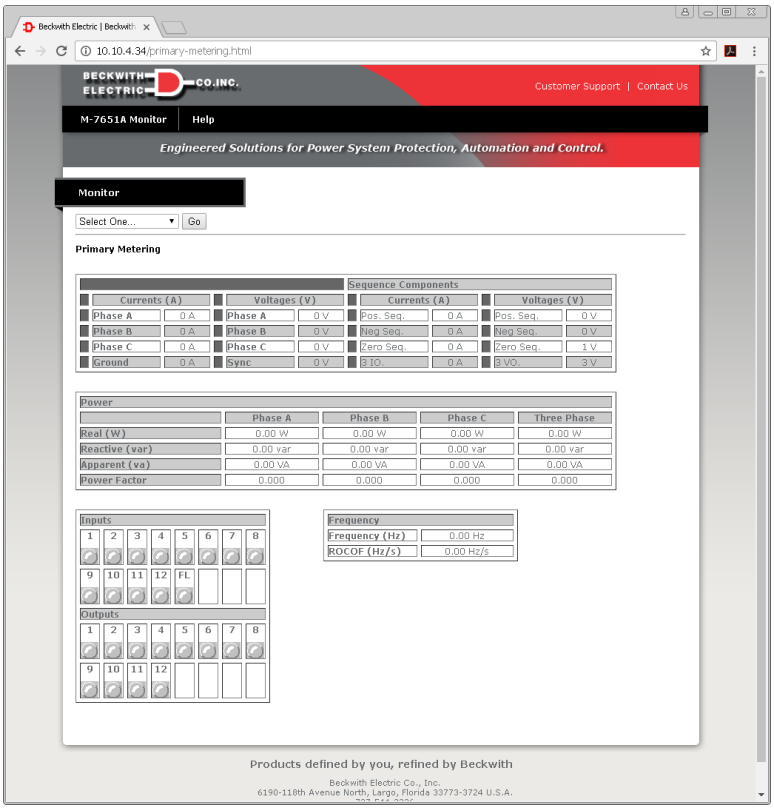


Figure 2-38 Web Browser Primary Metering Screen Example

Select the "Help" link from the top black toolbar to display Figure 2-39 which contains links to support information available on the Beckwith Electric website.

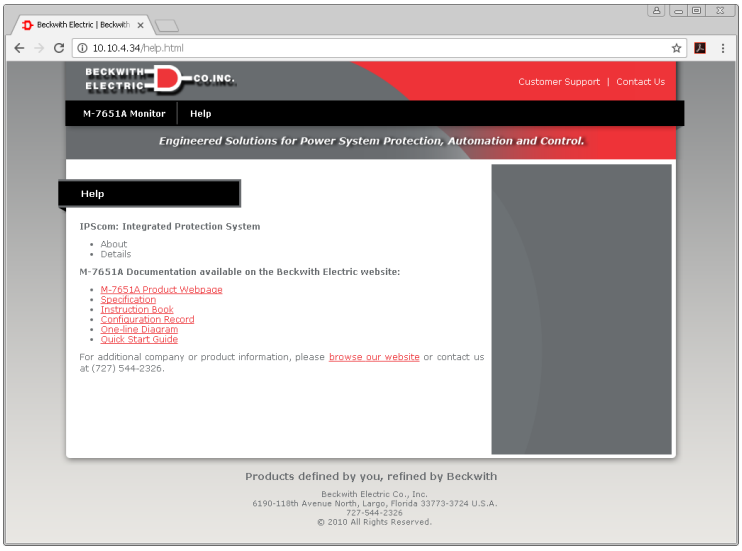


Figure 2-39 Web Browser Help Screen

REMOTE CONTROL

The Remote Control menu item located in the **Utility** dropdown menu displays the Remote Control screen (Figure 2-40). Remote Control allows the user to remotely open or close the relay. "Reset" and "Disable Hot Line Tag" commands can be initiated as well. See "Utility/ Remote Control" on page 3–52 for detailed information.

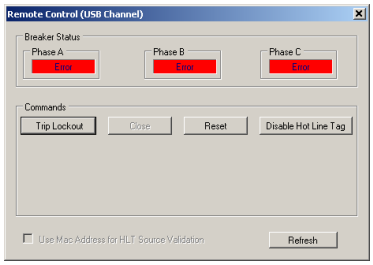


Figure 2-40 Three-Phase Ganged Remote Control Dialog Screen

Remotely Setting/Overriding Relay Outputs

■**NOTE:** Relay Outputs "Enable Remote Control" setting for the desired Output(s) must be enabled to remotely set/override the Output(s).

▲**CAUTION:** Setting or Overriding Relay Outputs remotely can adversely affect Breaker Operation.

The following operations can be performed from the IPScom "Remote Output Control" dialog screen Figure 2-41:

- Energize or De-energize Output 1 or 2
- Energize or De-energize Outputs 3 and 4 (also 5 – 12 for Expanded I/O units)
- Reset Latched Outputs 3 and 4 (also 5 – 12 for Expanded I/O units)
- Force Output Reset of all Outputs

To remotely Set or Override a Relay Output from IPScom perform the following:

5. Start IPScom, then establish communications with the target relay.
6. Select **Utility/Remote Output Control** from the IPScom toolbar. IPScom will display the Remote Output Control dialog screen (Figure 2-41).
7. Select the desired Output Contact(s) to be set/overridden.
8. Select the desired setting or override:
   - Energize
   - De-energize
   - Force Output Reset
   - Reset Latched Output

   IPScom will display a confirmation screen for the specific selection. If "Force Output Reset" was selected, then the Force Output Reset selection will change to a "Red" indication which means that all Output Contacts are de-energized. Also, the Output Contact selections will be grayed out.
9. Select **Yes** to implement the selected Setting or Override.

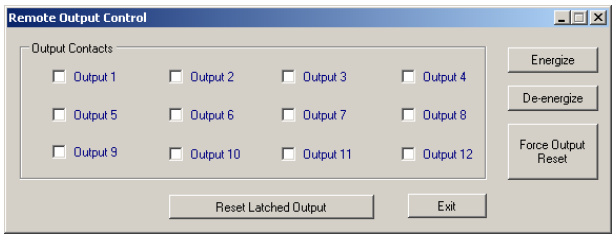


Figure 2-41 Remote Output Control Dialog Screen

SEND AN IEC 61850 CONFIGURATION FILE

To Send an IEC 61850 Configuration file proceed as follows:

1. Start the IPScom Communications Software on the PC.
2. Connect to the M-7651A relay.
3. Select **Communication/Setup/Protocol/IEC 61850/Send CID File**. IPScom will display the **Open** dialog screen with a default file extension of "*.cid".
4. Select the desired Configuration file, then select **Open**. IPScom will display the Writing File status screen (Figure 2-42) while the Configuration file is sent.

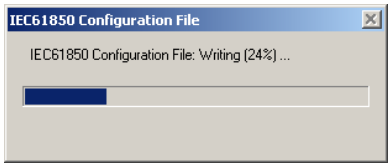


Figure 2-42 IEC Configuration File Writing Status Screen

5. When the file has been successfully sent to the relay, IPScom will display the IEC 61850 File Sent Successfully confirmation screen (Figure 2-43).

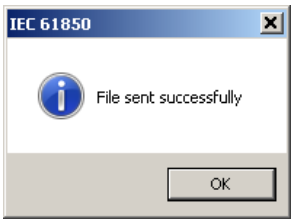


Figure 2-43 IEC Configuration File Sent Successfully Confirmation

Retrieve an IEC 61850 Configuration File

To Retrieve an IEC 61850 Configuration file proceed as follows:

1. Start the IPScom Communications Software on the PC.
2. Connect to the M-7651A relay.
3. Select **Communication/Setup/Protocol/IEC 61850/Retrieve CID File**. IPScom will briefly display a "Retrieving Directory" screen and then display the "Save As" dialog screen with a default file extension of "*.cid".
4. Name the Configuration file, then select **Save**. IPScom will display the "Download" status screen (Figure 2-44) while the Configuration file is transferred.

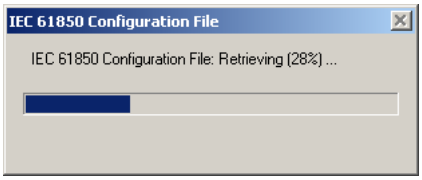


Figure 2-44 IEC Configuration File Download Status

5. When the file has been successfully downloaded from the relay, IPScom will display the File Retrieved Successfully confirmation screen (Figure 2-45).

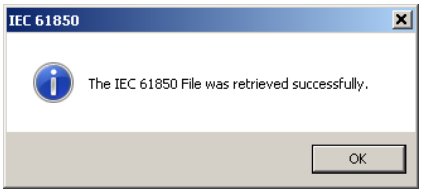
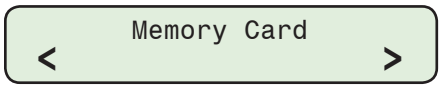


Figure 2-45 IEC Configuration File Retrieved Successfully Confirmation

SMART FLASH SD CARD

Accessing the Smart Flash SD Card Screens (HMI)

1. Verify that a (FAT) formatted Smart Flash SD Card is inserted into the Smart Flash SD Card slot.
2. Press **COMM**. The menu will advance directly to "Memory Card".

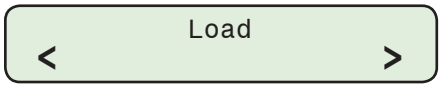


Depending on User Permissions, the Memory Card can now be utilized to:

- Load and Save Settings
- Save Datalog/Datalog Range
- Save Sequence of Events
- Save Oscillograph
- Save Trip Sequence Events
- Save Metering Data
- Clone Save/Clone Load
- Update Firmware
- Update Bootloader
- Record Datalog directly to SD Card
- Record IPsec Log directly to SD Card (Ethernet menu)

Loading Settings Files from a Smart Flash SD Card

A user with proper Access Permission can load Setpoints and Clone files from the "Load" submenu:



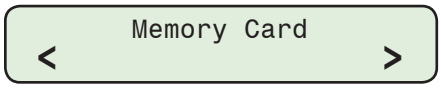
Loading Setpoints from a Smart Flash SD Card

The Setpoints file (*.spf) consists of the specific setpoint settings for ALL 8 Profiles. Loading a setpoint file from an SD Card overwrites the existing setpoint file. Care must be taken to ensure the correct file has been selected for loading onto the relay.

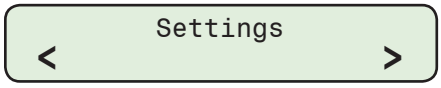
A Control File (*.sup) consists of the setpoints file as well as the Nameplate settings, the Front Panel setup file and the IPSLogic file. The user may choose specific elements of the (*.sup) file to load onto the unit. The "Load Setpoints" series of screens prompt the user to select the elements of the (*.sup) file to be loaded.

▲CAUTION: Setpoint changes are immediately acted upon by the relay and may cause undesired relay operation.

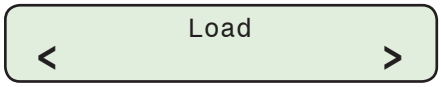
1. Insert the Smart Flash SD Card (that includes the setpoints file) into the relay as previously described.
2. Press **COMM**. The menu will advance directly to "Memory Card".



3. Press **ENT** or **CNFG** once. The unit will display the following:



4. Press **MNTR** or **COMM** as necessary until "Load" is displayed:



5. Press **CNFG** as necessary to navigate to the "Load Setpoints" menu item.

```
Load Setpoints
Press ENT to begin
```

6. Press **ENT**. The unit will display the following sequence of screens, which allow the user to select those elements of the (*.sup) file to be loaded:
   - Load only the Control File (*.sup) WITHOUT Nameplate settings
   - Load the entire (*.sup) file
   - Load only the Setpoints file WITHOUT Nameplate settings
   - Load only the IPSLogic file

```
SUP, Name Plate excl?
YES
```

```
Entire SUP?
YES
```

```
SPF, Name Plate excl?
YES
```

```
IPS Logic only?
YES
```

   Select **YES** at any screen to proceed with the selection. Select **NO** to advance to the next selection screen.

7. The unit will prompt the user to select the file to be loaded.

■ **NOTE:** If an arrow is displayed on either end of the bottom display line, additional setpoint files are available for selection.

```
     M7651A_→1.sup
← 05/10/2017   15:21 →
```

8. Utilize **MNTR** or **COMM** to select the desired file (*.sup).

9. The unit will display the following sequence of screens:

```
Load Setpoints
Loading file...
```

```
Load Setpoints
Processing file...
```

10. The unit will then display the following, which allows the user to perform a configuration match check to verify the compatibility of the Setpoints file with the unit configuration. The user may also load the file without the configuration match check. Select **YES** or **NO** as desired, then press **ENT**.

```
Check Config Match?
YES
```

    a. If **YES** was selected, the unit will perform an internal configuration match check. If the relay configuration matches the file, the unit will proceed with the Load Setpoints process.

    b. If **NO** was selected, the unit will load the file without performing a configuration match.

11. When the Load Setpoints process proceeds without errors, the unit will display the following sequence of screens:

```
Load Setpoints
Processing file...
```

```
Load Setpoints
File loaded
```

12. If **YES** was selected and the the relay configuration does not match the file, the unit will display one or more of the following error messages and the Load Setpoints process will cease:

```
Frequency Mismatch
```

```
Phase CT Mismatch
```

```
Gnd CT Mismatch
```

```
LEA Option Mismatch
```

■**NOTE:** During the Load Setpoints process (with or without "Check Config Match" selected, the following error messages may be displayed when applicable:

Setpoints file loaded with a setpoint out of range:

```
Loaded, range error
```

Setpoints file loaded which has generated an eeprom error:

```
Loaded, eeprom error
```

Setpoints file loaded, but the file is corrupt:

```
Loaded signature error
```

SD Card error, Setpoints file cannot be read:

```
File read error
```

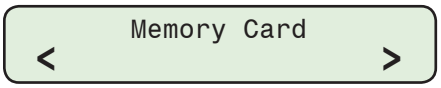
Press **ENT** or **EXIT** to return to the "Load Setpoints" screen.

Clone Load from a Smart Flash SD Card

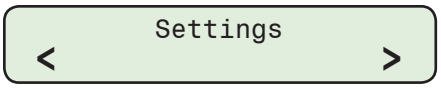
The Clone Load feature provides the user with the capability to load a relay Clone file with all the cloned relay's settings to another relay with the exception of the serial number.

▲**CAUTION:** Loading a Clone file that was created from a different firmware version may cause unintended relay operation. Contact Beckwith Electric to determine Clone file compatibility.

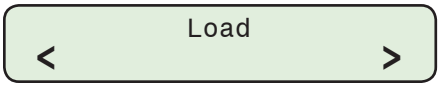
1. Insert the Smart Flash SD Card (that includes the Clone file) into the relay as previously described.
2. Press **COMM**. The menu will advance directly to "Memory Card".



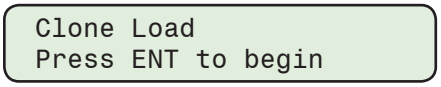
3. Press **ENT** or **CNFG** once. The unit will display the following:



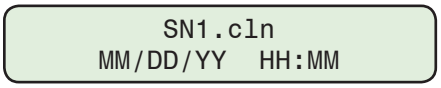
4. Press **MNTR** or **COMM** as necessary until "Load" is displayed:



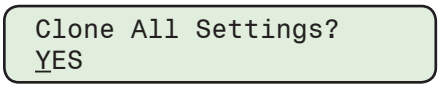
5. Press **CNFG** as necessary to navigate to the "Clone Load" menu item.



6. Press **ENT**. The unit will display the following:

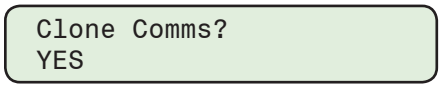


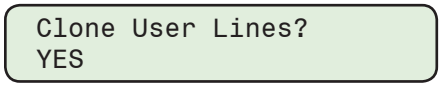
7. Utilize **MNTR** or **COMM** to navigate to the the desired Clone file.
8. Press **ENT**. The unit will display the following:



The user may choose to clone **ALL** settings, including Communications and User Lines; or to clone **ONLY** the Communications or User Lines settings.

a. To Clone **ALL** settings including Communications and User Lines, select **YES**.
b. To Clone **ONLY** Communications or User Lines settings, select **NO**. The following sequence of screens will be displayed:





c. Select **YES** or **NO** as desired.

9. Press **ENT**. The unit will display the following, which allows the user to perform a configuration match check which verifies the compatibility of the clone file with the unit configuration. The user may also load the Clone file without the configuration match check. Select **YES** or **NO** as desired, then press **ENT**.

```
Check Config Match?
YES
```

   a. If **YES** was selected, the unit will perform an internal configuration match check. If the relay configuration matches the clone file, the unit will proceed with the Clone Load process.

   b. If **NO** was selected, the unit will load the Clone file without performing a configuration match.

10. When the Clone Load process proceeds without errors, the unit will display the following sequence of screens:

```
Clone Load
Saving file...
```

```
Clone Load
File saved
```

11. If **YES** was selected and the the relay configuration does not match the clone file, the unit will display one or more of the following error messages and the Clone Load process will cease:

```
Frequency Mismatch
```

```
Phase CT Mismatch
```

```
Gnd CT Mismatch
```

```
LEA Option Mismatch
```

■ **NOTE:** During the Clone Load process (with or without the "Check Config Match" selected, the following error messages may be displayed when applicable:

Clone file loaded with a setpoint out of range:

```
Loaded, range error
```

Clone file loaded which has generated an eeprom error:

```
Loaded, eeprom error
```

Clone file loaded, but the file is corrupt:

```
Loaded signature error
```

SD Card error, clone file cannot be read:

```
File read error
```

Press **ENT** or **EXIT** to return to the "Clone Load" screen.

Saving Settings Files to a Smart Flash SD Card

A user with proper Access Permission can save Settings and Clone files from the "Settings" submenu:

```
        Settings
<                    >
```

Saving Settings Files to a Smart Flash SD Card

This selection saves the relay's entire *.SUP file to the SD Card. This *.SUP file consists of the setpoint settings for ALL 8 Profiles, and also includes Nameplate settings, the Front Panel setup file and the IPSLogic file. Saving the relay setpoint file to an SD Card allows the user to open the saved file in IPScom and then edit specific profiles while retaining any existing setpoint information for the profiles which are NOT changing. This edited file can then be saved onto an SD Card and reloaded onto the relay. Setpoint changes are immediately acted on by the relay and may cause undesired relay operation.

1. Insert the target Smart Flash SD Card (that has adequate space available) into the relay as previously described.

2. Press **COMM**. The menu will advance directly to "Memory Card".

```
      Memory Card
<                    >
```

3. Press **ENT** or **CNFG** once. The unit will display the following:

```
        Settings
<                    >
```

4. Press **CNFG** as necessary to navigate to the "Save Settings" menu item.

```
Save Settings
Press ENT to begin
```

5. Press **ENT**. The unit will prompt for a file name to be entered.

```
Enter file name:
m7651A
```

6. Utilize the arrow pushbuttons to enter the desired file name.

7. Press **ENT**. The unit will display the following sequence of screens:

```
Save Settings
Saving file...
```

```
Save Settings
File saved
```

8. Press **ENT** or **EXIT** to return to the "Save Settings" screen.

Clone Save to a Smart Flash SD Card

The Clone Save feature provides the user with the capability to save all of a relay's settings to a Smart Flash SD Card with the exception of the relay's serial number. The steps for performing a **Clone Save** are similar to the "Save Settings" steps.

Firmware and Bootloader Update from a Smart Flash SD Card

A user with proper Access Permission can update the unit Firmware and Bootloader files from the "Firmware" submenu:

```
        Firmware
<                   >
```

Firmware Update from a Smart Flash SD Card

1. Insert the Smart Flash SD Card (that contains the firmware update file) into the relay as previously described.

2. Press **COMM**. The menu will advance directly to "Memory Card".

```
      Memory Card
<                   >
```

3. Press **ENT** or **CNFG** once. The unit will display the following:

```
        Settings
<                   >
```

4. Press **MNTR** or **COMM** as necessary until "Firmware" is displayed:

```
        Firmware
<                   >
```

5. Press **CNFG** as necessary to navigate to the "Firmware Update" menu item.

```
Firmware Update
Press ENT to begin
```

6. Press **ENT**. The unit will display the following sequence of screens:

```
Firmware Update
Loading file...
```

```
Update Process
In Progress...
```

```
Updating Firmware
Please wait...
```

```
ATTENTION! Rebooting
in 29 seconds
```

The unit display will "countdown" to reboot and then display the initialization screens.

After a firmware update the relay setpoints and configuration are unaffected. IPScom communication with the relay will need to be reestablished.

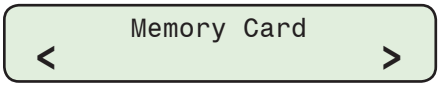
Bootloader Update from a Smart Flash SD Card

The Bootloader is a program that runs self-tests and then loads the main application firmware on the M-7651A D-PAC. Besides loading the main application firmware and performing self-tests when booting up, the bootloader program will take over during boot up when there is no valid application firmware found and also when forced to run by a special HMI interface command. The Bootloader does not have any relay protective functionalities, only communication and local HMI functionalities.

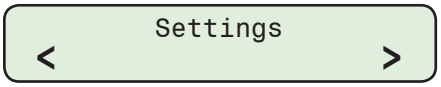
To update the Bootloader from a Smart Flash SD Card proceed as follows:

1. Insert the Smart Flash SD Card (that includes the Bootloader Update file) into the relay as previously described.

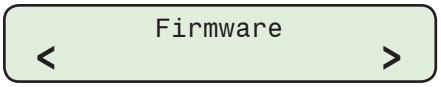
2. Press **COMM**. The menu will advance directly to "Memory Card".



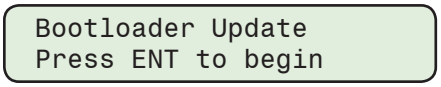
3. Press **ENT** or **CNFG** once. The unit will display the following:



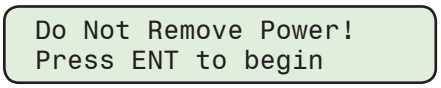
4. Press **MNTR** or **COMM** as necessary until "Firmware" is displayed:



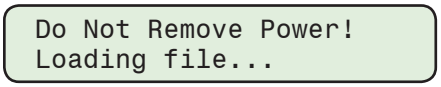
5. Press **CNFG** as necessary to navigate to the "Bootloader Update" menu item.

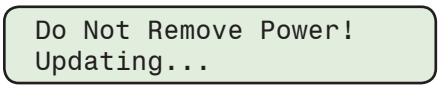


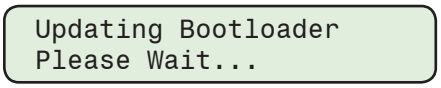
6. Press **ENT**. The unit will display the following:

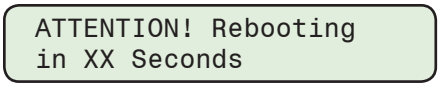


7. Press **ENT**. The unit will display the following sequence of screens:





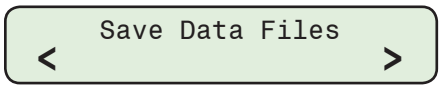




After 30 seconds the unit will reboot with the new bootloader file.

Saving Data Files to a Smart Flash SD Card

A user with proper Access Permission can save Data Files from the "Save Data Files" submenu:

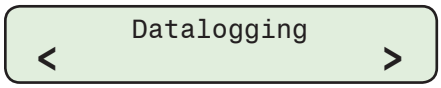


The following data files are available to be saved onto an SD Card:

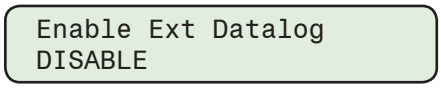
- Datalog/Datalog Range
- Sequence of Events Record
- SOE Record Range
- Oscillograph
- Metering Data
- Trip Sequence Event Record

Enable External Datalog Recording to a Smart Flash SD Card

A user with proper Access Permission can enable External Datalog Recording from the "Datalogging" submenu:



The Datalog may be recorded directly onto an inserted SD Card, rather than stored in the relay's internal memory. This feature is disabled by default, select "Enable Ext Datalog" from the Datalogging submenu to enable this feature.

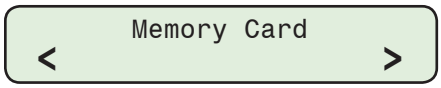


Saving IPsec Log Directly to a Smart Flash SD Card

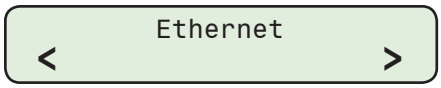
The IPsec Log may be recorded in the relay's internal memory or directly onto an inserted SD Card. This feature is located in the HMI Communications/Ethernet menu.

1. Insert the target Smart Flash SD Card (that has adequate space available) into the relay as previously described.

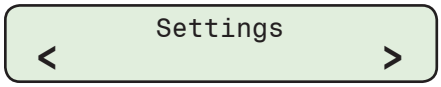
2. Press **COMM**. The menu will advance directly to "Memory Card".



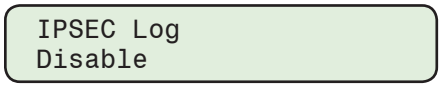
3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.



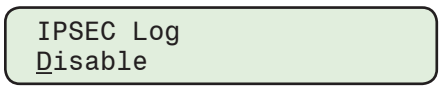
4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **CNFG** as necessary to navigate to the "IPSEC Log" menu item.



6. Press **ENT**. The unit will display the following:



7. Utilize the arrow pushbuttons to select "Memory" or "SDcard":
   - Memory – enables the IPsec Log and records the log in the relay's internal memory.
   - SDcard – enables the IPsec Log and records the log directly onto the inserted SD Card.
8. Press **ENT**. The unit will display the selection:

```
IPSEC Log
SDcard
```

Formatting an SD Card in FAT32

▲**CAUTION:** The contents of the SD Card will be erased when performing this procedure.

1. Select the computer (or My Computer) from the Windows® "Start" menu.
2. Right click on the SD Card icon and select Format.
3. Select "FAT32" in the File Format box and check "Quick Format" in the Format Options.
4. Click OK. The SD Card will be formatted and Windows will prompt when completed.

SD Card Key Generator

The SD Card Key Generator feature allows a User Name and Password to be saved to an SD Card. The SD Card with Key Generated User Name and Password can be inserted into the SD Card slot on the unit and all security privileges (from the HMI) will be available to the user.

1. Start IPScom.
2. Select **Utility/Cybersecurity/SD Card Key Generator**. IPScom will display the "SD Card Key Generator" dialog screen (Figure 2-46).

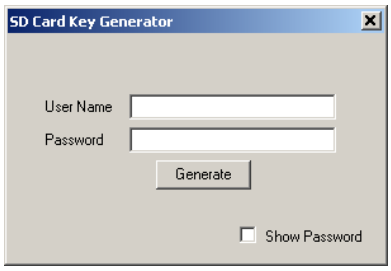


Figure 2-46 SD Card Key Generator Dialog Screen

3. Enter the desired User Name and Password.
4. Select **Generate**. IPScom will display the "Save SD Key" dialog screen (Figure 2-47).

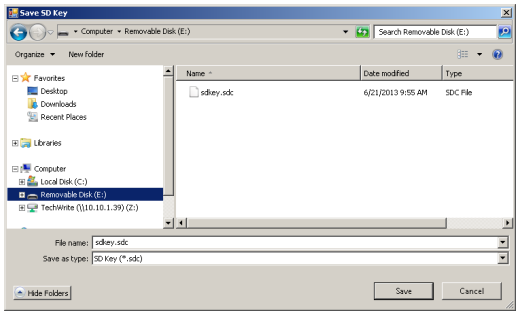


Figure 2-47 Save SD Key Dialog Screen

■**NOTE:** The file name cannot be changed. It must be "sdkey.sdc".

5. Select the location of the SD Card, then select **Save**. IPScom will briefly display the "SD Card Key Saved" confirmation screen (Figure 2-48) and then return to the main screen.

Figure 2-48 SD Card Key Saved Confirmation Screen

E-MAIL SUPPORT FROM IPSCOM

When connected to a relay, the **E-Mail Support** feature of IPScom allows the user to easily generate and send an E-mail request for technical support that contains all the pertinent data files associated with the technical support issue to support@beckwithelectric.com. The feature is available from the **Help/E-Mail Support** menu or by selecting the "**@**" icon in the Quick Access toolbar.

The following permissions are required to access the E-mail Support feature:

- View Data
- View Setpoints
- Read Files
- View Configuration
- Manage Users
- View Audit Log

To generate a Technical Support E-Mail request perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Help/E-Mail Support** from the IPScom toolbar. IPScom will display an "E-mail Support Do Not Disconnect" confirmation screen (Figure 2-49).

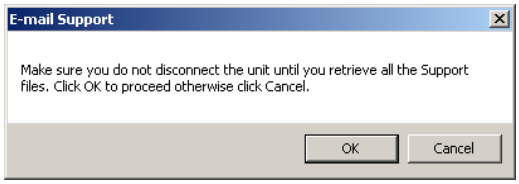


Figure 2-49 E-mail Support Do Not Disconnect Confirmation Screen

3. Select **OK**. IPScom will display a series of Download Status screens as it retrieves the Control (*.sup) file. IPScom will then display a confirmation screen (Figure 2-50).

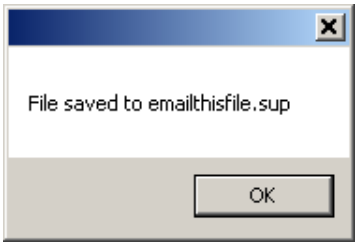


Figure 2-50 E-Mail Support File Saved Confirmation Screen

4. Select **OK**. IPScom will display a series of Download Status screens (Figure 2-51) as it retrieves the following files:
   - Audit Log.bkp
   - Description.txt
   - Details.txt
   - DNP.xml
   - ErrorFile.log
   - Errorlog.txt
   - Msglog.mlg
   - Users.bin

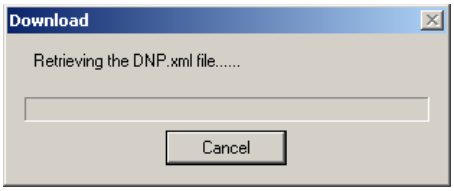


Figure 2-51 E-mail Support Files Download Status Screen

When the Support Files download is complete IPScom will display the "User Information" dialog screen (Figure 2-52).

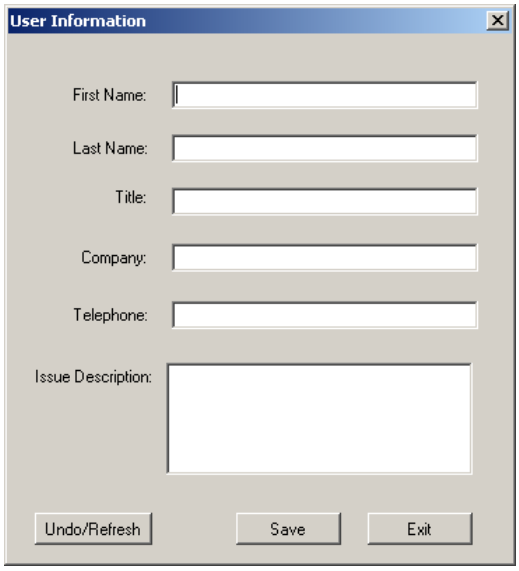


Figure 2-52 E-mail Support User Information Dialog Screen

■NOTE: Supplying User Information, though recommended, is not required to use the E-mail Support feature.

- Enter the User Information and a brief description of the support issue, then select **Save** to create a "Description.txt" file which will be included with the downloaded support files.

IPScom will create a "M-7651A D-PAC Support Files" folder on the desktop and then display the "E-mail Support Files Downloaded" confirmation screen (Figure 2-53). Any errors during the retrieve of the support files are logged into a "Errorlog.txt" file and the file is included in this folder.

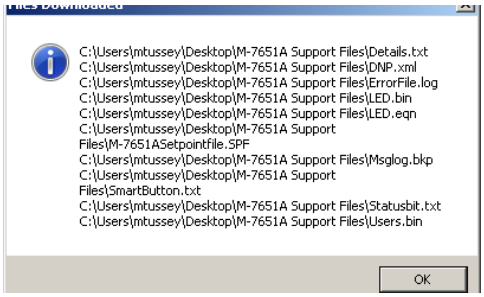


Figure 2-53 E-mail Support Files Downloaded Confirmation Screen

5. Select **OK**.

   If Microsoft® Outlook® is the default E-mail program, the files are automatically attached to a New E-mail (Figure 2-54).

   If Outlook is not the default E-mail program, IPScom will display a message screen prompting the user to send the support files located in the "M-7651A D-PAC Support Files" folder on the desktop to support@beckwithelectric.com.

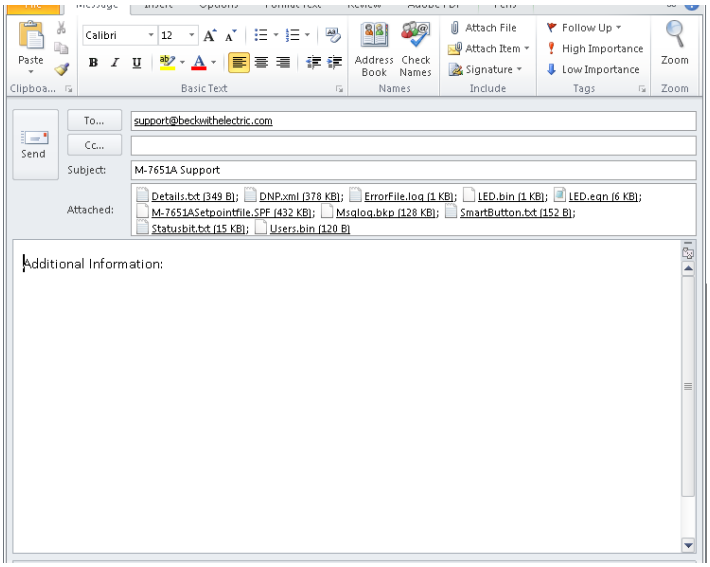


Figure 2-54 E-mail Support with Outlook Screen

COMPARING SETPOINT FILES

Comparing Setpoint Files does not require IPScom to be connected to a relay as long as the files to be compared are present on the PC. To compare two setpoint files proceed as follows:

1. Start IPScom.
2. From the IPScom menu bar select **File/Compare** and select either ".sup Files" or for legacy setpoint files, select ".spf Files".

   IPScom will display an "Open – File to Edit or Both Files" dialog screen with a default file extension of either ".sup" or ".spf".
3. Navigate to the desired "File to Edit or Both Files" location.
4. If the files to be compared are located in the same directory, both files may be selected and opened in one step. Select the desired file(s) and then select Open. If only one file was selected, IPScom will display an "Open – Reference File or Older File" dialog screen with a default file extension of either ".sup" or ".spf".
5. Navigate to the desired Reference File location.
6. Select the desired Reference File and then select Open. IPScom will perform a comparison of the selected files and display the results (Figure 2-55).

The IPScom File Compare results dialog screen includes the following features:

- Print/Print Preview
- Edit the newer file settings from the File Compare dialog screen by selecting the feature header hyperlink to display the settings screen. Changes may be saved into the newer Setpoint File.
- Save – allows any changes to be saved into the newer Control File or legacy Setpoint File.
- Options/Show if Equal – allows the user to also display those setting hyperlinks that are the same in both files.

- Options/Clone Next Function Clicked – clones the selected function (by clicking on the function header) from the "Reference" file to the "Edit" file. System settings and Communication settings cannot be cloned.
- Options/Clone Profiles and Functions – clones ALL Setpoint settings from the "Reference" file to the "Edit" file. System settings and Communication settings cannot be cloned.

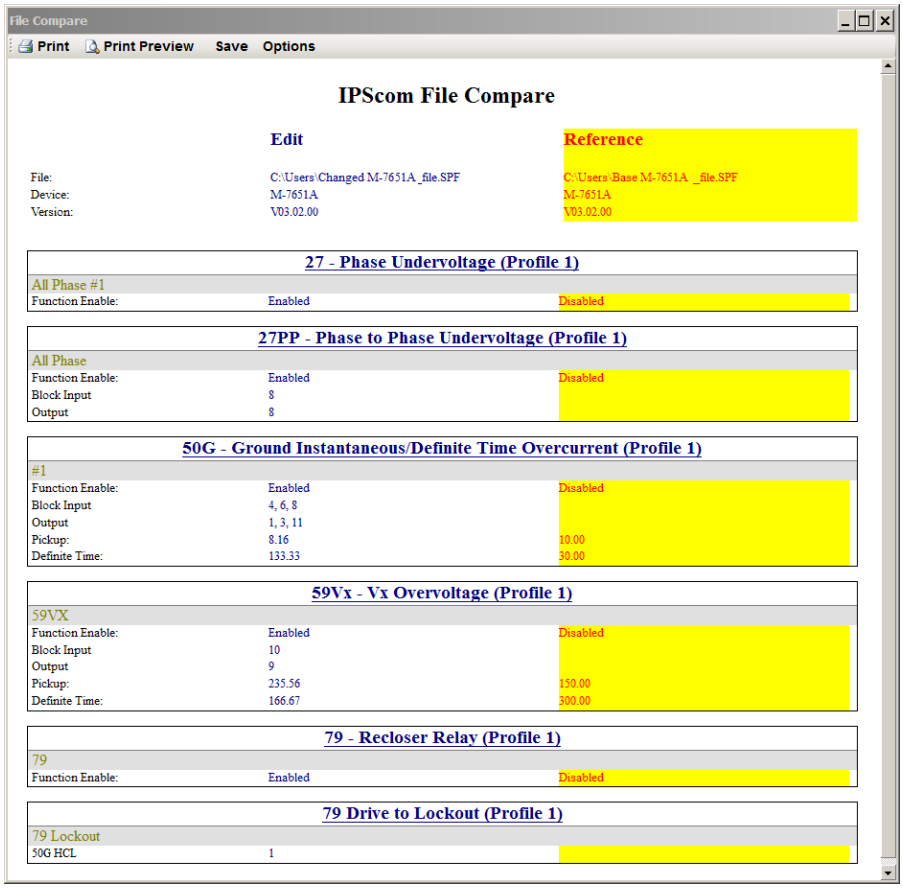


Figure 2-55 IPScom Setpoint File Compare Results Dialog Screen

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3 IPScom

3.0 Availability 3–1

3.1 Hardware Requirements 3–1

3.2 Installing IPScom 3–2

3.3 Communications Using Direct USB Connection 3–4

3.4 TIA-232 and TIA-485 Communications 3–5

3.5 Ethernet Communications 3–6

3.6 Overview of Operation 3–8

3.7 BecoPlot Analysis Software 3–65

■ **CYBER SECURITY NOTE:**
When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

This chapter is designed for the person or group responsible for the operation and setup of the M-7651A D-PAC. The S-7600 IPScom Communications Software can be used to successfully communicate system settings and operational commands to the M-7651A D-PAC as well as access the extensive monitoring and status reporting features. This chapter provides a general overview of each IPScom menu selection and command in the same order as they are displayed in the software program. Those IPScom features and functions that are covered in other sections of this Instruction Book will be noted and referenced.

3.0 Availability

IPScom S-7600 Communications Software is available on CD-ROM or from www.beckwithelectric.com. Also included on the CD-ROM is the companion Instruction Book in *.pdf format.

3.1 Hardware Requirements

IPScom will run on any computer that provides at least the following:

- Windows 7® or Windows 10®
- One USB (serial) port

Hardware Required for Direct USB (Serial) Communication

To use IPScom to communicate with a Beckwith Electric M-7651A D-PAC System using a direct USB (serial) connection, a USB cable is required.

3.2 Installing IPScom

The IPScom S-7600 installation program has been written to overwrite previous versions of IPScom. IPScom runs on Windows 7 or Windows 10 operating system. Familiarity with Windows® is important in using IPScom.

IPScom will be installed on the host PC's hard disk. While it does not require special installation procedures, an installation utility has been provided to make the process easier.

■**NOTE:** The installer must have Administrator rights on the computer that IPScom is being installed on.

Digital Signature

For enhanced Cyber Security and to be fully NERC CIP compliant, the IPScom installation program file (.exe) is digitally signed. This verification ensures that IPScom is signed by Beckwith Electric Co., Inc. Any changes to the software once it has been signed will invalidate the digital signature.

To verify the digital signature, access the "Properties" window by right-clicking the (.exe) file. If the version is signed, the Properties window will display an additional tab as shown in Figure 3-1. If the version is unsigned, the Properties window will be similar to Figure 3-2.

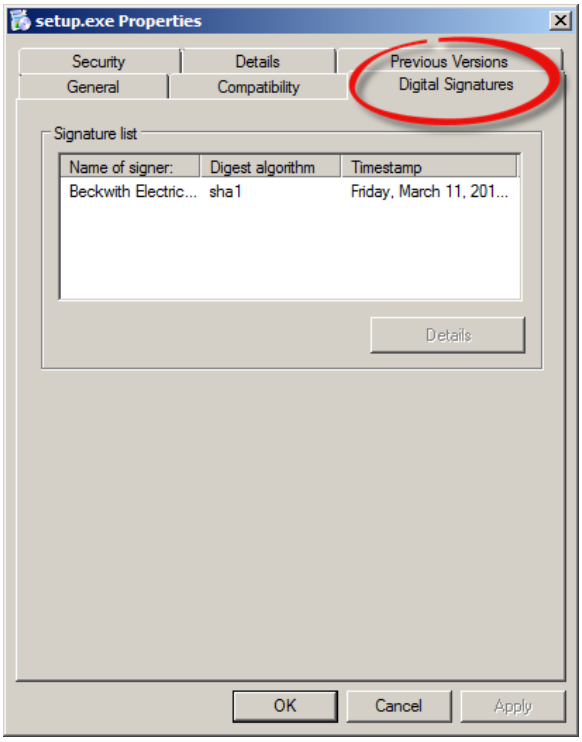


Figure 3-1 File "Properties" Digital Signature Tab – Signed Installation Program

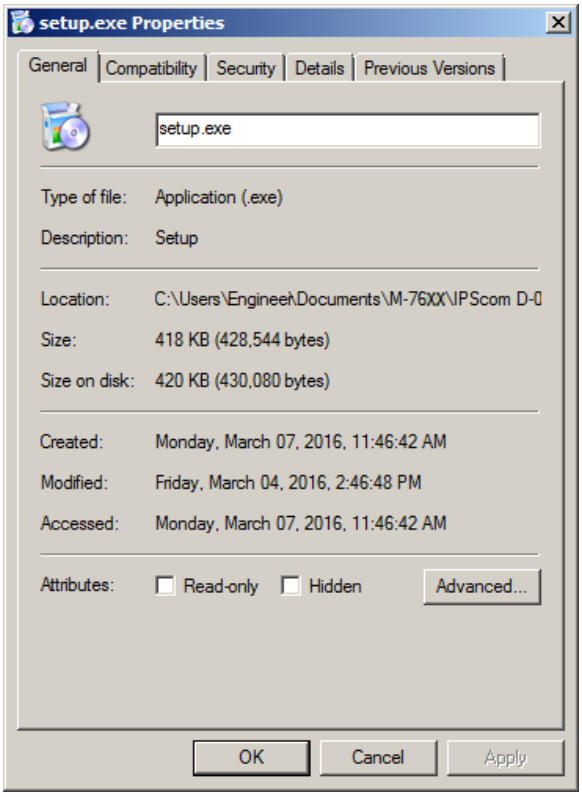


Figure 3-2 File "Properties" Unsigned Installation Program

To install IPScom:

1. Insert the IPScom software into your CD-ROM drive.
2. Select **Run** from the "Start Menu".
3. In the "Run" dialog box, initiate software installation by typing **D:\Setup.exe** (or other drive designator:\Setup.exe, depending on the letter designation for the CD-ROM drive).
4. The Installation Wizard will prompt the user through the installation process. After installation, the IPScom program icon is placed on the desktop (Figure 3-3).

Starting IPScom

Select the IPScom program-item icon from the Becoware group in the Program Manager, or select **IPScom** from the program list using the **Start** menu. The IPScom Main Screen will be displayed (Figure 3-12).

Figure 3-3 IPScom S-7600 Program-Item Icon

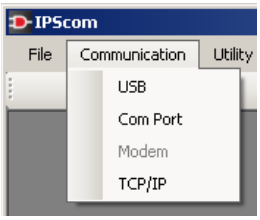
3.3 Communications Using Direct USB Connection

When the relay is connected to the PC utilizing a USB cable, Windows® will enumerate the relay as a HID device.

Direct Communication Using USB (HID) Connection

■**NOTE:** The M-7651A D-PAC and IPScom S-7600 Communications Software are shipped from the factory with the same default communication parameters. Therefore it may not be necessary to setup communication parameters for initial local communications. Default communication parameters are contained in the individual sections.

1. Ensure the following conditions exist:
   - IPScom is installed on the host computer
   - The relay is energized
2. Plug the USB cable into the host computer USB port.
3. Plug the USB cable into the USB port on the relay. The host computer will interrogate the relay to determine the type of hardware device it is.
4. Start the IPScom program, IPScom will display the IPScom "Main" dialog screen (Figure 3-12).
5. Select **Communication/USB** from the "Communication" drop-down menu.



IPScom will display the USB Port dialog screen (Figure 3-4).

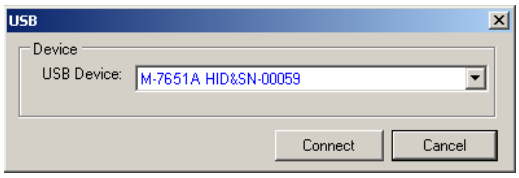


Figure 3-4 USB Port Connection Dialog Screen

6. Ensure that the correct USB device is displayed.
7. Select **Connect**. If Cyber Security is disabled, IPScom will attempt to connect to the target relay.
8. If IPScom returns a "Cannot Connect" error screen (Figure 3-5), verify the USB connections and retry the procedure.

Figure 3-5 Cannot Connect Error Screen

9. If Cyber Security is enabled, IPScom will display the "Log On" dialog screen (Figure 3-6).

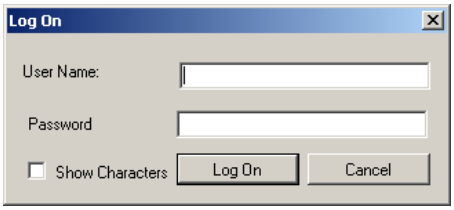


Figure 3-6 Log On User Name and Password Dialog Screen

10. Enter a valid User Name and Password and select **Log On**. IPScom will attempt to connect to the target relay.
11. If IPScom returns a "User Access Permissions Denied" error screen (Figure 3-7), IPScom will deny access until a valid User Name and Password are entered.

Figure 3-7 User Access Permissions Denied Error Screen

12. If Cyber Security is disabled, or a valid User ID/Password was entered, then IPScom will briefly display an "Access Granted" screen followed by the "Connected through USB" confirmation screen (Figure 3-8). IPScom will display the connected version of the IPScom Main Screen (Figure 3-14). The USB connection name is displayed in the Connection Status area at the bottom right corner of the main screen.

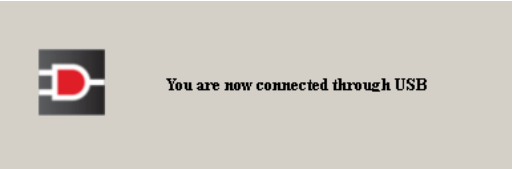


Figure 3-8 Connected through USB Confirmation Screen

3.4 TIA-232 and TIA-485 Communications

To use IPScom S-7600 Communications Software to communicate with the M-7651A D-PAC System using a TIA-232 or TIA-485 connection the following conditions must be met:

- The relay is physically connected to a TIA-232 or TIA-485 network consistent with the hardware and connection requirements.
- IPScom software communication parameters and device parameters must match the relay's default TIA-232 or TIA-485 settings and the selected/default device parameters. See also Communication Setup on page 4–9.

Elements of the relay's TIA-232 or TIA-485 Port communication parameters include the following (default settings):

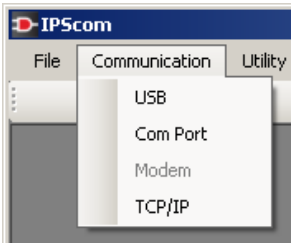
- Comm Port (COM1)
- Baud Rate (1200 bps)
- Parity (None)
- Stop Bit (1)
- Handshake (None)
- Read Timeout (100 msec)
- Write Timeout (100 msec)

Default device parameters that are at the default settings or have been configured locally at the relay include (default settings):

- Device Address (1)
- Protocol (MODBUS)
- Echo Cancel for Fiber Optic Loop (None)

Communication Using TIA-232 or TIA-485 Connection

1. Ensure the following conditions exist:
   - The relay is physically connected to the TIA-232 or TIA-485 network
   - IPScom is installed on the host computer
   - The relay is energized
2. Start the IPScom program. IPScom will display the IPScom "Main" dialog screen (Figure 3-12).
3. Select **Communication/Com Port** from the "Communication" drop-down menu.



   IPScom will display the Serial Port dialog screen (Figure 3-25).
4. Ensure that the correct COM port is displayed.
5. Ensure that both the Device and Comm settings are consistent with the relay's default values.
6. Select **Connect**. IPScom will attempt to connect to the target relay.
7. If Cyber Security is enabled, enter a valid User Name and Password (Figure 3-6) and then select **Log On**.
8. If IPScom returns a "Cannot Connect Error" screen (Figure 3-5) or a "Permissions Denied" error screen (Figure 3-7), then repeat the applicable steps.
9. If a valid User ID/Password was entered, then IPScom will display the "Successfully Connected through Serial" dialog screen (Figure 3-9). Select **OK**, IPScom will display the connected version of the IPScom Main Screen (Figure 3-14).

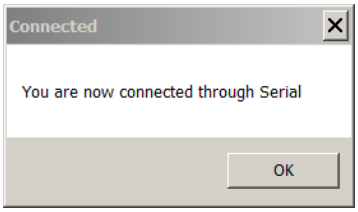


Figure 3-9 Connected through Serial Confirmation Screen

3.5 Ethernet Communications

The optional Ethernet Port can be purchased as either a RJ-45 (10/100 Base-T) interface or Fiber Optic through ST connector (100 Base-Fx) for Ethernet communication to the M-7651A D-PAC. The port supports up to four concurrent connections (both Port 3 and Port 4 combined). The maximum number of allowed DNP connections is four. The maximum number of MODBUS connections is four. The port supports DHCP protocol and also allows manual configuration of the Ethernet port. MODBUS protocol "Port Number" and DNP Protocol "Port Number" are always configured manually regardless of DHCP Enable/Disable option.

■**NOTE:** IPScom can be used through the Ethernet port and may be considered a MODBUS connection for the purpose of determining how many concurrent connections are allowed.

■**NOTE:** Using Fiber Ethernet requires the Auto Negotiate setting in the relay be set to Disable to operate correctly.

Communication Using Ethernet Connection

1. Ensure the following conditions exist:
   - The relay is physically connected to the Ethernet network
   - IPScom is installed on the host computer
   - The relay is energized
2. Start the IPScom program. IPScom will display the IPScom "Main" dialog screen (Figure 3-12).
3. Select **Communication/TCP/IP** from the **Communication** drop-down menu. IPScom will display the TCP/IP Connection Dialog Screen (Figure 3-26).
4. Enter the Device and TCP/IP parameters for the target relay or select from the Address Book.
5. Select **Connect**. IPScom will attempt to connect to the target relay.
6. If Cyber Security is enabled, enter a valid User Name and Password (Figure 3-6) and then select **Log On**.
7. If IPScom returns a "Cannot Connect Error" screen (Figure 3-5) or a "Permissions Denied" error screen (Figure 3-7), then repeat the applicable steps.
8. If a valid User ID/Password was entered, then IPScom will briefly display the "You are now connected" confirmation screen (Figure 3-10) and then display the connected version of the IPScom Main Screen (Figure 3-14).

Figure 3-10 Connected through Ethernet Confirmation Screen

If the relay is to be connected to a network that does not support DHCP protocol, then the following information must be obtained from the Network Administrator, to be entered locally at the relay or remotely utilizing IPScom:

- IP Address
- Net Mask
- Gateway (may be necessary)

■**NOTE:** The DNP and MODBUS Port addresses can not be set to the same value.

Also, if the network MODBUS Port address is not "502" or the DNP Port address is not "20000", then the MODBUS Port and DNP Port settings must be set.

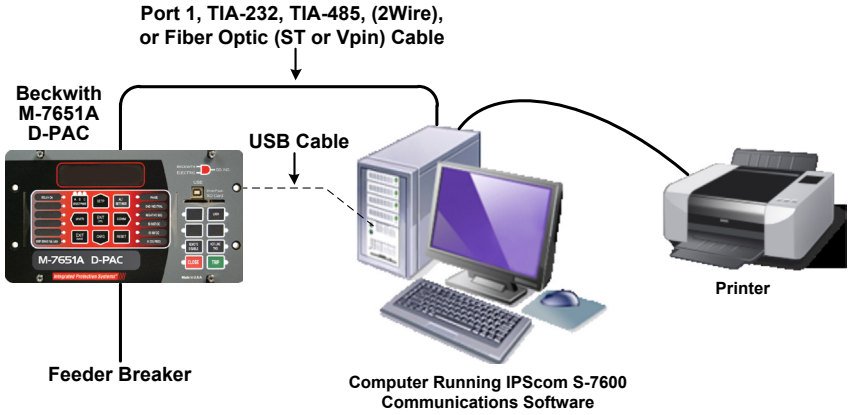


Figure 3-11 Direct Connection Diagram

3.6 Overview of Operation

The IPScom installation and establishing initial local communications are covered in **Section 3.2 Installing IPScom**. Once installed, the IPScom program icon is available from the Program Files directory and IPScom can be run like any other Windows® program. (The installation utility places IPScom in a Program Files group named Becoware.)

Selecting the IPScom Program from the Becoware Folder or selecting the IPScom Program Icon (Figure 3-3) from the Desktop will open the program and display the IPScom Main Screen (Figure 3-12).

Figure 3-12, represents the IPScom Main Screen menu structure. IPScom Main Screen "File Mode" menu structure and IPScom Main Screen "Connected" menu structure are presented in Figure 3-13 and Figure 3-14 respectively.

■**NOTE:** If communication is not established with the unit and no file is open, items relating to settings and monitoring are disabled. If not connected but a file is open, monitoring screens are displayed without data.

When in **File Mode** with a named file open, the file name and path to the file are displayed in the top menu bar.

When in **Connected Mode**, the IPScom Main Screen (Figure 3-14) will display the type of Connection that is in effect in the top Menu Bar.

The **Connected Mode** bottom Menu Bar will display:

- User Lines
- Fault Type
- Fault Distance
- Alarm Status
- IRIGB Status
- Firmware Version
- Unit Serial Number
- Active Profile
- Control Date and Time
- Connection Status

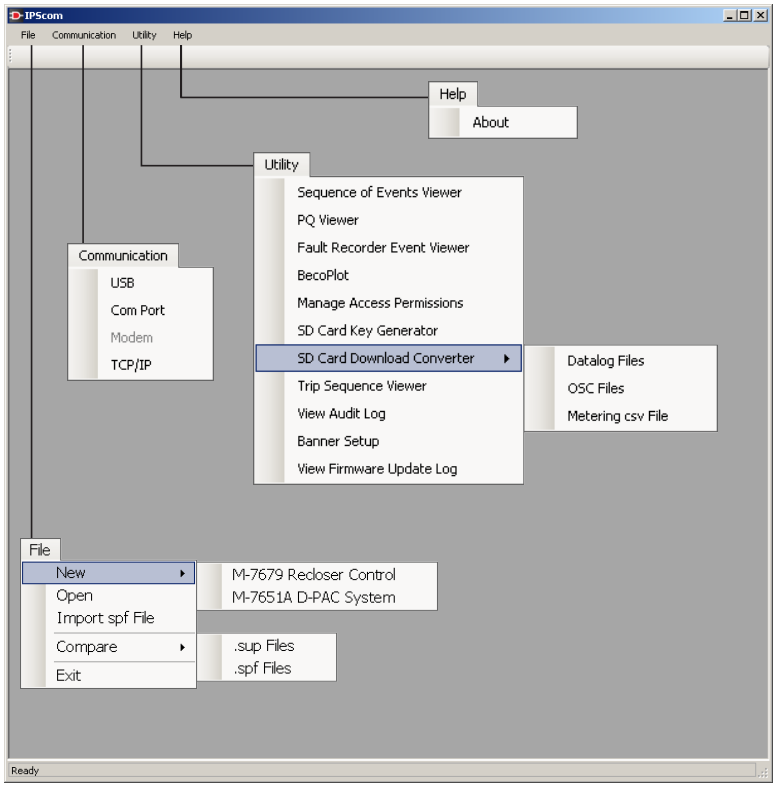


Figure 3-12 IPScom Main Screen Menu Selections

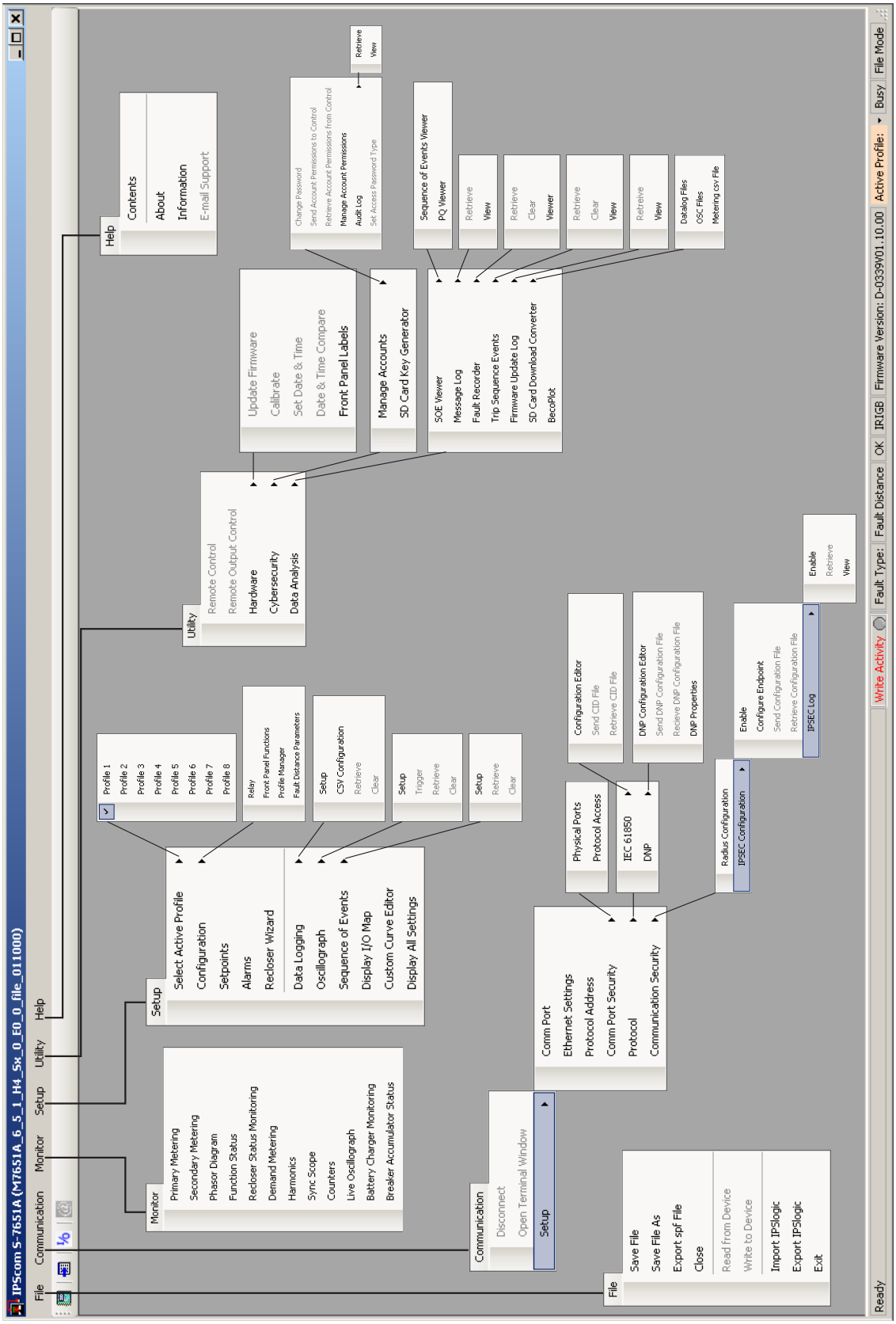


Figure 3-13 IPScom Main Screen Menu Selections (File Mode)

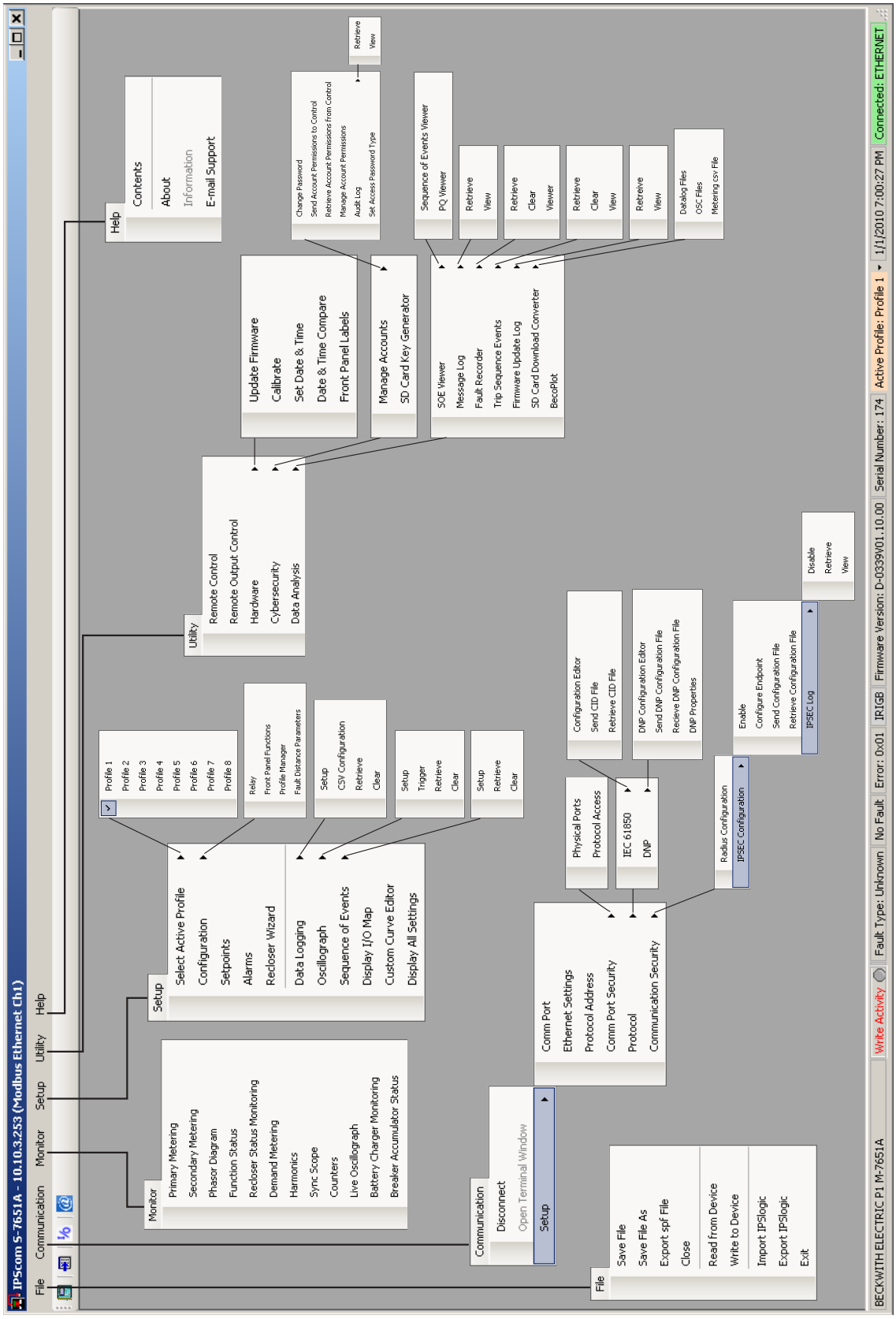


*Figure 3-14 IPScom Main Screen Menu Selections (**Connected**)*

Main Screen/Utility/Banner Setup

IPScom includes a Security Banner feature located in the Main Screen Utility menu dropdown. The Security Banner feature, when enabled, provides the user with the ability to display a user defined Banner when connecting to a control. The Security Banner will be displayed when connecting to a control and requires the user to acknowledge the contents of the Banner before proceeding to connect/login. The Security Banner is a function of IPScom and is not a setting that resides on the control.

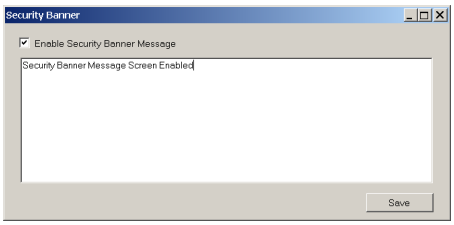


Figure 3-15 Security Banner Setup Dialog Screen

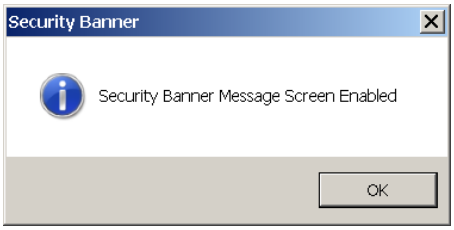


Figure 3-16 Security Banner Message Screen

M-7651A D-PAC System Alarms Displayed in IPScom

IPScom polls the M-7651A D-PAC for System Errors, Fault Type, Fault Distance, the Time and the Active Profile. When an error occurs or if an error exists when connecting to the M-7651A D-PAC, IPScom will display a message screen describing the errors (Figure 3-17). It will also flash a red warning indicator in the status bar with the error code. The description of the error code can be accessed at any time by double-clicking the flashing indicator. The Fault Type, Fault Distance and the Active Profile are also displayed in the status bar.

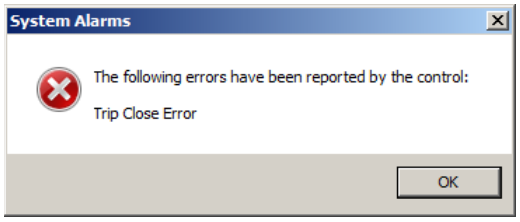


Figure 3-17 System Alarms Message Screen

The following are the errors that can be reported/displayed:

- Trip Close Error – occurs if the 52A and 52B contacts are in the same state.
- Battery Status Error – occurs if the battery is not present, fails the load test, or is not charging.
- EEprom Setpoint Checksum Error – occurs if the checksum is bad.
- DSP Watchdog Error – occurs if the DSP is not running correctly.
- Gas Pressure Error – occurs if the input for the gas pressure is high, or the pressure value is below the SF6 pressure limit setpoint.
- EEprom Calibration Checksum Error – occurs if the checksum is bad.
- DSP Failure Error – occurs if the DSP fails.
- Flash Not Formatted Error – occurs if the internal flash drive is not formatted.
- Max Breaker Operations Error – occurs when the Breaker Operation Limit setting has been exceeded.
- Internal Battery Failure – occurs when the internal battery that provides back up power to the non-volatile memory has failed.
- Battery Charger Communication Failed – occurs when the Battery Charger is enabled and the control cannot establish communication with the Battery Charger.

When a critical error occurs or if a critical error exists when connecting to the M-7651A D-PAC, IPScom will display a warning message and prompt the user to e-mail the support files to Beckwith Electric. The following are the errors that generate the Warning screen (Figure 3-18):

- Setpoints Checksum Error – occurs if the checksum is bad.
- Calibration Checksum Error – occurs if the checksum is bad.

Refer to "E-mail Support from IPScom" in Chapter 2 for detailed instructions for utilizing the E-mail Support feature.

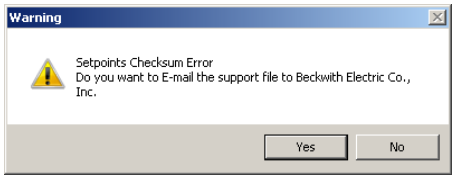


Figure 3-18 Warning Setpoints Checksum Error

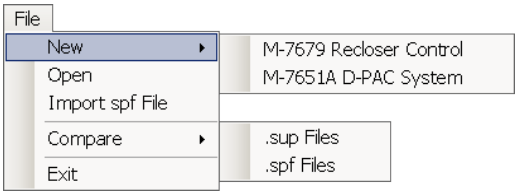
FILE MENU

The File Menu feature of IPScom utilizes a Control File (*.sup) that consists of the following subset of files to capture the control setup and configuration:

- version.txt (the version of the firmware)
- m7651A.spf (setpoints)
- led.eqn (led map file)
- ledmap.bin (binary file for LEDs)
- ipslogic.xml (IPSlogic map file)
- ipslogic.bin (binary file for IPSlogic)
- statusbits.txt (inputs used for the two map files)
- wakeupconfig.txt (wake list)
- SmartButton.txt (custom button file)

When IPScom is launched a file can either be created **New** or opened **Open**. For a new file, temporary working files are copied from default files. When an existing file is opened, the temporary working files are extracted from the opened file.

File Not Open or Not Connected Mode



The File drop down menu when IPScom is not connected to a relay, or a file is not open provides the following features:

New – Choose "M-7651A D-PAC System" to open the New File Dialog Screen (Figure 3-19) which allows the user to enter the parameters of the New File: including the Firmware Version, Operating Frequency, Phase Current Inputs, Ground Current Input, Voltage Inputs, Extended I/O, Operation Type, Ethernet Hardware, and Protocol options.

As these parameters are entered, IPScom will automatically update the "Smart String" displayed at the top of this window. This Smart String represents the Model Number of the relay. This Smart String is then displayed in the IPScom title bar in File mode.

When creating a new file, IPScom will create temporary working files based on the default files of the selected Firmware Version. When the user saves the Control File, these files will be used. When IPScom is closed, these files are deleted.

Open – Opens the file browser window to allow the user to select an existing file. It will not allow the user to create a new file. When opening a file, IPScom extracts the files stored in the Control File. The user can select **Save** or **Save As** to store these into the Control File.

Import spf File – This menu item allows the user to select a legacy *.spf file and insert it into the Control File.

Compare – The Setpoints File Compare feature provides the user with the ability to compare two Setpoints Files, "*.sup" or legacy "*.spf" and generate a report that presents the differences in setpoint values and settings in a side by side format. The report can be printed and can be displayed with just the differences or all the settings that exist in both files. The more current setpoint file may be edited and saved. See **Chapter 2**, **Operation** "Comparing Setpoint Files".

Exit – Exits the IPScom program.

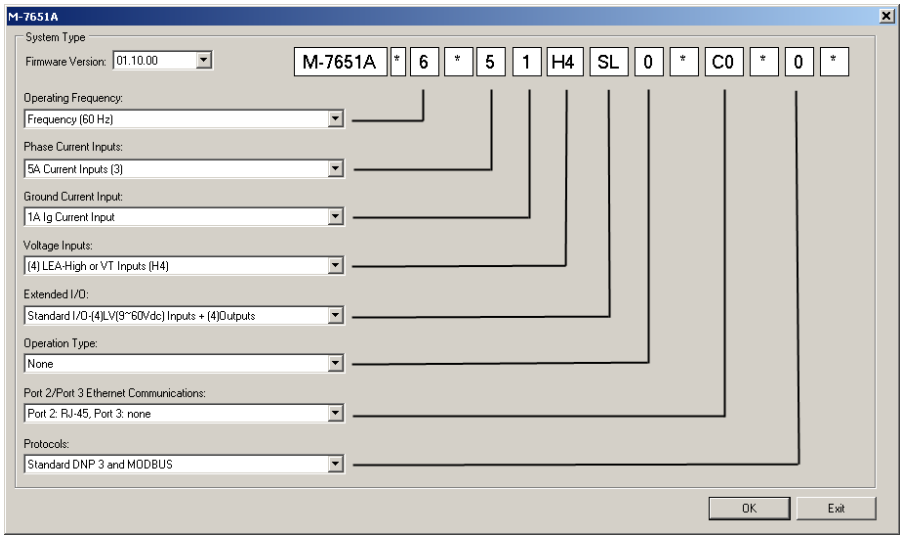
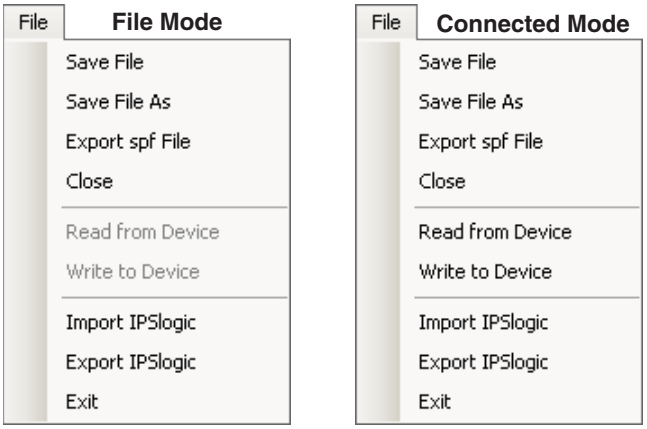


Figure 3-19 New File Dialog Screen

File Menu



The **File** toolbar item when IPScom is not connected to a relay or a file is open provides the following features:

Save File – This menu item will concatenate the working files into one Control File and then save it. If no filename has been associated (i.e. New File), a save window will be displayed so that the file can be named.

Save File As – This menu item will concatenate the working files into one Control File and then save it.

Export spf File – The feature allows the user to export an *.spf file to be used in the File Compare feature.

Close – Closes the open file in the window.

Read from Device – When connected to a relay, this menu item allows the user to download all the temporary files from the control to a working directory.

Write to Device – When connected to a relay, this menu item allows the user to select specific elements of the *.SUP file to upload to the relay (Figure 3-20). Selecting the "**?**" button displays the Name Plate settings Popup screen.

- SUP File Without Name Plate
- Entire SUP File
- Setpoints File Without Name Plate
- IPSLogic File Only
- Custom File Selection

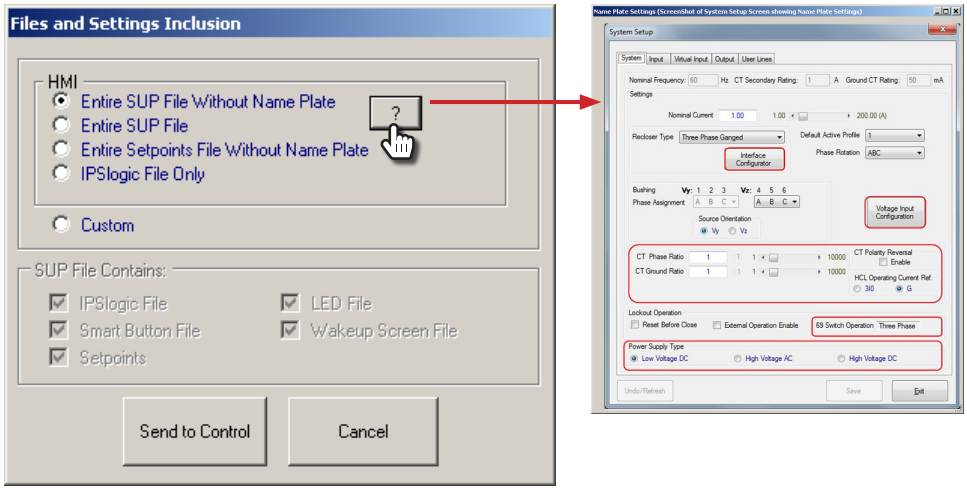


Figure 3-20 Write to Device Files and Settings Inclusion with Name Plate Popup Screen

■**NOTE:** If the Breaker Operation Type of the SUP file does not match the target relay, IPScom will display an Error message screen (Figure 3-21), and the file will not be written.

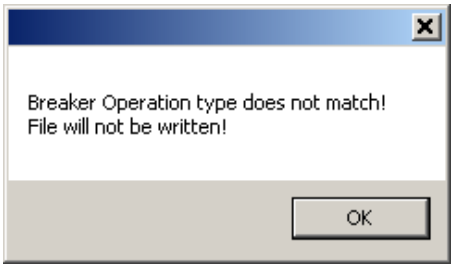


Figure 3-21 Breaker Operation Type Error Message

■**NOTE:** If the Phase Assignment of the SUP file does not match the target relay, IPScom will display a Warning message (Figure 3-22) prompting the user that a reboot is required to continue. If the user Cancels the operation, the SUP file will not be written to the unit.

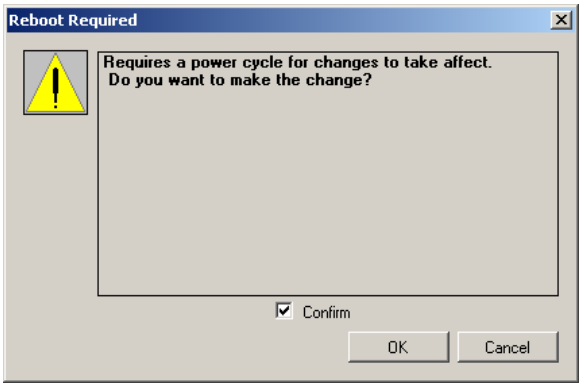


Figure 3-22 Phase Assignment Reboot Required Warning Screen

Import IPSlogic – This menu item allows the user to select and import individual profiles and elements of a saved IPSlogic file into IPScom.

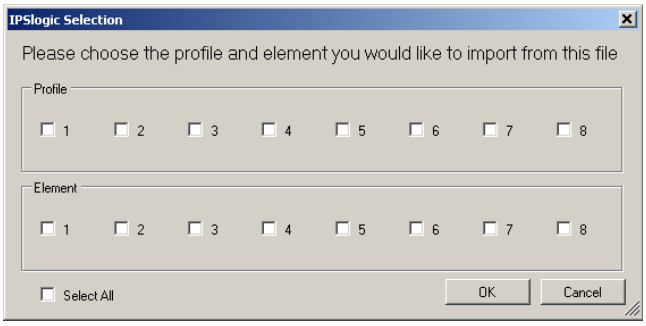


Figure 3-23 Import IPSlogic Profile and Element Selection Dialog Screen

Export IPSlogic – This menu item allows the user to export all IPSlogic circuits (all profiles and all elements) into a single (.ips) file that can be saved locally. By default all profiles and all elements are exported into one file, individual profiles and elements are not user-selectable on export. Selecting this menu item will display the IPSlogic File Export confirmation screen (Figure 3-24). The exported file may be imported for editing using the "Import IPSlogic" menu selection, which does allow user selection of individual profiles and elements on import.

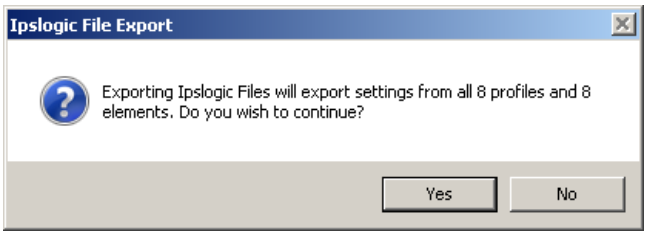
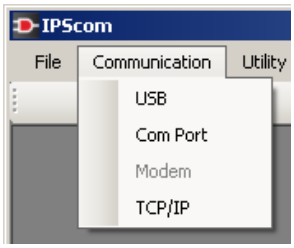


Figure 3-24 IPSlogic File Export Confirmation Screen

Exit – Exits the IPScom program.

COMMUNICATION MENU

Communication Menu (Not Connected)



The **Communication** (Not Connected) drop down menu is displayed when IPScom is not connected to a relay. This menu provides the user with access to the screens that are necessary to establish communication with the target relay. Menu selections include **USB**, **Com Port**, **Modem** and **TCP/IP**.

USB

The **USB** menu selection initiates the USB dialog screen to connect to the M-7651A D-PAC USB Port (Figure 3-4). The user is prompted to input the required Device and Access Level Code.

Com Port

The **Com Port** menu selection initiates the **Serial Port** dialog screen (Figure 3-25). The user is prompted to input the necessary communications information to open Serial communications through the selected Comm Port.

Device Address

Individual relay Device Addresses should be between 1 and 255. The default Device Address is 1. The Broadcast Address is 255, however, this should not be used in a typical situation, as this will create collisions if there is more than one relay present in the network. The individual addressing capability of IPScom and the relay allows multiple systems to share a direct or modem connection when connected through the Serial Port using a communications-line splitter. One such device enables 2 to 6 units to share one communications line.

▲CAUTION: The Echo Cancel check box should only be used when several relays are connected using a fiber optic loop network. Otherwise, echo cancel must not be selected or communication will be prevented.

When communicating by way of a fiber optic loop network, echo cancelling is available by checking the Echo Cancel box. This command masks the sender's returned echo.

▲CAUTION: If the serial port is connected to something other than a modem, and an IPScom modem command is executed, the results are unpredictable. In some cases, the computer may have to be reset.

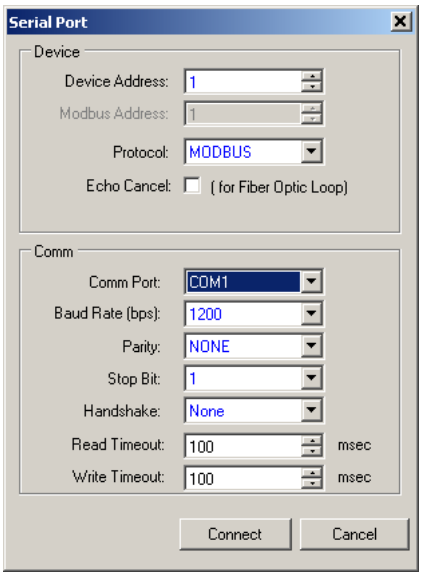


Figure 3-25 Serial Port Communication Dialog Screen

TCP/IP

The **TCP/IP** menu selection initiates the TCP/IP Connection dialog screen (Figure 3-26). The user is prompted to input the necessary communications information to open communications through the Ethernet port. The user can add the IP Address with Domain/Name of the users choice into the Address book and select **Save** for future use.

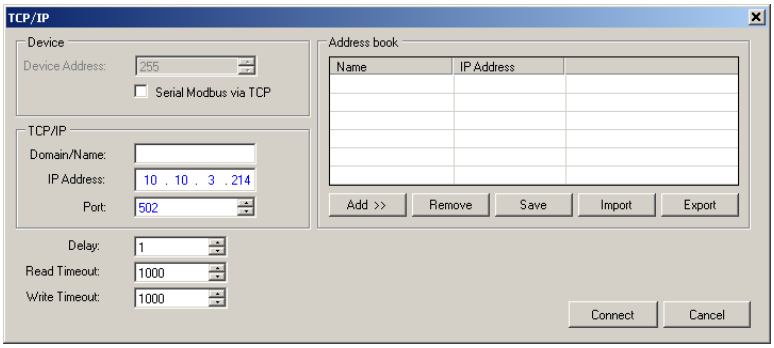
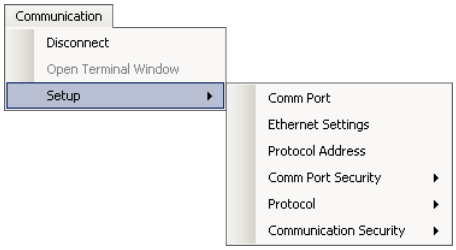


Figure 3-26 TCP/IP Connection Dialog Screen

Communication Menu (Connected)



The Connected **Communication** drop down menu is displayed when IPScom is connected to a relay. This menu provides the user with access to the screens that are necessary to **Disconnect** from the target relay or access the **Setup** menu items.

Communication/Disconnect

The Disconnect menu item prompts the user to confirm (Figure 3-27) the command.

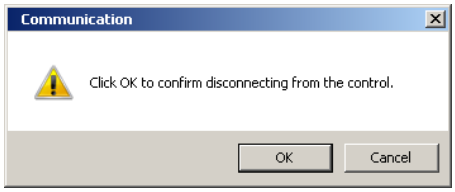


Figure 3-27 Disconnect Command Confirmation Screen

Communication/Open Terminal Window

Not Available at this time.

Communication/Setup/Comm Port

The **Setup/Comm Port** submenu provides the user with the capability to setup and configure Port 1 and Port 4 (Figure 3-28).

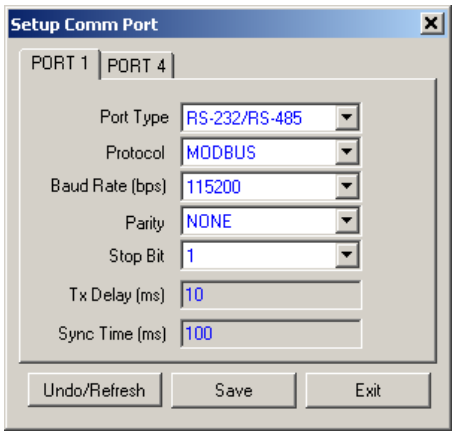


Figure 3-28 Setup Comm Port Dialog Screen

Communication/Setup/Ethernet Settings

The **Setup/Ethernet Settings** submenu provides for the setup and configuration of the optional Ethernet Ports 2 and 3 (Figure 3-29).

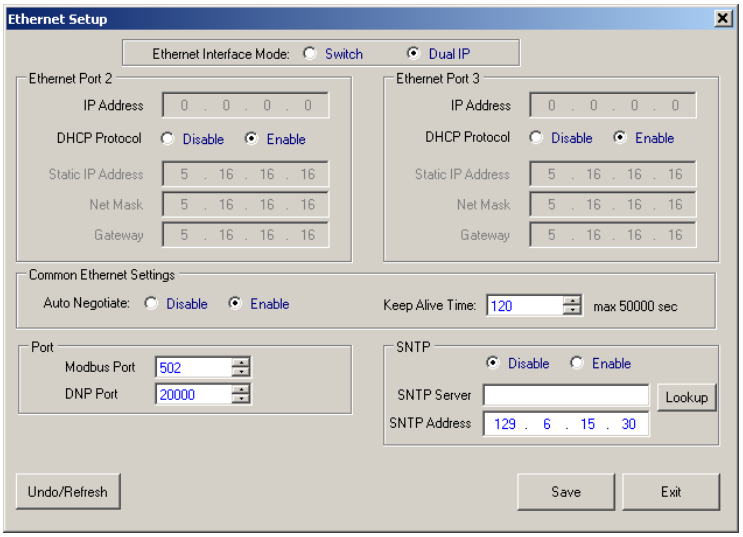


Figure 3-29 Ethernet Setup Dialog Screen

Communication/Setup/Protocol Address

The **Setup/Protocol Address** submenu provides the user with the capability to setup a MODBUS Protocol Address from 1 to 255 or a DNP Protocol Address from 1 to 65519 (Figure 3-30). The default Address is 1.

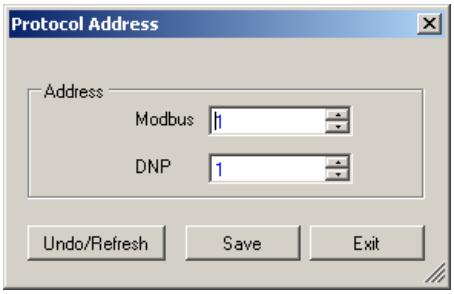


Figure 3-30 Protocol Address Screen

Communication/Setup/Comm Port Security/Physical Ports

The **Comm Port Security/Physical Ports** submenu provides the user with the capability to enable/disable the relay physical communication ports to comply with cyber security requirements (Figure 3-31).

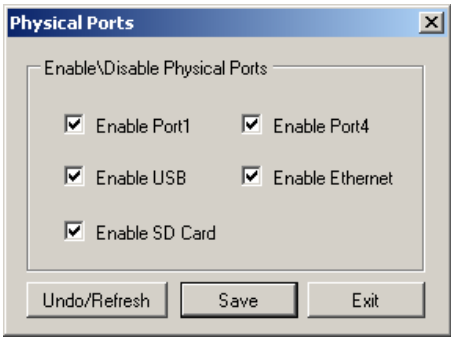


Figure 3-31 Enable/Disable Physical Communication Ports Dialog Screen

Communication/Setup/Comm Port Security/Protocol Access

The **Comm Port Security/Protocol Access** submenu provides the user with the capability to enable/disable specific communication protocols to comply with cyber security requirements (Figure 3-32).

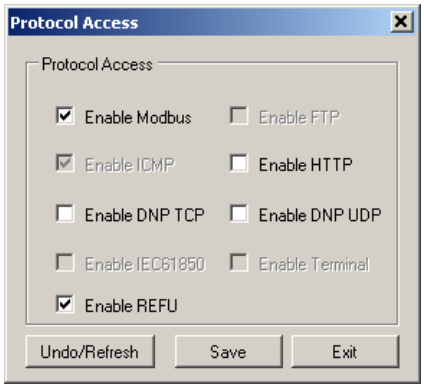
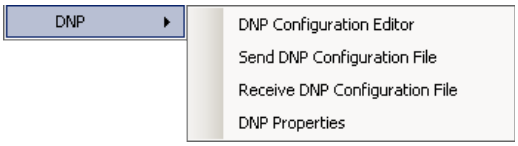


Figure 3-32 Enable/Disable Protocol Access Dialog Screen

Communication/Setup/Protocol/IEC 61850

The **Setup/Protocol/IEC 61850** submenu provides the user with the capability to send or retrieve a CID file when connected to a relay. This submenu also includes access to the **BECO SCL Configurator** tool for editing and validating IEC 61850 SCL files, including icd, cid, ssd and scd file formats.

Communication/Setup/Protocol/DNP



DNP/DNP Configuration Editor

The DNP Configuration Editor menu selection opens the M-7651A D-PAC DNP Configuration Editor dialog screen (Figure 3-33) which provides the user with the following capabilities:

- M-7651A D-PAC default DNP configuration file (*.xml) can be loaded for editing or become the basis for new DNP configuration files.
- Selected DNP configuration files (*.xml) other than M-7651A D-PAC default file can be loaded for editing or become the basis for new DNP configuration files.
- Binary Inputs, Analog Inputs, Binary/Control Outputs, Analog Outputs, and Counters may be added, edited or deleted.
- Dummy positions may be added to allow SCADA table matching.
- "Insert Offset Point" can be used to match a SCADA table.
- Variations may also be edited.
- File can be saved to disk.
- Saved files can be sent to the connected relay.
- Items in the editor can be moved, added and removed by dragging and dropping.
- Enable/Disable unsolicited response.
- Screen can be printed.
- Master Address for unsolicited responses and/or Source Address Validation.
- See the **M-7679 Communications Guide**, available on our website, for detailed information.
- A DNP Device Profile conforming to the DNP standard can be generated listing only the user selected DNP points. This XML formatted document can be used to record the relay's DNP map setup.

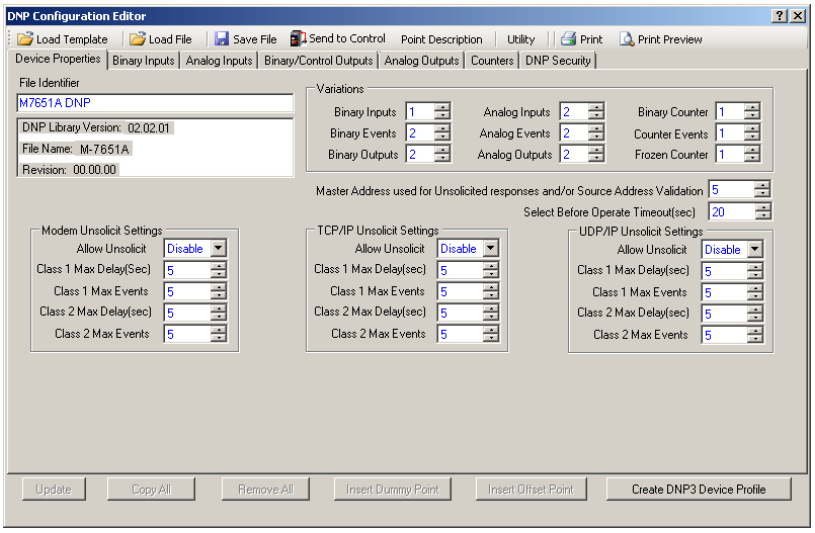


Figure 3-33 M-7651A D-PAC DNP Configuration Dialog Screen

DNP/Send DNP Configuration File

The Send DNP Configuration File menu selection provides the user with the capability to upload a DNP configuration file to the relay. To upload a DNP configuration file proceed as follows:

1. From the IPScom Main Screen select **Communication/Setup/Protocol/DNP/Send DNP Configuration File**. IPScom will display the Open File Dialog screen (Figure 3-34) with a default *.xml file extension.

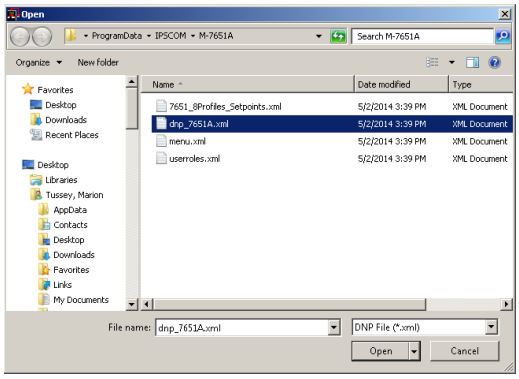


Figure 3-34 DNP Open File Dialog Screen

2. Select the target file, then select **Open**. IPScom will display the "Sending DNP Configuration File" status screen, followed by the DNP File sent successfully confirmation screen (Figure 3-35).

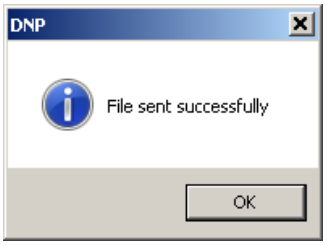


Figure 3-35 DNP Configuration File Sent Successfully Confirmation Screen

DNP/Receive DNP Configuration File

The Receive DNP Configuration File menu selection provides the user with the capability to download a DNP configuration file from the relay. To download a DNP configuration file proceed as follows:

1. From the IPScom Main Screen select **Communication/Setup/Protocol/DNP/Receive DNP Configuration File**. IPScom will briefly display the "Retrieving Directory" screen (Figure 3-36) and then display the "Save As" dialog screen (Figure 3-37) with a default *.xml file extension.

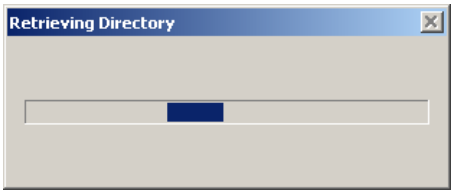


Figure 3-36 DNP Retrieving Directory Screen

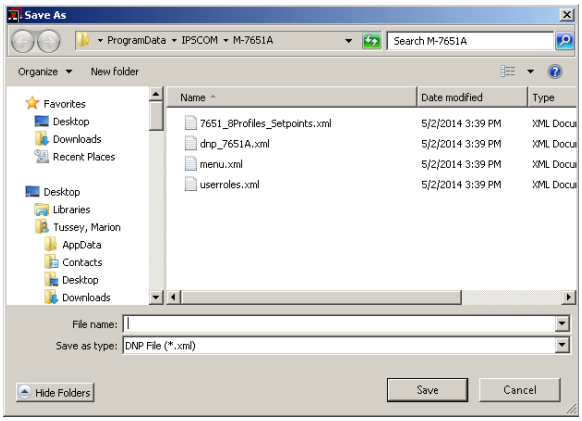


Figure 3-37 Receive DNP Configuration File Save As Dialog Screen

2. Select the target file or enter a name for the new file, then select **Save**. IPScom will display the "DNP Download" status screen, followed by the "DNP File Retrieved Successfully" Confirmation Screen (Figure 3-38). Select **OK**. IPScom will return to the Main Screen.

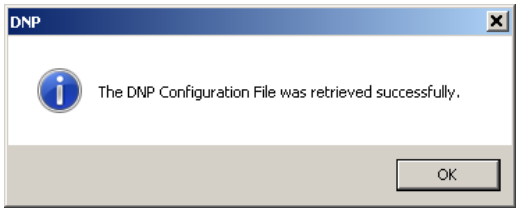


Figure 3-38 DNP Configuration File Retrieved Successfully Confirmation Screen

DNP/DNP Properties

The DNP Properties dialog screen (Figure 3-39) allows the user to set Source Address Validation parameters and also UDP Port Settings.

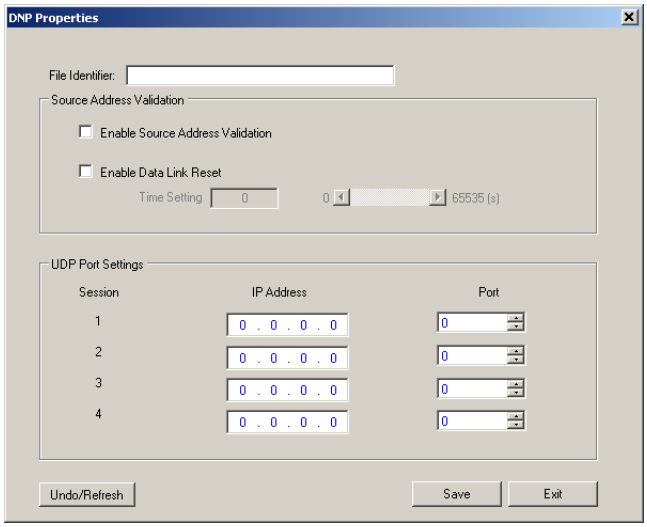


Figure 3-39 DNP Properties Dialog Screen

Setup/Communication Security/Radius Configuration

For Cyber Security, IPScom allows the user to configure up to two Remote Authentication Radius servers.

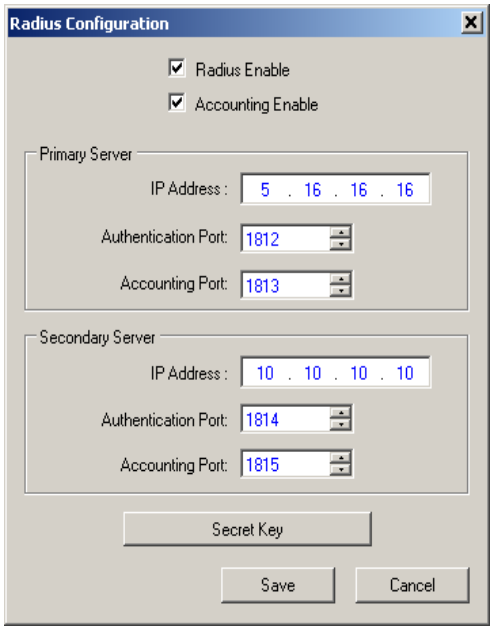


Figure 3-40 Radius Configuration Dialog Screen

Setup/Communication Security/IPsec Configuration/Enable

For Cyber Security, IPScom allows the user to enable Internet Protocol Security (IPsec). Select **Enable** from the IPsec Configuration dropdown menu. IPScom will display the "IPsec Enable Screen" (Figure 3-41).

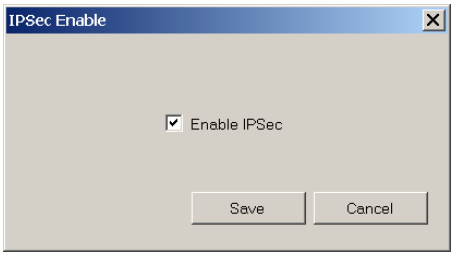


Figure 3-41 IPsec Enable Dialog Screen

IPsec Configuration/Configure Endpoint

Selecting IPsec Configuration/Configure Endpoint displays the "Configure Endpoint" (Figure 3-42) dialog screen which allows the user to add and configure IPsec Endpoints.

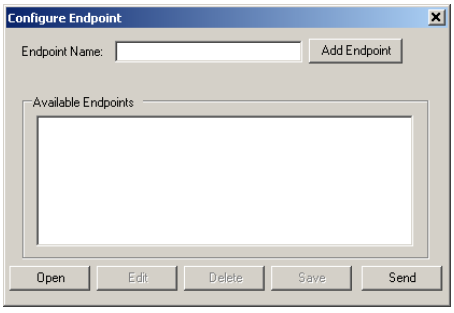


Figure 3-42 IPsec Configure Endpoint Dialog Screen

Select an available Endpoint from the "Configure Endpoint" screen and then select **Edit**. IPScom will display the "IPsec General Settings" screen (Figure 3-43) which allows the user to configure IPsec security settings, including IKE (Internet Key Exchange) Policy, IPsec Policy, Policy Lifetimes and Identities.

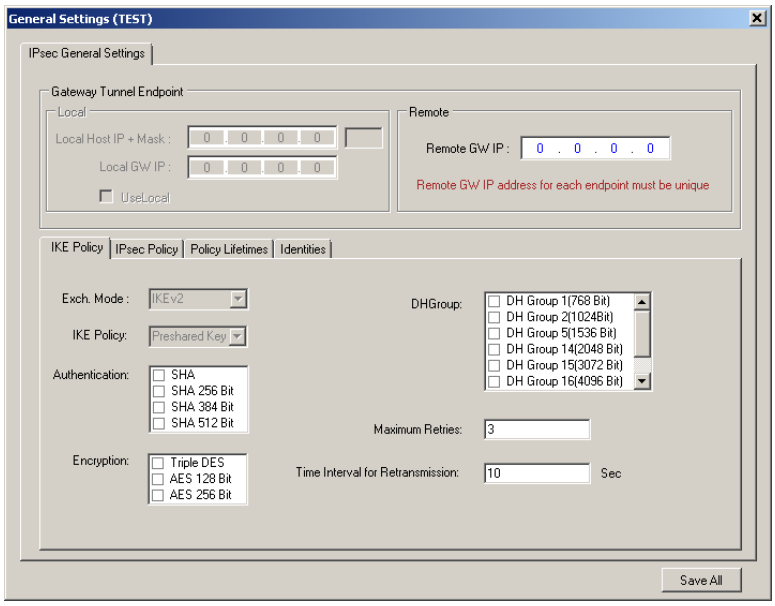


Figure 3-43 IPsec General Settings Dialog Screen

IPsec Configuration/Send Configuration File

Sends the IPsec Configuration file to the connected control.

IPsec Configuration/Retrieve Configuration File

Retrieves the IPsec Configuration file from the connected control.

IPsec Configuration/IPsec Log/Enable

This selection allows the user to enable recording of the IPsec log messages (Figure 3-44).

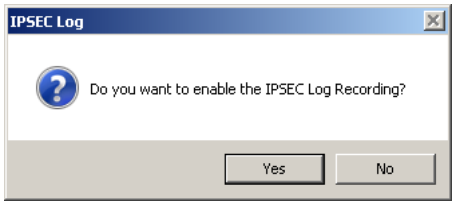


Figure 3-44 IPsec Log Enable Dialog Screen

When IPsec Log recording is enabled, IPScom will display the following information screen:

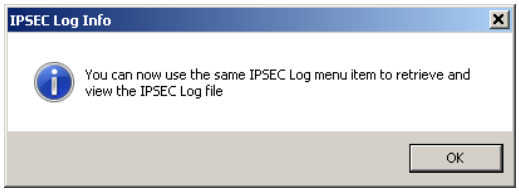


Figure 3-45 IPsec Log Menu Information Screen

IPsec Configuration/IPsec Log/Retrieve

When IPsec Log recording is enabled, this selection allows the user to retrieve the IPsec Log from a connected relay. IPScom will display the IPSEC Log (*.ilg) Save As screen which allows the user to save the Log file to the desired location (Figure 3-46). IPScom will display a download status screen and then display a confirmation screen (Figure 3-47).

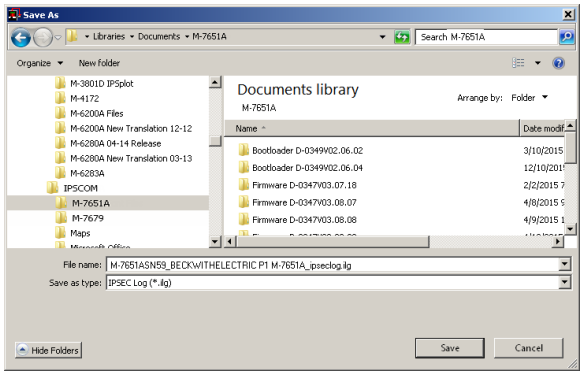


Figure 3-46 IPSEC Log Save As Dialog Screen

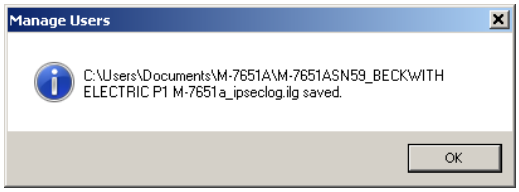


Figure 3-47 IPSEC Log Saved Confirmation Screen

IPsec Configuration/IPsec Log/View

This selection allows the user to select a downloaded IPsec Log file (*.ilg) for viewing. Navigate to the desired IPSEC Log file and **Open**. IPScom will display the IPSEC Log Viewer (Figure 3-48).

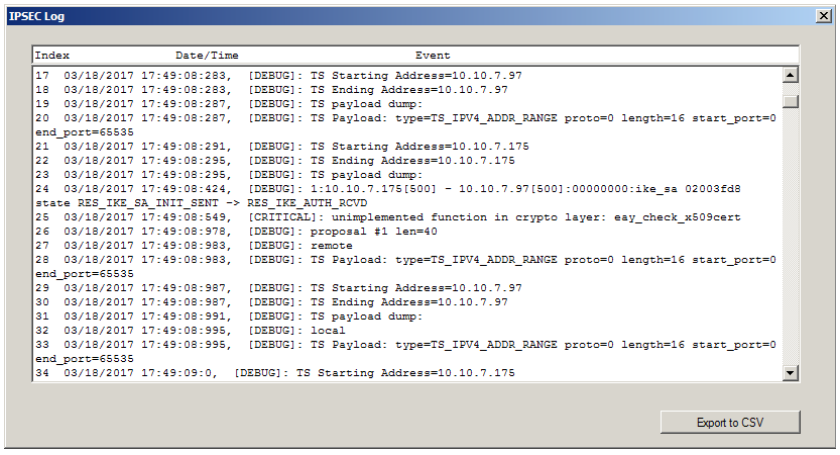
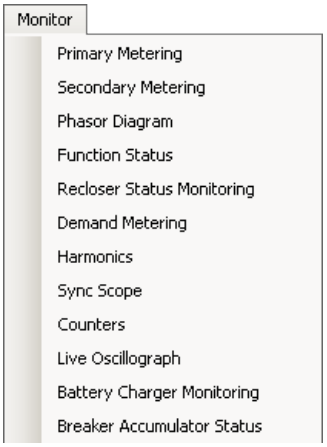


Figure 3-48 IPsec Log Viewer Screen

MONITOR MENU



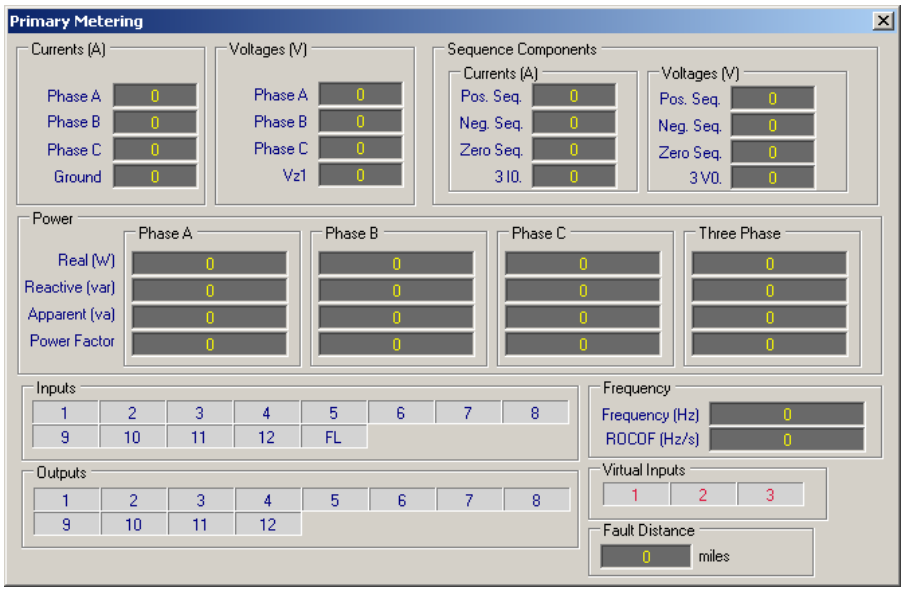
The **Monitor** Menu provides access to the screens used to monitor relay parameters. The submenus provided are: **Primary Metering**, **Secondary Metering**, **Phasor Diagram**, **Function Status**, **Recloser Status Monitoring, Demand Metering, Harmonics, Sync Scope, Counters, Live Oscillograph, Battery Charger Monitoring** and **Breaker Accumulator Status.**

Monitor/Primary Metering

The Primary Metering screen (Figure 3-49) allows the user to review PRIMARY parameters

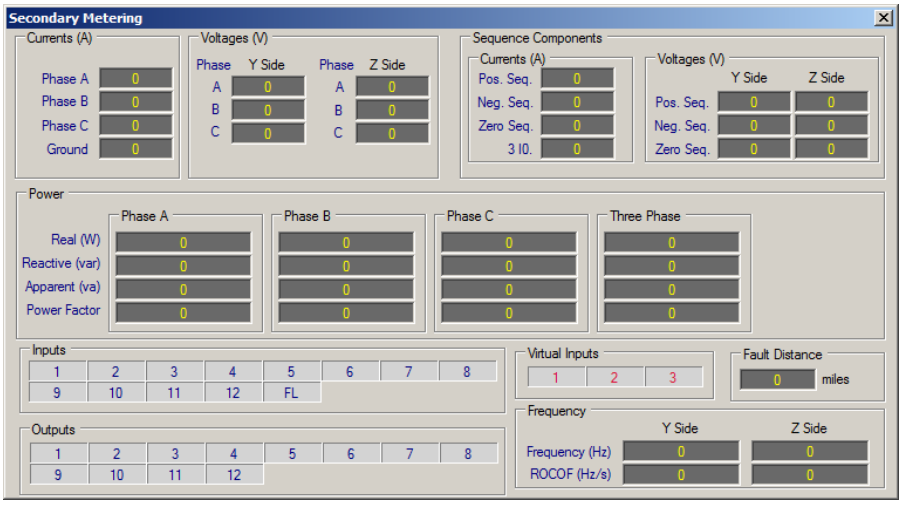
Monitor/Secondary Metering

The Secondary Metering screen (Figure 3-50) allows the user to review SECONDARY parameters:



■**NOTE:** When the VT Configuration is set to any Delta Connection, only three phase power metering is displayed in the Primary and Secondary Metering screens. Individual phase power metering is grayed out, and the value displayed is "0".

Figure 3-49 IPScom Primary Metering Screen (Voltage Input Option X4, L4, H4 or VT)



■**NOTE:** When the VT Configuration is set to any Delta Connection, only three phase power metering is displayed in the Primary and Secondary Metering screens. Individual phase power metering is grayed out, and the value displayed is "0".

Figure 3-50 IPScom Secondary Metering Screen (Voltage Input Option X6, L6 or H6)

Monitor/Phasor Diagram

The **Phasor Diagram** (Figure 3-51) provides the user with the ability to evaluate a reference Phase Angle to Phase Angle data from other windings. The data may be displayed in Primary or Secondary Metering values. The Phasor Diagram also includes a menu that allows the user to select/deselect sources to be displayed and Freeze capability to freeze the data displayed on the Phasor Diagram.

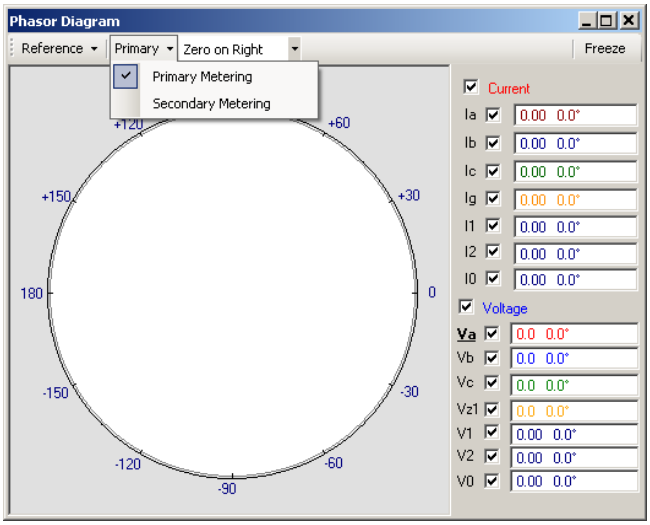


Figure 3-51 Phasor Diagram

Monitor/Function Status

The Function Status screen (Figure 3-52) displays the status of various functions, with a red circle indicating functions that have timed out, and a green circle for those functions that have picked up and are timing. Also displayed are Active Inputs and Outputs.

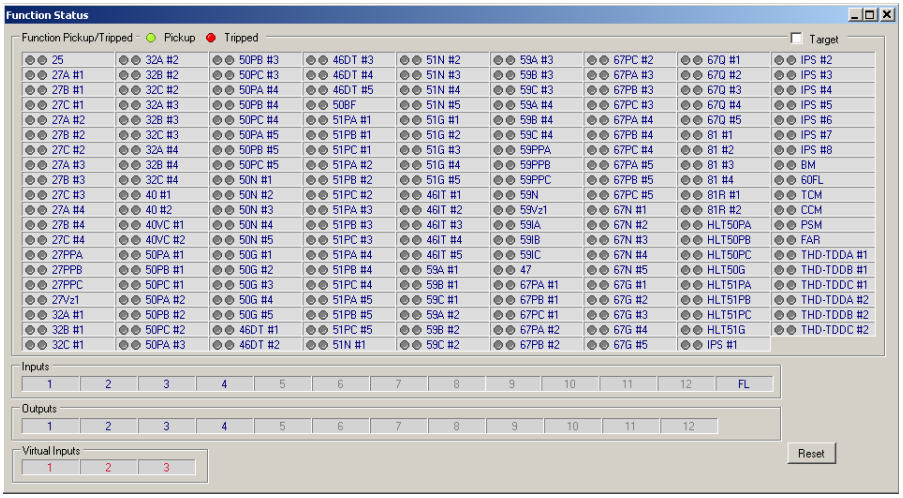


Figure 3-52 Function Status Screen

Monitor/Recloser Status Monitoring

The Recloser Status Monitoring screen (Figure 3-53) displays the Breaker Status, Reclose Settings and the Reclose Status. The Graph section of the screen displays real time reclose status parameters.

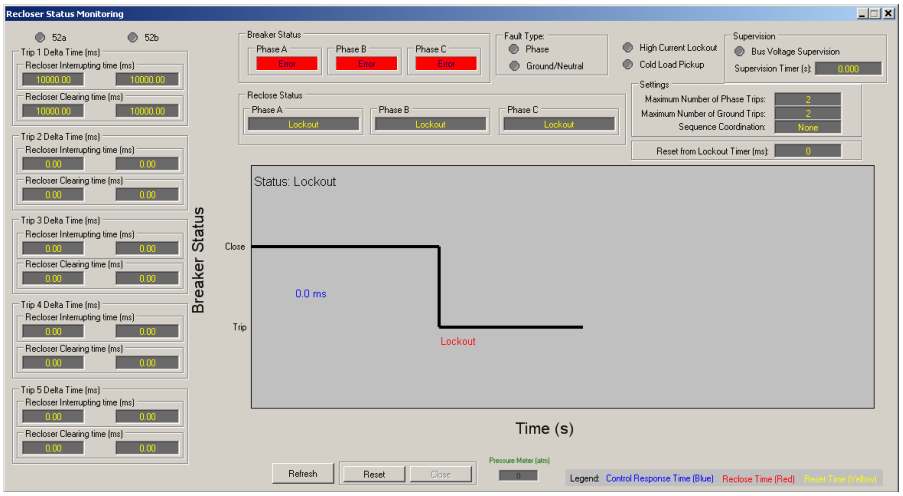


Figure 3-53 Recloser Status Monitoring (F79) Screen

Monitor/Demand Metering

The Demand Metering submenu item displays the Demand Metering screen (Figure 3-54). Real-time demand and metering information can be monitored from an addressed relay.

The **Demand Interval** applies to the Demand Present and the Demand History parameters. The Demand Interval can be set to 15, 30, and 60 minutes.

The **Max Demand Load Current (I_L)** setting is an element of the Total Demand Distortion calculation and is applied when the Total Demand Distortion function is enabled.

All Demand History and Energy Metering Values include the date and time at which each occurred.

■**NOTE:** Selecting "**UTC**" at the bottom of the screen displays the Date/Time in Universal Time Code format. Display either Primary or Secondary values using the "**Toggle**" selection.

The **Energy Metering** section displays the Energy Metering parameters. This feature enables the user to review real-time and historical demand metering information. This section includes Forward and Reverse Watt Hours and Forward and Reverse VAr Hours.

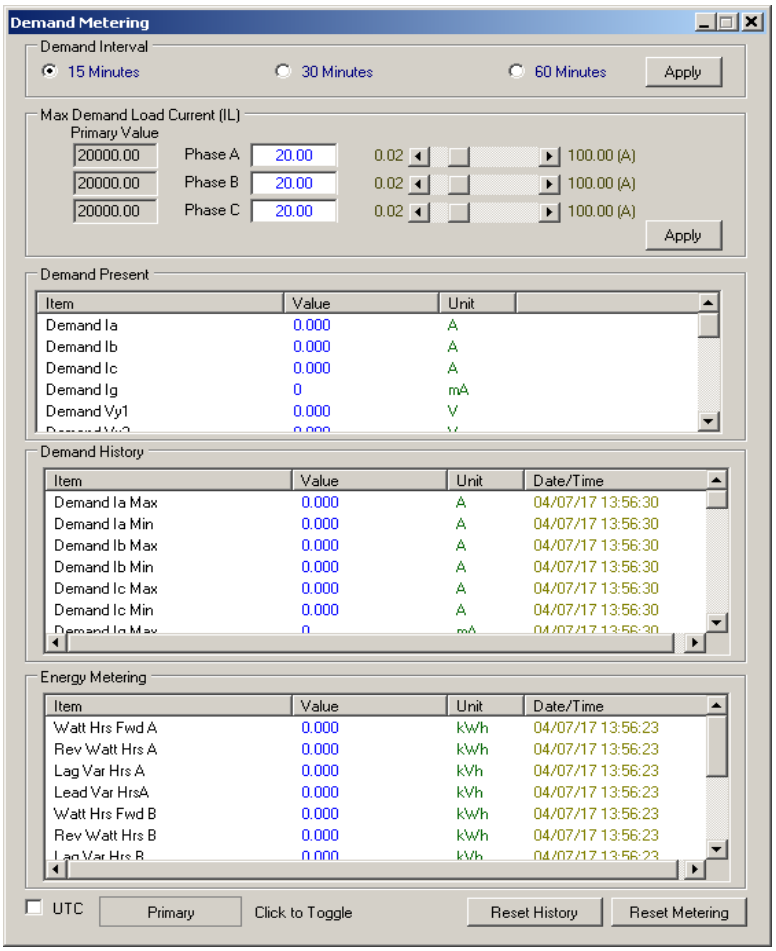


Figure 3-54 Demand Metering Screen

Monitor/Harmonics

The input signal is sampled at 128 samples per cycle, giving an overall sampling rate of 7680 samples per second for a 60 Hz system. This provides the ability to reproduce signals of up to 3840 Hz. Therefore, up to the 63rd harmonic can be calculated using discrete Fourier transform with a fundamental frequency of 60 Hz. The fundamental for both the Voltage and Current channels is calculated every sample meaning, every 130.2 µs. These voltage and current magnitudes are used in a real-time decision making algorithm and real-time metering.

Total Harmonic Distortion (THD) for both voltage and current are calculated and displayed using the following equations:

$$V\ THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2 + \ldots.}}{V_1} X\ 100\ \%$$

$$I\ THD = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots.}}{I_1} X\ 100\ \%$$

Total Demand Distortion (TDD) for current is calculated and displayed using the following equation:

$$I\ TDD = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots.}}{I_L} X\ 100$$

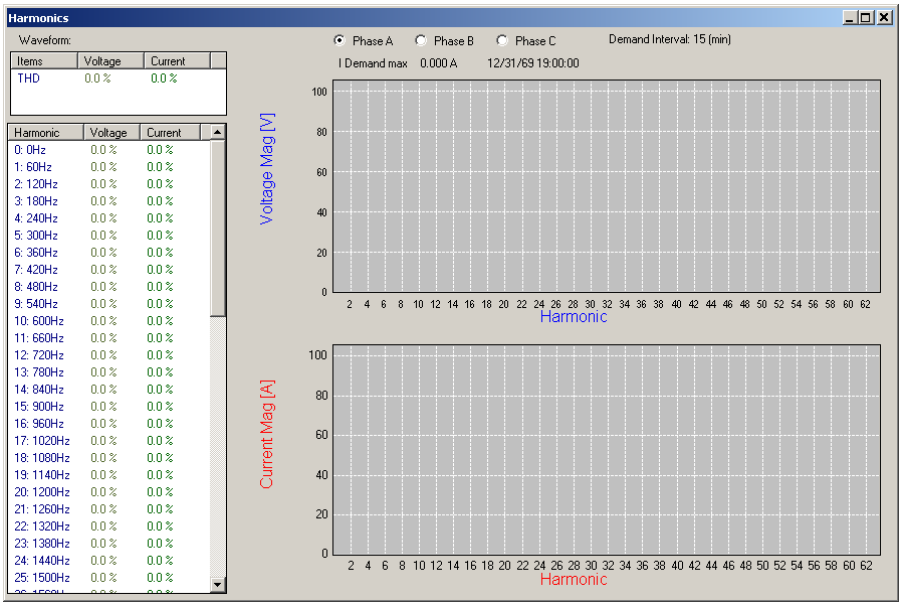


Figure 3-55 Harmonic Analysis Screen

Monitor/Sync Scope

The Sync Scope submenu item displays the Sync Scope monitoring screen (Figure 3-56).The Sync Scope graphic representation provides the phase difference between the measured quantities. See **Function 25 Sync Check** in Chapter 4 for additional information.

▲**CAUTION:** The M-7651A D-PAC Sync Scope should not be used to determine phase conditions for manual synchronizing because of possible communications time delay.

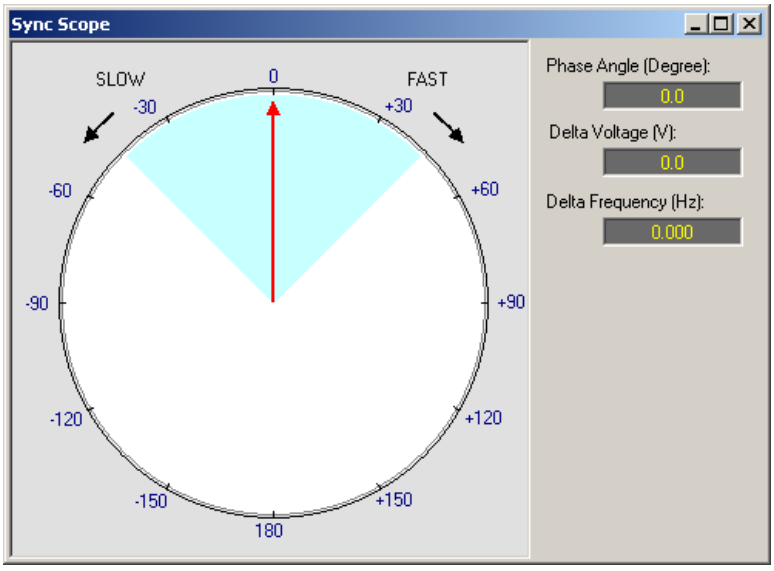


Figure 3-56 Sync Scope Monitor Screen

Monitor/Counters

The Counters submenu item displays the Counters Monitoring/Setting screen (Figure 3-57). The relay includes the following counters:

- Total Overcurrent Phase A Pickup and Trip
- Total Overcurrent Phase B Pickup and Trip
- Total Overcurrent Phase C Pickup and Trip
- Ground/Neutral Pickup and Trip
- Breaker Operations Phase A, B and C

The Pickup and the Trip are only for overcurrent functions. The Breaker Operations counter is the sum of the number of times the trip outputs were energized and the number of times the close outputs were energized. Counters are available as triggers for Datalogging and Sequence of Events.

The counter values are stored in non-volatile memory and are not affected by a loss of power to the relay. Each counter accommodates 99,999,999 operation counts. Each counter provides the user with the ability to preset a value. The counter will increment from the preset value. Each counter can be reset to zero.

Breaker Operation Alarm Limit

The "Operation Limit" provides the user with the ability to set a predetermined alarm point for the number of Breaker operations initiated by the relay. When the "Operation Limit" setting is exceeded the "Max Breaker Operations" alarm will be triggered if enabled.

■**NOTE:** The Undo/Refresh and Save buttons are applicable for the Operation Limit only, and do not affect the Counters. The Exit button closes the window.

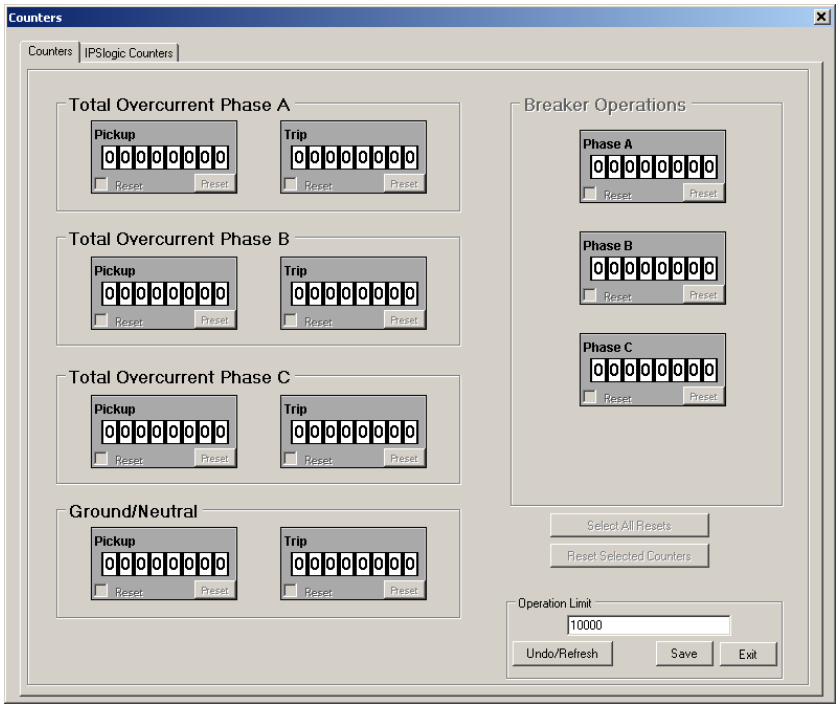


Figure 3-57 Counters Dialog Screen

Monitor/Counters/IPSlogic Counters

The IPSlogic Counters tab displays the IPSlogic Counters Monitoring/Setting screen (Figure 3-58). The counter is incremented each time the corresponding IPSlogic element times out. Each counter has a range of 0 to 65000. When a counter reaches the maximum value, it will not increment until reset to zero or preset to a lower value.

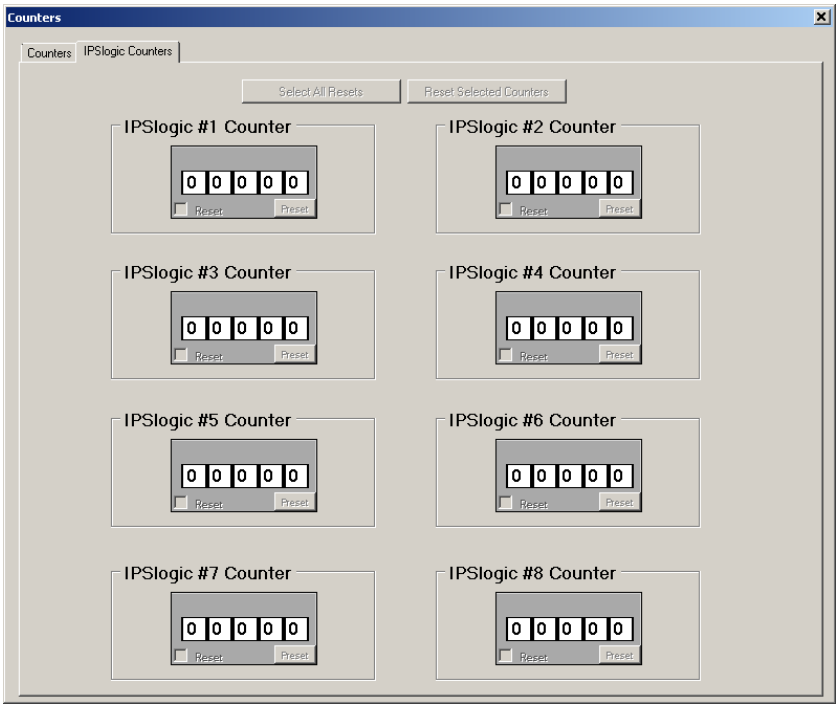


Figure 3-58 IPSlogic Counters Dialog Screen

Monitor/Live Oscillograph

Selecting the Live Oscillograph submenu item displays the Live Oscillograph confirmation screen (Figure 3-59). Select **Yes** and IPScom will display the Live Oscillograph screen (Figure 3-60). Select **Start** to display live data for the eight channels with Power, Power Quality, Phasors and Harmonics. Select **Stop** during the live display to pause the screen.

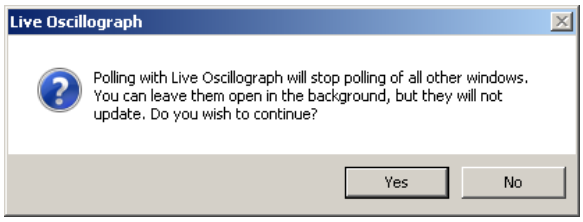


Figure 3-59 Live Oscillograph Confirmation Screen

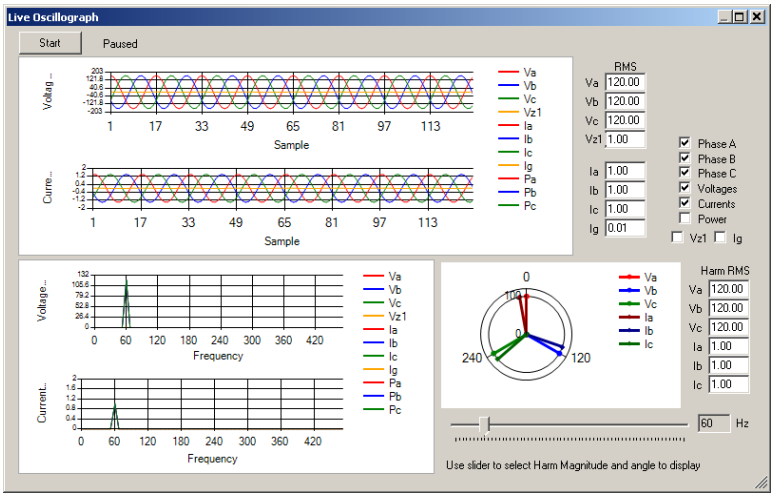


Figure 3-60 Live Oscillograph Display Screen

Monitor/Battery Charger Monitoring

When the Battery Charger function is Enabled in the **Setpoints/Common Setpoints/ IED Power Supply/Battery Charger Monitor** screen, this selection displays the Battery Charger Monitoring screen (Figure 3-61). Available monitoring parameters are based on the Battery Type selection. When the Battery Charger function is Disabled, IPScom will display an error message (Figure 3-62).

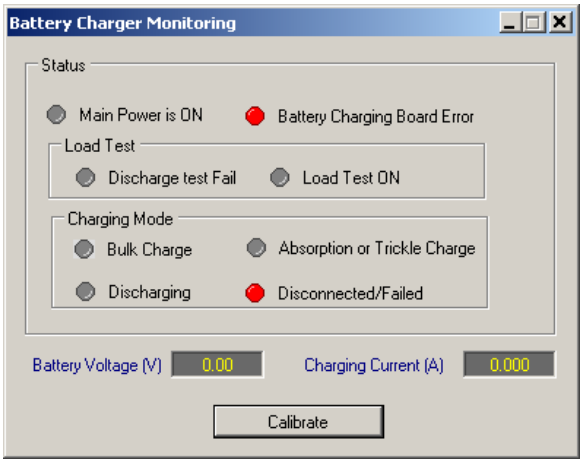


Figure 3-61 Battery Charger Monitoring Screen

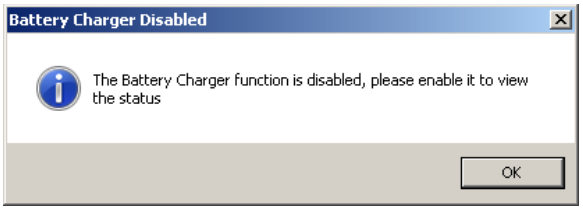


Figure 3-62 Battery Charger Function Disabled Error Screen

Monitor/Breaker Accumulator Status

When the Breaker Monitor function is enabled, the Breaker Accumulator Status screen (Figure 3-63) will display the Accumulator Status based on the Breaker Monitor Timing selection of the active profile. Preset Accumulator values for each phase may also be set.

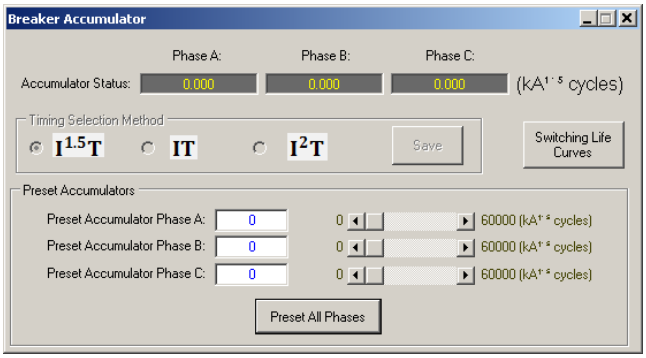
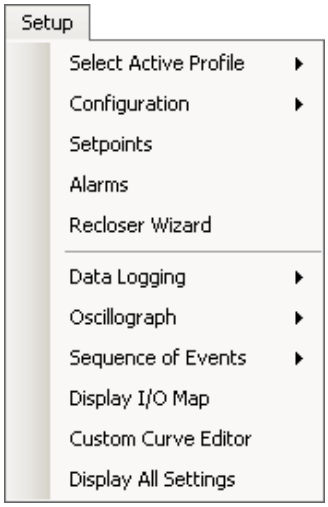


Figure 3-63 Breaker Accumulator Status Screen

SETUP MENU



The **Setup** menu provides access to the screens used to configure, monitor or interrogate the relay. The submenus provided are: **Select Active Profile, Configuration, Setpoints, Alarms, Recloser Wizard, Data Logging, Oscillograph, Sequence of Events, Display I/O Map, Custom Curve Editor** and **Display All Settings.**

Setup/Select Active Profile

Selects the Active Setpoint Profile providing the operating parameters of the relay.

Setup/Configuration/Relay

The **Configuration/Relay** selection displays the **System Setup** dialog screens which allow the user to input the relevant information regarding the system on which the relay is applied. Example screens are shown in Figure 3-64 through Figure 3-71. The settings displayed are based on the hardware configuration. See **Section 4.2 System Setup** for detailed information regarding the specific elements of the System Setup dialog screens.

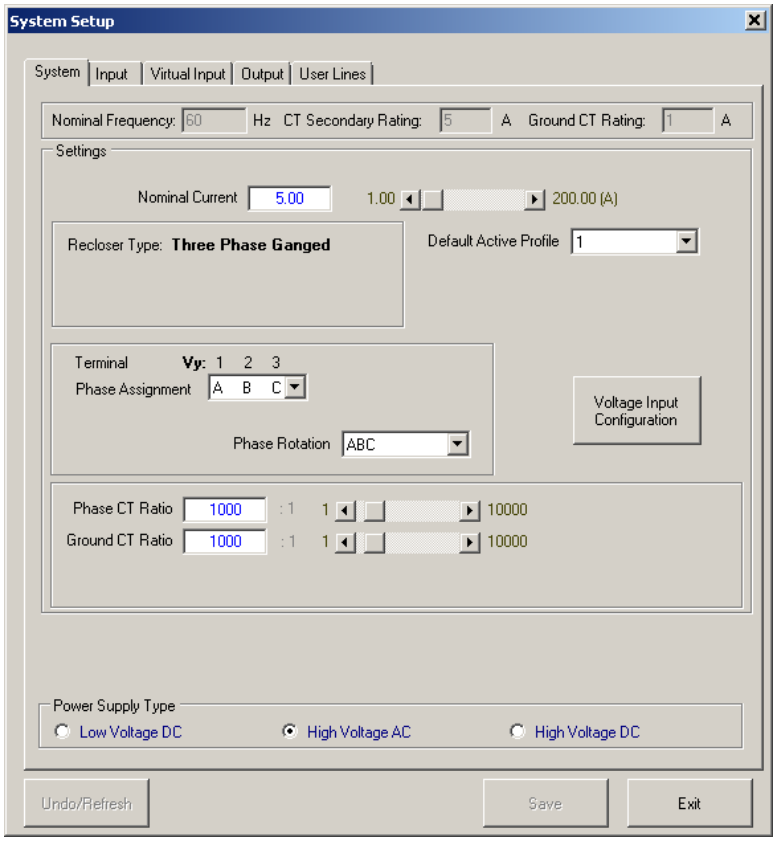


Figure 3-64 System Setup Screen (Shown: Voltage Input X4)

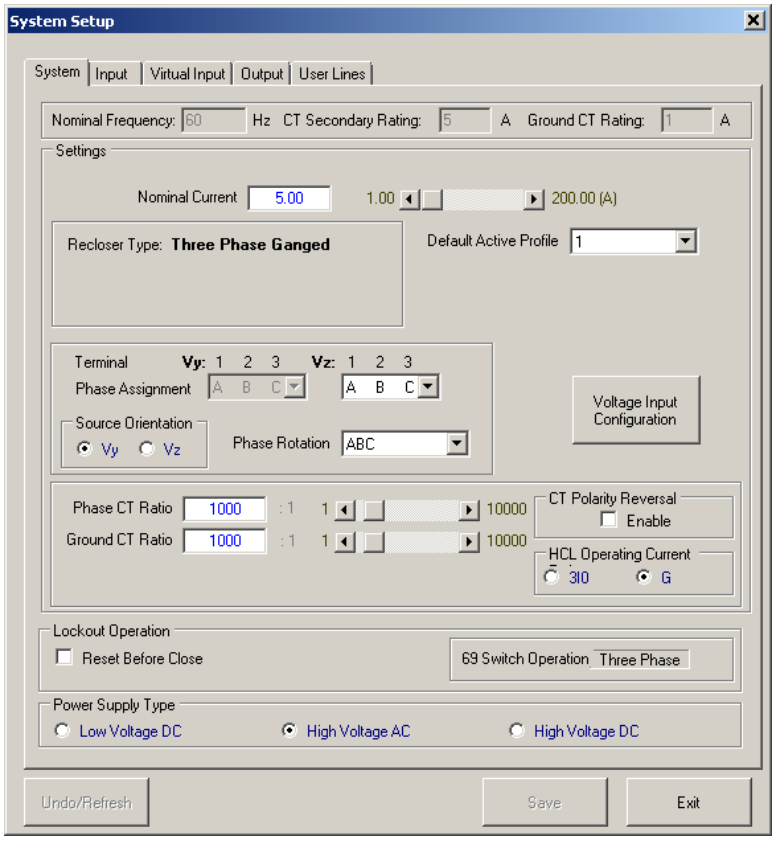


Figure 3-65 System Setup Screen (Shown: Voltage Input H6, Autoreclose Option)

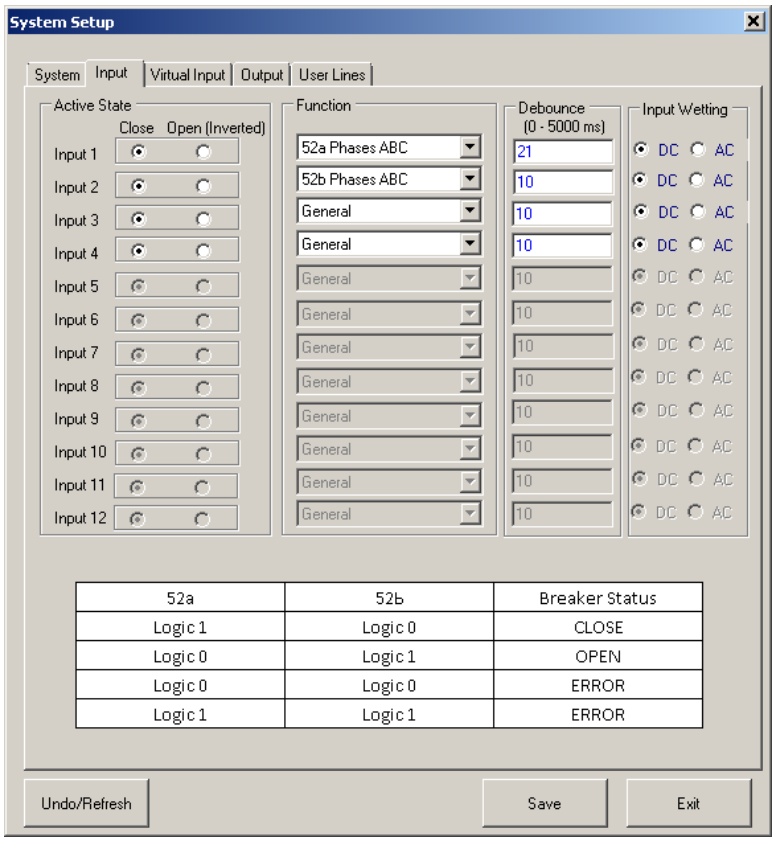


Figure 3-66 System Setup – Input Tab Dialog Screen (without Extended I/O)

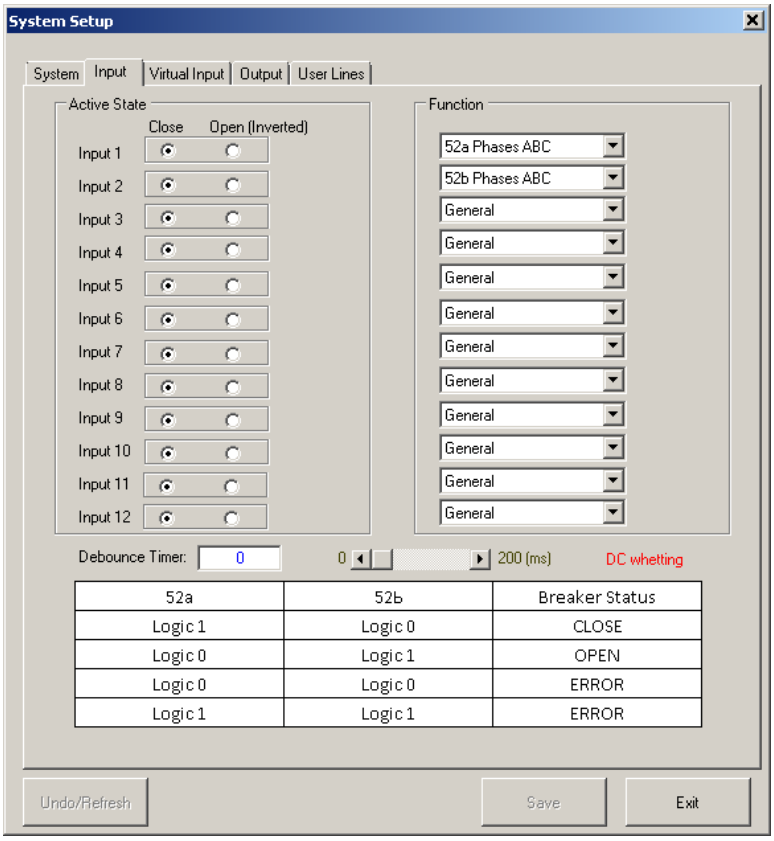


Figure 3-67 System Setup – Input Tab Dialog Screen (Autoreclose Option and Extended I/O)

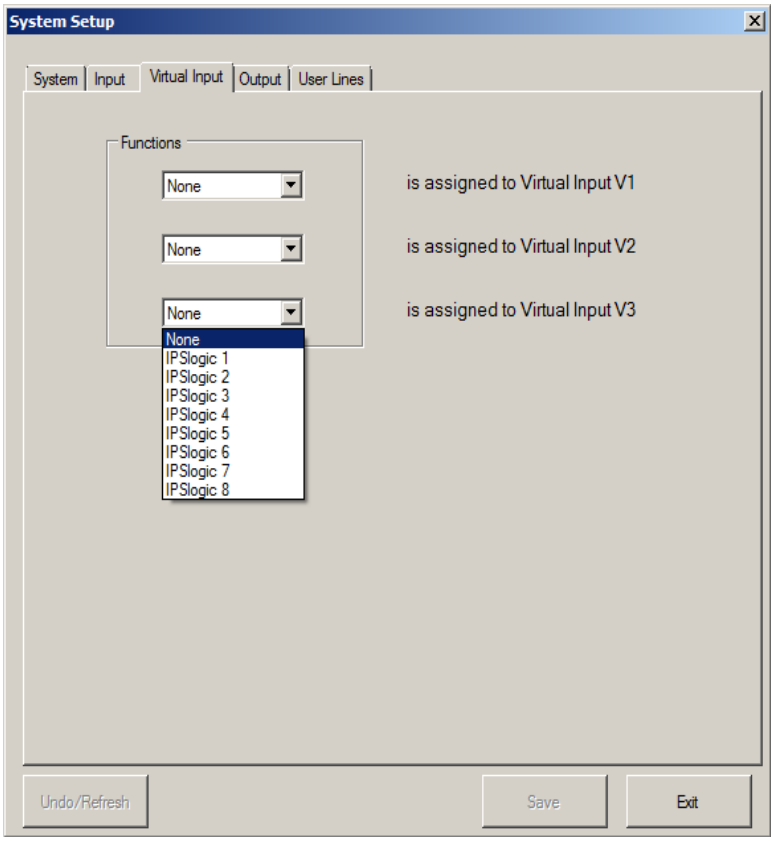


Figure 3-68 System Setup – Virtual Input Tab Dialog Screen

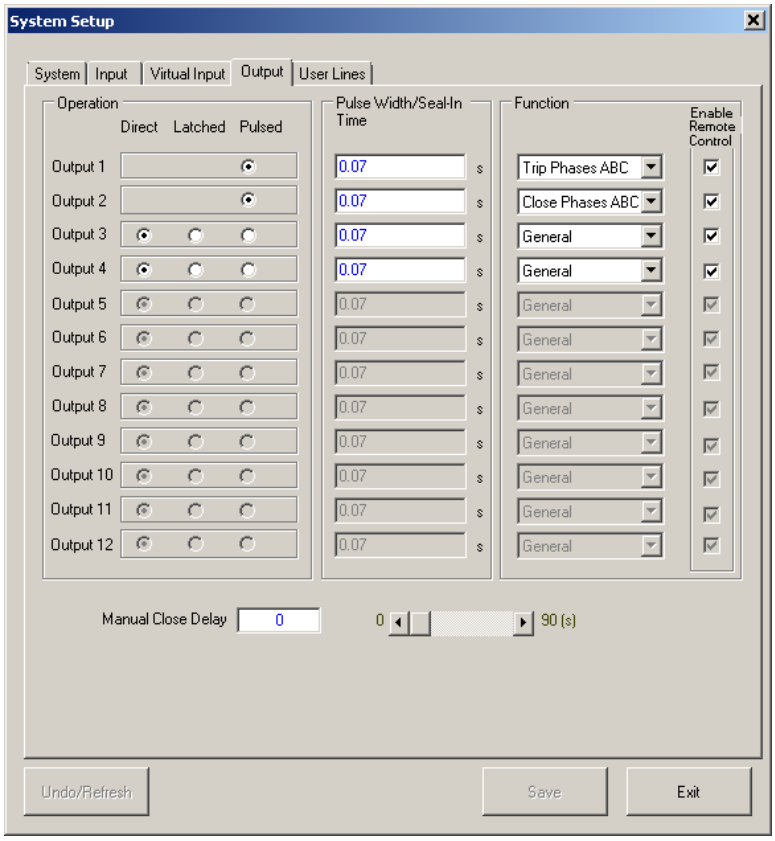


Figure 3-69 System Setup – Output Tab Dialog Screen (without Extended I/O)

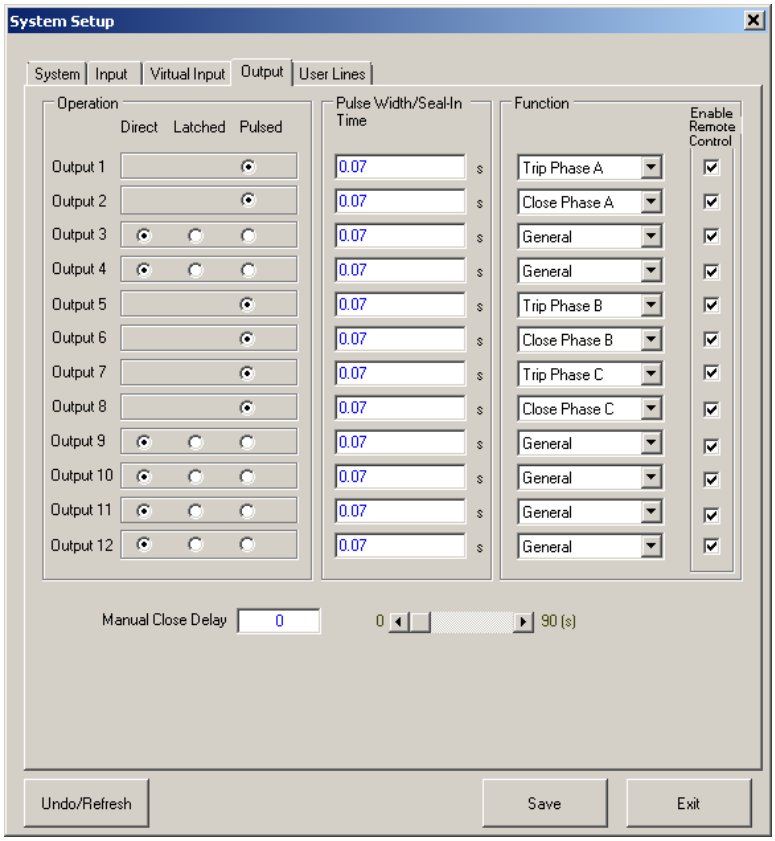


Figure 3-70 System Setup – Output Tab Dialog Screen (Autoreclose Option and Extended I/O)

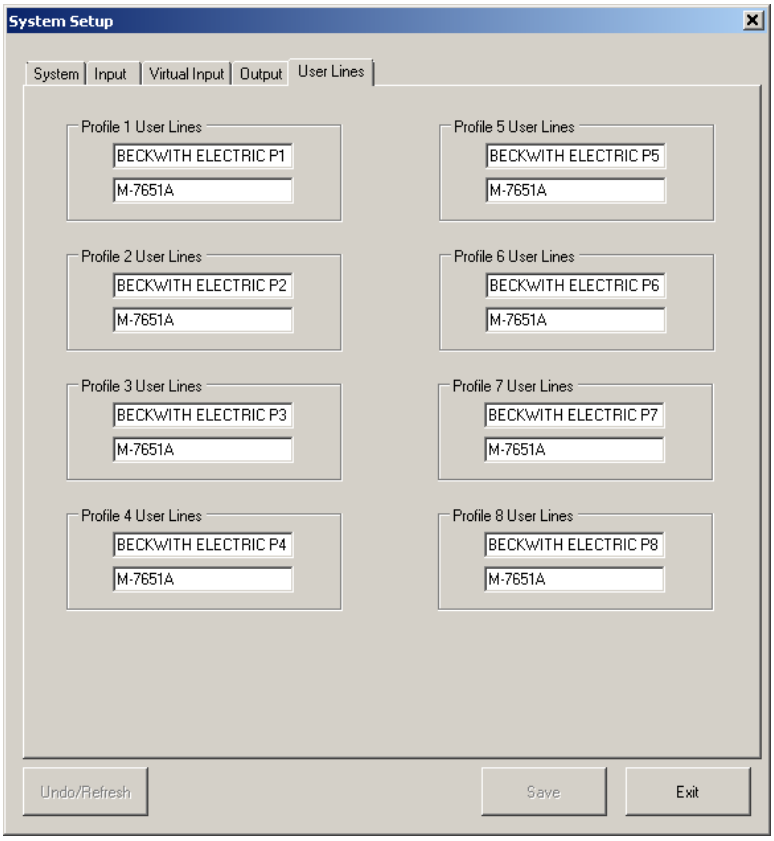
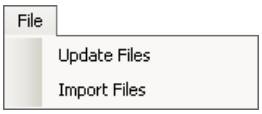


Figure 3-71 System Setup – User Lines Tab Dialog Screen

Setup/Configuration/Front Panel Functions

Front Panel Setup/File Menu



In File Mode, the Front Panel Setup "File/Update Files" selection saves ALL of the Front Panel configuration settings to the currently open SUP file. In Connected Mode, this selection will update the Front Panel configuration settings in the target control.

Front Panel Setup/Programmable Buttons

The Programmable Button feature allows the user to customize the functionality of the front panel pushbuttons S10 through S17 as shown in Figure 2-2. Pushbuttons S11, S13 and S15 are preassigned, but can be reprogrammed by the user through the interactive Front Panel Setup dialog screen (Figure 3-72). These six pushbuttons can also be mapped to "Smart Functions" as shown in Figure 3-73.

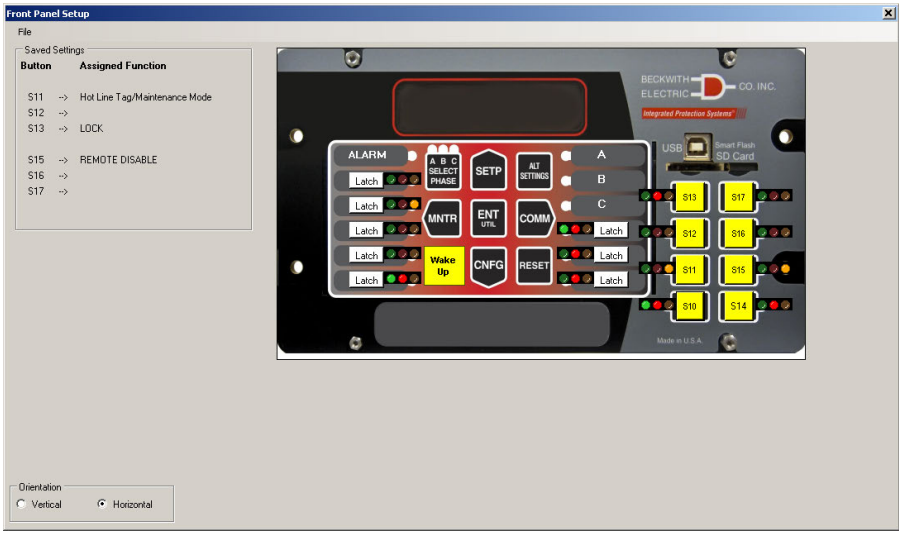


Figure 3-72 Front Panel Setup Dialog Screen

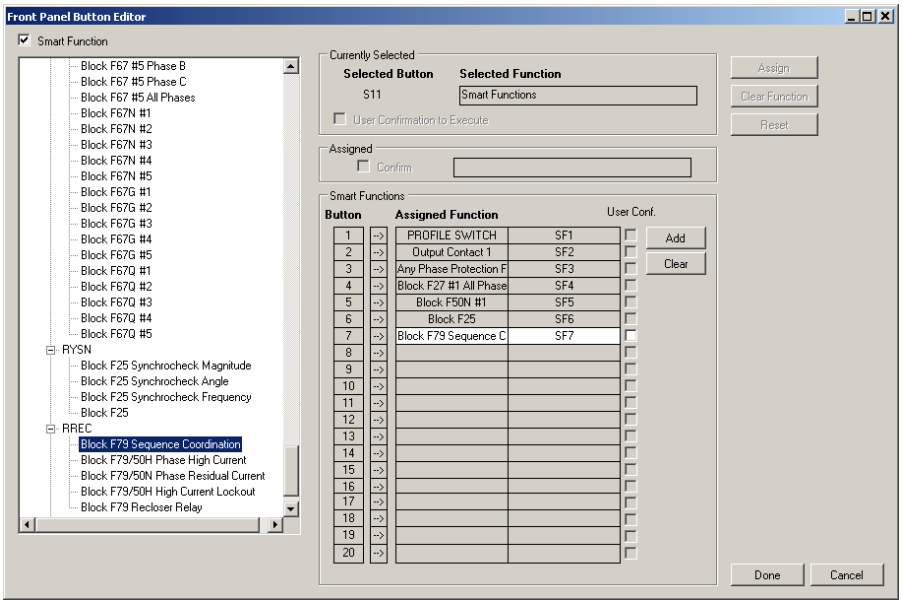


Figure 3-73 Button Function Setup "Smart Functions" Dialog Screen

Front Panel Setup/LEDs

The LED programming feature allows the user to customize the functionality of the LEDs through the Front Panel Setup screen (Figure 3-72). Selecting an LED red, green, or amber button activates the LED Editor Dialog Screen (Figure 3-74) which provides an interactive worksheet for programming the desired logic to activate or deactivate the LEDs based on the status of the relay functions.

Selecting the "Latch" button allows the user to customize the latch behavior of the LED. The LED may be programmed to latch on Red, Green, Amber, or None.

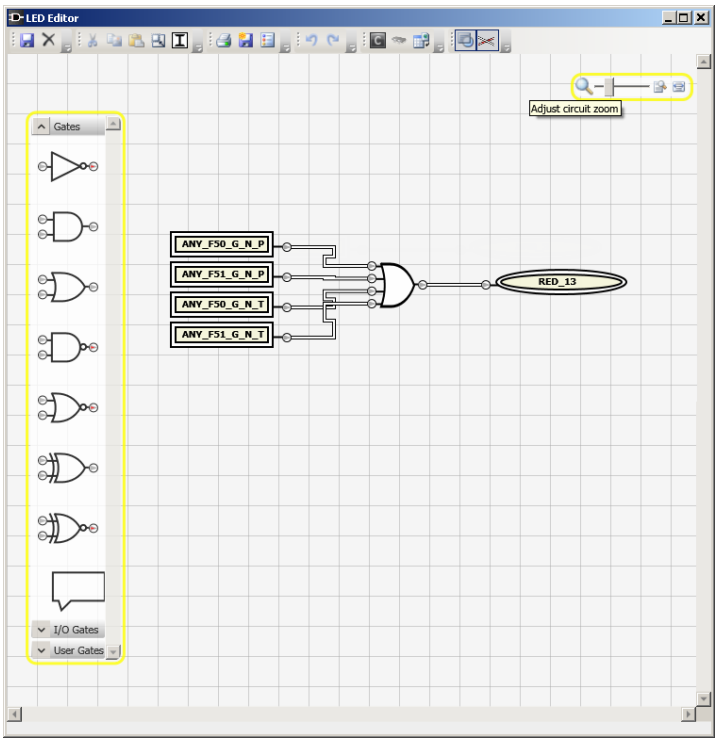


Figure 3-74 LED Editor Dialog Screen

Front Panel Setup/Wake Up Screen List

Select the **Wake Up** pushbutton in the Front Panel Setup Dialog Screen as shown in (Figure 3-75) to display the Wake Up Screen List (Figure 3-76).

The Wakeup Screens feature allows the user to select specific relay parameters that will be displayed when the relay is wakened by depressing the **EXIT/Wake** pushbutton. When the relay is wakened the selected parameters are displayed in a cycling fashion. The display can also be directed to a specific parameter by utilizing the ⬆ or ⬇ pushbuttons. Pressing the **EXIT** pushbutton returns to the User Lines screen.

See **Chapter 2**, **Operation**,and **Section 4.1 Unit Setup** for additional information.

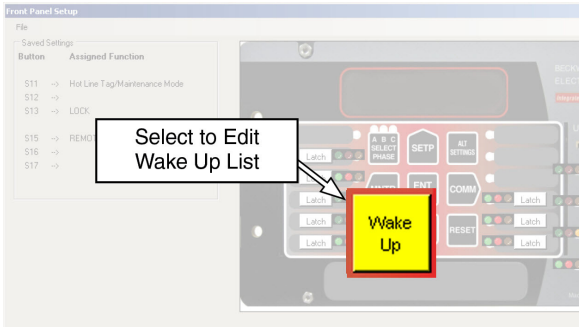


Figure 3-75 Front Panel Setup Dialog Screen – Edit Wake Up Screen Selection

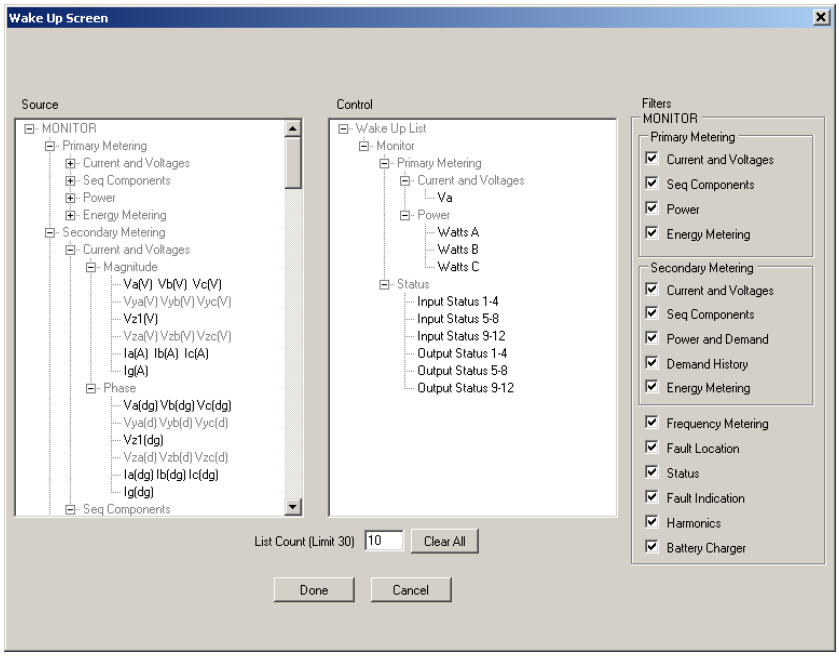


Figure 3-76 Wake Up Screen List Selection Screen

Setup/Configuration/Profile Manager

Profile Manager allows the user to perform the following:

- Set the Maximum Number of Profiles in use
- Assign a custom name to each profile

Profile Manager/Profile Names

The user may assign a custom name to each available profile. Each Profile Name can have up to 20 ASCII characters (excluding "~", "\", "{" "}" and "|").

When connected, the relay will then display the custom profile name in the Edit Profile and Active Profile menus. If the user has not assigned a custom name, then the control will display the generic "Profile #" where # is the profile number.

In IPScom, the custom name will display on the Profile tab in the Setpoints screen. The custom name will also be displayed in the Select Active Profile menu and status bar.

Profile Manager/Maximum Number of Profiles

The user may define the maximum number of profiles that can be used. The default maximum number of profiles is eight. The profiles available for programming will always be consecutive, for example if the maximum number of profiles is set to 4, then the ONLY profiles that will be available for programming will be Profile 1, 2, 3 and 4.

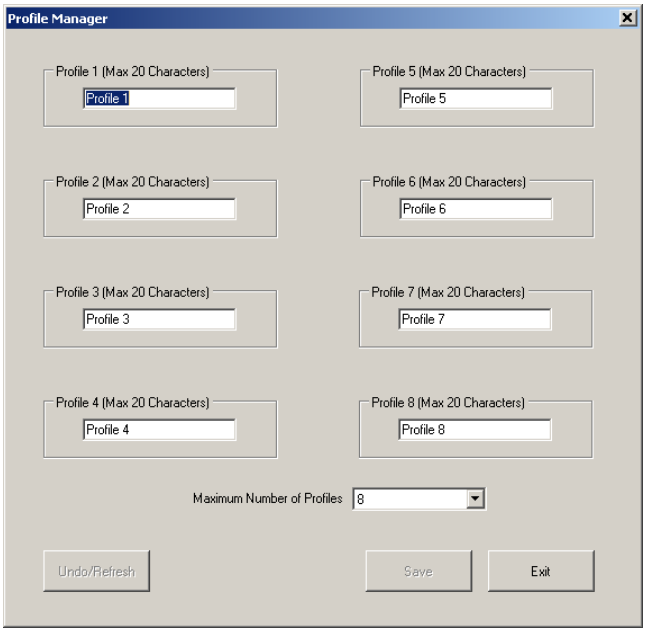


Figure 3-77 Profile Manager Dialog Screen

Setup/Configuration/Fault Distance Parameters

The Fault Distance Parameters window (Figure 3-78) allows the user to enter the necessary parameters used to calculate Fault distance. The fault locator uses the following to calculate fault distance:

- Fault Type
- Replica Line Impedance Settings (Z_{1L} and Z_{0L})
- Line Length
- Fault Conditions

The fault distance is calculated without communications channels, special instrument transformers, or pre-fault information.

This feature contributes to efficient dispatch of line crews and fast restoration of service. The fault locator requires three-phase voltage inputs (V_A, V_B and V_C). Wye-connected voltages are required for phase and ground fault distance calculations (i.e., all fault types). Only phase fault distance calculations are available with delta-connected voltages (i.e., A-B[G], B-C[G], C-A[G] and A-B-C).

The fault distance is not available when no voltage or only a single-phase voltage is connected. The fault distance also does not operate for ground faults on ungrounded, high-impedance grounded, or Petersen Coil grounded systems.

The Fault Distance is displayed in the Primary and Secondary Metering screens.

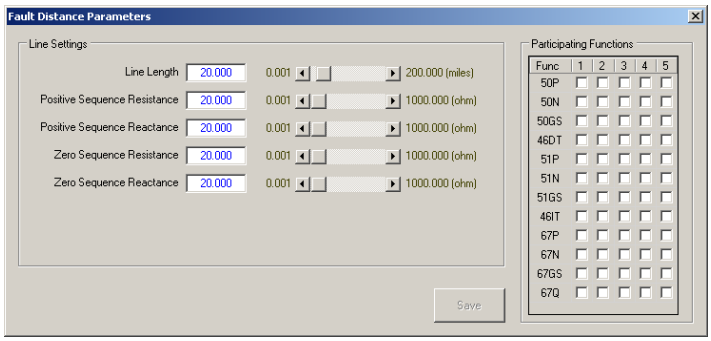


Figure 3-78 Fault Distance Parameters

Triggers

An event record with the fault distance is generated when the following functions trip:

- 50P, 50N, 50G/GS
- 51P, 51N, 51G/GS
- 46DT, 46IT
- 67P, 67N, 67G/GS, 67Q

Triggers are selectable to each individual element level (e.g., 67G3).

Fault Type

The fault type is displayed in the IPScom bottom menu bar using the following key:

- AG for A-phase to ground faults
- BG for B-phase to ground faults
- CG for C-phase to ground faults
- AB for A–B phase-to-phase faults
- BC for B–C phase-to-phase faults
- CA for C–A phase-to-phase faults
- ABG for A–B phase-to-phase to ground faults
- BCG for B–C phase-to-phase to ground faults
- CAG for C–A phase-to-phase to ground faults
- ABC for three-phase faults

Line Settings

Line impedance settings Z1MAG, Z1ANG, Z0MAG, and Z0ANG are used in the fault locator where:

$Z_{1L} = |Z1MAG| \angle Z1ANG$

$Z_{0L} = |Z0MAG| \angle Z0ANG$

A corresponding line length setting (LL) is also used in the fault locator.

Fault Location – Sequence of Events

The fault location is displayed in the Sequence of Events file and can be selected at any point along the event.

Setup/Setpoints

The **Setpoints** menu selection displays the Setpoints dialog screen from which the individual Function Setting dialog screens can be accessed. Figure 3-79 and Figure 3-80 represent typical examples of the Setpoints dialog screen. Selecting a Function Setting button will display the corresponding function dialog screen (See Figure 3-81 as an example).

See **Chapter 5 Setpoints** for detailed information regarding the specific elements of the Setpoints screens.

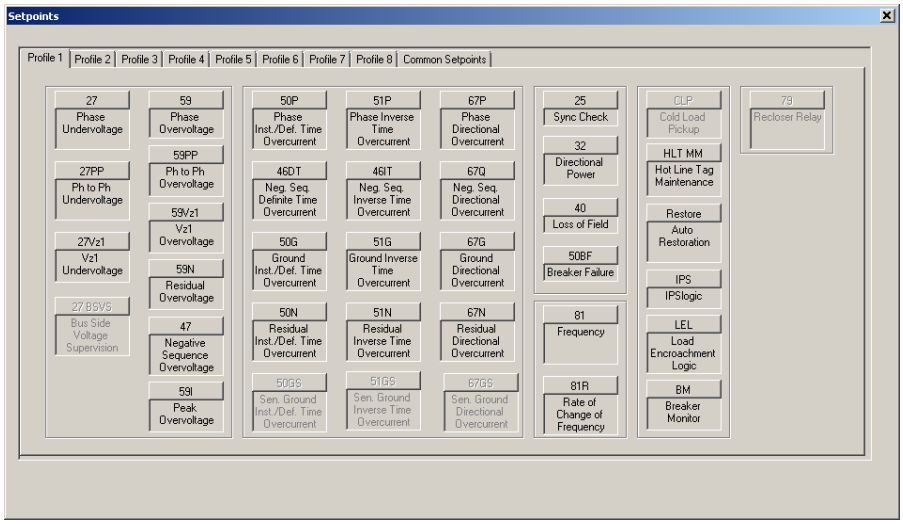


Figure 3-79 Setpoints Dialog Screen Example

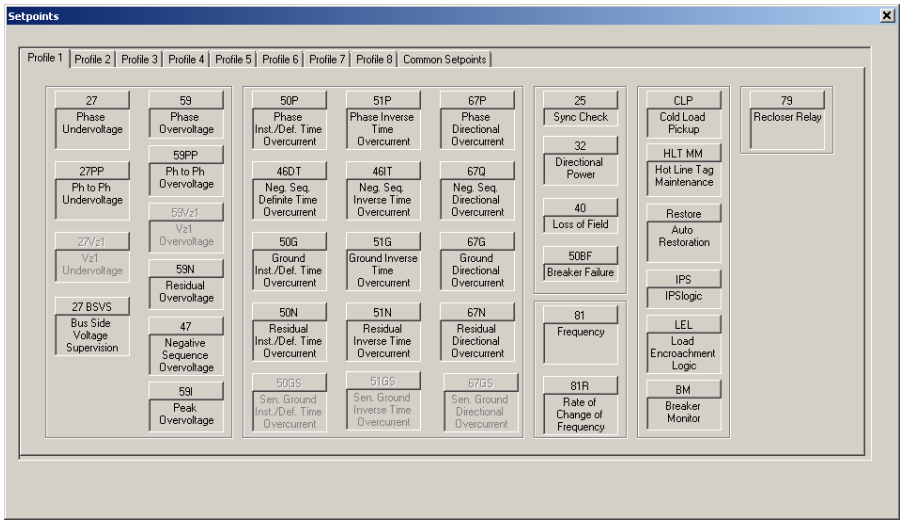


Figure 3-80 Setpoints Dialog Screen (Autoreclose Option)

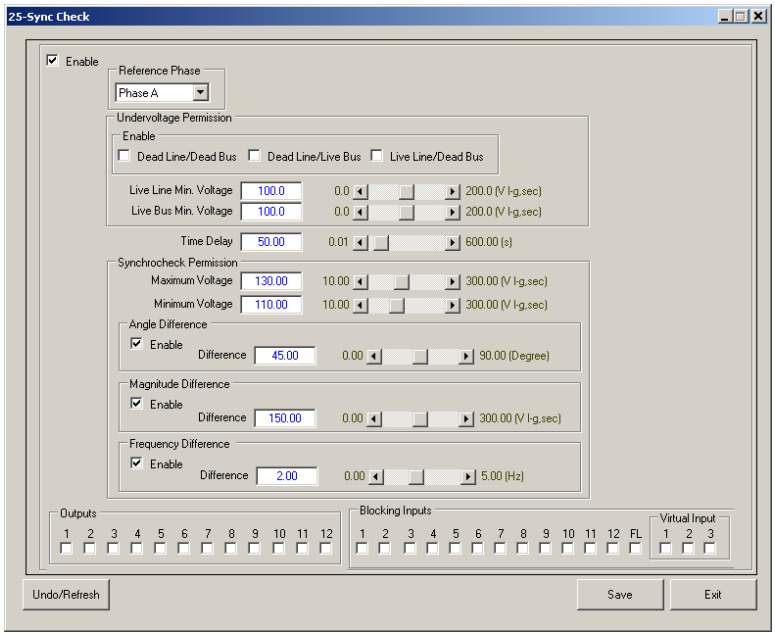


Figure 3-81 Example Function Dialog Screen

Setup/Alarms

The **Alarms** selection displays the Alarms dialog screen (Figure 3-82). The following Alarms can be enabled or disabled:

- Trip Close Alarm – occurs if the 52A and 52B contacts are in the same state.
- Battery Status Alarm – occurs if the battery is not present, fails the load test, or is not charging.
- Gas Pressure Alarm – occurs if the input for the gas pressure is high. Alarm is only selectable when the Autoreclose option is purchased.
- Max Breaker Operations Alarm – occurs if the Operations Limit is exceeded.

The following Alarms are enabled by default and may not be disabled:

- EEprom Setpoints Checksum Alarm – occurs if the checksum is bad.
- DSP Watchdog Alarm – occurs if the DSP is not running correctly.
- EEprom Calibration Checksum Alarm – occurs if the checksum is bad.
- Flash Not Formatted Alarm – occurs if the internal flash drive is not formatted.
- Internal Battery Failure – occurs when the internal battery that provides back up power to the non-volatile memory has failed. This condition will set the alarm when the relay reboots and the battery has been determined to have failed.

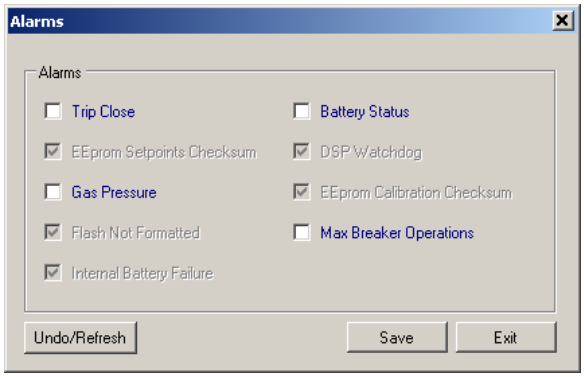


Figure 3-82 Alarms Dialog Screen

Setup/Recloser Wizard

The **Recloser Wizard** selection displays the Recloser Common Settings dialog screen (Figure 3-83). The Recloser Wizard is a series of settings screens which guide the user through the necessary steps to configure the Recloser Control. The Recloser Wizard screens include:

- Recloser Common settings – confirmation of hardware configuration
- Profile and File Name settings
- Phase Overcurrent settings
- Ground Overcurrent settings
- Residual (Neutral) Overcurrent settings
- Cold Load settings
- Hot Line Tag settings
- Automatic Reclosing settings
- Settings Final Confirmation

■**NOTE:** See **Section 5.4 Recloser Wizard** for detailed information regarding the Recloser Wizard settings screens.

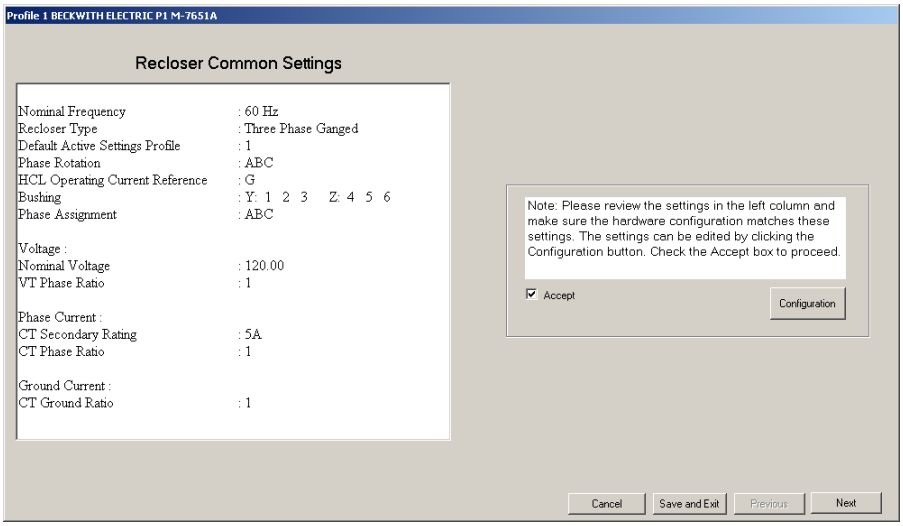


Figure 3-83 Recloser Wizard – Recloser Common Settings Screen

Setup/Data Logging

The **Extended Data Logging** feature provides the user with the ability to initiate data logging of all relay parameters of the selected relay for downloading at a later time. Data is recorded internally into non-volatile memory.

The Extended Data Logging feature significantly increases the amount of data that the relay can store – up to 210,000 records. The data log recorder contains two storage elements: the current data log file and compressed history files. The current file can contain up to 3500 records. Once this record limit is reached, the relay will create a new file, and continue to record data into this new file, while compressing the previous file in the background. This operation may take up to 20 minutes. Data log download is not possible while the compression task is active.

Data logging will continue indefinitely as long as the Data Log Interval is set to a non-zero value. A zero value for the data log interval will effectively disable data logging. The data log, can be downloaded using IPScom. The data can be viewed using the included BecoPlot Analysis Software or any Comtrade compatible viewer.

Data logging interval ranges from 0 to 3600 seconds with an increment of 60 seconds. Once data logging is enabled, the relay will store the data in records at the data log interval rate. The checksum is used to ensure the integrity of the record stored. Due to the internal structure of the Comtrade format, time stamping is always performed. A total of 260 Mbytes of data can be saved in non-volatile memory.

See Data Logging on page 4–21 for detailed information regarding setup of the Extended Data Logging feature and the retrieval and clearing of Data Log records.

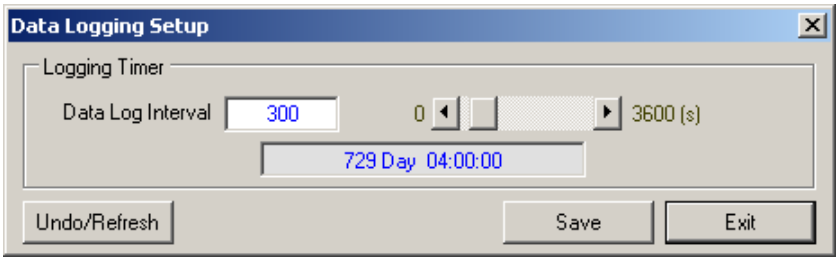


Figure 3-84 Data Logging Setup Dialog Screen

Setup/Oscillograph

The **Oscillograph** submenu allows setting and control over the relay's oscillograph recorder. The **Setup** command allows the user to set the number of samples per cycle, the post trigger delay, the length (in cycles) of the Oscillograph record and triggering designations to be made (Figure 3-85).

■**NOTE:** Selecting "Trigger Selection" in the Setup Oscillograph Recorder screen displays the "Oscillograph Trigger" dialog screen (Figure 3-86). It is NOT a command to trigger the Oscillograph.

The Setup/Oscillograph submenu item **Trigger** sends a command to the relay to capture a waveform. **Retrieve** allows the selection of a specific Oscillograph record and downloads and saves the data to a Comtrade format file. **Clear** erases all existing records. The included BecoPlot Oscillograph Analysis Software program (Utility/BecoPlot) or any Comtrade reader is required to view the downloaded oscillograph files.

See Oscillograph Recorder on page 2–12 for detailed information regarding retrieval and clearing of Oscillograph records.

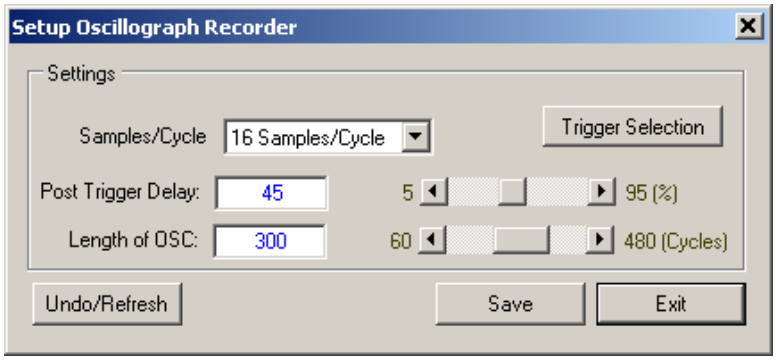


Figure 3-85 Setup Oscillograph Recorder Dialog Screen

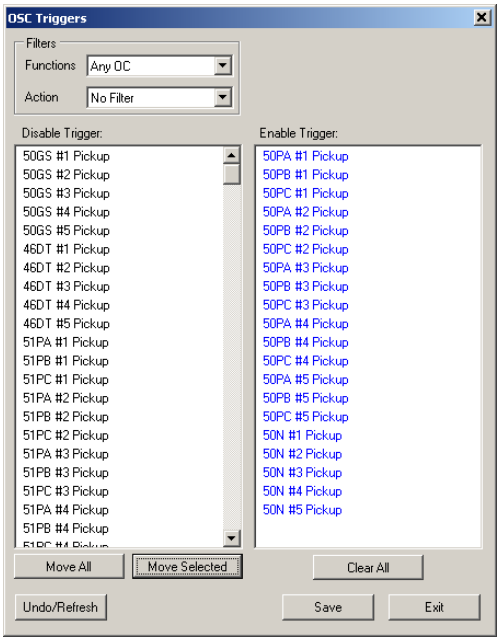


Figure 3-86 Oscillograph Trigger Selection Dialog Screen

Setup/Sequence of Events

The Sequence of Events submenu allows the user to **Setup**, **Retrieve** and **Clear** Sequence of Events records. The **Setup** command displays the **Sequence of Events Trigger Setup** dialog screen (Figure 3-87). To enable a trigger, scroll through the Trigger listing on the left side of the screen and drag the desired triggers to the "Enable Trigger" section on the right side of the screen. The trigger list can be filtered to display specific "Functions" (Overcurrent, Overvoltage, Overfrequency, Function ABC) or specific "Actions" (Pickup, Timeout, Pickup Dropout, Timeout Dropout). The **Retrieve** command allows the user to download and save the record to a file. The **Clear** command clears all Sequence of Events records in the relay.

See Sequence of Events on page 2–14 for detailed information regarding retrieval and clearing of Sequence of Events records.

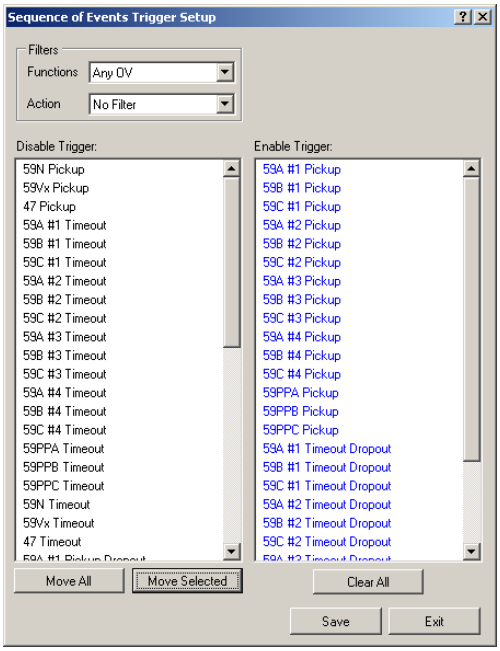


Figure 3-87 Sequence of Events Setup Dialog Screen

Setup/Display I/O Map

The **Display I/O Map** submenu displays the I/O Map dialog screen (Figure 3-88), which contains a chart of programmed input and output contacts, in order to allow scrolling through all relay output and blocking input configurations.

The I/O Map screen includes Function hyperlinks which allow the user to open an individual relay function setpoints screen and return to the scrolling dialog screen. All available parameters can be reviewed or changed when opening a function setpoints screen from the Display I/O Map scrolling dialog screen. The I/O Map may also be cloned to another Profile. Select the target Profile from the dropdown adjacent to the "Copy To" button, and then select **Copy To**. IPScom will display a "Clone Copy Complete" confirmation screen.

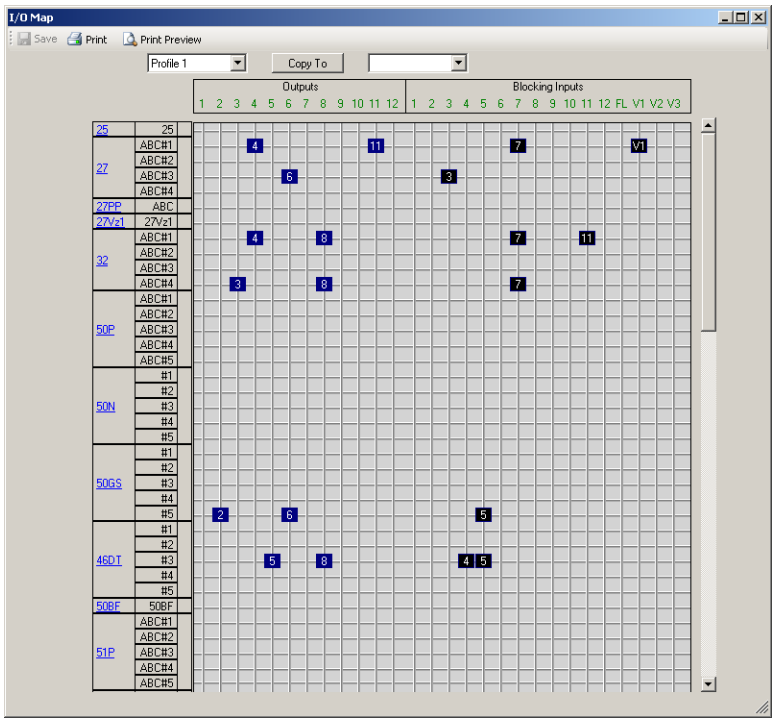


Figure 3-88 Display I/O Map Dialog Screen

Setup/Custom Curve Editor

The **Custom Curve Editor** submenu displays the Custom Curves interactive dialog screen (Figure 3-89), which allows the user to define up to 4 custom Inverse Time Curves. Each curve has a total of 64 user defined "x-y" coordinates. The "x" coordinate is the pickup ratio and the "y" coordinate is the time value. See **Section 5.1 System Setpoints** for detailed information.

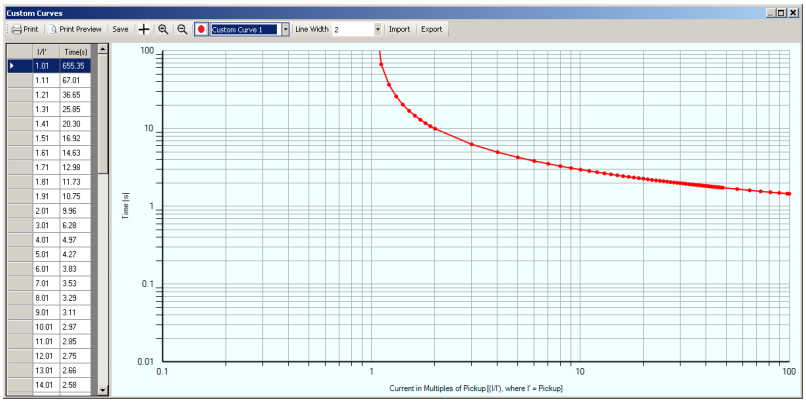


Figure 3-89 Custom Curves Dialog Screen

Setup/Display All Settings

Selecting **Display All Settings** displays the **All Setpoints** interactive screen (Figure 3-90). This screen contains the settings for each control function within a single window to allow scrolling through all control setpoint and configuration values. The individual Feature and Function selections are described in the applicable sections.

The All Setpoints screen includes Hyperlinks to allow the user to access the individual control function dialog screen, review and/or change settings, then return to the scrolling All Setpoints screen. All available function parameters can be reviewed or changed in the individual control function dialog screen. The All Setpoints screen can also be printed to any system printer.

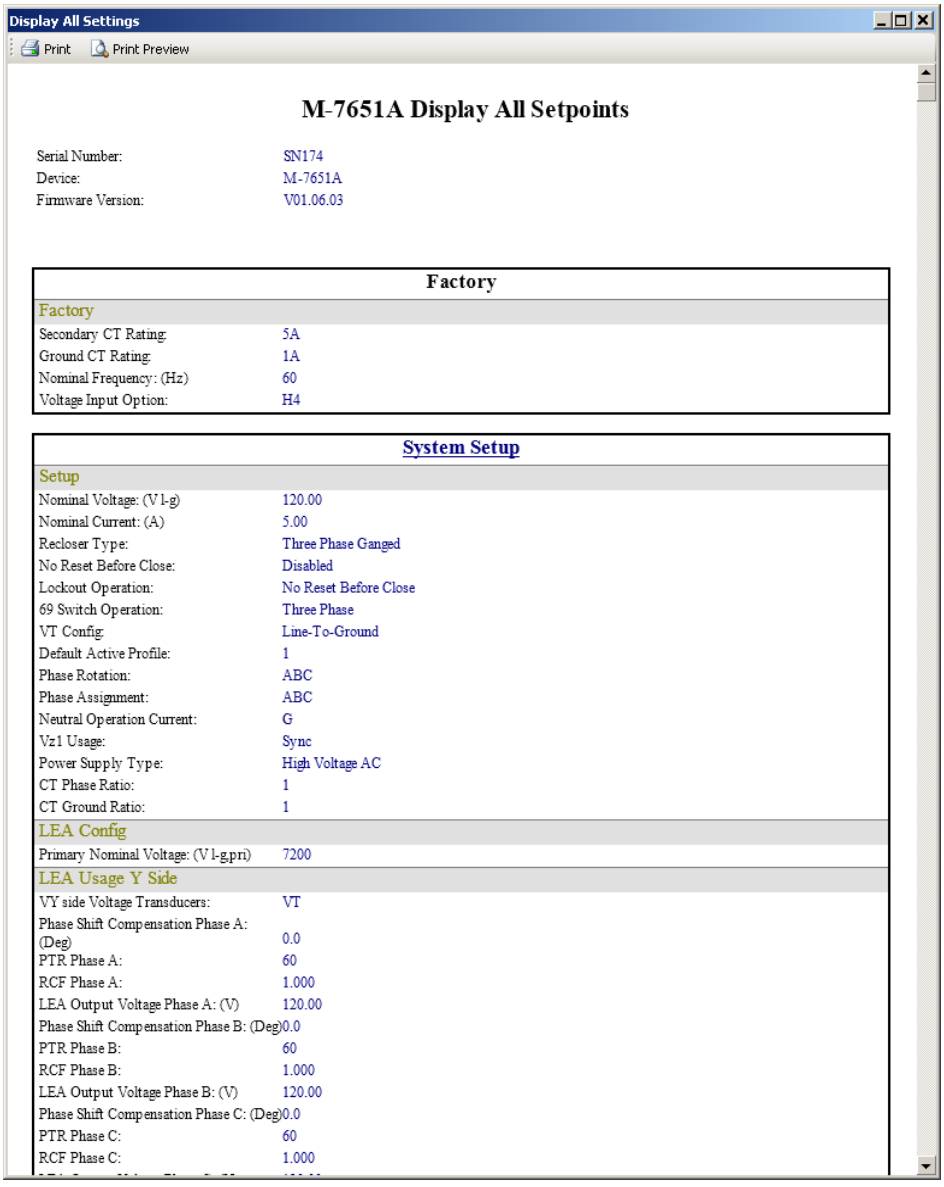
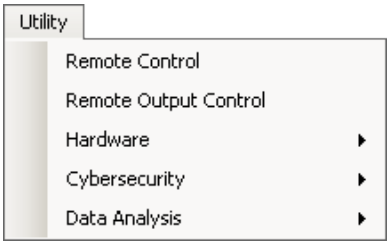


Figure 3-90 Display All Setpoints Interactive Screen

UTILITY MENU



Utility/Remote Control

The **Remote Control** feature allows the user to observe the status of the individual phase breakers of the relay. The user can also initiate the following commands:

- Trip Lockout
- Close
- Reset
- Disable Hot Line Tag/ Maintenance Mode

Trip Lockout – sends a remote Trip and Lockout command with a user confirmation.

Close – sends a remote Close command with a user confirmation.

Reset – sends a remote Reset command to clear the lockout state of target LEDs with a user confirmation.

Disable Hot Line Tag/Maintenance Mode – A Hot Line Tag (HLT) can only be deactivated by the same source that activated the HLT. The HLT status and the HLT attributes are saved in nonvolatile memory and will not be affected by a power loss.

The HLT attributes are the Channel ID or, with Ethernet communications, the Mac Address and the Source Mac Address. Source Validation is always performed either by the Channel ID or, if enabled, by the Mac Address of the client. The firmware will use the stored "Source Mac Address" value to determine whether to use the Channel ID or the Mac Address for Source Validation. This setting is stored in nonvolatile memory at the instant of HLT activation.

When the Remote Control application is launched, IPScom will determine the HLT status. This status will determine the state of the "Enable Hot Line Tag" button. If the HLT state is inactive, the user is allowed to activate HLT. If the HLT state is active, the HLT button will display "Disable Hot Line Tag".

If the Disable Hot Line Tag and the Channel ID, or the Mac Address, does not match the Source, the firmware will not allow the command. If the command is not accepted, the state of the "Disable Hot Line Tag" button will not change. When the front panel is used to toggle the HLT, the Firmware will reject the command if it was originally enabled by remote connection whose Channel ID and MAC Address are stored in nonvolatile memory.

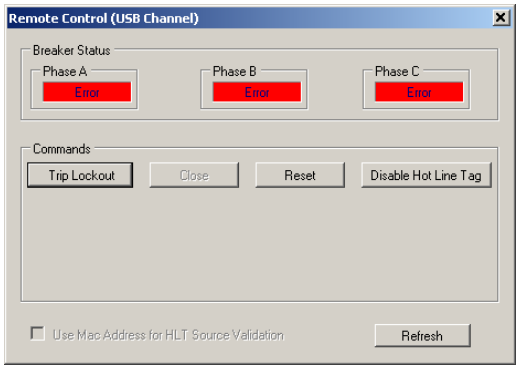


Figure 3-91 Remote Control Screen (Shown: Three-Phase Ganged Operation)

Utility/Remote Output Control

When the Relay Outputs "Enable Remote Control" feature is enabled, the user can perform the following operations from the IPScom "Remote Output Control" dialog screen Figure 3-92:

- Energize Output 1 or 2
- Energize Outputs 3 and 4 (also 5 through 12 for Expanded I/O units)
- De-energize Output 1 or 2
- De-energize Outputs 3 and 4 (also 5 through 12 for Expanded I/O units)
- Reset Latched Outputs 3 and 4 (also 5 through 12 for Expanded I/O units)
- Force Output Reset of all Outputs

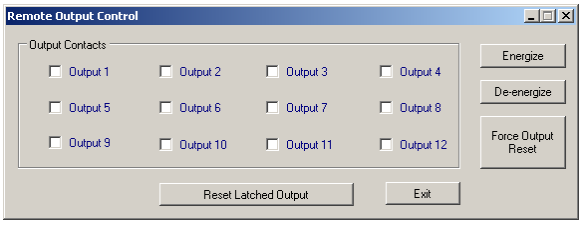
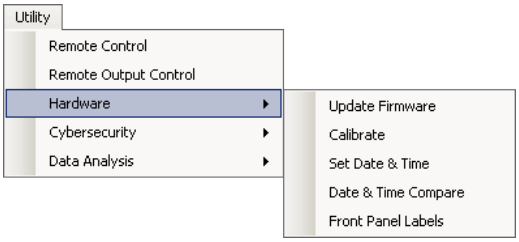


Figure 3-92 Remote Output Control Dialog Screen

Utility/Hardware Menu



Hardware/Update Firmware

The **Update Firmware** feature is available from the Utility menu selection. This feature allows the user to upload firmware updates to the relay. Firmware updates may be uploaded at any time, as the relay settings are not affected. To send a firmware update to the relay, proceed as follows:

1. Remove the relay from service.
2. From the IPScom Main Screen select **Utility/Hardware/Update Firmware**. IPScom will display the Open file dialog screen (Figure 3-93) with a default *.ppf file extension.

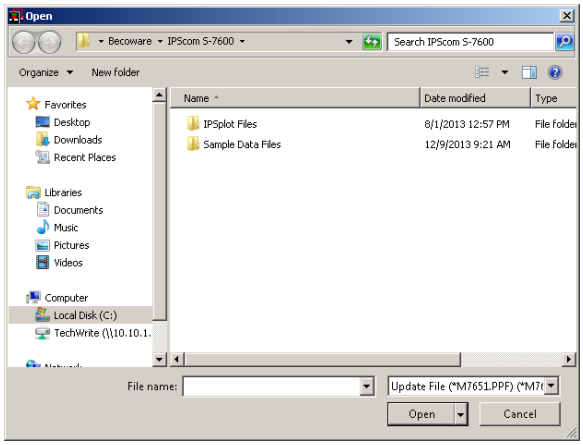


Figure 3-93 Update Firmware Open File Dialog Screen

3. Select the target file, then select **Open**. IPScom will display the following progress screens (Figure 3-94 and Figure 3-95).

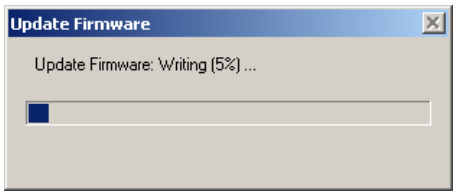


Figure 3-94 Sending Firmware File Progress Screen

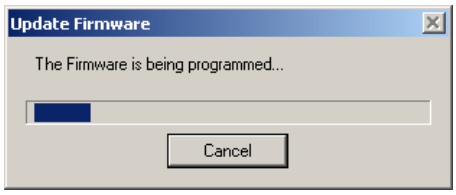


Figure 3-95 Firmware is Being Programmed Progress Screen

During the firmware update process, the relay HMI will display the following:

```
Receiving...
Firmware File
```

```
Update Process
In Progress...
```

```
Updating firmware
Please Wait
```

4. Upon completing the firmware update IPScom will display the following confirmation screen (Figure 3-96).

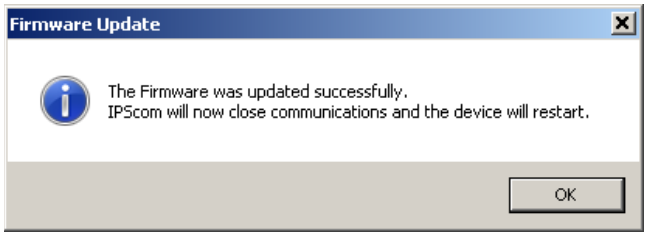


Figure 3-96 Firmware Updated Successfully Confirmation Screen

5. Select **OK**. The relay will display the following screen and reboot automatically. IPScom will return to the Main screen and communication will need to be reestablished.

```
ATTENTION! Rebooting
in 28 seconds
```

Hardware/Calibrate

The **Calibrate** menu selection provides the user with the capability to perform a calibration of the relay. Upon applying specified voltage and current inputs, the relay will perform the calibration automatically and report the success or failure of the calibration.

■**NOTE:** See **Section 4.2** System Setup for details regarding calibration with LEA input option.

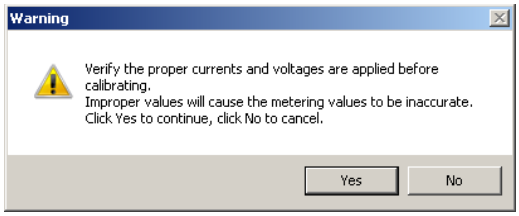


Figure 3-97 Calibration Warning Screen

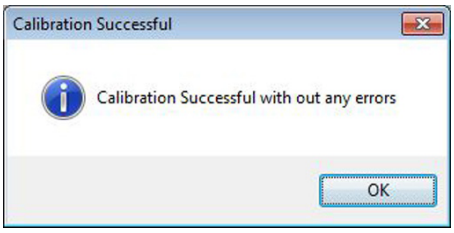


Figure 3-98 Calibration Successful Confirmation Screen

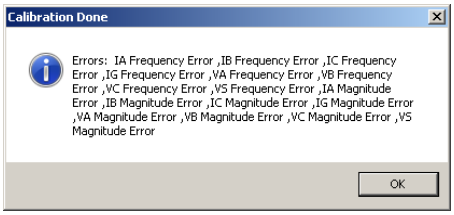


Figure 3-99 Calibration Done with Errors Screen

Hardware/Set Date & Time

The **Utility/Set Date & Time** submenu item enables the user to synchronize the internal clocks using the PC Clock or the addressed Control Clock.

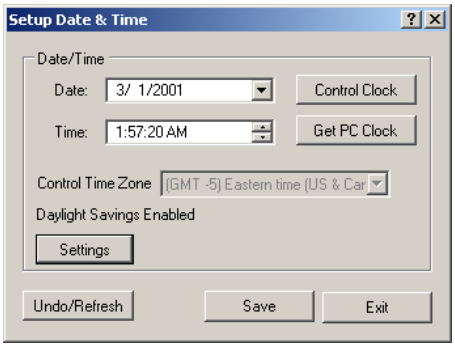


Figure 3-100 Setup Date & Time Dialog Screen

Selecting **Settings** from the Setup Date & Time dialog screen displays the "Time Zone and Daylight Savings" dialog screen (Figure 3-101)

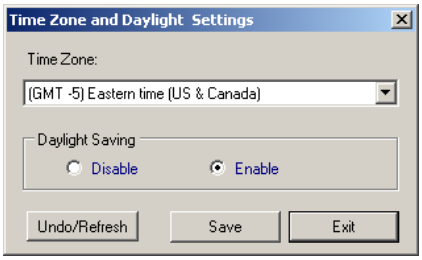


Figure 3-101 Time Zone and Daylight Savings Dialog Screen

Hardware/Date & Time Compare

The **Utility/Hardware/Date & Time Compare** submenu item enables the user to review the internal clocks for the PC or the addressed relay.

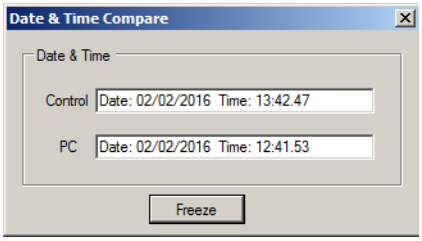


Figure 3-102 Date and Time Compare Screen

Hardware/Front Panel Labels

Selecting **Utility/Hardware/Front Panel Labels** opens a pdf form file in Adobe Acrobat (Figure 3-103). This form allows the user to create and print custom labels for the user programmable front panel LEDs and Pushbuttons. The desired custom labels are setup in the form template. The printout can then be inserted behind the front panel overlay.

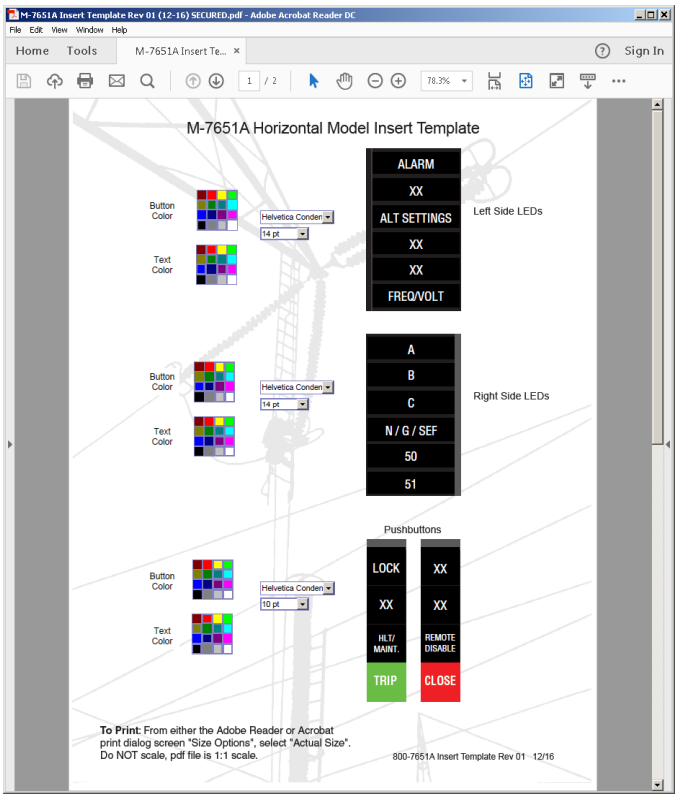
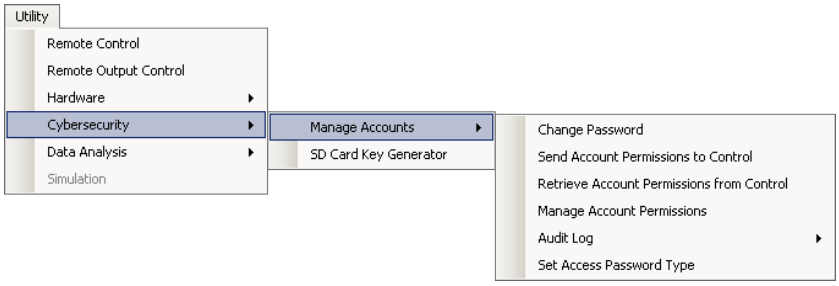


Figure 3-103 Front Panel Labels PDF Form Dialog Screen

Utility/Cybersecurity Menu



Cybersecurity/Manage Accounts

The Manage Accounts feature allows the user to change their password at any time (Figure 3-104). The Security Policy Administrator is able to:

- Send/Receive Account Permissions from the relay
- Manage the permissions associated with User Accounts and assign new Roles with customized permissions
- View/Retrieve the Audit Log
- Set Access Password Type

See the **M-7651A Communications Guide**, available on our website, for a comprehensive overview of the Manage Accounts screens and setting up Cyber Security.

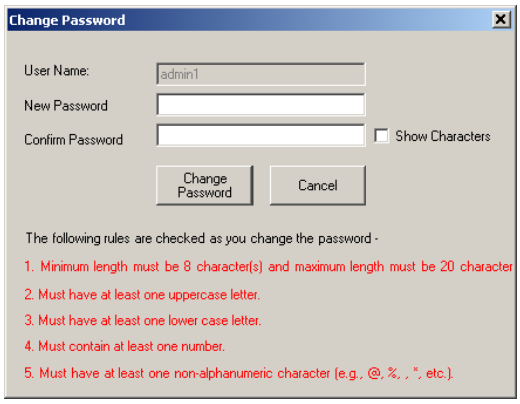


Figure 3-104 Change Password Dialog Screen

Cybersecurity/SD Card Key Generator

The SD Card Key Generator feature allows a User Name and Encrypted Password to be saved to an SD Card. The SD Card with Key Generated User Name and Encrypted Password can be inserted into the SD Card slot on the unit and all security privileges (from the HMI) will be available to the user.

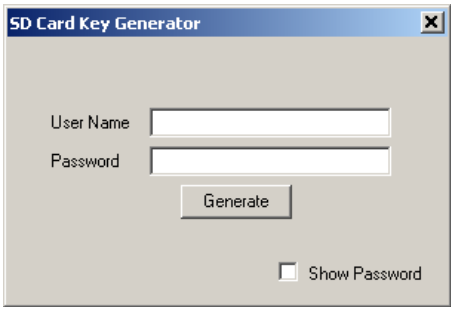
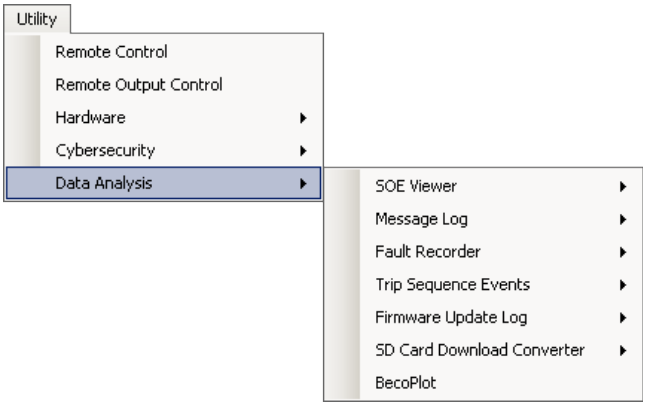


Figure 3-105 SD Card Key Generator Dialog Screen

Utility/Data Analysis Menu



Data Analysis/SOE Viewer/Sequence of Events Viewer

The View Sequence of Events Record screen (Figure 3-106) allows the user to open and print Sequence of Events files. If a record is highlighted in RED, this indicates that an Oscillograph record is associated with this Sequence of Events file, and it will be listed in the bottom section of the window. When connected to a unit, double-click on the Oscillograph record to retrieve the file.

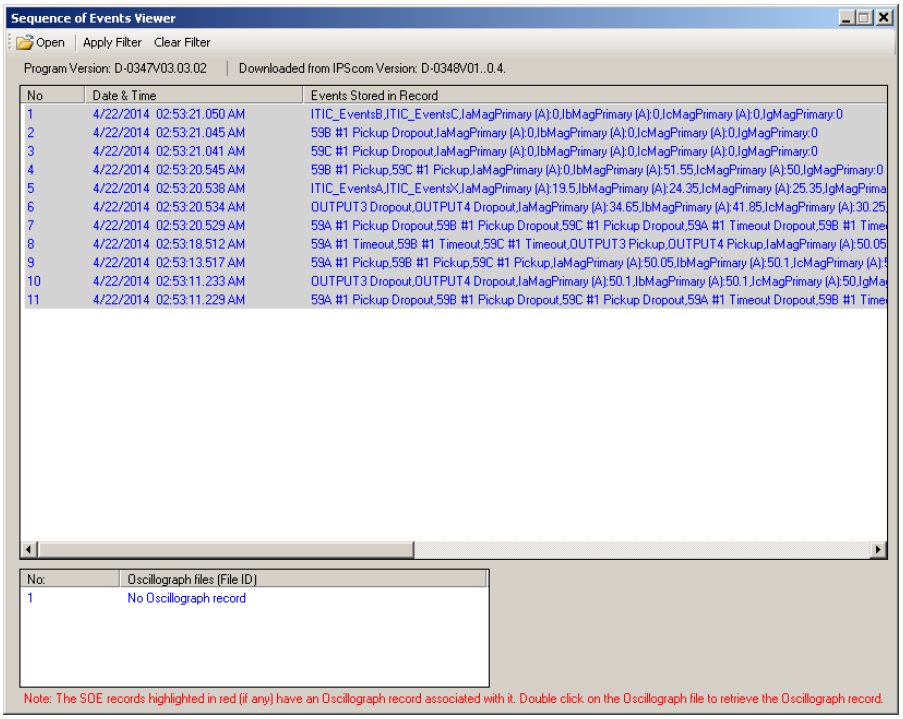


Figure 3-106 View Sequence of Events Dialog Screen

Data Analysis/SOE Viewer/PQ Viewer

The PQ Events Viewer (Figure 3-107) allows the user to open and print ITIC data from a Sequence of Events file. Hovering over a plotted point will display the details of the event in the "Event Data" portion of the screen. Select the **PQ Table Form** tab to view the ITIC event parameters in a Table format.

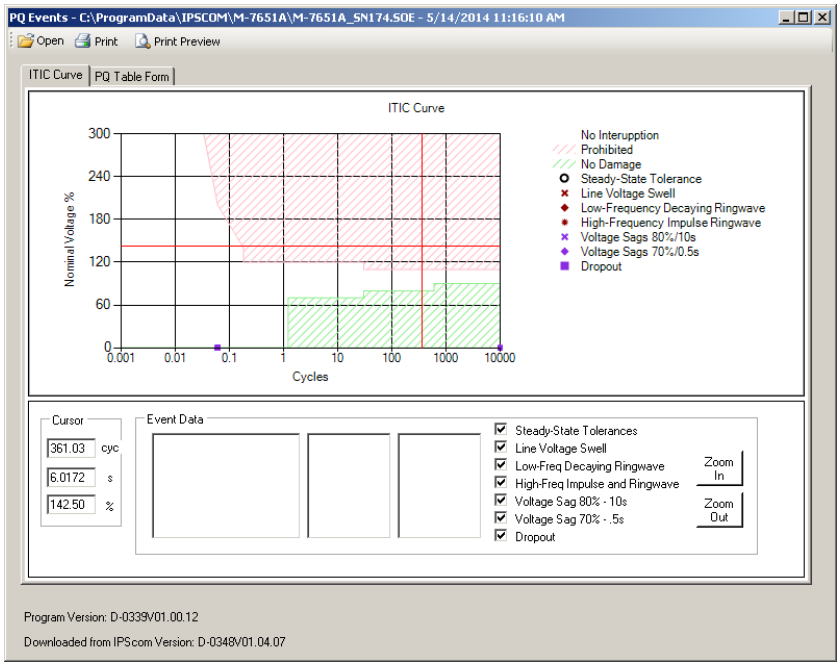


Figure 3-107 PQ Events Viewer Dialog Screen

Data Analysis/Message Log

The Message Log records commands sent to the control in a circular buffer. The **Message Log/Retrieve** selection allows the user to download and save the Message Log file (*.mlg) to the desired location. The Message Log can also be saved as a Comma Separated Values file (*.csv).

The **Message Log/View** selection prompts the user to open a saved Message Log file. IPScom will then open the Log file in the Message Log Viewer (Figure 3-108). Each Message Log entry includes: Index Number, Timestamp and Event Description

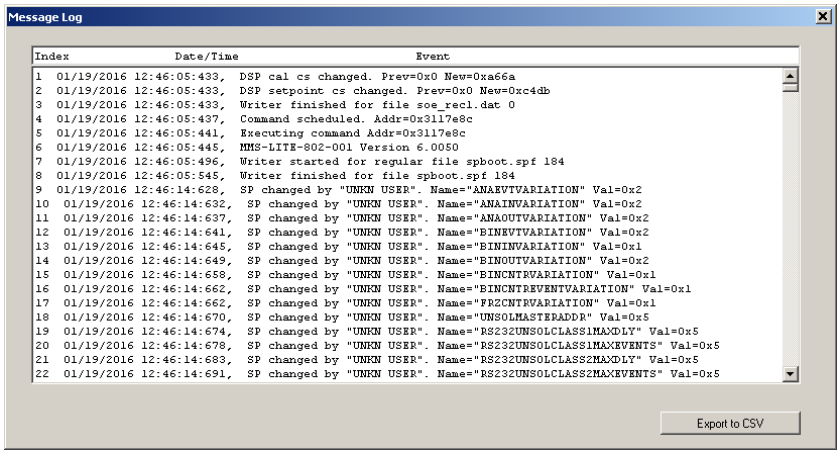


Figure 3-108 Message Log Viewer Screen

Data Analysis/Fault Recorder

The Fault Recorder submenu allows the user to **Retrieve, Clear** and **View** Fault Recorder record files. The **Retrieve** command downloads and saves the record to a (*.flt) file. The **Clear** command clears all Fault Recorder records in the relay. The **View** command launches the Fault Recorder Viewer (Figure 3-109). Double-click a file to display the Fault Record Event Detail screen (Figure 3-110).

■**NOTE:** The Fault Recorder Viewer can also be accessed from the **Utility** Menu when IPScom is initially opened, before connecting or entering File mode.

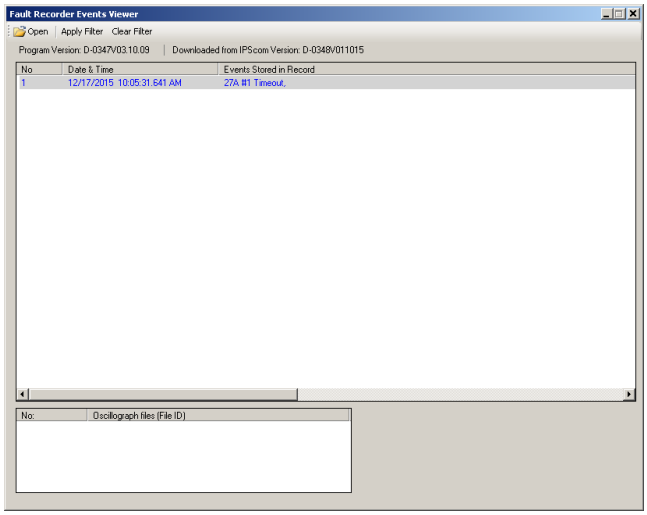


Figure 3-109 Fault Recorder Viewer Screen

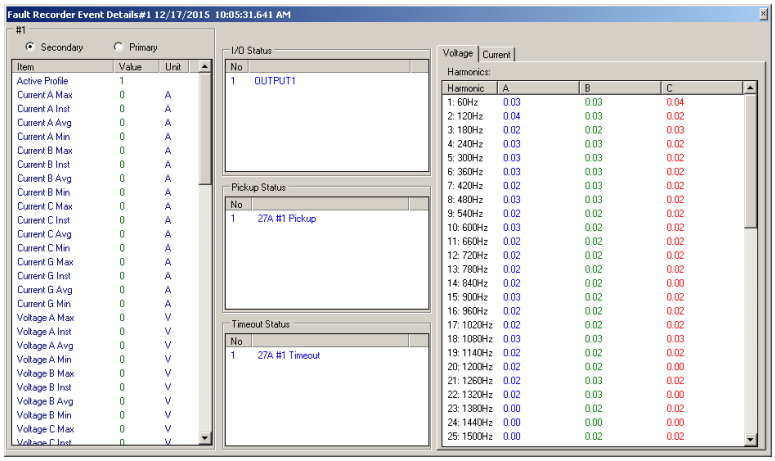


Figure 3-110 Fault Recorder Event Detail Screen

Data Analysis/Trip Sequence Events

The M-7651A has the ability to record Recloser Trip Sequence Events and store the record in non-volatile memory. Any change in the Trip Sequence Event State will initiate recording. Each record contains the following data:

- Recloser State
- Breaker Status
- Reclose Status
- Fault Type
- Cold Load Status
- High Current Lockout Status
- Profile number
- F79 Info
- Input Status
- Reclose Delay Timer
- Reclose Reset Timer
- Trip Timer
- Reclose interrupt time
- Supervision Timer
- Reset From Lockout Timer
- Function Pickup
- Function Timeout
- Time Stamp

The Trip Sequence Events submenu allows the user to **Retrieve, Clear** and **View** Trip Sequence Event files. The **Retrieve** command downloads and saves the record to a (*.TSE) file. The **Clear** command clears all Trip Sequence Event records in the relay.

The **View** command launches the Trip Sequence Viewer. Select **Open** to load a saved "TSE" file. Events are listed at the bottom of the window with the most recent event first. Double-click an event to display the Trip Sequence details in the graphical display (Figure 3-111). The Viewer contains Playback Controls that will cycle through the events. The user may click forward or reverse to view one step at a time or automatically play the sequence with adjustable speed control and pause the playback at any time.

■**NOTE:** The Trip Sequence Viewer can also be accessed from the **Utility** Menu when IPScom is initially opened, before connecting or entering File mode.

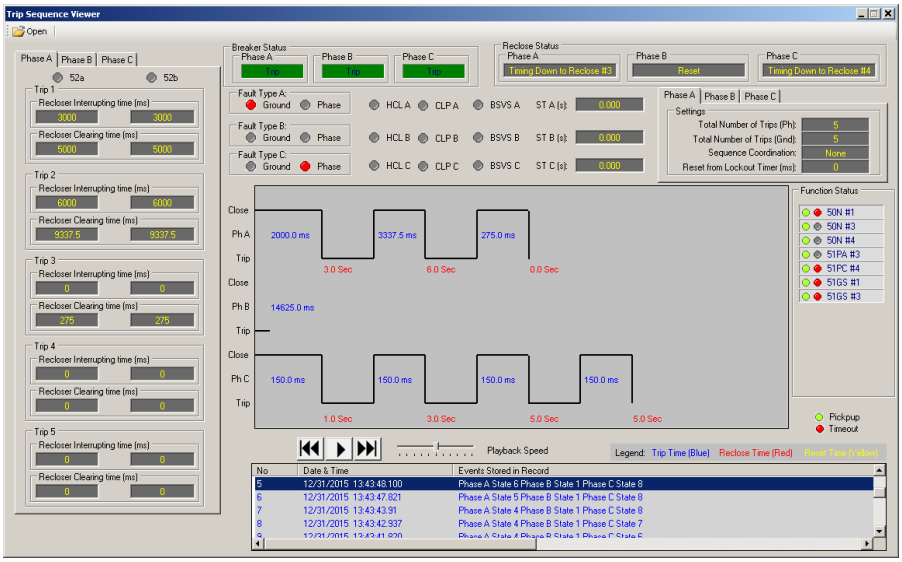


Figure 3-111 Trip Sequence Viewer Screen (Shown: Independent Phase Example)

Data Analysis/Firmware Update Log

This feature allows the user to download and save a Firmware Update Log text file (*.txt). **Firmware Update Log/View** allows the user to open a saved log file and displays the contents of the file which contains the timestamp, the firmware version and the User ID associated with each update (Figure 3-112).

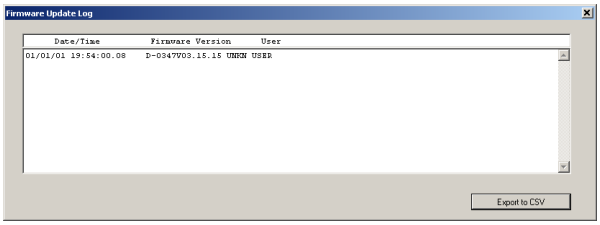


Figure 3-112 View Firmware Update Log Screen

Data Analysis/SD Card Download Converter

This feature allows Data Log or Oscillograph files downloaded from the M-7651A D-PAC to an SD card to be converted to *.cfg file format.

The "Metering csv File" selection will prompt the user to open a Metering data file (*.csv) that has been downloaded to an SD card. IPScom will then convert the condensed raw metering data to expanded text, and prompt the user to save the new expanded (*.csv) file that may be opened in any spreadsheet program.

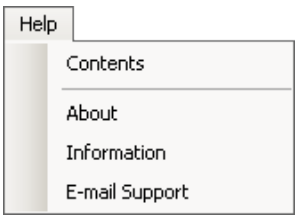
Example:

SD Card *.csv File Data	Converted Data in New *.csv File
I1MagPrimary	Primary Magnitude of Positive Sequence Current
SPhBPrimary	Primary Magnitude of Phase B Apparent Power

Data Analysis/BecoPlot

The BecoPlot Oscillographic Analysis Software runs in conjunction with IPScom software on any Windows® based computer running Windows 2000 or later, to enable the plotting and printing of waveform data downloaded from the M-7651A D-PAC System. See **Section 3.7 BecoPlot** for detailed information for this feature.

HELP MENU



The **Help** menu provides four selections.

The **Contents** submenu will open a PDF file of the Instruction Book in the user's default PDF Reader. The Bookmarks pane allows direct access to selected topics. The Table of Contents also contains hyperlinks to all topics.

Help/About

The **About** selection displays the IPScom version. (Figure 3-113).

Figure 3-113 Help "About" Screen

When connected to a relay, selecting "Details" from the About screen allows the user to save the relay information to a text file for viewing. See Figure (Figure 3-114).

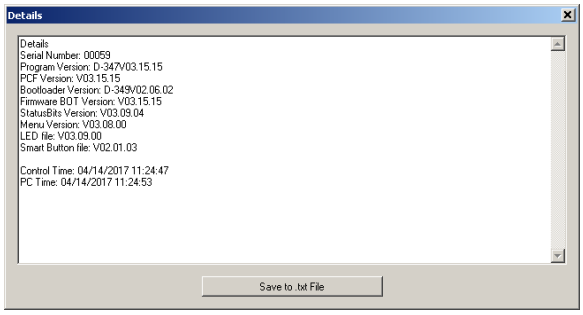


Figure 3-114 Details Text File Example

Help/Information

The **Information** selection (available in File Mode only) provides a means for the user to enter Optional Information if desired, generally used for third party software (Figure 3-115).

This information will be saved ONLY in the SPF file, not in the relay. This information can be added to provide third party software the means to add customized information to the SPF file.

- Company Info: End user Company Name
- Location: describes the location of a relay
- Relay Manufacturer: Beckwith Electric Co, Inc. (Constant)
- System Information: any relevant system information
- Date/Time when SUP file was last SAVED: this field is filled automatically when the user saves a SUP file to the local hard drive
- Original IPScom Version used for creation of this SUP file: this field is initially filled with the currently open IPScom version
- Additional Info: any additional information to be stored, such as, customer third party software version

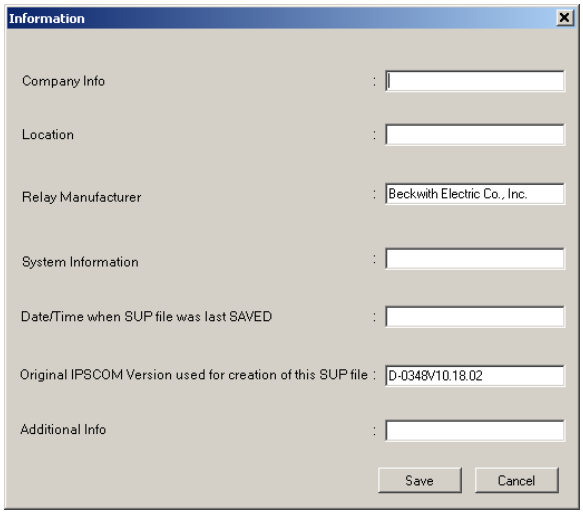


Figure 3-115 Information Screen

This information is available under the following XML tags:

<PRi>

<SN V="D-0123V01.00.00" Desc="Serial number string" />

<LOC V="Central office" Desc="Location string" />

<MAN V="Beckwith Electric Co., Inc." Desc="Manufacturer string" />

<MOD V="M-7651A V01" Desc="Relay Model string" />

<UTC V="1386002176.38692" Desc="Date/Time of last modification UTC format" />

<APP V="IPscom" Desc="PC-Software name which generated SPF file string" />

<VER V="V01234" Desc="PC-Software version which generated SPF file string" />

</PRi>

This information is available ONLY after the SPF file is decrypted.

Help/E-mail Support

When connected to a relay, the **E-mail Support** feature allows the user to easily send all necessary support files to support@beckwithelectric.com. The feature is available from the Help menu or by selecting the "**@**" icon in the Quick Access toolbar. See **Chapter 2, Operation** for more detailed information.

3.7 BecoPlot Analysis Software

The BecoPlot Analysis Software operates in conjunction with all IPScom Communications Software on any computer running Windows®. BecoPlot allows the user to plot and print relay data contained in Comtrade formatted files (*.cfg).

Overview

BecoPlot is a windows based program for viewing the data that has been retrieved using the Data Logging and Oscillograph features of IPScom.

When BecoPlot is started, a menu and tool bar are displayed. This section describes each BecoPlot menu selection and explains each BecoPlot command in the same order that they are displayed in the software program. Figure 3-116 presents the BecoPlot Menu and Submenu Callouts.

Starting BecoPlot

1. Select the **BecoPlot** menu item from the IPScom Menu (Utility/BecoPlot). The BecoPlot Window and Toolbar is displayed (Figure 3-116).
2. Select **File/Open** from the menu, and browse for the desired .cfg file.
3. Open the file. BecoPlot should display the saved data, as shown in Figure 3-117 & Figure 3-118.

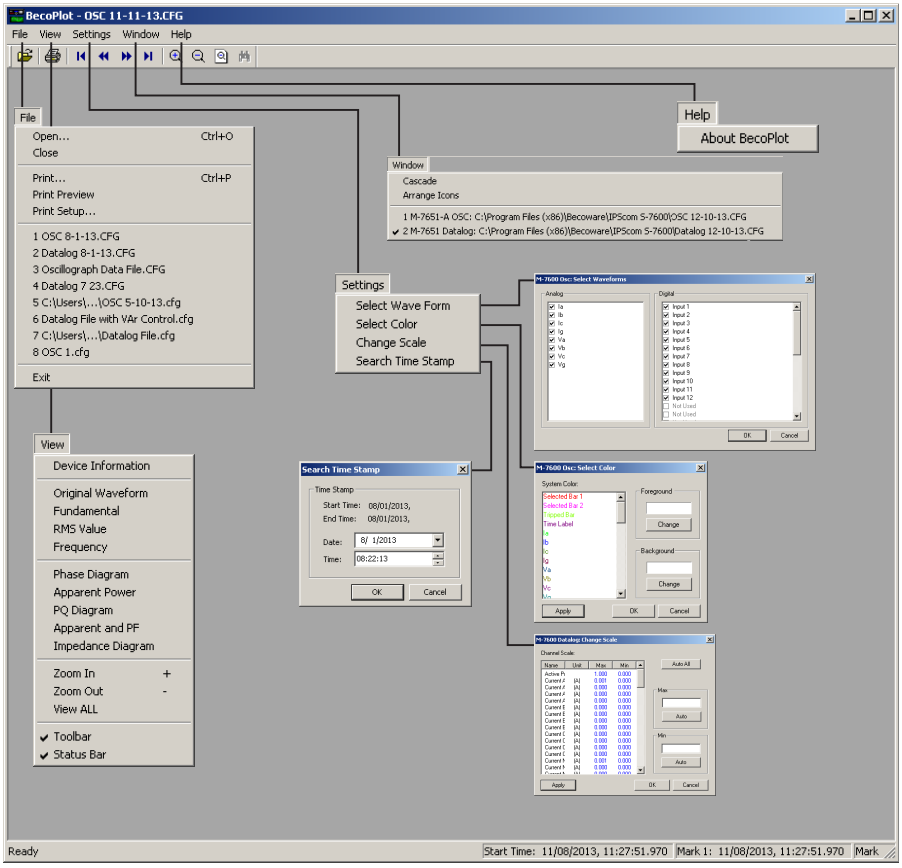


Figure 3-116 BecoPlot Main Window with Submenus

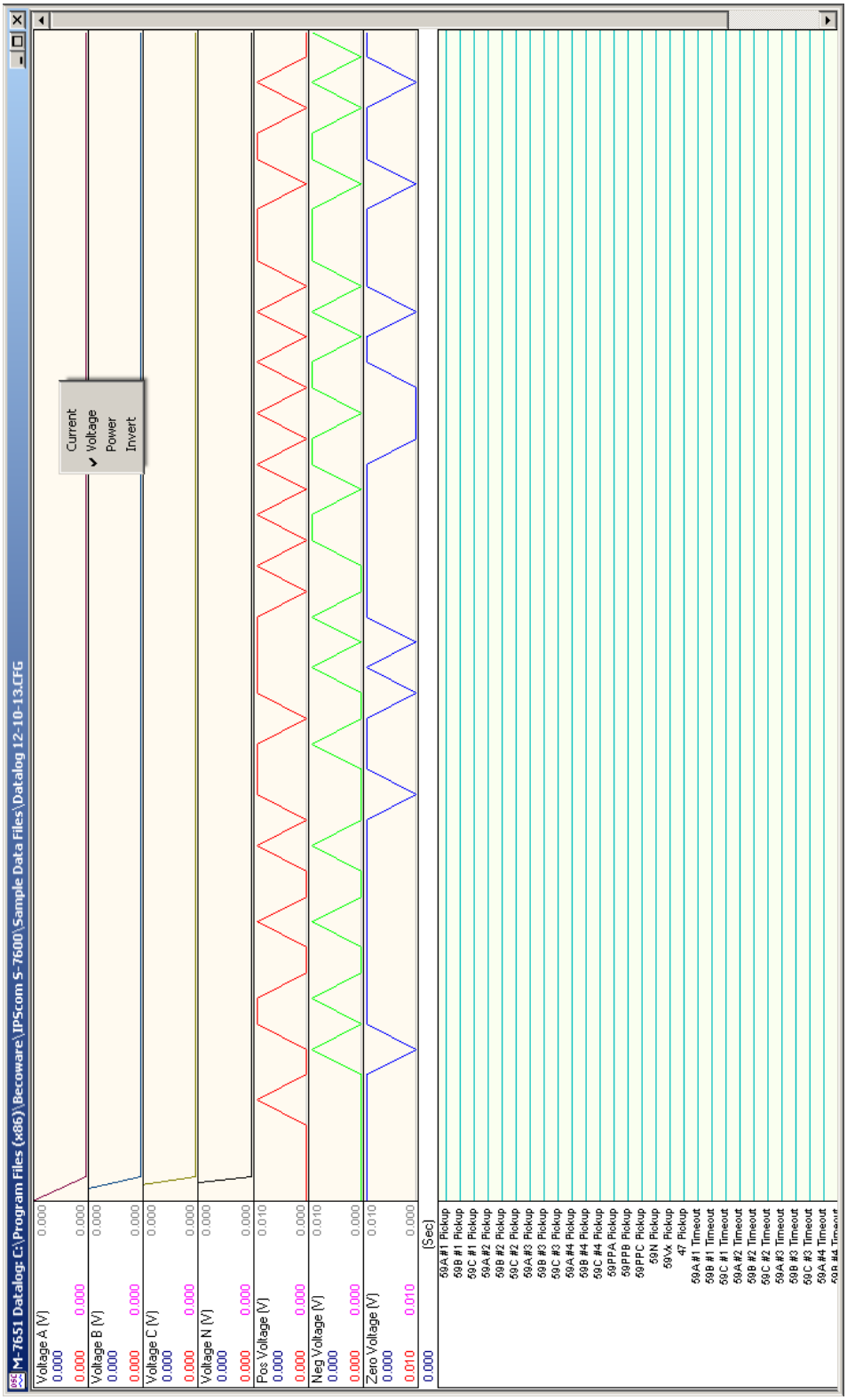


Figure 3-117 BecoPlot Window with Data Logging Data Example with Voltage Group Filter

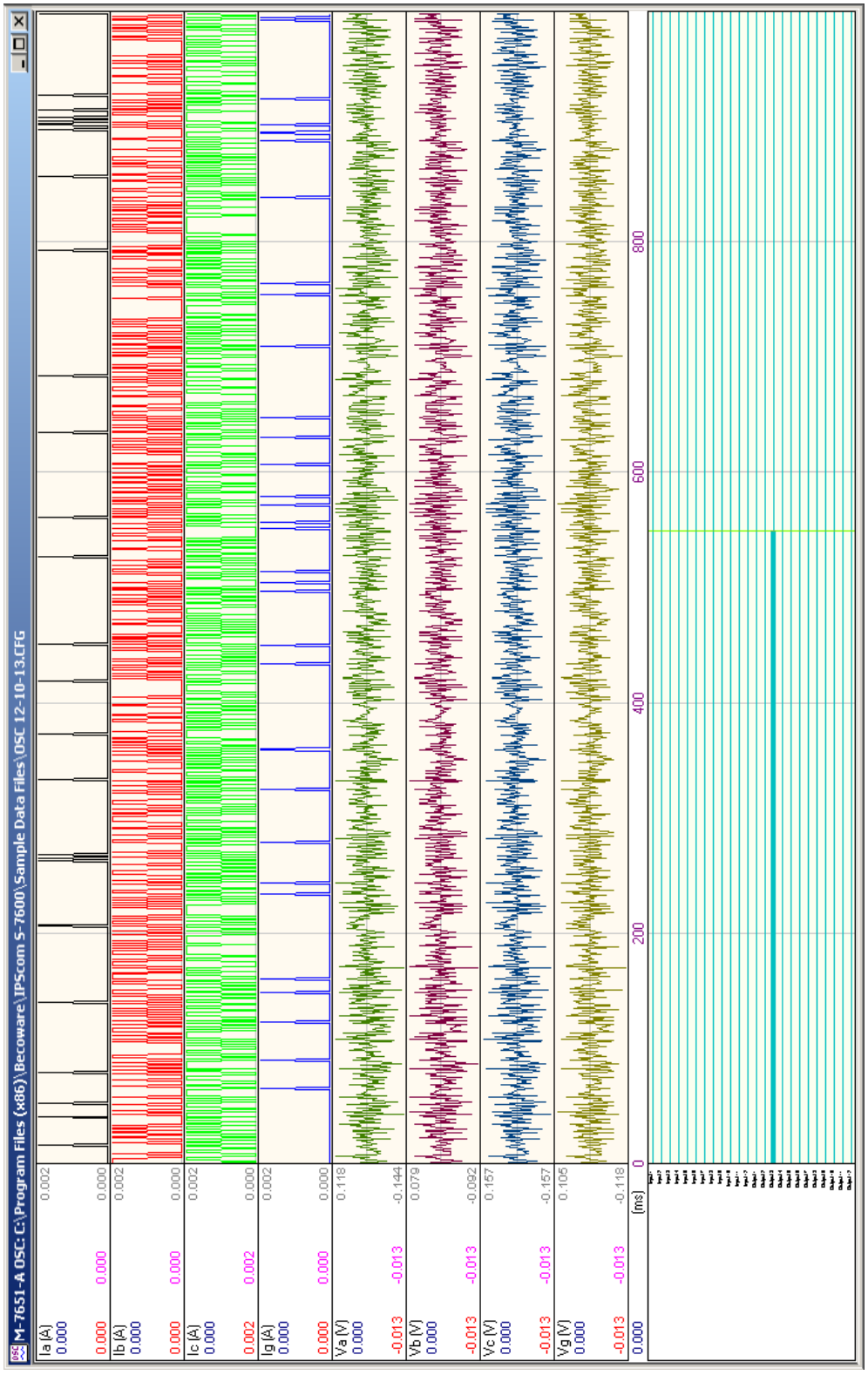


Figure 3-118 BecoPlot Window with Oscillograph Data Example

Markers

BecoPlot includes two user selectable markers. The first is positioned by double clicking on the plotted wave form data. The second is positioned by pressing and holding the **SHIFT** key and then double clicking on the plotted wave form data.

The markers can be dragged by moving the cursor over the marker until the cursor changes to a double-headed arrow ↔, then holding down the Left mouse button and dragging the marker. The first marker can also be moved an interval at a time by pressing the **LEFT** or **RIGHT** arrow key. The second marker can be moved by pressing the Shift key and the Left or Right arrow key.

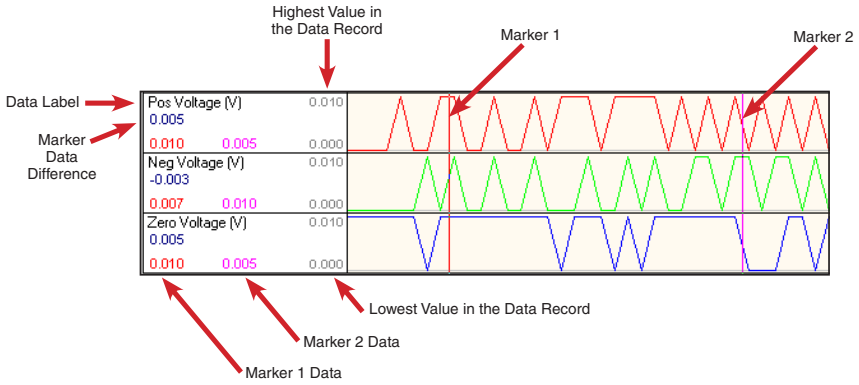


Figure 3-119 BecoPlot Screen With Callouts

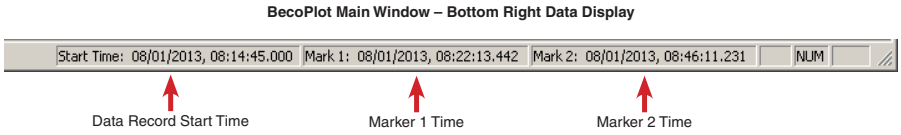


Figure 3-120 BecoPlot Main Screen Data Time Stamp Display

Right-Click Filter Menus

Right-Click menus are available to allow filtering of the data results. The Datalog screen contains additional Shift/Right-Click menus which allow filtering by Groups. Figure 3-121 and Figure 3-122 show the right-click menus available in either a Datalog or Oscillograph file.

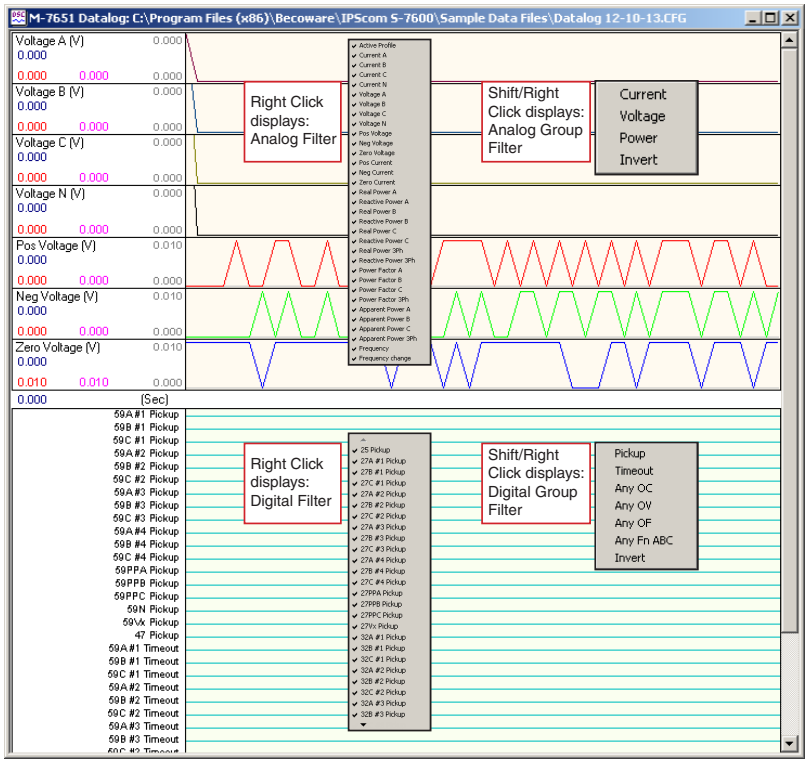


Figure 3-121 Datalog File Right-Click Filter Menus

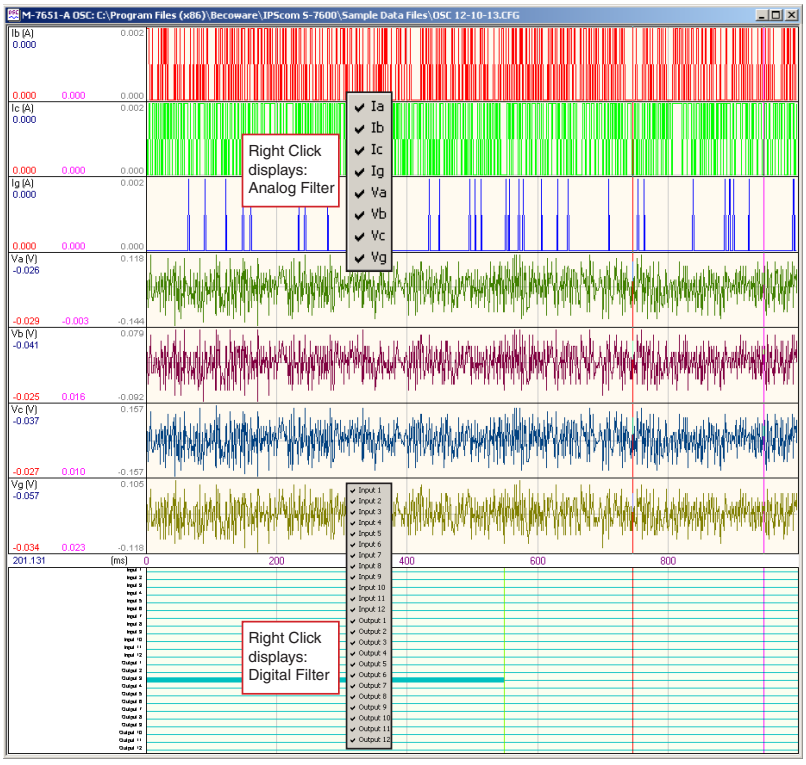
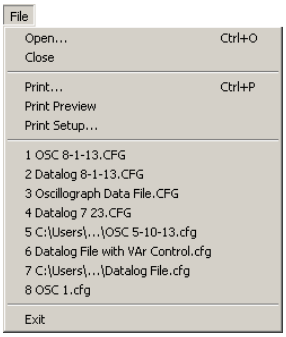


Figure 3-122 Oscillograph File Right-Click Filter Menus

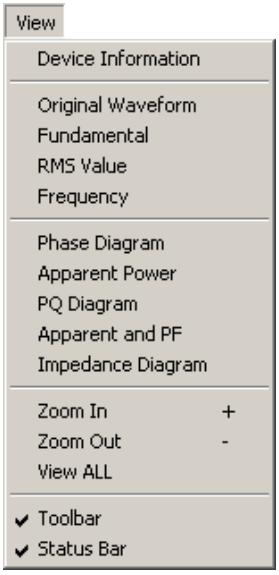
File Menu



The **File** menu allows the user to:

- Open an BecoPlot (.cfg) file previously downloaded by IPScom.
- Print the displayed BecoPlot data.
- A Print Preview of the displayed BecoPlot data.
- Select the printer and printer settings to be used.
- Select from previously viewed (.cfg) files (the last eight files displayed).
- Exit the BecoPlot program.

View Menu



The **View** menu allows the user to:

- Display the Device Information (Figure 3-123) for the corresponding BecoPlot data file.
- Original Waveform
- Fundamental
- RMS Value
- Frequency
- Phase Diagram
- Apparent Power
- PQ Diagram
- Apparent and PF
- Impedance Diagram
- Zoom In, increase the resolution of the tap data displayed on the screen.
- Zoom Out, decrease the resolution of the tap data displayed on the screen.
- View ALL, returns the display to include all data within the record.
- Select which Toolbar (Toolbar/Status Bar) is available on the display window.

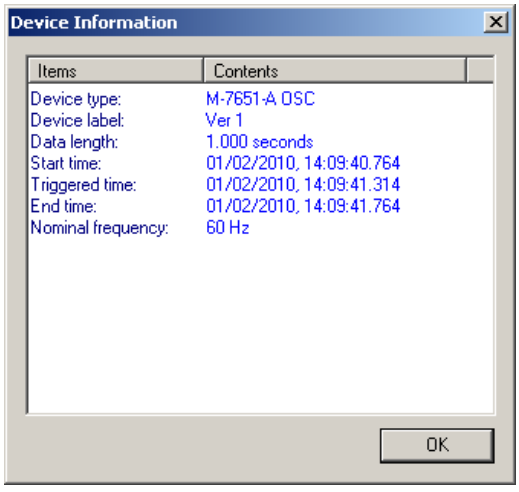
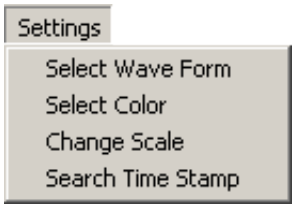


Figure 3-123 Device Information Screen

Settings Menu



The Settings menu allows the selection of the waveforms to be displayed and the format of display colors.

Select Wave Form

Allows the selection of any of the following Parameters to be plotted or printed (Figure 3-124):

- Current (Ia, Ib, Ic, Ig)
- Voltage (Va, Vb, Vc, Vg)
- Inputs 1 through 12
- Outputs 1 through 12

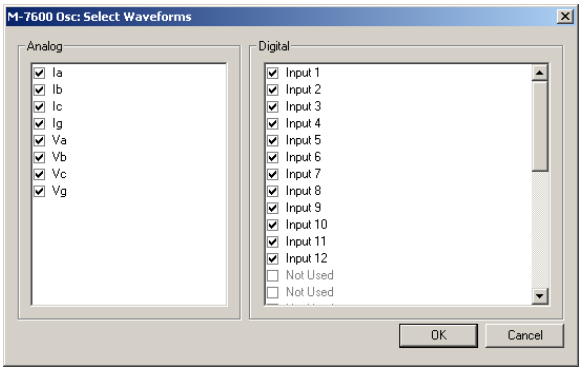


Figure 3-124 Select Waveforms Dialog Screen

Select Color

Provides the user with the capability to change Foreground and Background display color of individual Waveform traces for customized plotting (Figure 3-125).

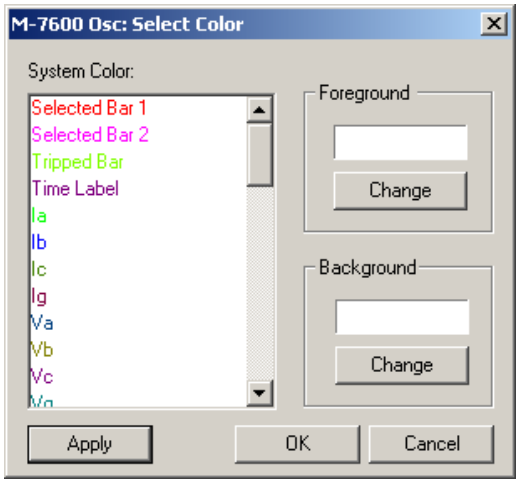


Figure 3-125 Select Color Dialog Screen

Change Scale

Provides the user with the capability to change the scaling of the displayed parameter.

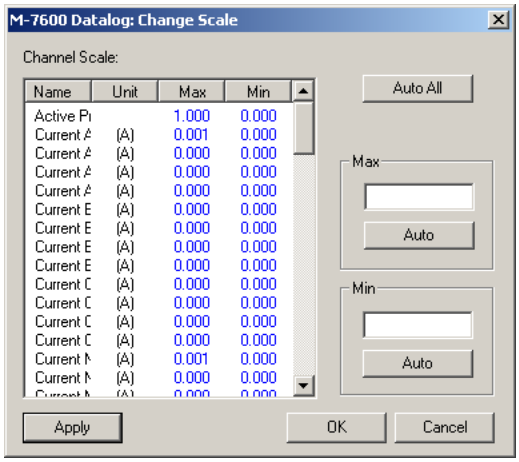


Figure 3-126 Change Scale Screen

Search Time Stamp

Provides the user with the capability to place the marker exactly at the desired time stamp in the BecoPlot window.

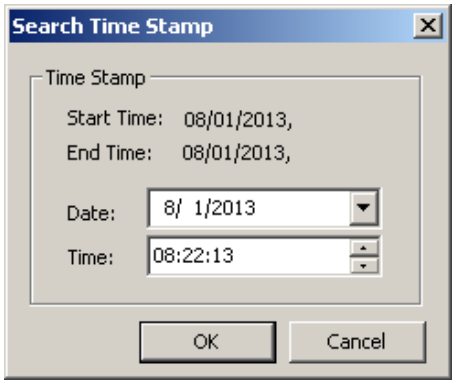
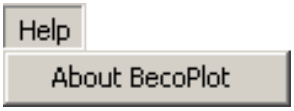


Figure 3-127 Search Time Stamp Screen

Help Menu



The **Help** menu provides access to the **About BecoPlot** command which provides version information for BecoPlot.

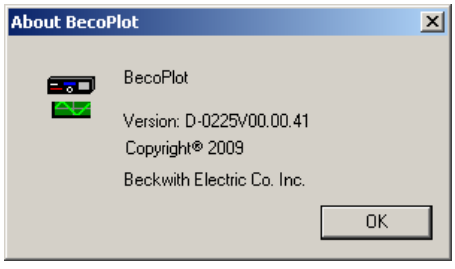


Figure 3-128 About BecoPlot Screen

4 System Setup

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■ **CYBER SECURITY NOTE:**

When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

Chapter four is designed for the person or group responsible for the Unit Setup and Configuration of the M-7651A D-PAC System.

Chapter 4 consists of:

- The Unit Setup Section, which consists of general unit setup information, Communications setup, Oscillograph, Sequence of Events and Data Logging setup.
- The System Setup Section provides the definitions of system quantities and equipment characteristics required by the relay which include CT, VT configuration selection, and Input and Output assignments.
- Functional and connection diagrams for a typical application of the relay.

The selection of the M-7651A D-PAC System Setup parameters can be performed using the S-7600 IPScom Communications Software and will be included where applicable.

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4.1 Unit Setup

GENERAL UNIT SETUP

The General Unit setup consists of the setup of the following features and functions:

- User Lines
- Time and Date
- Communications
- Oscillograph
- Sequence of Events
- Load Profile Trending (Data Logging)

Cyber Security

Access to all features using either the Front Panel HMI or IPScom Communications Software is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

USER LINES

The user station identification lines (User Lines) allow the user to uniquely identify the unit. The user can customize the User Lines for up to 8 individual device profiles. Each line of this display can have up to 20 ASCII characters (excluding "~" and "\"). User Lines are factory preset with "Beckwith Electric P1" for Line 1 and "M-7651A" for Line 2.

Setting User Lines from IPScom

To change the User Lines from IPScom perform the following:

1. Select **Setup/Configuration/Relay** from the IPScom toolbar. IPScom will display the System Setup dialog screen. Select the "User Lines" tab. IPScom will display the User Lines dialog screen (Figure 4-1).
2. Input the new Line 1/Line 2 information for the specific profiles.
3. Select **Save**, the desired User Lines will be saved to either the Relay or Open File.

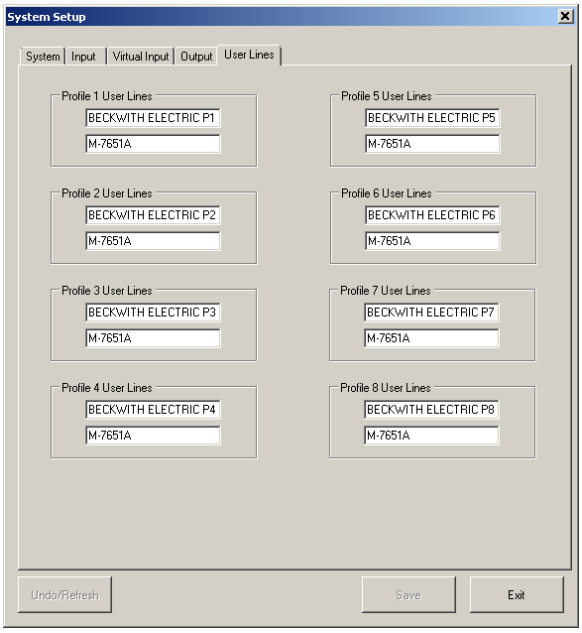


Figure 4-1 User Lines Dialog Screen

Setting User Lines From The HMI

When **ENT** is pressed at the Configuration/User Lines/User Line 1 or User Line 2 menu, an underline cursor is displayed under the left-most character. Each character is changed by using the ↑ and ↓ pushbuttons to select the ASCII character (the ASCII character list begins with "!"). The ← or → pushbutton is used to move the underline to the next character. When the **ENT** pushbutton is pressed, the new user line is stored into nonvolatile memory.

1. Press **CNFG** The menu will advance to "CONFIGURATION".

```
     CONFIGURATION
<SETP           COMM>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
       Nameplate
<                  >
```

3. Press **MNTR** or **COMM** as necessary until "USER LINES" is displayed.

```
       USER LINES
<                  >
```

4. Press **CNFG** as necessary until the following is displayed. This screen indicates that Profile 1 (P1) User Lines will be assigned.

```
User Line 1 P1
Beckwith Electric P1
```

5. Press **ENT**. The following will be displayed:

```
User Line 1 P1
Beckwith Electric P1
```

6. Utilizing the arrow pushbuttons enter the new Line 1/2 User Line(s), then press **ENT**. The following will be displayed.

```
User Line 1 P1
Beckwith Electric P1
```

7. Press **CNFG** to advance to the User Line 1/User Line 2 screens for Profiles 2 through 8. Repeat the steps above to assign User Lines to additional Profiles.

SYSTEM CLOCK

This feature allows the user to set the relay internal clock. The clock is used to time stamp system events and oscillograph operations. The system clock includes the capability to enable/disable Daylight Savings Time.

If the IRIG-B interface is used, the hours, minutes, and seconds information in the clock will be synchronized with IRIG-B time information every hour.

The relay can accept a demodulated IRIG-B signal using the 2 pin terminal block (TB-4). TTL is the only format supported.

IPScom Date & Time Compare

The **Utility/Hardware/Date & Time Compare** submenu item enables the user to compare the relay date/time with the PC date/time.

1. From the IPScom Main Screen Utility/Hardware dropdown menu select **Date & Time Compare**. IPScom will display Figure 4-2.

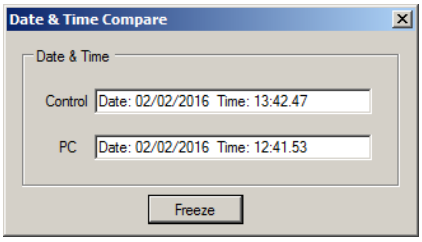


Figure 4-2 Date & Time Compare Screen

IPScom Set Date & Time

The **Utility/Hardware/Set Date & Time** submenu item enables the user to to set the relay Date & Time and enable or disable Daylight Savings Time.

▲**CAUTION:** Whenever the clock is reset and data logging is enabled the data log should be cleared.

1. From the IPScom Main Screen Utility/Hardware dropdown menu select **Set Date & Time**. IPScom will display a warning (Figure 4-3) regarding time stamped values.

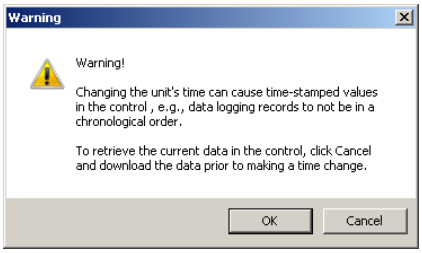


Figure 4-3 Setup Date & Time Warning Screen

2. Select **OK**. IPScom will display Figure 4-4.

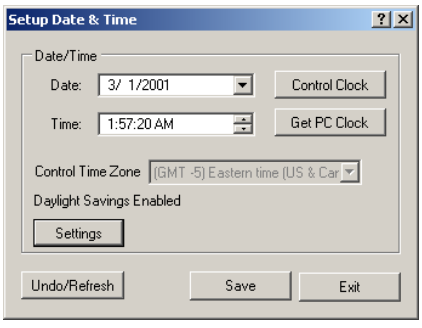


Figure 4-4 Setup Date & Time Dialog Screen

3. From the Setup Date & Time dialog screen (Figure 4-4) select **Settings**. IPScom will display the "Time Zone and Daylight Savings" settings dialog screen (Figure 4-5).

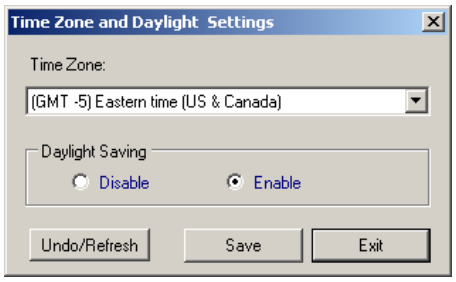


Figure 4-5 Time Zone and Daylight Savings Settings Dialog Screen

4. Enter the desired settings and select **Save**. IPScom will return to the Setup Date and Time dialog screen.
5. From the Setup Date & Time dialog screen (Figure 4-4) select either **Control Clock** or **PC Clock**.
6. If PC Clock was selected and the Date/Time of the PC is the desired time to be set in the relay, then select **Save**.
7. If Control Clock was selected, then input the desired Date/Time, then select **Save**.
8. IPScom will briefly display a "Setpoints Saved" confirmation screen and then return to the Main Screen.

Setting Date & Time and Daylight Savings From The HMI

▲**CAUTION:** Whenever clock is reset and data logging is enabled, the data log should be cleared.

1. Press **CNFG** to wake the unit. The menu will advance to "CONFIGURATION".

```
     CONFIGURATION
<SETP            COMM>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
       Nameplate
<                  >
```

3. Press **MNTR** or **COMM** as necessary, until the "Sys Clock and IRIGB" screen is displayed.

```
  Sys Clock and IRIGB
<                    >
```

4. Press **CNFG** as necessary, until the "Date and Time" dialog screen is displayed.

```
Date and Time
MM/DD/YY  HH:MM:SS:MS
```

5. Press **ENT**. The following will be displayed.

```
Set Date and Time
MM/DD/YY  HH:MM:SS
```

■**NOTE:** The cursor will be positioned under the left hand "Month" element of the date. Utilizing the Up/Down arrow pushbuttons will change the Month. Utilizing the Right/Left arrow pushbuttons will move the cursor between each element of the date and time.

6. Utilizing the arrow pushbuttons enter the desired Date and Time, then press **ENT**. The following will be displayed reflecting the settings that were entered.

```
Set Date and Time
XX/XX/XX  XX:XX:XX:XX
```

7. Press **CNFG** as necessary, until the "Daylight Saving" dialog screen is displayed.

```
Daylight Saving
DISABLE
```

8. Press **ENT**. The following will be displayed.

```
Daylight Savings
DISABLE
```

9. Press **SETP** or **CNFG** to select **ENABLE**, then press **ENT**. The following will be displayed:

```
Daylight Saving
ENABLE
```

10. Press **CNFG** as necessary, until the "Time Zone" dialog screen is displayed.

```
Time Zone
 -5
```

11. Press **ENT**. The following will be displayed.

```
Time Zone
 -5
```

12. Utilizing the arrow pushbuttons enter the Time Zone where the relay is installed. Press **ENT**. The following will be displayed reflecting the setting that was entered.

```
Time Zone
 XX
```

COMMUNICATION SETUP

Communication setup can be accomplished utilizing either IPScom or the HMI. The Communication setup consists of the setup of the following features and functions:

- COM Port definitions and Device Address
- Ethernet Port Settings
- Installing Modems

The M-7651A D-PAC includes five physical communication ports. The unused communications ports can be disabled through software to comply with cyber security requirements.

- Front – USB Port, Type B, Version 1.1. This port is used to locally set and interrogate the relay using a portable computer.
- Port 1, (optional) located on the rear of the relay can be either a Serial TIA-232, TIA-485, Fiber, or none.
- Port 2/Port 3, (optional) located on the rear of the relay can be either a RJ45 Ethernet 10/100 BASE-T or Fiber Ethernet 100 BASE-FX.

  Ethernet Ports are auto-detect, auto-negotiable 10/100Mbps, with support for multi-user rights for up to eight concurrent users.
- Port 4, (optional) located on the rear of the relay can be either a Serial TIA-232, TIA-485, Fiber, or none.

Time Synchronization Port:

- IRIG - B (B000)
- Input – Demodulated
- Input level – TTL
- Isolation – 1,500 Vdc

Direct Connection

In order for IPScom to communicate with the relay using direct serial connection, a serial "null modem" cable is required, with a 9-pin connector (DB9P) for the system, and an applicable connector for the computer (usually DB9S or DB25S).

An optional 10 foot null modem cable (M-0423) is available from the factory, for direct connection between a PC and the relay's serial port.

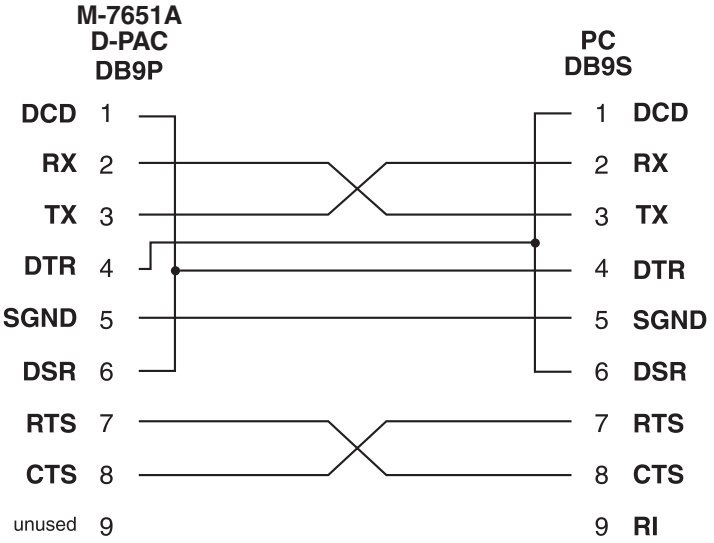


Figure 4-6 M-0243 Null Modem Cable

When fabricating communication cables, every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended. The TIA-232 standard specifies a maximum cable length of 50 feet for TIA-232 connections. If over 50 feet of cable length is required, other technologies should be investigated.

Other communication topologies are possible using the M-7651A D-PAC System. An Application Note, "Serial Communication with Beckwith Electric's Integrated Protection System Relays" is available from the factory or from our website at www.beckwithelectric.com.

▲**CAUTION:** The **Echo Cancel** check box should only be used when several relays are connected using a fiber optic loop network. Otherwise, echo cancel must not be selected or communication will be prevented.

▲**CAUTION:** If the serial port is connected to something other than a modem, and an IPScom modem command is executed, the results are unpredictable. In some cases, the computer may have to be reset.

IPScom COM Port Setup

■**NOTE:** Communication must be established with the target relay for this procedure. The IPSCom installation and establishing initial Local communications are covered in Chapter 3 IPScom.

1. From the IPScom Main Screen menu select **Communication/Setup/Comm Port**. IPScom will display the Setup Comm Port dialog screen (Figure 4-7).

   The System COM Port that is in use will be indicated at the top of the display.

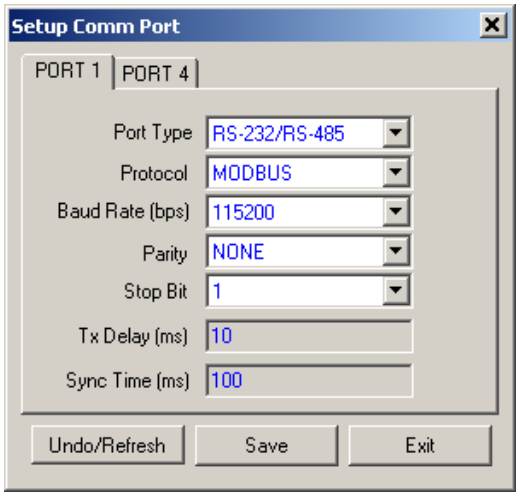


Figure 4-7 Setup Comm Port Dialog Screen

2. Select the desired COM Port to be setup (1 or 4).
3. Enter the desired communications parameters:
   - Protocol (MODBUS or DNP)
   - Baud Rate (1200 to 115200)
   - Parity (None, odd or even)
   - Stop Bits (1 or 2)
   - TX Delay (0 to 5000 ms)
   - Sync Time (0 to 5000 ms)
4. Select **Save**. IPScom will save the settings to the device or open file.

HMI COM Port Setup

If the default value for a parameter does not need to be changed, skip the applicable steps.

■**NOTE:** The steps necessary for configuring PORT 1 are described here. The steps to configure PORT 4 are similar.

1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".

```
    COMMUNICATIONS
<CNFG           UTIL>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
    PORT1 Settings
<                   >
```

3. Press **CNFG** as necessary, until the "Protocol" menu item is displayed.

```
Protocol
MODBUS
```

4. Press **ENT**. The following will be displayed.

```
Protocol
MODBUS
```

5. Utilizing **SETP** or **CNFG** select **MODBUS** or **DNP**, then press **ENT**. The selected protocol will be displayed.

```
Protocol
(MODBUS or DNP)
```

6. Follow the procedure above to enter the desired:
   - Baud Rate (1200 to 115200)
   - Parity (None, odd or even)
   - Stop Bits (1 or 2)
   - TX Delay (0 to 5000 ms)
   - Sync Time (0 to 5000 ms)
   - Port Type (RS-232/RS-485 or Fiber)
7. PORT 1 is now available for communications.

Optional Ethernet Ports

The optional Ethernet Port can be purchased as either a RJ-45 (10/100 Base-T) interface or Fiber Optic through ST connector (100 Base-Fx) for Ethernet communication to the M-7651A D-PAC. The port supports up to four concurrent connections (both Port 3 and Port 4 combined). The maximum number of allowed DNP connections is four. The maximum number of MODBUS connections is four. The port supports DHCP protocol and also allows manual configuration of the Ethernet port. MODBUS protocol "Port Number" and DNP Protocol "Port Number" are always configured manually regardless of DHCP Enable/Disable option.

Ethernet KeepAlive Time

If no communication activity is detected on a previously open ethernet socket, for the amount of time specified by the "KeepAlive Time" setting, the control will then close the socket and make it available for future connection.

■**NOTE:** KeepAlive Time applies only to Ethernet communication.

Auto Negotiation

Auto Negotiation is an Ethernet procedure by which two connected devices choose common transmission parameters, such as speed and duplex mode. In this process, the connected devices first share their capabilities for these parameters and then choose the fastest transmission mode they both support.

■**NOTE:** Auto Negotiation must be disabled if using Fiber Ethernet.

Dual Ethernet Support

Optional Dual Ethernet hardware is supported which can provide two individual Mac addresses that act as separate connections, with two TCP stacks. Self-Healing Ring topology is supported using either a managed or unmanaged ethernet switch. Failover Network topology is also supported.

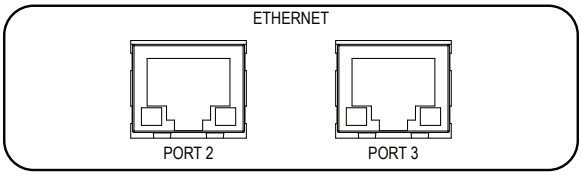


Figure 4-8 Optional Dual Ethernet Ports

Ethernet Port Configuration From IPScom

■**NOTE:** Manual configuration of the Ethernet Port (not enabling DHCP Protocol) requires that the IP Address, Net Mask and Gateway settings be obtained from the System Administrator.

1. Ensure the following conditions exist:
   a. IPScom is installed on the host computer
   b. The host computer is physically connected to the target relay through either a USB or Serial Port connection
   c. The host computer and the relay are physically connected to the target Ethernet network
2. Start the IPScom program. IPScom will display the IPScom **Main** dialog screen.
3. Select **Communication/USB or Com Port** from the **Communication** drop-down menu. IPScom will display the appropriate Connection Dialog Screen (Figure 3-4 or Figure 3-25).
4. Select **Connect**, IPScom will attempt to connect to the target relay.
5. IPScom will display the "Connected" confirmation screen (Figure 4-9). IPScom will then display the connected version of the IPScom Main Screen (Figure 3-14).

Figure 4-9 Connected Confirmation Screen

6. From the **Communication** drop-down menu, select **Setup/Ethernet Settings**. IPScom will then display the Ethernet Setup dialog screen (Figure 4-10).

7. If the Ethernet network that the target relay is connected to *supports DHCP Protocol*, then perform the following:
   a. From the Setup Ethernet dialog screen (Figure 4-10) select **DHCP Protocol Enable**.
   b. Enable or Disable "Auto Negotiate".
   c. Select the desired "KeepAlive Time" duration.
   d. Select **Save** to save the settings to the target relay.
   e. Go to Step 10.

8. If the Ethernet network that the target relay is connected to *does not support DHCP Protocol*, or manual configuration is desired, perform the following:
   a. Select **DHCP Protocol Disable**.
   b. Enable or Disable "Auto Negotiate".
   c. Select the desired "Keepalive Time" duration.
   d. Enter the IP Address, Net Mask, Gateway and the applicable MODBUS Port settings.
   e. Select **Save** to save the settings to the target relay.

■**NOTE:** The DNP and MODBUS Port addresses can not be set to the same value.

9. If the Network MODBUS Port address is not "502", set these parameters to match the target network settings.

The Ethernet option for the relay is now enabled. See **Communication Using Ethernet Connection** section of Chapter 3 to connect to the target relay through the Ethernet connection.

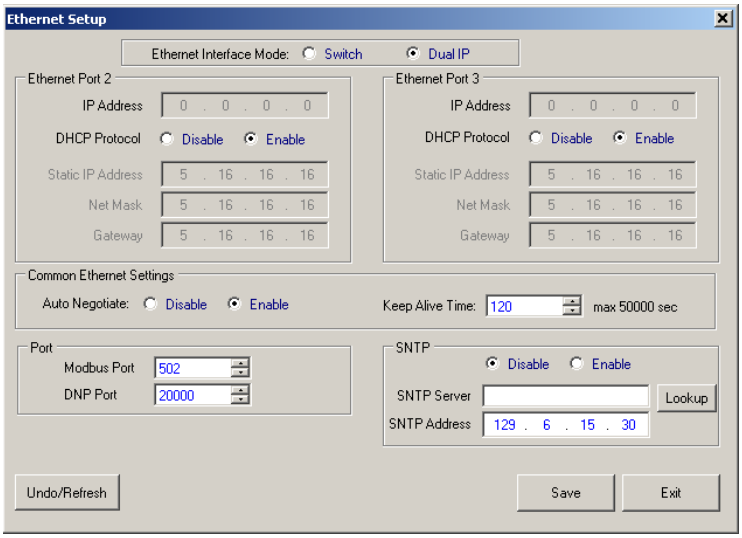


Figure 4-10 Setup Ethernet Dialog Screen (Shown: Dual Ethernet Option)

Network Time Synchronization

■**NOTE:** Network Time Synchronization requires the SNTP (Simple Network Time Protocol) "Server Name" or "Server IP Address" to be known.

1. From the **Communication** drop-down menu, select **Setup/Ethernet Settings**. IPScom will then display the " Ethernet Setup" dialog screen (Figure 4-10).
2. From the "SNTP Server" section of the dialog screen proceed as follows:
   a. If the Server Name is known, enter the Server Name and then select **Lookup**. IPScom will search for the corresponding IP Address.
   b. If the server IP Address is known, enter the IP Address.
3. Select **Save**. IPScom will save the settings to the device or open file.

Ethernet Port Configuration on a network that supports DHCP Protocol, from the HMI

1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".

```
    COMMUNICATIONS
<CNFG           UTIL>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
    PORT1 Settings
<                   >
```

3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.

```
        Ethernet
<                   >
```

4. Press **ENT** or **CNFG** once. The unit will display the following:

```
        Settings
<                   >
```

5. Press **CNFG** pushbutton as necessary until "DHCP Enable" is displayed. If "DHCP Enable" is ENABLED, go to Step 9.

```
DHCP Enable
DISABLE
```

6. Press **ENT**. The following will be displayed.

```
DHCP Enable
DISABLE
```

7. Utilizing **SETP** or **CNFG** select **ENABLE**, then press **ENT**.

```
DHCP Enable
ENABLE
```

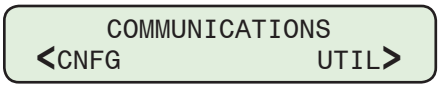
8. The relay is now addressable from IPScom over the target network.

■**NOTE:** The DNP and MODBUS Port addresses can not be set to the same value.

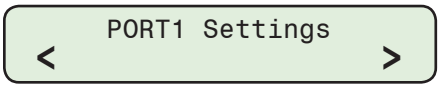
Also, if the network MODBUS Port address is not "502", go to the MODBUS Port Settings section of this chapter.

Ethernet Port Configuration on a network that <u>does not support</u> DHCP Protocol, from the HMI

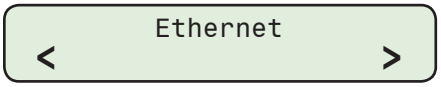
1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".



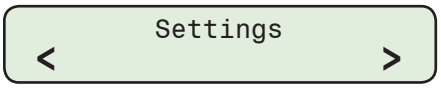
2. Press **ENT** or **CNFG** once. The unit will display the following:



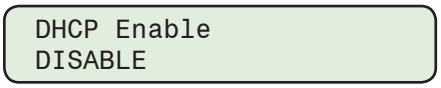
3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.



4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **CNFG** as necessary until "DHCP Enable" is displayed. Verify that "DHCP Enable" is set to DISABLE.



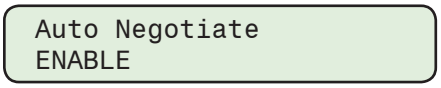
6. Continue through the sub-menu to enter the desired:
   - Static IP Address
   - Net Mask
   - Gateway

7. If the relay is connected to a host device which is capable of 10 and 100 mbps transmission rates and handles both half or full duplex modes, then the Ethernet port is now configured to support network communications with the MODBUS port default values. If the network requires specific MODBUS port settings, then see the MODBUS Port Setting section in this chapter.

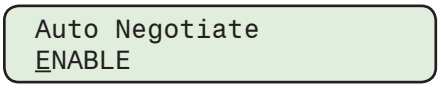
Auto Negotiation Settings From The HMI

■**NOTE:** Auto Negotiation must be disabled if using Fiber Ethernet.

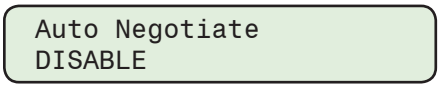
1. Utilize **SETP** or **CNFG** to navigate to the "Auto Negotiate" menu item, if a fixed speed of 100 mbps is desired as in the case of Fiber Optic mode



2. Press **ENT**. The following will be displayed.



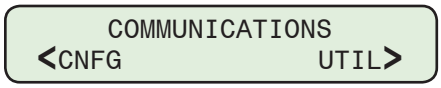
3. Utilizing **SETP** or **CNFG** select **DISABLE**, then press **ENT**.



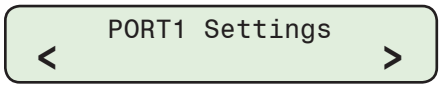
The Ethernet port is now configured to support network communications with the MODBUS port default values. If the network requires specific MODBUS port settings, see the following MODBUS Port Settings section.

MODBUS Port and DNP Port Settings From The HMI

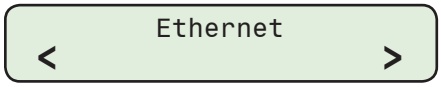
1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".



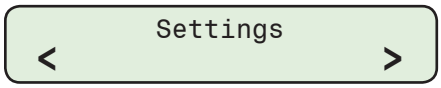
2. Press **ENT** or **CNFG** once. The unit will display the following:



3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.



4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **CNFG** as necessary, until the "Modbus Port" menu item is displayed.

6. Press **ENT**. The following will be displayed.

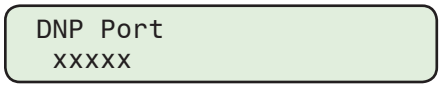
■**NOTE:** The DNP and MODBUS Port addresses cannot be set to the same value.

7. Utilizing the arrow pushbuttons enter the desired address, then press **ENT**.

8. Press **CNFG** once. The following will be displayed.

9. Press **ENT**. The following will be displayed.

10. Utilizing the arrow pushbuttons enter the desired address, then press **ENT**.

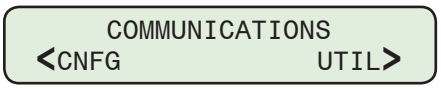


The relay is now addressable from IPScom over the network. Ensure that the MODBUS Port values are the same as the values manually set when attempting to communicate with the relay from IPScom.

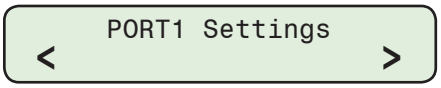
Network Time Synchronization Settings From The HMI

To enable and configure the SNTP (Simple Network Time Protocol) to allow Network Time Synchronization perform the following:

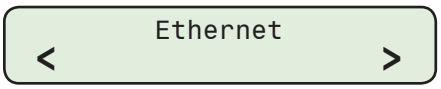
1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".



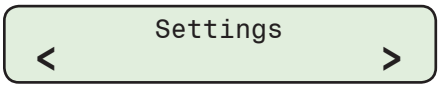
2. Press **ENT** or **CNFG** once. The unit will display the following:



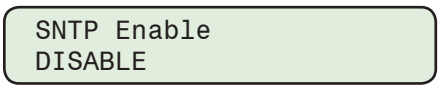
3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.



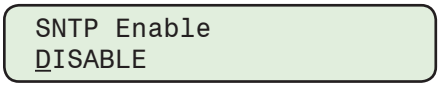
4. Press **ENT** or **CNFG** once. The unit will display the following:



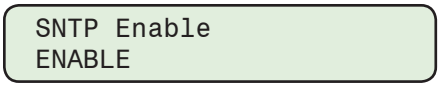
5. Press **CNFG** as necessary, until the "SNTP Enable" menu item is displayed.



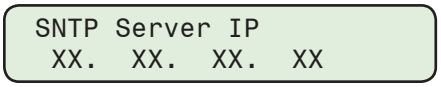
6. Press **ENT**. The following will be displayed.



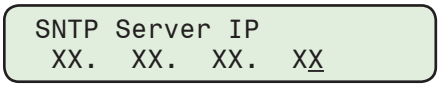
7. Utilizing **SETP** or **CNFG** select **ENABLE**, then press **ENT**.



8. Press **SETP** or **CNFG** as necessary until "SNTP Server IP" is displayed.



9. Press **ENT**. The following will be displayed.

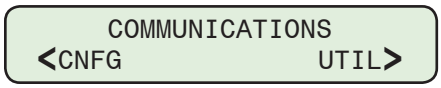


10. Utilizing the arrow pushbuttons input the desired IP Address, then press **ENT**. The desired IP Address will be displayed.

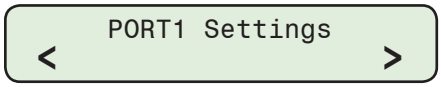
Ethernet Keepalive Time Settings From The HMI

This setting provides the user with the ability to set the Ethernet connection timeout parameter. The default value is 120 seconds and can be set to any value from 1 to 50000 seconds.

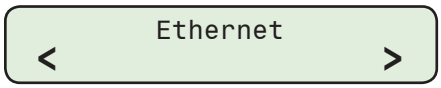
1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".



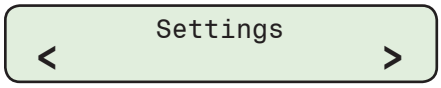
2. Press **ENT** or **CNFG** once. The unit will display the following:



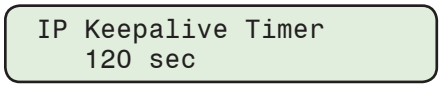
3. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.



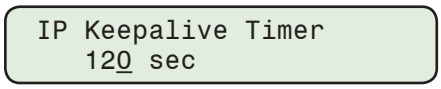
4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **CNFG** as necessary, until the "IP Keepalive Timer" menu item is displayed.



6. Press **ENT**. The following will be displayed.



7. Utilizing the arrow pushbuttons enter the desired setting, then press **ENT**. The desired Keepalive Time setting will be displayed.

OSCILLOGRAPH SETUP

The Oscillograph Recorder provides comprehensive data recording (voltage, current, and status input/output signals) for all monitored waveforms. The oscillograph recorder stores 100 records of up to 480 cycles regardless of the sampling rate (at 16, 32, 64 or 128 samples per cycle). Oscillograph data can be downloaded using the communications ports to any Windows® based computer running the IPScom S-7600 Communications Software. The included BecoPlot Oscillograph Analysis Software program (Utility/BecoPlot) or any Comtrade reader is required to view the downloaded oscillograph files. Oscillograph records are retained if power to the relay is interrupted.

The general information required to be input to complete the Oscillograph Setup includes:

- **Samples/Cycle** – The number of samples/cycle can be selected to either 16, 32, 64 or 128 samples/cycle.
- **Post-Trigger Delay** – A post-trigger delay of 5% to 95% must be specified. After triggering, the recorder will continue to store data for the programmed portion of the total record before re-arming for the next record. For example, a setting of 80% will result in a record with 20% pretrigger data, and 80% post-trigger data.
- **Length of OSC** – The length of the Oscillograph record in cycles can be specified from 60 to 480 cycles for 60 Hz applications and from 50 to 400 cycles for 50 Hz applications.

- **Function Triggers** – The recorder can be triggered remotely through communications using IPScom, or automatically, using programmed status signals (Figure 4-12).

Setup Oscillograph Recorder (IPScom)

See "Oscillograph Recorder" on page 2–12 for detailed information regarding retrieval and clearing of Oscillograph records.

1. From the IPScom Main Screen menu, select **Setup/Oscillograph/Setup**. IPScom will display the Oscillograph Setup dialog screen (Figure 4-11).
2. Select the number of Samples/Cycle.
3. Select the length of the Oscillograph record.
4. Select the Post Trigger Delay.
5. Select **Trigger Selection** from the setup screen. To enable a trigger scroll down through the Trigger listing on the left side of the dialog screen and drag the desired triggers to the "Enable Trigger" section on the right side of the screen. The trigger list can be filtered to display specific "Functions" (Overcurrent, Overvoltage, Overfrequency, Function ABC) or specific "Actions" (Pickup, Timeout, Pickup Dropout, Timeout Dropout).
6. Select **Save**. IPScom will save the settings to either the relay or open file.

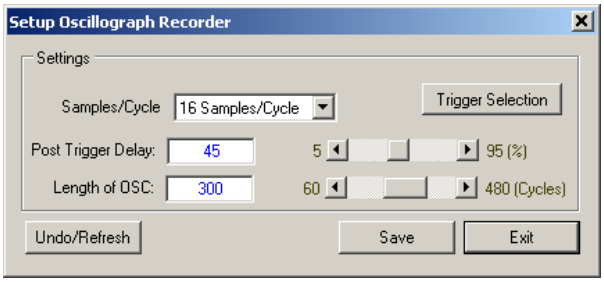


Figure 4-11 Oscillograph Setup Dialog Screen

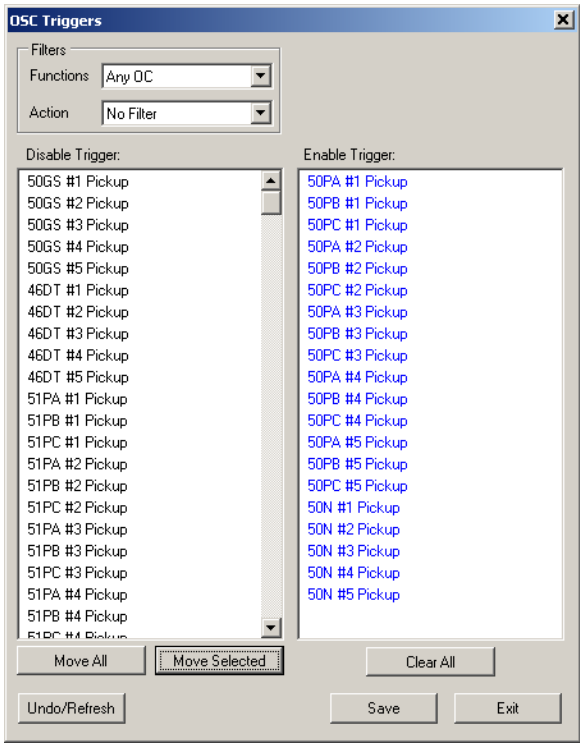


Figure 4-12 Oscillograph Trigger Selection Dialog Screen

SEQUENCE OF EVENTS RECORDER

Protective function Pickup, Trip, Dropout and/or Output/Input Pickup or Dropout are selected to trigger the Sequence of Events Recorder. See "Sequence of Events Recorder" on page 4–20 for detailed information regarding retrieval and clearing of Sequence of Events records.

Setup Sequence of Events Recorder (IPScom)

1. From the IPScom Main Screen menu select **Setup/Sequence of Events/Setup**. IPScom will display the Sequence of Events Setup dialog screen (Figure 4-13).
2. To enable a trigger, scroll down through the Trigger listing on the left side of the dialog screen and drag the desired triggers to the "Enable Trigger" section on the right side of the screen. The trigger list can be filtered to display specific "Functions" (Overcurrent, Overvoltage, Overfrequency, Function ABC) or specific "Actions" (Pickup, Timeout, Pickup Dropout, Timeout Dropout).
3. Select **Save**. IPScom will save the settings to either the relay or open file.

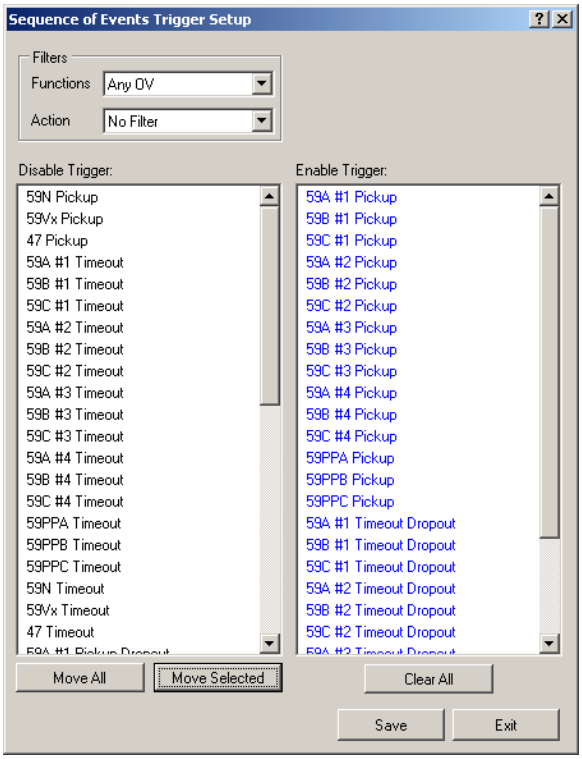


Figure 4-13 Sequence of Events Setup Dialog Screen

DATA LOGGING

▲**CAUTION:** Whenever the M-7651A D-PAC clock is reset and data logging is enabled the data log should be cleared.

The **Extended Data Logging** feature provides the user with the ability to initiate data logging of all relay parameters for downloading at a later time. Data is recorded internally into non-volatile memory. Utilizing IPScom, the data log is transferred in both Comtrade (.cfg) and CSV formats.

The Extended Data Logging feature significantly increases the amount of data that the relaycan store – up to 210,000 records. The data log recorder contains two storage elements: the current data log file and compressed history files. The current file can contain up to 3500 records. Once this record limit is reached, the relay will create a new file, and continue to record data into this new file, while compressing the previous file in the background. This operation may take up to 20 minutes. Data log download is not possible while the compression task is active.

Data logging will continue indefinitely as long as the Data Log Interval is set to a non-zero value. A zero value for the data log interval will effectively disable data logging. The data can be viewed using the included BecoPlot Analysis Software or any Comtrade compatible viewer.

The data logging interval ranges from 0 to 3600 seconds with an increment of 60 seconds. Once data logging is enabled, the relay will store the data in records at the data log interval rate. Each record has the following data:

- Active Profile
- Current & Voltage (A, B, C, G, Vz1): Maximum/Inst./Average/Minimum Voltage shown on both Y and Z sides, based on LEA Input Configuration
- Current, Voltage & Voltage Load: Positive, Negative, Zero
- Real Power, Reactive Power, Power Factor, Apparent Power (A, B, C, 3Ph)
- Frequency/ROCOF
- Counters
- Current & Voltage Harmonics THD (A, B, C)
- TDD (A, B, C)
- Function Pickup & Timeout
- Inputs & Outputs

The checksum is used to ensure the integrity of the record stored. Due to the internal structure of the Comtrade format, time stamping is always performed. A total of 260 Mbytes of data can be saved in non-volatile memory.

■**NOTE:** When a firmware update is performed, the data log must be retrieved and then cleared, prior to the firmware update. Failure to do so may result in loss of the data log record or corrupted data.

Data Logging Setup (IPScom)

This submenu item displays the **Data Logging Setup** Dialog Screen (Figure 4-14). In the **Logging Timer** section, the **Data Log Interval** allows the user to input the interval (in 60 second increments) at which the data will be logged. The **Save** command saves the Data Logging Setup to either the Open File when in File mode or the relay when IPScom is connected to a relay. The **Exit** command cancels any Data Logging setup changes before the changes have been sent to either the Recloser Control or Open File.

1. Select **Setup/Data Logging/Setup** from the IPScom toolbar. IPScom will display the Data Logging Setup dialog screen (Figure 4-14).

■**NOTE:** The Data Logging Setup dialog screen contains a self calculating "Duration" parameter that represents the number of days and the specific time when the data logging buffer will be full. The Data Log Interval is considered in this calculation.

2. Enter a Data Log Interval (0 to 3600 seconds in 60 second increments).
3. Select **Save**. IPScom will save the settings to either the relay or open file.

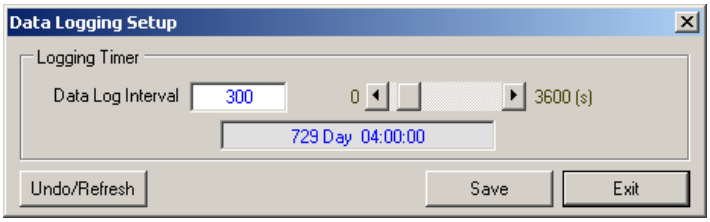


Figure 4-14 Data Logging Setup Dialog Screen

Data Logging/CSV Configuration

This submenu item displays the **Datalog CSV** dialog screen (Figure 4-15). This screen allows the user to specify the Data Logging parameters to include in the downloaded (.csv) file which can be viewed in a spreadsheet program.

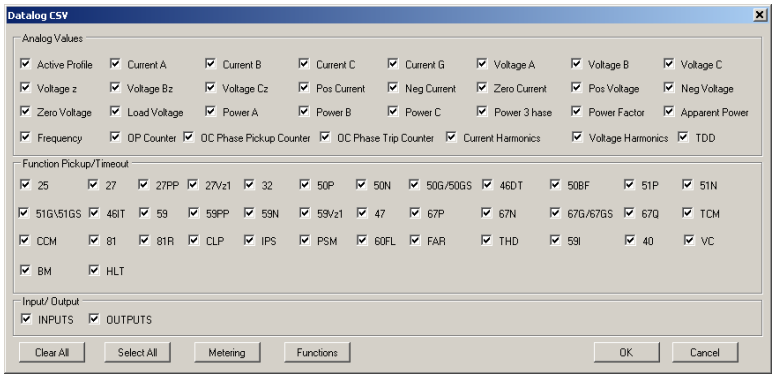


Figure 4-15 Datalog CSV Configuration Dialog Screen

Data Logging/Retrieve

■NOTE: When a firmware update is performed, the data log must be retrieved and then cleared, prior to the firmware update. Failure to do so may result in loss of the data log record or corrupted data.

The **Setup/Data Logging/Retrieve** submenu displays (Figure 4-16) with two options:

- **Latest File –** retrieves the current, uncompressed data log file into a user selected filename/location, in both Comtrade (.cfg) and CSV formats.
- **Datalog History –** displays a date range of all the compressed data log files, allowing the user to select the desired date range. IPScom retrieves the files into the default location: C:\ProgramData\IPSCOM\M-7679. A folder is created with the unit serial number "M-7679_SNXX_datalog". The folder contains the data log files in both Comtrade (.cfg) and CSV formats.

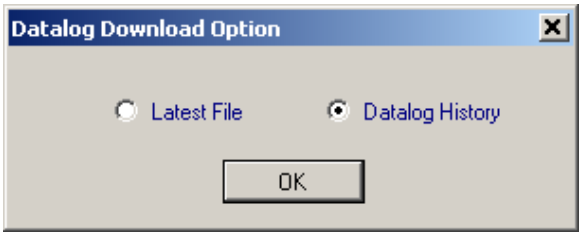


Figure 4-16 Datalog Download Option Dialog Screen

■**NOTE:** During Data Log retrieval, the relay will not save any new data until file retrieval is completed. File retrieval takes at least 15 seconds (file close timeout) plus the actual download time.

1. Select **Setup/Data Logging/Retrieve** from the IPScom toolbar. IPScom will display the Data Log Download Option dialog screen (Figure 4-16).
2. When **Latest File** is selected, IPScom will display the "Data Logging Record Save As" Dialog Screen.
3. Enter a filename and location for the retrieved Data Log file and select **Save**.
4. IPScom will display a download status screen followed by a confirmation screen (Figure 4-17). Select **OK**. IPScom will automatically open the file in BecoPlot.

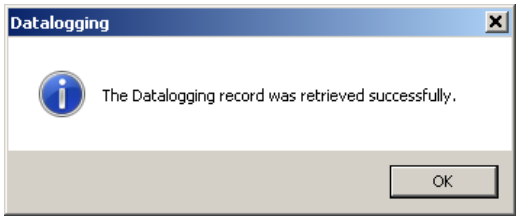


Figure 4-17 Data Log "Latest File" Retrieved Successfully Confirmation Screen

5. When **Datalog History** is selected, IPScom will display the "Datalog Range Download" Dialog Screen (Figure 4-18).

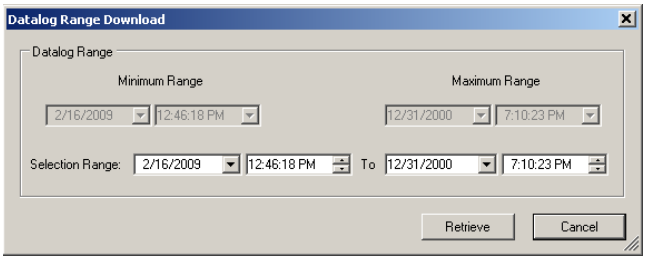


Figure 4-18 Datalog History Datalog Range Download Dialog Screen

6. Select the date range, and then select **Retrieve**.
7. IPScom will display the download status screen, followed by the "Datalogging Records Retrieved Successfully" Confirmation Screen which displays the default download location (Figure 4-19).

Figure 4-19 Datalogging History Records Downloaded Successfully Confirmation Screen

Data Logging/Clear

This submenu item when selected, clears the data logging information stored in the relay.

Data Log Saved to an SD Card

When the data log is saved to an SD Card, the transferred data log consists of two files, an xml file (.xml) and the data file (.dat). The data log (.xml) file must be converted to Comtrade format by IPScom to be viewed in a Comtrade compatible viewer. This tool is available in the IPScom Utility Menu (*Utility/Data Analysis/SD Card Download Converter/Datalog Files*).

ALARMS

The following Alarms can be enabled or disabled:

- Trip Close Alarm – occurs if the 52A and 52B contacts are in the same state.
- Battery Status Alarm – occurs if the battery is not present, fails the load test, or is not charging.
- Gas Pressure Alarm – occurs if the input for the gas pressure is high. Alarm is only selectable if the Autoreclose option is purchased.
- Max Breaker Operations Alarm – occurs if the Operations Limit is exceeded.

The following Alarms are enabled by default and may not be disabled:

- EEprom Setpoints Checksum Alarm – occurs if the checksum is bad.
- DSP Watchdog Alarm – occurs if the DSP is not running correctly.
- EEprom Calibration Checksum Alarm – occurs if the checksum is bad.
- Flash Not Formatted Alarm – occurs if the internal flash drive is not formatted.
- Internal Battery Failure – occurs when the internal battery that provides back up power to the non-volatile memory has failed. This condition will set the alarm when the relay reboots and the battery has been determined to have failed.

Setup Alarms from IPScom

1. From the IPScom Main Screen menu select **Setup/Alarms**. IPScom will display the Alarms Setup dialog screen (Figure 4-20).
2. Select any desired alarms.
3. Select **Save**. IPScom will save the settings to either the relay or open file.

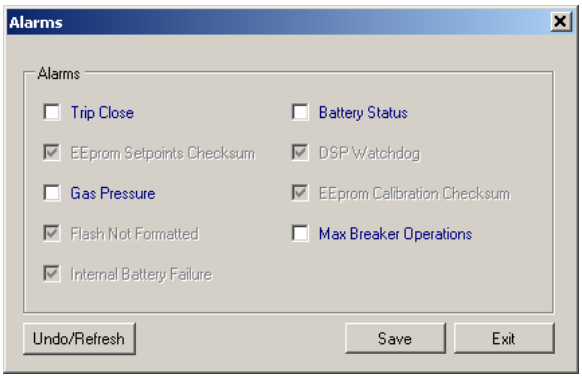


Figure 4-20 Alarms Setup Dialog Screen

4.2 System Setup

System setup data is required for proper operation of the relayrecloser control.

The System Setup consists of defining common information like CT and VT ratios, nominal voltage rating, nominal current rating and which profile is the Active Profile, etc. Values are entered similar to other setpoints. Configuration information is common to all profiles, and should be entered before setpoint and time settings.

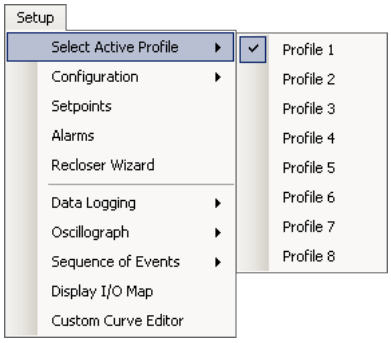
SELECTING THE ACTIVE SETPOINT PROFILE

To select the Active Setpoint Profile perform the following:

1. Start IPScom, then establish communications with the target relay.

■**NOTE:** To select a profile for **editing**, use the "Setpoints" dialog screen or the Recloser Wizard.

2. Select **Setup/Select Active Profile** from the IPScom toolbar. If custom Profile Names have been setup, they will display in this dropdown.



▲**CAUTION:** The relay will immediately respond to the new Active Setpoint Profile settings. If the relay is in Lockout state, the Active Profile will not change until the Lockout is removed.

3. Select the desired profile to activate. The Active Profile will be indicated in the menu dropdown. The relay front panel will display the User Lines for the Active Profile.

M-7651A D-PAC SYSTEM SETUP

The following settings have been configured at the factory and are indicated (grayed out and cannot be changed).

- Nominal Frequency (50 or 60 Hz)
- CT Secondary Rating (1 or 5 Amp)
- Ground CT Rating (1 A, 5 A, 200 mA, 50 mA or 10 mA)
- Operation Type (when Autoreclose Option is purchased)
- Voltage Inputs (VT, H4, L4, X4, H6, L6, X6)

■**NOTE:** When a "New File" is created in IPScom File Mode, these settings are selectable. Ensure that the settings match the factory settings of the target unit. Attempting to write a file to a M-7651A D-PAC that does not match the configuration settings, will result in IPScom returning an error message.

To setup the M-7651A D-PAC System perform the following:

1. From the IPScom Main Screen menu select **Setup/Configuration/Relay**. IPScom will display the applicable System Setup dialog screen (Figure 4-21, Figure 4-22 or Figure 4-23) as determined by the factory hardware configuration.

■**NOTE:** See Section 4.3 **System Diagrams** for Typical VT Three-Line Connection Diagrams.

2. Enter the desired settings. The configuration settings shown below are determined by the factory hardware configuration, and are displayed as applicable.
   - Nominal Voltage
   - Nominal Current
   - VT Configuration
   - Default Active Profile
   - Phase Rotation
   - Terminal Phase Assignment
   - Source Orientation
   - CT Polarity Reversal Enable
   - Lockout Operation
   - 69 Switch Operation
   - HCL Operating Current Reference
   - Power Supply Type
   - CT and VT Ratios
   - Voltage Input Configuration
3. Clicking the "Voltage Input Configuration" button displays the applicable Voltage Input Configuration dialog screen. See "**Voltage Input Configuration**" later in this Chapter for details.
4. Select **Save**, the System Settings will be saved to either the Relay or Open File.

Source Orientation Setting with LEA Hardware Options H6, L6 or X6

This setting is used to determine on which side the calculation of demand metering and energy metering is done. In addition this is also used for F32, F59I, THD protective function and CBEMA.

CT Polarity Reversal Enable

With LEA Hardware options H6, L6 or X6; enabling this setting reverses *ONLY* the **current** polarity by 180 degrees.

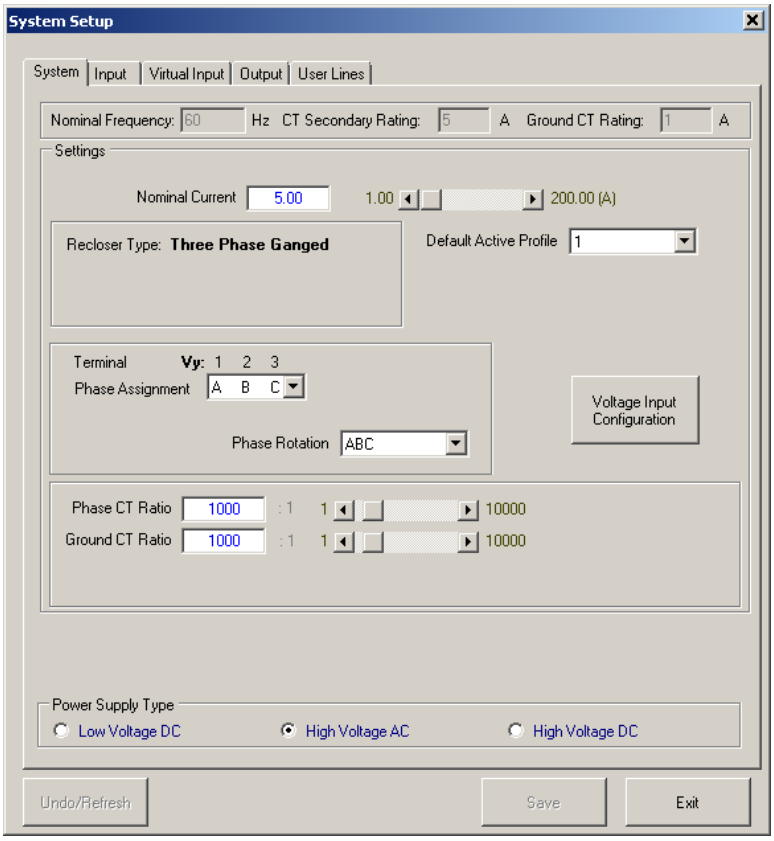


Figure 4-21 System Setup Screen, Voltage Input Option H4, L4 or X4

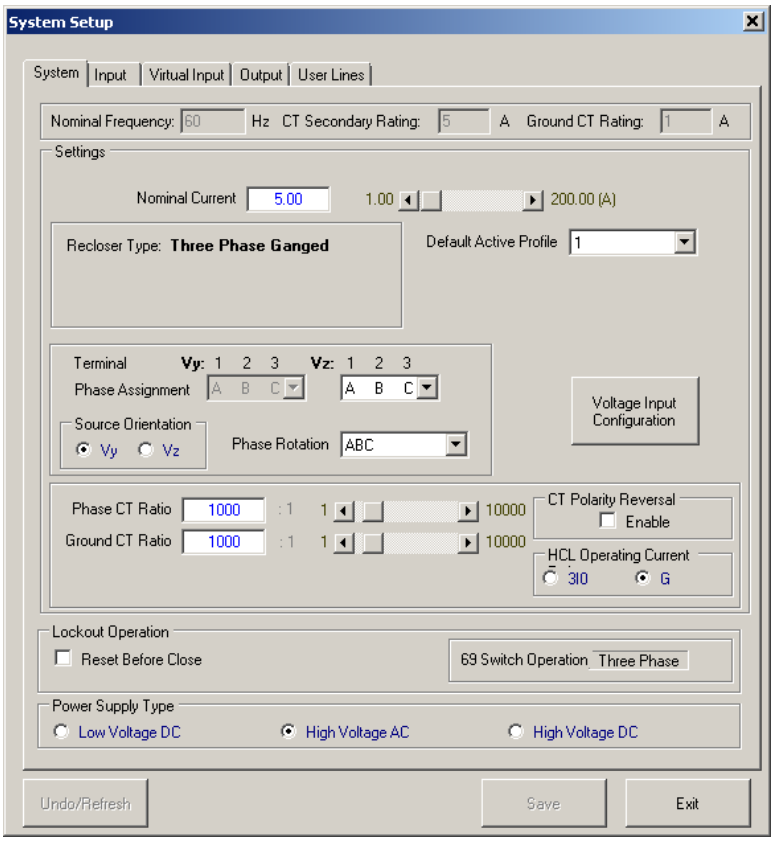


Figure 4-22 System Setup Screen, Voltage Input H6, L6 or X6 (Autoreclose Option)

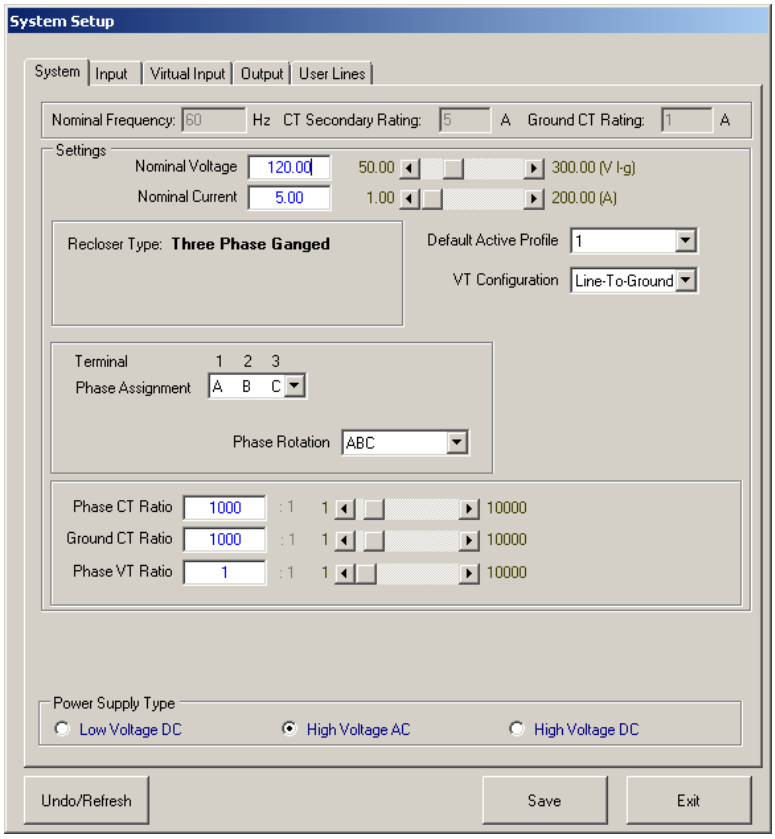


Figure 4-23 System Setup Dialog Screen, Voltage Input Option VT

VOLTAGE INPUT CONFIGURATION

The following Table lists the factory hardware options available for Voltage Inputs in the M-7651A.

Analog Hardware Voltage Input Options	
VT	120–300 Vac Voltage Inputs (4)
H4	LEA High Voltage Inputs (4) An0-An2 are configurable phase current, An3 is ground current, (3 LEAHs) An4-An6 are configurable load phase voltages and (1 LEAH) An7 is a source phase voltage or gnd voltage
L4	LEA Low Voltage Inputs (4) An0-An2 are configurable phase current, An3 is ground current, (3 LEALs) An4-An6 are configurable load phase voltages and (1 LEAL) An7 is a source phase voltage or gnd voltage
X4	LEA Low Voltage Inputs (3) + LEA High Input (1) An0-An2 are configurable phase current, An3 is ground current, (3 LEALs) An4-An6 are configurable load phase voltages and (1 LEAH) An7 is a source phase voltage or gnd voltage
H6	LEA High Voltage Inputs (6) An0-An2 are configurable phase current, An3 is ground current, (3 LEAHs) An4-An6 are configurable load phase voltages and (3 LEAHs) An7-An9 are source phase voltages
L6	LEA Low Voltage Inputs (6) An0-An2 are configurable phase current, An3 is ground current, (3 LEALs) An4-An6 are configurable load phase voltages and (3 LEALs) An7-An9 are source phase voltages
X6	LEA Voltage Inputs (3) + LEA High Input (3) An0-An2 are configurable phase current, An3 is ground current, (3 LEALs) An4-An6 are configurable load phase voltages and (3 LEAHs) An7-An9 are source phase voltages

LEAH = Low Energy Analog sensor High range (60–300 Vac) similar to a VT.

LEAL = Low Energy Analog sensor Low range (0.1–12 Vac).

By default **Y** side is configured as load side and **Z** is configured as source side voltage.

■**NOTE:** When configuration is H6, L6 or X6 all ground voltage functions are disabled.

Table 4-1 Analog Hardware Voltage Input Options

Voltage Input Configuration Settings

When an LEA Hardware Option is present, the IPScom System Setup dialog screen (Figure 4-24) will contain an additional "Voltage Input Configuration" button. This selection will display the applicable Voltage Input Configuration dialog screen (Figure 4-28 through Figure 4-34).

The LEA Configuration settings are used by the relay for LEAL and LEAH in order to calculate internal parameters such as multipliers for primary voltage calculation and scale factor to calculate a normalized voltage to 120 V.

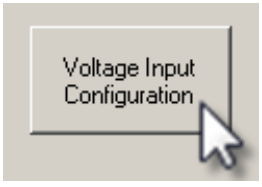


Figure 4-24 System Setup Dialog Screen Voltage Input Configuration Button

LEA Calibration Voltage from IPScom

For more accuracy the user can recalibrate the control in the field to any V_{cal} value allowable with the LEA range. Upon applying specified voltage and current inputs, the control will perform the calibration automatically and report the success or failure of the calibration. See Section 6.3 **Auto Calibration** for detailed information.

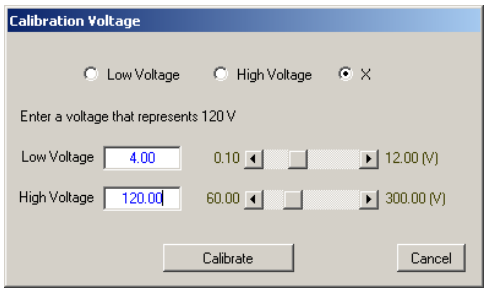


Figure 4-25 LEA Calibration Dialog Screen

Nominal Voltage Configuration – LEA Options H4, L4, X4, H6, L6 and X6

The LEA Configuration settings are used by the DSP for LEAL and LEAH in order to calculate internal parameters such as multipliers for primary voltage calculation and scale factor to calculate a normalized voltage to 120 V.

Example

Primary Nominal Voltage = 7200

LEA Output Voltage = 4 (as shown in Figure 4-25)

Internal V_{mult} = 7200/4 = 1800

V_{sec_nom} is internally a constant at 120 V

Then:

Normalized voltage = (4 x V_{sec_nom} x 1800)/7200 = 120 V

Normalized voltage = 120 V which is now going to be used internally by the relay as the operating voltage that will be applied to the protective functions and for metering. The host side and IPScom will in turn use the internal V_{mult} to scale that value to primary quantity.

■**NOTE:** Default for X6, the Y side is Low and the Z side is high.

■**NOTE:** Primary Nominal Voltage is ONE common setting for all Phases and for both Y and Z sides.

LEA Output Voltage Calculation

LEA Configuration setting ranges are as follows:

- Primary Nominal Voltage (PNV): 2000 – 40000
- PTR: 1 – 10000
- RCF: 0.1 – 2.0

Default Values:

- Primary Nominal Voltage = 7200 V l-g
- RCF the Ratio Correction coefficient = 1
- PTR the PT ratio = 1800
- Lea Output Voltage = 4 V

The LEA Output Voltage is calculated utilizing "Primary Nominal Voltage" (V_{nom}), "PT Ratio" (PTR) and "Ratio Correction Factor" (RCF):

LEA Output Voltage = **[V_{nom_pri} /(PTR * RCF)]**

The resultant LEA Output Voltage from the above calculation must be within 0.10 to 12.0 V for LEA Low Range and 60.0 to 300.0 V for High Range.

▲**CAUTION:** Misoperation of the unit will occur if the combination of settings for "Primary Nominal Voltage" (Vnom), "PT Ratio" (PTR) and "Ratio Correction Factor" (RCF) are written to the unit from a communication source other than IPScom (including the HMI) and result in a "LEA Output Voltage" that exceeds either the Low Range (0.10 to 12.0 V) or High Range (60.0 to 300.0 V).

Entering LEA Output Voltage calculation parameters and the system response to the entered values is subject to the following conditions:

- IPScom – If the combination of the V_{nom}, PTR and RCF exceeds the allowable LEA Output Voltage (Low or High range), IPScom will display an error message in red next to the Save button: "LEA Output Voltage is out of range for few terminals. Please change the PTR or Primary Nominal Voltage". The Save button will be greyed out, not allowing the settings to be saved to the unit.
- Communication source other than IPScom (including the HMI) – If the entered combination of V_{nom}, PTR and RCF exceeds the allowable LEA Output Voltage range (Low or High), the settings will be accepted by the unit but the unit will ignore the calculated out of range value and continue to use the last in range LEA Output Voltage.

Calibrating at different voltage will always be with reference to 7200 Primary nominal voltage, the PTR will be recalculated and the RCF will always be 1.

Calculation Formula for Secondary Voltage:

NCF = (Nom V_{sec} x PTR x RCF) / (Nom V_{pri})

Secondary Voltage = Lea Output Voltage * NCF

Example 1:

Nom V_{sec} = 120 V (always hardcoded in M-7651A)

Nameplate Values are the following:

- Nom V_{pri} = 7200V
- PTR = 10000
- RCF = 0.897

LEA output voltage = [7200/(10000*0.897)] = 0.803

If the measured primary voltage V l-g = 7480 V

then:

Measured output voltage = 7480/10000 = 0.748 V

Corrected output voltage = 0.748/0.897 = 0.834

Calculated NCF = (120 x 10000 x 0.897)/7200 = 149.5

then:

Secondary voltage displayed ($V_{X_display}$)= 0.834 x 149.5 = 124.67 V

Example 2:

All settings are the same as Example #1 except: RCF = 1.0

$V_{l\text{-}g}$ (nominal +5%) = 7200 x 1.05 = 7560 V

then:

Vx_display = 0.756 x 166.7 = 126.0 V (120 V + 5% = 126 V)

Phase Angle Shift Compensation

There are settings for each sensor as applicable to compensate or add phase angle shift to the corresponding measured signal. The angle range is from -180° to 180°, the positive angle represents leading direction and the negative angle represents lagging direction.

Example:

If Load Side Phase Shift 1 is 2°, the resultant calculated phasor for V1 load is shifted by 2 in the leading direction.

DUAL VT CONFIGURATION

With LEA Voltage Input option H4, L4, X4, H6, L6 or X6, the M-7651A has the capability to allow two VT configuration settings, one for the Y side (VTy) and one for the Z side (VTz). The available settings are determined by the factory hardware configuration.

When the Vy or Vz side voltage transducer is selected as "**VT**" the allowable VT configuration choices shown below are displayed as applicable.

- Wye
- LG-LL
- Phantom Wye A
- Phantom Wye B
- Phantom Wye C
- Phantom Delta AB
- Phantom Delta BC
- Phantom Delta CA
- Open Delta AB
- Open Delta BC
- Open Delta CA

■**NOTE:** When LEA is LOW or HIGH, the only allowable LEA configuration is Wye.

LEA Hardware X4 Voltage Input Configuration Settings Examples

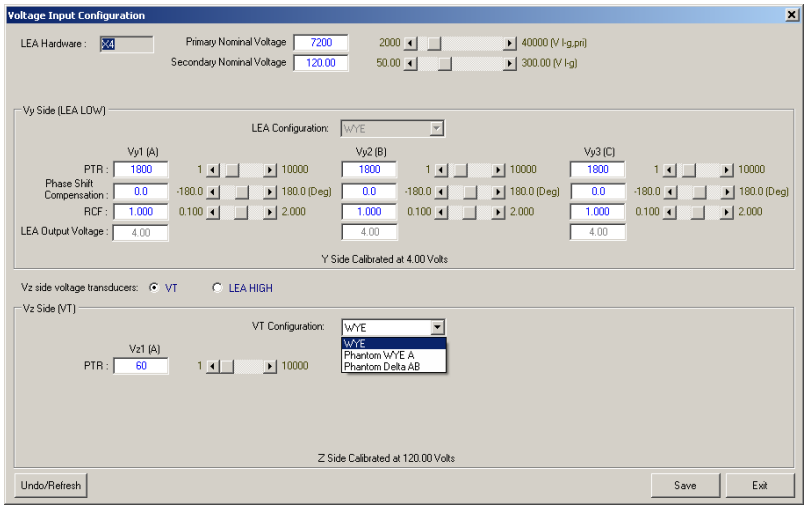


Figure 4-26 LEA Hardware X4 with Vz Side VT Configuration

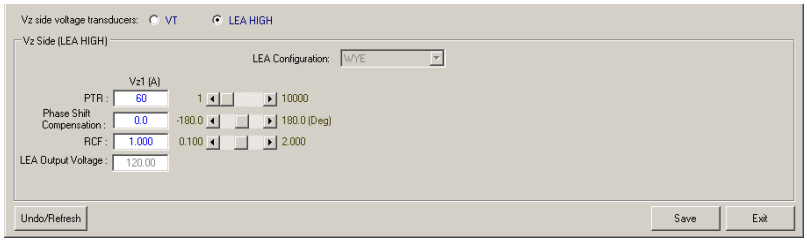


Figure 4-27 LEA Hardware X4 with Vz Side LEA High

LEA Hardware **H4** Voltage Input Configuration Settings Examples

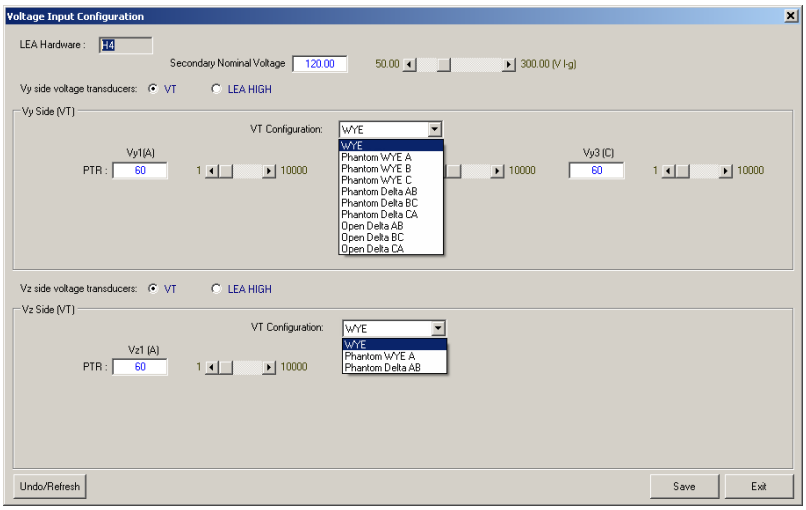


Figure 4-28 LEA Hardware H4 with Vy and Vz Side VT Configuration

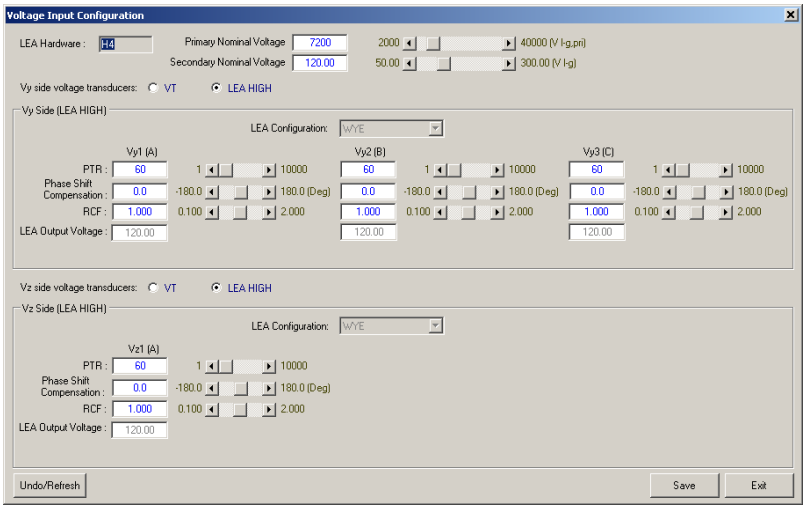


Figure 4-29 LEA Hardware H4 with Vy and Vz Side LEA HIGH

LEA Hardware **L4** Voltage Input Configuration Settings Example

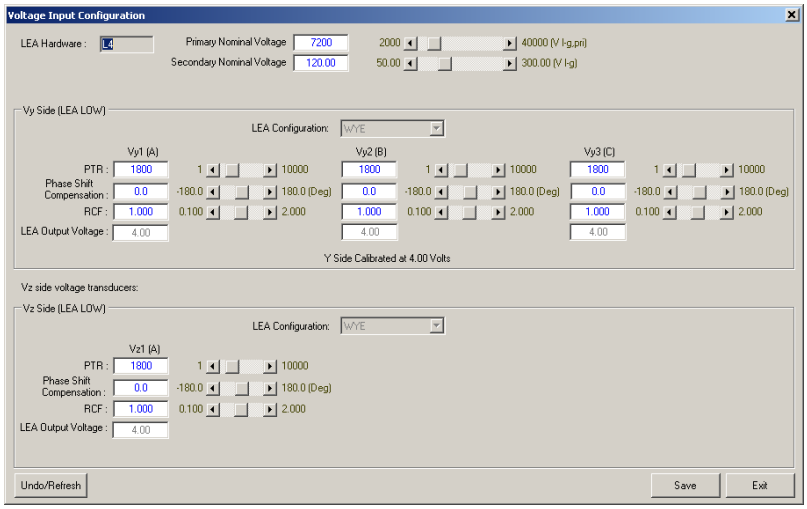


Figure 4-30 LEA Hardware L4 with Vy and Vz Side LEA LOW

LEA Hardware **H6** Voltage Input Configuration Settings Examples

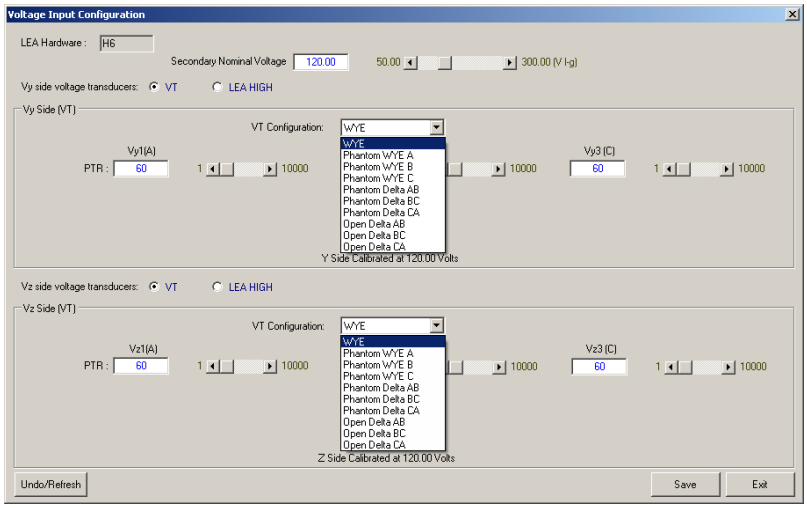


Figure 4-31 LEA Hardware H6 with Vy and Vz Side VT Configuration

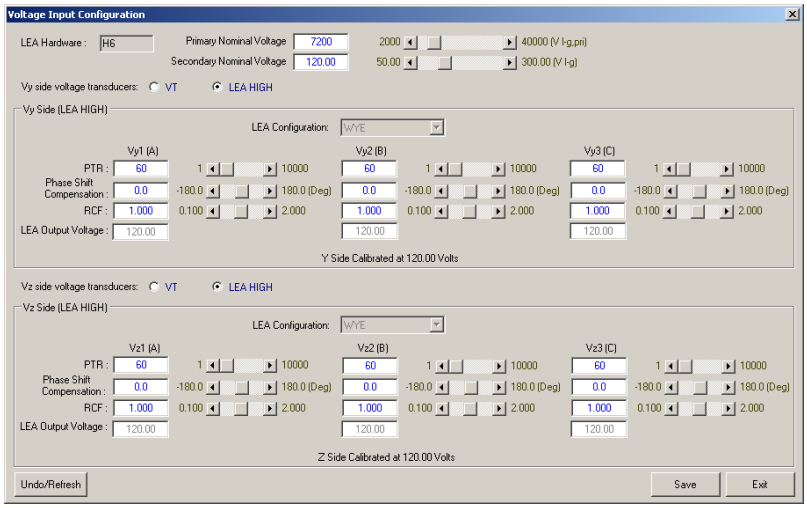


Figure 4-32 LEA Hardware H6 with Vy and Vz Side LEA HIGH

LEA Hardware **L6** Voltage Input Configuration Settings Example

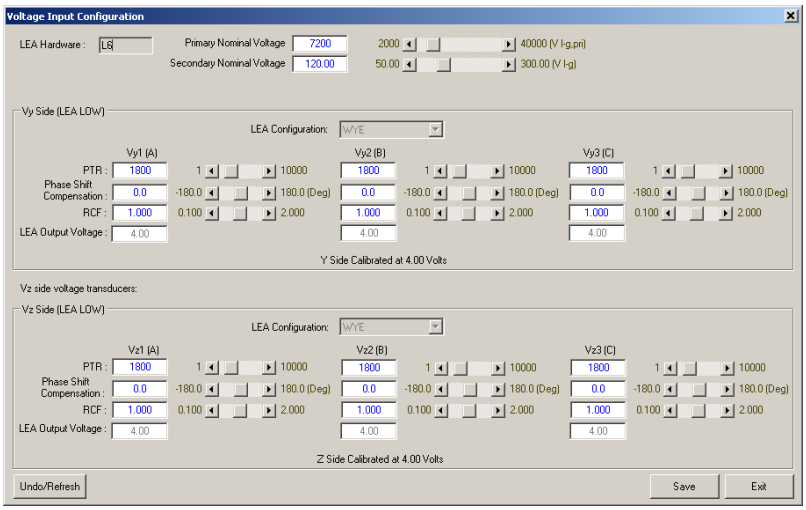


Figure 4-33 LEA Hardware L6 with Vy and Vz Side LEA LOW

LEA Hardware **X6** Voltage Input Configuration Settings Examples

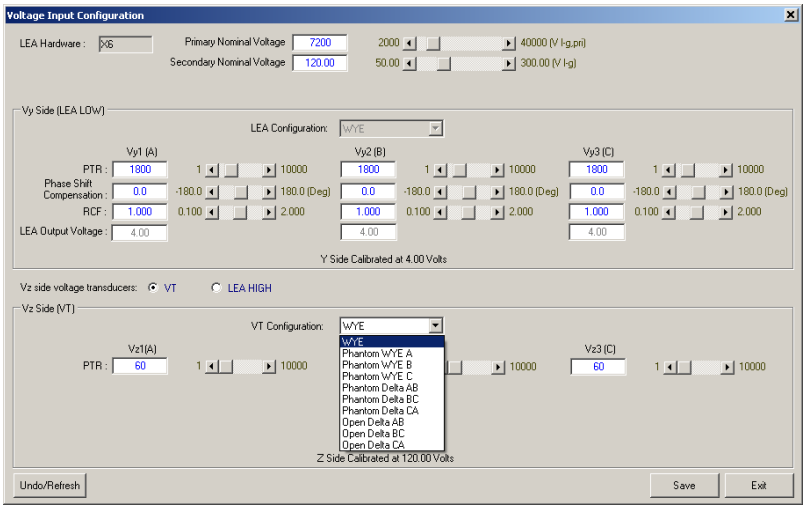


Figure 4-34 LEA Hardware X6 with Vy Side LEA LOW and Vz Side VT Configuration

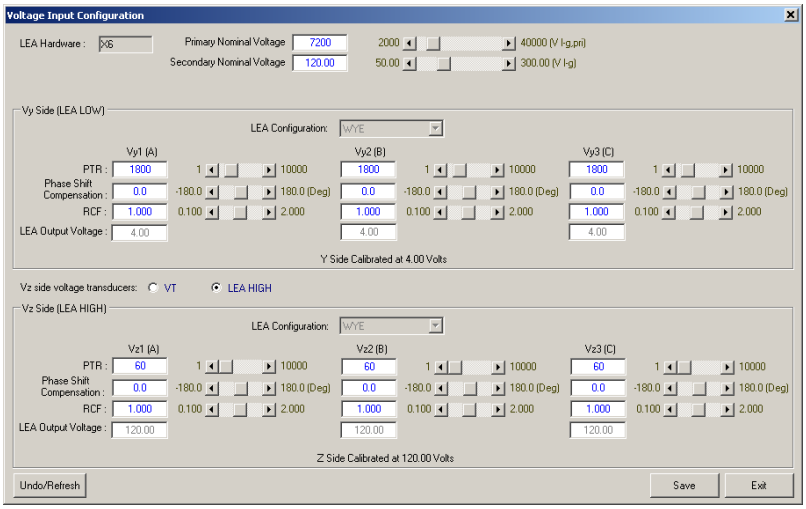


Figure 4-35 LEA Hardware X6 with Vy Side LEA LOW and Vz Side LEA HIGH

PHANTOM VOLTAGE – VT CONFIGURATION

The M-7651A D-PAC includes the capability to perform all three-phase voltage metering and protective functions utilizing a single VT input. The "VT Configuration" setting in the System Setup dialog screen (Figure 4-21) and the HMI "Configuration/Nameplate/VT Configuration" menu setting allows three-phase voltages and power quantities to be calculated/generated from a single metered quantity. The single-phase VT voltage input must be connected to either terminal TB5-9/10 (Vy_1/Ny) or TB5-11/12 (Vy_2/Ny) or TB5-13/14 (Vy_3/Ny).

The single-phase VT configuration settings available are shown in Table 4-2, depending on the connected voltage reference signals. The magnitude adjustment factors that are applied through the phantom voltage feature are, "1" for phase-to-neutral signals, and "1/ √3" to convert phase-to-phase signals to phase-to-neutral signals.

For example the M-7651A D-PAC derives Phase B and Phase C phase signals by rotating the $V_{PHANTOM}$ element by either 120° or –120°, depending on the phase rotation setting.

When a Phantom Voltage VT Configuration is selected, the fundamental power and energy quantities are based on the derived phantom voltages. Sequence components are not calculated and set to zero internally.

Magnitude and Phase Displacement Adjustment, Multiplied By Reference Voltage to Create $V_{phantom}$			
Voltage Reference	VT setting	Systems With ACB Rotation	Systems With ABC Rotation
Va	Phantom WYE A	1∠0°	1∠0°
Vb	Phantom WYE B	1∠120°	1∠-120°
Vc	Phantom WYE C	1∠-120°	1∠120°
Vab	Phantom Delta AB	1/ √3 ∠-30°	1/ √3 ∠30°
Vbc	Phantom Delta BC	1/ √3 ∠90°	1/ √3 ∠-90°
Vca	Phantom Delta CA	1/ √3 ∠-150°	1/ √3 ∠150°

Table 4-2 Phantom Voltage VT Configuration Table

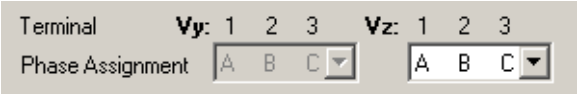
Phantom Voltage Examples – LEA Hardware X6

The following examples illustrate the following settings:

VTy = WYE
AINz = LEA HIGH
VTz = VT Configuration = Phantom WYE A
Terminal Assignment = ABC (**Example 1**)
Terminal Assignment = BCA (**Example 2**)

■**NOTE:** The Terminal Assignment must match the Phantom Voltage Input or vice versa.

Terminal Phase Assignment ABC:



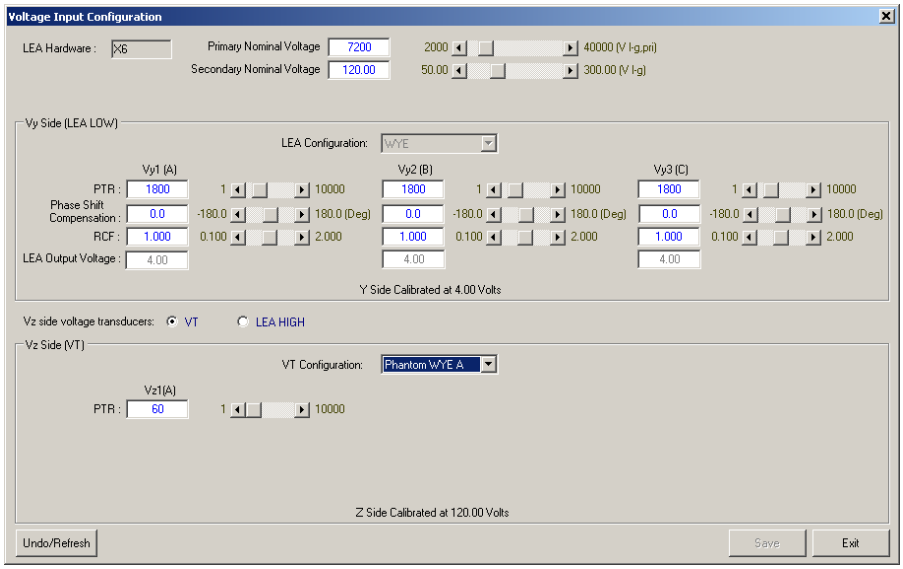
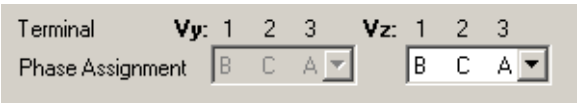


Figure 4-36 Example 1: Phantom WYE A, Terminal Assignment ABC

Terminal Phase Assignment BCA:



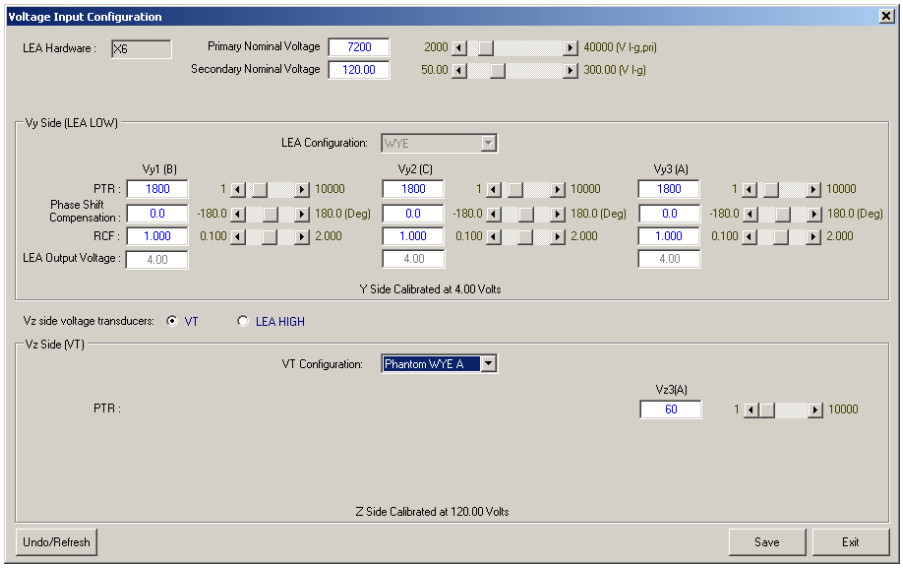


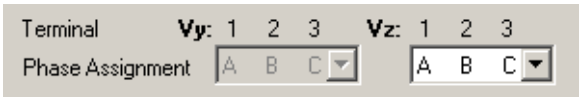
Figure 4-37 Example 2: Phantom WYE A, Terminal Assignment BCA

OPEN DELTA – VT CONFIGURATION

The following diagrams and screenshots illustrate several examples of Open Delta connections and the corresponding Voltage Input Configuration screens in IPScom.

Open Delta CA Example (LEA Hardware H6)

Terminal Phase Assignment: ABC



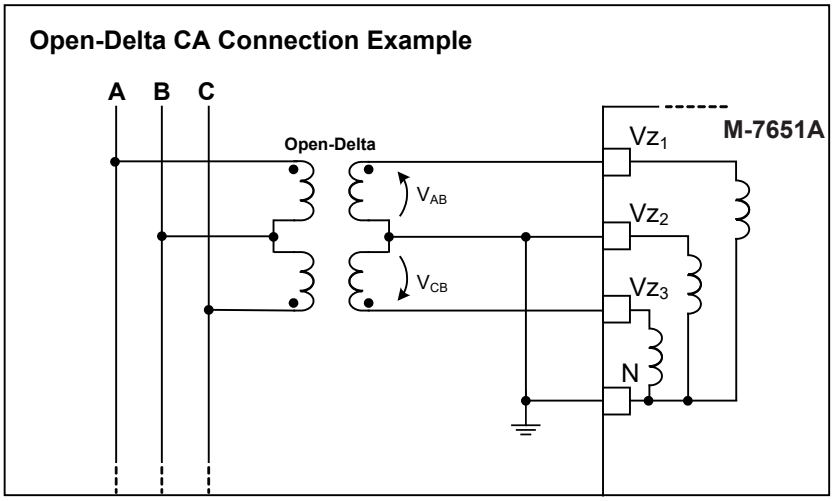


Figure 4-38 Open Delta CA Connection Example Diagram

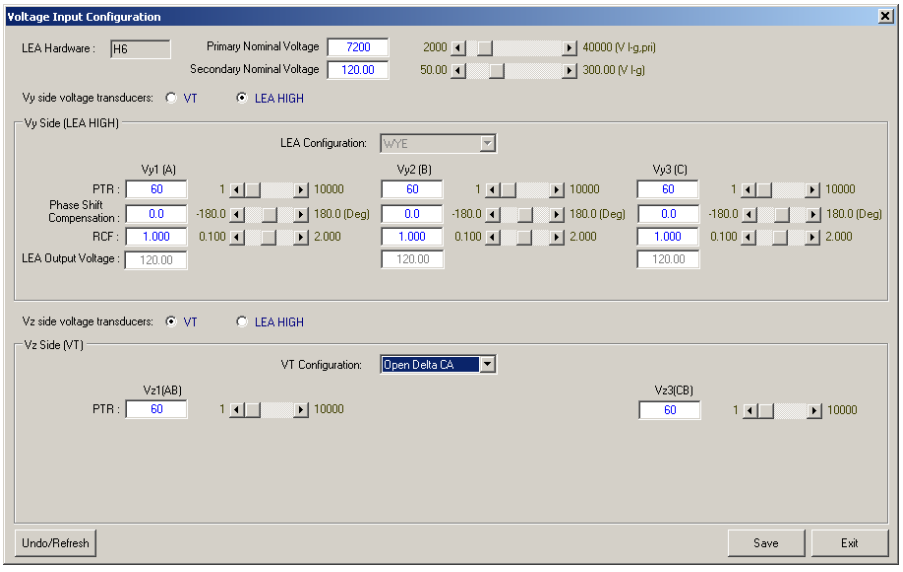
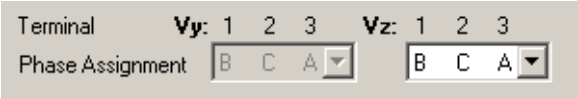


Figure 4-39 Voltage Input Configuration Screen, Open Delta CA Example

Open Delta AB Example (LEA Hardware H6)

Terminal Phase Assignment: BCA



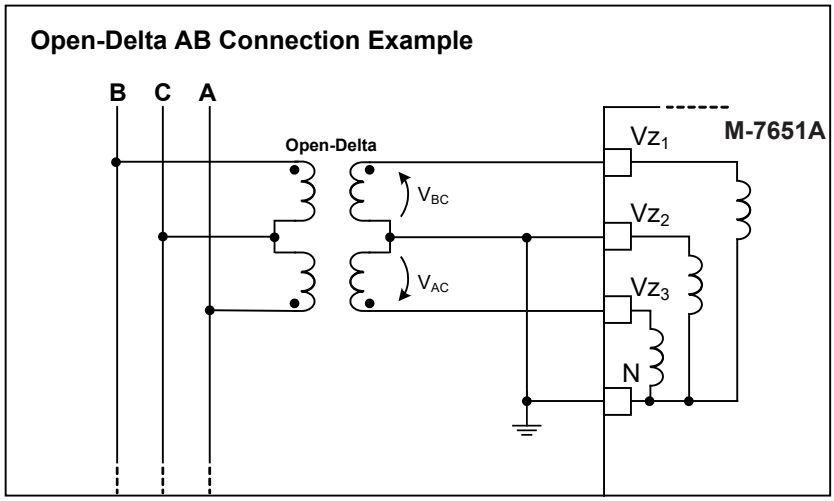


Figure 4-40 Open Delta AB Connection Example Diagram

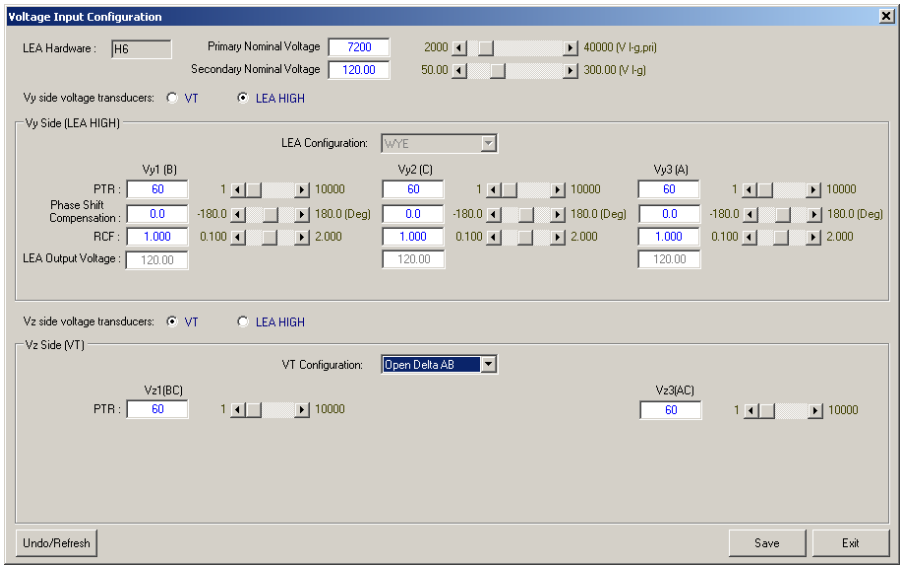
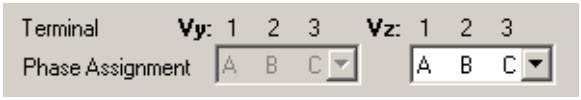


Figure 4-41 Voltage Input Configuration Screen, Open Delta AB Example

Open Delta BC Example (LEA Hardware H6)

Terminal Phase Assignment: ABC



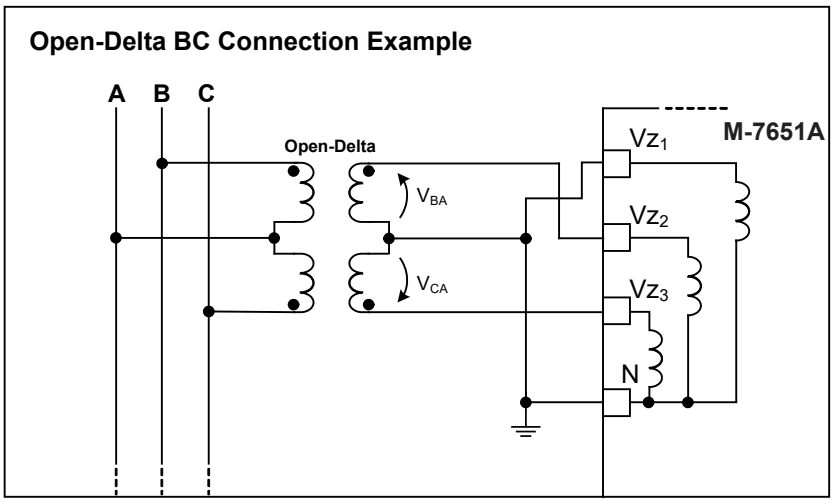


Figure 4-42 Open Delta BC Connection Example Diagram

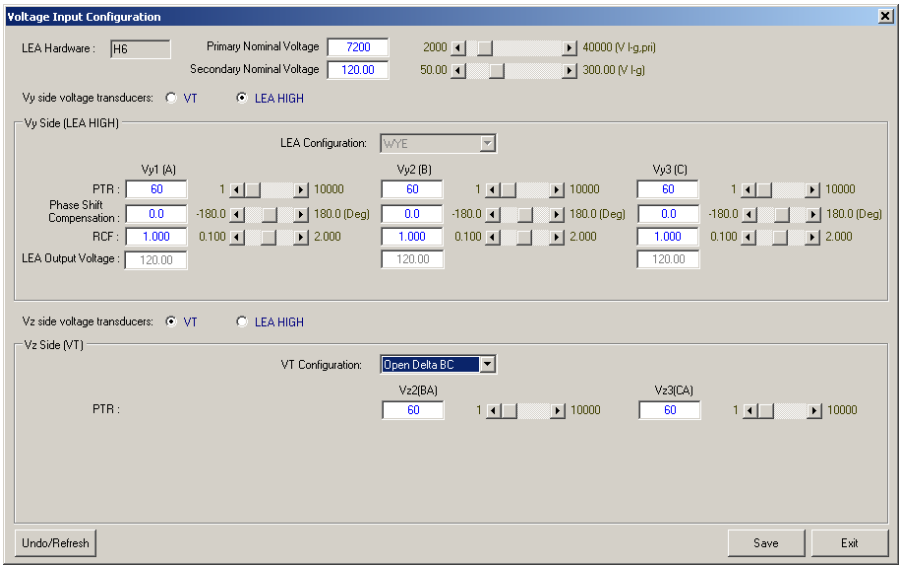


Figure 4-43 Voltage Input Configuration Screen, Open Delta BC Example

Open Delta Configuration Table

Terminal Assignment	VT Configuration	V1	V2	V3
ABC	Open Delta AB	VAC	VBC	x
ABC	Open Delta BC	x	VBA	VCA
ABC	Open Delta CA	VAB	x	VCB
ACB	Open Delta AB	VAC	x	VBC
ACB	Open Delta BC	x	VBA	VCA
ACB	Open Delta CA	VAB	VCB	x
BAC	Open Delta AB	VBC	VAC	x
BAC	Open Delta BC	VBA	x	VCA
BAC	Open Delta CA	x	VAB	VCB
BCA	Open Delta AB	VBC	x	VAC
BCA	Open Delta BC	VBA	VCA	x
BCA	Open Delta CA	x	VCB	VAB
CAB	Open Delta AB	x	VAC	VBC
CAB	Open Delta BC	VCA	x	VBA
CAB	Open Delta CA	VCB	VAB	x
CBA	Open Delta AB	x	VBC	VAC
CBA	Open Delta BC	VCA	VBA	x
CBA	Open Delta CA	VCB	x	VAB
X = Not Connected, No Signal Required				

Table 4-3 Open Delta Configuration Table

PROTECTIVE FUNCTION SETTINGS WITH LEA HARDWARE H6, L6 OR X6

The LOAD or SOURCE (Y or Z) side voltages are used for input signals for the following functions:

- Voltage protection functions: **F25, F27, F27PP, F59, F59PP, F59N, F47**
- Functions that use voltage for directionality **F67P, F67N, F67G/GS** and **F67Q**

When the H6, L6 or X6 hardware option is present, IPScom will display an additional setting in the Function Setpoint dialog screen which allows the user to select the side voltage that will be used by the function. See Figure 4-44 through Figure 4-46 for example screens.

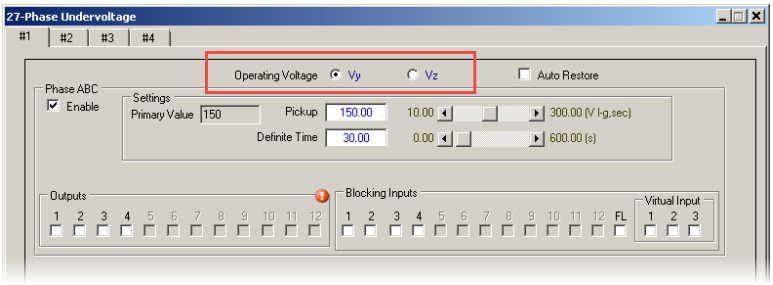


Figure 4-44 Function 27 Setpoints Dialog Screen with 6 Channel LEA Hardware Option

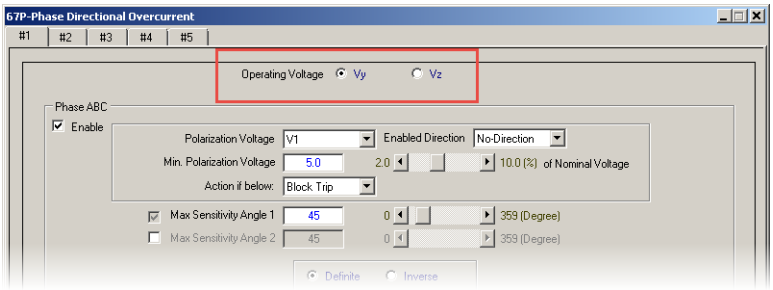


Figure 4-45 Function 67P Setpoints Dialog Screen with 6 Channel LEA Hardware Option

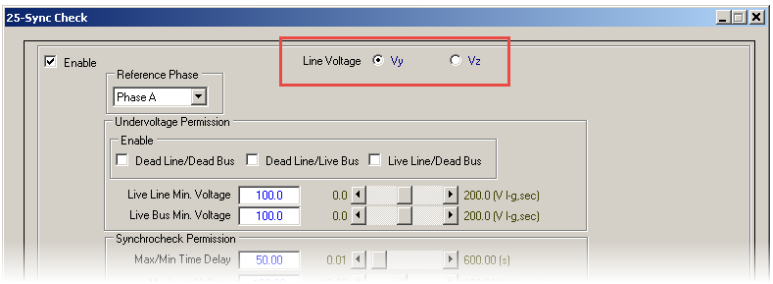


Figure 4-46 Function 25 Setpoints Dialog Screen with 6 Channel LEA Hardware Option

Frequency Calculation & Frequency Functions with LEA Hardware H6, L6 or X6

Frequency is calculated on both the Y and Z side. Frequency uses positive sequence voltage for DFT frequency calculation and maximum of the phase voltage magnitude for RMS frequency calculation. When the H6, L6 or X6 hardware option is present, IPScom will display an additional setting in the Frequency functions 81 and 81R which allows the user to switch the Operating voltage between the Y and Z side (Figure 4-47 and Figure 4-48).

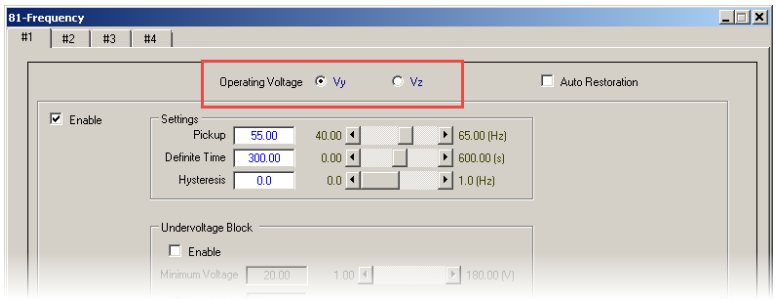


Figure 4-47 Function 81 Setpoints Dialog Screen with 6 Channel LEA Hardware Option

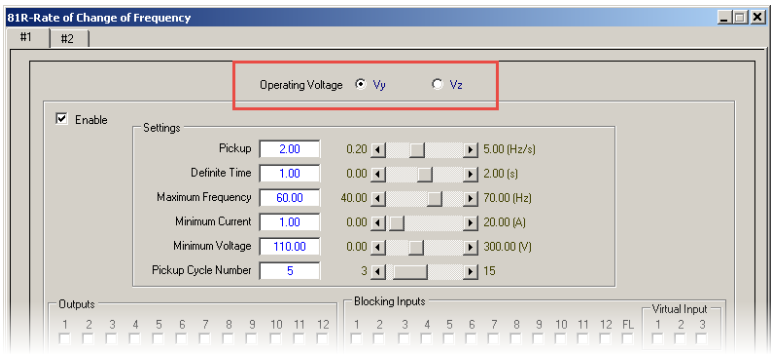


Figure 4-48 Function 81R Setpoints Dialog Screen with 6 Channel LEA Hardware Option

LEA Metering with LEA Hardware H6, L6 or X6

IPScom will display LEA measured and calculated values in the Primary and Secondary Metering screens. See Figure 4-49 as an example.

■**NOTE:** Secondary Metering Screen is identical.

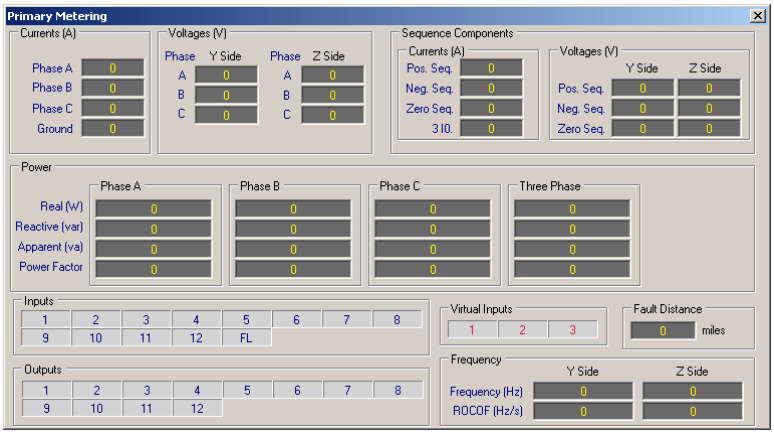


Figure 4-49 Primary Metering Screen with 6 Channel LEA Hardware Option

MANUALLY SETTING THE SYSTEM INPUTS

Active State

The Active State is used to invert the input states based on the connections. This allows the user to change the input state without physically changing the input on the back of the unit. The **Close** parameter designates the operated state established by closing rather than opening an external contact.

Debounce Timer

The DC signal Debounce Timer is configurable for each individual input. The timer may be set from 0 to 5000 ms. The default time setting is 10 ms.

Input Wetting

Input wetting is configurable for each individual input. When AC is selected, the debounce timer setting is not used for that input. AC wetting has fixed timing: 21 ms for 60 Hz units, 25 ms for 50 Hz units. The input will be set to "Logic 1" when the input remains active for at least the timer period. The timer starts to decrement when the input is inactive. The input will be set to "Logic 0" when the timer has expired. The threshold voltages for the AC inputs determine the active/inactive state.

1. From the IPScom Main Screen menu select **Setup/Configuration/Relay.** IPScom will display the System Setup screen.
2. Select the **Input** tab. IPScom will display the Input dialog screen (Figure 4-50 or Figure 4-51).
3. Select the Active State (Open or Close), the Debounce Time and the Input Wetting for each Input.
4. Select the Function to be associated with each Input (Table 4-4).

■**NOTE:** The Logic Table displayed in the Input dialog screen will update based on the selected function.

5. Select **Save**, the System Settings will be saved to either the Relay or Open File.

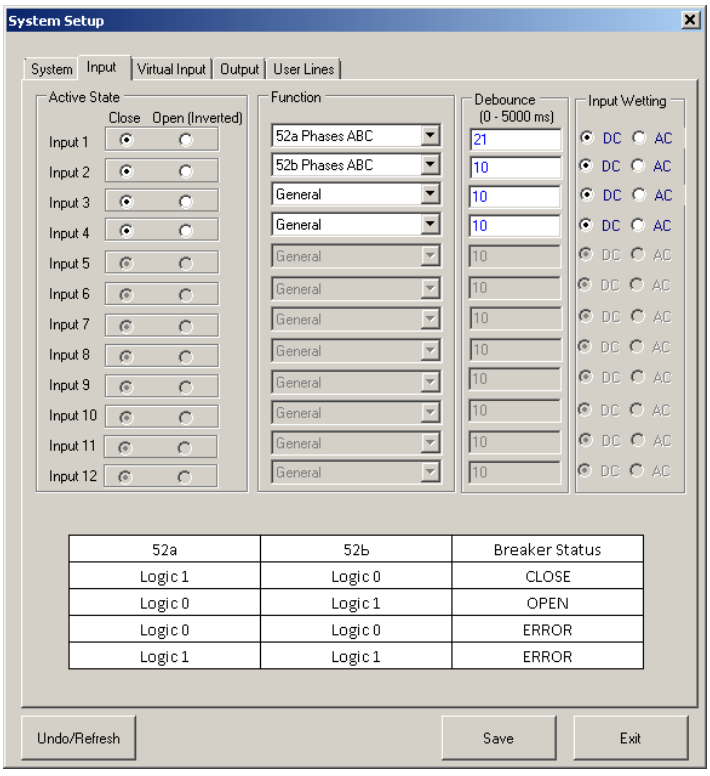


Figure 4-50 System Setup – Input Dialog Screen (without Extended I/O)

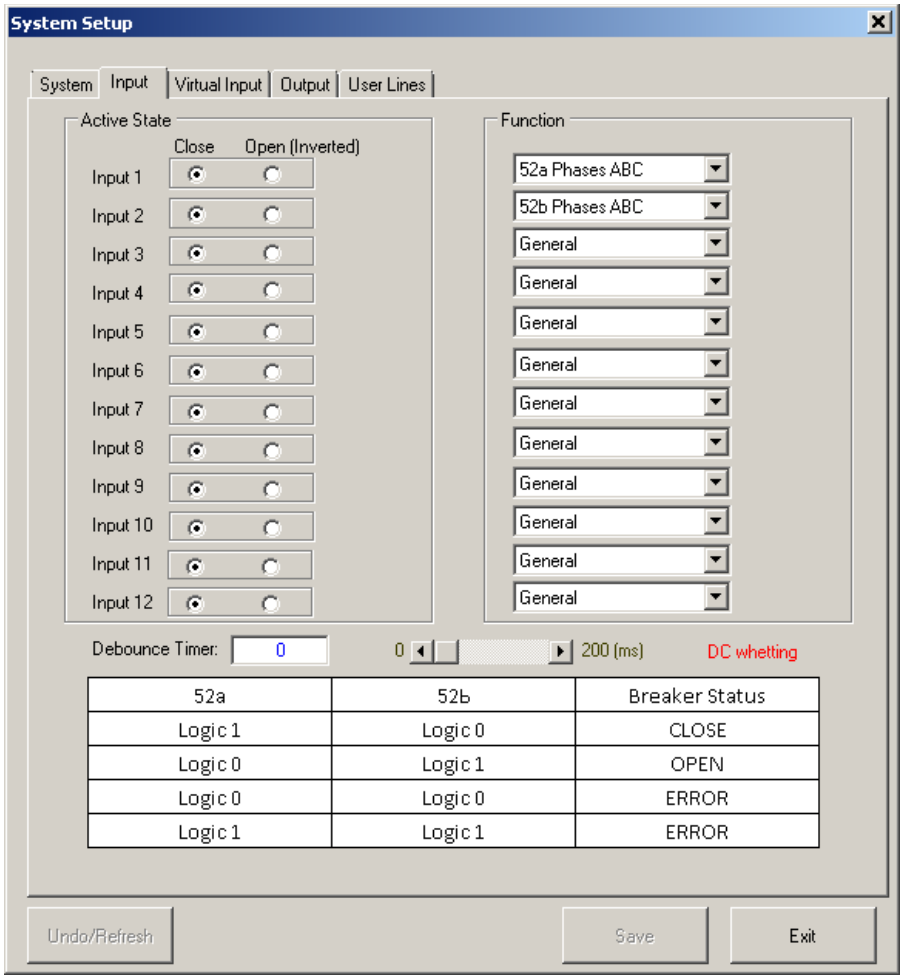


Figure 4-51 System Setup – Input Dialog Screen (Autoreclose Option and Extended I/O)

M-7651A System Inputs Function Selections		
Input	Default Configuration (Inputs 5-12 with Extended I/O)	Autoreclose Option
Input 1	**52a Phases ABC** General	**52a Phases ABC** General
Input 2	**52b Phases ABC** General	**52b Phases ABC** 52b/69 Lockout General
Input 3	**General**	69 Lockout **General**
Input 4	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 5	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 6	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 7	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 8	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 9	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 10	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General**
Input 11	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General** Battery Alarm
Input 12	HLT/Maintenance Profile Switching **General**	Gas Pressure HLT/Maintenance Profile Switching **General** AC Status
■**NOTE:** System Inputs Defaults are listed in **Bold** Type.		

Table 4-4 System Inputs Function Selections

Virtual Inputs

The M-7651A includes 3 Virtual Inputs (V1, V2 and V3) in addition to the physical inputs. The Virtual Inputs can be assigned to any of the eight IPSlogic functions utilizing the IPScom System Setup/Virtual Input dialog screen (Figure 4-52). When the IPSlogic assigned to the selected Virtual Input operates, then the Virtual Input is asserted and the Function is blocked.

A Virtual Input may be selected as a **Blocking Input** in any protective Function Setpoint screen. A Virtual Input may be selected as an **Initiating Input** in the 50BF, 60FL and Breaker Monitor Function Setpoints screens. As shown in Figure 4-53, once a Virtual Input has been assigned an IPSlogic function, the Virtual Input is displayed with a yellow highlight in each setpoint screen. Hovering over the input will display a tooltip with the assigned IPSlogic function.

The status of the Virtual Inputs is displayed in the Primary Metering screen (Figure 3-49), Secondary Metering screen (Figure 3-50) and the Function Status screen (Figure 3-52).

See **Section 4.4 System Setpoints/IPSlogic** for information regarding IPSlogic functions.

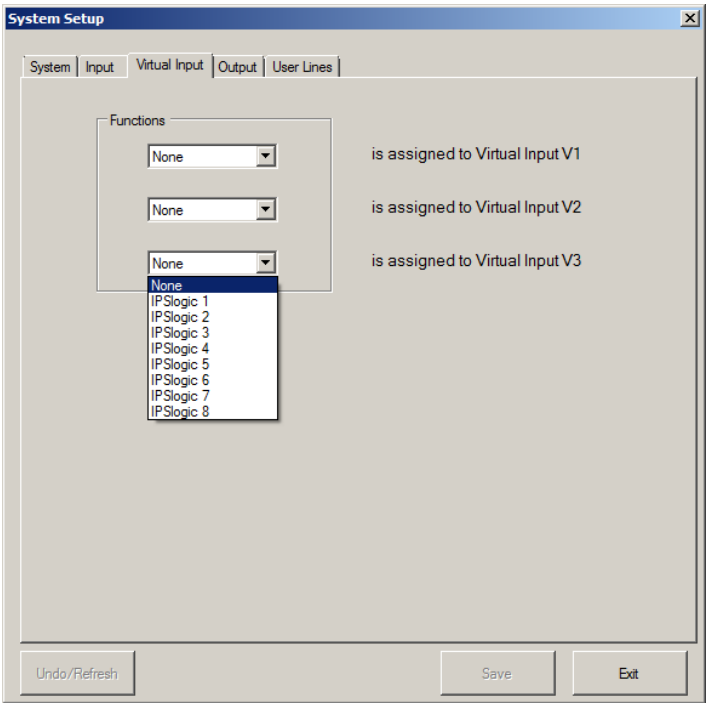


Figure 4-52 System Setup – Virtual Input Dialog Screen

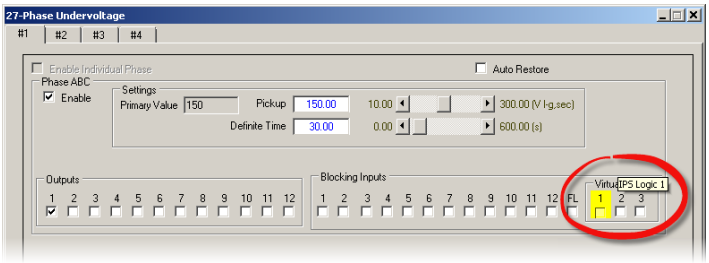


Figure 4-53 Example – Virtual Input Assigned to an IPSlogic Function

Profile Switching By Inputs

Up to three inputs (IN 4 through IN 12) can be dedicated to switch among the 8 profiles of the M-7651A D-PAC. Table 4-5 shows the logic for the profile assignment.

Profile Switching Input 3	Profile Switching Input 2	Profile Switching Input 1	Profile Assigned
0	0	0	1
0	0	1	2
0	1	0	3
0	1	1	4
1	0	0	5
1	0	1	6
1	1	0	7
1	1	1	8

Table 4-5 Profile Switching Inputs Logic

Profile Switching Input 1 to Profile Switching Input 3 can be physically assigned to any of the digital inputs on terminal TB1, TB6 and TB7 (extended I/O). For example, if the extended I/O is not available then only one digital input is available for profile switching namely IN 4 on TB1. If more than 2 profiles are needed then the extended I/O must be purchased. Each physical input (IN 4 through IN 12) can be configured through IPScom to participate in the profile switching scheme.

The relay determines which input is the least significant bit. The physical input with the smallest number designator will be the least significant bit. For example, if Inputs 4, 6 and 8 are chosen then Input 4 will be the least significant bit preceded by Input 6 and finally Input 8 shall be the most significant bit. The same rule applies if only two inputs are selected (maximum 4 profiles).

The user can configure up to three inputs (IN 4 through IN 12) for the profile selection. If one input is selected then the relay can only switch between profile 1 and 2. Two digital inputs provide up to 4 profiles (profile 1-4).

The inputs selected do not have to be consecutive terminals. IPScom provides safety logic to ensure that no more than three inputs can be selected for profile switching.

MANUALLY SETTING THE SYSTEM OUTPUTS

There are three output characteristics: Direct, Latched and Pulsed.

Direct mode – The contact can turn ON and OFF at any moment. Direct mode maintains the output contact energized as long as the condition that caused it to operate exists. After the actuating condition is cleared, the contact will reset after the programmed seal-in time has elapsed.

Latched mode – Once the contact is turned ON, it can only turn OFF when the relay receives a reset signal and the condition that caused the contact to operate no longer exists.

Pulsed mode – The output contact will turn ON for the pulse duration and then turn OFF at the end of the pulse duration.

Pulse Width/Seal-In Time

The Pulse Width/Seal-In Time range is from 0.01 to 136 seconds. In Pulsed mode, this parameter is used for the pulse width duration. The contact will dropout after the specified delay expires, even if the condition which caused the recloser to pickup still exists. When the output is in Direct mode this is the Seal-In time, which is the minimum guaranteed time a contact will operate. In Latched mode this setting is ignored by the relay.

Output Contact Type

General – designates contacts which have not been assigned to a protection function.

Trip Phase A (B, C) – designates contacts to be dedicated for the trip or open command. There can be up to three trip contacts: one for each phase operating independently or three trip contacts operating simultaneously. There can also be one trip contact operating all three phases. This will mainly be assigned to the 79 recloser function, but not limited to that function.

Close Phase A (B, C) – designates contacts to be dedicated for the close command. There can be up to three close contacts: one for each phase operating independently or three close contacts operating simultaneously. There can also be one close contact operating all three phases. This will mainly be assigned to the 79 recloser function, but not limited to that function.

HLT/Maintenance – When HLT/Maintenance is enabled the M-7651A D-PAC will trip for a fault then go to lockout. The relay switches over to reserved settings for 50P, 51P, 50G and 51G.

Enable Remote Control – specifies the contacts that are allowed to be activated remotely through communications. If the front panel Remote Disable pushbutton on the unit is is in the ON state (LED is illuminated), this setting in IPScom is not evaluated. The Enable Remote Control setting is only operational if the front panel Remote Disable button is in the OFF state (LED is extinguished).

The remote operation of each Output can be separately disabled, as opposed to the function of the Remote Disable button which disables ALL Outputs. Unchecking the corresponding checkbox for each Output disables remote functionality of that Output.

Outputs will not be operational in the following conditions:

- The user is attempting to send a Remote Trip/Close command
- The user is attempting to activate Outputs by sending a trigger signal (see Chapter 2, Remote Control for additional information.)
- When an Output is configured for Alarm, Battery Test, or Smart Button

■**NOTE:** Outputs assigned to functions are not affected by this selection. Any function timing out will trigger the assigned output, regardless of the state of the Enable Remote Control checkbox.

Manual Close Delay

The Manual Close Delay range is from 0 to 90 seconds. The relay waits for the specified time delay before the output contact operation is activated. This is **not** the Seal-In time.

Manually Setting the System Outputs from IPScom

1. From the IPScom Main Screen menu select **Setup/Configuration/Relay**. IPScom will display the System Setup screen (Figure 4-21).
2. Select the **Output** tab. IPScom will display the Output dialog screen (Figure 4-54 or Figure 4-55)

■**NOTE:** Outputs 5 through 12 are available with the optional expanded I/O.

3. Select the Characteristic (Direct, Latched or Pulsed) for each output.
4. Enter the Pulse Width/Seal-In Time for each output.
5. Select the Function to be associated with each Output (Table 4-4).
6. Select whether the output can be operated remotely.
7. Enter the Manual Close Delay from 0 to 90 seconds in 1 second increments.

■**NOTE:** The **Undo/Refresh** command allows the user to undo any changes in the System Setup screens before the settings are saved to either the Device or Open File.

8. Select **Save**, the System Settings will be saved to either the Relay or Open File.

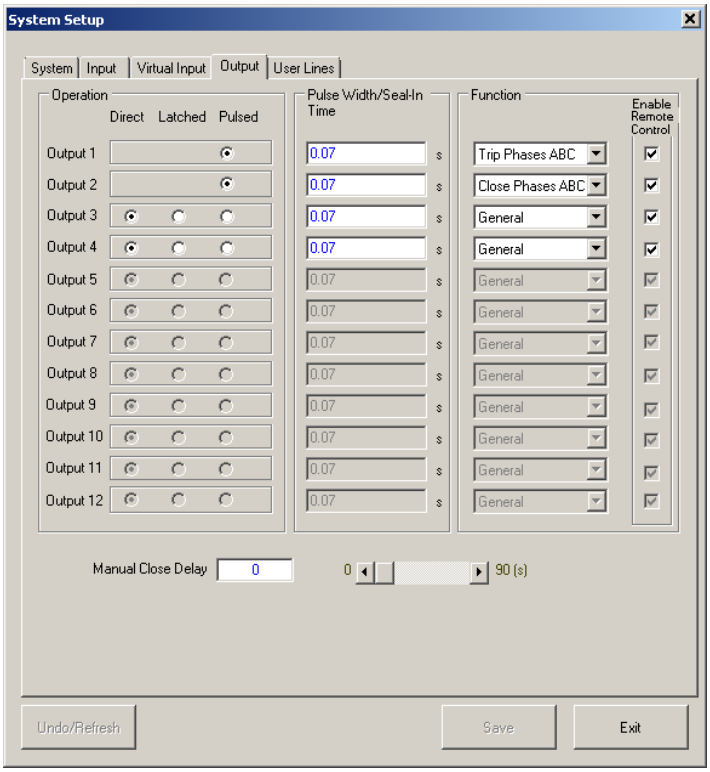


Figure 4-54 System Setup – Output Dialog Screen (without Extended I/O)

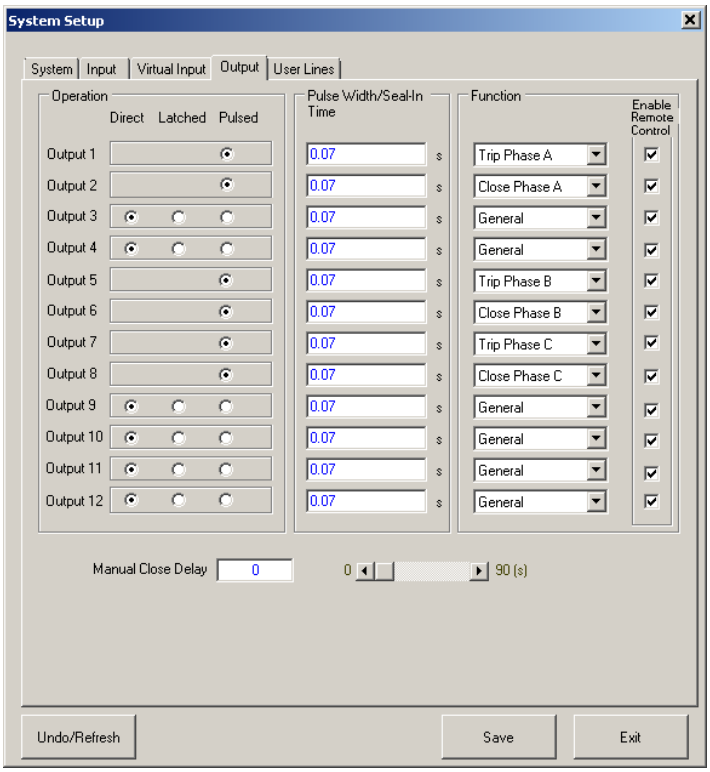


Figure 4-55 System Setup – Output Dialog Screen (Autoreclose Option and Extended I/O)

M-7651A System Outputs Function Selections		
Output	Default Configuration (Outputs 5-12 with Extended I/O)	Autoreclose Option
Output 1	**Trip Phases ABC** Trip Phase A	**Trip Phases ABC** Trip Phase A
Output 2	**Close Phases ABC** Close Phase A	**Close Phases ABC** Close Phase A
Output 3	HLT/Maintenance **General**	HLT/Maintenance **General**
Output 4	HLT/Maintenance **General** Alarm	HLT/Maintenance **General** Alarm
Output 5	HLT/Maintenance **General** Trip Phase B	HLT/Maintenance **General** Trip Phase B
Output 6	HLT/Maintenance **General** Close Phase B	HLT/Maintenance **General** Close Phase B
Output 7	HLT/Maintenance **General** Trip Phase C	HLT/Maintenance **General** Trip Phase C
Output 8	HLT/Maintenance **General** Close Phase C	HLT/Maintenance **General** Close Phase C
Output 9	HLT/Maintenance **General**	HLT/Maintenance **General**
Output 10	HLT/Maintenance **General**	HLT/Maintenance **General**
Output 11	HLT/Maintenance **General**	HLT/Maintenance **General**
Output 12	HLT/Maintenance **General**	HLT/Maintenance **General** Battery Alarm/Test
■**NOTE:** System Outputs Defaults are listed in **Bold** Type.		

Table 4-6 System Outputs Function Selections

INDEPENDENT POLE OPERATION

Independent Pole Operation is available with the extended IO. By default, in the System Setup/Outputs screen, Output 1 is set to Trip Phases ABC, and Output 2 is set to Close Phases ABC.

With the extended IO, Outputs 1, 5, 7 have a dropdown that allows Independent Pole selection to Trip Phase A, Trip Phase B and Trip Phase C. Outputs 2, 6, 8 have a dropdown that allows Independent Pole selection to Close Phase A, Close Phase B and Close Phase C (Figure 4-56). When any one of these outputs is selected to trip or close an individual phase, the corresponding outputs will automatically change to their respective individual phase.

Similarly, when any one of the outputs 1, 5 or 7 is changed to a different selection than the individual phase, then Output 1 will revert to Trip Phases ABC. When any one of the outputs 2, 6 or 8 is changed to a different selection than the individual phase, then Output 2 will revert to Close Phases ABC.

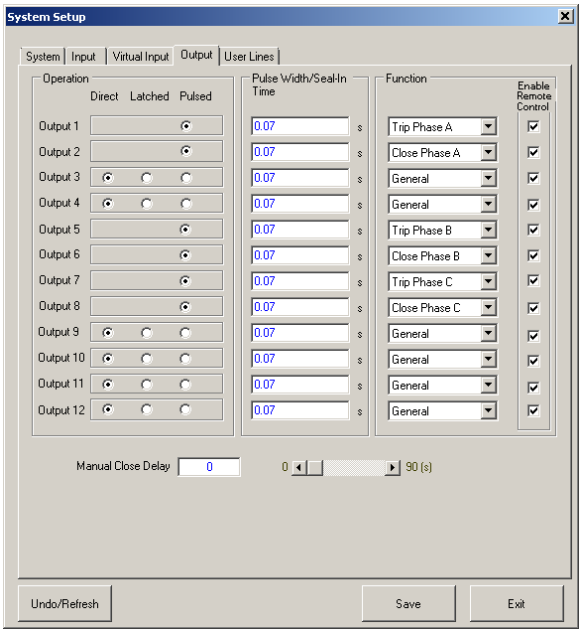


Figure 4-56 Independent Pole Operation – Outputs Setup

SETTING THE USER LINES

1. From the IPScom Main Screen menu select **Setup/Configuration/Relay**. IPScom will display the System Setup screen (Figure 4-21).
2. Select the **User Lines** tab. IPScom will display the User Lines dialog screen (Figure 4-57)
3. Enter the desired User Lines for up to 8 Profiles.

■**NOTE:** The **Undo/Refresh** command allows the user to undo any changes in the System Setup screens before the settings are saved to either the Device or Open File.

4. Select **Save**, the System Settings will be saved to either the Relay or Open File.

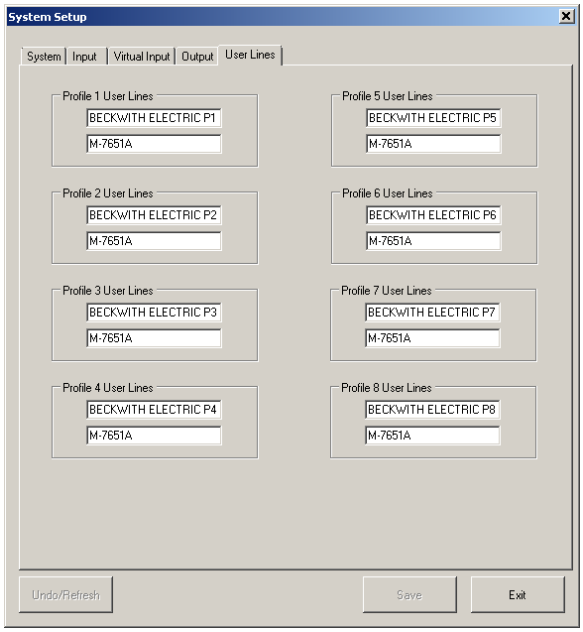


Figure 4-57 System Setup – User Lines Dialog Screen

PROGRAMMABLE PUSHBUTTONS FEATURE

The M-7651A D-PAC includes eight programmable pushbuttons S10 to S17 (Figure 4-58). The pushbuttons are programmable through the S-7600 IPScom Communications software.

The S10 (TRIP), S11 (HLT/Maint), S13 (LOCK) and S14 (CLOSE), S15 (REMOTE DISABLE) pushbuttons are pre-programmed to default functions but can be reprogrammed by the user to the desired function. Also, the S12, S16 and S17 pushbuttons are user programmable.

The programmable pushbuttons can be programmed to:

- Initiate an action
- Block an action
- Initiate and/or Block an action (Smart Function)

Also, the programmable pushbuttons have the capability to be programmed to wait for a confirmation from the user before executing the operation that it was assigned. Figure 4-59 and Figure 4-60 represent the elements of the Pushbutton Function Setup.

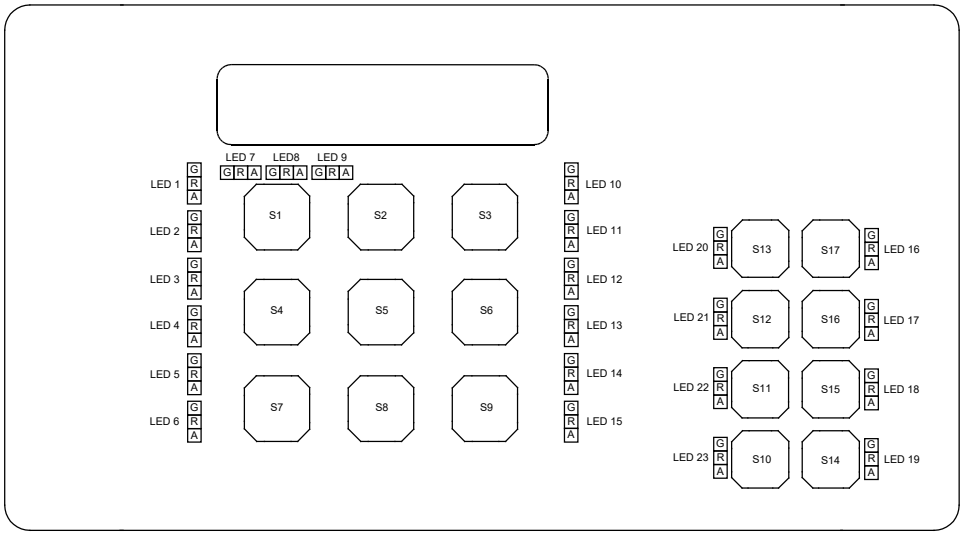


Figure 4-58 Pushbutton and LED Location Index

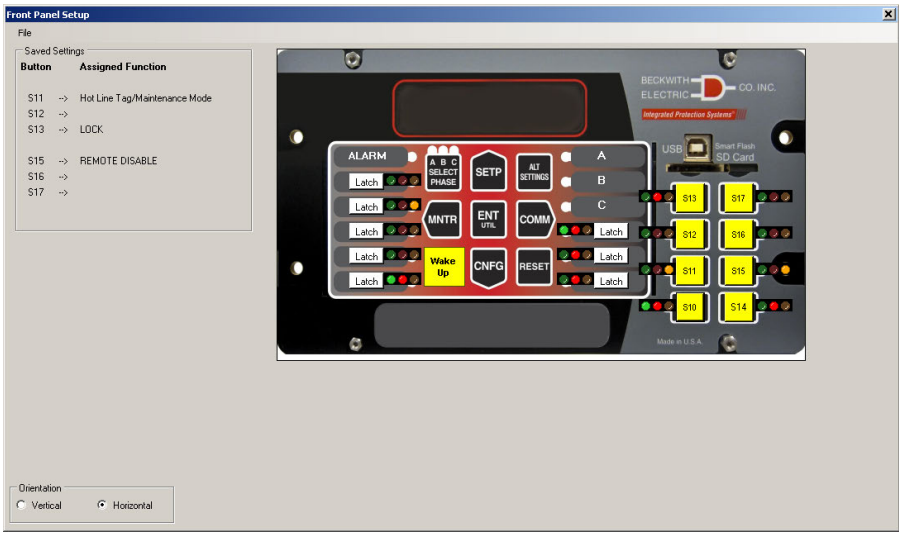


Figure 4-59 Front Panel Setup Dialog Screen

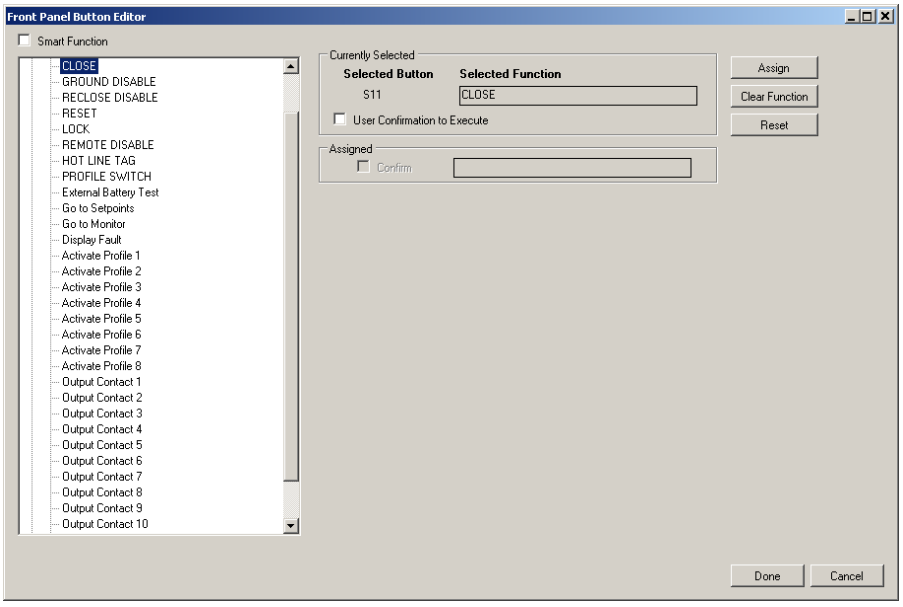


Figure 4-60 Front Panel Pushbutton Editor Dialog Screen

Action Initiate

The "Actions" that the pushbuttons can be programmed to initiate are shown in Table 4-7.

Block Initiate

Pushbutton Blocks include those relay operations and/or protective functions that can be assigned to a pushbutton. When the pushbutton is pushed, the assigned operations and/or protective functions will be blocked if the operation and/or protective function has not yet activated. If the operation has activated, the blocking has no effect.

The "Blocks" categories and the elements included in each category that the pushbuttons can be programmed to initiate are shown in Table 4-7.

INITIATE

SELECT PHASE
TRIP LOCKOUT
CLOSE
GROUND DISABLE
RECLOSE DISABLE
RESET
LOCK
REMOTE DISABLE
Hot Line Tag/Maintenance Mode
PROFILE SWITCH
External Battery Test
Go to Setpoints
Go to Monitor
Display Fault
Activate Profile 1
Activate Profile 2
Activate Profile 3
Activate Profile 4
Activate Profile 5
Activate Profile 6
Activate Profile 7
Activate Profile 8
Output Contact 1
Output Contact 2
Output Contact 3
Output Contact 4
Output Contact 5
Output Contact 6
Output Contact 7
Output Contact 8
Output Contact 9
Output Contact 10
Output Contact 11
Output Contact 12

BLOCKS

GLOBAL

Block Closing
Any Phase Protection Function Block
Any Overcurrent Block
Any Phase Overcurrent Block
Any Ground Block
Any Residual Block
Any Protection Function Block
Any Overvoltage Function Block
Any Undervoltage Block

PTOV/PTUV

Block F27 #1 Phase A
Block F27 #1 Phase B
Block F27 #1 Phase C
Block F27 #1 All Phases
Block F27 #2 Phase A
Block F27 #2 Phase B
Block F27 #2 Phase C
Block F27 #2 All Phases
Block F27 #3 Phase A
Block F27 #3 Phase B
Block F27 #3 Phase C
Block F27 #3 All Phases
Block F27 #4 Phase A
Block F27 #4 Phase B
Block F27 #4 Phase C
Block F27 #4 All Phases
Block 27PP Phase A
Block 27PP Phase B
Block 27PP Phase C
Block 27PP All Phases
Block 27Vz1
Block F40 #1
Block F40 #2
Block F40VC #1
Block F40VC #2
Block F47
Block F59 #1 Phase A
Block F59 #1 Phase B
Block F59 #1 Phase C
Block F59 #1 All Phases
Block F59 #2 Phase A
Block F59 #2 Phase B
Block F59 #2 Phase C
Block F59 #2 All Phases
Block F59 #3 Phase A
Block F59 #3 Phase B
Block F59 #3 Phase C
Block F59 #3 All Phases
Block F59 #4 Phase A
Block F59 #4 Phase B
Block F59 #4 Phase C
Block F59 #4 All Phases
Block F59N
Block F59Vz1
Block F59PP Phase AB
Block F59PP Phase BC
Block F59PP Phase CA
Block F59PP All Phases
Block 59I Phase A
Block 59I Phase B
Block 59I Phase C
Block 59I All Phases

PTOC/PHIZ/POIC

Block F46DT #1
Block F46DT #2
Block F46DT #3
Block F46DT #4
Block F46DT #5
Block F46IT #1
Block F46IT #2
Block F46IT #3
Block F46IT #4
Block F46IT #5
Block F50 #1 Phase A
Block F50 #1 Phase B
Block F50 #1 Phase C
Block F50 #1 All Phases
Block F50 #2 Phase A
Block F50 #2 Phase B
Block F50 #2 Phase C
Block F50 #2 All Phases
Block F50 #3 Phase A
Block F50 #3 Phase B
Block F50 #3 Phase C
Block F50 #3 All Phases
Block F50 #4 Phase A
Block F50 #4 Phase B
Block F50 #4 Phase C
Block F50 #4 All Phases
Block F50 #5 Phase A
Block F50 #5 Phase B
Block F50 #5 Phase C
Block F50 #5 All Phases
Block F50N #1
Block F50N #2
Block F50N #3
Block F50N #4
Block F50N #5
Block F50G/GS #1
Block F50G/GS #2
Block F50G/GS #3
Block F50G/GS #4
Block F50G/GS #5
Block F50BF
Block F51 #1 Phase A
Block F51 #1 Phase B
Block F51 #1 Phase C
Block F51 #1 All Phases
Block F51 #2 Phase A
Block F51 #2 Phase B
Block F51 #2 Phase C

Table 4-7 Front Panel Pushbutton Selection Table (1 of 2)

Block F51 #2 All Phases
Block F51 #3 Phase A
Block F51 #3 Phase B
Block F51 #3 Phase C
Block F51 #3 All Phases
Block F51 #4 Phase A
Block F51 #4 Phase B
Block F51 #4 Phase C
Block F51 #4 All Phases
Block F51 #5 Phase A
Block F51 #5 Phase B
Block F51 #5 Phase C
Block F51 #5 All Phases
Block F51N #1
Block F51N #2
Block F51N #3
Block F51N #4
Block F51N #5
Block F51G/GS #1
Block F51G/GS #2
Block F51G/GS #3
Block F51G/GS #4
Block F51G/GS #5

PTOF/PTUF/PFRC
Block F81 #1
Block F81 #2
Block F81 #3
Block F81 #4
Block All F81
Block Over Frequency Functions
Block Under Frequency Functions
Block F81R #1
Block F81R #2
Block All F81R
Block All Frequency Functions

PDOP/PDUP/PTOC
Block F32 Phase A Directional Power #1
Block F32 Phase B Directional Power #1
Block F32 Phase C Directional Power #1
Block F32 Three Phase Directional Power #1
Block F32 Phase A Directional Power #2
Block F32 Phase B Directional Power #2
Block F32 Phase C Directional Power #2
Block F32 Three Phase Directional Power #2
Block F32 Phase A Directional Power #3
Block F32 Phase B Directional Power #3
Block F32 Phase C Directional Power #3
Block F32 Three Phase Directional Power #3
Block F32 Phase A Directional Power #4
Block F32 Phase B Directional Power #4
Block F32 Phase C Directional Power #4
Block F32 Three Phase Directional Power #4
Block all F67F Directional
Block F67P #1 Phase A
Block F67P #1 Phase B
Block F67P #1 Phase C
Block F67P #1 All Phases
Block F67P #2 Phase A
Block F67P #2 Phase B
Block F67P #2 Phase C
Block F67P #2 All Phases
Block F67P #3 Phase A
Block F67P #3 Phase B
Block F67P #3 Phase C
Block F67P #3 All Phases
Block F67P #4 Phase A
Block F67P #4 Phase B
Block F67P #4 Phase C
Block F67P #4 All Phases
Block F67P #5 Phase A
Block F67P #5 Phase B
Block F67P #5 Phase C
Block F67P #5 All Phases
Block F67N #1
Block F67N #2
Block F67N #3
Block F67N #4
Block F67N #5
Block F67G/GS #1
Block F67G/GS #2
Block F67G/GS #3
Block F67G/GS #4
Block F67G/GS #5
Block F67Q #1
Block F67Q #2
Block F67Q #3
Block F67Q #4
Block F67Q #5

RYSN
Block F25 Synchrocheck Magnitude
Block F25 Synchrocheck Angle
Block F25 Synchrocheck Frequency
Block F25

RREC (with Autoreclose Option)
Block F79 Sequence Coordination
Block F79/50P High Current Lockout
Block F79/50N or F79/50G High Current Lockout
Block F79/50P and F79/50G High Current Lockout
Block F79 Recloser Relay

SCBR/XCBR/RBRF
Block F74 Trip Coil
Block F74 Close Coil

PMRI (with Autoreclose Option)
Block Cold Load Pickup

PTOV/PTOC
Block F60FL Fuse Failure

Table 4-8 Front Panel Pushbutton Selection Table (2 of 2)

Smart Functions

The relay includes 20 Smart Functions (SF1-SF20). The Smart Functions can be programmed to any of the operation or protective functions listed in the "Action Initiate" and "Block Initiate" selections. However, a Smart Function cannot be mapped to another Smart Function as it is described in the INITIATE category. When a pushbutton is programmed to a Smart Function, the relay will prompt the user to choose the Smart Function to be executed.

```
  EXEC SMART FUNCTION
<        SF1         >
```

By pressing the Left or Right arrow pushbutton, the user can scroll to the appropriate Smart Function. Pressing the ENT pushbutton will cause the relay to execute the selected Smart Function displayed on the HMI screen. If the EXIT key is pressed before the ENT pushbutton, the relay will exit out of the Smart Function mode. If no action is taken within 10 minutes, the relay will return to the main screen.

If the pushbutton is programmed to wait for a user confirmation, when pressed, the relay will prompt for a user confirmation before executing the Smart Function. In addition the Smart Function can be assigned a user defined name of up to 12 alphanumeric characters. For example SF1 can be assigned the name "TEST F27". The HMI will display the following when the smart key is activated.

```
  EXEC SMART FUNCTION
<      TEST F27      >
```

Pushbutton Programming (Initiate Action/Block)

To program a programmable pushbutton to Initiate or Block a relay function, proceed as follows:

1. From the IPScom Main Menu, select **Setup/Configuration/Front Panel Functions**. IPScom will display the "Front Panel Setup" dialog screen (Figure 4-59).
2. Select the desired programmable pushbutton. IPScom will display the Front Panel Pushbutton Editor dialog screen Figure 4-60.
3. Observe the "Currently Selected" section of the dialog screen and proceed as follows:
   a. If the selected pushbutton is not currently programmed, then go to Step 5.
   b. If the selected pushbutton indicates that it is currently programmed and the user desires to de-program the pushbutton, then select **Clear Function**. IPScom will display a confirmation dialog screen Figure 4-61.

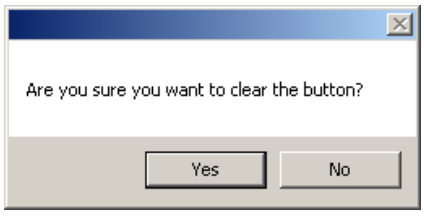


Figure 4-61 Clear Pushbutton Function Confirmation Screen

   c. Select **Yes**. IPScom will clear the currently programmed function for the selected pushbutton.
4. From the "Initiate and Blocks" section of the dialog screen, expand either the "Initiate" or the "Blocks" Explorer Tree as necessary to navigate to the desired function.
5. Select the desired function to be activated when the pushbutton is pressed. The selected function will be displayed in the "Currently Selected" section of the dialog screen.

6. If a user confirmation is desired before the pushbutton activates the programmed function, then select the "User Confirmation to Execute" check box.
7. Select **Assign**. IPScom will update the "Saved Settings" section of the dialog screen to indicate the pushbutton and the function that has been assigned.
8. To end the pushbutton editing session for the selected pushbutton select **Done**. IPScom will return to the Front Panel Setup dialog screen Figure 4-59.

■**NOTE:** At this point the pushbutton assignments have not been saved or sent to the relay. Therefore, exiting from the Button Function Setup dialog screen at this time will result in all pushbutton reprogramming being lost. IPScom will display the following Warning screen (Figure 4-62).

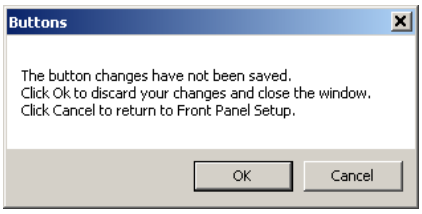
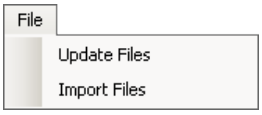


Figure 4-62 Button Changes Not Saved Warning Screen

9. If additional pushbuttons are to be programmed, repeat Steps 2 through 8 as necessary to program additional pushbuttons.
10. If all the desired pushbuttons have been programmed, select **File/Update Files**.



The pushbutton programming process is complete.

Pushbutton Programming (Smart Function)

To program a programmable pushbutton to a Smart Function pushbutton, proceed as follows:

1. From the IPScom Main Menu, select **Setup/Configuration/Front Panel Functions**. IPScom will display the "Front Panel Setup" dialog screen (Figure 4-59).
2. Select the desired programmable pushbutton. IPScom will display the Front Panel Pushbutton Editor dialog screen Figure 4-60.

■**NOTE:** When the "Smart Function" check box is selected, previous pushbutton programming does not have to be cleared.

3. Select the "Smart Function" check box. The Front Panel Pushbutton Editor dialog screen Figure 4-60 will display (Figure 4-64) as follows:
   - The "Currently Selected" section of the dialog screen will indicate that the selected pushbutton "Selected Function" is "Smart Functions"
   - A Smart Functions selection section of the dialog screen will be displayed that allows up to 20 Assigned Functions, that can be either "Initiate" and/or "Blocks" functions.
4. From the "Initiate and Blocks" section of the dialog screen, expand either the "Initiate" or the "Blocks" Explorer Tree as necessary to navigate to the desired function.
5. Select the desired function to be added to the Smart Function pushbutton. The selected function will be displayed in one of the twenty Assigned Function slots.
6. If a user confirmation is desired before the pushbutton activates the programmed function, then select the "User Conf" check box. Add or Clear assigned functions as desired.

7. Select **Done**. IPScom will display the Front Panel Setup dialog screen Figure 4-59. The selected pushbutton status in the "Saved Settings" section of the dialog screen (Figure 4-63). will indicate that the pushbutton has been assigned as a Smart Function.

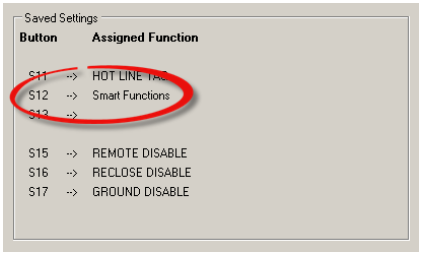
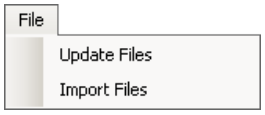


Figure 4-63 Button Setup "Saved Settings"

■NOTE: At this point the pushbutton assignments have not been sent to the relay or saved. Therefore, exiting from the Front Panel Setup dialog screen at this time will result in all pushbutton reprogramming being lost.IPScom will display the Warning screen (Figure 4-62).

8. If additional Smart Function pushbuttons are to be programmed, repeat Steps 2 through 7 as necessary to program additional pushbuttons.
9. If all the desired pushbuttons have been programmed, select **File/Update Files**.



The pushbutton programming process is complete.

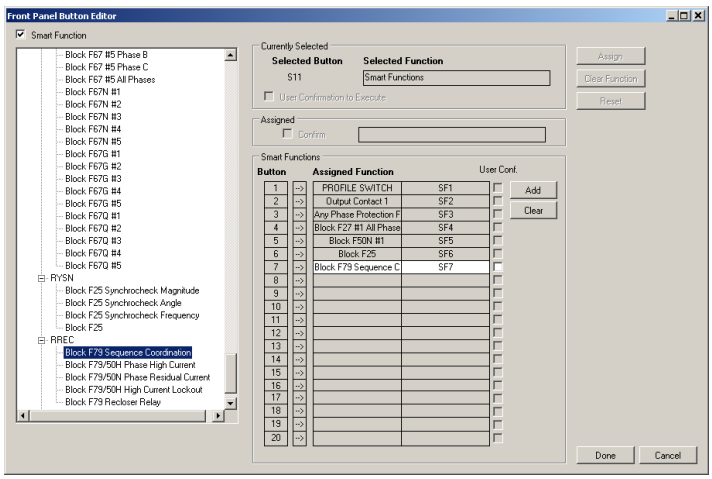


Figure 4-64 Button Smart Function Setup Dialog Screen

USER PROGRAMMABLE FRONT PANEL LEDs

The LED programming feature allows the user to customize the functionality of the LEDs 2, 3, 4, 5, 6, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22 and 23 through the Front Panel Setup screen (Figure 4-59). Selecting an LED red, green, or amber button activates the LED Editor Dialog Screen (Figure 4-65) which provides an interactive worksheet for programming the desired logic to activate or deactivate the LEDs based on the status of the relay functions.

Selecting the "Latch" button allows the user to customize the latch behavior of the LED. The LED may be programmed to latch on Red, Green, Amber, or None. LEDs 10, 11 and 12 are fixed to latch on Red. LED 13 is programmable and defaulted to latch on Red. LEDs 2, 3, 4, 5, 6, 14 and 15 are programmable and defaulted to None.

Overview of LED Programming

The LED programming feature consists of assembling various logical nodes that are linked to provide the desired logic to activate or deactivate the LEDs based on the status of the relay functions. The LEDs can also be setup to accommodate inverse logic of the relay functions. The logical nodes can be selected to be either AND, NAND, OR, NOR, XNOR or XOR (Exclusive OR). Examples of an Exclusive OR would be:

- Zero XOR Zero = Zero
- Zero XOR One = One
- One XOR Zero = One
- One XOR One = Zero

All relay function element status can be inverted in the logical nodes as well as the logical node outputs.

There are predefined collective function LED inputs. These can also be used as inputs. See Table 4-9 for the collective function input definitions.

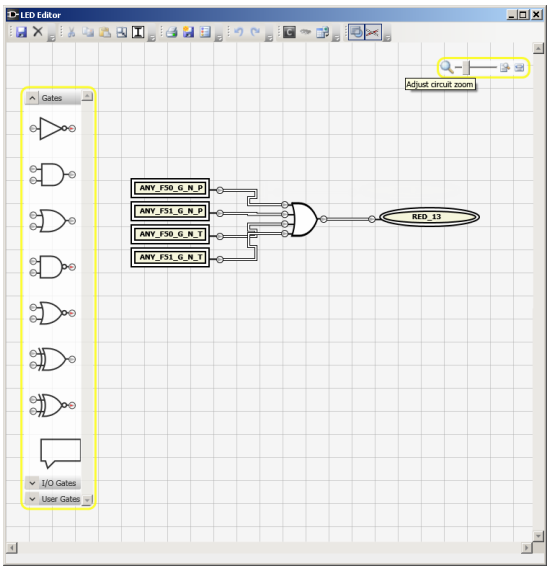


Figure 4-65 LED Editor Dialog Screen

LED Editor Main Toolbar

Hovering the mouse over the Main Toolbar icons will display a tooltip and keyboard shortcut (if applicable). Refer to the following diagram for icon definitions (Figure 4-66).

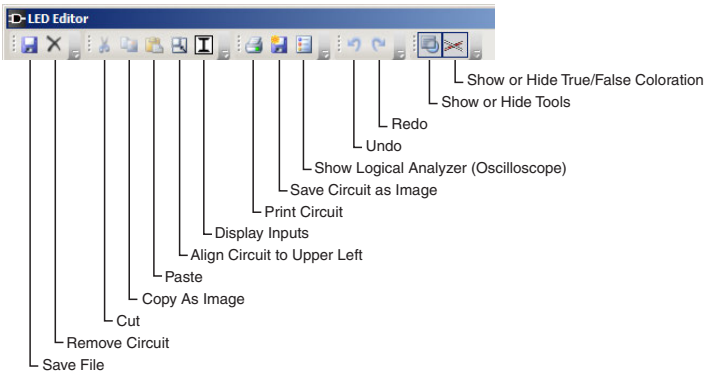


Figure 4-66 LED Editor Main Toolbar Icons Diagram

Predefined LED Collective Function Input Definitions	
ANY_F27_P	27_1A_Pickup / 27_1B_Pickup / 27_1C_Pickup / 27_2A_Pickup / 27_2B_Pickup / 27_2C_Pickup / 27_3A_Pickup / 27_3B_Pickup / 27_3C_Pickup / 27_4A_Pickup / 27_4B_Pickup / 27_4C_Pickup
ANY_F50_A_Z_P	50_1A_Pickup / 50_2A_Pickup / 50_3A_Pickup / 50_4A_Pickup / 50_5A_Pickup
ANY_F50_B_Z_P	50_1B_Pickup / 50_2B_Pickup / 50_3B_Pickup / 50_4B_Pickup / 50_5B_Pickup
ANY_F50_C_Z_P	50_1C_Pickup / 50_2C_Pickup / 50_3C_Pickup / 50_4C_Pickup / 50_5C_Pickup
ANY_F50_G_N_P	50G_1_Pickup / 50G_2_Pickup / 50G_3_Pickup / 50G_4_Pickup / 50G_5_Pickup / 50N_1_Pickup / 50N_2_Pickup / 50N_3_Pickup / 50N_4_Pickup / 50N_5_Pickup
ANY_F51_A_Z_P	51_1A_Pickup / 51_2A_Pickup / 51_3A_Pickup / 51_4A_Pickup / 51_5A_Pickup
ANY_F51_B_Z_P	51_1B_Pickup / 51_2B_Pickup / 51_3B_Pickup / 51_4B_Pickup / 51_5B_Pickup
ANY_F51_C_Z_P	51_1C_Pickup / 51_2C_Pickup / 51_3C_Pickup / 51_4C_Pickup / 51_5C_Pickup
ANY_F51_G_N_P	51G_1_Pickup / 51G_2_Pickup / 51G_3_Pickup / 51G_4_Pickup / 51G_5_Pickup / 51N_1_Pickup / 51N_2_Pickup / 51N_3_Pickup / 51N_4_Pickup / 51N_5_Pickup
ANY_46_P	46DT_1_Pickup / 46DT_2_Pickup / 46DT_3_Pickup / 46DT_4_Pickup / 46DT_5_Pickup / 46IT_1_Pickup / 46IT_2_Pickup / 46IT_3_Pickup / 46IT_4_Pickup / 46IT_5_Pickup
ANY_27_T	27_1A_Timeout / 27_1B_Timeout / 27_1C_Timeout / 27_2A_Timeout / 27_2B_Timeout / 27_2C_Timeout / 27_3A_Timeout / 27_3B_Timeout / 27_3C_Timeout / 27_4A_Timeout / 27_4B_Timeout / 27_4C_Timeout
ANY_F50_A_Z_T	50_1A_Timeout / 50_2A_Timeout / 50_3A_Timeout / 50_4A_Timeout / 50_5A_Timeout
ANY_F50_B_Z_T	50_1B_Timeout / 50_2B_Timeout / 50_3B_Timeout / 50_4B_Timeout / 50_5B_Timeout
ANY_F50_C_Z_T	50_1C_Timeout / 50_2C_Timeout / 50_3C_Timeout / 50_4C_Timeout / 50_5C_Timeout
ANY_F50_G_N_T	50G_1_Timeout / 50G_2_Timeout / 50G_3_Timeout / 50G_4_Timeout / 50G_5_Timeout / 50N_1_Timeout / 50N_2_Timeout / 50N_3_Timeout / 50N_4_Timeout / 50N_5_Timeout
ANY_F51_A_Z_T	51_1A_Timeout / 51_2A_Timeout / 51_3A_Timeout / 51_4A_Timeout / 51_5A_Timeout
ANY_F51_B_Z_T	51_1B_Timeout / 51_2B_Timeout / 51_3B_Timeout / 51_4B_Timeout / 51_5B_Timeout
ANY_F51_C_Z_T	51_1C_Timeout / 51_2C_Timeout / 51_3C_Timeout / 51_4C_Timeout / 51_5C_Timeout
ANY_F51_G_N_T	51G_1_Timeout / 51G_2_Timeout / 51G_3_Timeout / 51G_4_Timeout / 51G_5_Timeout / 51N_1_Timeout / 51N_2_Timeout / 51N_3_Timeout / 51N_4_Timeout / 51N_5_Timeout
ANY_F81_T	81_1_Timeout / 81_2_Timeout / 81_3_Timeout / 81_4_Timeout
ANY_F46_T	46DT_1_Timeout / 46DT_2_Timeout / 46DT_3_Timeout / 46DT_4_Timeout / 46DT_5_Timeout / 46IT_1_Timeout / 46IT_2_Timeout / 46IT_3_Timeout / 46IT_4_Timeout / 46IT_5_Timeout
ANY_F59_Z_T	59_1A_Timeout / 59_1B_Timeout / 59_1C_Timeout /59_2A_Timeout / 59_2B_Timeout / 59_2C_Timeout / 59_3A_Timeout / 59_3B_Timeout / 59_3C_Timeout / 59_4A_Timeout / 59_4B_Timeout / 59_4C_Timeout

Table 4-9 Predefined LED Collective Function Input Definitions

Programming LEDs (IPScom)

1. From the IPScom Main Menu, select **Setup/Configuration/Front Panel Functions**. IPScom will display the "Front Panel Setup" dialog screen (Figure 4-59).
2. Select the desired LED and it's color to program. IPScom will activate the LED Editor Screen (Figure 4-65) which provides an interactive worksheet for programming the desired logic to activate or deactivate the LEDs based on the status of the relay functions.
3. Use the various elements of the LED Editor interactive worksheet to program the LED logic.

Add Inputs

Select the "Display Inputs" icon from the LED Editor toolbar to display the Input Selection dialog screen (Figure 4-67). Use this tool to filter, select and insert inputs onto the worksheet.

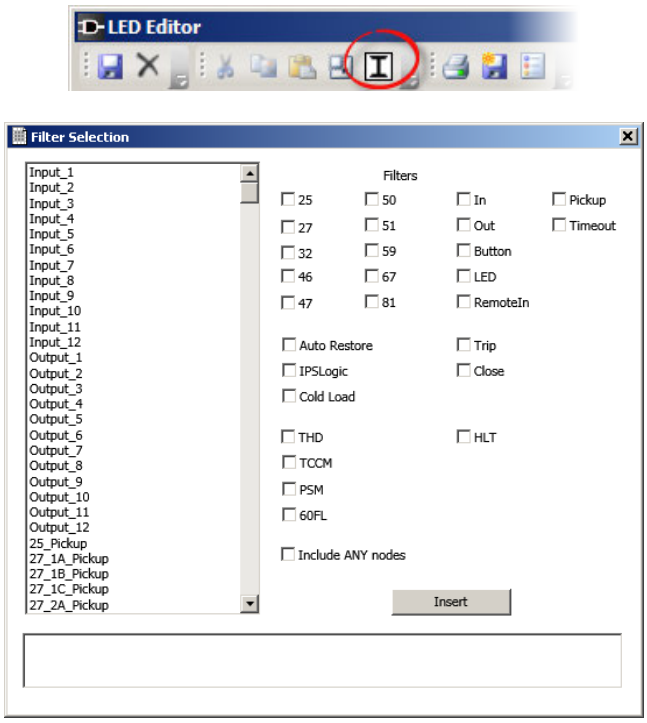


Figure 4-67 LED Editor Input Selection Dialog Screen

Add Logic Gates

Use the "Gates" tool to drag and drop logic gates onto the worksheet.

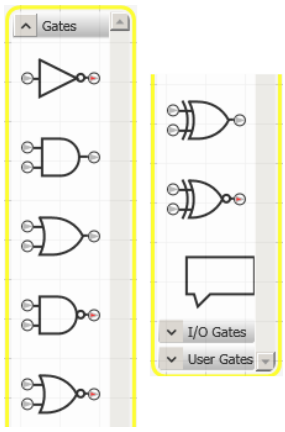


Figure 4-68 LED Editor "Gates" Tool

Show Logical Analyzer (Oscilloscope)

Use this tool to display the Oscilloscope for the currently selected LED circuit.

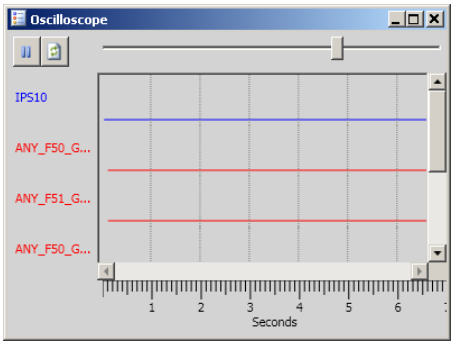
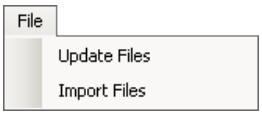


Figure 4-69 LED Editor Oscilloscope Tool

Saving LED Configuration

If all the desired LEDs have been programmed, select **File/Update Files**.



The LED programming process is complete.

WAKE UP SCREENS

When the **EXIT/WAKE** pushbutton is selected, the relay will respond as follows:

- Pressing "EXIT" when User Lines are being displayed will initiate a cycling display of the selected Wake Up parameters for a period of 15 minutes and then return to the User Lines display.
- If no Wake Up screens have been selected, then nothing will be displayed and the User Lines will flash for a moment.
- While in the Wake Up screen mode, if there is a Smart Flash SD Card inserted, the following screen will be displayed. Wake Up screen parameters can be saved to the Smart Flash SD Card in *.csv format.

```
Save Wakeup to SD
Press ENT to begin
```

Selecting/Editing Wake Up Screen Parameters

The Wakeup Screen Selection window displays the available parameters in the left column of the screen in an Explorer type interface. The Filters on the right side, allow the user to select specific menus to show in the left column. The Wake Up Screen parameters are selected by moving (dragging and dropping) each parameter from the "Source" column on the left to the "Control" column on the right. Likewise, items may be removed from the Control Wake Up list by dragging them back to the Source column. Any parameters that are not selectable are grayed out.

1. From the IPScom Main Menu, select **Setup/Configuration/Front Panel Functions**. IPScom will display the "Front Panel Setup" dialog screen (Figure 4-59).
2. Select the "Wake Up" button from the Front Panel Setup window. IPScom will display the Wake Up Screen selection window (Figure 4-71).

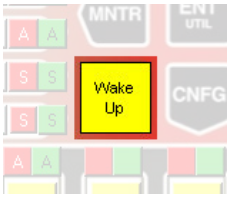


Figure 4-70 Select Wake Up Button

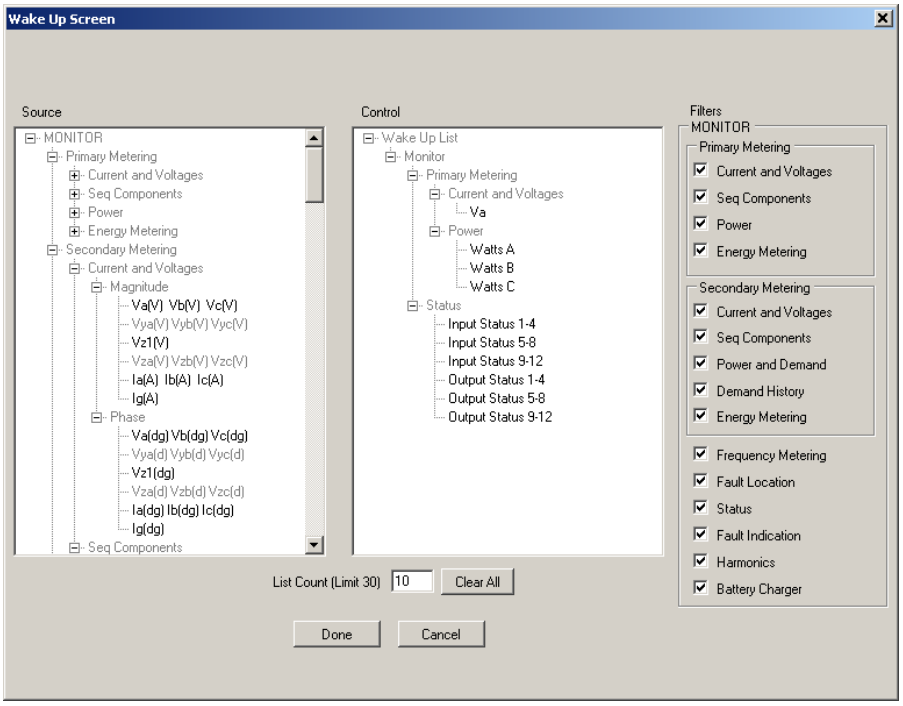
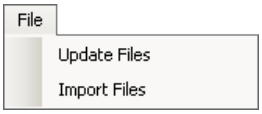


Figure 4-71 Wake Up Screen Dialog Screen

3. Select the Wake Up Screen parameters to be displayed by moving (dragging and dropping) each parameter from the "Source" column on the left to the "Control" column on the right. Likewise, items may be removed from the Control Wake Up list by dragging them back to the Source column.

   List Count displays a count of the selected Wake Up Screen parameters (Limit 30). The **Clear All** command clears ALL Wake Up Screen parameter selections from the Control column.

4. Select **Done**. IPScom will return to the Front Panel Setup window (Figure 4-59).
5. If all the desired Wake Up Screens have been programmed, select **File/Update Files**.



   The Wake Up Screen programming process is complete.

FRONT PANEL LABELS CONFIGURATION

Selecting **Utility/Front Panel Labels** opens a pdf form file in Adobe Acrobat (Figure 4-72). This form allows the user to create and print custom labels for the user programmable front panel LEDs and Pushbuttons. The desired custom labels are setup in the form template. The printout can then be inserted behind the front panel overlay.

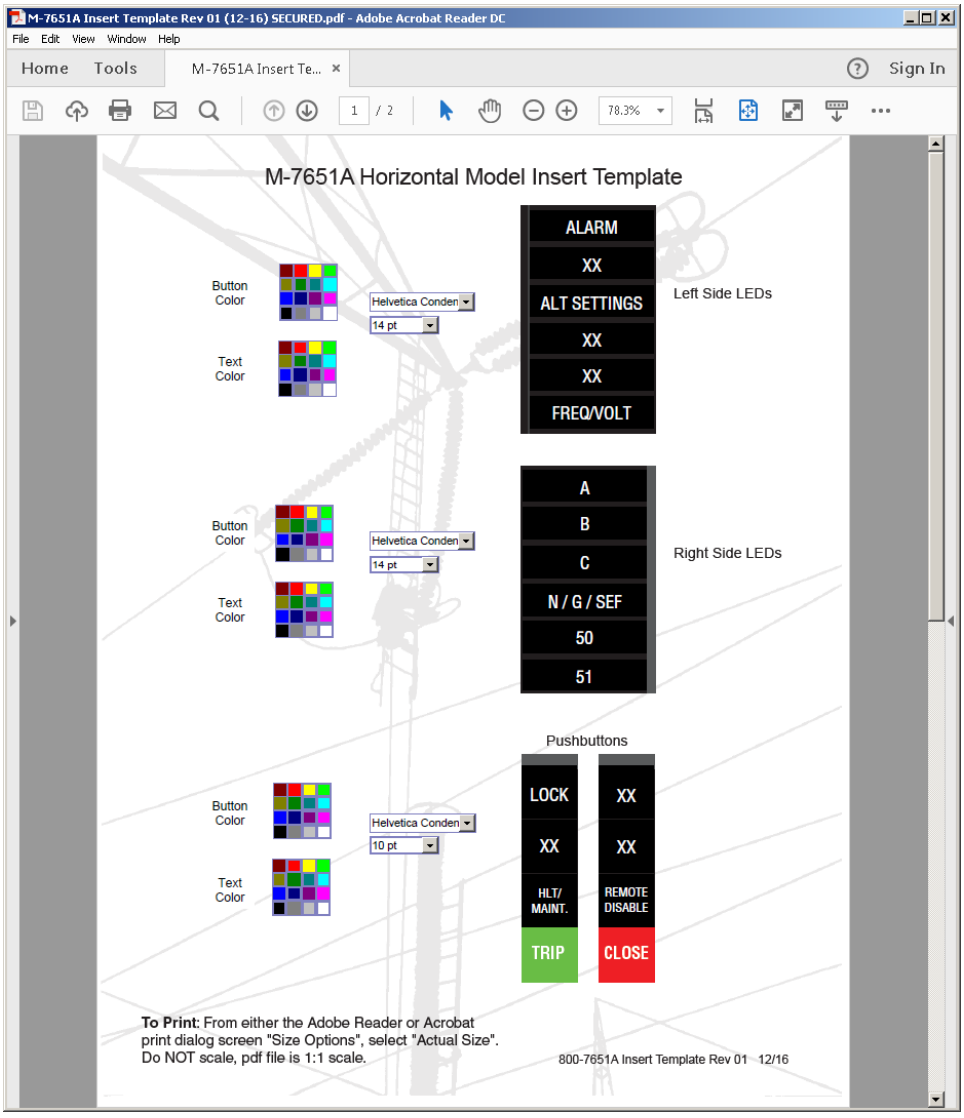


Figure 4-72 Front Panel Labels PDF Form Dialog Screen

4.3 System Diagrams

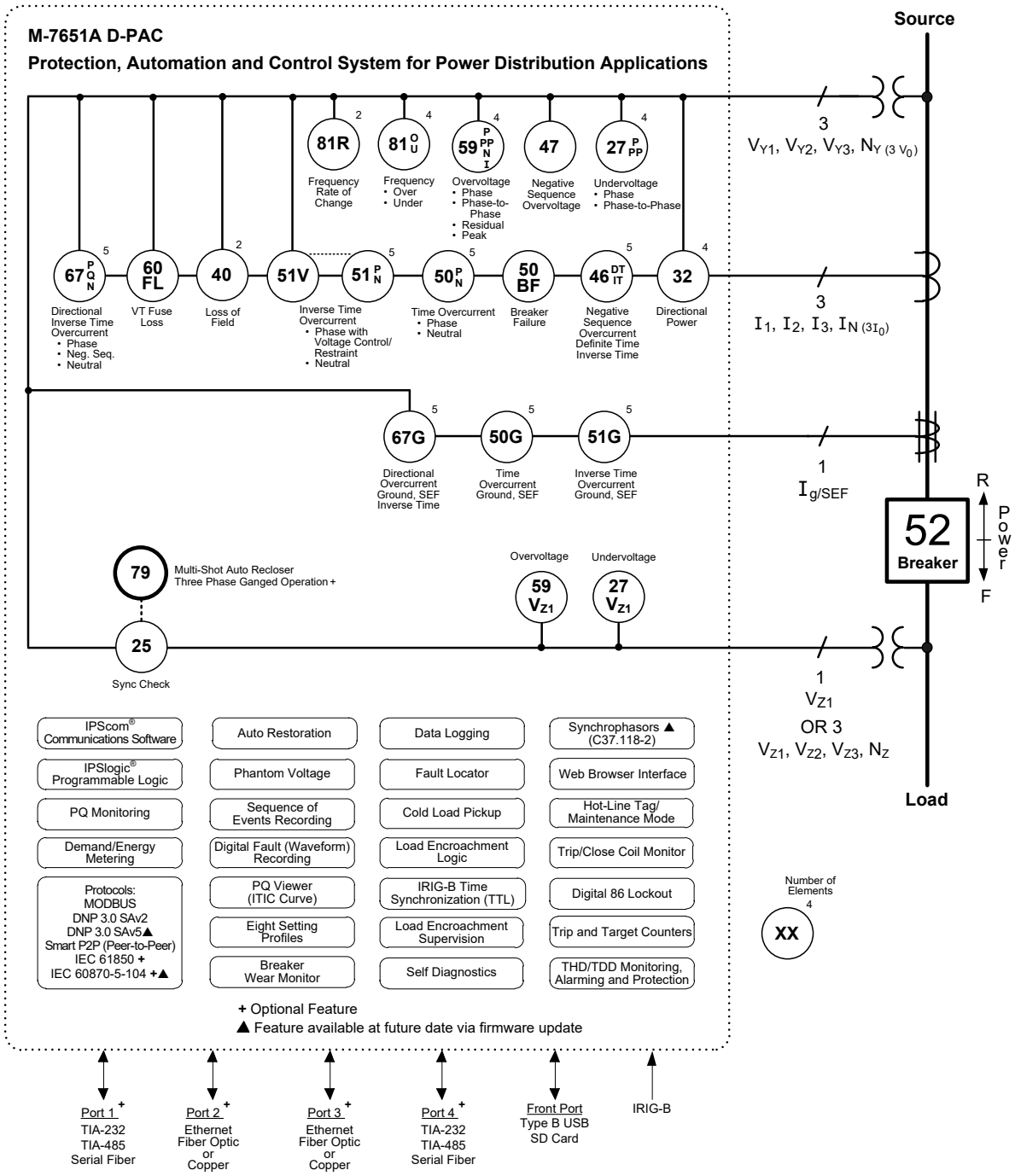


Figure 4-73 One-Line Functional Diagram

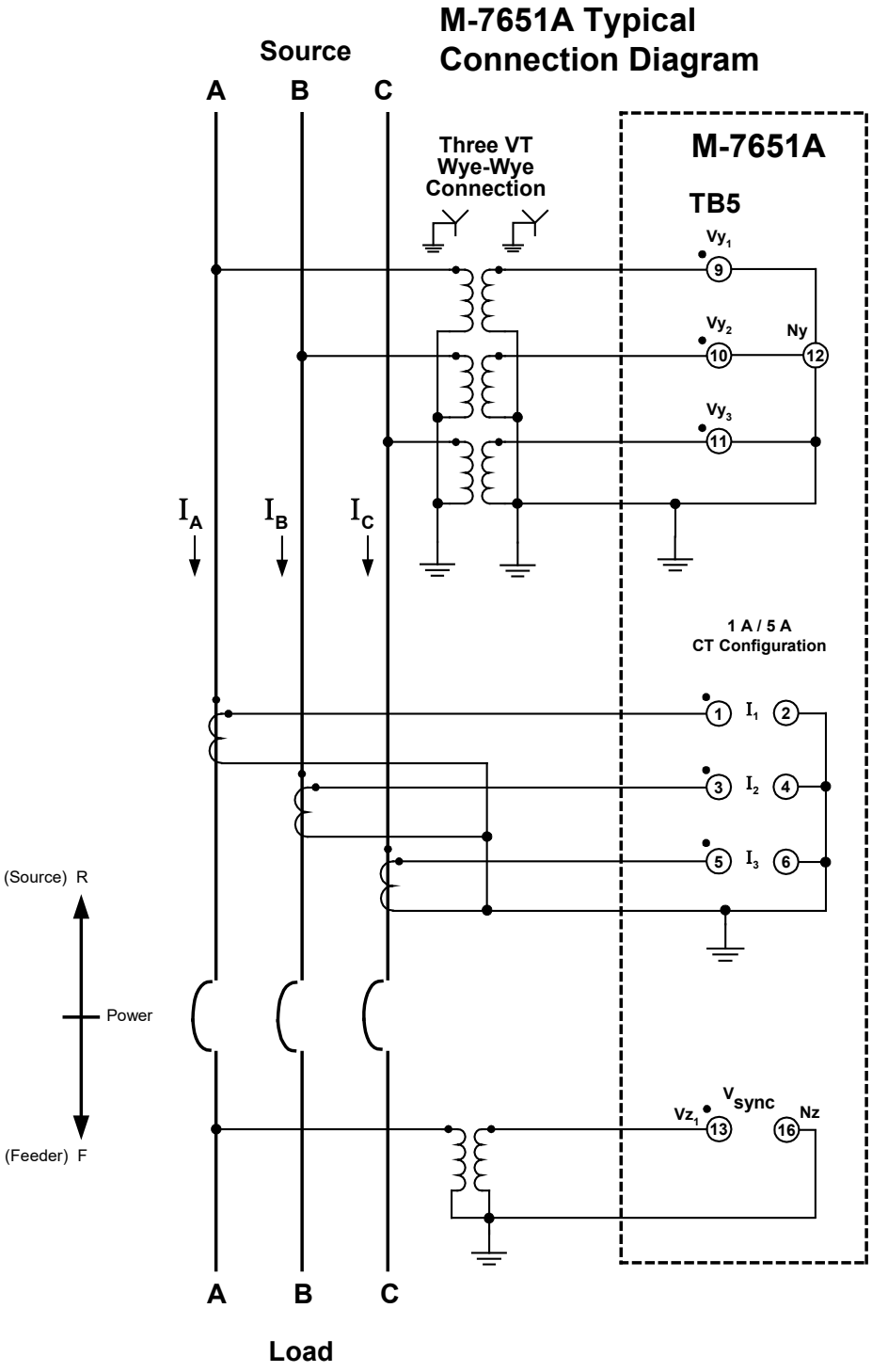


Figure 4-74 Three-Line Connection Diagram

4.4 System Configuration from the HMI

SYSTEM CONFIGURATION

The System Configuration settings detailed in this Chapter are also available in the Front Panel HMI. See **Chapter 2 Operation** for an overview of the HMI Menu structure and navigation.

6. Press **CNFG** to wake the unit. The menu will advance to "CONFIGURATION".

```
     CONFIGURATION
<SETP            COMM>
```

7. Press **ENT** or **CNFG** once. The unit will display the following:

```
       Nameplate
<                  >
```

8. Press **ENT** or **CNFG** once. The unit will display the following:

```
Nominal Voltage
 xxx.xx  V l-g
```

Continue through the Nameplate submenu to access the System Configuration screens. The displayed screens are based on the installed hardware. The following is a representative list:

- Nominal Voltage
- Nominal Current
- VTy Configuration
- VTz Configuration
- Phase Rotation
- Nominal Frequency
- CT Rating
- Default Profile
- Neutral Operating Current
- SEF Enable
- Power Supply Type
- Phase Assignment
- 69 Operation
- No Reset Before Close
- Interface Configuration

■**NOTE:** Hardware Options are Read Only screens which display the factory options installed in the unit.

LEA CONFIGURATION FROM THE HMI

LEA Common Settings

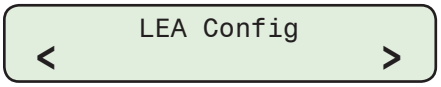
1. Press **CNFG** to wake the unit. The menu will advance to "CONFIGURATION".

```
     CONFIGURATION
<SETP            COMM>
```

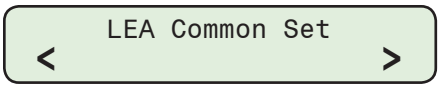
2. Press **ENT** or **CNFG** once. The unit will display the following:

```
       Nameplate
<                  >
```

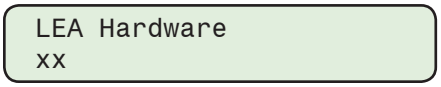
3. Press **MNTR** or **COMM** as necessary, until the "LEA Config" screen is displayed.



4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **ENT** or **CNFG** once. The unit will display the following:



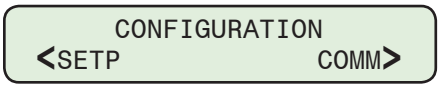
Continue through the LEA Common Set submenu to access the remaining LEA Common Settings. The displayed screens are based on the installed LEA hardware. The following is a representative list:

- Primary Nominal Voltage
- LEA Orientation
- Phase Assignment Z
- Calibration Voltage Low/High Y
- Calibration Voltage Low/High Z

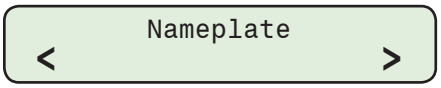
■**NOTE:** Hardware Options are Read Only screens which display the factory options installed in the unit. Calibration screens are Read Only calculated values.

LEA Y Side Settings

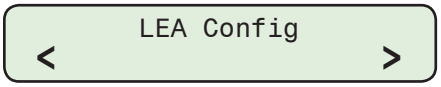
1. Press **CNFG** to wake the unit. The menu will advance to "CONFIGURATION".



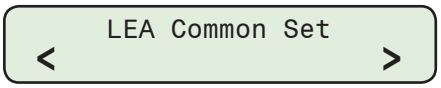
2. Press **ENT** or **CNFG** once. The unit will display the following:



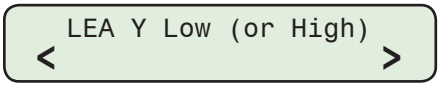
3. Press **MNTR** or **COMM** as necessary, until the "LEA Config" screen is displayed.



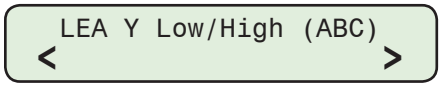
4. Press **ENT** or **CNFG** once. The unit will display the following:



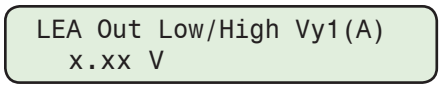
5. Press **MNTR** or **COMM** as necessary, until the "LEA Y Low" or "LEA Y High" screen is displayed.



6. Press **ENT** or **CNFG** once. The unit will display the following:



7. Press **ENT** or **CNFG** once. The following will be displayed.



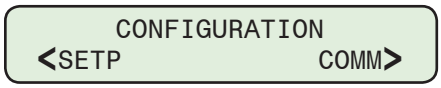
Continue through the LEA Y submenu to access the remaining LEA Y Side settings. The displayed screens are based on the installed LEA hardware and VTy Configuration setting. The following is a representative list:

- PTR Low/High Vy1 (A)
- RCF Low/High Vy1 (A)
- Phase Low/High Vy1 (A)
- LEA Out Low/High Vy2(B)
- PTR Low/High Vy2(B)
- RCF Low/High Vy2(B)
- Phase Low/High Vy2(B)
- LEA Out Low/High Vy3(C)
- PTR Low/High Vy3(C)
- RCF Low/High Vy3(C)
- Phase Low/High Vy3(C)

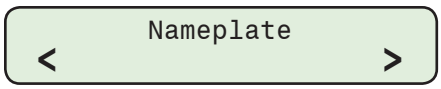
■**NOTE:** Hardware Options are Read Only screens which display the factory options installed in the unit. Calibration screens are Read Only calculated values.

LEA Z Side Settings

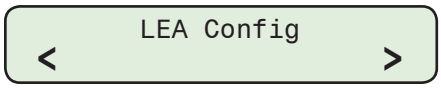
1. Press **CNFG** to wake the unit. The menu will advance to "CONFIGURATION".



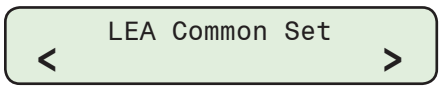
2. Press **ENT** or **CNFG** once. The unit will display the following:



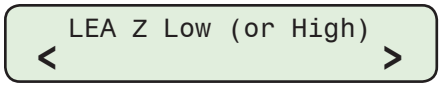
3. Press **MNTR** or **COMM** as necessary, until the "LEA Config" screen is displayed.



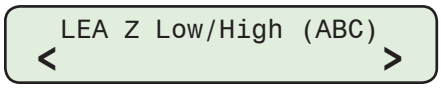
4. Press **ENT** or **CNFG** once. The unit will display the following:



5. Press **MNTR** or **COMM** as necessary, until the "LEA Z Low" or "LEA Z High" screen is displayed.



6. Press **ENT** or **CNFG** once. The unit will display the following:



7. Press **ENT** or **CNFG** once. The following will be displayed.

```
LEA Out Low/High Vz1(A)
  x.xx V
```

Continue through the LEA Z submenu to access the remaining LEA Z Side settings. The displayed screens are based on the installed LEA hardware and VTz Configuration setting. The following is a representative list:

- PTR Low/High Vz1 (A)
- RCF Low/High Vz1 (A)
- Phase Low/High Vz1 (A)
- LEA Out Low/High Vz2(B)
- PTR Low/High Vz2(B)
- RCF Low/High Vz2(B)
- Phase Low/High Vz2(B)
- LEA Out Low/High Vz3(C)
- PTR Low/High Vz3(C)
- RCF Low/High Vz3(C)
- Phase Low/High Vz3(C)

■**NOTE:** Hardware Options are Read Only screens which display the factory options installed in the unit. Calibration screens are Read Only calculated values.

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■ **CYBER SECURITY NOTE:**

When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

Chapter five is designed for the person or group responsible for the System Setpoints of the M-7651A D-PAC System.

Chapter 5 consists of:

- System Setpoints, Common Setpoints and 79 Reclose Function Setpoints Sections which describe the enabling of functions and setpoints, output contact assignments and digital input assignments.
- A Recloser Wizard Section which describes the configuration of the 79 Function reclose relay using the interactive settings wizard.

The selection of the M-7651A D-PAC Setpoints can be performed using the S-7600 IPScom Communications Software and will be included where applicable.

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5.1 System Setpoints

The individual protective functions, along with their pickup and timing settings are described in the following pages. Settings for disabled functions do not apply. Some menu and setting screens do not appear for functions that are disabled or not purchased. Dialog screens are as they appear using S-7600 IPScom Communications Software.

Setpoint Profiles (Multiple Settings Groups)

Up to eight setpoint profiles may be used. Each profile contains a function configuration and associated settings. One of the eight profiles may be designated as the Active Profile which will contain the parameters that the relay will actively use. Only the Active Profile may be edited.

▲**CAUTION:** During profile switching, relay operation is disabled for approximately 1 second.

Copy Profiles

From the Setpoints screen, the selected profile may be copied to other profiles. The Copy Profiles selection is accessed by right-clicking on the Profile tab to be copied, as shown in Figure 5-1. Then, right-click on the Profile tab of the Profile to which the settings are to be pasted. IPScom will display a confirmation screen before copying the settings (Figure 5-2).

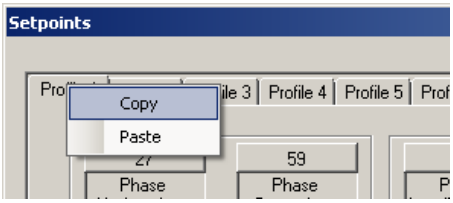


Figure 5-1 Copy Setpoints Profile – Right-Click Popup Menu

Figure 5-2 Copy Setpoints Profile Confirmation Screen

This feature can speed up the configuration process. For example, consider a situation where a breaker will be removed from service. Two profiles will be used: an "In Service" profile (Profile 1) and an "Out of Service" profile (Profile 2). Profile 2 will be identical to the "In Service" profile, with the exception of the overcurrent settings. Profile 1 is set to be the Active profile, and all setpoints entered. The Profile 1 settings will then be copied to Profile 2 when selected. Profile 2 is then selected as the Active Profile and the alternate Profile 2 setpoints modified. Utilizing this feature not only accelerates the configuration process, but also helps to remove the possibility of errors since the setpoints are not re-entered manually.

Utilizing the Smart Flash SD Card to Save and Load Setpoint Files

The setpoints file consists of the specific setpoint settings for all 8 Profiles. Saving the relay setpoint file to an SD Card allows the user to open the saved file in IPScom and then edit specific profiles while retaining any existing setpoint information for the profiles which are NOT changing. This edited file can then be saved onto an SD Card and reloaded onto the relay.

■**NOTE:** Setpoint file names may include any of the printable ASCII characters, excluding the "~" or "\" characters.

▲**CAUTION:** Setpoint changes are immediately acted on by the relay and may cause undesired relay operation.

Configure Relay Function Data

The relay is shipped with a certain group of standard functions, including other optional functions as purchased. Both of these groups define a configurable set of functions. Only members of this set may be enabled/disabled by the end user. *Optional functions not purchased cannot be enabled*.

Functions designated as **DISABLED** are inactive and will not be available for tripping. All menus associated with inactive functions will be unavailable.

The general information required to complete the input data on this section includes:

- Enable/Disable
- Function specific settings
- Output choices (OUT 1–OUT 4; for units with expanded I/O, OUT 5–OUT 12)
- Input blocking choices (IN 1–IN 4; for units with expanded I/O, IN 5–IN 12)

■**NOTE:** The Relay Input/Output Configuration Worksheet is contained in **Appendix B**. The worksheet is provided to define and record the input and output configuration for the relay.

FUNCTIONS

Configuration of the relay consists of enabling the functions for use in a particular application, designating the output contacts each function will operate, and which control/status inputs will block the function. The choices include four programmable output contacts (OUT 1–OUT 4) and four control/status inputs (IN 1–IN 4), or twelve programmable output contacts (OUT 1–OUT 12) and twelve control/status inputs (IN 1–IN 12) for units purchased with expanded I/O.

The blocking control/status inputs and output contact assignments must be chosen before entering the settings for the individual functions. Both may be recorded on the Relay Configuration Worksheet in **Appendix B**, **Relay I/O Configuration Worksheet**.

Special Considerations

Status Inputs 1, 2 and 3 are pre-assigned as follows:

- IN 1, 52a breaker contact
- IN 2, 52b breaker contact
- IN 3, 69 Lockout

Outputs:

- 1, 2, 5, 6, 7 and 8 are form "a" contacts (normally open)
- 3, 4, 9, 10 and 11 are form "c" contacts (center tapped "a" and "b" normally closed)

The following functions in Table 5-1 can be configured using enable/disable output, and status input blocking designations:

FUNCTION	DESCRIPTION
25	Sync Check
27	Phase Undervoltage
27PP	Phase-to-Phase Undervoltage
27Vz1	Vz1 Undervoltage
27BSVS	Bus Side Voltage Supervision
32	Directional Power
40	Loss of Field
46DT	Negative-Sequence Definite Time Overcurrent
46IT	Negative-Sequence Inverse Time Overcurrent
47	Negative-Sequence Overvoltage
50BF	Breaker Failure
50P	Phase Instantaneous/Definite Time Overcurrent
50G	Ground Instantaneous/Definite Time Overcurrent
50N	Residual Instantaneous/Definite Time Overcurrent
51P/51V	Phase Inverse Time Overcurrent with Voltage Control/Restraint
51N	Residual Inverse Time Overcurrent
51G	Ground Inverse Time Overcurrent
59	Phase Overvoltage
59PP	Phase-to-Phase Overvoltage
59I	Peak Overvoltage
59N	Residual Overvoltage
59Vz1	Vz1 Overvoltage
60FL	VT Fuse Loss Detection

FUNCTION	DESCRIPTION
67P	Phase Directional Overcurrent
67N	Residual Directional Overcurrent
67G	Ground Directional Overcurrent
67Q	Negative-Sequence Directional Overcurrent
81	Frequency
81R	Rate-of-Change of Frequency
BM	Breaker Monitor
CLP	Cold Load Pickup
HLT	Hot Line Tag
Restore	Auto Restoration
PSBC	IED Power Supply/Battery Charger Monitor
TCM/CCM	Trip/Close Circuit Monitoring
THD/TDD	Total Harmonic Distortion/ Total Demand Distortion
Optional Protective Functions (with 200 mA, 50 mA or 10 mA Ground CT option)	
50GS	Sensitive Ground Instantaneous/ Definite Time Overcurrent
51GS	Sensitive Ground Inverse Time Overcurrent
67GS	Sensitive Ground Directional Overcurrent
Optional Reclose Functions	
79	Auto Reclose
79 Sequence	Trip Reclose Sequence
79 Lockout	Drive to Lockout
Supervision	Supervision Functions

Table 5-1 Available Functions

CONFIGURING SETPOINTS

The **Setup/Setpoints** command displays the Setpoints dialog screen (Figure 5-3) from which the individual relay function dialog screens can be accessed. Selecting a Function Setting button will display the corresponding function dialog screen (See Figure 5-4 as an example).

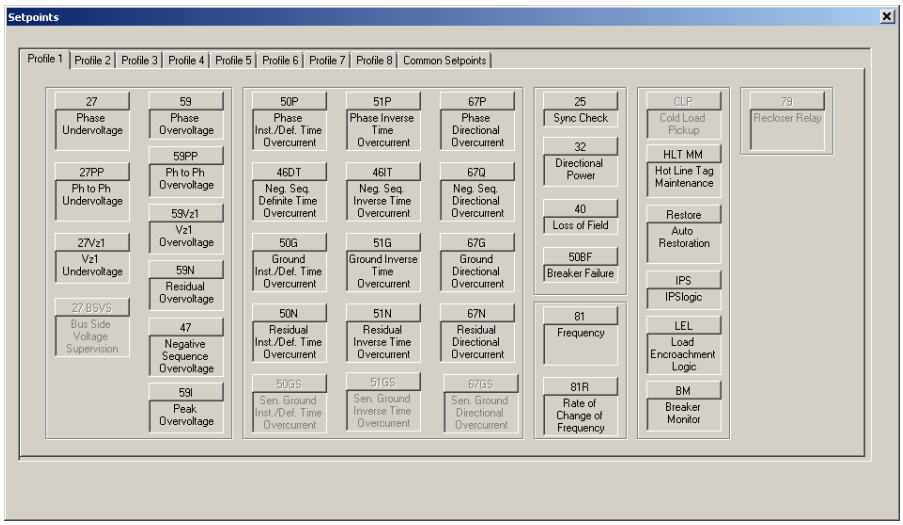


Figure 5-3 Setpoints Dialog Screen

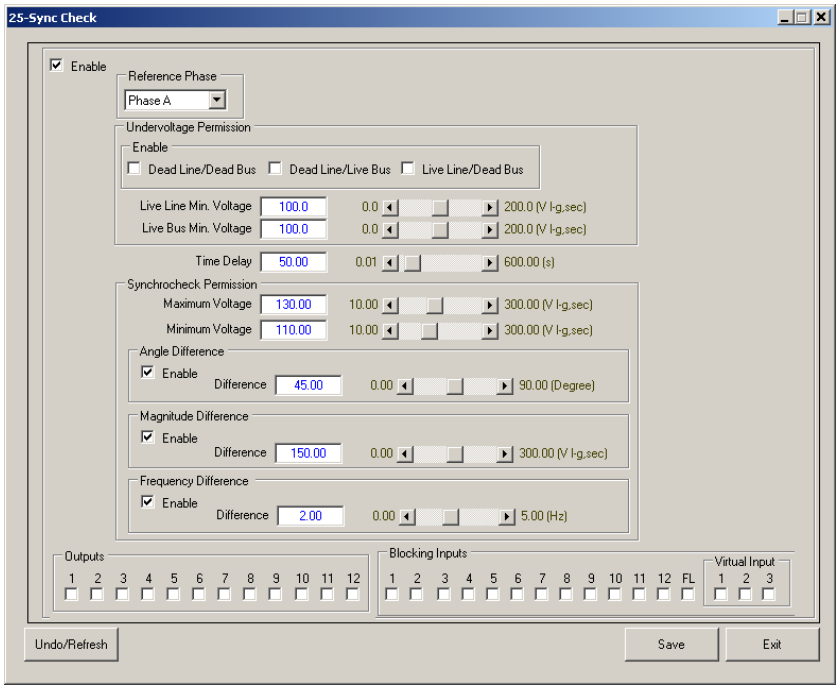


Figure 5-4 Sync Check Function Setpoints Screen Example

USER DEFINED CUSTOM CURVES

IPScom allows the user to define up to four custom overcurrent curves. Each curve has a total of 64 user defined "x-y" coordinates. The "x" coordinate is the pickup ratio and the "y" coordinate is the time value.

To create a custom curve perform the following:

1. From the IPScom Main Screen menu select **Setup/Custom Curve Editor**. IPScom will display the Custom Curves interactive dialog screen (Figure 5-7).

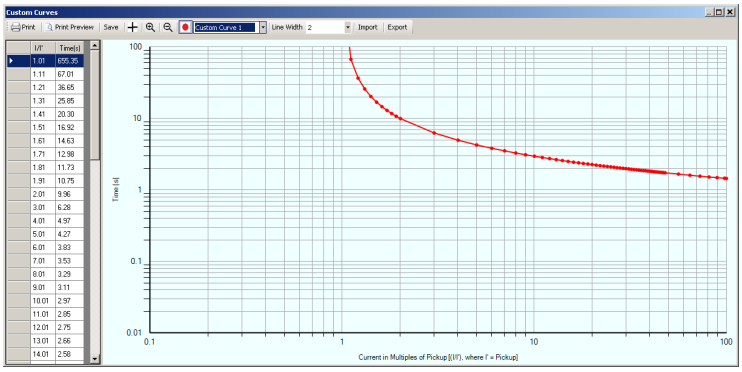


Figure 5-5 Custom Curves Interactive Screen

2. Select the Custom Curve (1 through 4) to be created or edited from the dropdown.
3. Use the left side table to manually enter the "x" (Current in Multiples of Pickup) and "y" (Time) coordinates. The corresponding point will be moved to the entered coordinates.
4. Select **Display Point** as shown below to show all points in the curve which can then be dragged into the desired position.

5. Select **Import** to load an existing curve into the window as a starting point, or to load data from an existing text file (Figure 5-6).

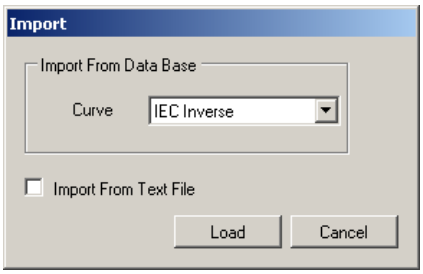


Figure 5-6 Custom Curve Import Screen

6. When the curve has been created as desired, select **Save**. IPScom will display a "Setpoints Saved" confirmation screen (Figure 5-7).

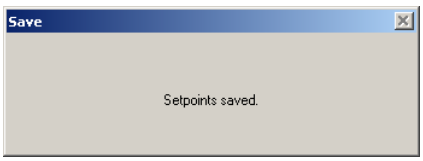


Figure 5-7 Custom Curve Setpoints Saved Confirmation Screen

The Custom Curve is now available for use in any Inverse Time Overcurrent Setpoints screen. If desired, select **Export** to save the Custom Curve data to a text file.

25 SYNC CHECK

The sync check function (25) is used to ensure that the voltage magnitude, phase angle and frequency of the selected line reference phase (A, B or C) and the Bus (Vz_1 selected to Vsync) are within acceptable limits before the relay is synchronized. The sync check function includes the following checks:

- Minimum Voltage
- Phase Angle
- Delta Frequency
- Delta Voltage
- Dead Line/Dead Bus
- Dead Line/Live Bus
- Live Line/Dead Bus

Undervoltage Permission (25D)

The Line Minimum Voltage Limit and Bus Minimum Voltage Limit define the Live/Dead voltage levels used in Undervoltage Permission schemes (Dead Line/Dead Bus, Dead Line/Live Bus and Live Line/Dead Bus) when the undervoltage scheme(s) are enabled.

When the measured Vsync voltage is less than or equal to the Minimum Line Voltage Limit, Vsync is considered dead. When the measured Vsync is greater than or equal to Minimum Line Voltage Limit, Vsync is considered live.

The opposite side of the breaker (i.e., bus) uses the positive sequence voltage measurement (V_1) for three-phase consideration in determining live/dead detection and is compared to the Minimum Bus Voltage Limit. The following different combinations may be selected:

- Dead Line/Dead Bus
- Dead Line/Live Bus
- Live Line/Live Bus

Sync Check Permission (25S)

The sync check permissions function consists of the angle difference, magnitude voltage difference and frequency difference elements. Each of these elements may be enabled individually.

The Sync Voltage and Reference Voltage must both be equal to or less than the Maximum Voltage setting in order for 25S to be enabled. The Sync Voltage and Reference Voltage must both also be equal to or greater than the Minimum Voltage setting in order for 25S to be enabled.

Figure 5-10 is the overall logic diagram for the Sync Check function.

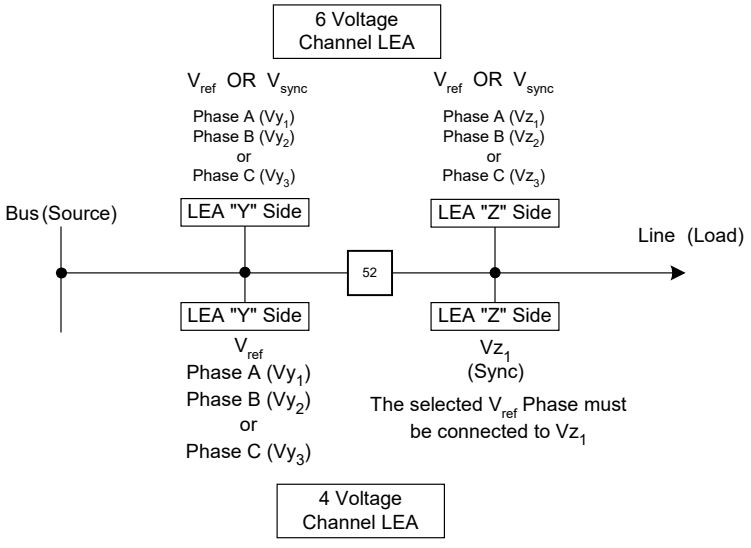


Figure 5-8 Function 25 Voltage Sources

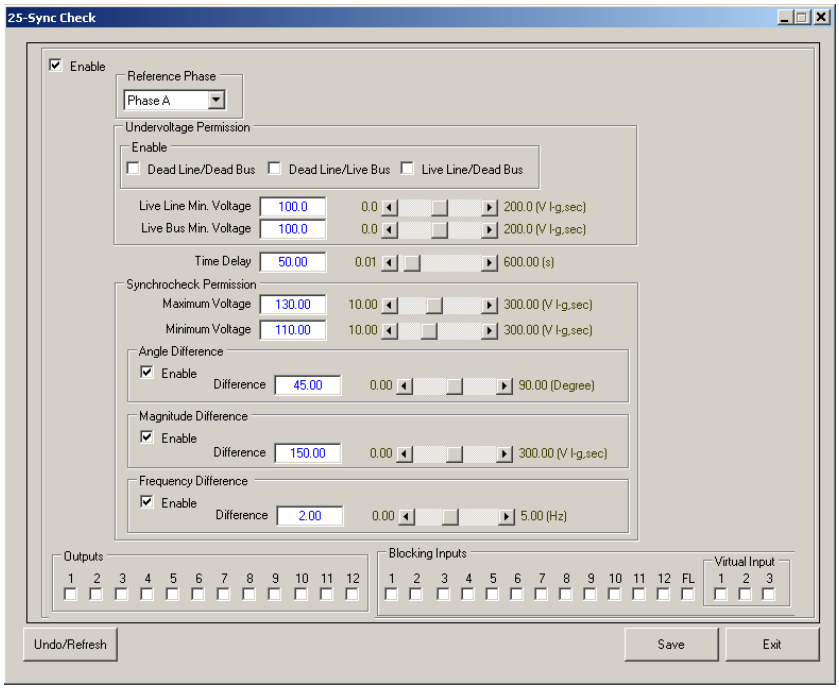


Figure 5-9 Function 25 Sync Check Setpoints Screen

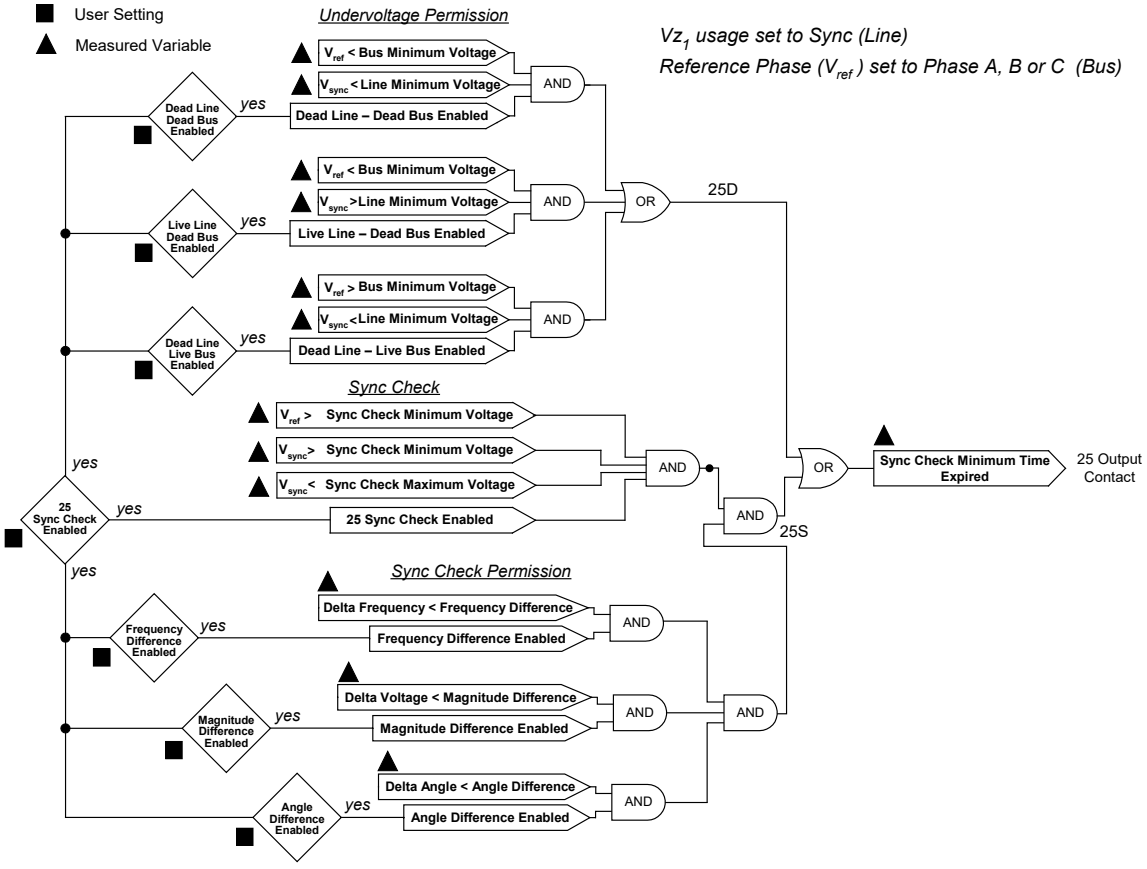


Figure 5-10 Function 25 Sync Check Logic Diagram

27 PHASE UNDERVOLTAGE

Use the Phase Undervoltage function (27) to detect any condition causing long- or short-term undervoltage. The ranges and increments are presented in Figure 5-11 and . 27 #2 through 27 #4 Screens are identical to 27 #1.

■**NOTE:** When the Auto Restoration function is enabled, select **Auto Restore** to include the 27 Undervoltage function in the Auto Restoration logic.

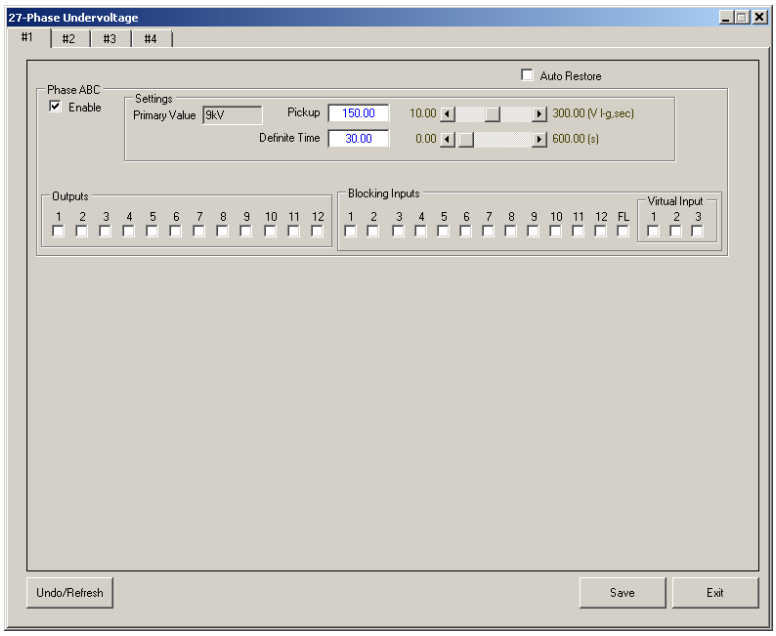


Figure 5-11 Function 27 Phase Undervoltage Setpoint Screen (Shown: Three-Phase Ganged)

27PP PHASE-TO-PHASE UNDERVOLTAGE

Use the Phase-to-Phase Undervoltage function (27PP) to detect any condition causing long- or short-term undervoltage. This element operates on Phase-to-Phase voltage (i.e., V_{AB}, V_{BC}, V_{CA}). 27PP can only be enabled when the VT configuration is line-to-ground.

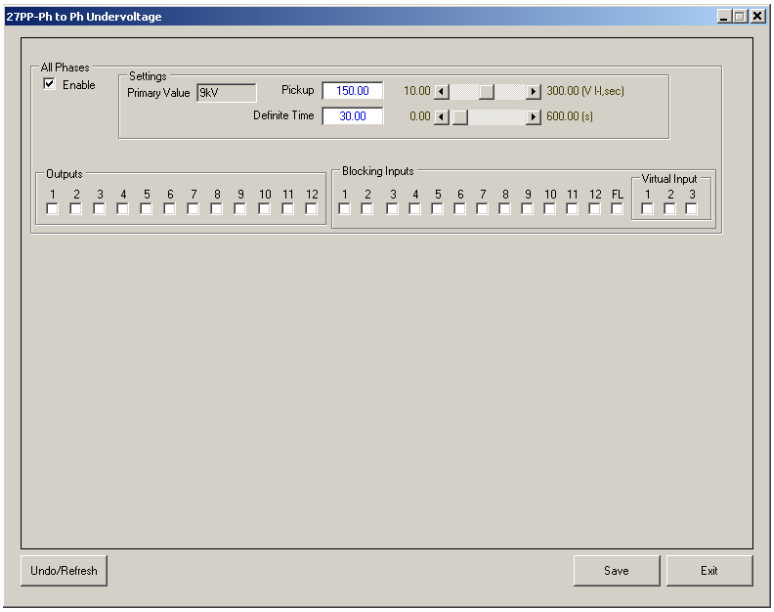


Figure 5-12 Function 27PP Phase-to-Phase Undervoltage Setpoints (Three-Phase Ganged)

27 VZ1 UNDERVOLTAGE

A single phase undervoltage element is available when the voltage input Vz1 is setup as 27/59. Use the 27 Vz1 Undervoltage function to detect any condition causing long term undervoltage on the line (load) side of the relay.

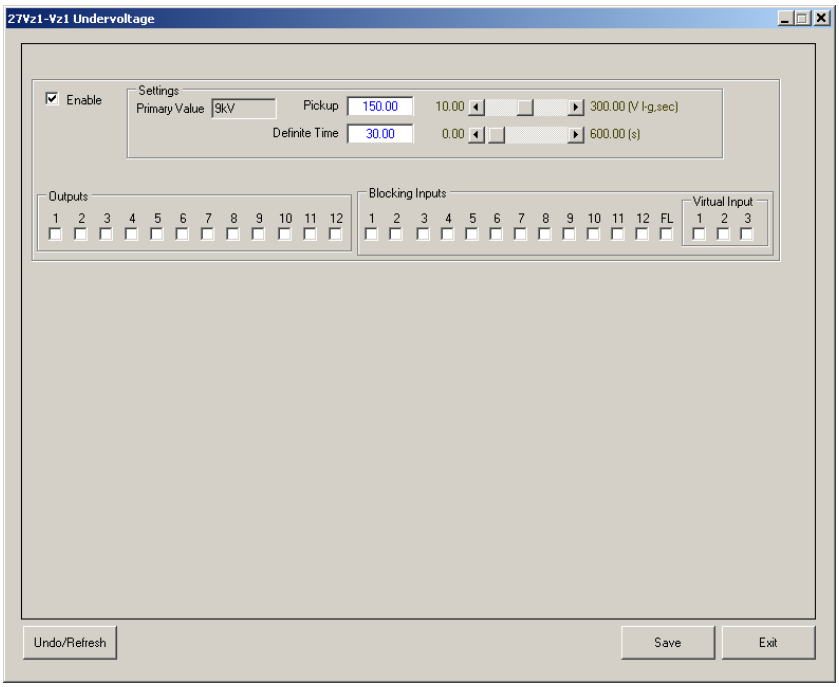


Figure 5-13 Function 27Vz1 Undervoltage Setpoints Screen

32 DIRECTIONAL POWER

Directional Power protection (32) is available as either Reverse Overpower, Reverse Underpower, Forward Overpower or Forward Underpower configuration presented in Figure 5-15. The directional power function provides four power elements, each with a magnitude setting and time delay, and configurable as an underpower or overpower element. Each element can be selected to operate on real or imaginary power.

Directional Power operates on three-phase power. The setting range is from –3.00 PU to 3.00 PU. Normalized PU power flow measurements are based on the Nominal Voltage and Nominal Current setting, as shown in **Section 4.3 System Setup**.

▲**CAUTION:** Proper CT polarity is important in defining the direction of power flow. Refer to Figure 4-74 for proper connections.

To calculate the desired pickup:

Line-to-Ground Voltage:

$P_{NOM} = 3 \bullet V_{NOM} \bullet I_{NOM}$ (Secondary Nominal Power)

$$\text{Pickup} = \pm \frac{\text{Primary Power}}{P_{NOM} \bullet \text{VTR} \bullet \text{CTR}} \text{ (Three-Phase)}$$

Line-to-Line or Line-Ground-to-Line-Line:

$P_{NOM} = \sqrt{3} \bullet V_{NOM} \bullet I_{NOM}$ (Secondary Nominal Power)

$$\text{Pickup} = \pm \frac{\text{Primary Power}}{P_{NOM} \bullet \text{VTR} \bullet \text{CTR}} \text{ (Three-Phase)}$$

Directional Choice

Typically, Forward looking elements are used to detect an overload while Reverse looking elements are used to detect a backfeed. Other applications are possible, such as the detection of an under power condition.

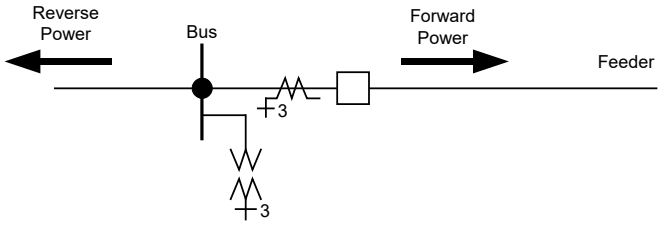


Figure 5-14 Directional Power Flow

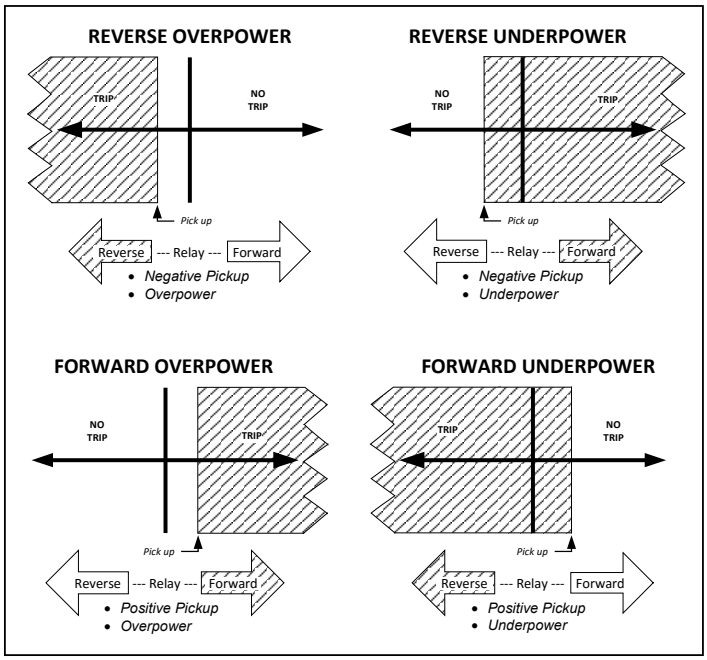


Figure 5-15 Directional Power Configurations

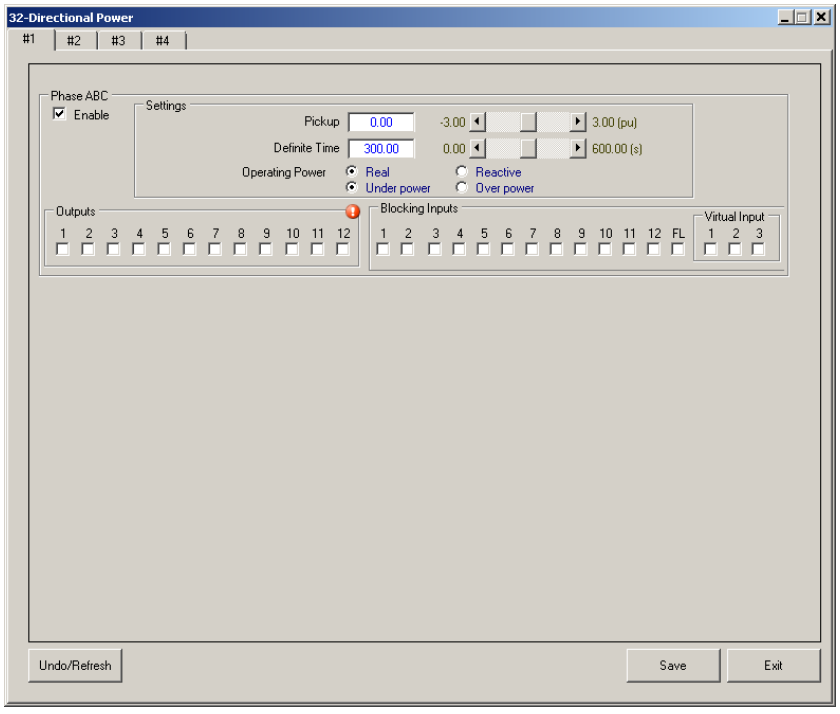


Figure 5-16 Function 32 Directional Power Setpoints Screen

40 LOSS OF FIELD

The Loss-of-Field function (40) provides protection for a partial or complete loss of field. A variety of possible settings make the M-7651A D-PAC very flexible when applied to loss-of-field protection for distributed generation applications. Ranges and increments are presented in Figure 5-17.

■**NOTE:** This protection is applied only for synchronous generators.

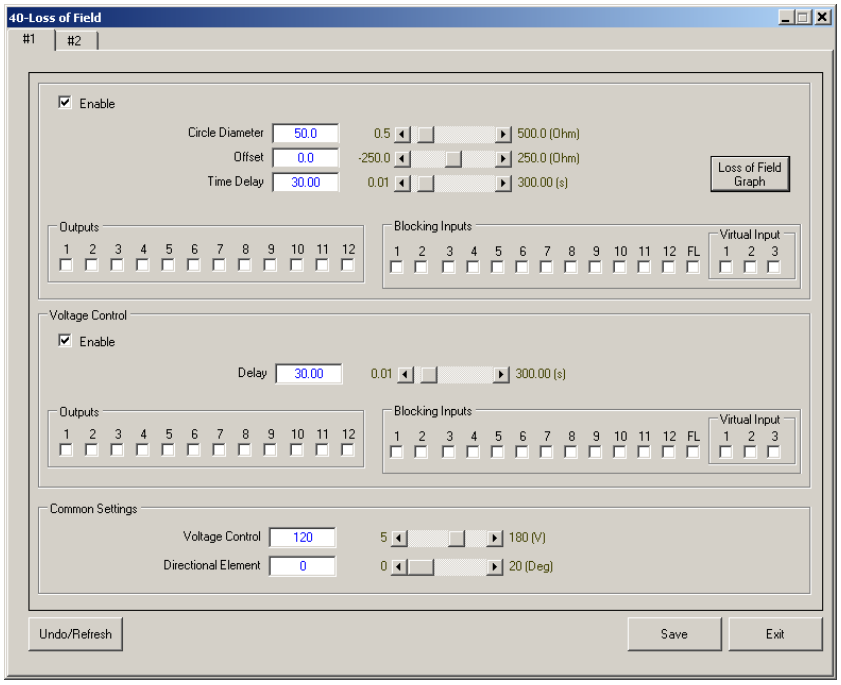


Figure 5-17 Function 40 Loss of Field Setpoints Screen

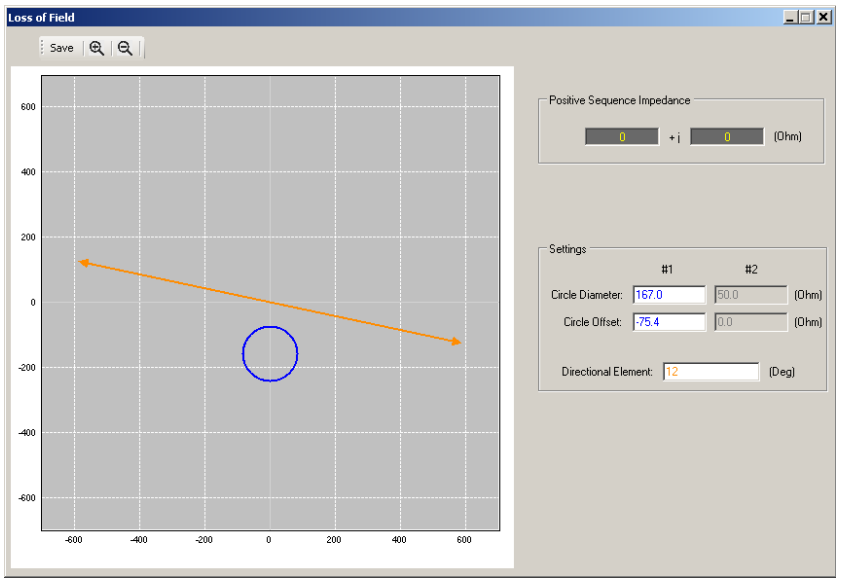


Figure 5-18 Loss of Field Graph

The loss-of-field function is implemented with two offset mho elements, a directional element and an undervoltage element for voltage control. The settings for each zone are adjusted individually.

- The two offset mho elements with individual timers permit reliable reactive reach settings.
- A common directional unit is provided to block operation during slightly underexcited conditions. The directional unit (Q_D) can be set from 0° to 20°.
- The voltage control allows for faster tripping when low voltage occurs due to the VAr intake by the generator during a loss of excitation.

Each zone has two time delay settings. The second time delay is applicable when voltage control is enabled and the timer only starts if the positive-sequence voltage is less than the voltage control setting. The delay with voltage control (VC) is enabled separately for each zone; however the voltage level setting is common.The 40 function, with and without voltage control, can be programmed to close two different output contacts if desired.

■**NOTE:** The first approach uses a negative offset and as such is inherently directional; therefore the directional element is not required.

The settings for the offset mho elements should be such that the relay detects the loss-of-field condition for any loading while not misoperating during power swings and fault conditions. Two approaches are widely used in the industry, both of which are supported by the M-7651A. Both approaches require name plate data for the generator. They are illustrated in Figure 5-19, Loss of Field (40) – Protective Approach I and Figure 5-20, Loss of Field (40) – Protective Approach II.

Positive-sequence impedance measurements are used for the loss of field functions. All impedance settings are secondary relay quantities and can be derived via the following formula:

$Z_{SEC} = Z_{PRI} \bullet (CTR/VTR)$

Where:

Z_{SEC} = secondary impedance

Z_{PRI} = primary impedance

CTR = current transformer ratio

VTR = voltage transformer ratio

First Approach

Both of the elements (Zones 1 and 2) are set with an offset equal to:

$-X_d/2$

$X_d \equiv$ direct axis transient (saturated) reactance of the generator

The Zone 1 diameter is set equal to 1.0 per unit impedance on the machine base. This mho element detects loss-of-field from 30 percent full load to full load. Use a short time delay (≈10 cycles) for fast protection.

The Zone 2 diameter is set equal to X_d.

Xd ≡ direct axis synchronous (unsaturated) reactance of the generator

This mho element can detect a loss-of-field condition from almost no load to full load. Use a time delay of 30 to 60 cycles to prevent possible unwanted operation during stable swings. The time delay with voltage control is typically set shorter than the non-voltage controlled time delay.

Second Approach

Zone 1 is set with an offset equal to:

$-X_d/2$

The diameter is set equal to:

$1.1 \bullet X_d - X_d/2$

The time delay is 10 to 30 cycles.

Zone 2 is set to coordinate with the generator minimum excitation limit and steady-state stability limit. In order to obtain proper coordination the offset of this element must be set to be positive. Typically the offset is set equal to the unit transformer reactance (X_T).

The diameter is approximately equal to:

$1.1\ X_d + X_T$

Use a time delay of 30 to 60 cycles to prevent possible unwanted operation during stable swings.

A typical setting for the directional element is 13° (i.e., power factor equals 0.974). This setting is common for both zones.

■**NOTE:** The first approach can also be used for Zone 1 and the second approach for Zone 2, where better coordination with AVR limiters, machine capability limits, and steady state stability limits can be obtained.

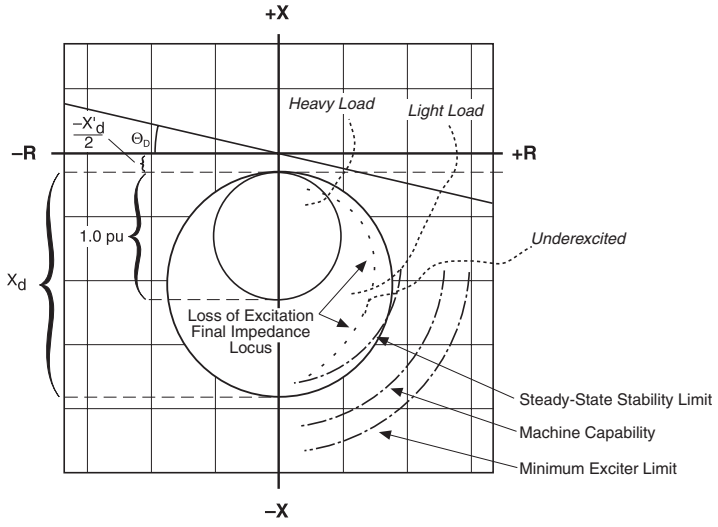


Figure 5-19 Function 40 Loss of Field – Protective Approach I

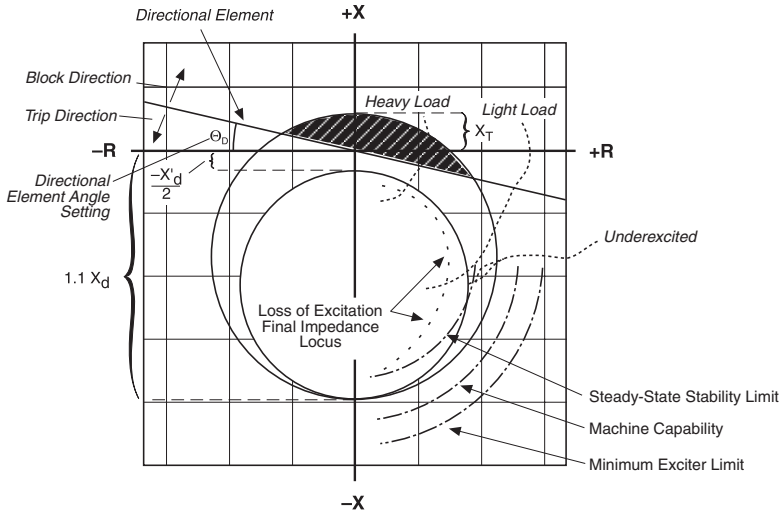


Figure 5-20 Function 40 Loss of Field – Protective Approach II

46DT NEGATIVE-SEQUENCE DEFINITE TIME OVERCURRENT

The Negative-Sequence Overcurrent function is very sensitive and can detect unbalance due to an open pole. Care must be taken not to set the pickup so sensitive it will operate due to unbalance from unequal single phase load. This function has a definite time element. The definite time pickup value and operating time are normally associated as an alarm. 46DT #2 through 46DT #5 screens are identical to 46DT #1.

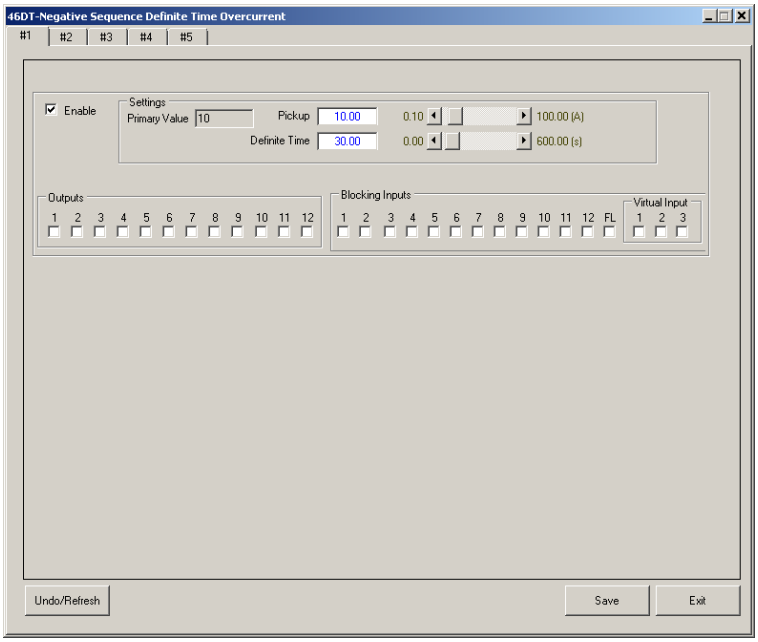


Figure 5-21 Function 46DT Negative-Sequence Definite Time Overcurrent Setpoints Screen

46IT NEGATIVE-SEQUENCE INVERSE TIME OVERCURRENT

The 46IT Inverse Time function can be selected as an IEC, IEEE, US, Traditional Recloser Curve (101-202), Definite Time or user defined Custom Curve. 46IT #2 through 46IT #5 screens are identical to 46IT #1.

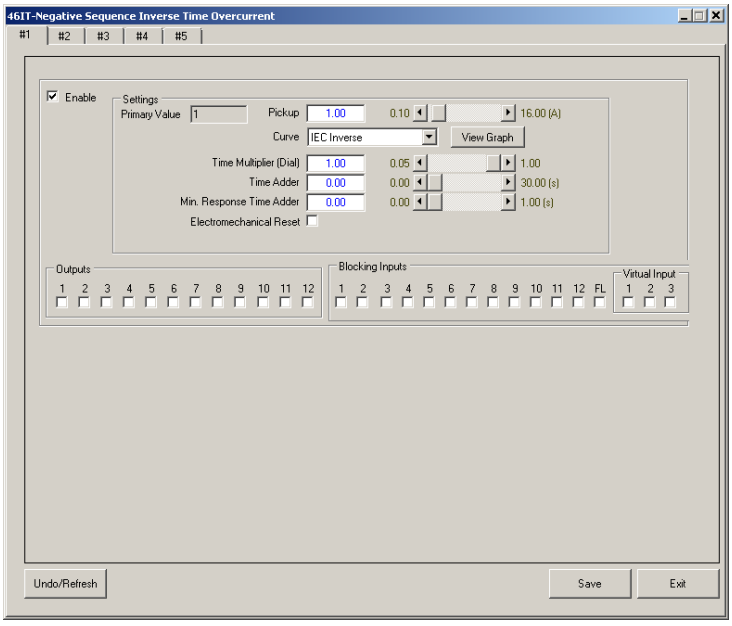


Figure 5-22 Function 46IT Negative-Sequence Inverse Time Overcurrent Setpoints Screen

47 NEGATIVE-SEQUENCE OVERVOLTAGE

The Negative-Sequence Overvoltage function provides protection for voltage unbalance and reverse phase sequence. The operating signal is V_2.

Voltage unbalance can occur due to blown fuses on transformers, open conductors, load unbalance and other such events. Phase reversal may occur when lines are repaired and conductors are inadvertently swapped. Ranges and increments are presented in Figure 5-23.

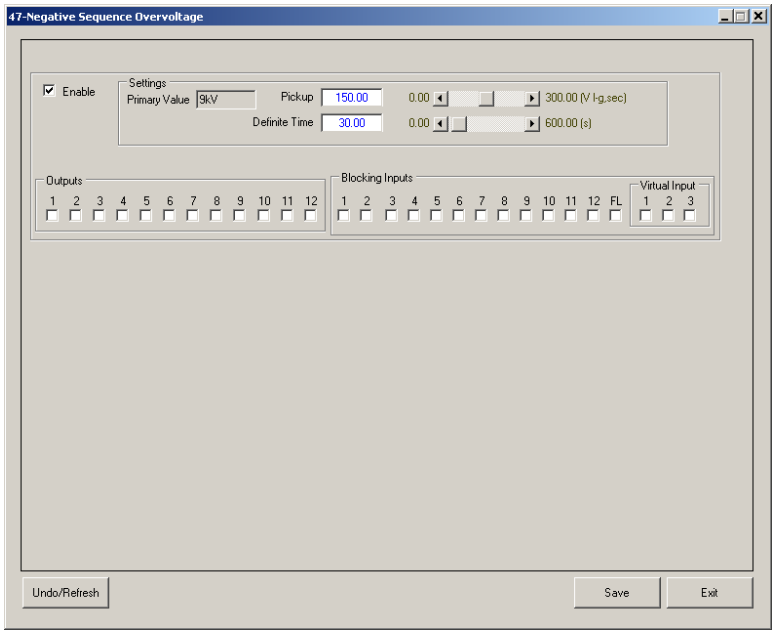


Figure 5-23 Function 47 Negative-Sequence Overvoltage Setpoints Screen

50P PHASE INSTANTANEOUS/DEFINITE TIME OVERCURRENT

The 50P Phase Instantaneous/Definite Time Overcurrent function provides fast tripping for high magnitude phase faults. The settings must be set such that it will not pickup for faults or conditions outside the immediate protective zone. The selected phase overcurrent elements (50P) operate when any individual Phase A, B or C current exceeds the pickup. 50P #2 through 50P #5 Screens are identical to 50P #1.

50P High Current Lockout (HCL)

There is a dedicated definite time phase and residual overcurrent for each auto-reclose shot. These are typically set to pickup for close-in high current magnitude faults and a short time delay (e.g., five cycles or less). If an HCL overcurrent element operates, then the auto-reclose cycle immediately goes to lockout.

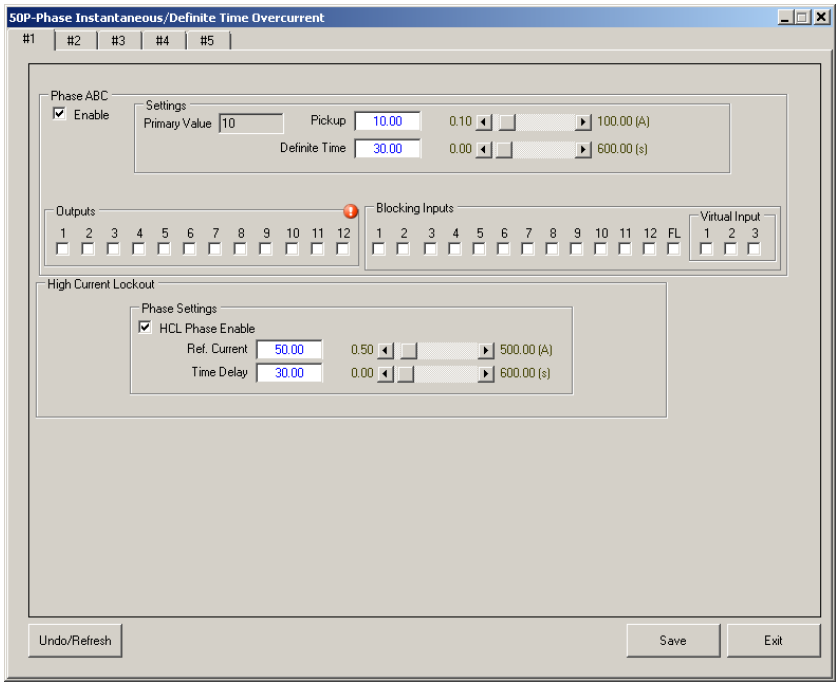


Figure 5-24 Function 50P Phase Instantaneous/Definite Time Overcurrent Setpoints Screen (Shown: Three Phase Ganged)

50G GROUND INSTANTANEOUS/DEFINITE TIME OVERCURRENT

The 50G Ground Instantaneous/Definite Time Overcurrent function provides reliable protection for ground faults. This element can be set more sensitive than the phase overcurrent since ground current typically only exists during unbalanced conditions. The settings must be set such that they will not pickup for faults or conditions outside the immediate protective zone. 50G operates on the ground current input I_G. Operation occurs when the ground current magnitude exceeds the pickup. 50G #2 through 50G #5 Screens are identical to 50G #1.

50G High Current Lockout (HCL)

There is a dedicated definite time phase and residual overcurrent for each auto-reclose shot. These are typically set to pickup for close-in high current magnitude faults and a short time delay (e.g., five cycles or less). If an HCL overcurrent element operates, then the auto-reclose cycle immediately goes to lockout.

■**NOTE:** 50G High Current Lockout settings are only available when the HCL Operating Current Reference is configured as "G".

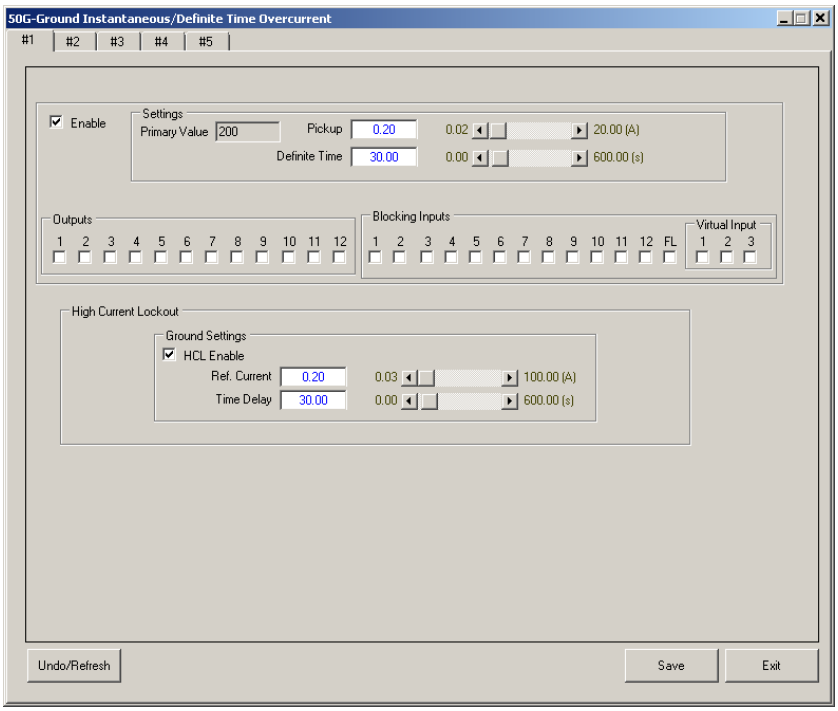


Figure 5-25 Function 50G Ground Instantaneous/Definite Time Overcurrent Setpoints Screen

50N RESIDUAL INSTANTANEOUS/DEFINITE TIME OVERCURRENT

The 50N Residual Instantaneous/Definite Time Overcurrent function provides reliable protection for ground faults. This element can be set more sensitive than the phase overcurrent since neutral current typically only exists during unbalanced conditions. 50N operates on the arithmetic sum of the three-phase current (i. e., $I_a + I_b + I_c$). Operation occurs when the neutral current magnitude exceeds the pickup.

Ranges and Increments are presented in Figure 5-26. 50N #2 through 50N #5 Screens are identical to 50N #1.

50N High Current Lockout (HCL)

There is a dedicated definite time phase and residual overcurrent for each auto-reclose shot. These are typically set to pickup for close-in high current magnitude faults and a short time delay (e.g., five cycles or less). If an HCL overcurrent element operates, then the auto-reclose cycle immediately goes to lockout.

■**NOTE:** 50N High Current Lockout settings are only available when the HCL Operating Current Reference is configured as "3IO".

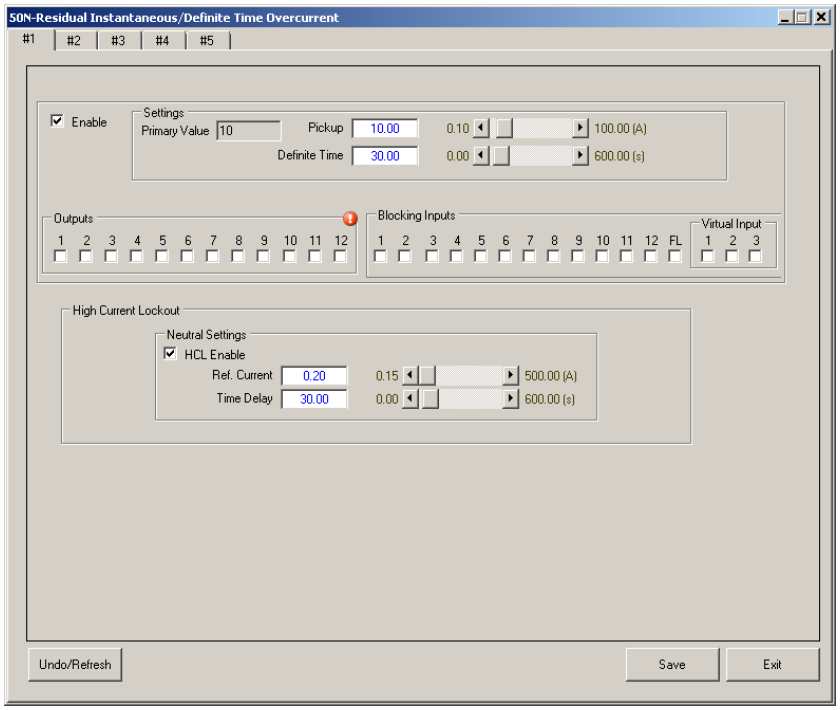


Figure 5-26 Function 50N Residual Instantaneous/Definite Time Overcurrent Setpoints Screen

50GS SENSITIVE GROUND INSTANTANEOUS/DEFINITE TIME OVERCURRENT

The 50GS Sensitive Ground Instantaneous/Definite Time Overcurrent function provides reliable protection for ground faults on high impedance grounded and ungrounded distribution systems. This element is set extremely sensitive since the ground fault current is very low. 50GS operates on the ground current input I_G. Operation occurs when the ground current magnitude exceeds the pickup. 50GS #2 through 50GS #5 Screens are identical to 50GS #1.

50GS High Current Lockout (HCL)

There is a dedicated definite time phase and residual overcurrent for each auto-reclose shot. These are typically set to pickup for close-in high current magnitude faults and a short time delay (e.g., five cycles or less). If an HCL overcurrent element operates, then the auto-reclose cycle immediately goes to lockout.

■**NOTE:** 50GS High Current Lockout settings are only available when the HCL Operating Current Reference is configured as "G".

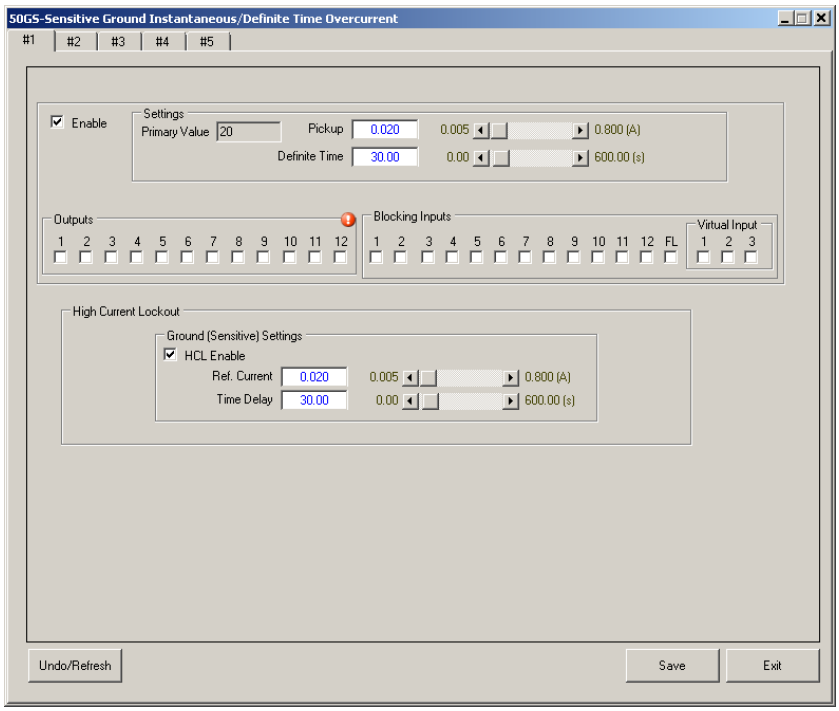


Figure 5-27 Function 50GS Ground Sensitive Overcurrent Setpoints Screen

50BF BREAKER FAILURE

The relay closes an output contact to trip the breaker when it detects a fault or other abnormal condition. Breaker failure protection provides another level of protection should the breaker fail to open. For example the relay can send a direct transfer trip command to the first upstream switch that can break fault current should the breaker fail.

■**NOTE:** The breaker failure protection can be initiated by a trip command from the relay or an external trip command.

The breaker failure condition is detected by the presence of current for a set time after a trip command has been sent to the breaker. The breaker failure timer is started whenever any one of the designated output contacts or the external programmed breaker initiate status input operates. The breaker failure timer continues to time if a current level detector is still picked up indicating the breaker is still closed; otherwise, the breaker failure timer is reset.

There is an option to issue a retrip command before a breaker failure trip is asserted if the breaker has a second trip coil.

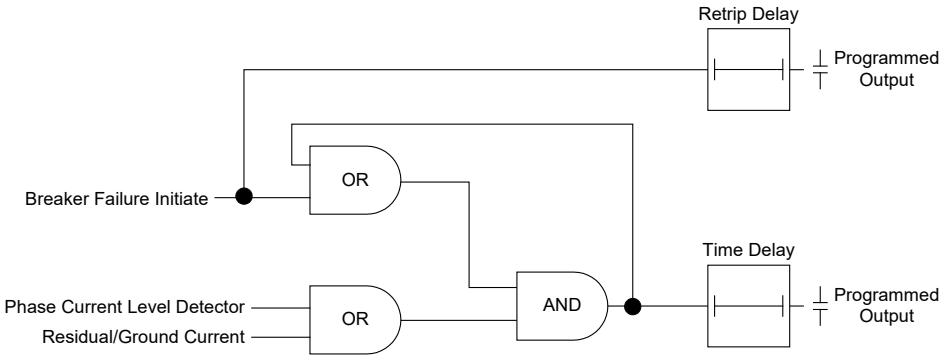


Figure 5-28 Breaker Failure Logic Diagram

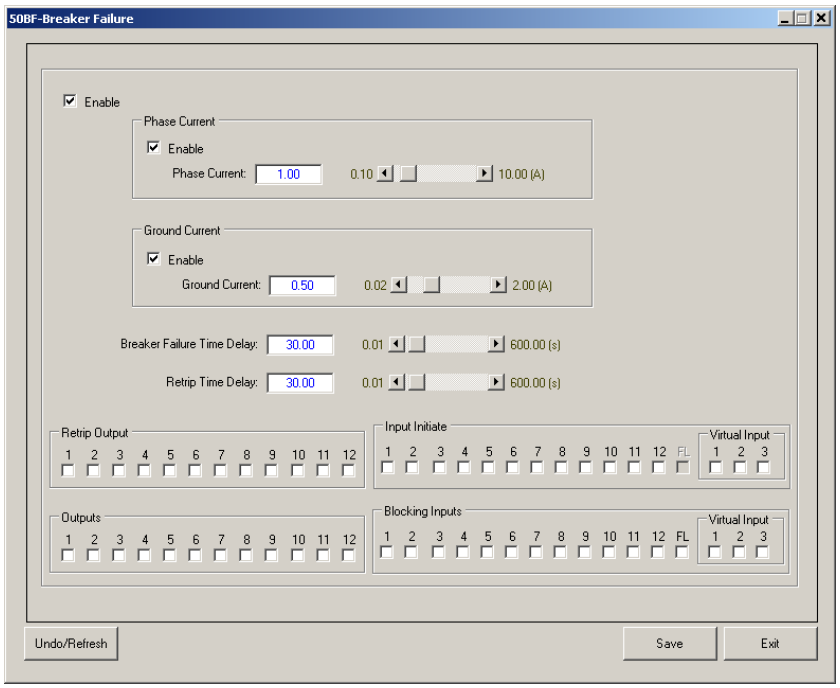


Figure 5-29 Function 50BF Breaker Failure Setpoints Screen

51P/51V PHASE INVERSE TIME OVERCURRENT WITH VOLTAGE CONTROL OR VOLTAGE RESTRAINT

The Phase Inverse Time Overcurrent with Voltage Control/Restraint setting screen allows the user to Enable/Disable Phase Overcurrent protection and enter the operating parameters. Use up to five individual elements to provide inverse time phase overcurrent protection. The M-7651A D-PAC provides over 50 different time-current curves plus four user programmable curves to facilitate coordination with other overcurrent elements in the network. Table 5-2 lists the choices of time-current curves. Use Traditional Recloser curve modifiers to alter the time-current curves (including both US or IEC):

- Time Multiplier – shifts entire curve up or down
- Time Adder – adds set amount of time to curve
- Minimum Response Time – minimum time required to trip

Refer to Figure 5-31 Inverse Time Overcurrent Characteristic as a visual aid.

Time overcurrent relays (51) are basic to most distribution protection schemes. This is the main element to trip circuits selectively for phase faults and coordinate them with up or downstream devices. The 51P function includes voltage control or restraint. Under certain conditions, steady-state fault currents during a three-phase fault can decrease to below the full load current. In order to provide overcurrent protection for those conditions, the voltage control/restraint element should be enabled.

When voltage restraint is selected, the pickup of the 51P is modified continuously according to the voltage inputs, as shown in Figure 5-30. For voltage controlled operation, the function is not active unless the voltage is below the voltage control setpoint. 51P #2 through 51P #5 Screens are identical to 51P #1.

This function should be blocked by fuse loss if in the voltage control mode. Fuse loss blocking is not required for the restraint mode because the pickup is automatically held at 100% Pickup (see Figure 5-30) during fuse loss conditions, and will continue to operate correctly.

■**NOTE:** Select **Use LEL** to enable the Load Encroachment Logic feature. When enabled, the LEL logic will supervise the 51P elements. Refer to "Load Encroachment Logic" later in this section.

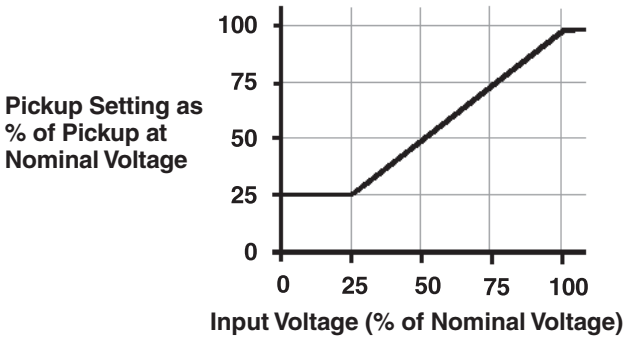


Figure 5-30 51P Voltage Restraint Characteristic

Curve Category	Curve Selection
IEC Curves (IEC 60255-151)	Inverse, Very Inverse, Extremely Inverse
IEEE Curves (IEEE C37.112)	Moderately Inverse, Very Inverse, Extremely Inverse
Traditional Recloser Curves ■NOTE: (Newer curves are shown with the older curve designations in parentheses)	101 (A); 102 (1); 103 (17); 104 (N); 105 (R); 106 (4); 107 (L); 111 (8*); 112 (15); 113 (8); 114 (5); 115 (P); 116 (D); 117 (B); 118 (M); 119 (14); 120 (Y); 121 (G); 122 (H); 131 (9); 132 (E); 133 (C); 134 (Z); 135 (2); 136 (6); 137 (V); 138 (W); 139 (16); 140 (3); 141 (11); 142 (13); 151 (18); 152 (7); 161 (T); 162 (KP); 163 (F); 164 (J); 165 (KG); 200; 201; 202
US Curves	Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse
Definite Time	Definite Time
User-Designed Programmable Curves	Four Programmable Curves

Table 5-2 M-7651A D-PAC Curve Selection

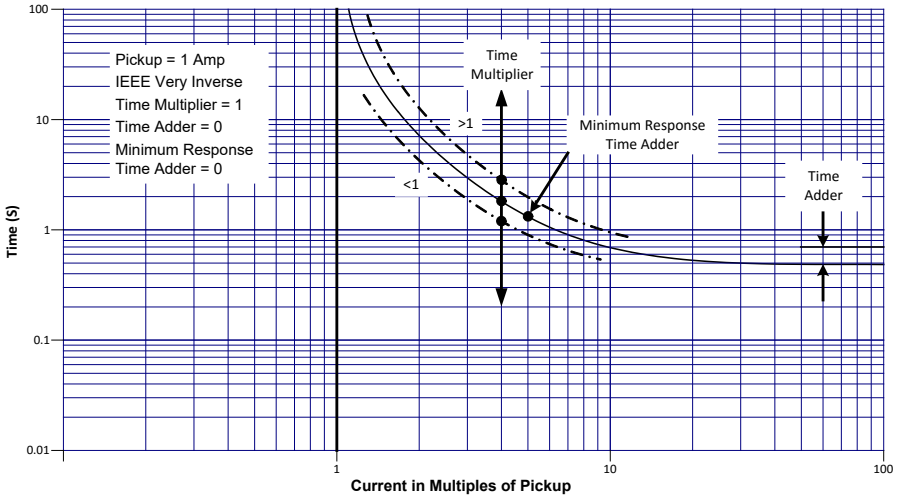


Figure 5-31 Inverse Time Overcurrent Characteristic

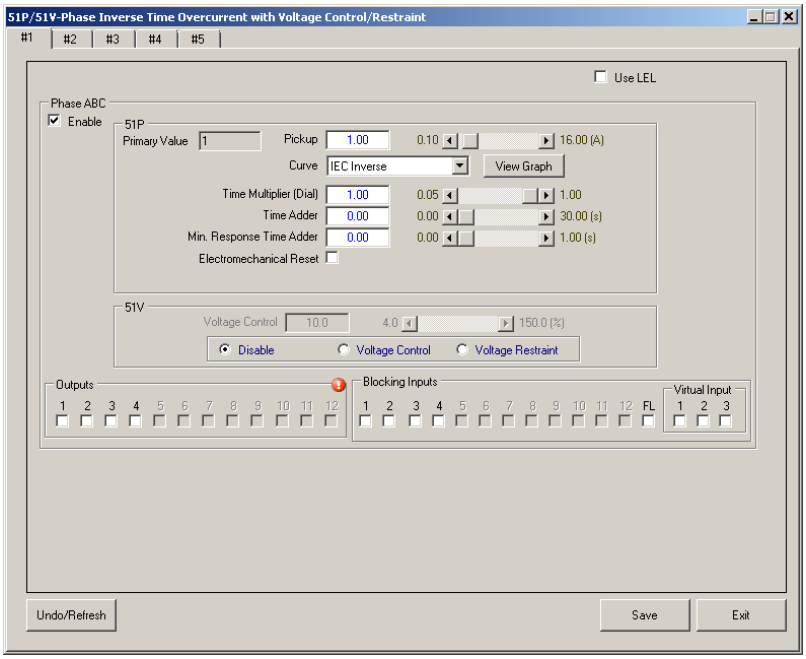


Figure 5-32 Function 51P/51V Phase Inverse Time Overcurrent with Voltage Control/Restraint Setpoints Screen (Shown: Three Phase Ganged)

51N RESIDUAL INVERSE TIME OVERCURRENT

The (51N) Residual Inverse Time Overcurrent function provides protection against ground faults and operates on the neutral current ($I_N = I_A + I_B + I_C$). These elements have greater sensitivity than the phase overcurrent protection, but care should be taken to set the pickup above normal standing unbalance due to conditions such as unequal single phase load. Ranges and increments are presented in Figure 5-33.

The curves available for use are shown in Table 5-2. An additional one cycle time delay should be added to these curves in order to obtain the relay operating time. The operating time is fixed at 20 times pickup and above since the inverse time-current characteristics saturate at this level. 51N #2 through 51N #5 Screens are identical to 51N #1.

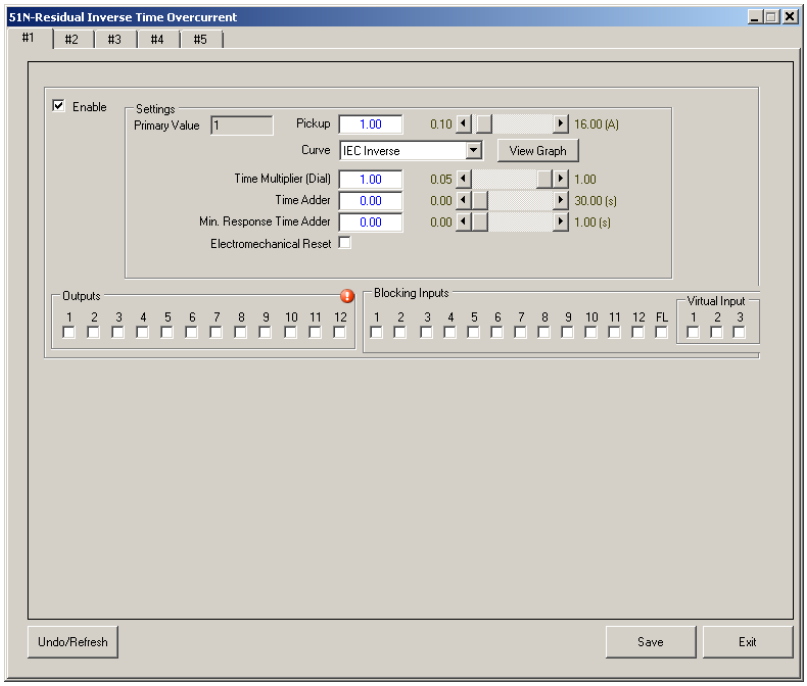


Figure 5-33 Function 51N Residual Inverse Time Overcurrent Setpoints Screen

51G GROUND INVERSE TIME OVERCURRENT

The 51G Ground Inverse Time Overcurrent function provides protection against ground faults and operates on the single phase current input I_G. These elements have greater sensitivity than the phase overcurrent protection, but care should be taken to set the pickup above normal standing unbalance due to conditions such as unequal single phase load. The curves available are listed in Table 5-2. 51G #2 through 51G #5 Screens are identical to 51G #1.

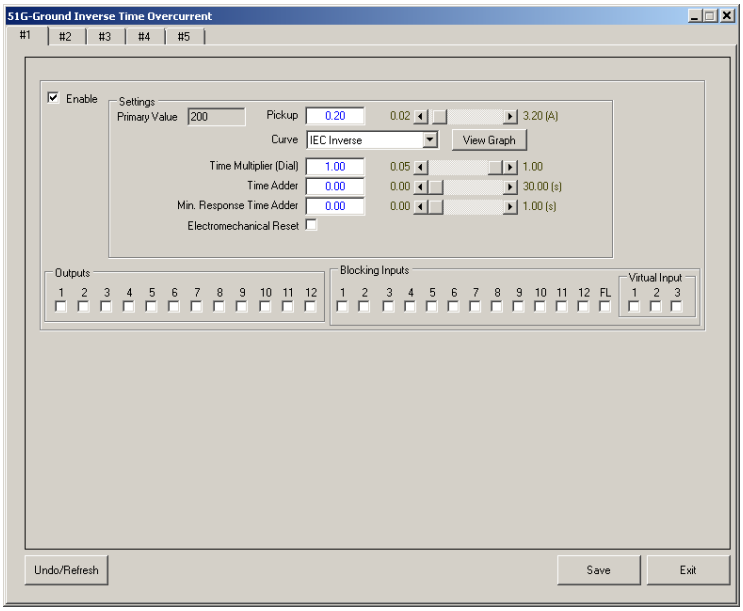


Figure 5-34 Function 51G Ground Inverse Time Overcurrent Setpoints Screen

51GS SENSITIVE GROUND INVERSE TIME OVERCURRENT

The 51GS Sensitive Ground Inverse Time Overcurrent function provides protection against ground faults and operates on the single phase current input I_G. These elements are extremely sensitive to provide protection for high impedance grounded and ungrounded distribution systems. Care should be taken to set the pickup above normal standing unbalance due to conditions such as unequal single phase load. The curves available are listed in Table 5-2. 51GS #2 through 51GS #5 Screens are identical to 51GS #1.

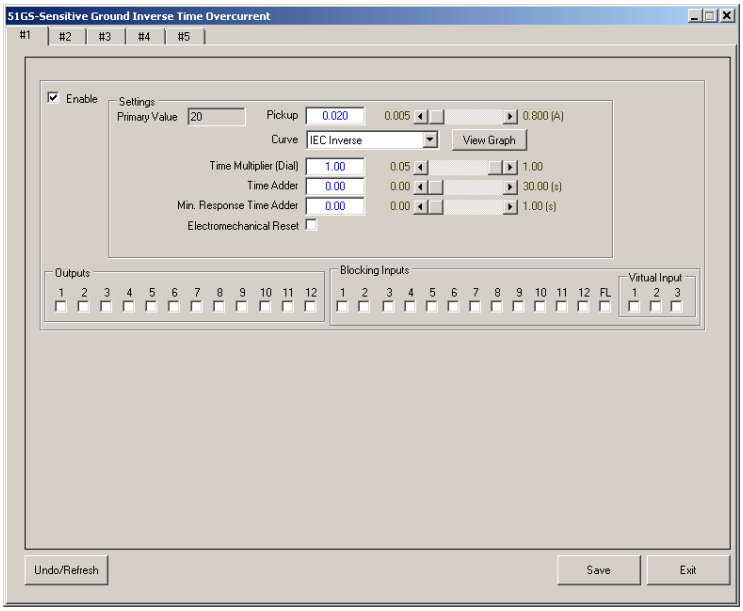


Figure 5-35 Function 51GS Sensitive Ground Inverse Time Overcurrent Setpoints Screen

59 PHASE OVERVOLTAGE

Use the 59 Phase Overvoltage function to provide overvoltage protection. The relay provides overvoltage protection functions with four definite-time setpoints, any one of which can be programmed to trip the breaker or send an alarm. Ranges and increments are presented in Figure 5-36. 59 #2 through 59 #4 Screens are identical to 59 #1.

■**NOTE:** When the Auto Restoration function is enabled, select **Auto Restore** to include the 59 Phase Overvoltage function in the Auto Restoration logic.

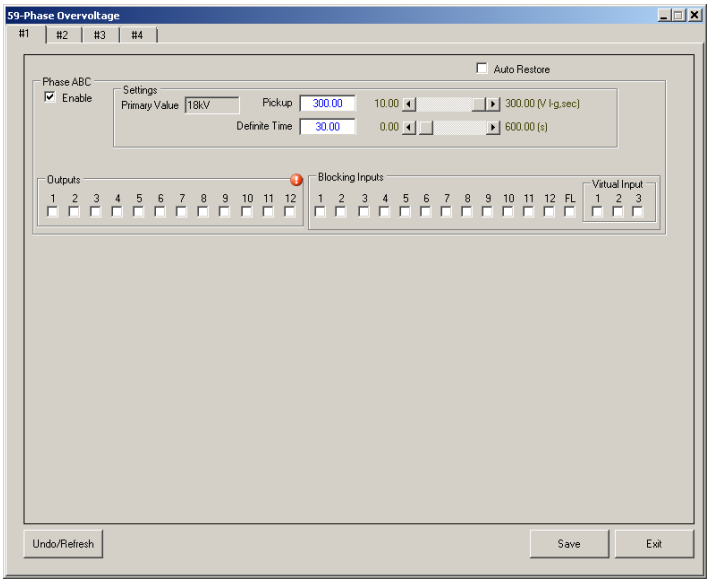


Figure 5-36 Function 59 Phase Overvoltage Setpoints Screen (Shown: Three Phase Ganged)

59PP PHASE-TO-PHASE OVERVOLTAGE

Use the Phase-to-Phase Overvoltage function (59PP) to detect overvoltage conditions. This element operates on Phase-to-Phase voltage (i.e., V_{AB}, V_{BC}, V_{CA}). Therefore it does not pickup due to ground effects such as ground potential rise or zero-sequence mutual coupling. Ranges and increments are presented in Figure 5-37. 59PP can only be enabled when the VT configuration is line-to-ground.

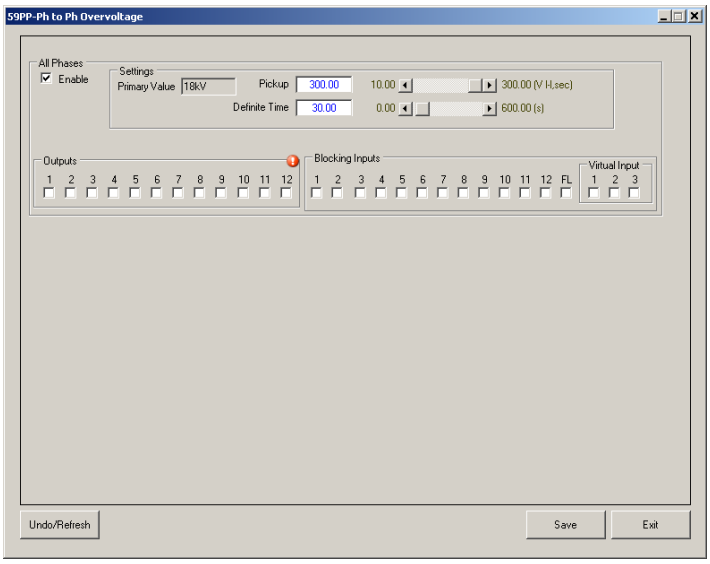


Figure 5-37 Function 59PP Phase-to-Phase Overvoltage Setpoints Screen (Shown: Three Phase Ganged)

59N RESIDUAL OVERVOLTAGE

The 59N function responds only to the fundamental frequency component, rejecting all other harmonic components. This overvoltage function is only available when the relay is configured for Line-to-Ground or Line-Ground-to-Line-Line voltage. The operating signal is the arithmetic sum of the three phase-to-ground voltages (i.e., VA + VB + VC). Ranges and increments are presented in Figure 5-38.

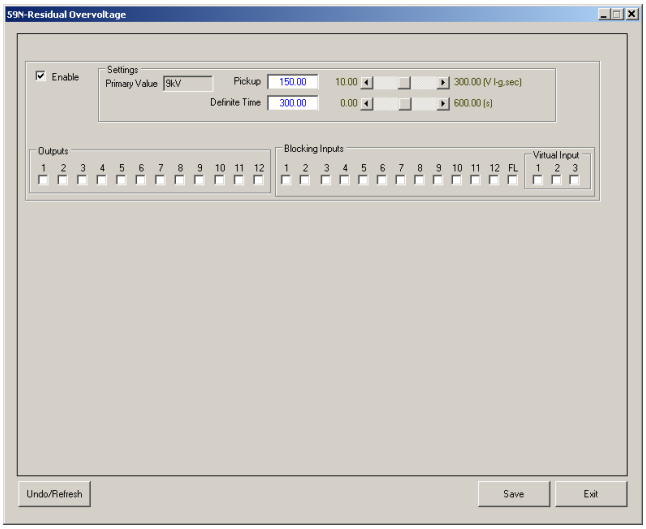


Figure 5-38 Function 59N Residual Overvoltage Setpoints Screen

59I PEAK OVERVOLTAGE

Most overvoltage relays operate based on the RMS value of voltage. There is, however, a system phenomenon known as ferroresonance which may occur on an islanded system with induction generators and capacitor banks. At this time, the voltage waveform will be expected to be very rich in harmonics, to the extent that it is possible that the peak voltage of the non-sinusoidal wave will be dangerously high, even though the RMS value of the same voltage remains in an acceptable range.

Because it is necessary to describe voltage for this purpose in terms of the peak value of voltage (not RMS), it is convenient to define the pickup in per unit of the peak of the nominal sinusoidal waveform. The per unit (PU) value is based on the RMS nominal voltage setting. For example, a pickup equal to 100 percent for 120 volts nominal will operate at the following instantaneous peak voltage: 120 V • √2 = 170 V.

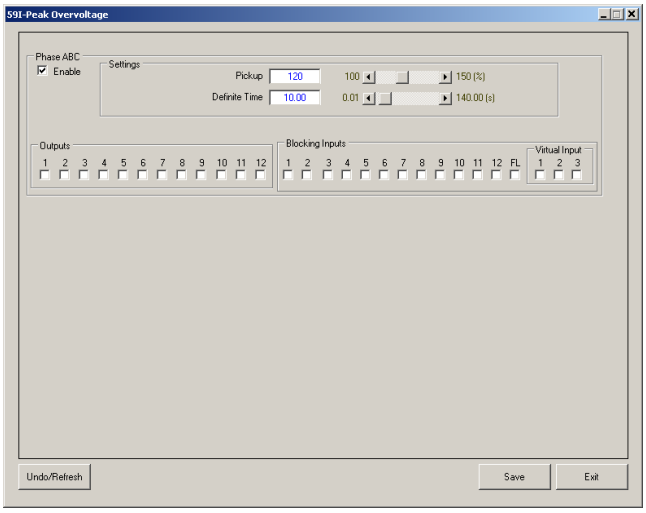


Figure 5-39 Function 59I Peak Overvoltage Setpoints Screen (Shown: Three Phase Ganged)

59VZ1 OVERVOLTAGE

A single phase overvoltage element is available when voltage input Vz1 is setup as 27/59. Use the 59Vz1 Overvoltage function to detect any condition causing long term overvoltage on the line side of the relay.

The function 59Vz1 can detect ground faults if the voltage input Vz1 is connected across a broken delta VT and provides protection for ground faults on the distribution feeder (Figure 5-40). Set the pickup setting higher than the maximum standing system unbalance voltage. The time delay should be set to coordinate with downstream ground relaying. Ranges and increments are presented in Figure 5-41.

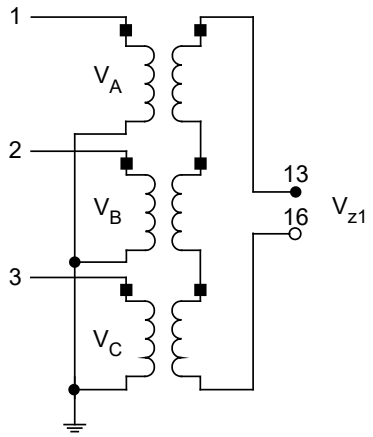


Figure 5-40 Vz1 Broken Delta Connection

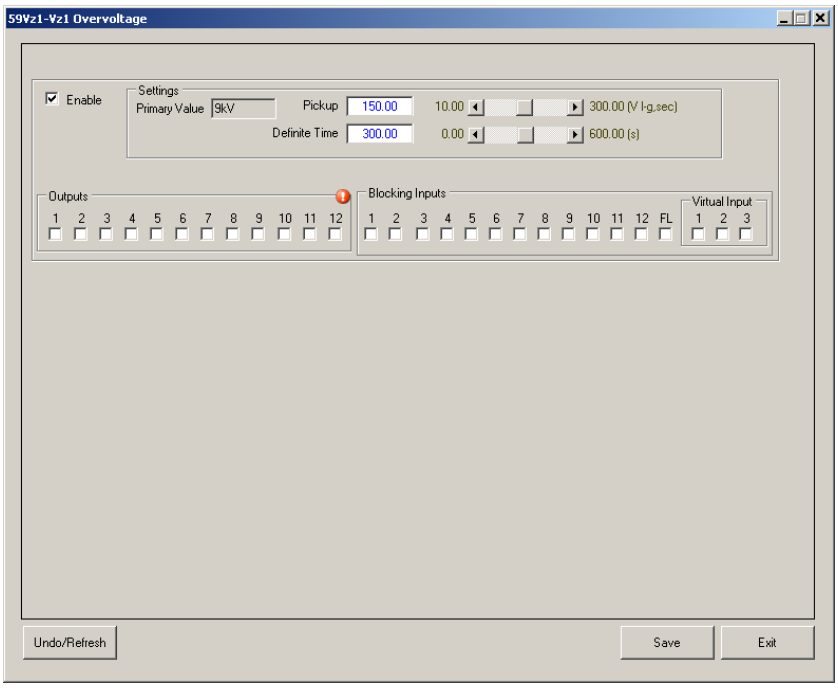


Figure 5-41 Function 59Vz1 Overvoltage Setpoints Screen

67P PHASE DIRECTIONAL OVERCURRENT

■**NOTE:** 67P is intended to only operate for balanced three-phase faults. 67Q operates for phase-to-phase and phase-to-phase-to-ground while 67N (or 67G) operates for single phase-to-ground faults. Therefore, every fault type is covered (i.e., AG, BG, CG, AB, BC, CA, ABG, BCG, CAG and ABC).

Each Phase Directional Overcurrent element can be configured as Directional or Non-Directional. Forward or Reverse looking operation depends upon the setting for the Maximum Sensitivity Angle. Figure 5-42 "Phase Directional Overcurrent – Directional Characteristic" illustrates an element to be forward looking for three-phase faults on a distribution feeder. 60 to 70 degrees is a typical line angle for a distribution feeder. The polarizing voltage is V_1.

Each directional element has two Angles, a Maximum Sensitivity Angle, and an Angle Band. Figure 5-43 illustrates the directional characteristic when the Angle Band is enabled. This is the umbrella characteristic and adds security to the directional decision.

Up to five independent Phase Directional Overcurrent elements can be enabled, 67P#1 through 67P#5. Therefore, they can be used for high speed communication assisted tripping schemes that require both forward and reverse looking elements. Ranges and increments are presented in Figure 5-44.

Minimum Polarizing Voltage

The directional element can be selected to either trip or block trip when the polarizing voltage drops below a settable level (i.e., 2.0-10.0 percent of the nominal voltage). Use this option to prevent unwanted operation for cases such as a fault in the non-trip direction coupled with a bolted short circuited located at the VT secondary terminals.

Definite/Inverse Time Characteristic

Each element can be configured to operate on a Definite or an Inverse Time Overcurrent characteristic. Refer to Function 51P, Phase Inverse Time Overcurrent, earlier in this section, for detailed information regarding the Inverse Time Overcurrent settings.

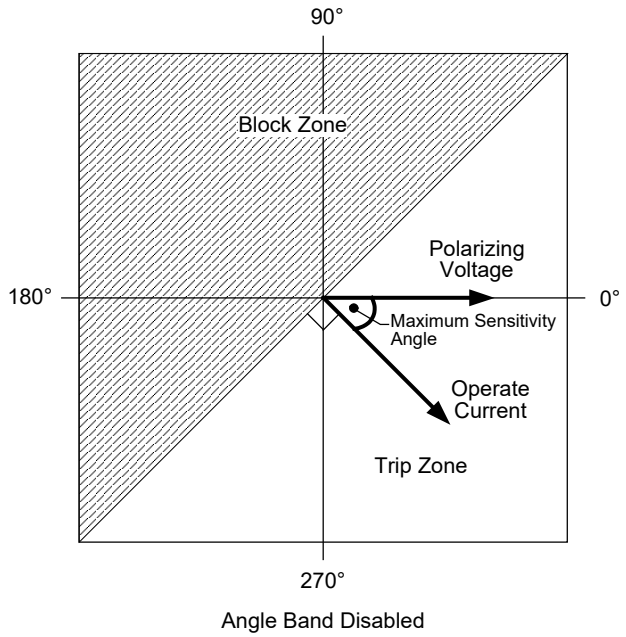
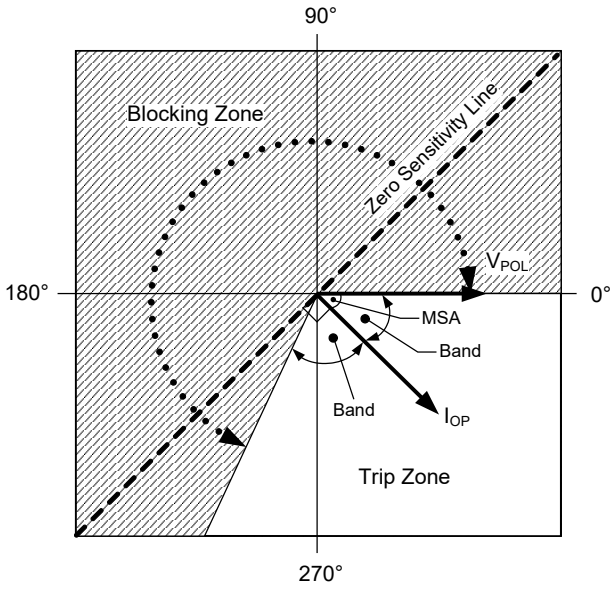


Figure 5-42 67P Phase Directional Overcurrent – Directional Characteristic



V_{POL} = Polarizing Voltage (Reference)
I_{OP} = Operate Current
MSA = Maximum Sensitivity Angle
Band = Angle Band

Figure 5-43 67P Directional Characteristic with Angle Band Enabled

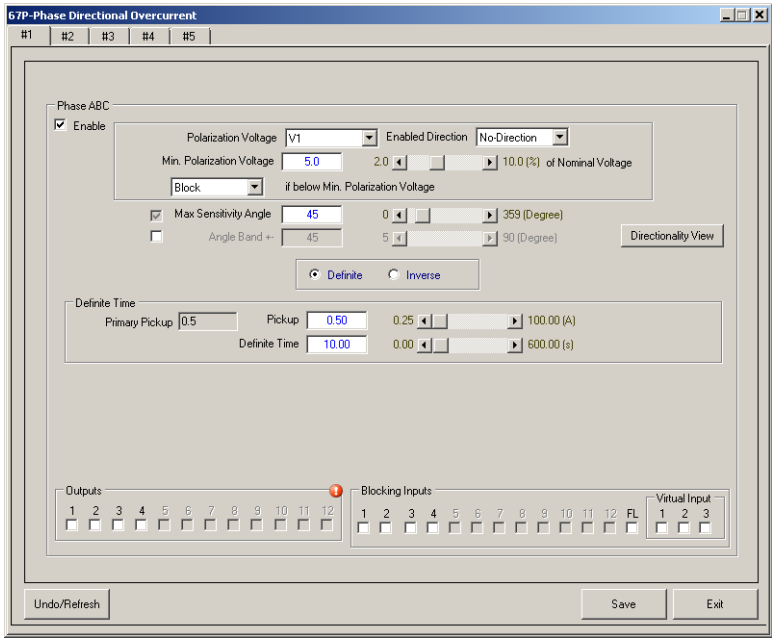


*Figure 5-44 Function 67P Directional Overcurrent **Definite Time** Setpoints Screen*

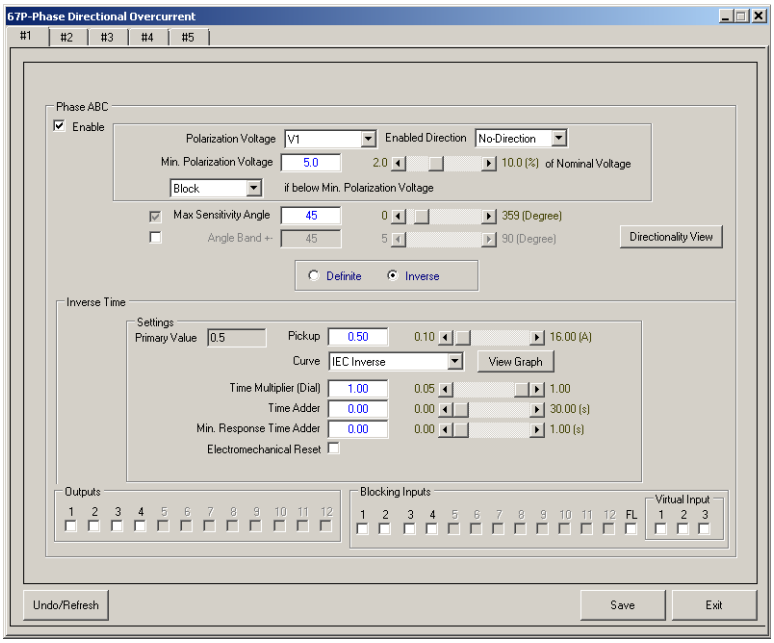


*Figure 5-45 Function 67P Directional Overcurrent **Inverse Time** Setpoints Screen*

67 Directionality View

Selecting "Directionality View" in any 67 Function screen will display a graphical representation of the entered Maximum Sensitivity Angle.

■**NOTE:** MSA cannot be deselected, but the value may be changed.

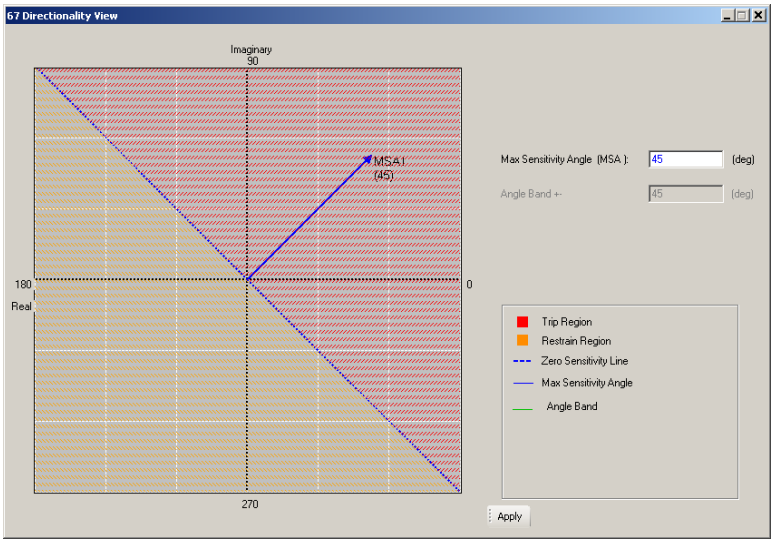


Figure 5-46 Function 67 Directionality View Default MSA

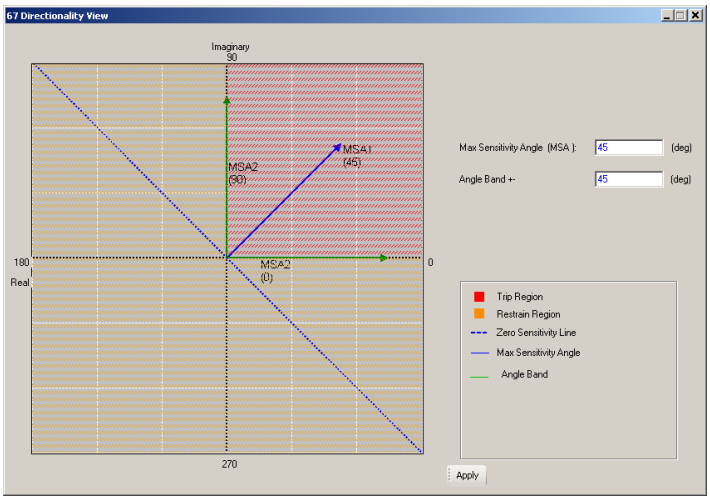


Figure 5-47 Function 67 Directionality View Default MSA and Angle Band

67N RESIDUAL DIRECTIONAL OVERCURRENT

Each Residual Directional Overcurrent element can be configured as Directional or Non-Directional. Forward or Reverse looking operation depends upon the setting for the Maximum Sensitivity Angle. Figure 5-50 "Residual Directional Overcurrent – Directional Characteristic" illustrates setting an element to be forward looking for ground faults on a distribution feeder. 60 to 70 degrees is a typical line angle for a distribution feeder. Figure 5-51 shows the phase relationship between the residual voltage and current for a single line-to-ground fault in the forward direction with respect to the relay on a purely reactive system.

Up to five independent Residual Directional Overcurrent elements can be enabled, 67N #1 through 67N #5. Each directional element has two Angles, a Maximum Sensitivity Angle, and an Angle Band. Figure 5-43 illustrates the directional characteristic when the Angle Band is enabled. This is the umbrella characteristic and adds security to the directional decision.

The choice of polarizing voltage is positive-sequence voltage, negative-sequence voltage, zero-sequence voltage or the single phase auxiliary voltage Vz_1. Typically the zero-sequence voltage is the best choice.

The operate current is the arithmetic sum of the three phase currents ($I_N = I_A + I_B + I_C$). Ranges and increments are presented in Figure 5-48.

Minimum Polarization Voltage

The directional element can be selected to either trip or block trip when the polarizing voltage drops below a settable level (i.e., 2.0–10.0 percent of the nominal voltage). Use this option to prevent unwanted operation for cases such as heavy load coupled with standing system unbalance. Choose settings for reliability (trip) if the relay is located in a weak area of the power system (i.e., low magnitude residual voltage during ground faults).

Definite/Inverse Time Characteristic

Each element can be configured to operate on a Definite or an Inverse Time Overcurrent characteristic. Refer to Function 51N, Residual Inverse Time Overcurrent, earlier in this section, for detailed information regarding the Inverse Time Overcurrent settings.

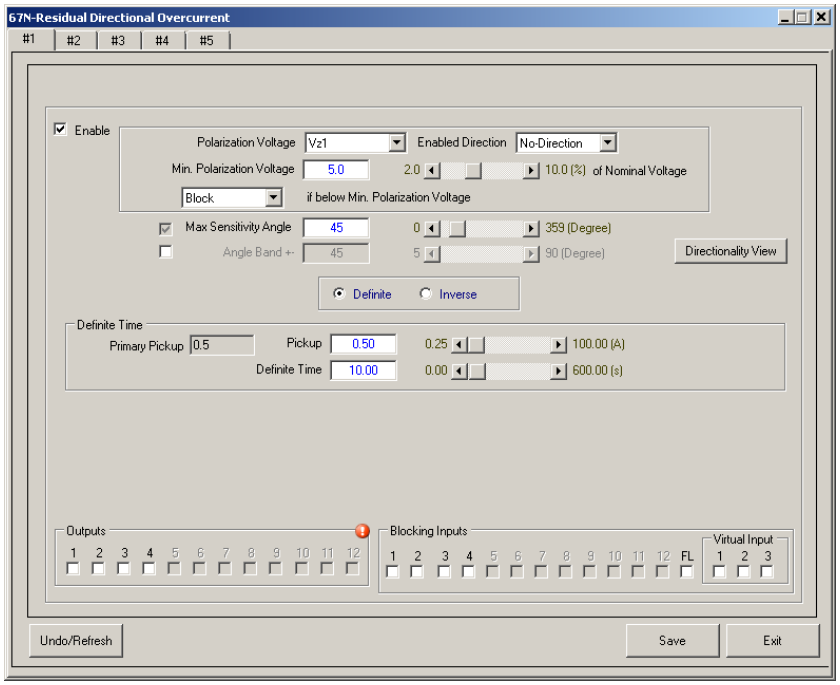


*Figure 5-48 67N Residual Directional Overcurrent **Definite Time** Setpoints Screen*

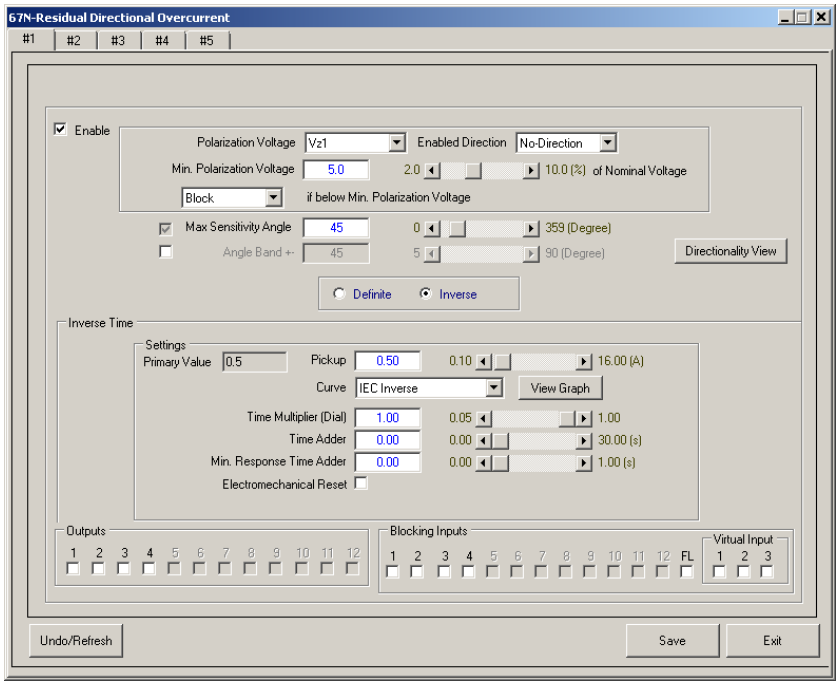


*Figure 5-49 67N Residual Directional Overcurrent **Inverse Time** Setpoints Screen*

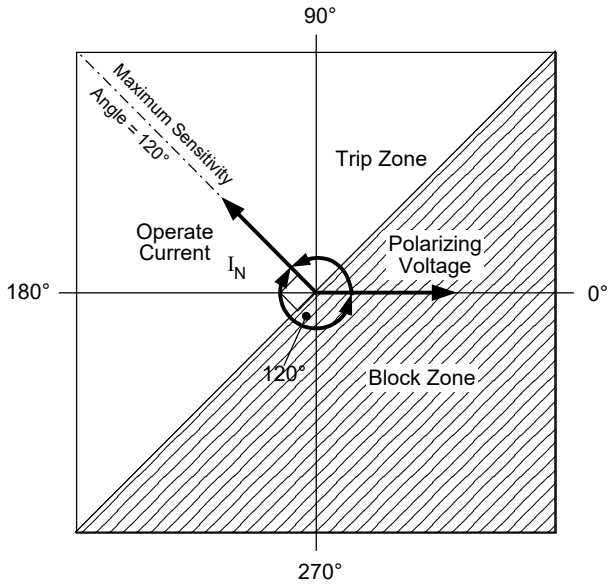


Figure 5-50 67N Residual Directional Overcurrent – Directional Characteristic

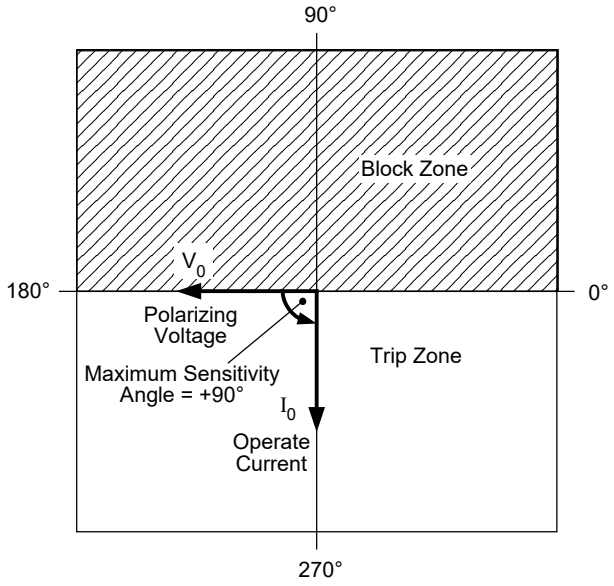


Figure 5-51 67N Residual Directional Overcurrent – Polarizing Voltage (V_0) and Operate Current (I_0) for Forward Single Line-To-Ground Fault – Pure Reactive System

67G GROUND DIRECTIONAL OVERCURRENT

Each Ground Directional Overcurrent element can be configured as Directional or Non-Directional. Forward or Reverse looking operation depends upon the setting for the Maximum Sensitivity Angle. Figure 5-52 "Ground Directional Overcurrent – Directional Characteristic" illustrates setting an element to be forward looking for ground faults on a distribution feeder. 60 to 70 degrees is a typical line angle for a distribution feeder. Figure 5-53 shows the phase relationship between the polarizing voltage and ground current for a single line-to-ground fault in the forward direction with respect to the relay on a purely reactive system.

Up to five independent Ground Directional Overcurrent elements can be enabled, 67G #1 through 67G #5. Each directional element has two Angles, a Maximum Sensitivity Angle, and an Angle Band. Figure 5-43 illustrates the directional characteristic when the Angle Band is enabled. This is the umbrella characteristic and adds security to the directional decision.

The choice of polarizing voltage is positive-sequence voltage, negative-sequence voltage, zero-sequence voltage or the single phase auxiliary voltage Vz_1. Typically the zero-sequence voltage is the best choice. Vz_1 is also suitable if there is a three-phase VT with a broken delta secondary. Refer to Figure 5-54 "Broken Delta Polarizing Source".

The operate current is the single phase current input I_G. Ranges and increments are presented in Figure 5-55.

Minimum Polarization Voltage

The directional element can be selected to either trip or block trip when the polarizing voltage drops below a settable level (i.e., 2.0–10.0 percent of the nominal voltage). Use this option to prevent unwanted operation for cases such as heavy load coupled with standing system unbalance. Choose settings for reliability (trip) if the relay is located in a weak area of the power system (i.e., low magnitude residual voltage during ground faults).

Definite/Inverse Time Characteristic

Each element can be configured to operate on a Definite or an Inverse Time Overcurrent characteristic. Refer to Function 51G, Ground Inverse Time Overcurrent, earlier in this section, for detailed information regarding the Inverse Time Overcurrent settings.

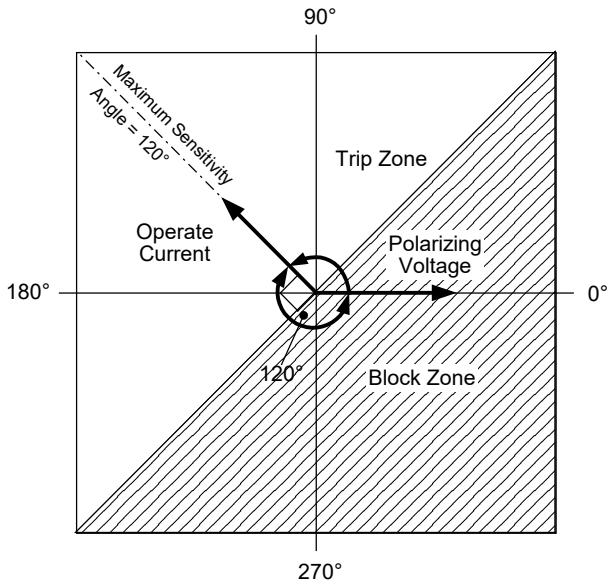


Figure 5-52 67G Ground Directional Overcurrent – Directional Characteristic

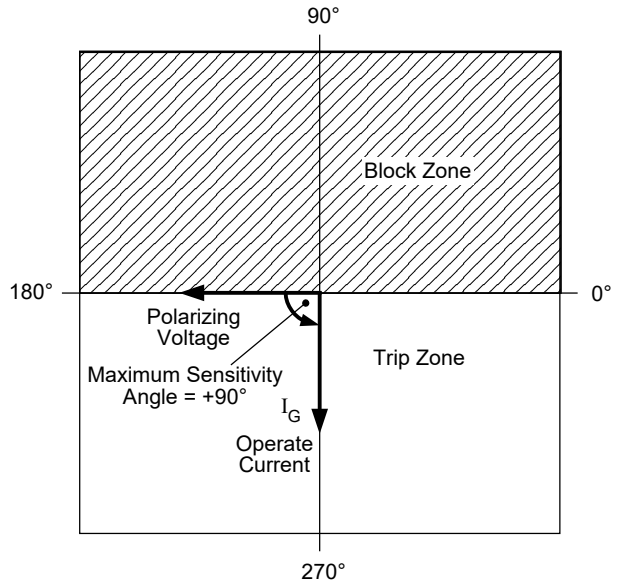
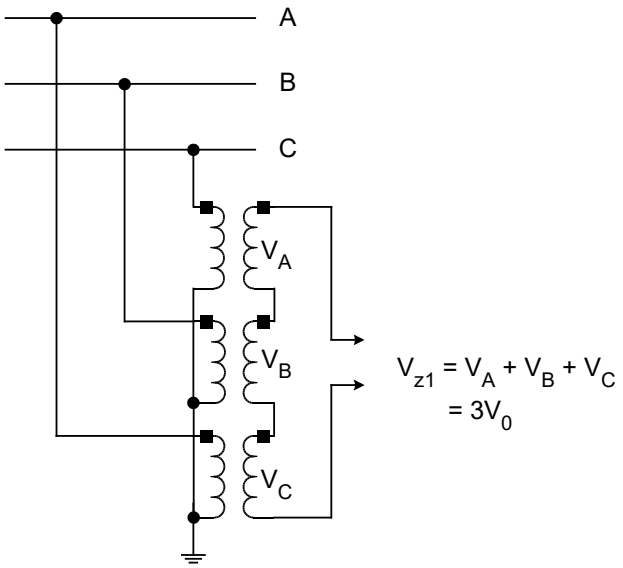


Figure 5-53 67G Ground Directional Overcurrent – Polarizing Voltage and Operate Current (I_G) for Forward Single Line-To-Ground Fault – Pure Reactive System



(Refer to Figure 6-2)

Figure 5-54 67G Broken Delta Polarizing Source

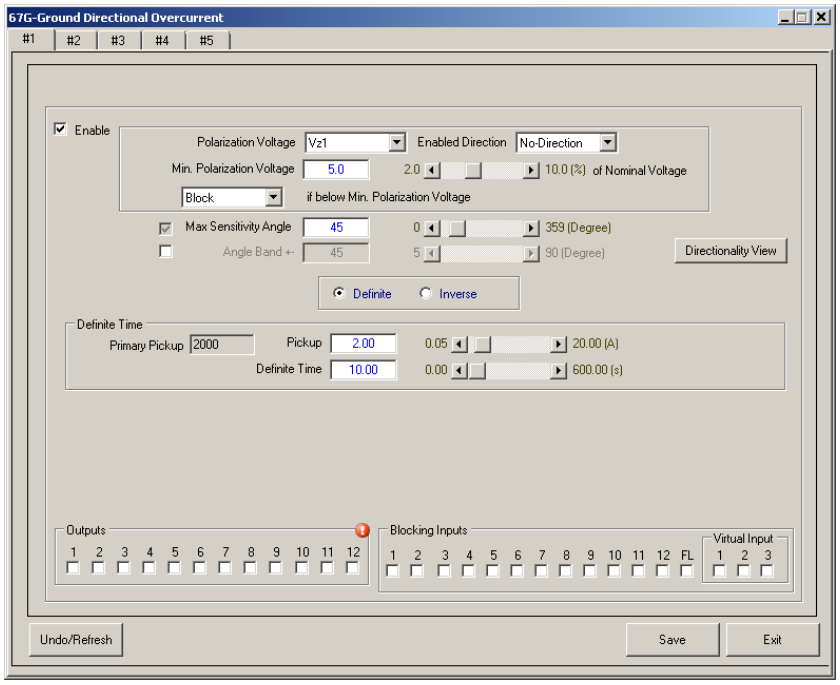


*Figure 5-55 67G Ground Directional Overcurrent **Definite Time** Setpoints Screen*

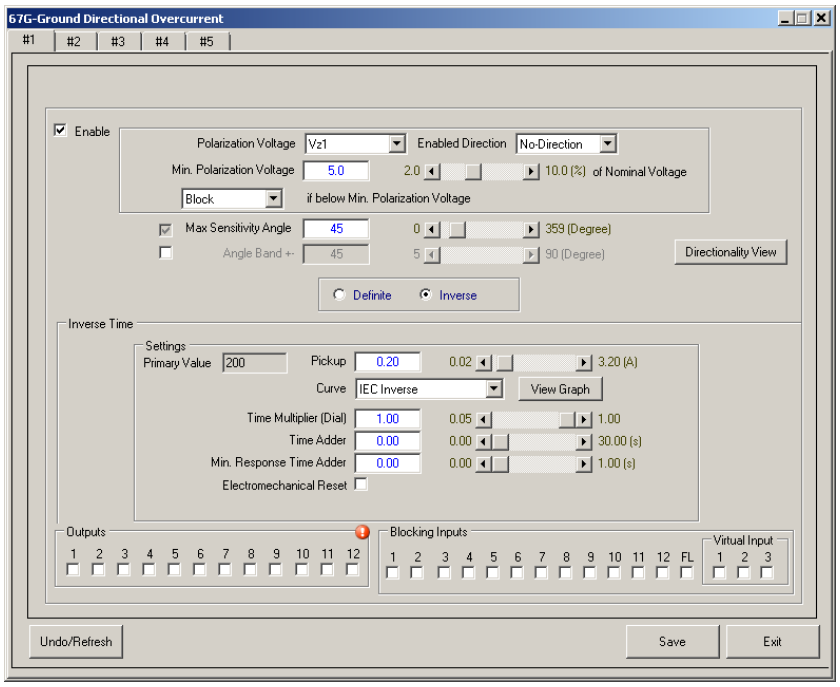


*Figure 5-56 67G Ground Directional Overcurrent **Inverse Time** Setpoints Screen*

67Q NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT

Each Negative-Sequence Directional Overcurrent element can be configured as Directional or Non-Directional. Forward or Reverse looking operation depends upon the setting for the Maximum Sensitivity Angle. Figure 5-59 "Negative-Sequence Directional Overcurrent – Directional Characteristic" illustrates setting an element to be forward looking for unbalanced faults on a distribution feeder. 60 to 70 degrees is a typical line angle for a distribution feeder. Figure 5-60 shows the phase relationship between the polarizing voltage and negative sequence current for an unbalanced fault in the forward direction with respect to the relay on a purely reactive system.

Up to five independent Negative Sequence Directional Overcurrent elements can be enabled, 67Q #1 through 67Q #5. Each directional element has two Angles, a Maximum Sensitivity Angle, and an Angle Band. Figure 5-43 illustrates the directional characteristic when the Angle Band is enabled. This is the umbrella characteristic and adds security to the directional decision.

The choice of polarizing voltage is positive-sequence voltage, negative-sequence voltage, zero-sequence voltage or the single phase auxiliary voltage Vz_1. Negative-sequence voltage is the best choice.

The operate current is the negative-sequence current I_2. Ranges and increments are presented in Figure 5-57.

Minimum Polarization Voltage

The directional element can be selected to either trip or block trip when the polarizing voltage drops below a settable level (i.e., 2.0–10.0 percent of the nominal voltage). Use this option to prevent unwanted operation for cases such as heavy load coupled with standing system unbalance. Choose settings for reliability (trip) if the relay is located in a weak area of the power system (i.e., low magnitude negative-sequence voltage during unbalanced faults).

Definite/Inverse Time Characteristic

Each element can be configured to operate on a Definite or an Inverse Time Overcurrent characteristic. Refer to Function 51Q, Negative-Sequence Inverse Time Overcurrent, earlier in this section, for detailed information regarding the Inverse Time Overcurrent settings.

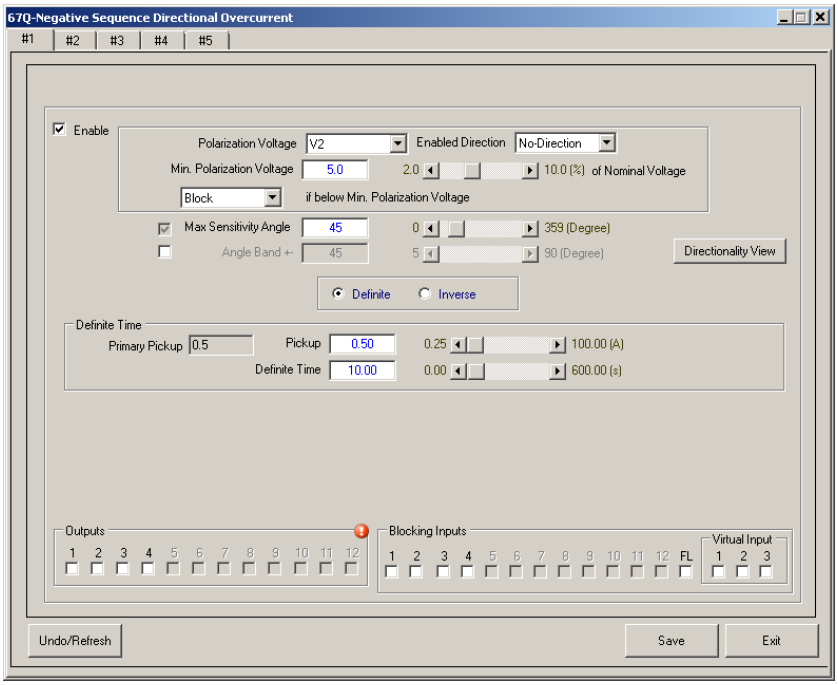


*Figure 5-57 67Q Negative-Sequence Directional Overcurrent **Definite Time** Setpoints Screen*

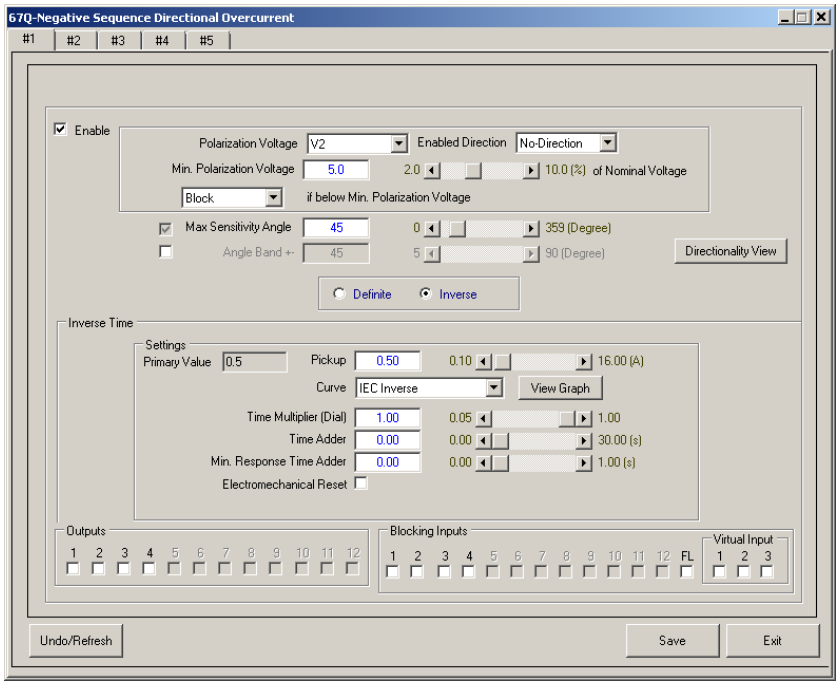


*Figure 5-58 67Q Negative-Sequence Directional Overcurrent **Inverse Time** Setpoints Screen*

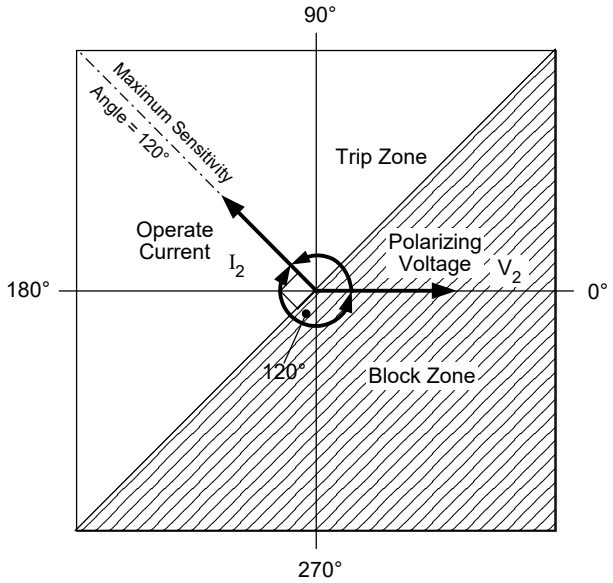


Figure 5-59 67Q Negative-Sequence Directional Overcurrent – Directional Characteristic

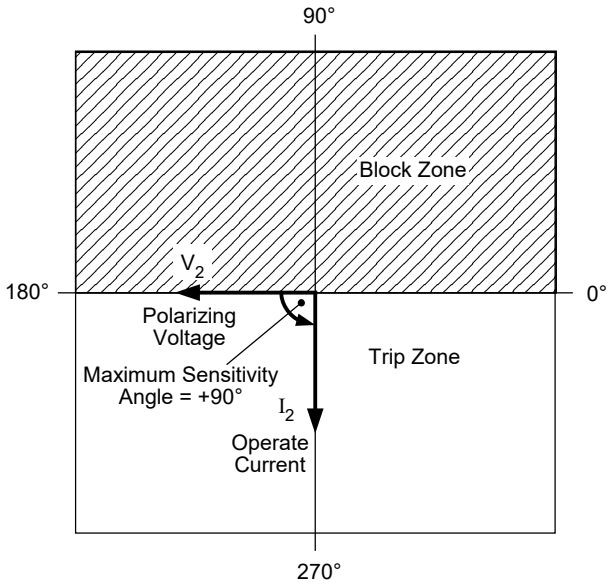


Figure 5-60 67Q Negative-Sequence Directional Overcurrent – Polarizing Voltage (V_2) and Operate Current (I_2) for Forward Unbalanced Fault – Pure Reactive System

67GS SENSITIVE GROUND DIRECTIONAL OVERCURRENT

Each Sensitive Ground Directional Overcurrent element can be configured as Directional or Non-Directional. Forward or Reverse looking operation depends upon the setting for the Maximum Sensitivity Angle. 60 to 70 degrees is a typical line angle for a distribution feeder.

Up to five independent Sensitive Ground Directional Overcurrent elements can be enabled, 67GS #1 through 67GS #5. Each directional element has two Angles, a Maximum Sensitivity Angle, and an Angle Band. Figure 5-43 illustrates the directional characteristic when the Angle Band is enabled. This is the umbrella characteristic and adds security to the directional decision.

The choice of polarizing voltage is positive-sequence voltage, negative-sequence voltage, zero-sequence voltage or the single phase auxiliary voltage Vz_1. Typically the zero-sequence voltage is the best choice. Vz_1 is also suitable if there is a three-phase VT with a broken delta secondary. Refer to Figure 5-54 "Broken Delta Polarizing Source".

The operate current is the single phase current input I_G. Ranges and increments are presented in Figure 5-61.

Minimum Polarization Voltage

The directional element can be selected to either trip or block trip when the polarizing voltage drops below a settable level (i.e., 2.0–10.0 percent of the nominal voltage). Use this option to prevent unwanted operation for cases such as heavy load coupled with standing system unbalance. Choose settings for reliability (trip) if the relay is located in a weak area of the power system (i.e., low magnitude residual voltage during ground faults).

Definite/Inverse Time Characteristic

Each element can be configured to operate on a Definite or an Inverse Time Overcurrent characteristic. Refer to Function 51GS, Sensitive Ground Inverse Time Overcurrent, earlier in this section, for detailed information regarding the Inverse Time Overcurrent settings.

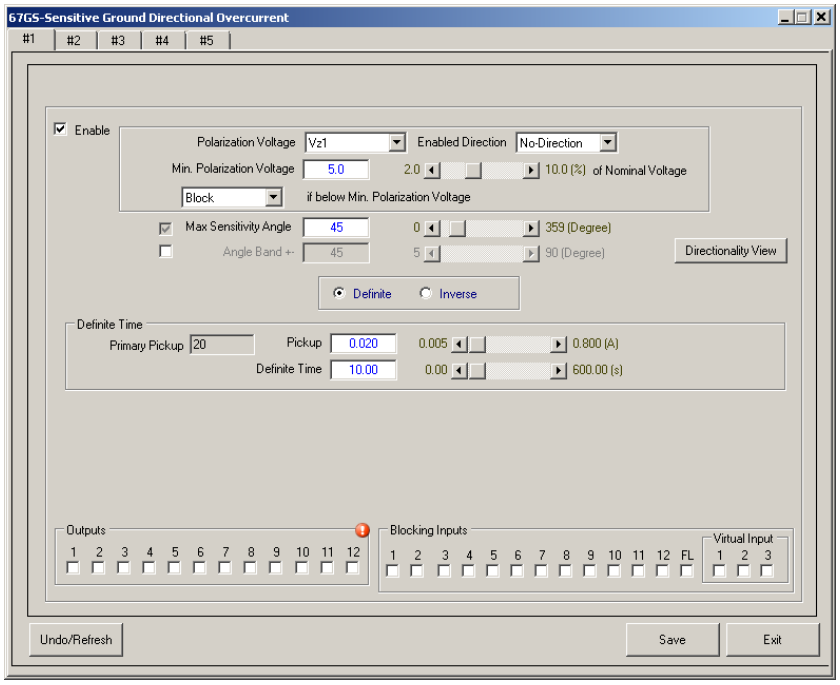


*Figure 5-61 67GS Sensitive Ground Directional Overcurrent **Definite Time** Setpoints Screen*

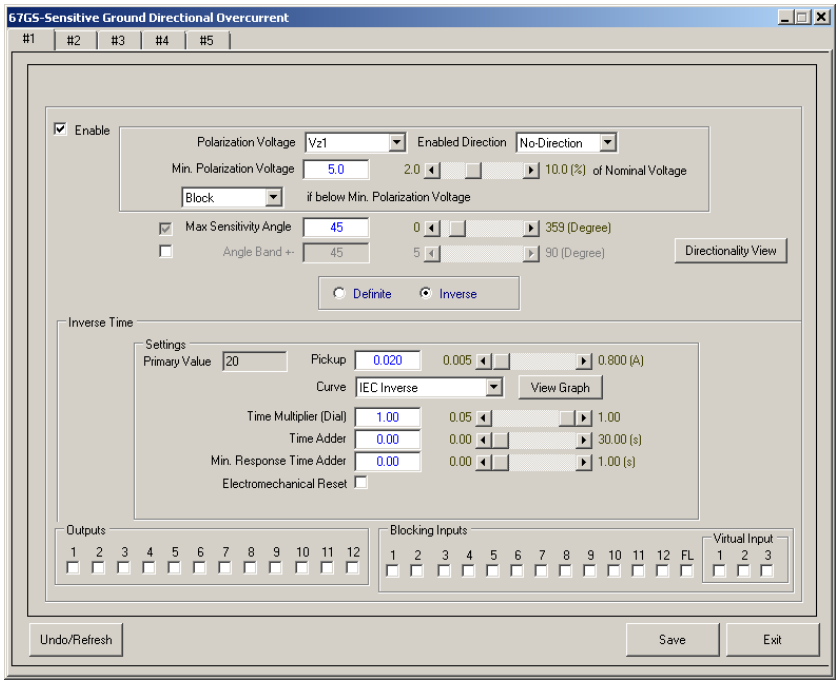


*Figure 5-62 67GS Sensitive Ground Directional Overcurrent **Inverse Time** Setpoints Screen*

81 FREQUENCY

Frequency protection (81) provides overfrequency and underfrequency protection. This function has four independent elements with their own pickup and time delay settings. The overfrequency mode is automatically selected when the frequency setpoint is programmed higher than the nominal frequency (50 or 60 Hz). The underfrequency mode is selected when the setpoint is programmed below the nominal frequency. Ranges and increments are presented in Figure 5-64. Sample settings of the 81 function are shown in Figure 5-65.

Undervoltage Block

When Undervoltage Blocking is enabled, the frequency protection is automatically disabled when the measured positive-sequence voltage is less than the pickup setting.

Minimum Load

When Minimum Load is enabled, the frequency protection is automatically disabled when the measured current is less than the pickup setting.

Hysteresis

Hysteresis makes the frequency protection more sensitive once it has picked up, as illustrated in Figure 5-63 for the case of an overfrequency operation. The effective pickup is dynamically adjusted to prevent contact chatter.

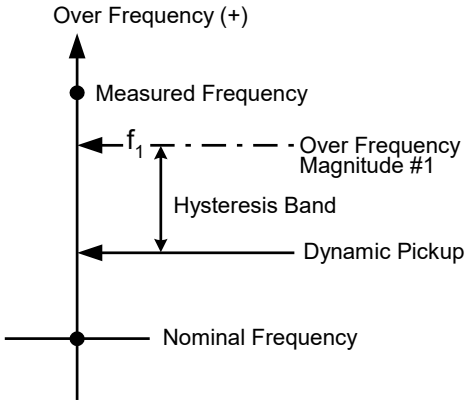


Figure 5-63 81 Hysteresis

In order to prevent mis-operation during switching transients, the time delay should be set to greater than five (5) cycles. 81 #2 through 81 #4 Screens are identical to 81 #1.

■**NOTE:** When the Auto Restoration function is enabled, select **Auto Restore** to include the 81 Frequency function in the Auto Restoration logic.

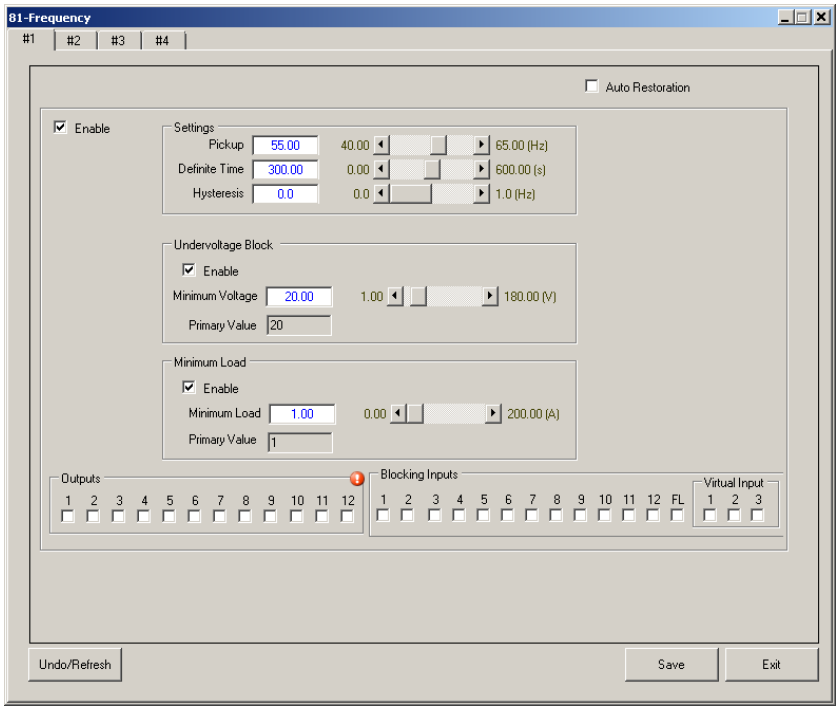


Figure 5-64 Function 81 Frequency Setpoints Screen

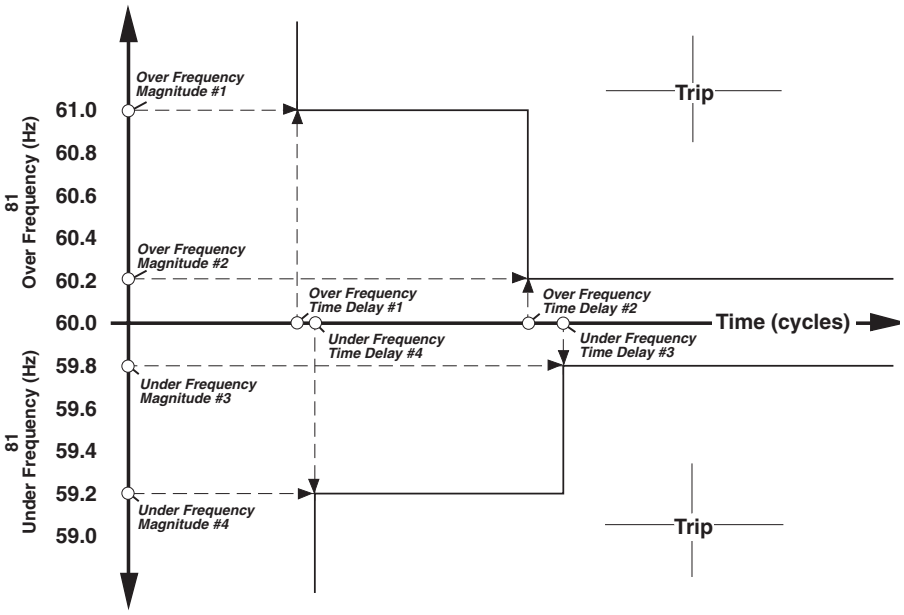


Figure 5-65 Example of (81) Frequency Trip Characteristics

81R RATE-OF-CHANGE OF FREQUENCY

The Rate-of-Change of Frequency function (81R) can be used for load shedding or tripping applications. The function is automatically disabled during unbalanced system events such as faults and other disturbances when the function detects negative-sequence voltage (2.5 V or greater). The pickup and definite time delay settings should be based on simulation studies. The ranges and increments are shown in Figure 5-66.

Minimum Voltage

The positive-sequence voltage (V_1) measured by the relay must be equal to or greater than this threshold to enable 81R.

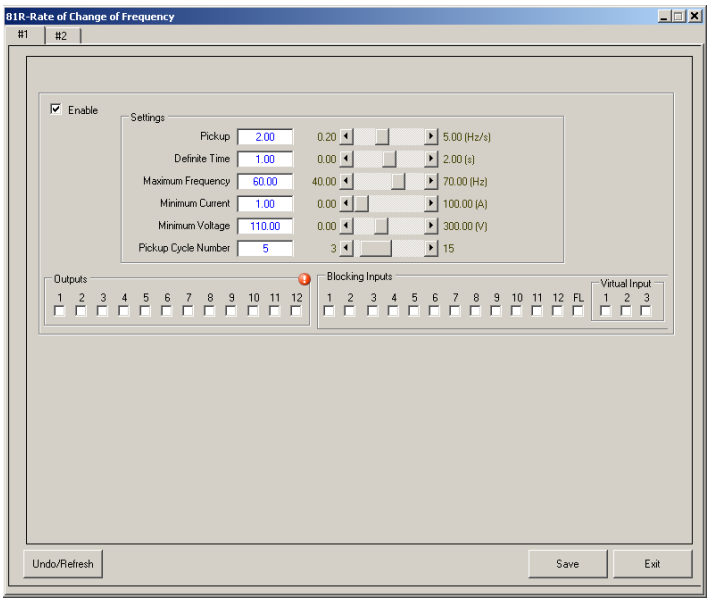


Figure 5-66 81R Rate-of-Change of Frequency Setpoints Screen

CLP COLD LOAD PICKUP – (Available when Autoreclose option is purchased)

The Cold Load Pickup Setpoints dialog screen (Figure 5-69) contains alternate settings for the 50P, 50N, 50G/GS, 51P, 51N, 51G/GS and High Current Lockout functions. These alternate settings override the existing settings of any enabled function after the relay is tripped open and the lockout condition has been active for a period greater than the user programmed period (Time Locked out to Activate Cold Load).

■**NOTE:** The Cold Load Pickup overrides the existing settings for ALL elements of 50P, 50G(GS), 50N, 51P, 51G(GS) or 51N when selected. High Current Lockout "Override Phase HCL" overrides the existing HCL settings for 50P. High Current Lockout "Override Ground/Neutral HCL" overrides the existing HCL settings for 50G(GS) or 50N.

As illustrated in Figure 5-67, I_{rst} (Percentage of the existing Minimum Trip Phase Current Setting) and I_{grst} (Percentage of the existing Minimum Trip Ground Current Setting) are the phase and ground settings below which the relay will revert to the existing settings prior to any CLP override. I_{rst} and I_{grst} comparisons are performed independently.

Pickup time is the minimum time period the measured ground current (I_g) or phase current (I_{ph}) must be less than the I_{grst} and I_{rst} settings respectively before exiting the Cold Load Pickup period. The Active Duration setting is the maximum period for the Cold Load Pickup logic. Cold Load Time is the maximum duration of the Cold Load Pickup session.

In addition, when Cold Load Pickup is in effect, all 46 and 67 functions (46DT, 46IT, 67P, 67G/GS, 67N, 67Q) are de-activated as long as the cold load condition is in effect.

Minimum Trip is defined as the minimum pickup setpoint value of all the participating overcurrent functions in Trip Sequence #1. In the example shown in Figure 5-68, for Phase current it will be the minimum pickup value for 50P#1, 51P#1, 46IT#1, 67P#4 and 67Q#2. Note sequence component is treated as a phase function. For Ground/Residual current it will be the minimum of 50N#2, 50GS#5, 51GS#4. If no overcurrent elements are selected for phase current protection, then Phase current restore evaluation is disabled. Similarly if there are no Residual and/or Ground Overcurrent functions selected, then the Ground/ Residual restore evaluation is disabled.

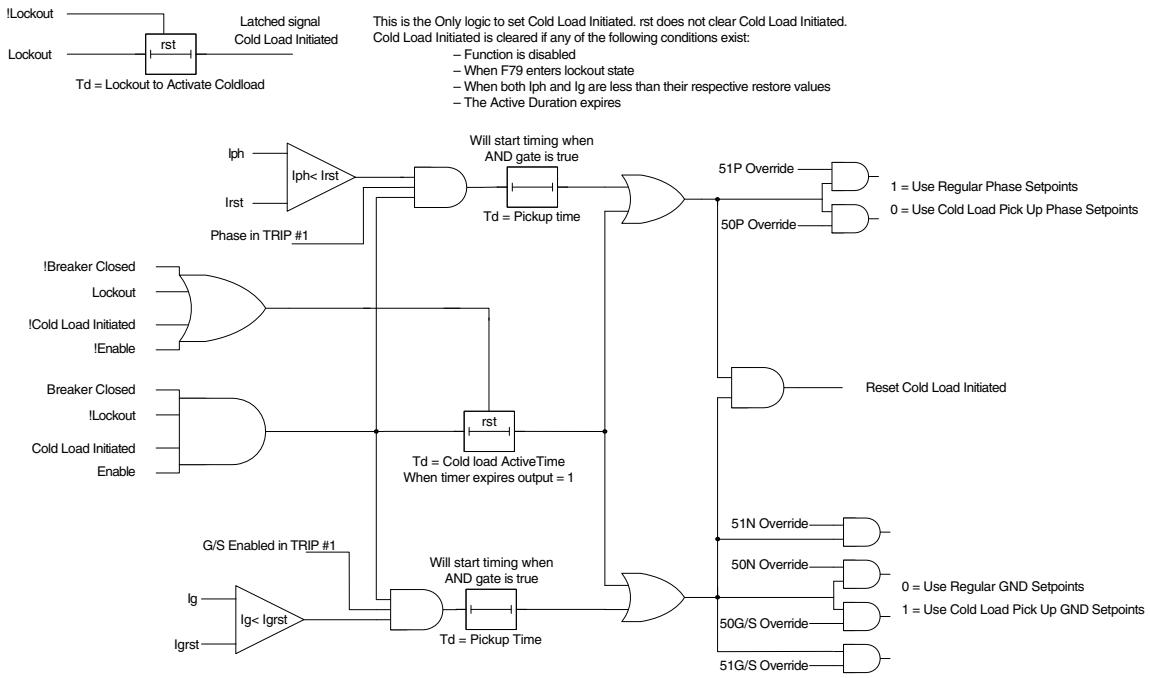


Figure 5-67 Cold Load Pickup Logic Diagram

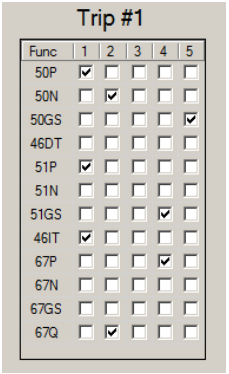


Figure 5-68 Cold Load Pickup Minimum Trip Example

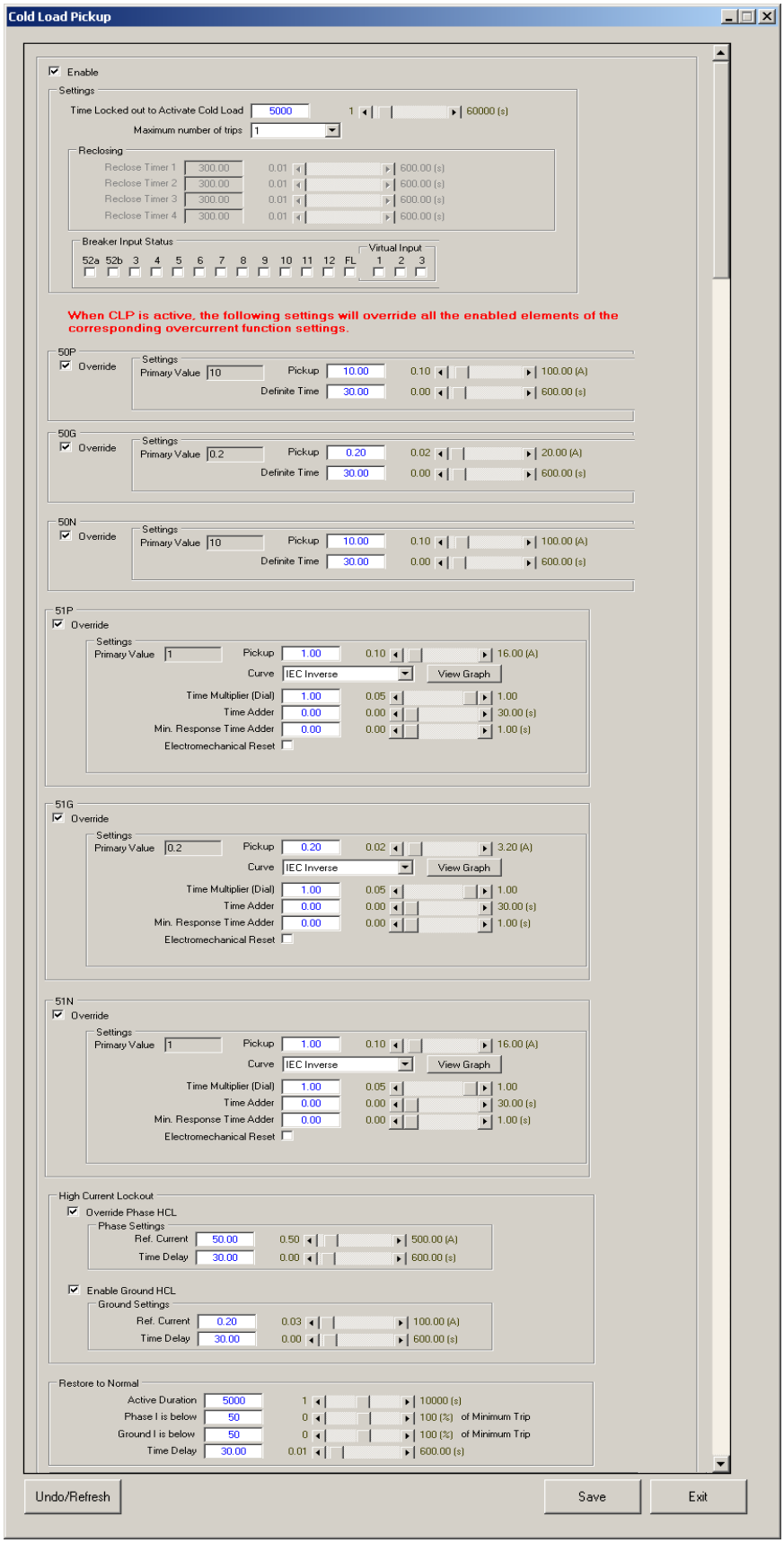


Figure 5-69 Function CLP Cold Load Pickup Setpoints Screen

RESTORE AUTO RESTORATION

The Auto Restoration feature recloses the breaker after a loadshed caused by a non-overcurrent function (under/overvoltage or under frequency). Auto Restoration will ONLY occur when the trip is caused by the user selected F27 undervoltage, F59 overvoltage and/or F81 frequency functions.

Auto Restoration is initiated when the following conditions exist:

- The function is enabled.
- The breaker has been tripped by the user selectable function 27, 59 or 81.
- No overcurrent faults occurred.

Both voltage and frequency restoration can be enabled simultaneously and can work independently of each other, or BOTH restoration conditions must exist before the load is restored (i.e., CLOSE command is issued).

When the frequency (or both the frequency AND the voltage if "Use Voltage AND Frequency Restoration Limits" is enabled) meets the restoration limits, the relay starts the Schedule Timer.

When the frequency (or both the frequency AND the voltage) no longer meets the restoration limits, the schedule timer will stop counting, but does **not** reset. The accumulated schedule time to this point is retained and when the frequency (or both the frequency AND the voltage) is back within the set limits, the Schedule Timer resumes its count.

When the Schedule Timer times out and the frequency (or both the frequency AND the voltage) meets the restoration limits for the period defined by the transient Time Delay, auto restoration is permitted and the CLOSE command issued.

The restoration attempt is abandoned if the relay is not able to successfully restore the load within the user-defined restoration Abort Time following a loadshed event. Restoration is cancelled when an external CLOSE command is received. If an External command is received when the fault is not yet cleared, the relay will close the breaker which will cause a protection function to trip again. The abort timer is reset when the CLOSE command is received. Therefore, when it trips again the abort timer will also re-start.

Auto Restoration Settings:

Mode – The undervoltage Mode can be set to either "Three-Phase" or "Single-Phase".

High Voltage Limit – The High Voltage Limit setting is a secondary value expressed in volts. The setting should be less than the lowest overvoltage pickup setting. This setting should be set at a value that the measured voltage must not exceed to allow restoration. This setting is applicable to both voltage and frequency elements.

Low Voltage Limit – The Low Voltage Limit setting is a secondary value expressed in volts. The setting should be greater than the highest undervoltage pickup setting. This setting should be set at a value that the measured voltage must exceed to allow restoration. This setting is applicable to both voltage and frequency elements.

High Frequency Limit – The setting should be less than the highest High Frequency pickup setting. This setting should be set at a value that the measured frequency must not exceed to allow restoration.

Low Frequency Limit – The setting should be greater than the lowest Low Frequency pickup setting. This setting should be set at a value that the measured frequency must exceed to allow restoration.

Schedule Time – The setting in seconds, delays the restoration. If an instantaneous restoration is desired, then a setting of zero should be entered. This setting is applicable to both voltage and frequency elements. When a restoration is authorized and the Schedule Timer begins timing, if the restoration is rescinded then the timing of the Schedule Timer will halt and resume from that point when restoration is re-started.

Abort Time – The Abort Time setting is the time period (seconds) that the relay will abandon the restoration attempt if the restoration has not been completed within the Schedule Time. This setting is applicable to both voltage and frequency elements.

Time Delay – The Time Delay setting is the time period that the measured voltage and/or frequency must be within the High and Low Voltage and High and Low Frequency settings to authorize a restoration sequence.

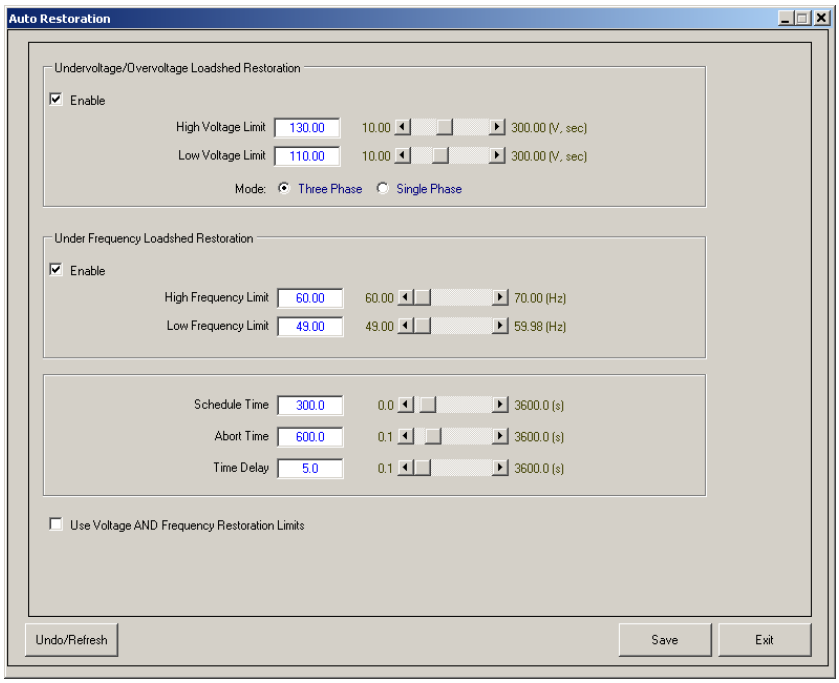


Figure 5-70 Auto Restoration Setpoints Screen

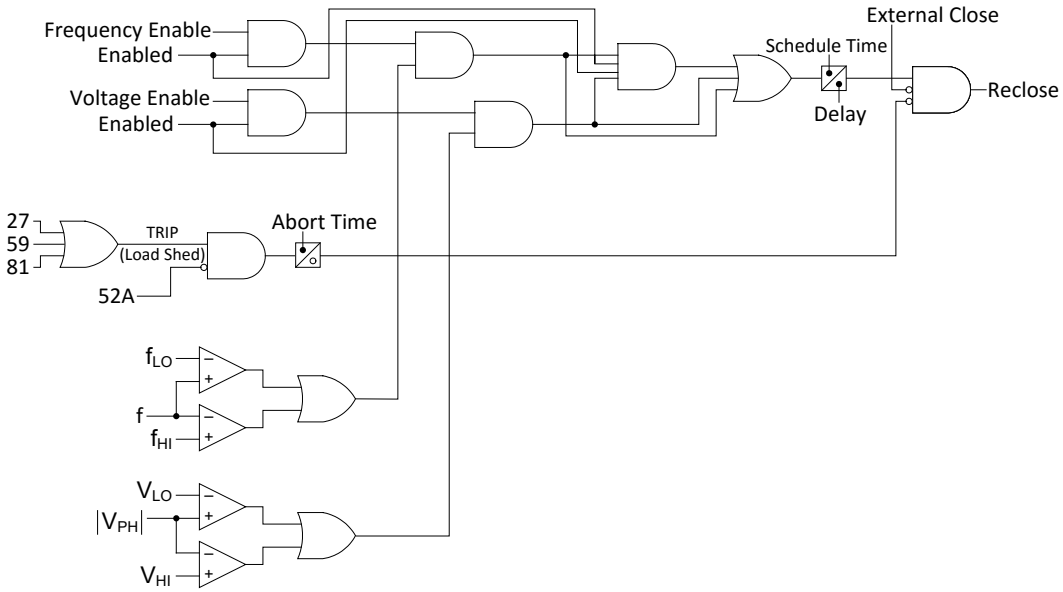


Figure 5-71 Auto Restoration Conceptual Logic Diagram

HLT MM HOT LINE TAG/Maintenance Mode

Hot Line Tag/Maintenance Mode settings are evaluated as protection elements. The Hot Line Tag/Maintenance Mode elements include 50P, 51P, 50G/GS and 51G/GS. The HLT/MM function will Trip AND Lockout.

The Hot Line Tag/Maintenance Mode may be activated by the front panel pushbutton, an input contact, or a communication point. When the relay is put into Hot Line Tag/Maintenance Mode, the following occurs:

- Upon any TRIP command, the relay will drive to LOCKOUT, only when the Autoreclose Option is purchased.
- A TRIP command will trip all 3 phases.
- All CLOSE commands are blocked, regardless of whether theAutoreclose Option is purchased.
- The Hot Line Tag/Maint LED illuminates.
- The Reclose Disable LED illuminates.
- HLT/MM Pickup and Timeout status are stored in the Sequence of Events.
- HLT/MM Pickup and Timeout are available as triggers for the Sequence of Events and Oscillograph.
- HLT/MM status is available in IPSlogic and communication point.

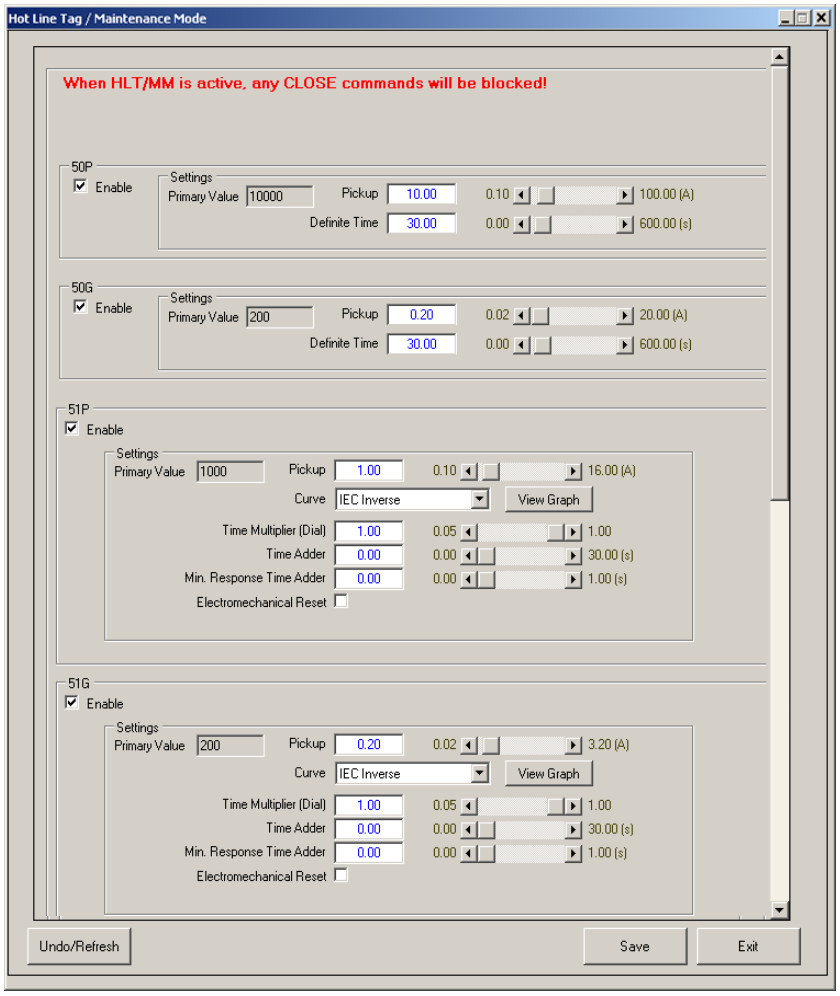


Figure 5-72 HLT MM – Hot Line Tag/Maintenance Mode Setpoints Screen

IPSlogic

The relay provides eight logic functions and associated IPSlogic. These functions can be used in conjunction with IPSlogic to expand the capability of the unit by allowing the user to define customized operating logic.

The IPSlogic Function can be programmed to perform any or all of the following tasks:

- Change the Active Setting Profile
- Activate Hot Line Tag
- Trip/Lockout All Phases, Phase A, Phase B or Phase C
- Activate a front panel HMI Custom Message
- Close an Output Contact
- Be assigned as a Virtual Input

Since there are eight IPSlogic Functions per setting profile, depending on the number of different relay settings defined, the scheme may provide up to 64 different logic schemes.

IPSlogic Setpoints

To setup the IPSlogic Setpoints perform the following:

1. From the IPScom Main Menu, select **Setup/Setpoints** or select the Setpoints icon from the quick access toolbar. IPScom will display the Setpoints dialog screen (Figure 5-3).
2. Select **IPS–IPSlogic**. IPScom will display the "IPSlogic Setpoints" dialog screen (Figure 5-73).
3. Assign the Time Delay, Virtual IPSlogic Outputs, Outputs, Blocking Inputs and Virtual Inputs as desired.

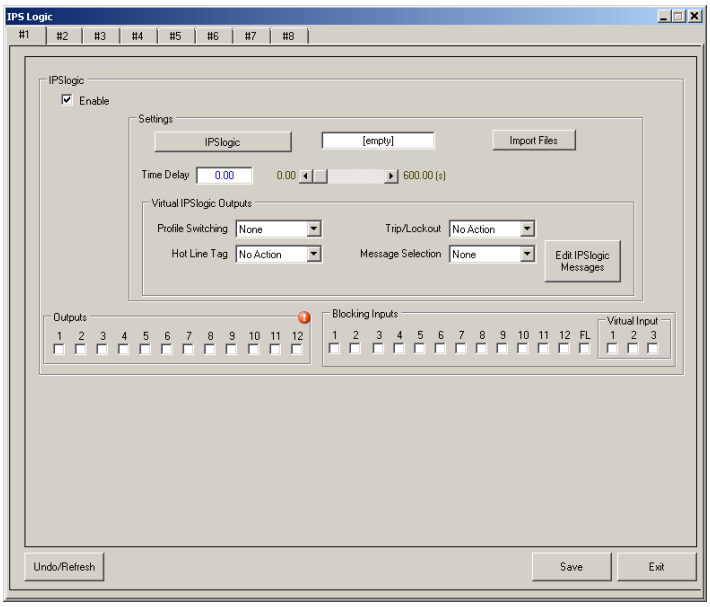


Figure 5-73 IPSlogic Setpoints Screen

IPSlogic Custom Messages

IPSlogic allows the user to setup Custom Messages to be displayed on the HMI at the top level main screen (where user lines and alarms are displayed).

The order in which the messages are displayed is as follows:

- Display Alarms
- Display sequential Custom Messages, or User Lines when the Custom Messages buffer is empty.

There are 8 Custom Messages available from IPSlogic. Each message can have two lines. The 8 Custom Messages are shared among all 8 profiles.

Select the **Edit IPSlogic Messages** box to display Figure 5-74 which allows the user to edit the Custom Message text.

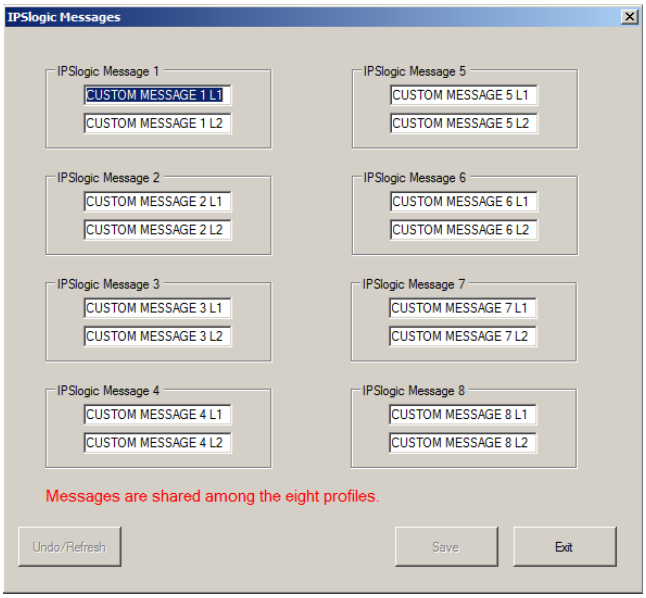


Figure 5-74 Edit IPSlogic Messages Dialog Screen

Programming IPSlogic

▲**CAUTION:** Logic feedback is prohibited unless a **LATCH** gate has been used in the logic. Use of feedback ***without*** a LATCH gate can produce unpredictable results.

1. From the IPSlogic Setpoints dialog screen, select **IPSlogic**. IPScom will activate the IPSlogic Editor Screen (Figure 5-75) which provides an interactive worksheet for programming the desired IPSlogic.
2. Use the various elements of the IPSlogic Editor interactive worksheet to program the IPSlogic.

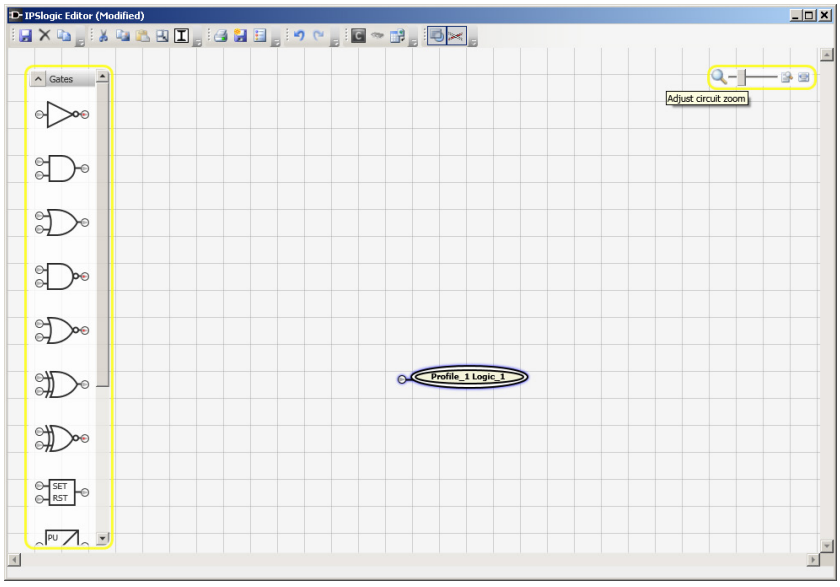


Figure 5-75 IPSlogic Editor Screen

IPSlogic Editor Main Toolbar

Hovering the mouse over the Main Toolbar icons will display a tooltip and keyboard shortcut (if applicable). Refer to the following diagram for icon definitions (Figure 5-76).

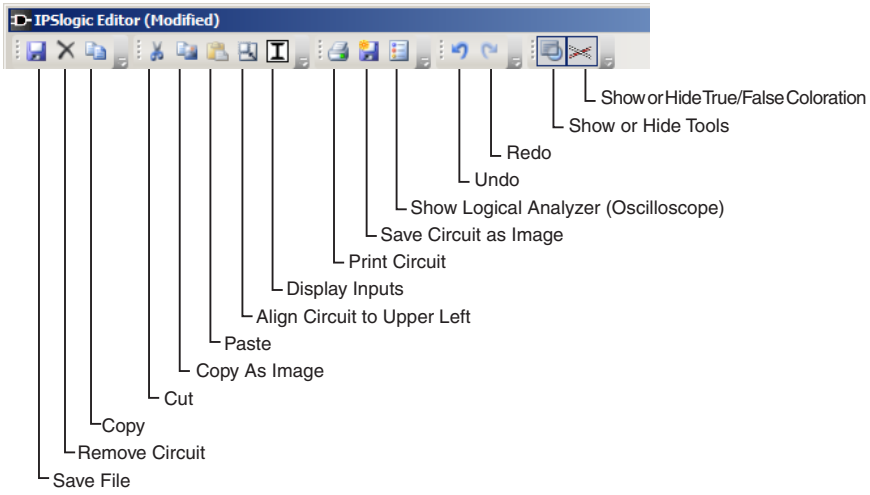


Figure 5-76 IPSlogic Editor Main Toolbar Icons Diagram

Add Inputs

Select the "Display Inputs" icon from the IPSlogic Editor toolbar to display the Input Selection dialog screen (Figure 5-77). Use this tool to filter, select and insert inputs onto the worksheet.

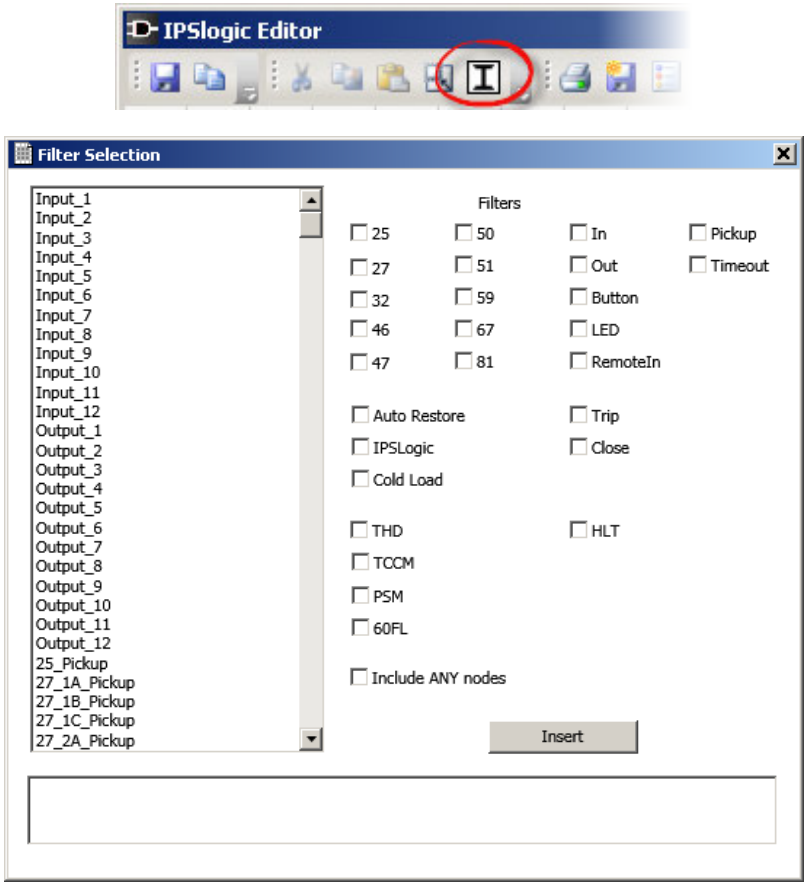


Figure 5-77 IPSlogic Editor Input Selection Dialog Screen

Add Logic Gates

Use the "Gates" tool to drag and drop logic gates onto the worksheet. Hovering over a Gate will display a Tooltip with the Gate description.

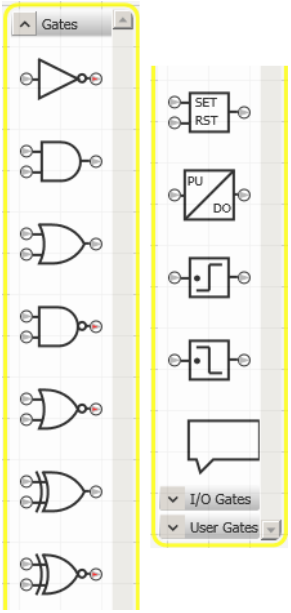


Figure 5-78 IPSlogic Editor "Gates" Tool

Show Logical Analyzer (Oscilloscope)

Use this tool to display the Oscilloscope for the currently selected IPSlogic circuit.

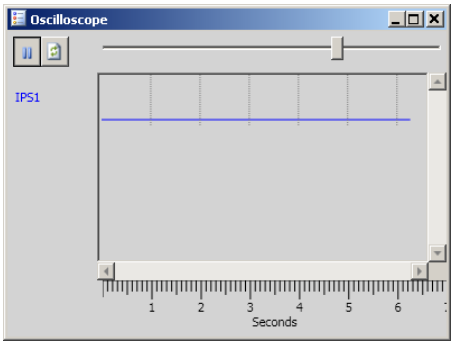


Figure 5-79 IPSlogic Editor Oscilloscope Tool

LEL LOAD ENCROACHMENT LOGIC

Load encroachment logic (LEL) is a built in logic that when enabled, will supervise the 51P Time Overcurrent elements. Select **Use LEL** from the 51P Setpoints dialog screen to enable LEL supervision as defined in the LEL Setpoints dialog screen (Figure 5-81). When Supervision Output is "false", all enabled 51P functions with "Use LEL" selected are effectively deactivated.

The Directional Element is provided by one of the 67P functions. Positive Sequence Voltage and Current are used to calculate the impedance.

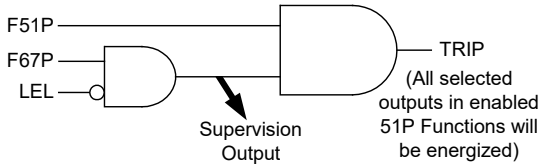


Figure 5-80 Load Encroachment Logic Diagram

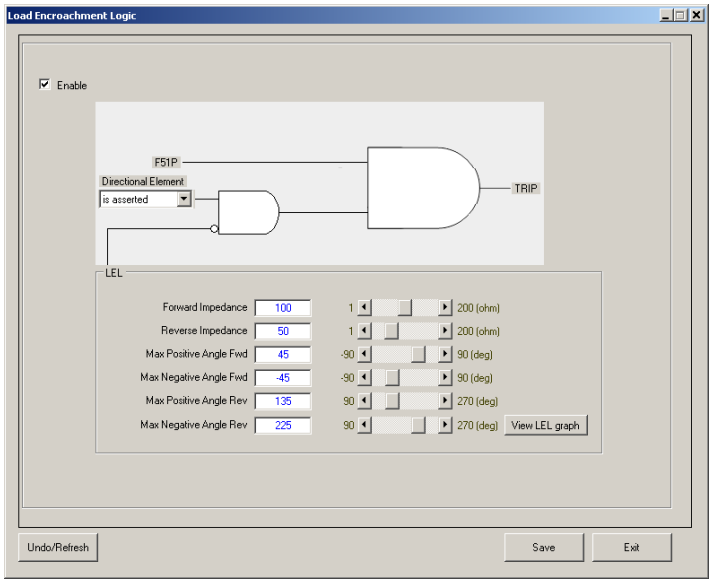


Figure 5-81 Load Encroachment Logic Setpoints Screen

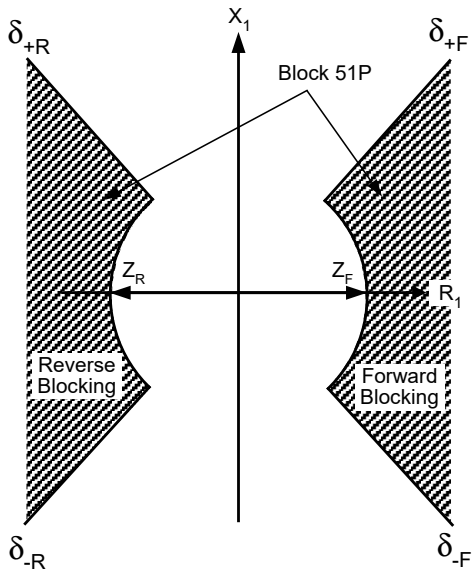


Figure 5-82 Load Encroachment Logic Application

Load Encroachment Logic Graph

Select **View LEL Graph** from the Load Encroachment Logic Setpoints dialog screen to display a graphical representation of the LEL settings (Figure 5-83).

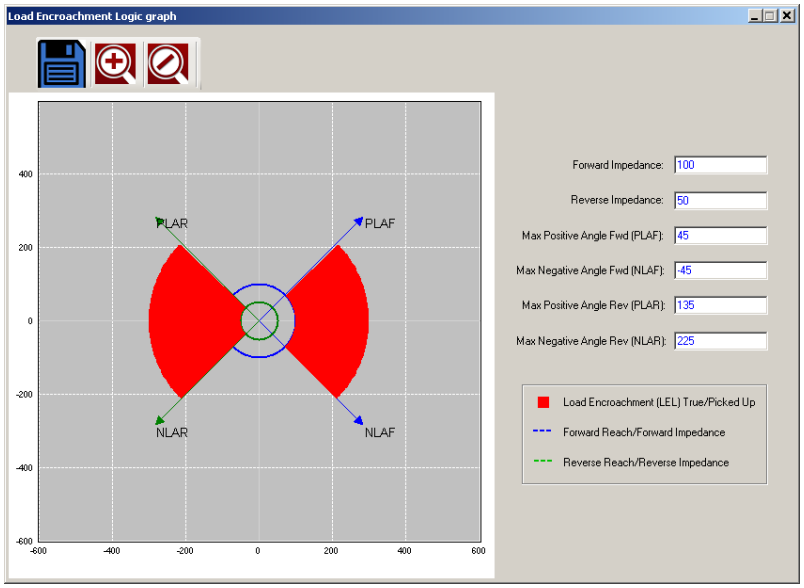


Figure 5-83 Load Encroachment Logic Graph

LEL Directional Element F67

The LEL Directional Element setting selects which F67 Element is to be used to detect directionality. When "is asserted" is selected, this means that no directionality exists for the supervision gate.

When one directional element is chosen, the corresponding F67 function is not available for other protective functionality.

As shown in the following example, the Directional Element "is from F67P #1" (Figure 5-84) is selected. The corresponding F67P #1 Setpoints dialog screen (Figure 5-85) will reflect the following restrictions and behavior:

- F67#1 is automatically enabled.
- Outputs and Blocking Inputs have all the checkboxes unchecked and grayed out to avoid accidental user selection.
- The "Action if below" setting is "Block Trip" and grayed out.
- Definite Time is zero and Curve Selection Option is Definite Time by default.
- Enabled Direction is set to directional and grayed out.

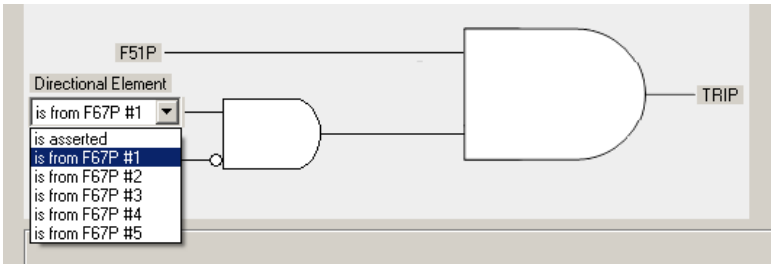


Figure 5-84 LEL Directional Element F67P #1 Selected

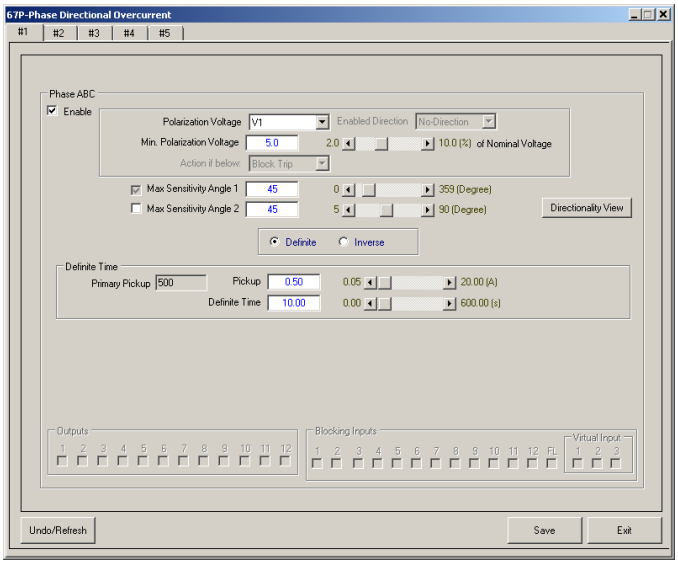


Figure 5-85 LEL Directional Element F67P #1 Resultant Setpoints Screen

BM BREAKER MONITOR

The relay records the amount of current carried in each phase each time the breaker trips. The relay's operational logic employs an algorithm integrating the amount of unfiltered AC current at the time of each trip and the number of operations (close to open) as a method of calculating wear. The control uses this information to establish wear setpoints derived in accordance with ANSI C37.61-1973, and initiates a signal to assert an alarm or modify the recloser operation parameters, such as reducing the total number of reclose operations.

The Breaker Monitor feature calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current through the breaker contacts as an arc. The pickup value ($kA^{1.5}$, kA, kA^2 cycles) is based on the Timing Selection Method chosen in the Breaker Accumulator Status window. The per-phase values are added to an accumulated total for each phase, and then compared to a user-programmed threshold value. When the threshold is exceeded in any phase, the relay can set a programmable output contact.

The accumulated value for each phase can be displayed. The Breaker Monitoring feature requires an initiating contact to begin accumulation, and the accumulation begins after the set time delay.

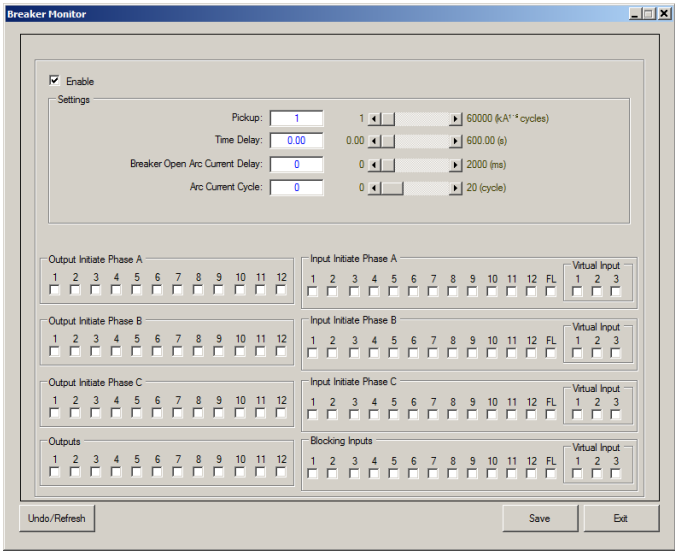


Figure 5-86 Breaker Monitor Setpoints Screen

Breaker Accumulator Status – Monitor Submenu

When the Breaker Monitor function is enabled, the Breaker Accumulator Status screen (Figure 5-88) will display the Accumulator Status based on the Breaker Monitor Timing selection of the active profile. Preset Accumulator values for each phase may also be set.

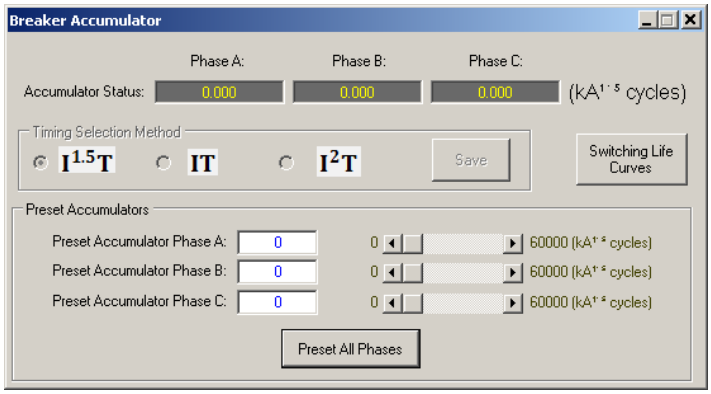


Figure 5-87 Breaker Accumulator Status Screen

Breaker Accumulator – Switching Life Curves Graph

There are three Switching Life Curves, which are depicted in (Figure 5-88):

- Meiden S-M72QCA
- Cutler-Hammer WL-35460
- Custom Curve – corresponds to Custom Curve 4 in the Custom Curve Editor

■NOTE: The Y-axis in Switching Life Curves cannot have decimal values, but the custom curve allows decimal values. Therefore, IPScom will round off the decimal values. As a result, there may be a very minute difference between the actual Custom Curve and the Switching Life Custom Curve.

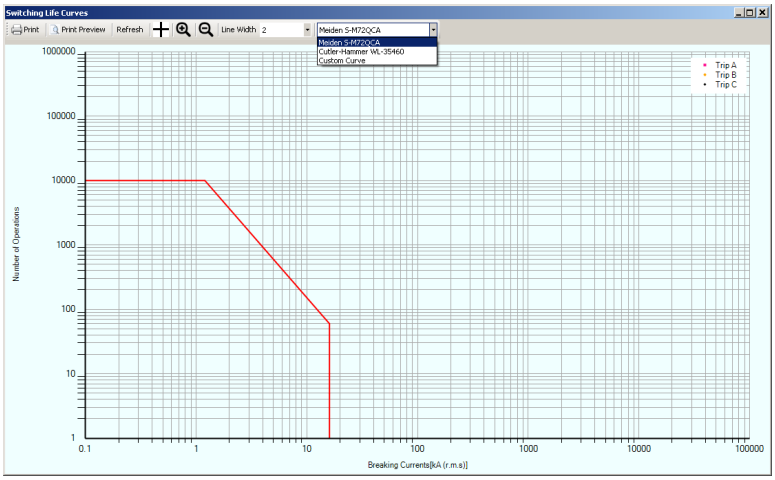


Figure 5-88 Breaker Accumulator – Switching Life Curves Graph

5.2 Common Setpoints

The following setpoints are NOT part of the individual profile. These are independent setpoints common to all profiles. These setpoints are located in the "Common Setpoints" tab of the Setpoints dialog screen.

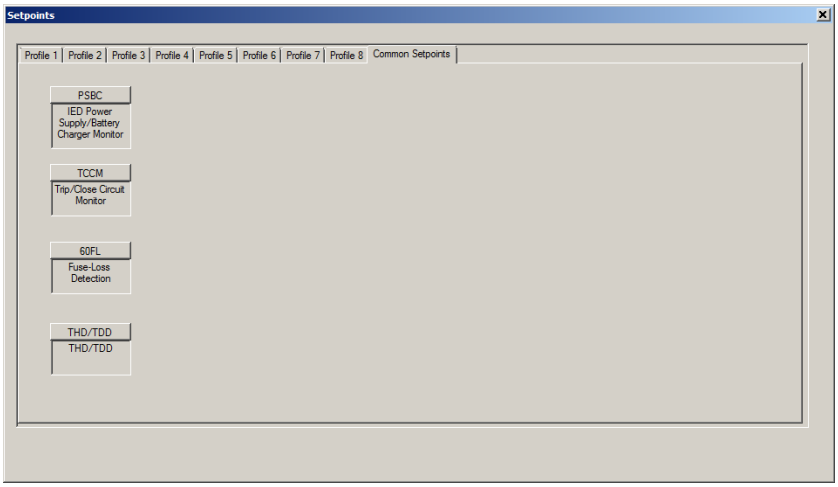


Figure 5-89 Common Setpoints Screen

PSBC IED POWER SUPPLY/BATTERY CHARGER MONITOR

IED Power Supply Monitor

The Power Supply Monitor alarms on delay when the input voltage to the Power Supply is too high or too low. Table 5-3 lists the setting ranges.

■**NOTE:** The measured Power Supply Voltage is an internal signal produced by the internal power supply of the unit.

Power Supply	Low Voltage	High Voltage
Low Voltage DC	18.0 – 60.0 Volts	18.0 – 100.0 Volts
High Voltage DC	60.0 – 250.0 Volts	60.0 – 315.0 Volts
High Voltage AC	60.0 – 250.0 Volts	60.0 – 280.0 Volts

Table 5-3 Power Supply Monitor Voltage Setting Ranges

Battery Charger Monitor

Select the installed Battery Charger Model from the dropdown list:

- M-2032A
- G & W VRC
- BECO Drive (M-2034)
- M-2032A-SF6 Contact
- M-2032A-SF6 Voltage
- BECO Drive (M-2034)-SF6 Contact
- BECO Drive (M-2034)-SF6 Voltage

The Battery Charger Monitor function must be enabled to access the IPScom "Battery Charger Monitoring" screen in the Monitor menu. The Monitoring parameters are determined by the selected Battery Charger Model.

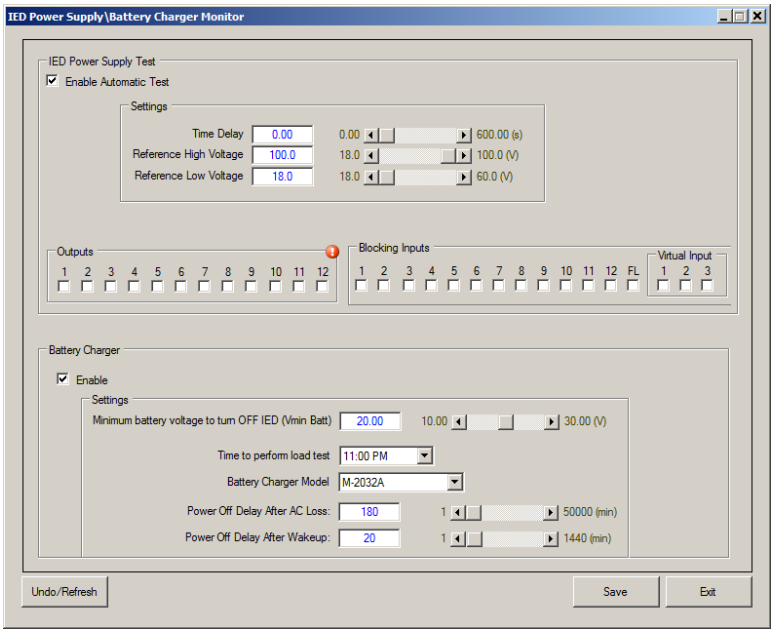


Figure 5-90 PSBC – IED Power Supply/Battery Charger Monitor Setpoints Screen

TCCM TRIP/CLOSE CIRCUIT MONITORING

Trip Circuit Monitor

The physical connections for this circuit are shown in Figure 5-92. A selectable opto-isolated input monitors the dc trickle current flowing through the trip circuit. If the trip coil fails as an open circuit, then continuity is interrupted. An alarm occurs when there is no dc trickle current and the breaker is closed. If a trip occurs or the breaker is open, then the monitoring is disabled.

■**NOTE:** The input selected for Trip Coil Monitor should be configured when the active state is Open.

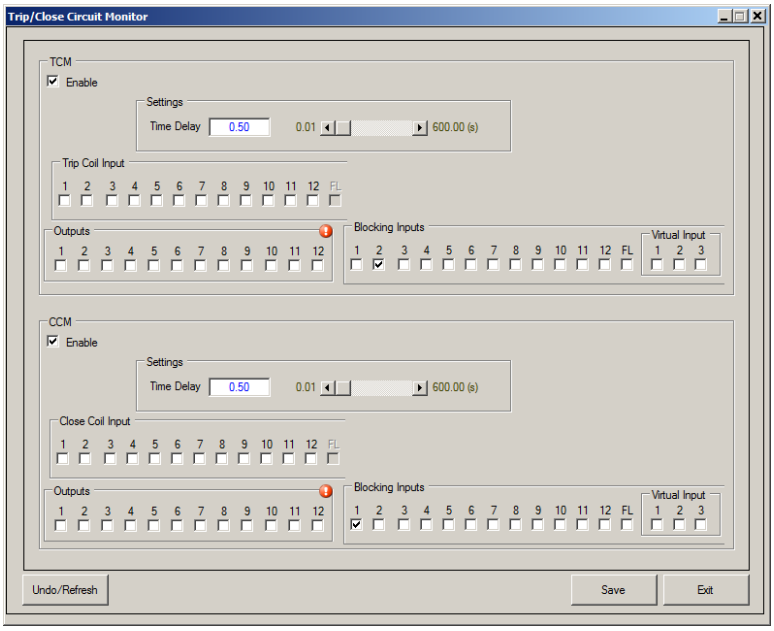


Figure 5-91 TCM/CCM – Trip/Close Circuit Monitor Setpoints Screen

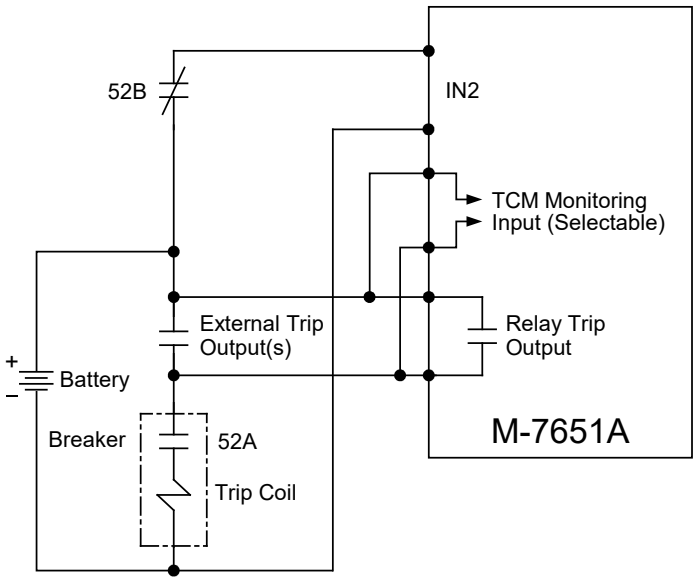


Figure 5-92 Trip Circuit Monitoring Input

Close Circuit Monitor

Figure 5-91 displays the settings for the CCM function.

The CCM inputs are provided for monitoring the continuity of the close circuits. Close circuit monitoring is performed in the active breaker status only. Both the DC supply and continuity for the close circuit is monitored. If a close coil is detected as being open for the time delay then transfers are blocked.

This function is blocked when the breaker is open, as indicated by 52b Contact Input. If the CCM is monitoring a lockout relay, a 86 Contact Input should be used to block when the lockout relay is tripped. This function is also blocked when any output contact is closed.

The output of the Close Circuit Monitoring function can be programmed as an alarm to alert maintenance personnel.

CCM Connection Considerations

External connections for the Close Circuit Monitoring function are shown in Figure 5-93 and Figure 5-94. Beckwith Electric Co., Inc. recommends that the M-7651A D-PAC CCM circuit be connected directly to the close coil, bypassing the anti-pump "Y" relay portion of the close circuit as illustrated in Figure 5-93.

The type of anti-pump "Y" relay that is often found within the close coil circuit is generally a high impedance type, such as an IDEC RR Series Power Relay. The relay coil resistance is high (approximately 8.5 to 10K Ohms), and it's rated pickup current is 11 to 13 mA, ±15% at 20° C. However, the relay's dropout voltage is approximately 10 to 15% of rated 110 Vdc voltage. Therefore, the anti-pump relay may be held up and would not drop out until the leakage current is reduced to approximately 2 mA.

▲CAUTION: Connecting the M-7651A D-PAC Close Coil Monitor (CCM) in parallel with other relay CCMs in the close coil circuit where the anti-pump "Y" relay is not bypassed may not provide reliable breaker closing operations.

If the close coil circuit configuration does not support connecting the CCM directly to the close coil (Figure 5-94), then Beckwith Electric Co., Inc. does not recommend connecting the M-7651A D-PAC CCM in parallel with other relay CCMs. If two or more CCMs are connected to the close coil circuit, there is a high probability that the anti-pump "Y" coil will not drop out. Therefore, only one CCM, either a M-7651A D-PAC or other relay should be used in the close coil circuit to provide reliable breaker closing operation.

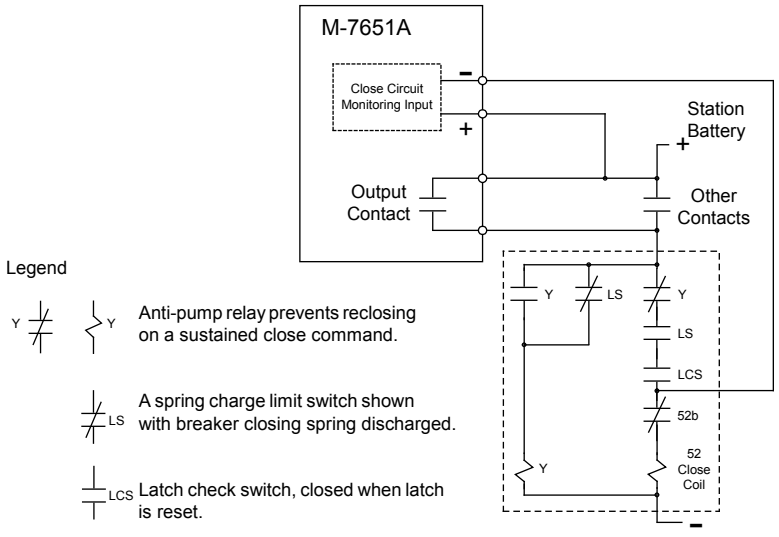


Figure 5-93 Recommended Close Circuit Monitoring Input Configuration

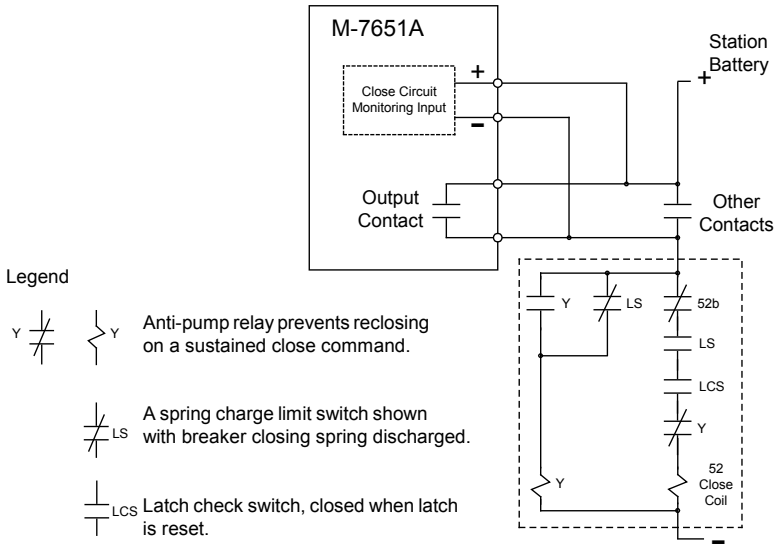


Figure 5-94 Close Circuit Monitoring Input Configuration with Anti-pump Relay Not Bypassed

60FL VT FUSE LOSS

Some functions may operate inadvertently when a VT fuse is blown or an event causes a loss of one, two, or all three potentials to the relay. Provisions are incorporated for both internal and external potential loss detection and blocking of user defined functions. The logic scheme and options are illustrated in Figure 5-95.

Internal Fuse Loss Detection Logic

The internal logic scheme available will detect a loss of one, two, or all three potentials.

For the loss of one or two potentials, positive and negative-sequence quantities are compared. The presence of negative-sequence voltage in the absence of negative-sequence current is considered to be a fuse loss condition. An additional supervising condition includes a minimum positive-sequence voltage to assure voltage is being applied to the relay.

For the loss of all three phase potentials, a comparison of the three-phase voltage is made to the three-phase current. If all three potentials are less than 0.05 V_{nom}, all three currents are less than 1.25 I_{nom}, and I_1 is greater than 0.33A, then a three-phase loss of potential is declared. A seal-in circuit is provided to ensure a three-phase fuse loss condition is not declared during a three-phase fault if the fault current should decay below 1.25 I_{nom}.

Protection functions in the relay may be blocked by assertion of the fuse failure logic (FL), in each function's respective setting screen. Typical functions to block on a loss of potential event are 27, 32, 59, 67, 79 and 81.

60FL is enabled to alarm. The internal FL logic is always enabled and available to block selected protection functions.

A frequency check element is included in the fuse loss detection logic to avoid erroneous alarms. The 60FL alarm will be inhibited if the measured frequency is greater than 55.12 Hz (F_U) or less than 44.88 Hz (F_L) for a 50 Hz system. The 60FL alarm will be inhibited if the measured frequency is greater than 65.12 Hz (F_U) or less than 54.88 Hz (F_L) for a 60 Hz system. The Frequency Band Detector does not inhibit the 60FL three-phase loss of potential logic since it is not possible to calculate the frequency during this condition.

External Fuse-Loss Function

For the specific application where the preceding logic cannot be considered reliable (such as when current inputs to the relay are not connected, or sustained positive-sequence current during fault conditions is minimal), an external fuse failure function can be used as an input to the relay. The external 60FL function contact is connected across any control/status input. The relay protection functions are then blocked by an assertion of the control/status input (INx), as a blocking function in each function's respective setting screen.

■**NOTE:** 60FL must be enabled if "FL" is used as a blocking input for any of the protection functions.

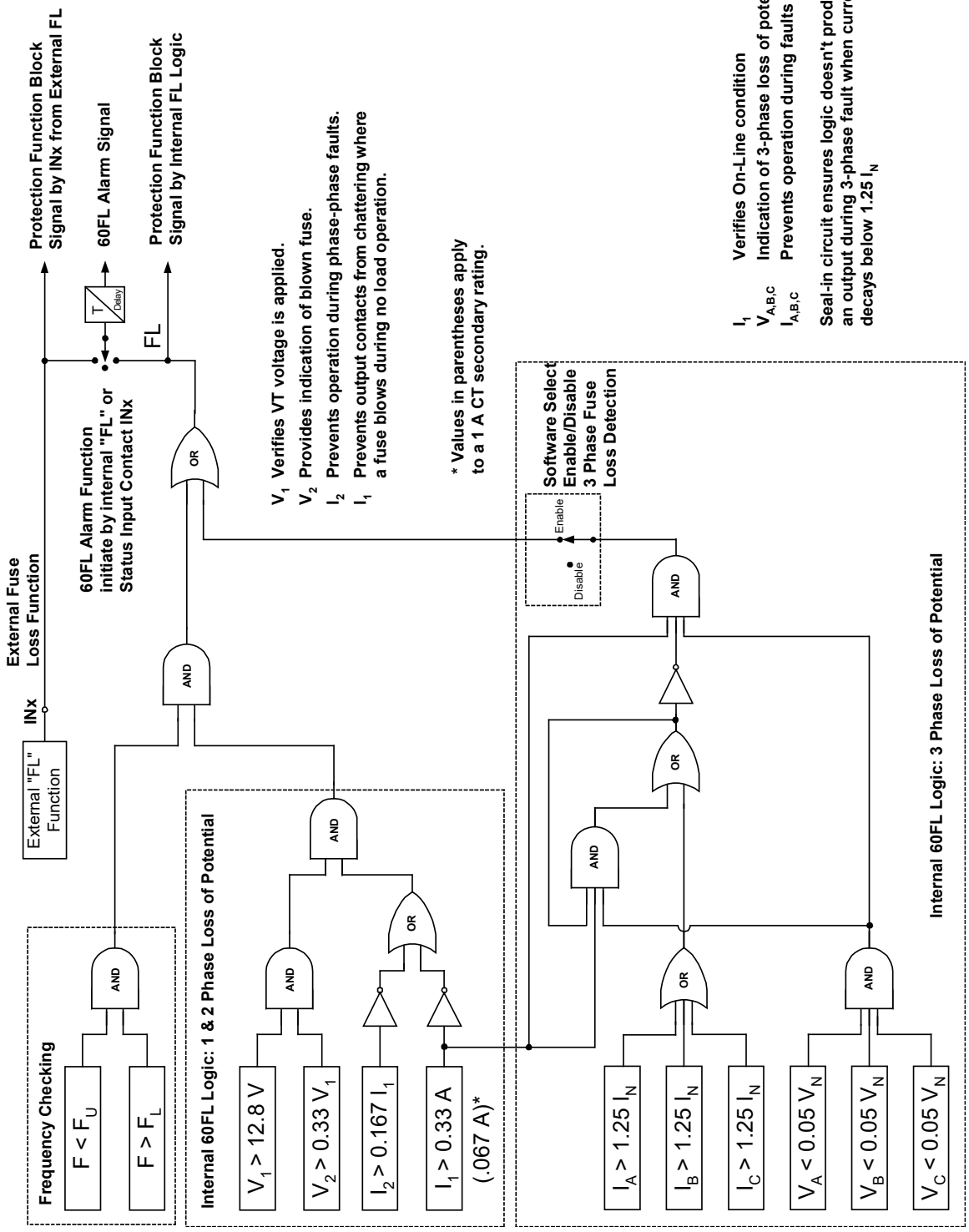


Figure 5-95 Fuse Loss (60FL) Function Logic

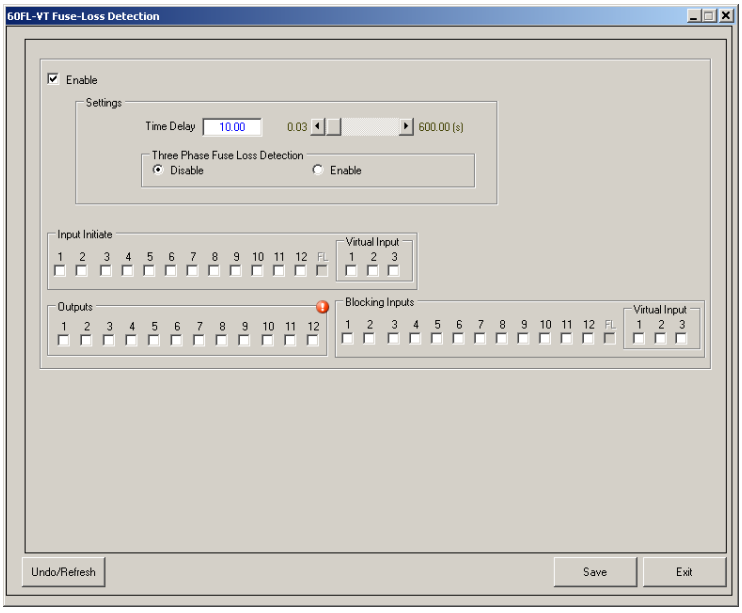


Figure 5-96 Function 60FL Fuse Loss Setpoints Screen

THD/TDD TOTAL HARMONIC DISTORTION/TOTAL DEMAND DISTORTION

The THD/TDD feature consists of two setpoints that can be used for alarm or tripping. Selecting THD or TDD will apply the selection to the entire element even when Individual Phase is enabled. For example, Element #1 can use TDD and Element #2 can operate on THD or both elements can use TDD or THD. When Individual Phase is enabled in an element the TDD or THD selection will apply to all three phases.

THD/TDD includes the ability to trigger the Sequence of Events recorder (when selected), trigger the Oscillograph (when selected), and display alarm messages on the HMI. The THD setting can be selected to either Current or Voltage, while the TDD setting is only available in Current. Also, individual phases may be selected. The TDD value is also displayed in the SOE viewer and Harmonics display and also can be used as a Smart Button function block.

THD calculation

$$V\ THD = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2 + \ldots.}}{V_1} X\ 100\ \%$$

$$I\ THD = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots.}}{I_1} X\ 100\ \%$$

TDD calculation

$$I\ TDD = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + I_5^2 + \ldots.}}{I_L} X\ 100$$

Where I_L is the Maximum Demand Load Current which is a user programmable setting in the **Demand Metering** screen (Figure 5-97). Only the Total Demand Distortion for current will be calculated for each phase.

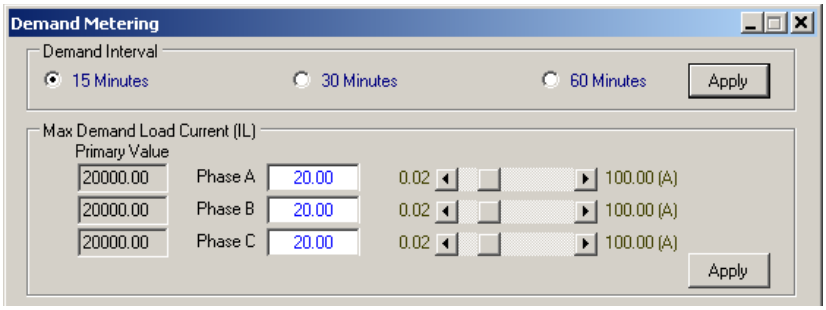


Figure 5-97 Demand Metering Screen (I_L Section)

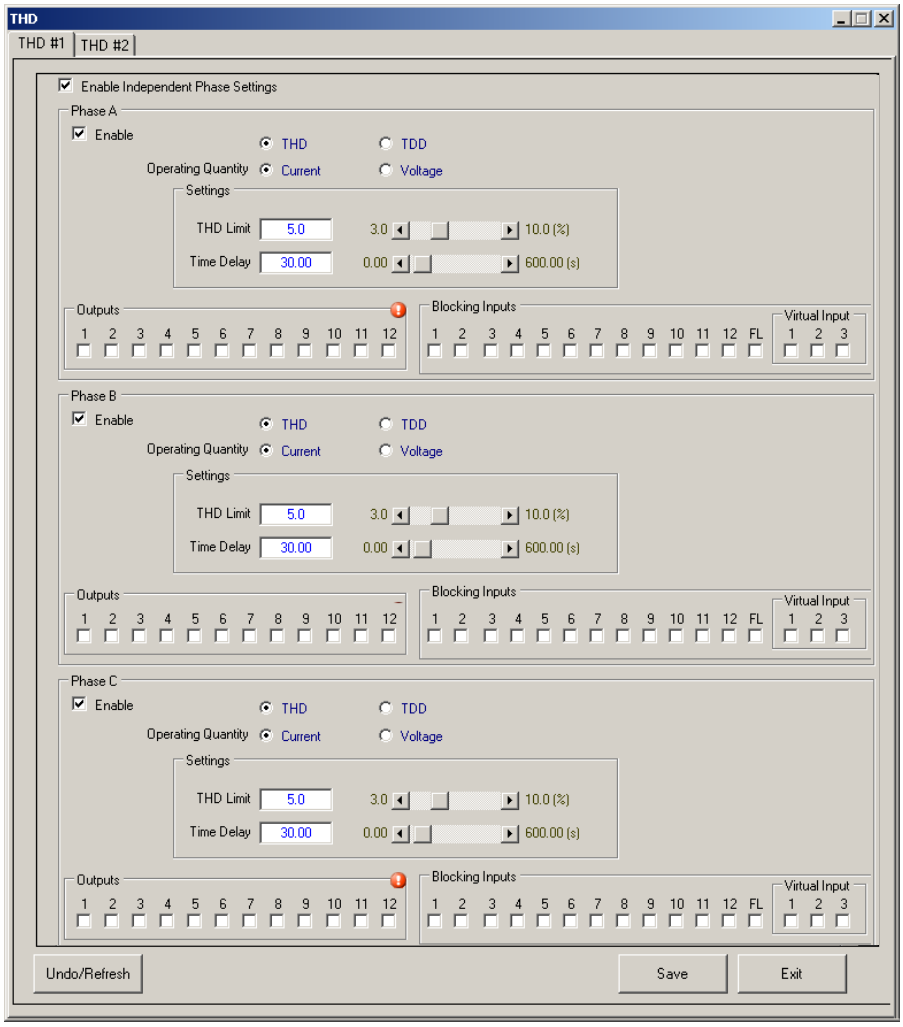


Figure 5-98 THD/TDD Setpoints Screen with Independent Phase Enabled

5.3 79 Recloser Relay

■**NOTE:** This Function is available when the Autoreclose option is purchased.

TRIP AND CLOSE LOGIC

The breaker is tripped independently by any protective function. The 79 Automatic Reclose function is executed every quarter of a cycle after all the enabled protective functions have been executed at least once. The algorithm of the 79 Reclose function is state machine driven. The state machine consists of 12 states distributed within the 4 states outlined in the the IEEE C37.104 [1] standard. Each state is run after the occurrence of a specific event.

As cited from the IEEE C37.104 standard [1], the four states are:

"**Reset State** – the circuit breaker is closed and the auto reclose function is waiting to receive an initiate to start timing to reclose after the breaker opens."

"**Cycle State** – the circuit breaker is open and the auto reclose function is timing toward its set time to close the circuit breaker, OR, the circuit breaker is closed following a successful auto reclose, timing toward its set time to return to the reset state."

"**Lockout State** – the auto reclosing function has advanced through its programmed or set sequence of circuit breaker close operations, and in each case the protective relay has detected a fault and tripped the circuit breaker open again. The circuit breaker is now open and "locked out", meaning that the circuit breaker must now be closed by some other means (local-manual or remote manual)."

"**Power-Up State** – **may** be used in some auto reclosing relays when the relay is powered up. In this state the auto reclose relay assesses its inputs to determine the state of the breaker and the auto reclose initiate and supervision inputs. After assessing these inputs, the auto reclose relay typically changes to the Reset State if the breaker is closed and no other inputs are active, or to the Lockout State if the breaker is open or if drive-to-lockout inputs are active."

Figure 5-99 shows the transition state diagram of the recloser.

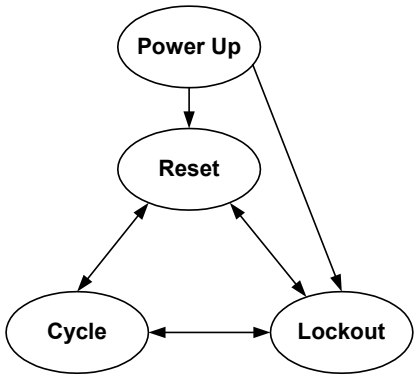


Figure 5-99 Recloser Transition State Diagram

79 Lockout Feature

Prior to entering any state in the state machine (meaning this is executed ahead of every state); the selected functions in the 79 Drive To Lockout are evaluated. The 79 Drive To Lockout functions selection is shown in Figure 5-100.

If the 79 Drive To Lockout detects any lockout condition (any one of the functions selected in the "79 Drive To Lockout" dialog screen has tripped) then the recloser state is set to state 11 (pre lockout state). In state 11 the OPEN command is sent to the breaker and the recloser state is moved to state 12 which is the lockout state.

[1] *IEEE Guide for Automatic Reclosing of Circuit Breakers for AC Distribution and Transmission Lines*, IEEE Standard C37.104-2012

The High Current Lockout (HCL) applies to the individual Trip Sequence. For example, the #1 HCL when selected will only lockout Trip Sequence #1. The protective element applies to the entire Trip Sequence regardless of which element is chosen. Only one element can be chosen in each protective function. As shown in Figure 5-100, the 27 #3 element will apply to all Trip Sequences, similarly for 32 #1 and 81 #4. For 27 and 32 protective functions, any phase that has operated will lockout the 79 function when selected.

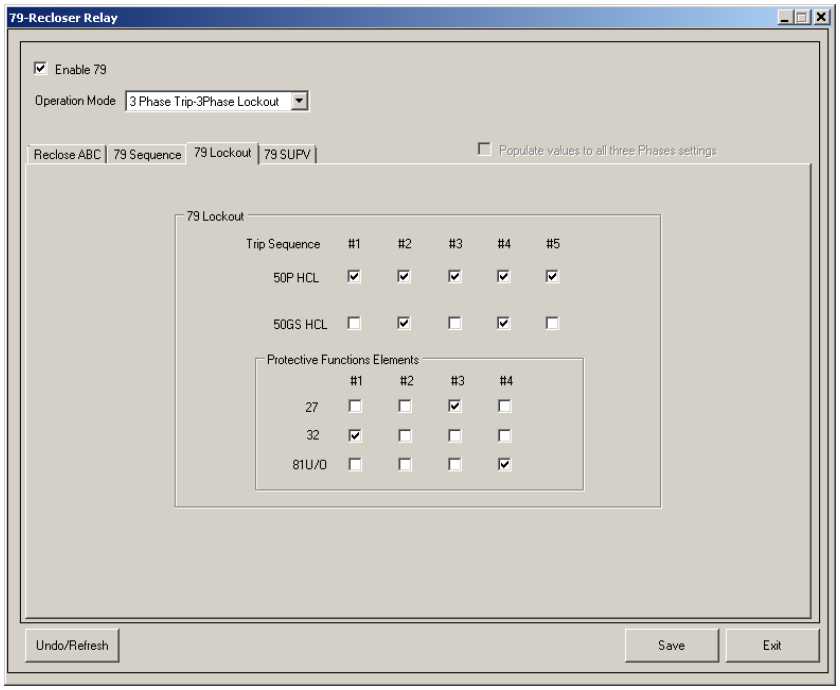


Figure 5-100 79 Drive To Lockout Function Selection Tab

79 Supervision Feature

The 79 Supervisory Functions allow the user to select those functions, or IPSlogic, that when tripped will cause the 79 reclosing operation to be blocked and eventually lockout if the selected supervision functions are still tripped after the supervision time has elapsed. For example, one of the functions that can be selected for supervision is the Undervoltage Bus Side Supervision (27 BSVS). If any undervoltage condition is detected based on the 27BSVS setting, then the recloser will remain in its present state, consequently blocking the close command transmission to the breaker. The recloser state will be set to lockout after the supervision timer expires if the undervoltage condition still exists. Figure 5-101 shows the Supervision Functions selection screen.

The supervision algorithm is executed only during the cycle state. The relay will evaluate the condition of the selected supervision functions and determine whether to allow a close operation to occur. The supervision algorithm is executed after the Reclose Timer has expired and before the reclose command is sent to the breaker. If **any** of the selected supervisory functions has tripped, the 79 recloser state will remain the same, thus blocking the reclose operation. For the recloser state to advance, all selected supervisory functions must be in normal state (or dropout) then the recloser state will advance to the next cycle state after sending a close command or the supervision timer has expired, which in this case will cause the recloser state to be driven to lockout. The supervision timer is started when any selected supervisory function has picked up during a given cycle state. The supervision timer is reset after all supervisory functions have gone to dropout in that same given cycle state or after the timer has expired.

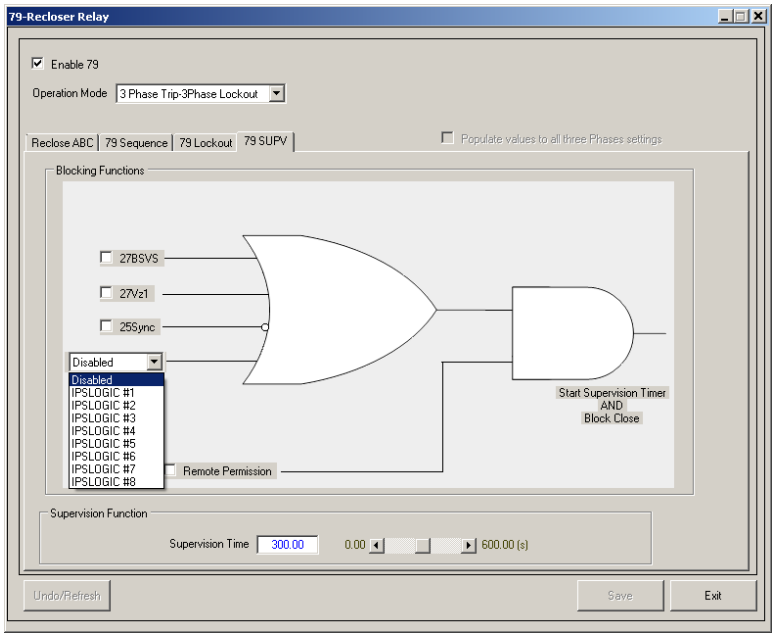


Figure 5-101 Supervision Functions Tab

Terminology

Important Terminology: The word **deactivate** in the context of the 79 function means that although a protective function is enabled by the user, it is not permitted to run. Vice versa, the word activate means the opposite of deactivate.

Breaker Status Truth Table

Breaker status 52A and 52B are used to determine whether the breaker circuit is open or closed. Input 1 is dedicated to monitor 52A and Input 2 is dedicated to 52B or common 52B/69 Lockout. Failure to do so will result in the relay displaying the wrong status and also some protective functions will not perform correctly.

The truth table (Table 5-4) shows how the relay decodes the input levels when Input 2 is configured as 52B.

52A	52B	Breaker Status
Logic 1	Logic 0	CLOSE
Logic 0	Logic 1	OPEN
Logic 0	Logic 0	error
Logic 1	Logic 1	error

Table 5-4 Relay Status Input Levels

The truth table (Table 5-5) shows how the relay decodes the input levels when Input 2 is configured as common 52B/69 Lockout.

52A	52B/69	Breaker Status
Logic 1	Logic 0	CLOSE
Logic 0	Logic 1	OPEN
Logic 0	Logic 0	LOCKOUT
Logic 1	Logic 1	error

Table 5-5 Relay Status Input Levels with Common 52B/69 Lockout

79 Automatic Reclose Function State Machine

The following describes the actions performed in each state and how they are distributed within the four states described in the IEEE C37.104 standard:

State 1 (Reset State/Power Up)

This state is an initial transitional state. This state is run to initialize the state machine. The following actions are performed:

1. Activation of selected functions in the Trip Sequence #1 setting.
2. Initialization of all 79 function timers to known values.
3. If the relay just powered up, then check if breaker is open. If open then lockout. Else proceed to next state.
4. If relay not just powered up, then check for lockout condition.

State 2 (Reset State)

The following actions are performed in this state:

1. Check for Hot Line Tag/Maintenance Mode, if active skip check for Sequence coordination.
2. Check sequence coordination if enabled then evaluate any selected protective function (Trip Sequence #1) for dropout. If sequence coordination function generates an event, then skip next state to keep pace with the downstream recloser. The next state to be executed is state 4.
3. Check if any activated functions have timed out. If true advance to next state. Else remain in same state.

State 3 (Cycle State with Reclose Count = 1)

This state produces the first reclose attempt after the Reclose delay (phase fault or ground fault delay) has expired. The following actions are performed:

1. If Hot Line Tag/Maintenance Mode command was received, then the next state will be the lockout state. Note: Lockout will happen in the next quarter cycle.
2. Check if the Phase count or Ground count has been exceeded. See "Phase Count and Ground Count Exceeded Lockout Algorithm" later in this section. If this check is true, then relay will lockout within the next quarter cycle.
3. When the reclose timer expires then perform Reclose Supervision as described above and if permitted, then send the CLOSE command. Advance to the next state and also activate selected functions defined in Trip Sequence #2 setting.
4. If CLOSE operation is blocked, remain in state 3 until either supervision timer has expired.

State 4 (Cycle State)

This state is run a quarter of a cycle after the CLOSE command has been sent. The following actions are performed:

1. If there is no prior pending overcurrent fault, then run the reset timer and check it against the reset time (auto) setting. If expired reset state to initial state 2. This means there is no longer any fault.
2. Check sequence coordination if enabled, then evaluate any selected protective function (Trip Sequence #2) for dropout. If sequence coordination function generates an event then skip next state.
3. Check if any activated protective functions have timed out and tripped. If true advance to next state. Else remain in same state.

State 5 (Cycle State with Reclose Count = 2)

The following actions are performed:

1. If sequence coordination is enabled, then check if there is any on-going selected overcurrent operation.
2. Check if the Phase Count or Ground Count has been exceeded. See "Phase Count and Ground Count Exceeded Lockout Algorithm" later in this section. If this check is true, then relay will lockout within the next quarter cycle.
3. When the reclose timer expires then perform Reclose Supervision as described above and if permitted, then send the CLOSE command. Advance to the next state and also activate selected functions defined in Trip Sequence #3 setting.
4. If CLOSE operation is blocked, remain in state 5 until either supervision timer has expired.

State 6 (Cycle State)

This state is run a quarter of a cycle after the CLOSE command has been sent. The following actions are performed:

1. If there is no prior pending overcurrent fault, then run the reset timer and check it against the reset time (auto or manual) setting. If expired reset state to initial state 2.
2. Check sequence coordination if enabled, then evaluate any selected protective function (Trip Sequence #3) for dropout. If sequence coordination function generates an event then skip next state.
3. Check if any activated functions have timed out. If true advance to next state. Else remain in same state.

State 7 (Cycle State with Reclose Count = 3)

The following actions are performed:

1. If sequence coordination is enabled then check if there is any on-going selected overcurrent operation.
2. Check if the Phase Count or Ground Count has been exceeded. See "Phase Count and Ground Count Exceeded Lockout Algorithm" later in this section. If this check is true, then relay will lockout within the next quarter cycle.
3. When the reclose timer expires then perform Reclose Supervision as described above and if permitted, then send the CLOSE command. Advance to the next state and also activate selected functions defined in Trip Sequence #4 setting.
4. If CLOSE operation is blocked, remain in state 7 until either supervision timer has expired.

State 8 (Cycle State)

This state is run a quarter of a cycle after the CLOSE command has been sent. The following actions are performed:

1. If there is no prior pending overcurrent fault, then run the reset timer and check it against the reset time (auto or manual) setting. If expired reset state to initial state 2.
2. Check sequence coordination if enabled then evaluate any selected protective function (Trip Sequence #4) for dropout. If sequence coordination function generates an event then skip next state.
3. Check if any activated functions have timed out. If true advance to next state. Else remain in same state.

State 9 (Cycle State with Reclose Count = 4)

The following actions are performed:

1. If sequence coordination is enabled then check if there is any on-going selected overcurrent operation.
2. Check if the Phase Count or Ground Count has been exceeded. See "Phase Count and Ground Count Exceeded Lockout Algorithm" later in this section. If this check is true, then relay will lockout within the next quarter cycle.

3. When the reclose timer expires then perform Reclose Supervision as described above and if permitted, then send the CLOSE command. Advance to the next state and also activate selected functions defined in Trip Sequence #5 setting.
4. If CLOSE operation is blocked, remain in state 9 until either supervision timer has expired.

State 10 (Cycle State)

This state is run a quarter of a cycle after the CLOSE command has been sent. The following actions are performed:

1. If there is no prior pending overcurrent fault, then run the reset timer and check it against the reset time (auto or manual) setting. If expired reset state to initial state 2.
2. Check if any activated functions have timed out. If true advance to next state. Else remain in same state.

State 11 (pre Lockout)

This is an intermediate lockout state. For safety purposes an OPEN command is always sent to the breaker. Advance to the final lockout state (state 12).

State 12 (Lockout)

The 79 function will remain in this state indefinitely waiting for a RESET command. Upon receiving the RESET command, the state machine is reset to state 2. After receiving the RESET signal the Reset from Lockout Timer is ready to be started by the manual close operation.

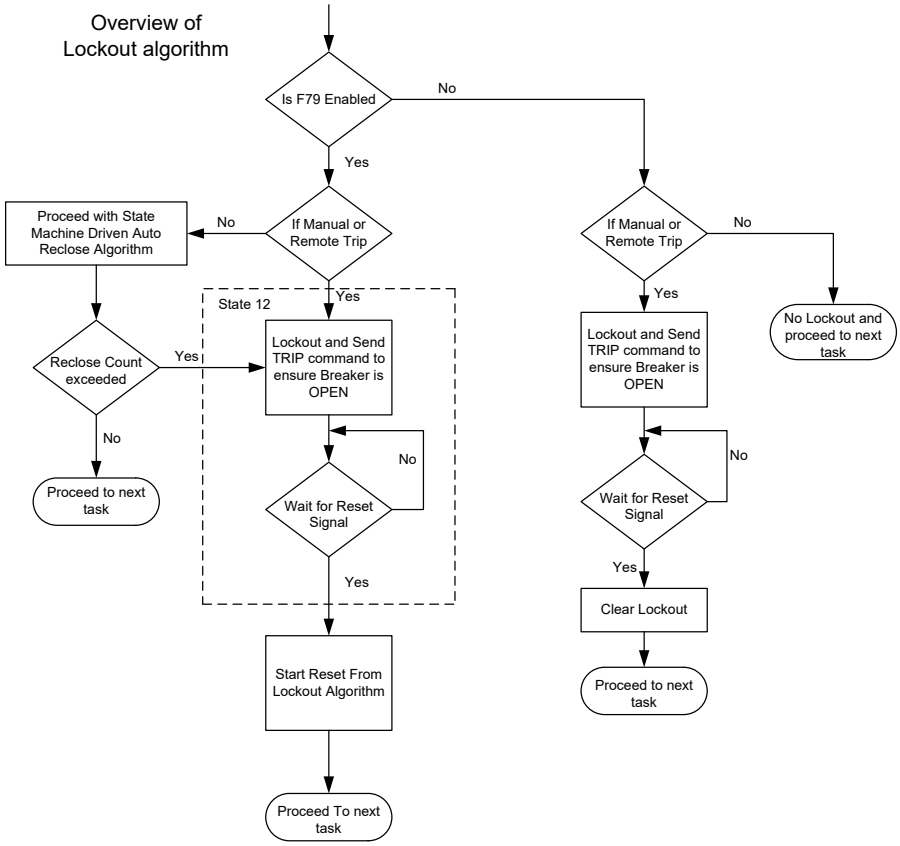


Figure 5-102 Function 79 Lockout Algorithm Diagram (Three-Phase Ganged)

STAGE	DESCRIPTION	CLOSE LED	LED A	LED B	LED C	TRIP LED
1	RECLOSER IS CLOSED AND READY	RED	RED	RED	RED	OFF
2	RECLOSER IS OPEN AND LOCKOUT	OFF	AMBER	AMBER	AMBER	GREEN
3	RECLOSER OPEN	OFF	GREEN	GREEN	GREEN	GREEN
4	RECLOSE CLOSED AND RESET AFTER LOCKOUT TIMER STARTS	RED	RED	RED	RED	OFF
5	AFTER AUTO RECLOSE RESET TIMER STARTS	RED	RED	RED	RED	OFF

Table 5-6 Default Front Panel LED Display During a Reclose Cycle

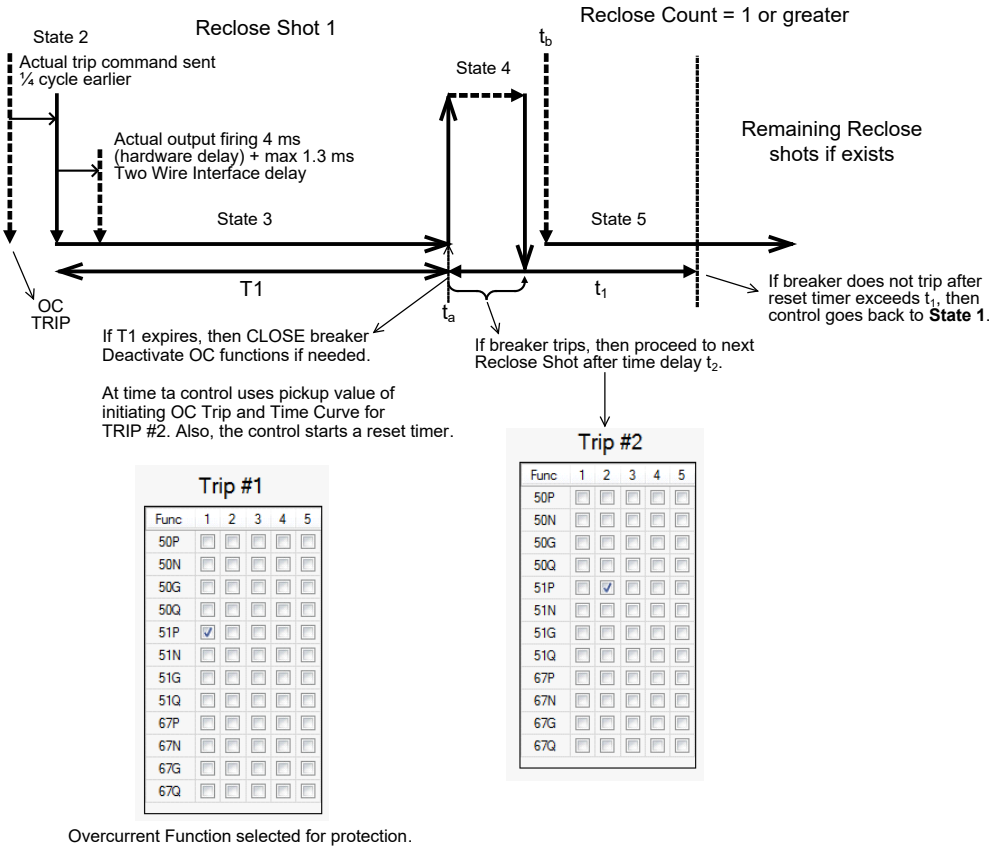


Figure 5-103 Tripping of the Breaker (Timing Diagram)

Phase Count and Ground Count Exceeded Lockout Algorithm

The 79 function is driven to lockout if the following logic is true:

Regardless of ground precedence setting, if the reclose count exceeds both the phase count and the ground count, then the relay will initiate LOCKOUT sequence. If Ground Precedence is selected then the relay will follow the following logic:

If reclose count exceeds only the ground count AND a ground overcurrent function has operated, then initiate LOCKOUT sequence. If reclose count exceeds only the phase count AND an overcurrent phase function has operated AND no ground overcurrent function has operated, then initiate LOCKOUT sequence.

If ground precedence is not selected, then the following logic is applied:

If reclose count exceeds only the ground count AND no overcurrent phase function has operated AND ground overcurrent function has operated, then initiate LOCKOUT sequence. If reclose count exceeds only the phase count AND phase overcurrent has operated, then initiate LOCKOUT sequence.

Sequence Coordination

In case there are multiple reclosers which operate in serial connections, the Sequence Coordination feature prevents unnecessary trip of source-side recloser by Overcurrent element due to load-side fault. When this feature is enabled and the fault is restored to normal state by load-side recloser during source-side recloser time-delayed operation, source-side recloser only increments the reclosing counts without tripping. However, source-side recloser performs tripping at the last reclosing count. If the reclosing function is disabled, Sequence Coordination function is no longer carried out.

A sequence coordination event is generated when a selected overcurrent function has pickup and then dropped out before the delay timer has expired (before the function operates).

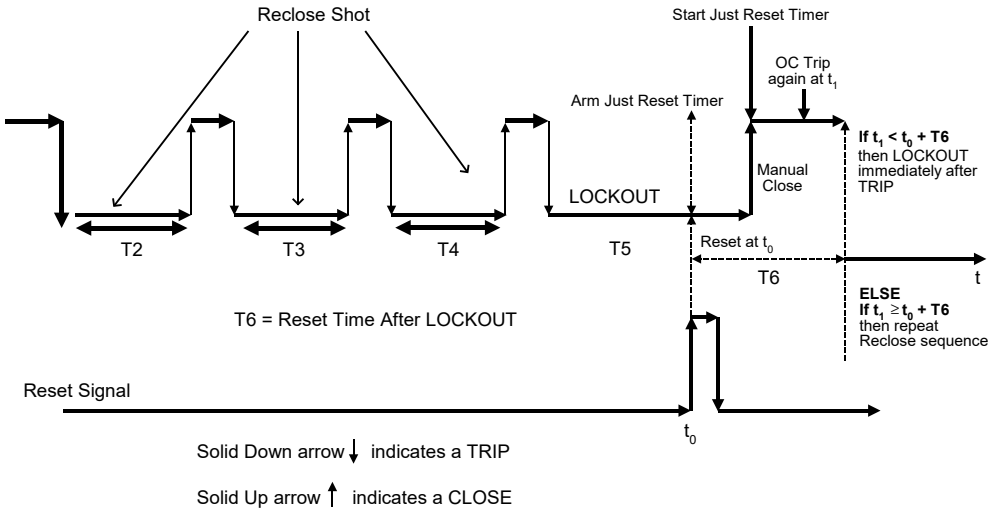


Figure 5-104 Reset Time from Lockout after Manual Close (Replace Reset Time after Manual Close)

The Figure 5-104 timing diagram explains how the Reset Time from lockout after manual close works. When the Reclose Function is in LOCKOUT state, a reset signal is necessary to reset the state machine to state 1. When the reset signal is received, the M-7651A D-PAC will arm a timer (Just Reset) which is defined by the "Reset Time After Lockout" setting. The actual manual closure of the breaker will cause the timer to start counting. If an overcurrent (OC) trips after a manual close, and if this event happens within the Reset Time after lockout setting, the 79 will LOCKOUT immediately. Else if the trip event happens after the timer has expired, the entire programmed trip sequence will be repeated accordingly.

External Operation

■**NOTE:** This feature is always enabled.

The M-7651A can detect external commands (external close or external trip) and will take action similar to Trip-Lockout and Close front panel commands to its lockout state based on the received external command.

External Close Command

To detect an external close, the relay has to be in trip and lockout state. In this trip and lockout state, if the relay detects an external close (a state change on 52a/52b inputs), then it will reset the lockout.

External Trip Command

To detect an external trip, the relay has to be in close state and in any of the following Reclose States: 0, 1, 3, 5, 7 or 9. In this close state, if the relay detects an external trip (a state change on 52a/52b inputs), then it will issue a Trip and Lockout Command.

The relay can be configured as:

- Both 52a – 52b
- Only 52a
- Only 52b

Only the configured input state change dictates the external Trip/Close command algorithm.

79 RECLOSER STATUS MONITORING

Selecting **Monitor/Recloser Status Monitoring** from the IPScom main menu displays the Recloser Status Monitoring screen which allows real time monitoring of the recloser. See Figure 5-105 and Figure 5-106 for situational examples of the status monitoring screen.

Example #1: First reclose sequence with an overcurrent current function timing to operate. Fault type is a phase fault as indicated.

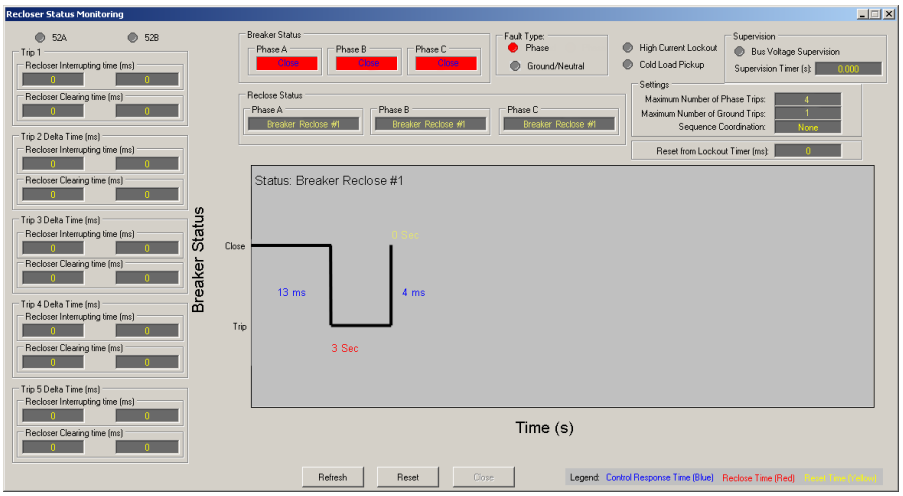


Figure 5-105 Recloser Status Monitoring Screen – Example #1

Example #2: All 4 reclose sequence occurred and LOCKOUT condition.

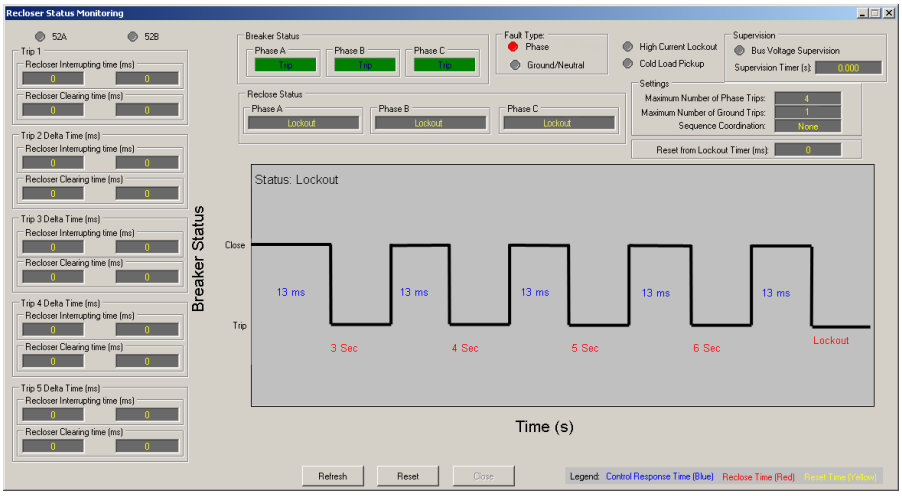


Figure 5-106 Recloser Status Monitoring Screen – Example #2

79 RECLOSER RELAY SETPOINTS

The Recloser Relay dialog screen allows the user to set the Reclosing Sequence and Reclose Interval. The Reclosing Sequence is an extension of the single Reclosing Operation. When a breaker opens and closes automatically, it will continue until the specified count is reached. Any overcurrent fault will cause a trip after the trip time expires, at which time the 79 function will start the Reclose Interval.

At the end of the Reclose Interval the control will automatically send a close command to the breaker. This process will continue until the maximum number of trips is reached or until the fault clears, whichever occurs first. Once the maximum number of trips is reached, the control will automatically be placed in Lockout and prevent further operation until the unit is reset.

The Recloser Relay has sequence coordination available to prevent fast curve trips due to faults beyond downstream reclosers. Ranges and increments are presented in Figure 5-108 through Figure 5-114.

When the user selects the 79 Recloser Relay function from the Setpoints screen, IPScom will display a "Settings Match!" confirmation screen (Figure 5-107). The user must verify that the IPScom configuration settings match the hardware configuration of the Recloser. The user must select **Confirm** before proceeding. If "Remember Selection" is checked, IPScom will not display this screen prompt again.

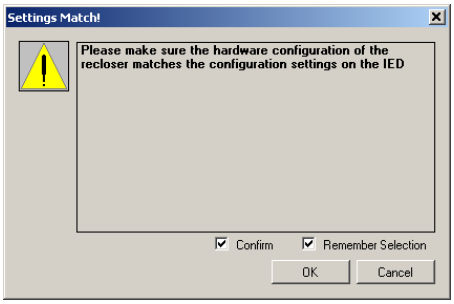


Figure 5-107 79 Recloser Relay Settings Match Confirmation Screen

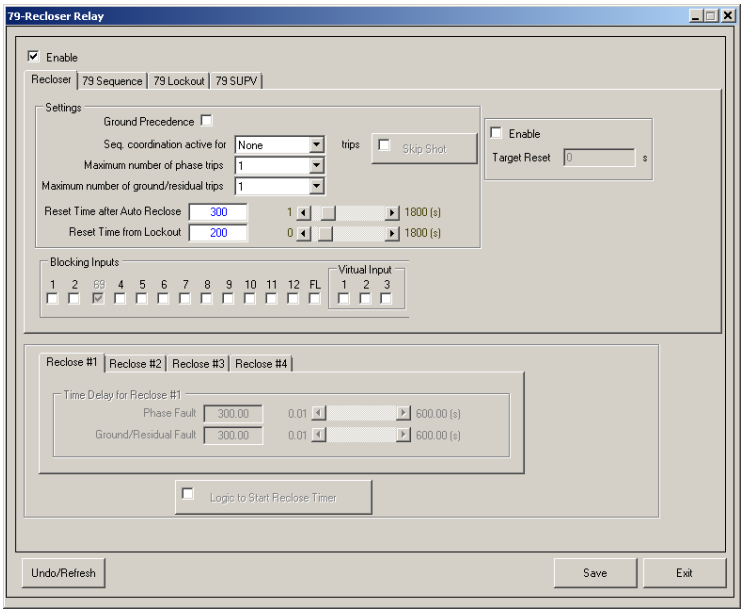


Figure 5-108 79 Recloser Relay Setpoints Screen (Three-Phase Ganged Operation)

Resetting Targets

All fault types detected are captured and displayed in a target. The last fault will remain latched in both the HMI display and IPScom Function Status screen until the fault is manually or automatically reset. Select the "Target" checkbox in the IPScom Function Status screen to display the latest target status. When enabled, the Target Reset Timer (Figure 5-109) allows all targets to be reset after a specified period of time, following a successful close of the recloser. The Target Reset Timer can be set to a maximum of 65000 seconds.

Figure 5-109 79 Recloser Relay: Target Reset Timer Settings

The targets may be reset utilizing either a programmable pushbutton, remote communication command, or through the dedicated Target Reset Timer.

A successful Recloser close operation is defined as follows:

- "Reset Time after Auto Reclose" timer has expired
- The control has no functions currently timed out – no tripping elements picked up
- Breaker is in the Close position

79 Recloser Relay Skip Shot

As defined in the IEEE C37.104 standard, a shot is defined as a combination of a Reset and a Cycle state. The Skip Shot feature evaluates the IPSlogic (Skip Shot Trigger) selected by the user during each shot. For example, as shown in Figure 5-110, the maximum number of phase trips selected in the 79 Recloser Relay settings screen is four (4), as a result, there will be three (3) shots. If IPSlogic #1 is asserted during shot 2, then the shot count will be incremented by one and the next state will be Reset state 3, in which the auto reclose function is waiting to receive an initiate to start timing to reclose, after the breaker opens.

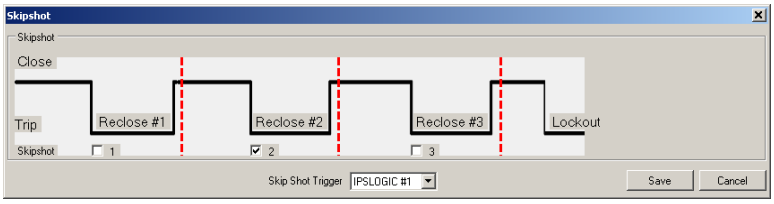


Figure 5-110 79 Recloser Relay Skipshot Settings Screen

79 Logic to Start Recloser Timer

This selection allows IPSlogic to be added to the Recloser Timer settings (Figure 5-111).

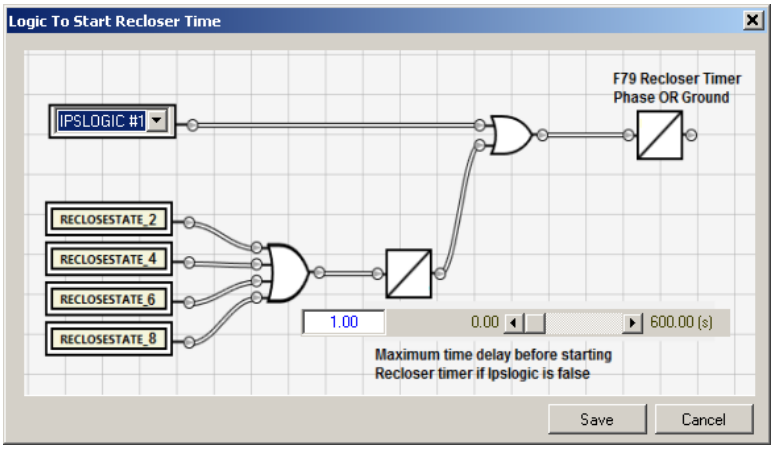


Figure 5-111 79 Recloser Relay Logic to Start Recloser Timer Settings Screen

79 Trip Reclose Sequence

The Trip Reclose Sequence dialog screen (Figure 5-112) allows the user to select the protection functions which will increment the Auto-Reclose cycle for up to 5 Reclose Trips.

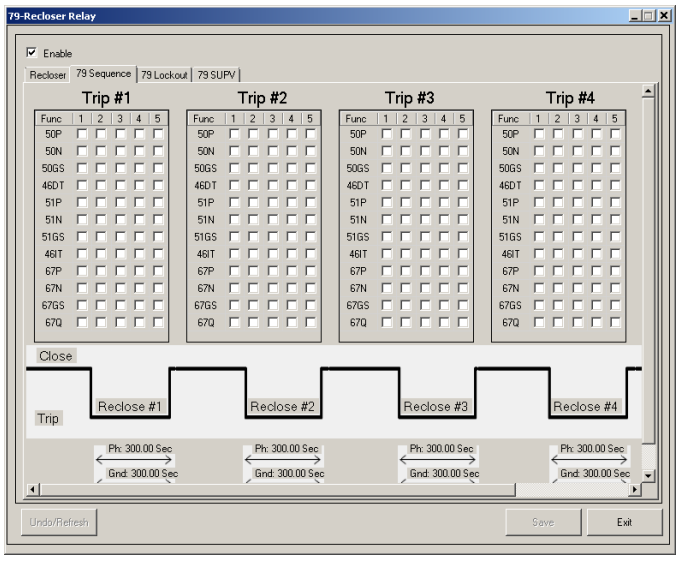


Figure 5-112 Function 79 Sequence – Trip Reclose Sequence

27 Bus Side Voltage Supervision Setpoints

Bus Side Voltage Supervision blocks reclosing until the bus voltage rises above the pickup setting. Figure 5-113 illustrates how the Bus Side Voltage Supervision works. If the voltage does not come back before the supervision timer expires, then the reclosing logic automatically goes to lockout.

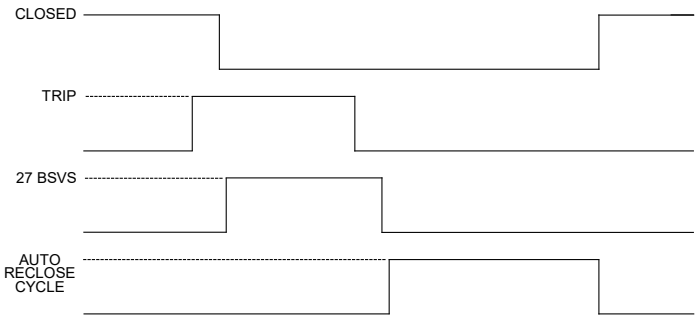


Figure 5-113 Auto Reclose Single Shot Timing with 27BSVS Enabled

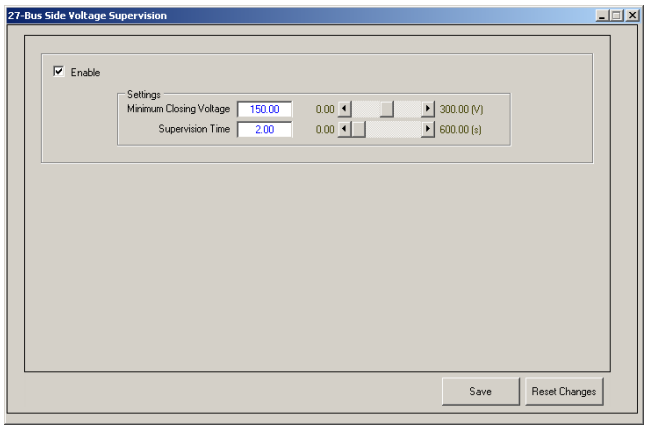


Figure 5-114 Recloser Relay Function 27 Bus Side Voltage Supervision Setpoints

5.4 Recloser Wizard

The M-7651A D-PAC includes both advanced setup dialog screens and a Recloser Wizard to setup the 79 Reclose functions. Each method provides both the advanced users and less frequent users with an intuitive user friendly interface.

The Recloser Wizard feature is a tool to help novice users setup the M-7651A D-PAC and configure the 79 Automatic Reclose functions with the minimum necessary settings to allow the recloser to function properly.

The Recloser Wizard is launched from the Setup/Recloser Wizard menu selection which displays the first Recloser Wizard "Common Settings" dialog screen (Figure 5-116). The Common Settings dialog screen is the first in a series of successive dialog screens that when completed result in a basic recloser Settings Profile. The Recloser Wizard dialog screens include:

- Recloser Common settings – confirmation of hardware configuration
- Profile and File Name settings
- Phase Overcurrent settings
- Ground Overcurrent settings
- Residual (Neutral) Overcurrent settings
- Cold Load settings
- Hot Line Tag settings
- Automatic Reclosing settings
- Settings Final Confirmation

If the cancel button is selected while in any Recloser Wizard screen, IPScom will display a "Settings for the current profile will not be saved" Warning screen (Figure 5-115). Select **Yes**, IPScom will not save any changes and will revert back to the existing Function 79 settings that were saved in the Setpoint Profile that was being edited.

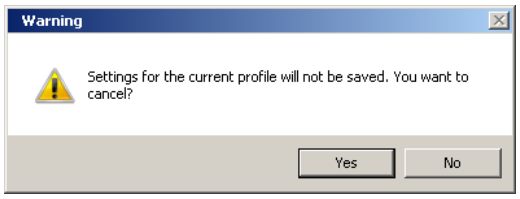


Figure 5-115 Recloser Wizard "Cancel" Warning Screen

Recloser Wizard Common Settings Screen

The Recloser Wizard Common Settings confirmation screen (Figure 5-116) allows the user to verify the system settings of the M-7651A D-PAC. The user should carefully review the displayed settings to ensure that these settings match the hardware configuration. If these settings need to be edited, select the "Configuration" button. This will display the IPScom System Setup screen. Once the system settings have been verified, the user must check the "Accept" checkbox to proceed.

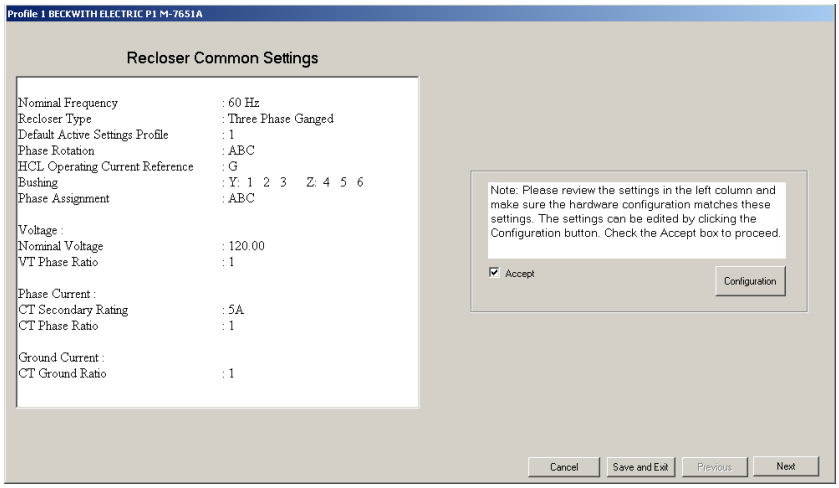


Figure 5-116 Recloser Wizard Common Settings Screen

Recloser Wizard Profile Screen

The Recloser Wizard Profile screen (Figure 5-117) provides the user with the capability to edit the User Lines associated with each individual profile defined by the "Setting Profile to Create" entry. The User Lines can be used for a circuit description or a settings description. The "Setting Profile to Create" selection indicates which profile the user is currently configuring.

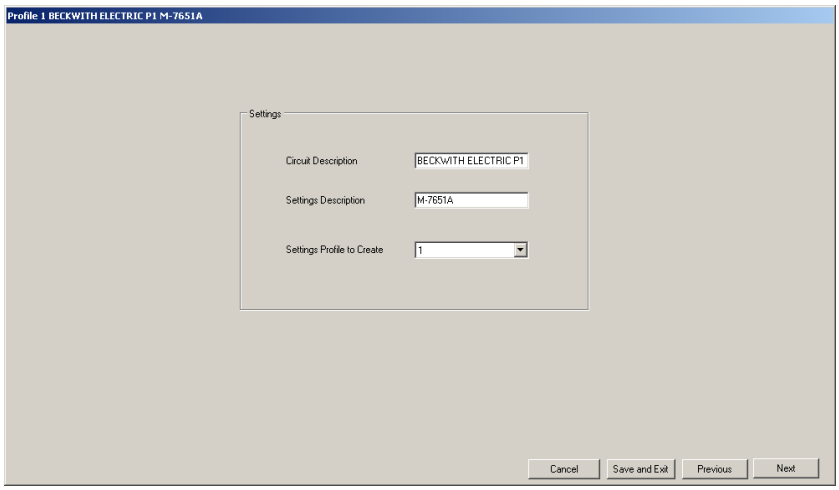


Figure 5-117 Recloser Wizard Profile Screen

Recloser Wizard Phase Overcurrent Settings Screen

The Recloser Wizard Phase Overcurrent Settings screen (Figure 5-118) allows the user to select the Overcurrent Functions that initiate a Recloser Trip signal when the Minimum Trip Setting is exceeded. Each Trip sequence includes dedicated overcurrent protective function such as 50P and 51P and a High Current Lockout (HCL) function. Each 50P and 51P is an element of the recloser protective functions and the HCL function is internal to the 79 Automatic Reclose function.

For example, Trip Sequence 1 is dedicated to 50P#1 and 51P#1 elements and so on. Therefore in the example illustrated in Figure 5-118, the 51P will be enabled and the 50P will be disabled (Figure 5-119 and Figure 5-120 respectively).

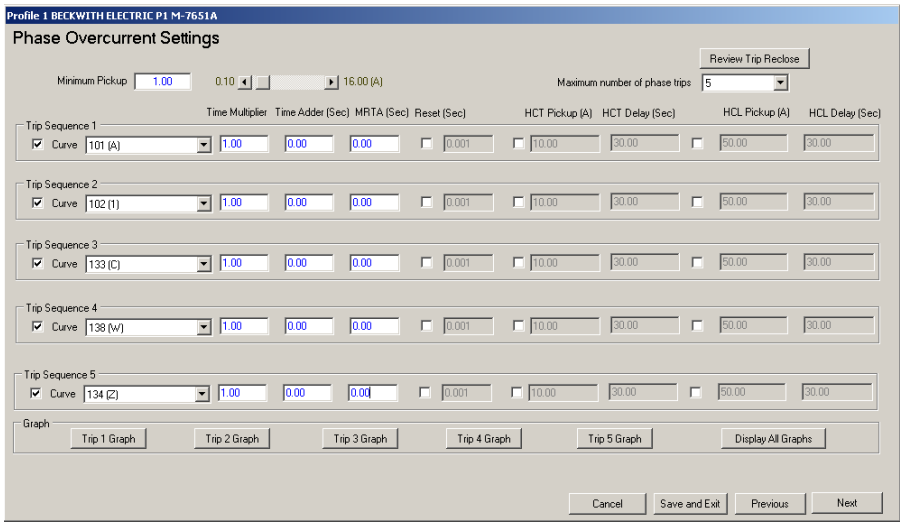


Figure 5-118 Recloser Wizard Phase Overcurrent Settings Screen

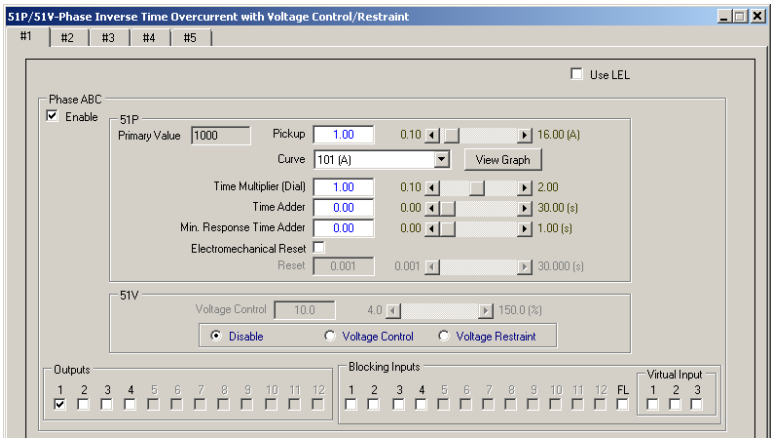


Figure 5-119 51P Function Settings Screen

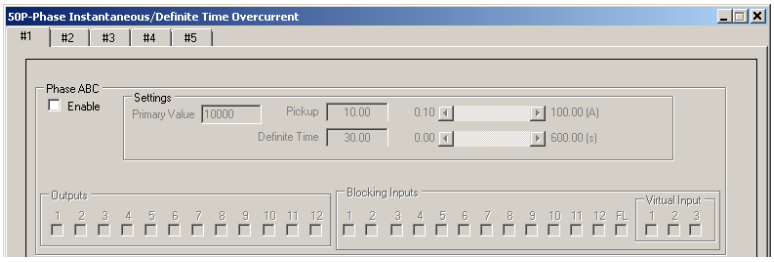


Figure 5-120 50P Function Settings Screen

Depending on the number of Phase Counts (Figure 5-118), the equivalent number of Trip Sequences are available to the user. The "Enable" check box, when unchecked, will deactivate all of the Overcurrent protective functions.

■**NOTE:** "Deactivate" is defined as the Recloser Wizard software internally disabling the function although the user has enabled the function.

The "Trip Graph" and "Display all Graphs" selections display the selected curves individually or collectively, in a graphical logarithmic format as shown in Figure 5-121, Display All Graphs.

▲**CAUTION:** When the user opens the Display All Graphs screen, Ipscom will automatically disable the 79 function to prevent any inadvertent operation while settings are being manipulated.

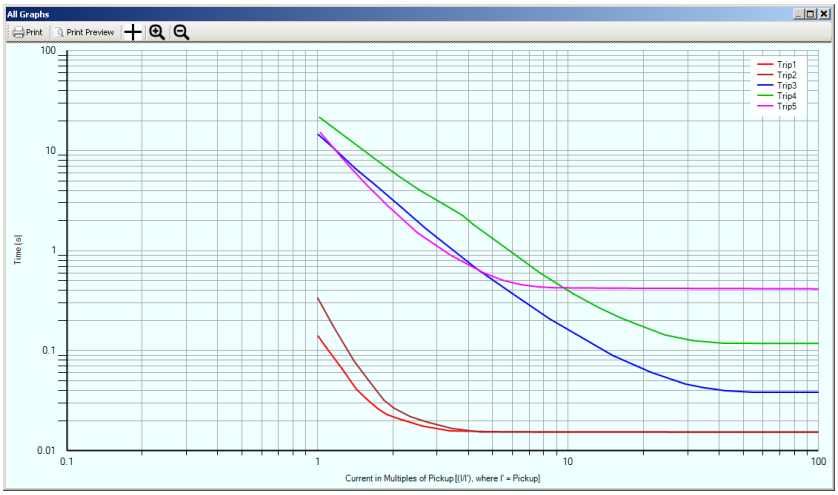


Figure 5-121 Recloser Wizard Display All Graphs Feature

Recloser Wizard Ground Overcurrent Settings Screen

The Recloser Wizard Ground Overcurrent Settings screen (Figure 5-122) is dedicated to the ground functions and its behavior is similar to the Phase Overcurrent Settings dialog screen.

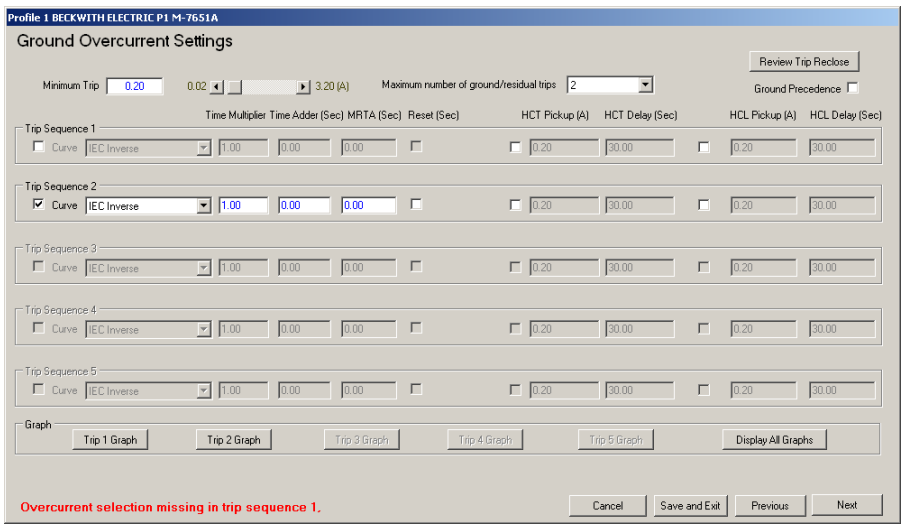


Figure 5-122 Recloser Wizard Ground Overcurrent Settings Screen

When Ground Precedence is selected, the following flowchart controls the lockout conditions.

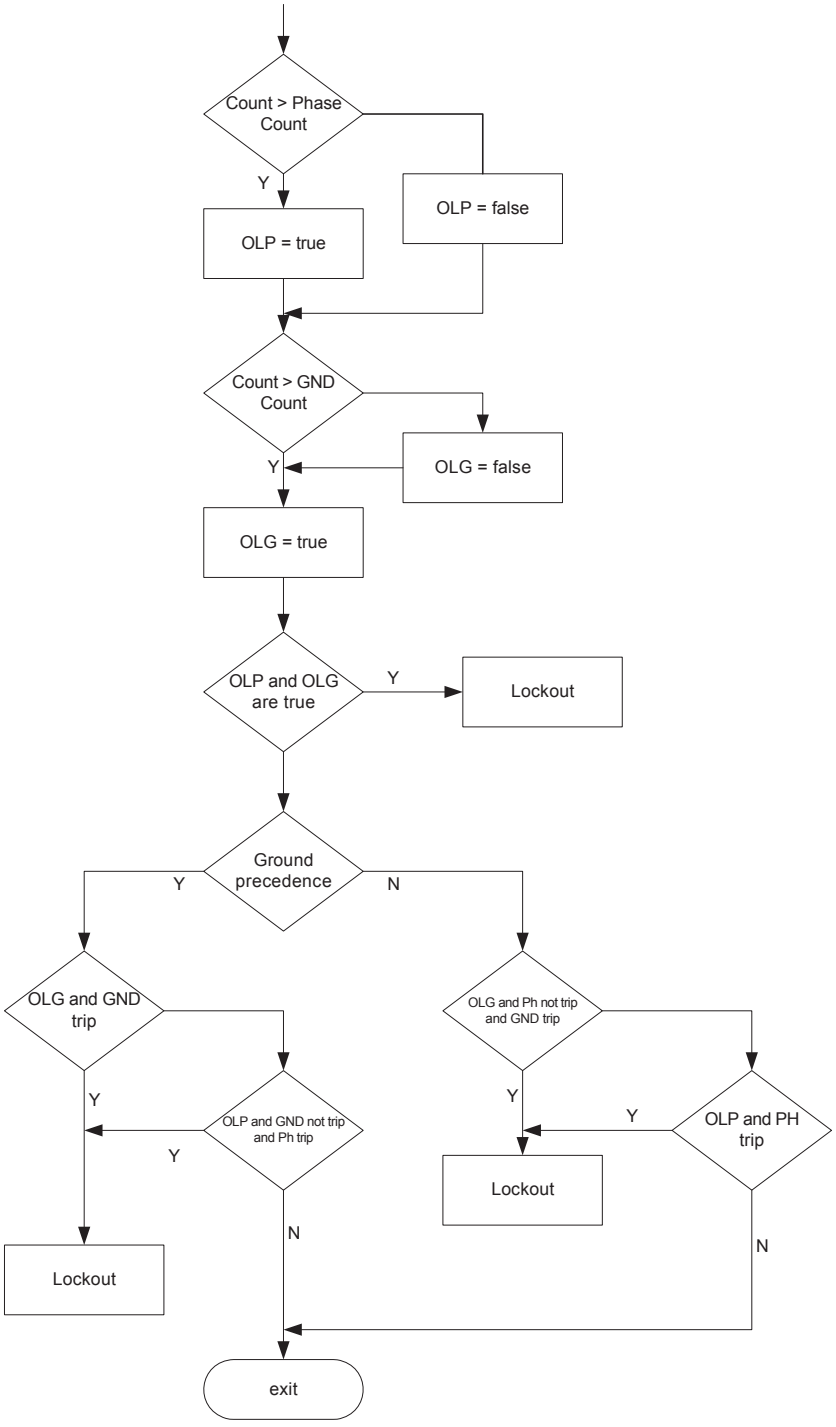


Figure 5-123 Ground Precedence Flowchart

Recloser Wizard Residual (Neutral) Overcurrent Settings Screen

The Recloser Wizard Residual (Neutral) Overcurrent Settings screen (Figure 5-124) is dedicated to the residual functions and its behavior is similar to the Phase Overcurrent Settings dialog screen.

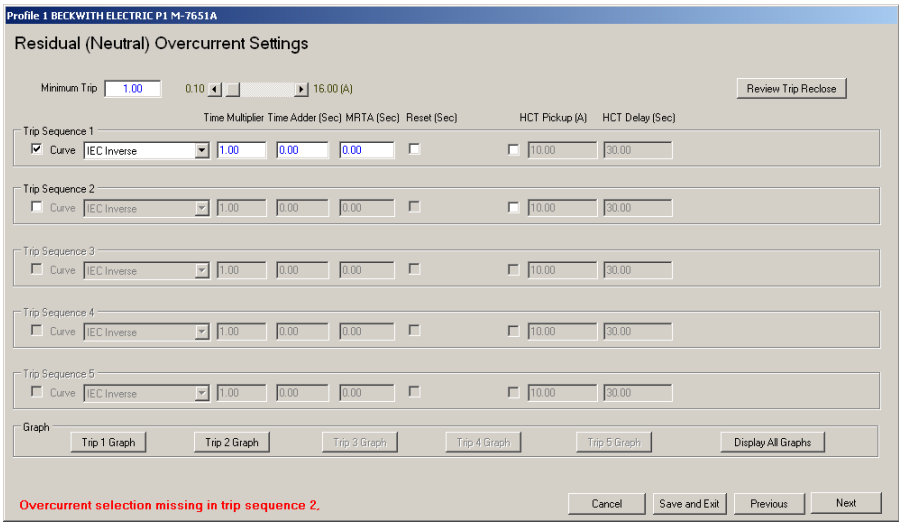


Figure 5-124 Recloser Wizard Residual (Neutral) Overcurrent Settings Screen

Recloser Wizard Cold Load Settings Screen

The Recloser Wizard Cold Load Pickup Setpoints screen (Figure 5-125) contains alternate settings for the 50P, 50N, 50G/GS, 51P, 51N, 51G/GS and High Current Lockout functions. These alternate settings override the existing settings of any enabled function after the relay is tripped open and the lockout condition has been active for a period greater than the user programmed period (Time Locked out to Activate Cold Load).

As illustrated in Figure 5-126, I_{rst} (Percentage of the existing Minimum Trip Phase Current Setting) and I_{grst} (Percentage of the existing Minimum Trip Ground Current Setting) are the phase and ground settings below which the relay will revert to the existing settings prior to any CLP override. I_{rst} and I_{grst} comparisons are performed independently.

Pickup time is the minimum time period the measured ground current (I_g) or phase current (I_{ph}) must be less than the I_{grst} and I_{rst} settings respectively before exiting the Cold Load Pickup period. The Active Duration setting is the maximum period for the Cold Load Pickup logic. Cold Load Time is the maximum duration of the Cold Load Pickup session.

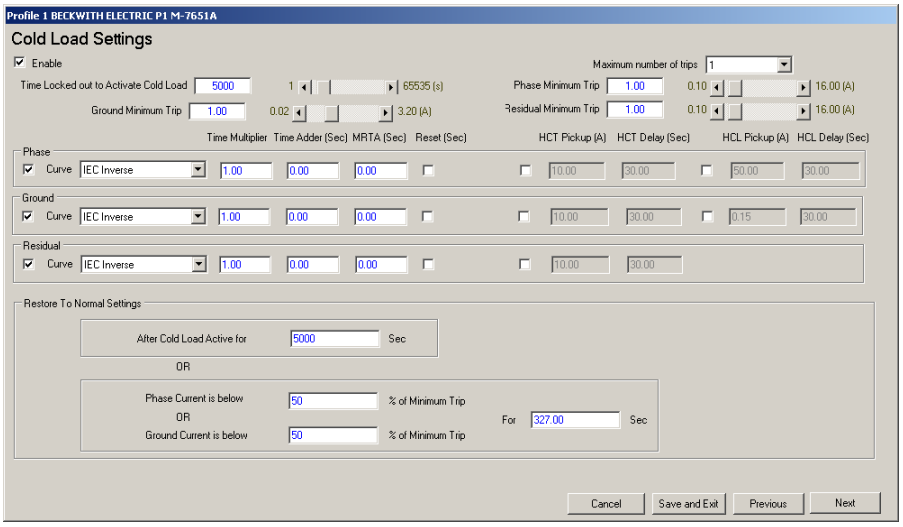


Figure 5-125 Recloser Wizard Cold Load Settings Screen

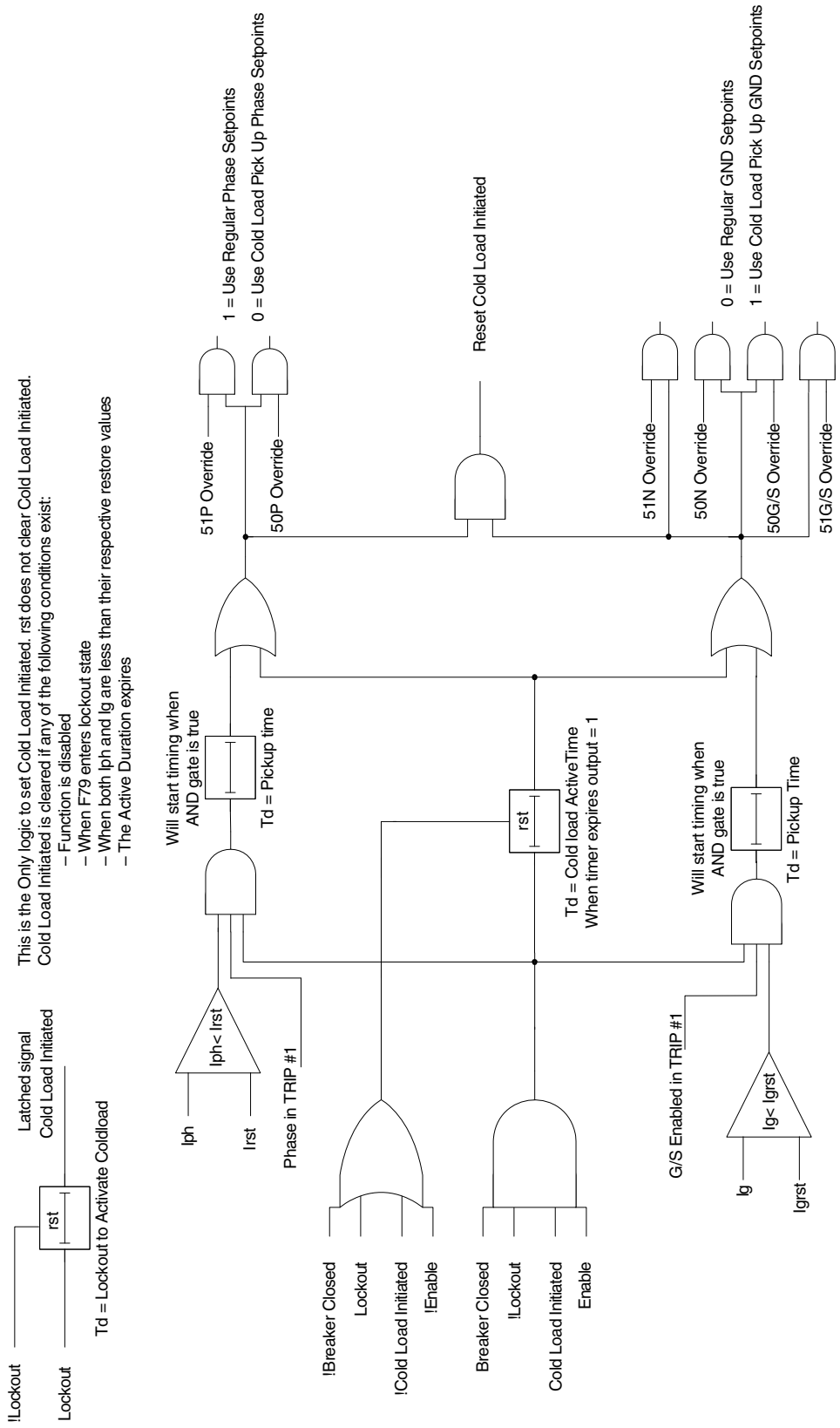


Figure 5-126 Cold Load Pickup Function Logic

Recloser Wizard Hot Line Tag Settings Screen

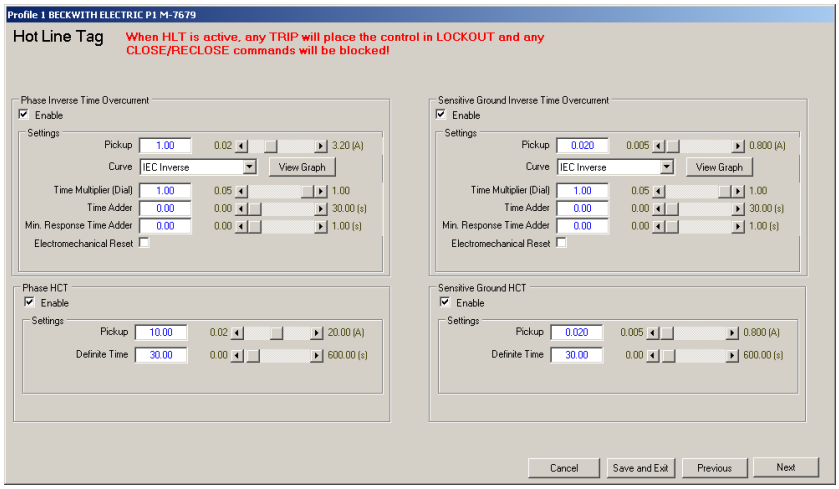


Figure 5-127 Recloser Wizard Hot Line Tag Settings Screen

Recloser Wizard Automatic Reclosing Settings Screen

The Automatic Reclosing settings screen (Figure 5-128) allows the user to modify the time delay between trip and automatic reclose of the breaker. Each type of fault has its own Reclose Interval. Also, the Cold Load Pickup interval can also be configured.

Sequence Coordination can also be configured for the number of desired trips. Note that the trip is consecutive. In cases where there are multiple Reclosers which operate utilizing serial connections, the Sequence Coordination feature prevents unnecessary tripping of source-side Reclosers by instantaneous elements due to a load-side fault. When this feature is enabled, and the detected fault is restored to normal state by the load-side Recloser during the source-side Recloser's time delayed operation, the source-side Recloser will only increment the reclosing counts without tripping. However, the source-side Recloser performs tripping at the last reclosing count. If the reclosing function is disabled, the Sequence Coordination function is no longer carried out.

Selecting the "79 Drive to Lockout" button displays Figure 5-129 which allows the user to configure the 79 Lockout feature. Selecting the "Supervision Functions" button displays Figure 5-130 which allows the user to configure the 79 Drive to Lockout Blocking Functions logic and Supervision Time.

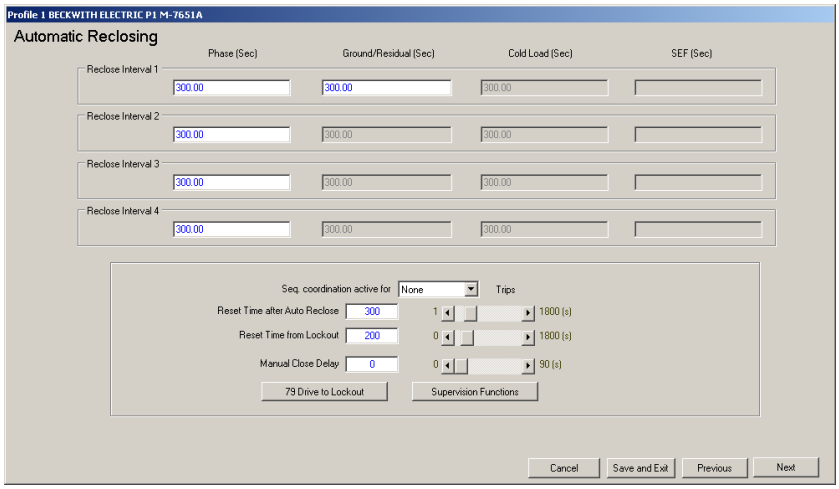


Figure 5-128 Recloser Wizard Automatic Reclosing Screen

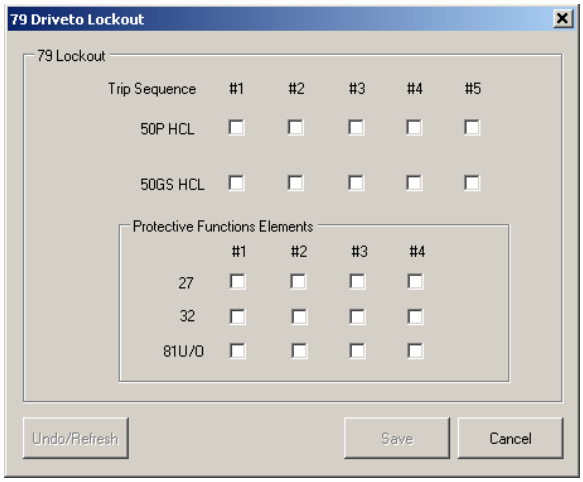


Figure 5-129 79 Drive to Lockout Screen

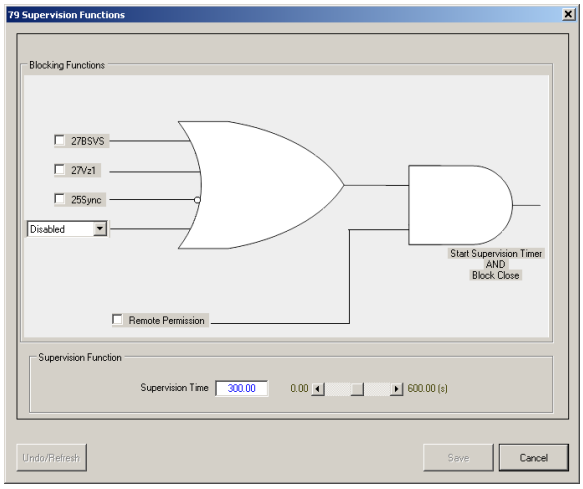


Figure 5-130 79 Supervision Functions Screen

Navigation Panel Dialog Screen

The Navigation Panel Dialog screen (Figure 5-131) allows the user to perform the following:

- Duplicate Function 79 settings
- Configure Function 79 in other profiles
- Review and edit previously configured Function 79 settings

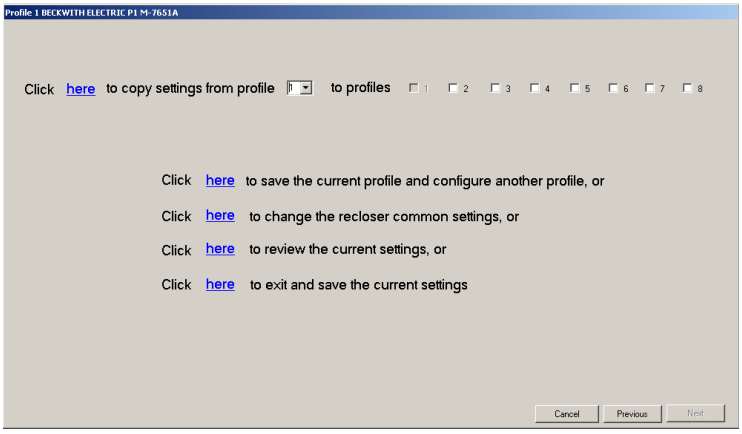


Figure 5-131 Navigation Panel Screen

5.6 Configuring Setpoints from the HMI

SELECTING A PROFILE FOR EDITING FROM THE HMI

3. Press **SETP** to wake the unit. The menu will advance to "SETPOINTS".

```
        SETPOINTS
<MNTR            CNFG>
```

4. Press **ENT** or **CNFG** once. The unit will display the following:

```
         PROFILE
<                    >
```

5. Press **ENT** or **CNFG** once. The unit will display the following:

```
Edit Profile
Profile 1
```

6. Press **ENT**. The following will be displayed.

```
Edit Profile
Profile 1
```

7. Utilizing **SETP** or **CNFG** enter the desired Profile for Editing, then press **ENT**. The following will be displayed reflecting the Profile selected for Editing.

```
Edit Profile
Profile X
```

SETTING OVERCURRENT FUNCTIONS FROM THE HMI

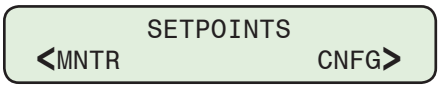
The following Overcurrent function settings are available from the HMI:

- **Phase Functions** – Elements #1 through #5
  - 50P ABC (Three-Phase Ganged)
  - 51P ABC (Three-Phase Ganged)
  - High Current Lockout – HCLPABC (Three-Phase Ganged)
- **Ground (or Sensitive Ground) Functions** – Elements #1 through #5
  - 50G (50GS)
  - 51G (51GS)
  - HCLG (HCLGS) – High Current Lockout, when HCL Operating Current Reference is set to "G"
- **Residual Functions** – Elements #1 through #5
  - 50N
  - 51N
  - HCLN – High Current Lockout, when HCL Operating Current Reference is set to "3I0"

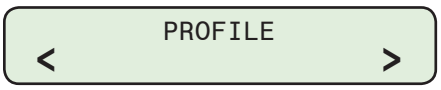
Example: Setting 50P, Element #1, Three-Phase Ganged Operation Mode

The following steps outline the setup of Function 50P, Element #1, Three-Phase Ganged Operation mode. The steps to setup Elements #2 through #5 are similar. The steps to setup Functions 51P, 50G(GS), 51G(GS), 50N, 51N and High Current Lockout are similar.

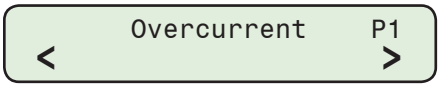
1. Press **SETP** to wake the unit. The menu will advance to "SETPOINTS".



2. Press **ENT** or **CNFG** once. The unit will display the following:

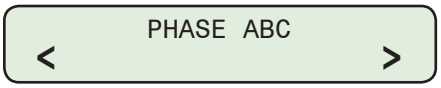


3. Press **MNTR** or **COMM** as necessary, until the "Overcurrent" screen is displayed.

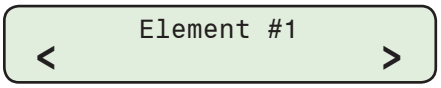


Ensure that the correct Profile to be edited is displayed in the upper right corner of the screen. If not, refer to the previous section "Selecting a Profile for Editing From the HMI".

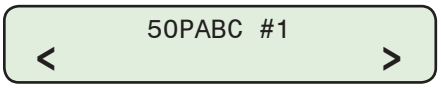
4. Press **ENT** or **CNFG** once. The unit will display the following:



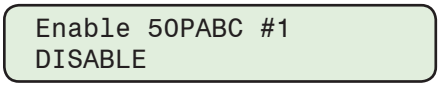
5. Press **ENT** or **CNFG** once. The unit will display the following:



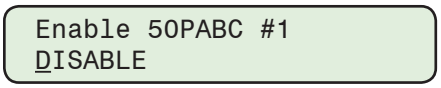
6. Press **ENT** or **CNFG** once. The unit will display the following:



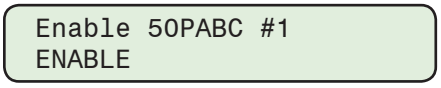
7. Press **ENT** or **CNFG** once. The unit will display the following:



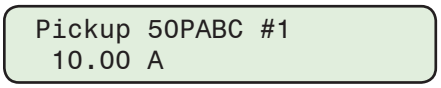
8. Press **ENT**. The following will be displayed.



9. Utilizing the arrow pushbuttons select **ENABLE**, then press **ENT**. The following will be displayed.



10. Press **CNFG** as necessary, until the "Pickup 50PABC #1" screen is displayed.



11. Press **ENT**. The following will be displayed.

```
Pickup 50PABC #1
 10.00 A
```

12. Utilizing the arrow pushbuttons enter the desired Pickup, then press **ENT**. The following will be displayed reflecting the setting that was entered.

```
Pickup 50PABC #1
 xx.xx A
```

13. Press **CNFG** as necessary, until the "Time Delay 50PABC #1" screen is displayed.

```
Time Delay 50PABC #1
  30.00 s
```

14. Press **ENT**. The following will be displayed.

```
Time Delay 50PABC #1
  30.00 s
```

15. Utilizing the arrow pushbuttons enter the desired Time Delay, then press **ENT**. The following will be displayed reflecting the setting that was entered.

```
Time Delay 50PABC #1
 xxx.xx s
```

16. Press **ENT** as necessary to navigate back through the menu hierarchy. Repeat these steps as necessary to set additional Overcurrent functions.

SETTING 79 RECLOSER RELAY (THREE-PHASE GANGED) FROM THE HMI

1. Press **SETP** to wake the unit. The menu will advance to "SETPOINTS".

```
        SETPOINTS
<MNTR           CNFG>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
         PROFILE
<                    >
```

3. Press **MNTR** or **COMM** as necessary, until the "79 Recloser" screen is displayed.

```
      79 Recloser    P1
<                    >
```

   Ensure that the correct Profile to be edited is displayed in the upper right corner of the screen. If not, refer to the section "Selecting a Profile for Editing From the HMI".

4. Press **ENT** or **CNFG** once. The unit will display the following:

```
          79 ABC
<                    >
```

5. Press **ENT** or **CNFG** once. The unit will display the following:

```
Enable
DISABLE
```

6. Press **ENT**. The following will be displayed.

```
Enable
DISABLE
```

7. Utilizing the arrow pushbuttons select **ENABLE** then press **ENT**. The following will be displayed.

```
Enable
ENABLE
```

8. Press **CNFG** as necessary, until the "Ground Precedence" dialog screen is displayed.

```
Ground Precedence
DISABLE
```

9. Press **ENT**. The following will be displayed.

```
Ground Precedence
DISABLE
```

10. Utilizing the arrow pushbuttons select **ENABLE** or **DISABLE**, then press **ENT**. The following will be displayed reflecting the setting that was entered.

```
Ground Precedence
DISABLE or ENABLE
```

11. Press **CNFG** as necessary, to access the remaining 79 ABC settings screens. Follow the above procedure to setup the following:
    - Sequence Coordination (None, 1, 2 or 3)
    - Maximum Number of Phase Trips (1 to 5)
    - Maximum Number of Ground Trips (1 to 5)
    - Reset Time after Auto Reclose (1 to 1800 seconds)
    - Reset Time from Lockout (0 to 1800 seconds)
    - Phase Fault Time Delay for Reclose #1 through #4 (0.01 to 600.00 seconds)
    - Ground Fault Time Delay for Reclose #1 through #4 (0.01 to 600.00 seconds)

12. Press **ENT** as necessary to navigate back through the menu hierarchy.

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6 Testing

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6.1 Equipment/Test Setup

No calibration is necessary, as the M-7651A D-PAC System is calibrated and fully tested at the factory. If calibration is necessary because of a component replacement, follow the auto calibration procedure detailed in Section 6.3 Auto Calibration. These test procedures are based on the prerequisite that the functions are enabled and have settings as described in **Chapter 5, Setpoints**.

Equipment Required

The following equipment is required to perform the test procedures:

1. Two Digital Multimeters (DMM) with 10 A current range.
2. 120 Vac or 0 to 125 Vdc variable supply for system power.
3. Three-phase independent voltage sources (0 to 250 V) variable phase to simulate VT inputs.
4. Three-phase independent current sources (0 to 25 A) variable phase to simulate CT inputs.
5. Electronic timer accurate to at least 8 ms.

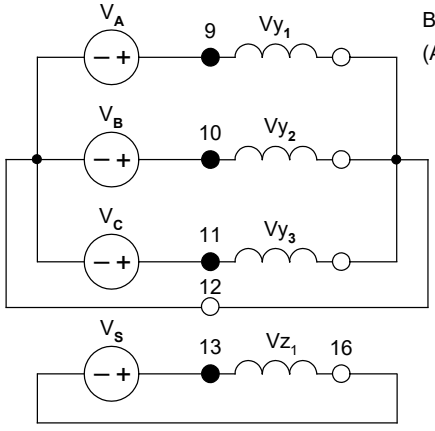
Setup

1. Connect system power to the power input terminals on TB3. The relay provides a choice of two main power supply input ranges: a low voltage range of 18 to 60 Vdc and a high range of 90 to 280 Vac or 90 to 315 Vdc.

■**NOTE:** The proper voltage for the relay is clearly marked on the power supply label affixed to the rear panel.

2. For each test procedure, connect the voltage and current sources according to the configuration listed in the test procedure and follow the steps outlined.

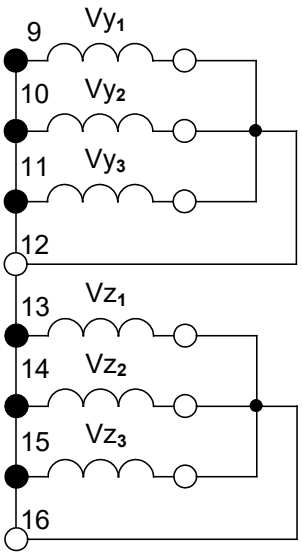
■**NOTE:** The phase angles shown here use leading angles as positive and lagging angles as negative. Some manufacturers of test equipment have used lagging angles as positive, in which case V_B=120 V ∠120° and V_C=120 V ∠240°. Similarly other voltages and currents phase angles should be adjusted. These test configurations are for ABC phase rotation. They must be adjusted appropriately for ACB phase rotation.



Balanced Voltage
(ABC Phase Rotation)

$V_A = |V_{TEST}| \angle 0°$ Volts
$V_B = |V_{TEST}| \angle -120°$ Volts
$V_C = |V_{TEST}| \angle +120°$ Volts
V_S = Varies Depending upon test

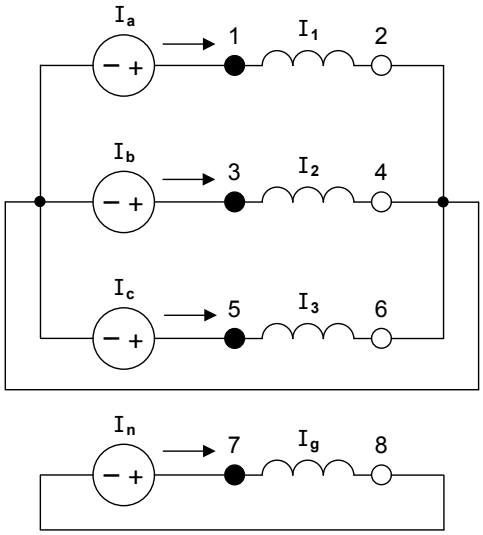
Figure 6-1 Voltage Inputs: Configuration V1



■ **NOTE**: If the Relay is purchased with four voltage inputs, the Vz_1 is the Sync voltage input.

If the Relay is purchased with six voltage inputs, then the user can select which Phase is for Sync. For example Vz_1, Vz_2, or Vz_3.

Figure 6-2 Voltage Inputs: Configuration V2



Balanced Current
(ABC Phase Rotation)

$I_a = |I_{TEST}| \angle 0°$ Amps

$I_b = |I_{TEST}| \angle -120°$ Amps

$I_c = |I_{TEST}| \angle +120°$ Amps

I_n = Varies Depending upon test

Figure 6-3 Current Inputs: Configuration C1

6.2 Functional Test Procedures

This section details the test quantities, inputs and procedures for testing each function of the relay. The purpose is to confirm the function's designated output operation, the accuracy of the magnitude pickup settings, and the accuracy of time delay settings. Whereas the first test described, "Power On Self Test," does not require electrical quantity inputs, all other functional tests require inputs, and the necessary connection configurations are shown. Time Current equations are illustrated in the individual function tests where applicable.

In all test descriptions, a process for calculating input quantities to test the actual settings of the function will be given if needed.

▲**CAUTION:** Care must be taken to reset or re-enable any functions that have been changed from the intended application settings when the test procedures are complete. When a function is re-enabled, both output arrangements and blocking input designations must be reestablished.

In many test cases, it will be necessary to disable other functions not being tested at the time. This action is to prevent the operation of multiple functions. The complete description of the method to disable/enable functions and the method to enter setting quantities is found in detail in **Chapter 5 Setpoints**.

It is desirable to ***record and confirm*** the actual settings of the individual functions before beginning test procedures. The Relay I/O Configuration Worksheet is contained in **Appendix B**. The worksheet is provided to define and record the blocking inputs and output configuration for the relay.

During the lifetime of the relay, testing of individual functions due to changes in application settings will be more likely than an overall testing routine. An index of the individual test procedures is at the beginning of this chapter.

It may be desirable to program all test settings in an alternate settings profile, or to save the relay settings in IPScom to preserve a desired setup.

Many options for test sequences and methods are possible. As an example, the operation of the output contacts can be tested along with the operation of the LED's in the Diagnostic Test Procedures. The operation of the output contacts may also be confirmed with the LED and function operation during **Functional Test Procedures**, if desired.

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Figure 6-4.

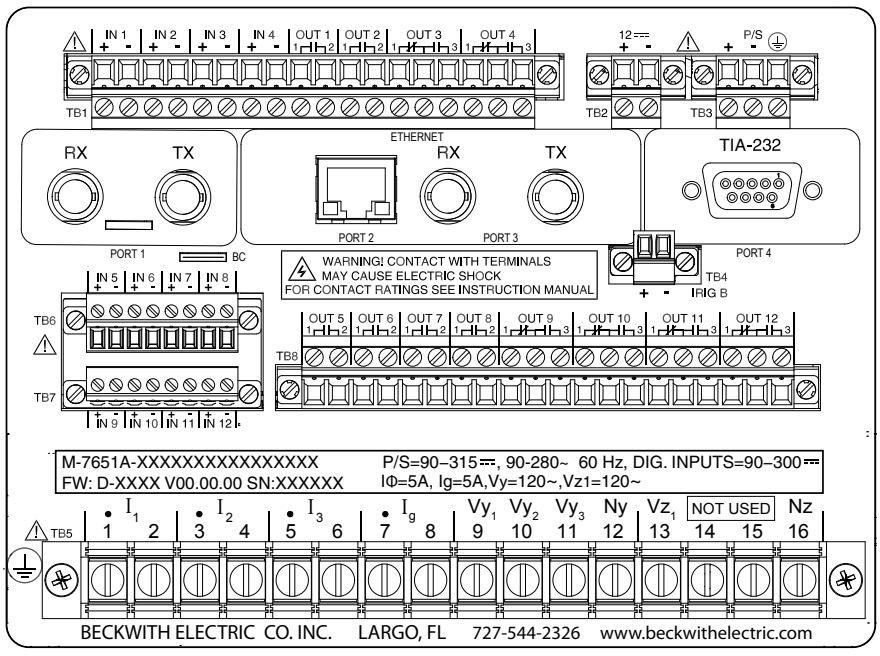


Figure 6-4 External Connections

POWER ON SELF TESTS

VOLTAGE INPUTS: none

CURRENT INPUTS: none

1. Apply proper power to the power input terminals.
2. The following sequence of actions will take place in the following order:
   a. Each time the relay is powered up, it will briefly display a series of screens that include:
      - Initializing
      - Loading Configuration
      - Loading DSP
      - User Lines Screen Blanking

   b. Self-Diagnostic Tests:
      - Both DSP and Host processors perform an entire sdram test upon booting up. The DSP will test the entire RAM. If any error is detected, the DSP processor will halt and prevent any further loading of the DSP program. This will be indicated by the host as a DSP communication error.
      - The host processor performs a similar memory test over its entire RAM. Any error will stop the program loading processor. This will be indicated by the host displaying a memory error message on the LCD.
      - An eeprom integrity test is also performed on power up.
      - The host will also check if the internal flash drive is formatted. If it is not, it will display an error message on the LCD and also generate a communication error flag to indicate to IPScom or any client that an unformatted media drive exists.

   c. Run-time Diagnostic Tests:
      - The host and the DSP compute the checksum over the settings space of each individual memory. The host will then compare its calculated checksum against that of the DSP calculated checksum. If an error is found, the host will display an appropriate alarm message on the LCD and also set an internal error flag that can be used to generate an event.
      - Intra-board communications errors will be reported as soon as they are detected.

25 SYNC CHECK

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Undervoltage Permission

Dead Line-Dead Bus (DLDB)		Dead Line-Live Bus (DLLB)	Live Line-Dead Bus (LLDB)	
Live Line Min. Voltage	**LM**	0.0 to 200.0 V	Volts	± 0.2 V or ± 0.5%
Live Bus Min. Voltage	**BM**	0.0 to 200.0 V	Volts	± 0.2 V or ± 0.5%
Sync Check Permission				
Max/Min Time Delay	**SD**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Maximum Voltage	**25U**	10.0 to 300.0 V	Volts	± 0.2 V or ± 0.5%
Minimum Voltage	**25L**	10.0 to 300.0 V	Volts	± 0.2 V or ± 0.5%
Angle Difference	**PA**	0.00° to 90.00°	Degrees	± 0.3°
Magnitude Difference	**DV**	0.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Frequency Difference	**DF**	0.00 to 5.00 Hz	Hertz	± 0.02 Hz
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 25 function.

Test Setup:

1. Determine the 25 Sync Check settings to be tested. Refer to Sync Check Logic Diagram (Figure 5-10).
2. Enter the 25 Sync Check settings to be tested using the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. The 25 function requires one voltage input for V_{sync} (Line) and one voltage input for the reference (Bus). The reference (Line) is either a Line-to-Ground or Line-to-Line voltage depending on the VT configuration.

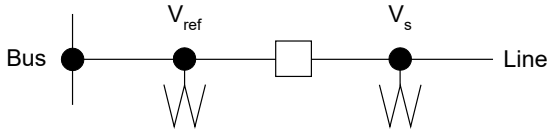
   This test procedure refers to V_{ref} (Bus) as the reference voltage and V_{sync} (Line) as the source voltage.
6. Apply nominal voltage to V_{ref} (Bus) and V_{sync} (Line).

Undervoltage Permission Tests:

■**NOTE:** Apply each of these tests for the permissions that are enabled.

Use IPScom Communications Software to monitor the 25 function status.

Nominal Voltage =	V_{nom}
Line =	Sync
Bus =	Ref



- ***Dead Line-Dead Bus***

1. Slowly decrease V_{ref} and V_{sync} magnitude until V_{ref} is less than **BM** and V_{sync} is less than **LM**. The **25 SYNC CHECK** green virtual LED will illuminate.
2. Increase V_{ref} and V_{sync} to the nominal voltage. The 25 green virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

- ***Dead Line-Live Bus***

1. Slowly decrease V_{ref} magnitude until it is less than **BM**. The 25 green virtual LED will illuminate.
2. Increase V_{ref} to the nominal voltage. The 25 green virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

- ***Live Line-Dead Bus***

1. Slowly decrease V_{sync} magnitude until it is less than **LM**. The 25 green virtual LED will illuminate.
2. Increase V_{sync} to the nominal voltage. The 25 green virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Phase Angle Limit Test:

1. Establish a Phase Angle Difference between V_{ref} and V_{sync} greater than **PA** +5°.
2. Use IPScom Communications Software to monitor the 25 function status. Slowly decrease the phase angle difference until the 25 green virtual LED illuminates. The phase angle difference should be equal to **PA** ±0.3°.
3. Increase the phase angle difference until the 25 green virtual LED extinguishes.
4. Press the **RESET** pushbutton to reset targets.

Upper and Lower Voltage Limit Test:

1. Establish a Phase Angle Difference between V_{ref} and V_{sync} that is less than **PA**.
2. Use IPScom Communications Software to monitor the 25 function status. The 25 green virtual LED will illuminate.
3. Slowly increase the voltage magnitude of V_{sync}. The 25 green virtual LED will extinguish when V_{sync} is greater than **25U**.
4. Return V_{sync} to the nominal voltage. The 25 green virtual LED will illuminate.
5. Slowly decrease the voltage magnitude of V_{sync}. The 25 green virtual LED will extinguish when V_{sync} is less than **25L**.
6. Return V_{sync} to the nominal voltage. The 25 green virtual LED will illuminate.

Magnitude Difference Test:

1. Set V_{ref} to a value greater than V_{nom} + **DV** and V_{sync} equal to V_{nom}.
2. The 25 green virtual LED will extinguish.
3. Slowly decrease the magnitude of V_{ref} until the 25 green virtual LED illuminates. The magnitude of V_{ref} should be equal to or less than V_{nom} + **DV**.

Frequency Difference Test:

1. Apply nominal voltage to V_{ref} and V_{sync}. The phase angle difference should be less than **PA** and the Function 25 green virtual LED will be illuminated.
2. Slowly increase the frequency of V_{sync} until the 25 green virtual LED extinguishes. The frequency of V_{sync} should be just greater than **DF**.

27 PHASE UNDERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 27 function (27 #1 through 27 #4) to be tested.

Test Setup:

1. Determine the 27 Phase Undervoltage settings to be tested.
2. Enter the 27 Phase Undervoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 27 function status. Slowly decrease the Phase A input voltage until the **27 PHASE UNDERVOLTAGE** virtual LED illuminates. Repeat this step for Phase B and Phase C if the individual phase elements are enabled.

   The voltage level should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Increase the Phase A input voltage to the nominal voltage, the corresponding green Function 27 virtual LED in the Function Status Monitoring Screen will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately (**P** – 1) volts and start timing.

   The contacts will close after **D** seconds ± the accuracy range in the Test Settings above.
3. Repeat the Pickup Test and Time Test if necessary for Phase B and C.

27PP PHASE-TO-PHASE UNDERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■ **NOTE:** Only enable the 27PP function to be tested. This function can only be enabled when the VT configuration is Line-to-Ground.

Test Setup:

1. Determine the 27PP Phase-to-Phase Undervoltage settings to be tested.
2. Enter the 27PP Phase-to-Phase Undervoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 27 function status. Slowly decrease V_{AB} until the **27PP PHASE-TO-PHASE UNDERVOLTAGE** virtual green LED illuminates.

   The voltage level should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Increase V_{AB} to the nominal voltage, the corresponding green 27PP virtual LED in the Function Status Monitoring Screen will extinguish.
3. Press the **RESET** pushbutton to reset targets
4. Repeat these steps for V_{BC} and V_{CA}.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately (**P** – 1) volts and start timing.

   The contacts will close after **D** seconds ± the accuracy range in the Test Settings above.
3. Repeat the Pickup Test and Time Test if necessary for voltage inputs V_{BC} and V_{CA}.

27Vz1 UNDERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Enable only the 27Vz1 function to be tested.

Test Setup:

1. Determine the 27Vz1 Undervoltage settings to be tested.
2. Enter the 27Vz1 Undervoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1. Inject a single phase voltage into the Vz_1 voltage input.

Pickup Test:

1. Use IPScom Communications Software to monitor the 27Vz1 function status. Slowly decrease the Vz_1 input voltage until the **27Vz1 UNDERVOLTAGE** virtual green LED illuminates.

   The voltage level should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Increase the Vz_1 input voltage to the nominal voltage, the corresponding green 27Vz1 function virtual green LED in the Status Function Monitoring Screen will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately (**P** – 1) volts and start timing.

   The contacts will close after **D** seconds ± the accuracy range in the Test Settings above.

32 DIRECTIONAL POWER

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup	**P**	-3.00 to +3.00 PU	Watts or VArs	± 0.02 PU or ± 6%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	
VT Configuration	V1			
Directional Power Sensing		(Real/Reactive)		

■**NOTE:** Only enable the 32 function to be tested.

Test Setup:

1. Determine the 32 Directional Power settings to be tested.
2. Enter the 32 Directional Power settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

POSITIVE REAL POWER:

Pickup Test:

1. Verify the pickup setting is positive and the operating power is real.
2. Inject balanced nominal three-phase voltage.
3. Calculate test current magnitude as follows: $I_{TEST} = \frac{Pickup}{3 \bullet V_{nom}}$
4. Apply balanced three-phase current in-phase with the voltage.
5. Use IPScom Communications Software to monitor the 32 function status. Slowly increase current until Phases A, B and C, **32 DIRECTIONAL POWER** green virtual LEDs illuminate.

   The power level should be equal to **P** Watts ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Apply (**P** + 1) Watts and start timing.

   The output contact will close after **D** seconds ± the accuracy range in the Test Settings above.

NEGATIVE REAL POWER:

Pickup Test:

1. Verify the pickup setting is negative and the operating power is reactive.
2. Inject balanced nominal three-phase voltage.
3. Calculate test current magnitude as follows: $I_{TEST} = \frac{Pickup}{3 \bullet V_{nom}}$
4. Apply balanced three-phase current 180 degrees out of phase with the voltage.
5. Use IPScom Communications Software to monitor the 32 function status. Slowly increase current until Phases A, B and C, **32 DIRECTIONAL POWER** green virtual LEDs illuminate.

   The power level should be equal to **P** Watts ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Apply (**P** + 1) Watts and start timing.

   The output contact will close after **D** seconds ± the accuracy range in the Test Settings above.

POSITIVE REACTIVE POWER:

Pickup Test:

1. Verify the pickup setting is positive and the operating power is real.
2. Inject balanced nominal three-phase voltage.
3. Calculate test current magnitude as follows: $I_{TEST} = \frac{Pickup}{3 \bullet V_{nom}}$
4. Apply balanced three-phase current 90 degrees lagging the voltage.
5. Use IPScom Communications Software to monitor the 32 function status. Slowly increase current until Phases A, B and C, **32 DIRECTIONAL POWER** green virtual LEDs illuminate.

   The power level should be equal to **P** VArs ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Apply (**P** + 1) VArs and start timing.

   The output contact will close after **D** seconds ± the accuracy range in the Test Settings above.

NEGATIVE REACTIVE POWER:

Pickup Test:

1. Verify the pickup setting is negative and the operating power is reactive.
2. Inject balanced nominal three-phase voltage.
3. Calculate test current magnitude as follows: $I_{TEST} = \frac{Pickup}{3 \bullet V_{nom}}$
4. Apply balanced three-phase current 90 degrees leading the voltage.
5. Use IPScom Communications Software to monitor the 32 function status. Slowly increase current until Phases A, B and C, **32 DIRECTIONAL POWER** green virtual LEDs illuminate.

   The power level should be equal to **P** VArs ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Apply (**P** + 1) VArs and start timing.

   The output contact will close after **D** seconds ± the accuracy range in the Test Settings above.

40 LOSS OF FIELD
(ZONES 1 OR 2, ZONES 1 OR 2 WITH VOLTAGE CONTROL)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Circle Diameter 1 Amp CT Rating	**P**	(0.1 to 100) (0.5 to 500)	Ohms
Offset 1 Amp CT Rating	**O**	(-50 to 50) (-250 to 250)	Ohms
Time Delay	**D**	(1 to 8160)	Cycles
Voltage Control	**V**	(5 to 180)	Volts
Delay with VC		(1 to 8160)	Cycles
Directional Element	**E**	(0 to 20)	Degrees
Outputs	**Z**	(1 to 12)	OUT
VT Configuration	Line-Ground		

■**NOTE:** Disable the function with the higher reach (diameter minus offset) setting first (lower current) and test the lower reach setting operation.

Test Setup:

1. Determine the Function 40 Loss of Field settings to be tested.
2. Enter the Function 40 Loss of Field settings to be tested utilizing either the HMI or IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

   ■**NOTE:** For proper testing, use **I** ≤ 3 x CT rating.

6. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as **R ohms = (P - O ohms)** where **O** is usually negative.
   b. Define "trip current" as **I = (Selected Voltage ÷ R ohms)**. The voltage level may be selected based on the desired test current level.
   c. Define "offset current" as **IO = (Selected Voltage ÷ O ohms).**
7. Set the three-phase voltages V_A, V_B, and V_C to the **Selected Voltage** value from Step 6, and set the phase angle between the voltage and current inputs to 90° (current leading voltage).

Pickup Test:

1. Press and hold the **RESET** pushbutton, then slowly increase the three-phase currents until the **40 LOSS OF FIELD** pickup indicator illuminates on the IPScom Function Status screen. The level will be equal to "**I**" calculated in Test Setup Step 6 with the resulting impedance within ±0.1 ohms or ±5%.
2. If the offset setting is negative then continue to increase the three-phase currents until the **40 LOSS OF FIELD** pickup indicator extinguishes on the IPScom Function Status screen. The level will be equal to "**IO**" calculated in Test Setup Step 6 with the resulting offset impedance within ±0.1 ohms or ±5%.
3. Release the **RESET** pushbutton.
4. Decrease the three-phase currents. The **OUTPUT LED(**s) will extinguish.
5. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the contact **(Z)** closes.
2. Set the three-phase voltages V_A, V_B, and V_C to the **Selected Voltage** value from Test Setup Step 6, and set the phase angle between the voltage and current inputs to 90° (current leading voltage).
3. Apply **I** + 10% Amps and start timing. Contacts will close after **D** cycles ±1 cycle or ±1%.

Time Test With Voltage Control:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Enable the Voltage Control setting utilizing either the HMI or IPScom Communications Software.
3. Set the three-phase voltages V_A, V_B, and V_C to a voltage where the positive-sequence voltage is less than the Voltage Control setting.
4. Set phase currents and phase angles to establish the impedance value within the mho pickup and start timing. Contacts will close after **D** cycles ±1 cycle or ±1%.

46DT NEGATIVE-SEQUENCE DEFINITE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay		0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 46DT function (46DT #1 through 46DT #5) to be tested.

Test Setup:

1. Determine the 46DT Negative-Sequence Overcurrent settings to be tested.
2. Enter the 46DT Negative-Sequence Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 46DT function status, then slowly increase Current Input 1 until the **46DT NEGATIVE-SEQUENCE OVERCURRENT** virtual LED illuminates.

   ■**NOTE:** If current is injected into Current Input 1 only, then the negative-sequence current is equal to one third of the magnitude.

   The current level of operation will be (**P**) amps ± the accuracy range in the Test Settings above.
2. Decrease the current input. The corresponding green 46DT virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately 110% of **P** amps and start timing. The operating time will be ± the accuracy range in the Test Settings above.
3. Reduce Current Input 3, to 0 amps.

46IT NEGATIVE-SEQUENCE INVERSE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 3.20 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 16.00 A	Amps	± 0.1 A or ± 3%
Curve:				
IEC – Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.05 to 1.00		± 2 cycles or ± 5%
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.10 to 25.00		± 2 cycles or ± 5%
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse				
Time Multiplier	**K**	0.05 to 15.00		± 2 cycles or ± 5%
Traditional Recloser – 101 to 202				
Time Multiplier	**K**	0.10 to 2.00		± 2 cycles or ± 5%
Definite Time				
Time Multiplier	**K**	0.10 to 100.00		± 2 cycles or ± 5%
Time Adder	**A**	0.00 to 30.00 s	Seconds	± 0.01 s or ± 1%
Minimum Response Time Adder	**B**	0.00 to 1.00 s	Seconds	± 0.01 s or ± 1%

■**NOTE:** Only enable the 46IT function (46IT #1 through 46IT #5) to be tested.

Test Setup:

■**NOTE:** If current is injected into only one phase, then the relay will operate at one third the value.

For example:

$I_A = I_{TEST}$

$I_B = I_C = 0$

$$\therefore I_{OPERATE} = \frac{I_{TEST}}{3}$$

If you inject single phase current, it will require three times pickup to operate.

1. Determine the 46IT Negative-Sequence Inverse Time Overcurrent settings to be tested.
2. Enter the 46IT Negative-Sequence Inverse Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
5. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P** amps. It is suggested that the user select 4 or 5 test points to verify curve. See the note above regarding injecting a single phase current.

Pickup Test:

1. Use IPScom Communications Software to monitor the 46IT function status. Slowly increase the Phase A Current Input until the **46IT NEGATIVE-SEQUENCE INVERSE TIME OVERCURRENT** green virtual LED illuminates on the IPScom function status screen.

   The current level of operation will equal **3P** amps ± the accuracy range in the Test Settings above.

2. Reduce the Phase A Current Input to 0 amps. The 46IT green virtual LED will extinguish.

3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.

2. Apply current equal to the chosen test level calculated in Test Setup Step 5 to Phase A Current Input and start timing. Use S-7600 IPScom Communications Software to display the appropriate curve graph.

3. Select **Setup/Setpoints/46IT** and select "View Graph".

   Read the operating time from the appropriate Inverse Curve Family and **K** (Time Multiplier) setting graph. The accuracy specified is valid for currents above 1.5 times the pickup current.

4. Reduce Phase A Current Input to 0 amps.

5. Press the **RESET** pushbutton to reset targets.

6. Repeat Steps 2, 3 and 4 for each test level chosen.

47 NEGATIVE-SEQUENCE OVERVOLTAGE

VOLTAGE INPUTS: As described

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	0.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Definite Time	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

Test Setup:

1. Determine the 47 Negative-Sequence Overvoltage function settings to be tested.
2. Enter the 47 Negative-Sequence Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect balanced three-phase voltage as shown in Figure 6-1, Voltage Inputs: Configuration V1. Reverse the phase rotation (e.g., ACB if the relay is set for ABC phase rotation).

Pickup Test:

1. Use IPScom Communications Software to monitor the 47 function status. Apply balanced three-phase voltage.
2. Slowly increase the voltage magnitude until the **47 OVERVOLTAGE** virtual LED illuminates.

   The voltage level of operation should be equal to **P** volts ± the accuracy range in the Test Settings above.
3. Decrease the voltage magnitude until the corresponding green 47 virtual LED extinguishes.
4. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z**) so that the timer stops timing when the contacts **(Z)** close.
2. Apply balanced single-phase voltage with a magnitude equal to (P+1) volts and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.
3. Remove the voltage.

50P PHASE INSTANTANEOUS/DEFINITE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay		0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 50P function (50P #1 through 50P #5) to be tested.

Test Setup:

1. Determine the 50P Phase Instantaneous/Definite Time Overcurrent settings to be tested.
2. Enter the 50P Phase Instantaneous/Definite Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 50P function, then slowly increase Current Input 1 (Phase A) until the **50P PHASE OVERCURRENT** virtual LED illuminates.

   The current level of operation will be (**P**) amps ± the accuracy range in the Test Settings above.
2. Decrease the current input. The corresponding green 50P virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately 110% of **P** amps and start timing. The operating time will be ± the accuracy range in the Test Settings above.
3. Reduce Current Input 1 to 0 amps.
4. Test may be repeated using Current Inputs 1 (Phase A), 2 (Phase B), and 3 (Phase C) individually.

50N RESIDUAL INSTANTANEOUS/DEFINITE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: As described

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay		0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 50N function (50N #1 through 50N #5) to be tested.

Test Setup:

1. Determine the 50N Residual Instantaneous/Definite Time Overcurrent settings to be tested.
2. Enter the 50N Instantaneous/Definite Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1. The relay internally calculates I_N as follows: $I_N = I_1 + I_2 + I_3$. Therefore, if current is only injected into I_1 then $I_N = I_1$.

Pickup Test:

1. Use IPScom Communications Software to monitor the 50N Function, then slowly increase I_N until the **50N RESIDUAL OVERCURRENT** virtual LED illuminates.

   The current level of operation will be (**P**) amps ± the accuracy range in the Test Settings above.
2. Decrease the current input. The corresponding green 50N virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply approximately 110% of **P** amps to I_N and start timing. The operating time will be **D** cycles ± the accuracy range in the Test Settings above.
3. Reduce the current input to 0 amps.

50G GROUND INSTANTANEOUS/DEFINITE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: As described

TEST SETTINGS:

Pickup				
1 A Gnd CT	**P**	0.02 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A Gnd CT	**P**	0.10 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay		0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 50G function (50G #1 through 50G #5) to be tested.

The relay either provides ground or neutral overcurrent protection. This is selectable via the relay configuration. Ground current is measured from the relay current input I_G.

Test Setup:

1. Determine the 50G Ground Instantaneous/Definite Time Overcurrent settings to be tested.
2. Enter the 50G Ground Instantaneous/Definite Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect I_G test current input as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 50G function. Slowly increase the current input I_G until the **50G Ground Overcurrent** virtual LED illuminates. The current level of operation is (**P**) amps ± the accuracy range in the Test Settings above.
2. Decrease the current input. The corresponding green 50G virtual LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts (**Z**) so that the timer stops timing when the contacts (**Z**) close.
2. Apply approximately 110% of **P** Amps and start timing. The operating time will be ± the accuracy range in the Test Settings above.
3. Reduce the current to relay current input I_G to 0 Amps.

50GS SENSITIVE GROUND INSTANTANEOUS/DEFINITE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: As described

TEST SETTINGS:

Pickup				
10 mA Gnd CT	**P**	0.001 to 0.160 A	Amps	(TBD)
50 mA Gnd CT	**P**	0.005 to 0.800 A	Amps	0.0015 A or ± 3%
200 mA Gnd CT	**P**	0.020 to 2.500 A	Amps	(TBD)
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 50GS function (50GS #1 through 50GS #5) to be tested.

The relay either provides ground or neutral overcurrent protection. This is selectable via the relay configuration. Ground current is measured from the relay current input I_G.

Test Setup:

1. Determine the 50GS Sensitive Ground Instantaneous/Definite Time Overcurrent settings to be tested.
2. Enter the 50GS Sensitive Ground Instantaneous/Definite Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect I_G test current input as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 50GS function status. Slowly increase the current input I_G until the **50GS Sensitive Ground Overcurrent** virtual green LED illuminates. The current level of operation is (**P**) amps ± the accuracy range in the Test Settings above.
2. Decrease the current input. The corresponding green 50GS virtual green LED will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts (**Z**) so that the timer stops timing when the contacts (**Z**) close.
2. Apply approximately 110% of **P** Amps and start timing. The operating time will be ± the accuracy range in the Test Settings above.
3. Reduce the current to relay current input I_G to 0 Amps.

50BF BREAKER FAILURE

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
Phase Current				
1 A CT	**P**	0.02 to 2.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 10.00 A	Amps	± 0.1 A or ± 3%
Residual/ Ground Current				
1 A CT	**R**	0.02 to 2.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**R**	0.10 to 10.00 A	Amps	± 0.1 A or ± 3%
Time Delay (BF)	**D2**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Retrip Delay	**D1**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Retrip Output	**RT**	(1 to 12)	OUT	
Breaker Failure Output	**BF**	(1 to 12)	OUT	
Input	**BFI**		IN	

■ **NOTE:** Only enable the 50BF function.

Test Setup:

1. Determine the 50BF Breaker Failure settings to be tested.
2. Enter the 50BF Breaker Failure settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 50BF function status. Apply balanced three-phase current and assert the **BFI** Input.
2. Slowly increase the current magnitude until the **50BF BREAKER FAILURE** green virtual LED illuminates.

   The current level of operation will be (**P**) amps ± the accuracy range in the Test Settings above.
3. Repeat this test injecting residual current if the residual overcurrent element (50R) is enabled.

Time Test:

RETRIP:

1. Connect a timer to output contact **(RT)** so that the timer stops timing when the contact **(RT)** closes.
2. Assert the **BFI** Input.
3. The Retrip output **(RT)** will close after **D1** Seconds ± the accuracy range in the Test Settings above.

BREAKER FAILURE:

1. Connect a timer to output contact **(BF)** so that the timer stops timing when the contact **(BF)** closes.
2. Assert the **BFI** Input.
3. Inject balanced current with a magnitude equal to **(P + 1)** Amps and start timing. The Breaker Failure output **(BF)** will close after **D2** Seconds ± the accuracy range in the Test Settings above.

51P PHASE INVERSE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 3.20 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 16.00 A	Amps	± 0.1 A or ± 3%
Curve:				
IEC – Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.05 to 1.00		± 2 cycles or ± 5%
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.10 to 25.00		± 2 cycles or ± 5%
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse				
Time Multiplier	**K**	0.05 to 15.00		± 2 cycles or ± 5%
Traditional Recloser – 101 to 202				
Time Multiplier	**K**	0.10 to 2.00		± 2 cycles or ± 5%
Definite Time				
Time Multiplier	**K**	0.10 to 100.00		± 2 cycles or ± 5%
Time Adder	**A**	0.00 to 30.00 s	Seconds	± 0.01 s or ± 1%
Minimum Response Time Adder	**B**	0.00 to 1.00 s	Seconds	± 0.01 s or ± 1%
Voltage Control	**VC**	4.0 to 150.0	%	TBD
Voltage Restraint	**VR**	4.0 to 150.0	%	TBD

■**NOTE:** Only enable the 51P function (51P #1 through 51P #5) to be tested.

Test Setup:

1. Determine the 51P Phase Inverse Time Overcurrent settings to be tested.
2. Enter the 51P Phase Inverse Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
5. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P Amps**. It is suggested that the user select 4 or 5 test points to verify curve.

Pickup Test:

1. Use IPScom Communications Software to monitor the 51P function status. Slowly increase the Phase A current input until the **51P PHASE INVERSE TIME OVERCURRENT** green virtual LED illuminates on the IPScom Function Status screen.

   The current level of operation will equal **P** amps ± the accuracy range in the Test Settings above.
2. Reduce the Phase A Current Input to 0 amps. The 51P green virtual LED(s) will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply current equal to the chosen test level calculated in Test Setup Step 5 to Phase A current input and start timing. Use IPScom Communications Software to display the appropriate curve graph.
3. Select **Setup/Setpoints/51P** and select "View Graph".

   The operating time will be as read from the appropriate Inverse Curve Family and **K** (Time Multiplier) setting graph. The accuracy specified is valid for currents above 1.5 times the pickup current.
4. Reduce Phase A current input to 0 amps.
5. Press the **RESET** pushbutton to reset targets.
6. Repeat Steps 2, 3 and 4 for each test level chosen.

51P WITH VOLTAGE CONTROL OR VOLTAGE RESTRAINT

■**NOTE:** Only test Voltage Control or Voltage Restraint if either setting is enabled.

Voltage Control Test:

1. Enable 51P Voltage Control utilizing either the HMI or S-7600 IPScom Communications Software.
2. Apply balanced three-phase nominal voltage.
3. Press and hold the **RESET** pushbutton, then slowly increase the Phase Current Input until the **PHASE OVERCURRENT 51P** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
4. Release the **RESET** pushbutton.
5. When the assigned **OUTPUT** LED(s) illuminates then decrease the Input Voltage to **VC** Volts. The assigned **OUTPUT** LED(s) will extinguish at **VC** Volts ± the accuracy range in the Test Settings above.
6. Press the **RESET** pushbutton to reset targets.
7. Reduce Phase Current Input to 0 amps.
8. Increase the Input Voltage to **Nominal Voltage**.

Voltage Restraint Test:

1. Enable 51P Voltage Restraint utilizing either the HMI or S-7600 IPScom Communications Software.
2. Apply balanced three-phase nominal voltage.
3. Set **P** Amps equal to 2 Amps utilizing either the HMI or IPScom Communications Software.
4. Apply current equal to 1.5 Amps to the Phase Current Input.
5. Decrease the Input Voltage to 75% of **Nominal Voltage**. The **PHASE OVERCURRENT 51P** LED will illuminate, or the pickup indicator will illuminate on the IPScom Function Status screen.
6. Repeat Steps 2, 3 and 4 with reduced input voltage values and current reduced by the same percentage as value (see Figure 5-30 51P Voltage Restraint Characteristic).

51P LOAD ENCROACHMENT LOGIC (LEL)

■**NOTE:** This procedure demonstrates how to test 51P when Load Encroachment Logic (LEL) is enabled.

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Forward Impedance	Z_F	1 to 200 Ohms
Reverse Impedance	Z_R	1 to 200 Ohms
Maximum Positive Angle Forward	δ_{+F}	-90 to 90 Degrees
Maximum Negative Angle Forward	δ_{-F}	-90 to 90 Degrees
Maximum Positive Angle Reverse	δ_{+R}	90 to 270 Degrees
Maximum Negative Angle Reverse	δ_{-R}	90 to 270 Degrees

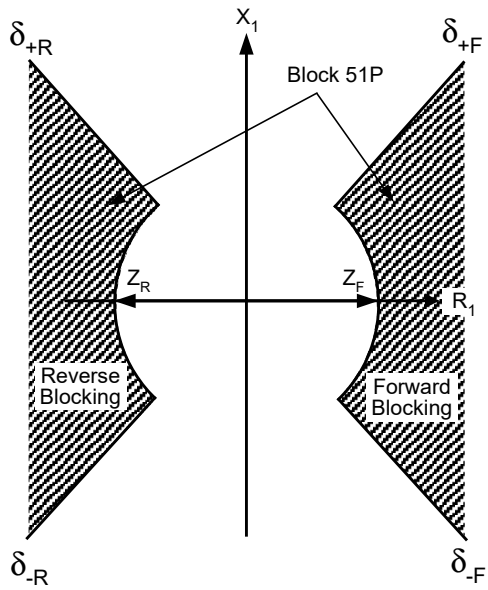


Figure 6-5 Load Encroachment Block Characteristic

■**NOTE:** Apply balanced three-phase voltage and current when testing LEL. LEL operates on the positive-sequence impedance (Z_1) measured by the relay. LEL will block 51P if Z_1 is within the forward or reverse blocking characteristics.

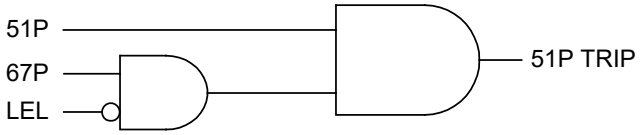


Figure 6-6 Load Encroachment Logic Diagram

■**NOTE:** When LEL is enabled, one level Phase Directional Overcurrent element (67P #1 – 67P #5) must be selected to supervise 51P. 51P will not trip unless the selected 67P element is picked up and has timed out. Refer to the 67P section later in this chapter, for detailed steps to test the 67P function.

51N RESIDUAL INVERSE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 3.20 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 16.00 A	Amps	± 0.1 A or ± 3%
Curve:				
IEC – Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.05 to 1.00		± 2 cycles or ± 5%
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.10 to 25.00		± 2 cycles or ± 5%
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse				
Time Multiplier	**K**	0.05 to 15.00		± 2 cycles or ± 5%
Traditional Recloser – 101 to 202				
Time Multiplier	**K**	0.10 to 2.00		± 2 cycles or ± 5%
Definite Time				
Time Multiplier	**K**	0.10 to 100.00		± 2 cycles or ± 5%
Time Adder	**A**	0.00 to 30.00 s	Seconds	± 0.01 s or ± 1%
Minimum Response Time Adder	**B**	0.00 to 1.00 s	Seconds	± 0.01 s or ± 1%

■ **NOTE:** The neutral operating current must be selected to $3I_0$. The relay operates on the sum of the phase currents, that is, $I_N = I_A + I_B + I_C$.

■ **NOTE:** Only enable the 51N function (51N #1 through 51N #5) to be tested.

Test Setup:

1. Determine the 51N Residual Inverse Time Overcurrent settings to be tested.
2. Enter the 51N Residual Inverse Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1. Only inject current in the Phase A current input.
5. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P** amps. It is suggested that the user select 4 or 5 test points to verify curve.

Pickup Test:

1. Use IPScom Communications Software to monitor the 51N function status. Slowly increase the Phase A current input until the **51N RESIDUAL INVERSE TIME OVERCURRENT** green virtual LED illuminates on the IPScom Function Status screen.

   The current level of operation will equal **P** amps ± the accuracy range in the Test Settings above.
2. Reduce the Phase A current input to 0 amps. The 51N green virtual LED(s) will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply current equal to the chosen test level calculated in Test Setup Step 5 to Phase A current input and start timing. Use IPScom Communications Software to display the appropriate curve graph.
3. Select **Setup/Setpoints/51N** and select "View Graph".

   Read the operating time from the appropriate Inverse Curve Family and **K** (Time Multiplier) setting graph. The accuracy specified is valid for currents above 1.5 times the pickup current.
4. Reduce Phase A current input to 0 amps.
5. Press the **RESET** pushbutton to reset targets.
6. Repeat Steps 2, 3 and 4 for each test level chosen.

51G GROUND INVERSE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
1 A CT	**P**	0.02 to 3.20 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.10 to 16.00 A	Amps	± 0.1 A or ± 3%
Curve:				
IEC – Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.05 to 1.00		± 2 cycles or ± 5%
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.10 to 25.00		± 2 cycles or ± 5%
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse				
Time Multiplier	**K**	0.05 to 15.00		± 2 cycles or ± 5%
Traditional Recloser – 101 to 202				
Time Multiplier	**K**	0.10 to 2.00		± 2 cycles or ± 5%
Definite Time				
Time Multiplier	**K**	0.10 to 100.00		± 2 cycles or ± 5%
Time Adder	**A**	0.00 to 30.00 s	Seconds	± 0.01 s or ± 1%
Minimum Response Time Adder	**B**	0.00 to 1.00 s	Seconds	± 0.01 s or ± 1%

■ **NOTE:** Only enable the 51G function (51G #1 through 51G #5) to be tested.

■ **NOTE:** The ground current (I_g) input must be selected as the neutral operating current.

Test Setup:

1. Determine the 51G Ground Inverse Time Overcurrent settings to be tested.
2. Enter the 51G Ground Inverse Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current input as shown in Figure 6-3, Current Inputs: Configuration C1. Inject current into the ground current input (I_g).
5. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P** amps. It is suggested that the user select 4 or 5 test points to verify curve.

Pickup Test:

1. Use IPScom Communications Software to monitor the 51G function status. Slowly increase the ground current input until the **51G GROUND INVERSE TIME OVERCURRENT** green virtual LED illuminates on the IPScom Function Status screen.

   The current level of operation will equal **P** amps ± the accuracy range in the Test Settings above.
2. Reduce the ground current input to 0 amps. The 51G green virtual LED(s) will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply current equal to the chosen test level calculated in Test Setup Step 5 to ground current input and start timing. Use IPScom Communications Software to display the appropriate curve graph.
3. Select **Setup/Setpoints/51G** and select "View Graph".

   Read the operating time from the appropriate Inverse Curve Family and **K** (Time Multiplier) setting graph. The accuracy specified is valid for currents above 1.5 times the pickup current.
4. Reduce ground current input to 0 amps.
5. Press the **RESET** pushbutton to reset targets.
6. Repeat Steps 2, 3 and 4 for each test level chosen.

51GS SENSITIVE GROUND INVERSE TIME OVERCURRENT

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup				
10 mA Gnd CT	**P**	0.001 to 0.160 A	Amps	(TBD)
50 mA Gnd CT	**P**	0.005 to 0.800 A	Amps	0.0015 A or ± 3%
200 mA Gnd CT	**P**	0.020 to 2.500 A	Amps	(TBD)
Curve:				
IEC – Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.05 to 1.00		± 2 cycles or ± 5%
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse				
Time Multiplier	**K**	0.10 to 25.00		± 2 cycles or ± 5%
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse				
Time Multiplier	**K**	0.05 to 15.00		± 2 cycles or ± 5%
Traditional Recloser – 101 to 202				
Time Multiplier	**K**	0.10 to 2.00		± 2 cycles or ± 5%
Definite Time				
Time Multiplier	**K**	0.10 to 100.00		± 2 cycles or ± 5%
Time Adder	**A**	0.00 to 30.00 s	Seconds	± 0.01 s or ± 1%
Minimum Response Time Adder	**B**	0.00 to 1.00 s	Seconds	± 0.01 s or ± 1%

■**NOTE:** Only enable the 51GS function (51GS #1 through 51GS #5) to be tested.

■**NOTE:** The ground current (I_g) input must be selected as the neutral operating current.

Test Setup:

1. Determine the 51GS Sensitive Ground Inverse Time Overcurrent settings to be tested.
2. Enter the 51GS Sensitive Ground Inverse Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1. Inject current into the ground current input (I_g).
5. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P Amps**. It is suggested that the user select 4 or 5 test points to verify curve.

Pickup Test:

1. Use IPScom Communications Software to monitor the 51GS function status. Slowly increase the ground current input until the **51GS SENSITIVE GROUND INVERSE TIME OVERCURRENT** green virtual LED illuminates on the IPScom Function Status screen.

   The current level of operation will equal **P** amps ± the accuracy range in the Test Settings above.
2. Reduce the ground current input to 0 amps. The 51GS green virtual LED(s) will extinguish.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply current equal to the chosen test level calculated in Test Setup Step 5 to ground current input and start timing. Use IPScom Communications Software to display the appropriate curve graph.
3. Select **Setup/Setpoints/51GS** and select "View Graph".

   Read the operating time from the appropriate Inverse Curve Family and **K** (Time Multiplier) setting graph. The accuracy specified is valid for currents above 1.5 times the pickup current.
4. Reduce ground current input to 0 amps.
5. Press the **RESET** pushbutton to reset targets.
6. Repeat Steps 2, 3 and 4 for each test level chosen.

59P PHASE OVERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Input Voltage Select			(Phase)	
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 59P function (59P #1 through 59P #4) to be tested.

Test Setup:

1. Determine the 59P Phase Overvoltage settings to be tested.
2. Enter the 59P Phase Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 59P function status. Apply balanced three-phase voltage and then slowly increase the voltage magnitude until the **59P PHASE OVERVOLTAGE** virtual LED illuminates.

   The voltage level of operation should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Decrease the voltage magnitude until the corresponding green 59P virtual LED extinguishes.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply balanced three-phase voltage with a magnitude equal to (**P**+1) volts and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.
3. Reduce the voltage input to nominal voltage.

59PP PHASE-TO-PHASE OVERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup (line-to-line)	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Input Voltage Select			(Phase)	
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 59PP function to be tested. 59PP can only be enabled when the VT configuration is Line-to-Ground.

Test Setup:

1. Determine the 59PP Phase-to-Phase Overvoltage settings to be tested.
2. Enter the 59PP Phase-to-Phase Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 59PP Phase-to-Phase function status. Apply balanced three-phase voltage and then slowly increase the voltage magnitude until the **59PP PHASE-TO-PHASE OVERVOLTAGE** virtual green LED illuminates.

   The voltage level (line-to-line) of operation should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Decrease the voltage magnitude until the corresponding green 59PP virtual green LED extinguishes.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply balanced three-phase voltage with a magnitude equal to (**P**+1) volts and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.
3. Reduce the voltage input to Nominal Voltage.

59I PEAK OVERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	100 to 150 %	% of nominal voltage	± 3%
Time Delay	**D**	0.01 to 140.00 s	Seconds	± 0.05 s
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 59I function.

Test Setup:

1. Determine the 59I Peak Overvoltage settings to be tested.
2. Enter the 59I Peak Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 59I function status. Apply balanced three-phase second harmonic voltage (i.e., 100 Hz at 50 Hz nominal or 120 Hz at 60 Hz nominal) and then slowly increase the voltage magnitude until the **59I PEAK OVERVOLTAGE** virtual green LED illuminates.

   The voltage magnitude should be equal to **P** % ± the accuracy range in the Test Settings above.
2. Decrease the voltage magnitude until the corresponding green 59I virtual green LED extinguishes.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply (**P**+5) % and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.

59N RESIDUAL OVERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Input Voltage Select			(Phase)	
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 59N function.

■**NOTE:** 59N operates on the internally calculated value $3V_0$ (i.e., $V_A + V_B + V_C$).

Test Setup:

1. Determine the 59N Residual Overvoltage settings to be tested.
2. Enter the 59N Residual Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 59N residual function status. Apply single-phase voltage to V_A input and then slowly increase the voltage magnitude until the **59N RESIDUAL OVERVOLTAGE** virtual green LED illuminates.

   The voltage level of operation should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Decrease the voltage magnitude until the corresponding green 59N virtual green LED extinguishes.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply single-phase voltage to V_A input with a magnitude equal to (**P**+1) volts and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.
3. Reduce the voltage input to zero.

59Vz1 OVERVOLTAGE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	10.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Input Voltage Select			(Phase)	
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 59Vz1 function to be tested.

Test Setup:

1. Determine the 59Vz1 Overvoltage settings to be tested.
2. Enter the 59Vz1 Overvoltage settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

Pickup Test:

1. Use IPScom Communications Software to monitor the 59Vz1 function status. Apply single phase voltage to the Vz_1 input and then slowly increase the voltage magnitude until the **59Vz1 OVERVOLTAGE** virtual green LED illuminates.

   The voltage level of operation should be equal to **P** volts ± the accuracy range in the Test Settings above.
2. Decrease the voltage magnitude until the corresponding green 59Vz1 virtual green LED extinguishes.
3. Press the **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply single phase voltage to the Vz_1 input with a magnitude equal to (**P**+1) volts and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above.
3. Reduce the voltage input to nominal voltage.

60FL VT FUSE LOSS DETECTION

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Time Delay	**D**	0.03 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** It is necessary for "FL" to be designated as an initiating input (see Section 5.1 **System Setpoints**) in order to test this function.

Test Setup:

1. Determine the 60FL VT Fuse Loss Detection settings to be tested.
2. Enter the 60FL VT Fuse Loss Detection settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software. (FL initiate must be selected for this test.)
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
6. Inject nominal balanced three-phase voltage.

LOSS OF ONE PHASE VOLTAGE

Pickup Test:

1. Remove voltage from the V_A input. The **60FL** green virtual LED will illuminate on the IPScom Communications Software function status screen.
2. Restore voltage to the V_A input then press the **RESET** button to reset the targets.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Repeat Step 1 from the Pickup Test.

   The operating time will be **D** seconds ± the accuracy range in the Test Settings above.
3. Repeat Step 2 from the Pickup Test.

LOSS OF ALL THREE-PHASE VOLTAGES

Pickup Test:

1. Inject fifteen percent nominal balanced current.
2. Simultaneously remove voltage from all three voltage inputs V_A, V_B and V_C. The **60FL** green virtual LED will illuminate on the IPScom Communications Software function status screen.
3. Restore voltage to the V_A, V_B and V_C inputs.
4. Press the **RESET** button to reset the targets.

Time Test:

1. Connect a timer to output contact **(Z)** so that the timer stops timing when the output contact closes.
2. Repeat Step 1 from the Pickup Test.

   The operating time will be **D** seconds ± the accuracy range in the Test Settings above.
3. Repeat Step 2 from the Pickup Test.

67P DIRECTIONAL PHASE OVERCURRENT

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Direction		(No-Direction, Directional)		
Polarization Voltage		V_1		
Max. Sensitivity Angle	**MSA**	0° to 359°	Degrees	
Angle Band + –		5° to 90°	Degrees	
Pickup				
1 A CT	**P**	0.05 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.25 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Min. Polarization Voltage	**VMIN**	2.0 to 10.0 %	% V_{nom}	± 3%
Action if $V_{pol} < V_{min}$		(Block Trip, Trip)		
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 67P function (67P #1 through 67P #5) to be tested.

Test Setup:

1. Determine the 67P Directional Instantaneous/Definite Time Overcurrent settings to be tested.
2. Enter the 67P Directional Instantaneous/Definite Time Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Directional Pickup Test:

1. Refer to Figure 6-7 (forward looking) or Figure 6-8 (reverse looking) to perform this test.
2. Use IPScom Communications Software to monitor the 67P function.
3. Apply balanced nominal three-phase voltage.
4. Apply single phase current for the selected operating current (e.g., I_a) equal to 150 percent of the pickup **P** at an angle with respect to the polarizing voltage outside of the operate zone.
5. Slowly rotate the current in the positive phase direction until the **67P Directional Phase Overcurrent** virtual green LED illuminates.

   The angle of operation will be equal to **MSA** ± 90° (See Figure 6-7 and Figure 6-8).
6. Slowly decrease the current magnitude until the 67P virtual green LED extinguishes. The current level of dropout will be just less than **P** ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Increase the current magnitude to 150 percent of pickup **P** and start timing. The contacts will close after **D** seconds ± the accuracy range in the Test Settings above. The test current must be in the trip region of the directional characteristic.
3. If Inverse Time Overcurrent is selected, refer to the test section 51P for test instructions.

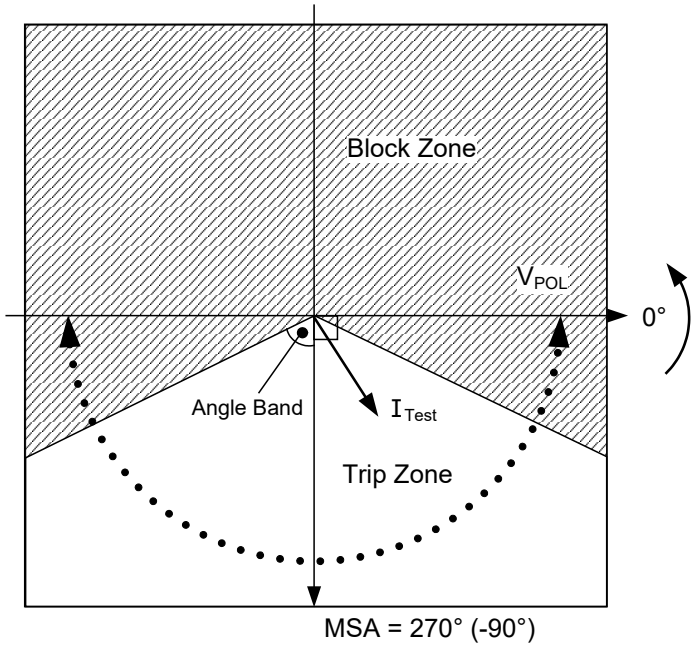


Figure 6-7 Function 67 Directional Trip Characteristic (Forward Looking)

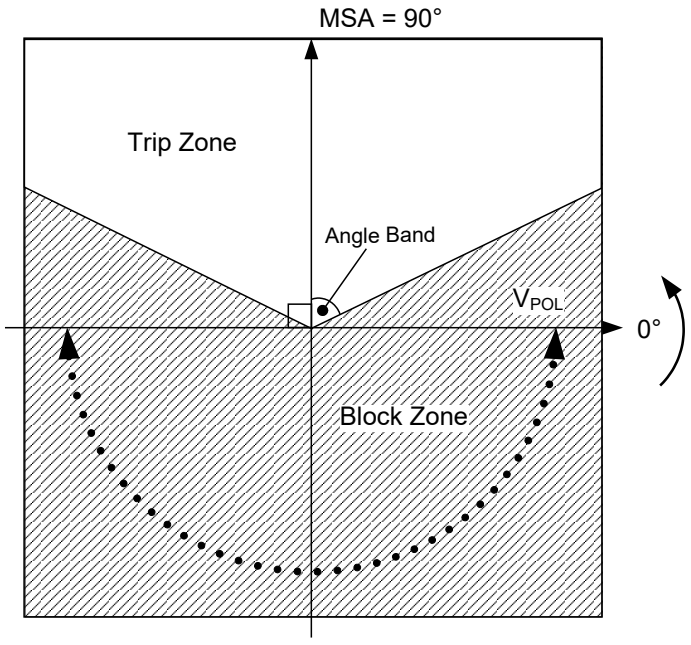


Figure 6-8 Function 67 Directional Trip Characteristic (Reverse Looking)

67N RESIDUAL DIRECTIONAL OVERCURRENT

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Direction		(No-Direction, Directional)		
Operate Current		I_N		
Polarization Voltage		(Vz_1, V_1, V_2, V_0)		
Max. Sensitivity Angle	**MSA**	0° to 359°	Degrees	
Angle Band + –		5° to 90°	Degrees	
Pickup				
1 A CT	**P**	0.05 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.25 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Min. Polarization Voltage	**VMIN**	2.0 to 10.0 %	% V_{nom}	± 3%
Action if $V_{pol} < V_{min}$		(Block Trip, Trip)		
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 67N function (67N #1 through 67N #5) to be tested.

Test Setup:

1. Determine the 67N Residual Directional Overcurrent settings to be tested.
2. Enter the 67N Residual Directional Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Directional Pickup Test:

1. Refer to Figure 6-7 (forward looking) or Figure 6-8 (reverse looking) to perform this test.
2. Use IPScom Communications Software to monitor the 67N function.
3. Apply a single phase voltage to polarize the relay. For example if voltage is applied to V_a only, then: $V_0 = V_2 = V_a/3$
4. Apply single phase current for the operating current I_N equal to 150 percent of the pickup **P** at an angle with respect to the polarizing voltage outside of the operate zone.
5. Slowly rotate the current in the positive phase direction until the **67N Residual Directional Overcurrent** virtual green LED illuminates.

   The angle of operation will be equal to **MSA** ± 90°.
6. Slowly decrease the current magnitude until the 67N virtual green LED extinguishes. The current level of dropout will be just less than **P** ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Increase the current magnitude to 150 percent of pickup **P** and start timing. The contacts will close after **D** seconds ± the accuracy range in the Test Settings above. The test current must be in the trip region of the directional characteristic.
3. If Inverse Time Overcurrent is selected, refer to the test section 51N for test instructions.

67G GROUND DIRECTIONAL OVERCURRENT

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Direction		(No-Direction, Directional)		
Operate Current		I_g		
Polarization Voltage		(Vz_1, V_1, V_2, V_0)		
Max. Sensitivity Angle	**MSA**	0° to 359°	Degrees	
Angle Band + –		5° to 90°	Degrees	
Pickup				
1 A CT	**P**	0.05 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.25 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Min. Polarization Voltage	**VMIN**	2.0 to 10.0 %	% V_{nom}	± 3%
Action if $V_{pol} < V_{min}$		(Block Trip, Trip)		
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 67G function (67G #1 through 67G #5) to be tested.

Test Setup:

1. Determine the 67G Ground Directional Overcurrent settings to be tested.
2. Enter the 67G Ground Directional Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Directional Pickup Test:

1. Refer to Figure 6-7 (forward looking) or Figure 6-8 (reverse looking) to perform this test.
2. Use IPScom Communications Software to monitor the 67G function.
3. Apply a single phase voltage to polarize the relay. For example if voltage is applied to V_a only, then: $V_0 = V_2 = V_a/3$
4. Apply current to the current input I_g equal to 150 percent of the pickup **P** at an angle with respect to the polarizing voltage outside of the operate zone.
5. Slowly rotate the current in the positive phase direction until the **67G Ground Directional Overcurrent** virtual green LED illuminates.

   The angle of operation will be equal to **MSA** ± 90°.
6. Slowly decrease the current magnitude until the 67G virtual green LED extinguishes. The current level of dropout will be just less than **P** ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Increase the current magnitude to 150 percent of pickup **P** and start timing. The contacts will close after **D** seconds ± the accuracy range in the Test Settings above. The test current must be in the trip region of the directional characteristic.
3. If Inverse Time Overcurrent is selected, refer to the test section 51G for test instructions.

67Q NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Direction		(No-Direction, Directional)		
Operate Current		I_2		
Polarization Voltage		V_2		
Max. Sensitivity Angle	**MSA**	0° to 359°	Degrees	
Angle Band + –		5° to 90°	Degrees	
Pickup				
1 A CT	**P**	0.05 to 20.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**P**	0.25 to 100.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Min. Polarization Voltage	**VMIN**	2.0 to 10.0 %	% V_{nom}	± 3%
Action if $V_{pol} < V_{min}$		(Block Trip, Trip)		
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 67Q function (67Q #1 through 67Q #5) to be tested.

Test Setup:

1. Determine the 67Q Negative-Sequence Directional Overcurrent settings to be tested.
2. Enter the 67Q Negative-Sequence Directional Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Directional Pickup Test:

1. Refer to Figure 6-7 (forward looking) or Figure 6-8 (reverse looking) to perform this test.
2. Use IPScom Communications Software to monitor the 67Q function.
3. Apply a single phase voltage to polarize the relay. For example if the test voltage is applied to V_a only, then: $V_2 = V_a/3$
4. Apply single phase current for the operating current I_2 equal to 150 percent of the pickup **P** at an angle with respect to the polarizing voltage outside of the operate zone. For example if the test current is applied to I_a only, then: $I_2 = I_a/3$
5. Slowly rotate the current in the positive phase direction until the **67Q NEGATIVE-SEQUENCE DIRECTIONAL OVERCURRENT** virtual green LED illuminates.

   The angle of operation will be equal to **MSA** ± 90°.
6. Slowly decrease the current magnitude until the 67Q virtual green LED extinguishes. The current level of dropout will be just less than **P** ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Increase the current magnitude to 150 percent of pickup **P** and start timing. The contacts will close after **D** seconds ± the accuracy range in the Test Settings above. The test current must be in the trip region of the directional characteristic.
3. If Inverse Time Overcurrent is selected, refer to the test section 51Q for test instructions.

67GS SENSITIVE GROUND DIRECTIONAL OVERCURRENT

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Direction		(No-Direction, Directional)		
Operate Current		I_g		
Polarization Voltage		(Vz_1, V_1, V_2, V_0)		
Max. Sensitivity Angle	**MSA**	0° to 359°	Degrees	± 4°
Angle Band + –		5° to 90°	Degrees	± 4°
Pickup				
10 mA Gnd CT	**P**	0.005 to 0.200 A	Amps	(TBD)
50 mA Gnd CT	**P**	0.025 to 1.000 A	Amps	0.0015 A or ± 3%
200 mA Gnd CT	**P**	0.020 to 2.500 A	Amps	(TBD)
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Min. Polarization Voltage	**VMIN**	2.0 to 10.0 %	% V_{nom}	± 3%
Action if $V_{pol} < V_{min}$		(Block Trip, Trip)		
Programmed Outputs	**Z**	(1 to 12)	OUT	

■**NOTE:** Only enable the 67GS function (67GS #1 through 67GS #5) to be tested.

Test Setup:

1. Determine the 67GS Sensitive Ground Directional Overcurrent settings to be tested.
2. Enter the 67GS Sensitive Ground Directional Overcurrent settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Directional Pickup Test:

1. Refer to Figure 6-7 (forward looking) or Figure 6-8 (reverse looking) to perform this test.
2. Use IPScom Communications Software to monitor the 67GS function.
3. Apply a single phase voltage to polarize the relay. For example if voltage is applied to V_a only, then: $V_0 = V_2 = V_a/3$
4. Apply single phase current for the operating current I_g equal to 150 percent of the pickup **P** at an angle with respect to the polarizing voltage outside of the operate zone.
5. Slowly rotate the current in the positive phase direction until the **67GS Sensitive Ground Directional Overcurrent** virtual green LED illuminates.

   The angle of operation will be equal to **MSA** ± 90°.
6. Slowly decrease the current magnitude until the 67GS virtual green LED extinguishes. The current level of dropout will be just less than **P** ± the accuracy range in the Test Settings above.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Increase the current magnitude to 150 percent of pickup **P** and start timing. The contacts will close after **D** seconds ± the accuracy range in the Test Settings above. The test current must be in the trip region of the directional characteristic.
3. If Inverse Time Overcurrent is selected, refer to the test section 51GS for test instructions.

79 RECLOSER (TRIP RECLOSER SEQUENCE, 50HCL AND 27BSVS)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Trip Reclose Sequence (per trip)

Function	1	2	3	4	5
50P	☐	☐	☐	☐	☐
50N	☐	☐	☐	☐	☐
50G(GS)	☐	☐	☐	☐	☐
51P	☐	☐	☐	☐	☐
51N	☐	☐	☐	☐	☐
51G(GS)	☐	☐	☐	☐	☐
51Q	☐	☐	☐	☐	☐
67P	☐	☐	☐	☐	☐
67N	☐	☐	☐	☐	☐
67G(GS)	☐	☐	☐	☐	☐
67Q	☐	☐	☐	☐	☐

79 RECLOSE RELAY

Sequence Coordination

Ground Precedence	**GP**	(Enable/Disable)		
Sequence Coordination	**SC**	(None/1/2/3) Active # of trips		
Phase Reclose Count	**PRC**	(1/2/3/4/5)		
Ground Reclose Count	**GRC**	(1/2/3/4/5)		

Reset Timers

After Auto Reclose	**T79RST**	1 to 1800 s	Seconds	± 0.01 s or ± 1%
After Manual Close	**TMCRST**	1 to 1800 s	Seconds	± 0.01 s or ± 1%

Time Delay for Reclose # (up to four total)

Phase Fault	**DP#**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Ground Fault	**DG#**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%

High Current Lockout (per trip)

Phase Pickup				
1 A CT	**50PLO**	0.10 to 100.00 A	Amps	± 0.02 A or ± 3%
5 A CT	**50PLO**	0.50 to 500.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**DPLO**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Ground Pickup				
1 A Gnd CT	**50RLO**	0.03 to 100.00 A	Amps	± 0.02 A or ± 3%
5 A Gnd CT	**50RLO**	0.15 to 500.00 A	Amps	± 0.1 A or ± 3%
Time Delay	**DRLO**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%

Bus Side Voltage Supervision

Min. Closing Voltage	**VMINCL**	0.00 to 300.00 V	Volts	± 0.2 V or ± 0.5%
Supervision Time	**TVMINCL**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%

Programmed Outputs

Phase Fault Trip:	**TRIP_PH**	(1 to 12)	OUT
Ground Fault Trip:	**TRIP_G**	(1 to 12) OUT	OUT
Reclose:	**79**	(1 to 12) OUT	OUT

■**NOTE:** It is not necessary to test the pickup for the time overcurrent tripping elements. These tests are performed separately for each overcurrent function.

■**NOTE:** Only enable the functions you are using to reclose.

Test Setup:

1. Determine the 79 Reclose settings to be tested.
2. Enter the 79 Reclose settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all **non-related** functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect the test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Real Time Recloser Status Monitoring:

1. Use S-7600 IPScom Communications Software to monitor the Recloser Status.
2. Select **Monitor/Recloser Status Monitoring** from the IPScom Main screen menu bar. IPScom will display the Recloser Status Monitoring screen (Figure 6-9) which displays the status of the following:
    - Fault Type (phase or ground)
    - Sequence Coordination
    - Trip Time
    - Breaker Status (per phase)
    - Reclose Time
    - Reclose Status (per phase)
        - reset
        - auto-reclose in-progress
        - locked out
    - Reclose Count (i.e., total number of recloses for both phase and ground)
    - High Current Lockout
    - Cold Load Pickup
    - Bus Voltage Supervision
    - Reset Time

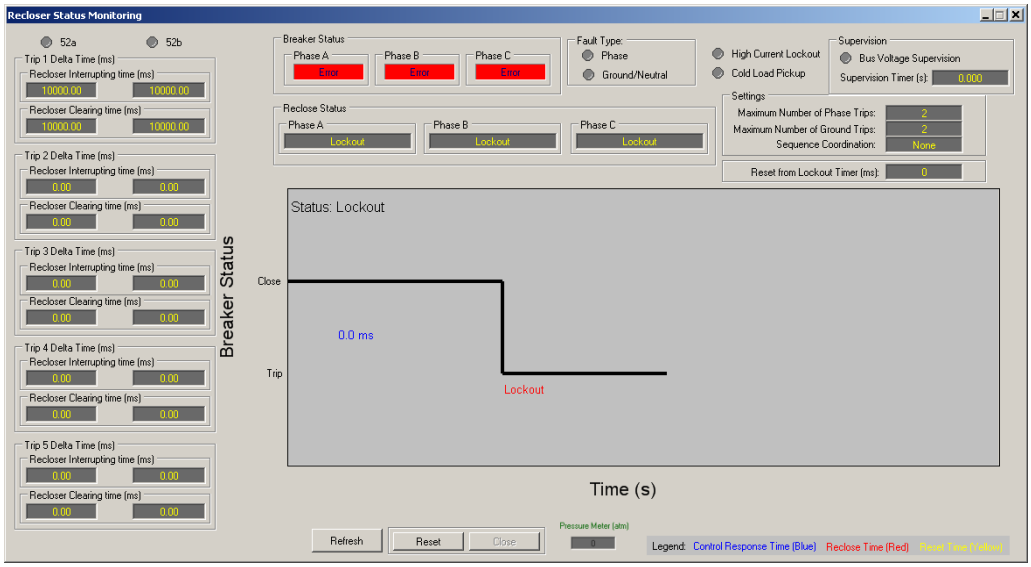


Figure 6-9 Recloser Status Monitoring Screen

Real Time Function Status Monitoring:

1. Use S-7600 IPScom Communications Software to monitor the Function Status.
2. Select **Monitor/Function Status** from the IPScom Main screen menu bar. IPScom will display the Function Status screen (Figure 6-10) which displays the status of the following:
   - Overcurrent element status (50P, 50G(GS), 50N, 51P, 51G(GS), 51N)
   - Input and Output status

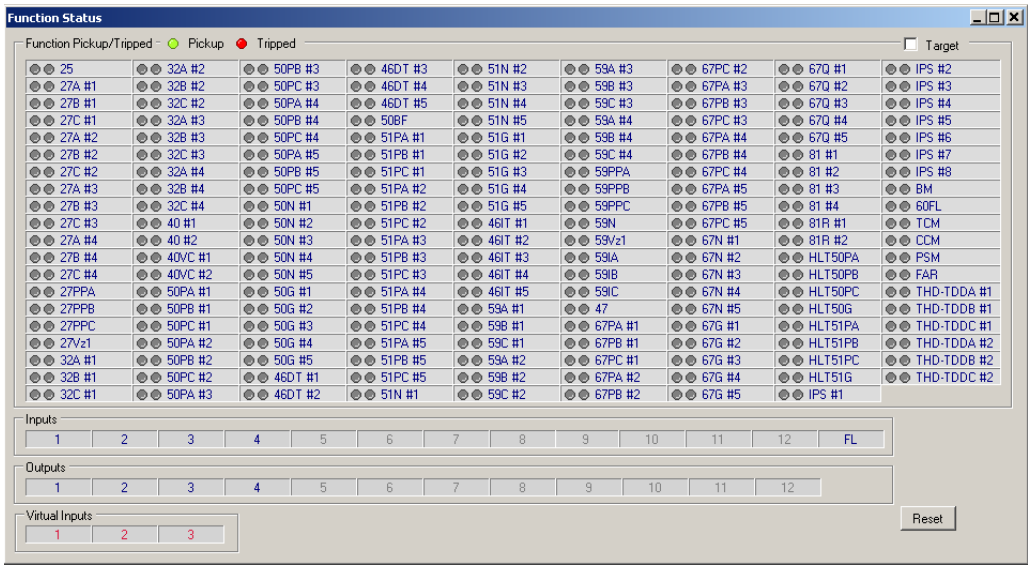


Figure 6-10 Function Status Screen

Reclose Delay Time Tests:

Figure 6-11 illustrates a two shot auto-reclose cycle that goes to lockout following the third trip. Observe the reclose delay time following each trip by monitoring the close output.

■**NOTE:** Reclose delays for phase and ground each trip can be set independently.

■**NOTE:** 51R represents 51G and/or 51N.

The close output will close after **D#** seconds (± the accuracy range in the Test Settings above) following the corresponding trip. 51R1 and 51R2 correspond to the residual time overcurrent elements. The neutral operating current ($3I_0$ or I_g) is based on the relay configuration.

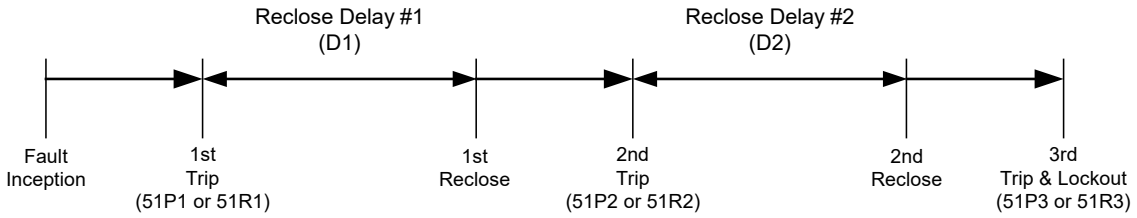


Figure 6-11 Two Shot Reclose Auto-Reclose Cycle

Ground Precedence Test:

Figure 6-12 illustrates how **ground precedence** works for a two shot auto-reclose cycle. Only the residual overcurrent elements (i.e., 51R1 and 51R2) can trip when ground precedence is enabled.

1. Simulate a fault condition that picks up both the phase and residual overcurrent element for each trip (e.g., phase-to-phase-to-ground fault).
2. Only the residual overcurrent elements will trip.

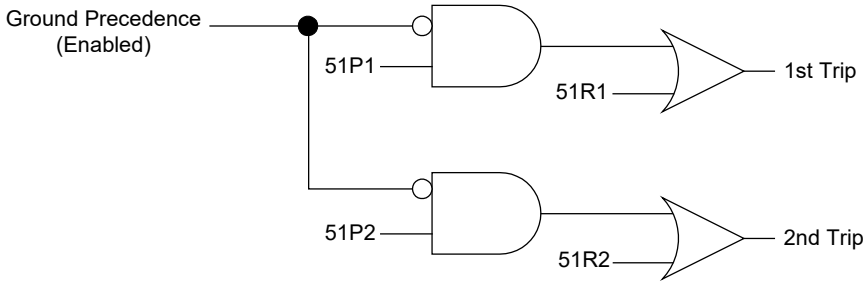


Figure 6-12 Ground Precedence

Sequence Coordination Test:

Figure 6-13 illustrates how **sequence coordination** works:

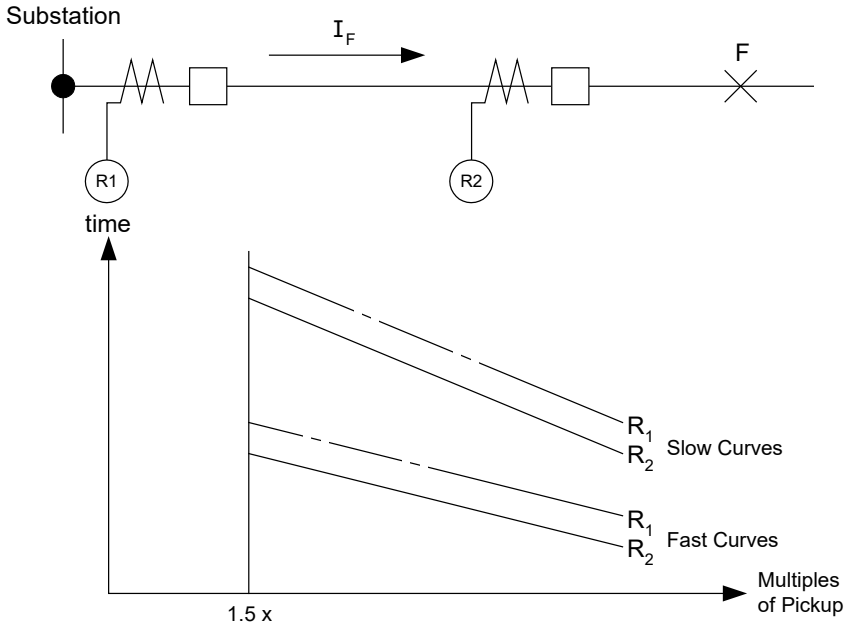


Figure 6-13 Sequence Coordination Example

Example: Recloser R_1 is located at the substation while recloser R_2 is a recloser located further downstream in the distribution system. Both reclosers are programmed to trip twice for an auto-reclose cycle then go to lockout. Both reclosers use a fast time overcurrent characteristic for the first trip and a slower time overcurrent characteristic for the second trip. The reclosers must maintain coordination so that for any faults beyond R_2 the recloser will trip first to minimize the outage. *Sequence coordination increments the trip count for recloser R1 when it detects a fault but does not trip.* Therefore if the fault is still present following the first reclose at R_2 then R_1 will maintain coordination and not over trip dropping the entire feeder.

Sequence Coordination Trip:

1. Inject balanced three phase current high enough in magnitude to pick up 51P1.
2. Remove the current before 51P1 trips.
3. The recloser will increment.
4. Inject balanced three phase current high enough in magnitude to pick up 51P2.
5. 51P2 will trip.
6. Repeat steps 1 through 5 injecting single phase current to increment the trip counter and operate 51G2 or 51N2 based on the neutral operating current configuration ($3I_0$ or I_g).

50HCL HIGH CURRENT LOCKOUT

High Current Phase Lockout Pickup Test:

1. Monitor the High Current Lockout function using either the Recloser Status Monitoring Screen **High Current Lockout** virtual LED or the trip output contact.
2. Inject balanced three phase current high enough in magnitude to pick up 51P1.
3. Quickly increase the current magnitude so that the high current phase lockout trips before 51P1. The current level of operation will be **50PLO** ± the accuracy range in the Test Settings above.

High Current Phase Lockout Time Test:

1. Connect a timer to the trip output contact so that the timer stops timing when the contacts close.
2. Repeat steps 1 and 2 from the High Current Phase Lockout Pickup Test.
3. Increase the current magnitude to 150 percent of pickup **50RLO** and start timing. The contacts will close after **DPLO** seconds ± the accuracy range in the Test Settings above.

High Current Ground Lockout Pickup Test:

1. Monitor the High Current Lockout function using either the Recloser Status Monitoring Screen **High Current Lockout** virtual LED or the trip output contact.
2. Inject single phase current high enough in magnitude to pick up 51R1.
3. Quickly increase the current magnitude so that the high current ground lockout trips before 51R1. The current level of operation will be **50RLO** ± the accuracy range in the Test Settings above.

High Current Ground Lockout Time Test:

1. Connect a timer to the trip output contact so that the timer stops timing when the contacts close.
2. Repeat steps 1 and 2 from the High Current Ground Lockout Pickup Test.
3. Increase the current magnitude to 150 percent of pickup **50RLO** and start timing. The contacts will close after **DRLO** seconds ± the accuracy range in the Test Settings above.

27 BSVS BUS SIDE VOLTAGE SUPERVISION

Bus Side Voltage Supervision Test:

Bus side voltage supervision is an undervoltage element. When the bus voltage on any phase is less than the pickup, then reclosing is blocked.

1. Monitor the **Bus Voltage Supervision** virtual LED in the Recloser Status Monitoring Screen.
2. Inject enough current to trip on minimum phase or ground.
3. Apply voltage and gradually decrease the magnitude. The Bus Voltage Supervision virtual LED will illuminate after the voltage magnitude drops below **VMINCL** (± the accuracy range in the Test Settings above) and **TVMINCL** time delay on pickup has expired.

81 FREQUENCY

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	40.00 to 65.00 Hz	Hz	± 0.02 Hz
Time Delay	**D**	0.00 to 600.00 s	Seconds	± 0.01 s or ± 1%
Hysteresis	**X**	0.0 to 1.0 Hz	Hz	
Programmed Outputs	**Z**	OUT	(1 to 12)	

■**NOTE:** Only enable the 81 function (81 #1 through 81 #4) to be tested.

Test Setup:

1. Determine the 81 frequency settings to be tested.
2. Enter the 81 frequency settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all other functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Apply nominal balanced three-phase voltage.

OVER FREQUENCY

Pickup Test:

1. Use IPScom Communications Software to monitor the 81 function status. Slowly increase the frequency until the **81 FREQUENCY** green virtual LED illuminates on the monitor function status screen to indicate that the function has picked up.

   The frequency level will be equal to **P** Hz ± the accuracy range in the Test Settings above, only if **P** is within 3 Hz of $f_{nom\ (60\ Hz)}$, otherwise it is ± 0.1 Hz.
2. Decrease the frequency to nominal frequency. The virtual LED(s) will extinguish.
3. Press **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply (**P** + 0.5) Hz and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above, whichever is greater.

UNDER FREQUENCY

Pickup Test:

1. Use IPScom Communications Software to monitor the 81 function status. Slowly decrease the frequency until the **81 FREQUENCY** green virtual LED illuminates on the monitor function status screen to indicate that the function has picked up.

   The frequency level will be equal to **P** Hz ± the accuracy range in the Test Settings above, only if **P** is within 3 Hz of $f_{nom\ (60\ Hz)}$, otherwise it is ± 0.1 Hz.
2. Increase the frequency to nominal frequency. The virtual LED(s) will extinguish.
3. Press **RESET** pushbutton to reset targets.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Apply (**P** – 0.5) Hz and start timing. The contacts will close after **D** cycles ± the accuracy range in the Test Settings above, whichever is greater.

81R RATE OF CHANGE OF FREQUENCY (#1, #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Pickup	**P**	0.20 to 5.00 Hz/s	Hz/Sec	± 0.02 Hz/s
Time Delay	**D**	0.00 to 2.00 s	Seconds	± 0.01 s or ± 1%
Negative-Sequence Voltage Inhibit	**N**	0 to 99	%	
Programmed Outputs	**Z**	(1 to 12)	OUT	
Function 81			See Below	

■**NOTE:** Testing of the 81R function requires a three-phase voltage source capable of smoothly sweeping the frequency of all voltages at a variable rate, continuously.

Test Setup:

1. Disable all other functions prior to testing.
2. Confirm settings to be tested.
3. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
4. It is recommended that the 81 function be used to establish a window of operation for the 81R function which is smaller than the actual sweep range of the frequency applied. This is accomplished by enabling 81#1 to pickup at a frequency 1 Hz higher than the minimum frequency of the ramp, and assign a unique output. Set 81#2 to pickup 1 Hz lower than the maximum frequency of the ramp, and assign a unique output (see Figure 6-14). The frequencies given are suggested for testing rates below 10 Hz/S. Higher rates will require consideration of the capabilities of the test equipment involved. Connect both of these outputs to an input with jumpers, and set the 81R function to block on this input (see Figure 6-15). Set the time delays and seal-in times of the 81 functions to minimum. This setup results in an operational window that is free of erroneous Hz/S measurements when the voltage source begins or ends a sweep.

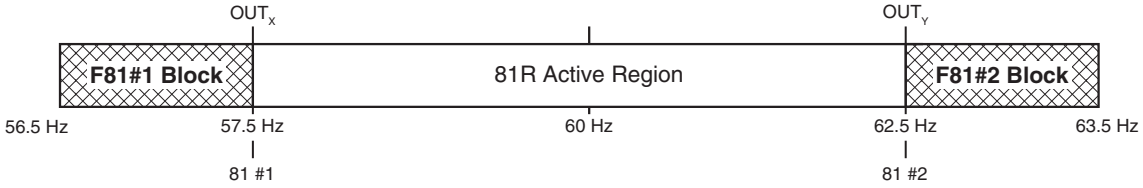


Figure 6-14 Function 81R Blocking Regions

It is important to remember that the 81 elements being used will operate in the 81R blocking regions, and the 81R output contact operation must be distinguished from the 81 output contacts when using this setup.

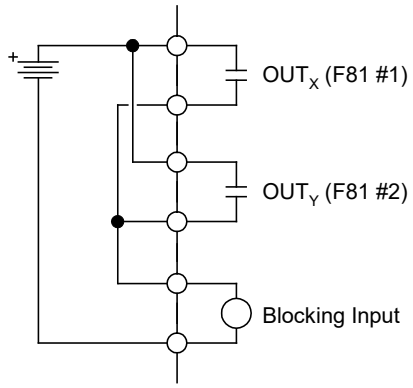


Figure 6-15 Function 81R Connection Diagram

Pickup Test:

1. Apply nominal voltage to all three phases. Calculate the time for the pickup setting and apply a sweep rate 25% less than the pickup (**P**).
2. Use IPScom Communications Software to monitor the 81R function status. Slowly increase the sweep rate until the **81R FREQUENCY** green virtual LED illuminates on the monitor function status screen to indicate that the function has picked up.

   The level will be equal to **P** ± the accuracy range in the Test Settings above.
3. Decrease the sweep rate until the **81R FREQUENCY** green virtual LED extinguishes.

Timer Test:

1. Reset targets and apply nominal voltage to all three phases at a sweep rate 25% below **P**.
2. Apply a sweep rate 25% above **P** with the associated output contact connected to a timer and start timing. The output contact will close after **D** cycles ± the accuracy range in the Test Settings above.

CLP COLD LOAD PICKUP

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Time Locked Out to Activate Cold Load	**CLT**	Seconds	(1 to 60000)
Number of Recloses	**#79**		(0 to 4)

Restore to Normal:

Active Duration	**AD**	Seconds	(1 to 10000)
I_{ph} < % I_{nom}	**%IPH**	Percent	(0 to 100)
I_g < % I_{nom}	**%IG**	Percent	(0 to 100)
Time Delay	**TD**	Seconds	(0.01 to 600.00)

Reclose Timers (Same for phase and ground):

Reclose Timer 1	**D1**	Seconds	(0.01 to 600.00)
Reclose Timer 2	**D2**	Seconds	(0.01 to 600.00)
Reclose Timer 3	**D3**	Seconds	(0.01 to 600.00)
Reclose Timer 4	**D4**	Seconds	(0.01 to 600.00)

50P1:

Pickup	**P1**	Amps	(0.02 to 20.00)
Definite Time	**D01**	Seconds	(0.00 to 600.00)

50G1:

Pickup	**P2**	Amps	(0.02 to 20.00)
Definite Time	**D02**	Seconds	(0.00 to 600.00)

51P1 (Minimum Phase Trip):

Pickup	**P3**	Amps	(0.02 to 3.20)

Curve: **C3**

IEC – Inverse, Very Inverse, Extremely Inverse
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse
Traditional Recloser – 101 to 202

Time Multiplier	**TM**		
IEC			(0.05 to 1.00)
US			(0.05 to 15.00)
IEEE			(0.10 to 25.00)
Traditional Recloser			(0.10 to 2.00)
Time Adder	**TA**	Seconds	(0.00 to 30.00)
Min. Response Time Adder	**MRTA**	Seconds	(0.00 to 1.00)
Electromechanical Reset	**ER**		(Enabled, Disabled)

51N1 or 51G1 (Minimum Ground Trip):

*P*ickup	**P4**	Amps	(0.02 to 3.20)
Curve:	**C4**		

IEC – Inverse, Very Inverse, Extremely Inverse
US – Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse
IEEE – Moderately Inverse, Very Inverse, Extremely Inverse
Traditional Recloser – 101 to 202

Time Multiplier	**TM**		
IEC			(0.05 to 1.00)
US			(0.05 to 15.00)
IEEE			(0.10 to 25.00)
Traditional Recloser			(0.10 to 2.00)
Time Adder	**TA**	Seconds	(0.00 to 30.00)
Min. Response Time Adder	**MRTA**	Seconds	(0.00 to 1.00)
Electromechanical Reset	**ER**		(Enabled, Disabled)

Phase High Current Lockout:

Pickup	**P**	Amps	(0.10 to 100.00)
Definite Time	**D**	Seconds	(0.00 to 600.00)

Ground High Current Lockout:

Pickup	**P**	Amps	(0.03 to 100.00)
Definite Time	**D**	Seconds	(0.00 to 600.00)

■**NOTE:** Only enable the Cold Load Pickup Functions to be tested.

Test Setup:

1. Determine the Cold Load Pickup settings to be tested.
2. Enter the Cold Load Pickup settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
3. Disable all **non-related** functions prior to testing.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Real Time Monitoring:

1. Use IPScom Communications Software to monitor the Cold Load Pickup function.
2. From the IPScom Main screen menu bar select Monitor/Recloser Status Monitoring. IPScom will display the Recloser Status Monitoring screen (Figure 6-9) which displays the Cold Load Pickup status.

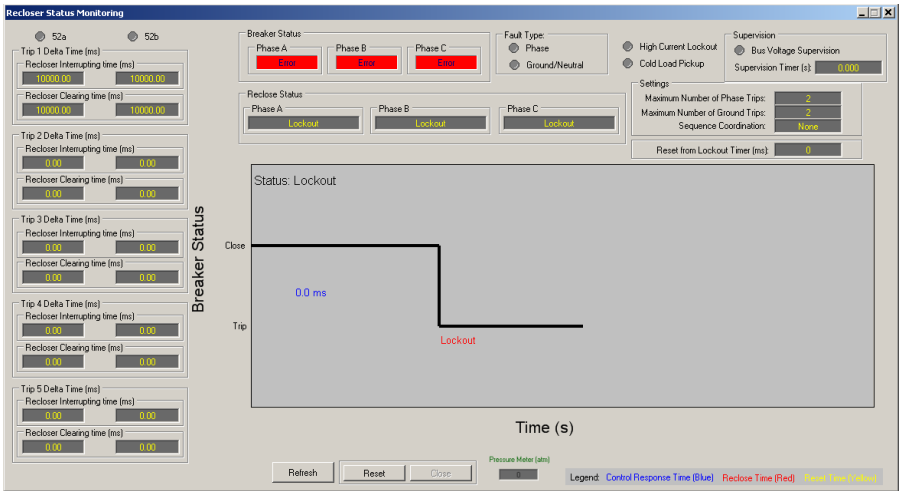


Figure 6-16 Recloser Status Monitoring Screen

Time to Activate Cold Load Pickup Test:

1. Place the recloser in the lockout state.
2. Use the IPScom Recloser Status Monitoring screen to monitor the **Cold Load Pickup** virtual LED.

   ■**NOTE:** The breaker must be closed.

3. The Cold Load Pickup virtual LED will illuminate in **CLT** seconds (±0.5 cycles) after the recloser goes to lockout.

Overcurrent Pickup and Time Tests:

Repeat the pickup and time tests for the following overcurrent elements using the governing settings while the recloser is in the Cold Load Pickup state:

50P1, 50G(GS)1*, 50N1*, 51P1, 51N1*, 51G(GS)1*, High Current Phase Lockout, High Current Ground Lockout

* The neutral operating current configuration ($3I_0$ or I_g) determines which function is active.

Reclose Timer Tests:

The recloser loads new settings for the reclose timers and the total number of recloses while it is in the Cold Load Pickup state.

■**NOTE:** The recloser uses the same settings for both phase and ground faults during this condition.

Repeat the reclose timer tests using the governing settings while the recloser is in the Cold Load Pickup state: D1, D2, D3, D4

Restore to Normal Tests:

Figure 6-17 illustrates how the recloser determines when to restore normal settings following Cold Load Pickup.

I_{rst} and I_{rstR} respectively refer to the pickup settings **%IPH** and **%IG**. I_R is the neutral operating current ($3I_0$ or I_g).

■**NOTE:** The breaker must be closed (that is, 52A contact is asserted).

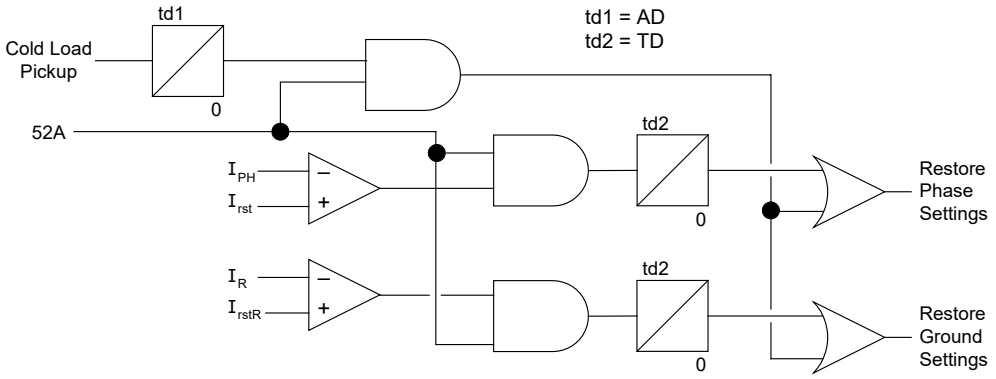


Figure 6-17 Restore to Normal Logic Diagram

Active Duration Time Test:

1. Place the recloser in the lockout state with no current applied to the recloser.
2. Use the IPScom Recloser Status Monitoring screen to monitor the **Cold Load Pickup** virtual LED. The recloser must be in the Cold Load Pickup state before proceeding to the next step.

   ■**NOTE:** The breaker must be closed.

3. Apply phase current greater in magnitude than **%IPH** and ground current greater than **%IG**.
4. The Cold Load Pickup virtual LED will extinguish in **AD** seconds (±0.5 cycles).

Time Delay Test:

1. Place the recloser in the lockout state with no current applied to the recloser.
2. Use the IPScom Recloser Status Monitoring screen to monitor the **Cold Load Pickup** virtual LED. The recloser must be in the Cold Load Pickup state before proceeding to the next step.

   ■**NOTE:** The breaker must be closed.

3. Apply phase current less than **%IPH** and ground current less than **%IG**.
4. The Cold Load Pickup virtual LED will extinguish in **TD** seconds (±0.5 cycles).

HLT MM HOT LINE TAG/MAINTENANCE MODE

■**NOTE:** The M-7651A D-PAC will trip for a fault then go to lockout when Hot Line Tag/Maintenance Mode is enabled and the relay switches over to reserved settings for 50P, 51P, 50G/GS and 51G/GS. Enable Hot Line Tag/Maintenance Mode to test these settings.

Follow the guidelines presented in this section as appropriate for 50P, 51P, 50G/GS and 51G/GS.

The M-7651A D-PAC will drive to lockout immediately following a trip. You will not be able to issue a close command from the front panel, via SCADA until the auto-reclose function is reset.

■**NOTE:** Hot Line Tag/Maintenance Mode settings take precedence when Cold Load Pickup is active.

TCM TRIP CIRCUIT MONITORING

VOLTAGE INPUTS: As Described

CURRENT INPUTS: None

TEST SETTINGS:

Time Delay	**D**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

Test Setup:

1. Determine the Trip Circuit Monitoring function settings to be tested.
2. Disable all other functions prior to testing.
3. Connect a DC voltage supply capable of supplying 24/48/125/250 Vdc (marked on the rear of the relay) across the input selected for Trip Circuit monitoring.
4. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.

> ■**NOTE:** This procedure assumes the input selected for the Trip Coil Monitor is in the active state when Open.

Pickup and Time Test:

1. Enable the Trip Circuit Monitoring function and then enter the settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
2. Apply the applicable DC voltage (24/48/125/250 Vdc, marked on the rear of the relay) across the selected TCM input.
3. If the DC voltage is removed from the input then the virtual green **TCM** LED will illuminate on the Function Status Monitor. The virtual red **TCM** LED will then illuminate once the function has timed out after **D** seconds ± the accuracy range in the Test Settings above.
4. Re-apply the applicable DC voltage and the virtual LEDs will extinguish.

CCM CLOSE CIRCUIT MONITORING

VOLTAGE INPUTS: As Described

CURRENT INPUTS: None

TEST SETTINGS:

Time Delay	**D**	0.01 to 600.00 s	Seconds	± 0.01 s or ± 1%
Programmed Outputs	**Z**	(1 to 12)	OUT	

Test Setup:

1. Determine the Close Circuit Monitoring function settings to be tested.
2. Disable all other functions prior to testing.
3. Connect a DC voltage supply capable of supplying 24/48/125/250 Vdc (marked on the rear of the relay) across the input selected for Close Circuit monitoring.
4. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.

> ■**NOTE:** This procedure assumes the input selected for the Close Coil Monitor is in the active state when Open.

Pickup and Time Test:

1. Enable the Close Circuit Monitoring function and then enter the settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.
2. Apply the applicable DC voltage (24/48/125/250 Vdc, marked on the rear of the relay) across the selected CCM input.
3. If the DC voltage is removed from the input then the virtual green **CCM** LED will illuminate on the Function Status Monitor. The virtual red **CCM** LED will then illuminate once the function has timed out after **D** seconds ± the accuracy range in the Test Settings above.
4. Re-apply the applicable DC voltage and the virtual LEDs will extinguish.

BM BREAKER MONITOR AND ACCUMULATOR

VOLTAGE INPUTS: None

CURRENT INPUTS: As Described

TEST SETTINGS:

Pickup	**P**	(1 to 60,000)	Cycles*
Delay	**D**	(0.00 to 600.00)	Seconds
Timing Method		($I^{1.5}T$, IT or I^2T)	
Preset Accumulators: Phase A, B, or C		(0 to 60,000)	
Programmed Outputs	**Z**	(1 to 12)	OUT
Blocking Inputs		(1 to 12)	
Output Initiate		(1 to 12)	
Input Initiate		(1 to 12)	

*kA cycles, $kA^{1.5}$ cycles or kA^2 cycles is dependent on the Timing Method that is selected.

Test Setup:

1. Determine the Breaker Monitoring Function settings to be tested (Input Initiate or Output Initiate).
2. Enter the Breaker Monitoring Function settings to be tested utilizing IPScom Communications Software.
3. Connect a current input to I_1 terminals 1 and 2, I_2 terminals 3 and 4, and I_3 terminals 5 and 6.

Accumulator Test:

1. Apply a current value that considers Timing Method and Pickup Setting to current input I_1.
2. Energize the designated input and/or assert the output contact selected as initiate.
3. Utilizing IPScom Communications Software (Monitor/Breaker Accumulator Status), verify that the Accumulator Status value for Phase A increments in **D** cycles ±1 cycle or ±1%.
4. De-assert the output and/or de-energize the input in Step 2.
5. Decrease applied I_1 current to 0 amps.
6. If desired, repeat test for I_2 and I_3.

Pickup Test:

1. Apply a current value that considers Timing Method and Pickup Setting to current input I_1.

   ■**NOTE:** If the target pickup setting is a large value, the Preset Accumulator Settings feature can be used to pre-set the accumulator values to just below the target setting.

2. Utilizing IPScom Communications Software (Monitor/Breaker Accumulator Status) to monitor the accumulator value, energize the designated input or assert the output contact selected as initiate and then de-energize the input or de-assert the output.

   Following the time out of the delay the accumulator will increment. Repeat as necessary to increment the accumulator to a point where the pickup setting is exceeded.

3. When the accumulator value exceeds the pickup value the **OUTPUT** LED(s) will illuminate and the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The output contacts **Z** will operate in **D** cycles ±1 cycle or ±1% from the last initiate.

4. If desired, repeat test for I_2 and I_3.

PSM IED POWER SUPPLY MONITORING

VOLTAGE INPUTS: + and – Terminals on the Power Supply inputs

CURRENT INPUTS: None

TEST SETTINGS: Power Supply Type — Low Voltage (24/48 Vdc) or High Voltage (125/220 Vac/Vdc)

Time Delay	**D**	Seconds	(0 to 60000)
Reference High Voltage	**VHI**	Volts	(60.0 to 300.0)
Reference Low Voltage	**VLO**	Volts	(60.0 to 250.0)
Programmed Outputs	**Z**	OUT	(1 to 4)
Blocking Inputs			(4)

■**NOTE:** The range of the Low Voltage Power Supply is 18–60 Vdc. The range of the High Voltage Power Supply is 90–280 Vac/90–315 Vdc.

Test Setup:

1. Apply a variable voltage source to the power supply. Set the output voltage from the source equal to the nominal rating of the power supply.
2. Determine the Power Supply Monitoring settings to be tested.
3. Enter the Power Supply Monitoring settings to be tested utilizing either the HMI or S-7600 IPScom Communications Software.

High Voltage Test:

1. Use IPScom Communications Software to monitor the **PSM** green virtual LED. Slowly increase the output voltage from the source. The **PSM** green virtual LED will illuminate when the output voltage from the source is **VHI** (±3 Vac or ±2 Vdc).
2. Lower the supply voltage to the nominal rating of the power supply. The **PSM** green virtual LED will extinguish.

Low Voltage Test:

1. Slowly decrease the output voltage from the source. The **PSM** green virtual LED will illuminate when the output voltage from the source is **VLO** (±3 Vac or ±2 Vdc).
2. Raise the supply voltage to the nominal rating of the power supply. The **PSM** green virtual LED will extinguish.

Time Test:

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. Raise the supply voltage to (**VHI** + 4) Volts. The contacts will close after **D** seconds ±0.5 cycles.

6.3 Auto Calibration

VT CALIBRATION PROCEDURE

The M-7651A D-PAC System includes an Auto Calibration feature. To perform an automatic calibration proceed as follows:

Required Equipment

- Voltage source capable of providing a 120 Vac source voltage
- Voltage source capable of providing a 0.1 to 12.5 Vac source voltage
- Current source capable of providing a 1 Amp current source
- Current source capable of providing a 50 mA current source

Calibration Procedure

1. Determine the recloser voltage input configuration, then connect the voltage source as shown in Figure 6-23.
2. Determine the recloser current input configuration, then connect the current source as shown in Figure 6-24.
3. Apply the appropriate voltage to the relay.
   - 120 Vac for VT and LEA High voltage
   - 5 Vac for LEA Low Voltage
4. Apply the appropriate current to the unit:
   - 1 Amp ∠0° current
   - 50 mA ∠0° current
5. Start S-7600 IPScom Communications Software, then connect to the relay.
6. From the IPScom Main Screen select Utility/Hardware/Calibrate. IPScom will display the "Calibration Warning" screen (Figure 6-18).

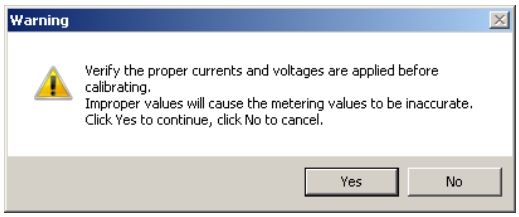


Figure 6-18 Calibration Warning Screen

7. Select **Yes**. IPScom will display the "Confirm Calibration" screen (Figure 6-19).

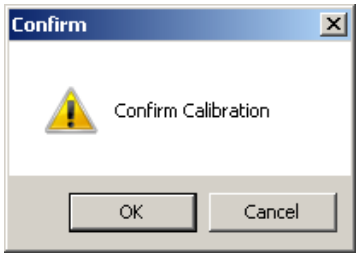


Figure 6-19 Confirm Calibration Screen

8. Select **OK**. IPScom will respond in one of the following manners:
   - If LEA input hardware is not present on the unit, the calibration process will initiate. Go to Step 11.
   - If LEA input hardware is present on the unit, then IPScom will display the LEA Calibration Voltage dialog screen Figure 6-20. Go to Step 9.

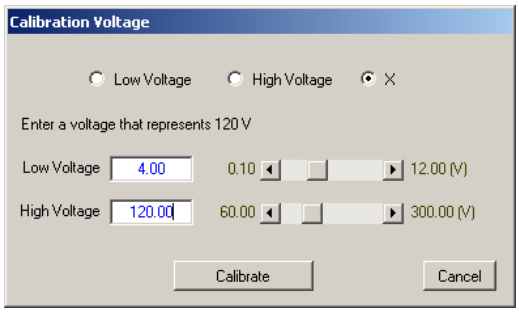


Figure 6-20 LEA Calibration Voltage Dialog Screen

9. Select **Low Voltage** or **High Voltage**.
10. Enter the appropriate voltage for the inputs being calibrated, then select "Calibrate".
11. When the calibration is Successful without any errors, IPScom will display the "Calibration Successful" confirmation screen (Figure 6-21).

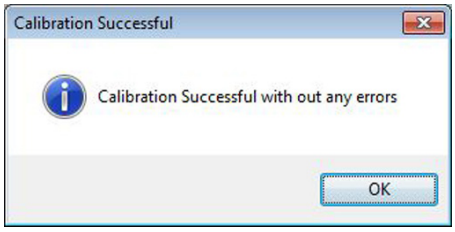


Figure 6-21 Calibration Successful Screen

When the calibration is complete but with errors, IPScom will display the "Calibration Done" screen (Figure 6-22) listing any errors.

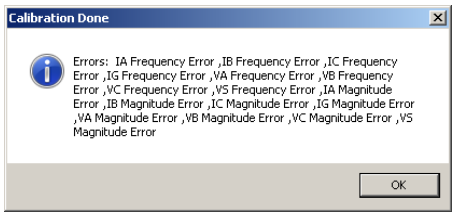


Figure 6-22 Calibration Done with Errors Screen

12. Restore the Relay and current and voltage inputs to the pre-calibration configuration.

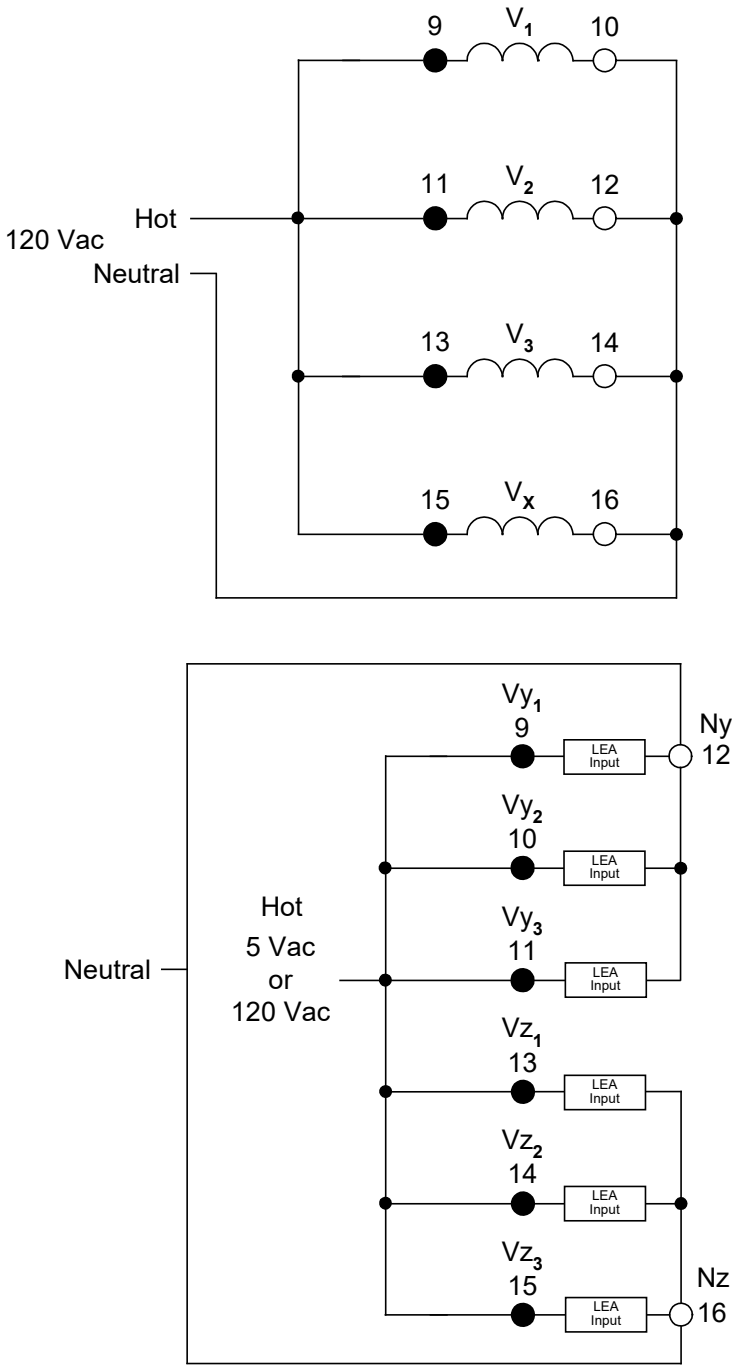


Figure 6-23 Calibration Voltage Input Configuration

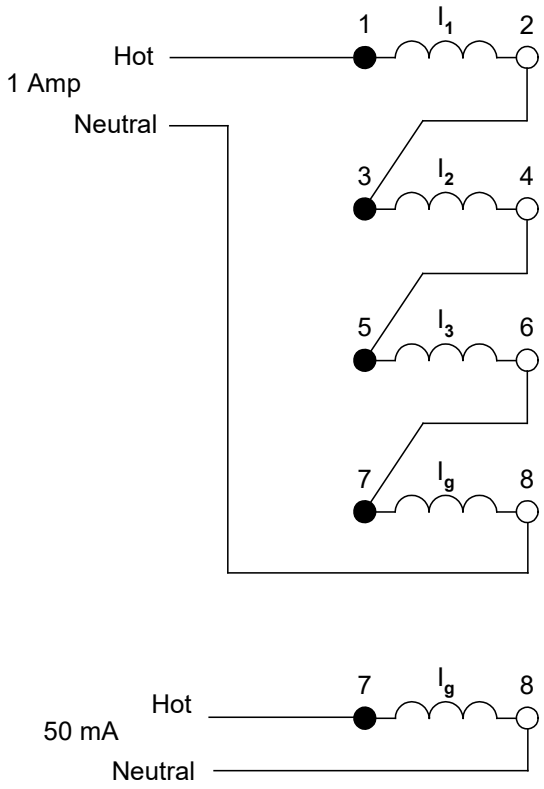


Figure 6-24 Calibration Current Input Configuration

7 Installation

7.1 General Information 7–1
7.2 Mechanical/Physical Dimensions 7–2
7.3 External Connections 7–7

7.1 General Information

The person or group responsible for the installation of the control will find all mechanical information required for physical installation, equipment ratings, and all external connections in this chapter. For reference, the Three-Line Connection Diagrams are repeated from Chapter 4.

It is suggested the terminal connections illustrated here be transferred to station one-line wiring and three-line connection diagrams, station panel drawings and station dc wiring schematics.

■**NOTE:** Prior to installation of the equipment, it is essential to review the contents of this manual to locate data which may be of importance during installation procedures. The following is a quick review of the contents in the chapters of this manual.

Instruction Book Chapter Reference

- **Chapter 2, Operation –** guides the operator through the status and metering screens, including monitoring the status and information on the target history.
- **Chapter 4, System Setup –** information regarding the setup procedure. This includes details necessary for input of the communications data, unit setup data, configure relay data, and oscillograph recorder setup information.
- **Chapter 6, Testing –** Tests which may be desirable at the time of installation, any additional tests required during commissioning.

7.2 Mechanical/Physical Dimensions

Figure 7-1 contains the physical dimensions of the relay that are required for mounting.

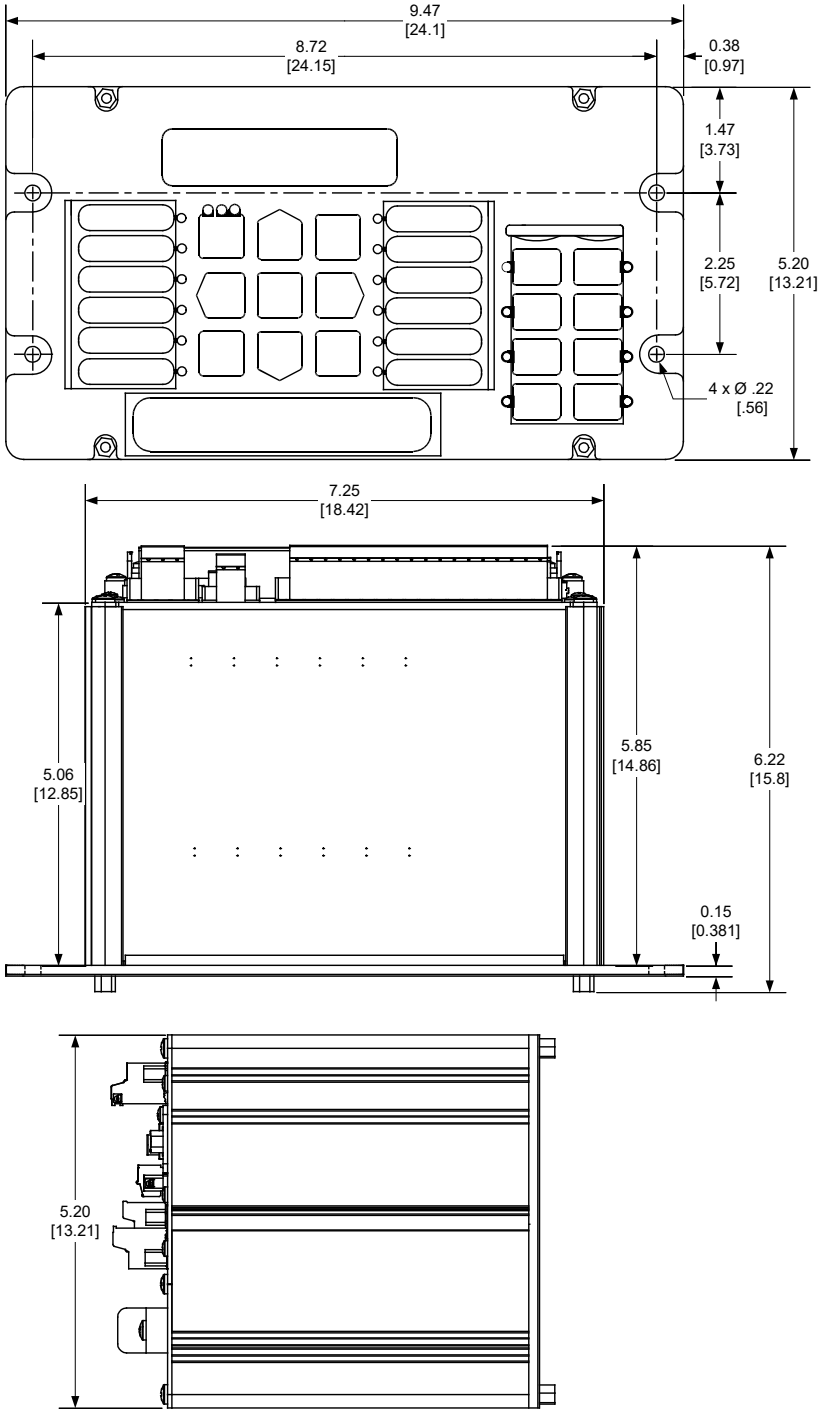


Figure 7-1 M-7651A D-PAC Horizontal External Dimensions

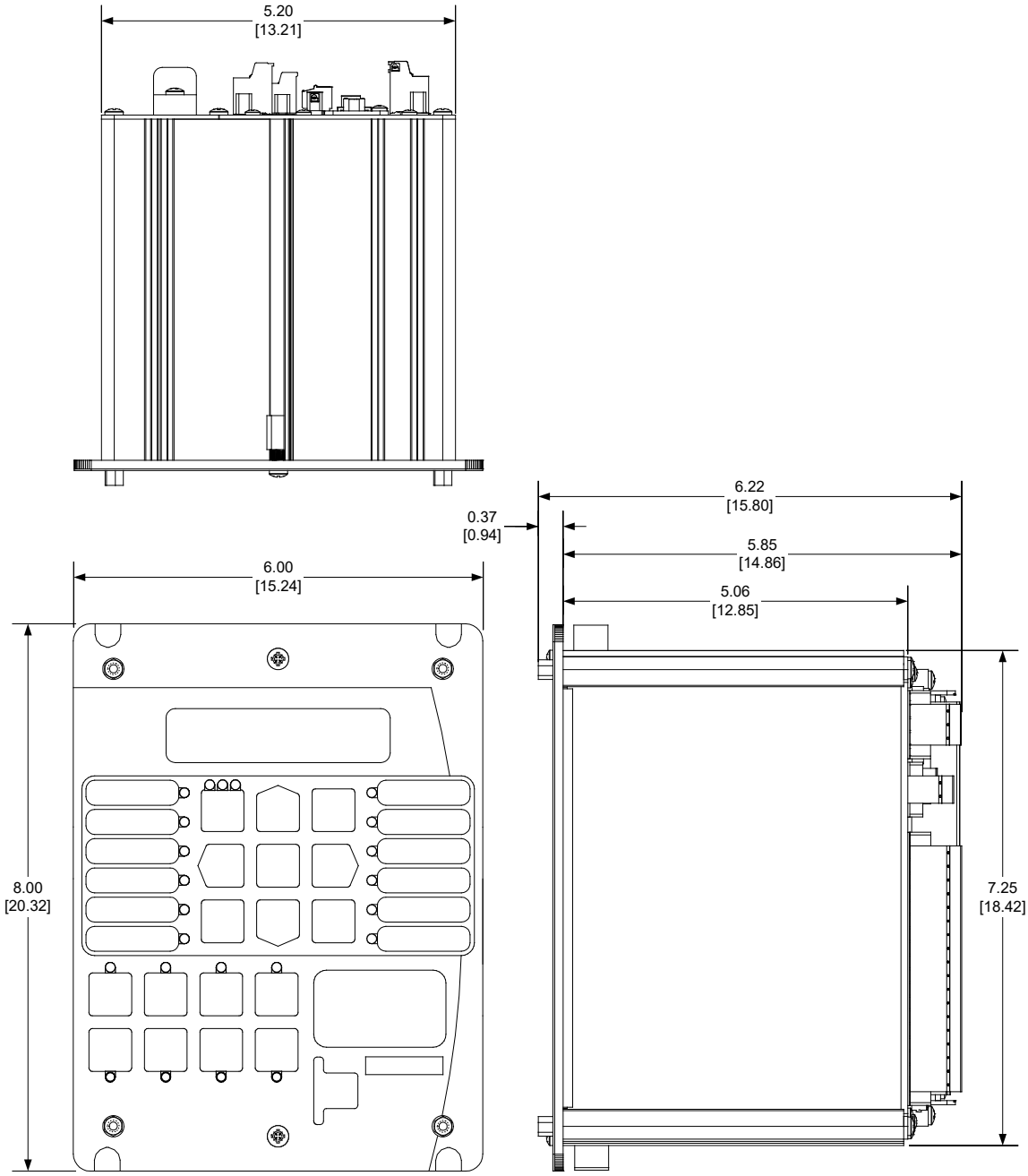


Figure 7-2 M-7651A D-PAC Vertical External Dimensions

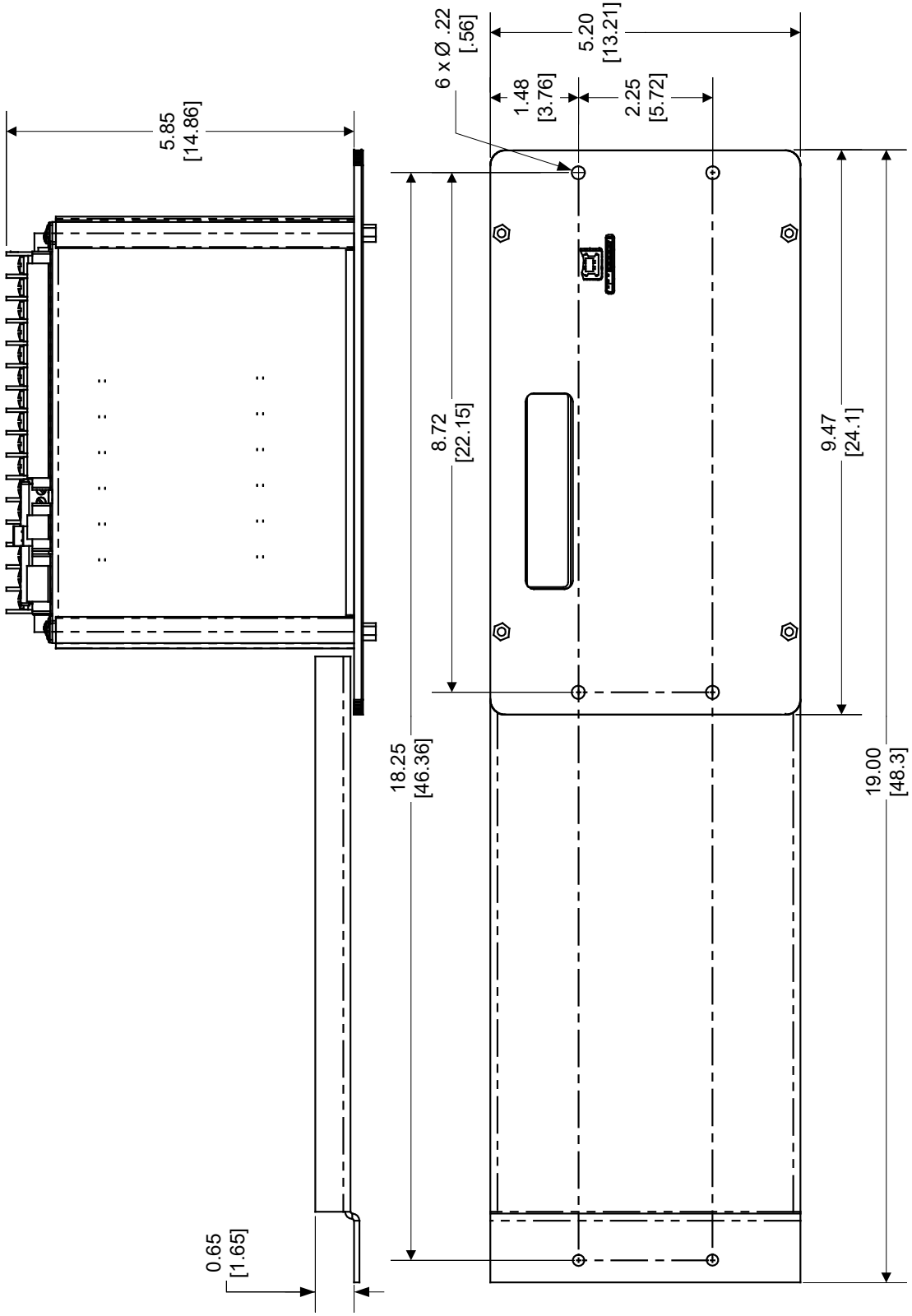


Figure 7-3 M-7651A D-PAC 19 Inch Rack Mount Adapter Frame Dimensions

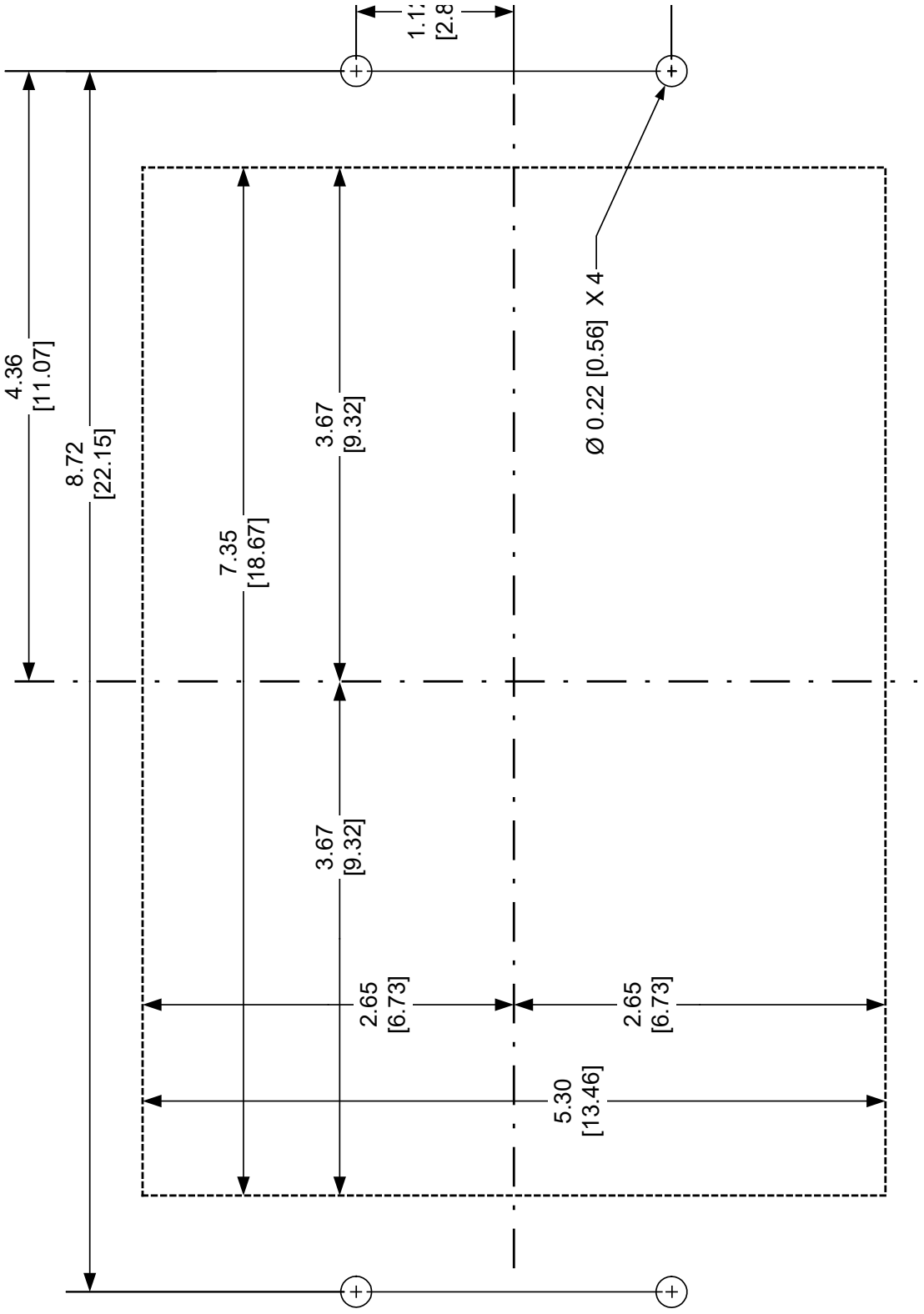


Figure 7-4 Horizontal Panel Mount Cutout Dimensions

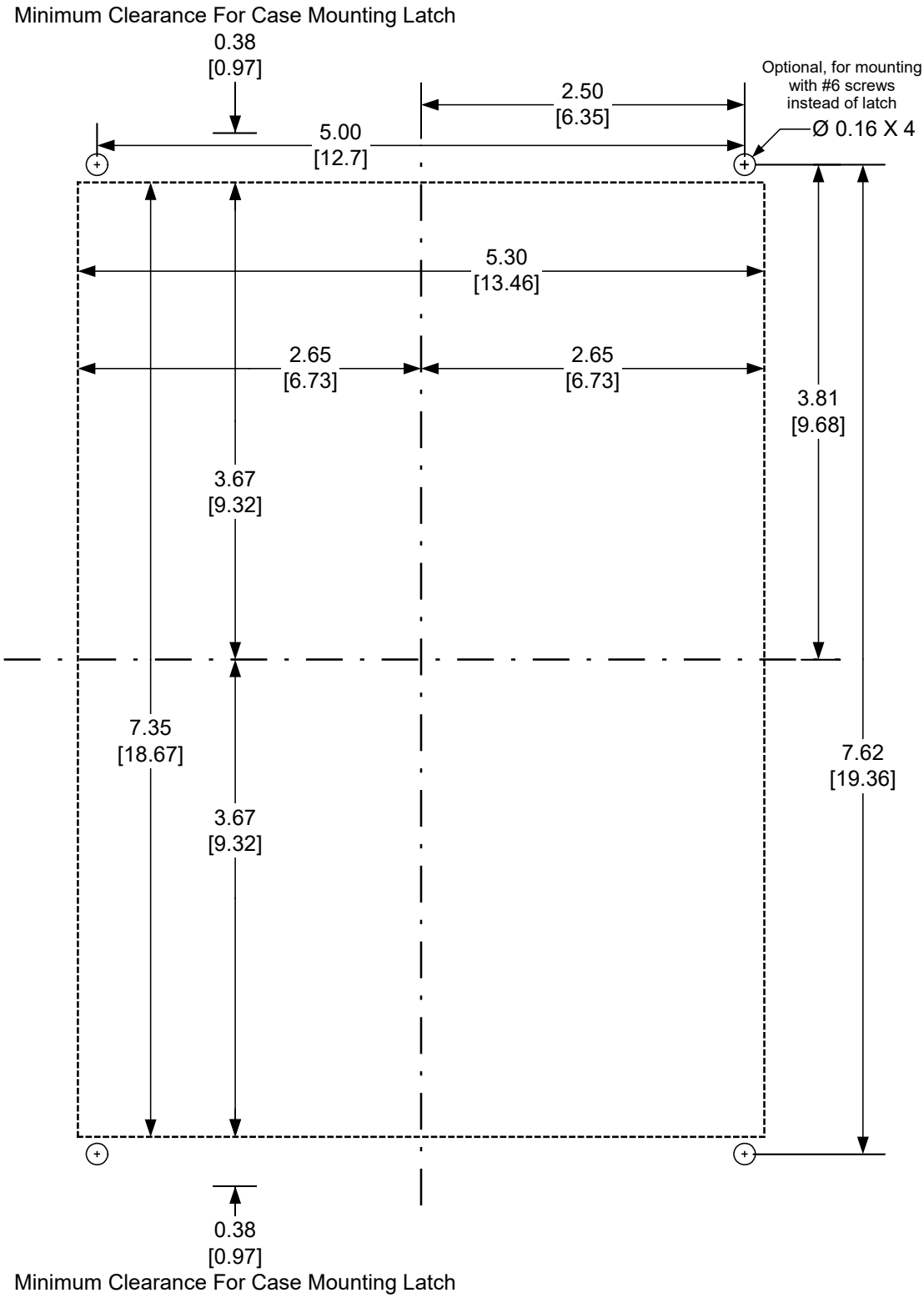


Figure 7-5 Vertical Panel Mount Cutout Dimensions

7.3 External Connections

WARNING: The protective grounding terminal must be connected to an earthed ground anytime external connections have been made to the unit.

WARNING: Do not open live CT circuits. Live CT circuits should be shorted prior to disconnecting CT wiring to the M-7651A D-PAC. Death or severe electrical shock may result.

POWER SUPPLY

IED Power Supply

One of two power supply input ranges are available when the M-7651A D-PAC is purchased. The low voltage range is 18 to 60 Vdc 12 VA. The high voltage range is 90 to 280 Vac or 90 to 315 Vdc 15 VA. The power source should supply a minimum of 15 watts. The power source should be fused. The low voltage range fuse should be 3 AG 1.0 A or equivalent. The high voltage fuse should be 3 AG 0.5 A or equivalent.

The power supply connects to TB-3; polarity is indicated on the rear panel of the M-7651A D-PAC.

Backup Power Supply Input

This input is used to provide backup power to the M-7651A D-PAC in case of loss of the Main Power Supply. The input range of this supply is 11 to 14 Vdc. The power source used to supply this power should be isolated, filtered, and well regulated. The power source should supply a minimum of 15 watts.

The power supply connects to TB-2; polarity is indicated on the rear panel of the M-7651A D-PAC.

Grounding Requirements

The M-7651A D-PAC is designed to be mounted in an adequately grounded panel, using ground bonding techniques (metal-to-metal mounting) and hardware that assures a low impedance ground.

Unit Isolation

Sensing inputs should be equipped with test switches and shorting devices where necessary to isolate the unit from external potential or current sources.

A switch/fuse for the M-7651A D-PAC's power shall be included in the installation, and shall be in close proximity to the relay and within easy reach of the operator, and shall be plainly marked as being the power disconnect device for the relay.

Insulation Coordination

Sensing Inputs: 60 V to 300 V, Installation Category IV, Transient Voltages not to exceed 5,000 V.

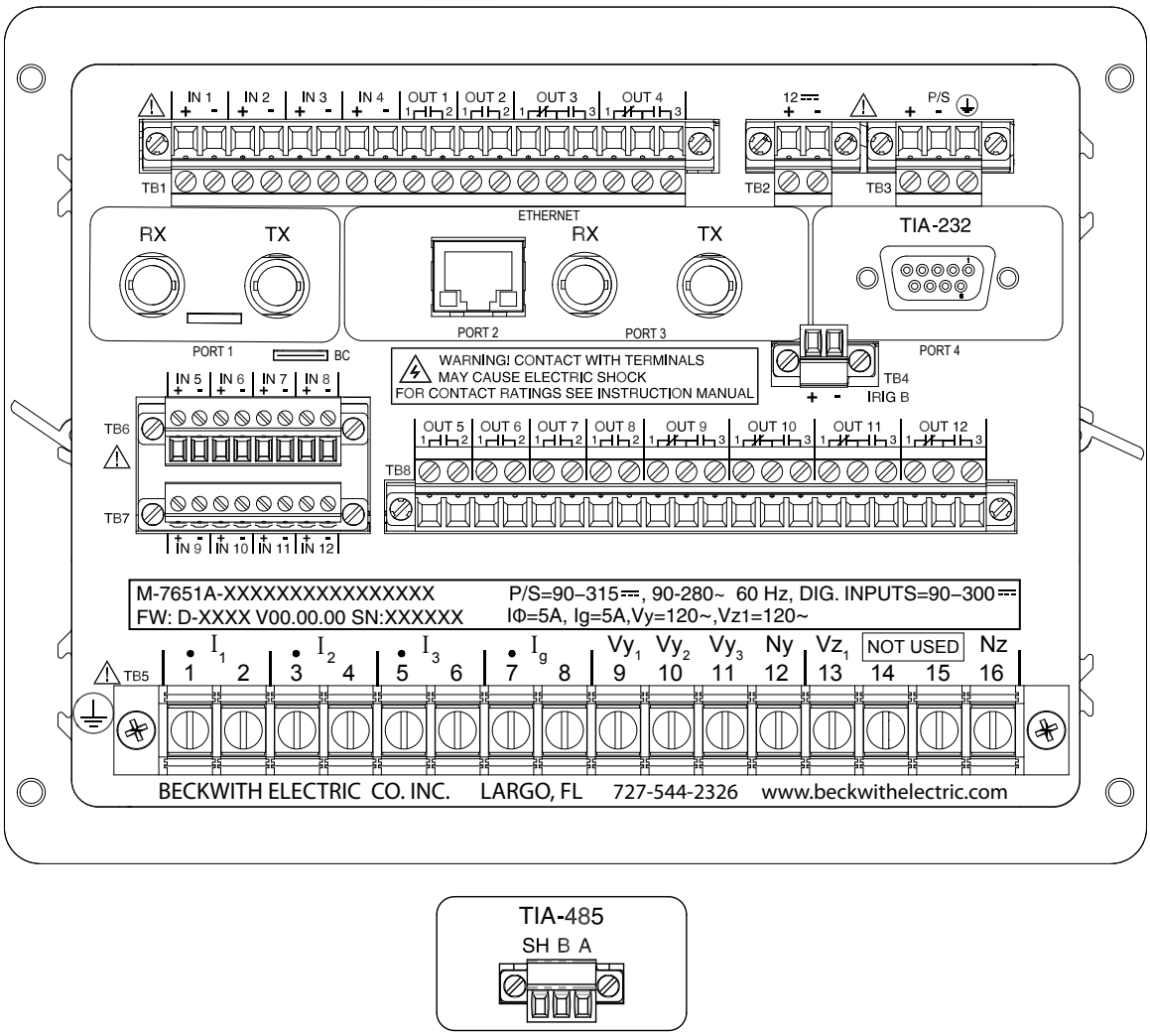
Torque Requirements

- TB-1, 2, 3, 8 4.4–5.3 in-lbs
- TB-5* 7–8 in-lbs
- TB-4, 6, 7 2–2.2 in-lbs

*TB-5 terminal block connections must be made with No. 22-12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector and wire insulation used must be rated at 75° C minimum.

Relay Outputs

All outputs are shown in the de-energized state for standard reference. Relay standard reference is defined as protective elements in the non-trip, reconnection and sync logic in the non-asserted state, or power to the relay is removed. Output contacts are high speed operation contacts.



WARNING: The protective grounding terminal must be connected to an earthed ground any time external connections have been made to the unit.

Figure 7-6 External Connections

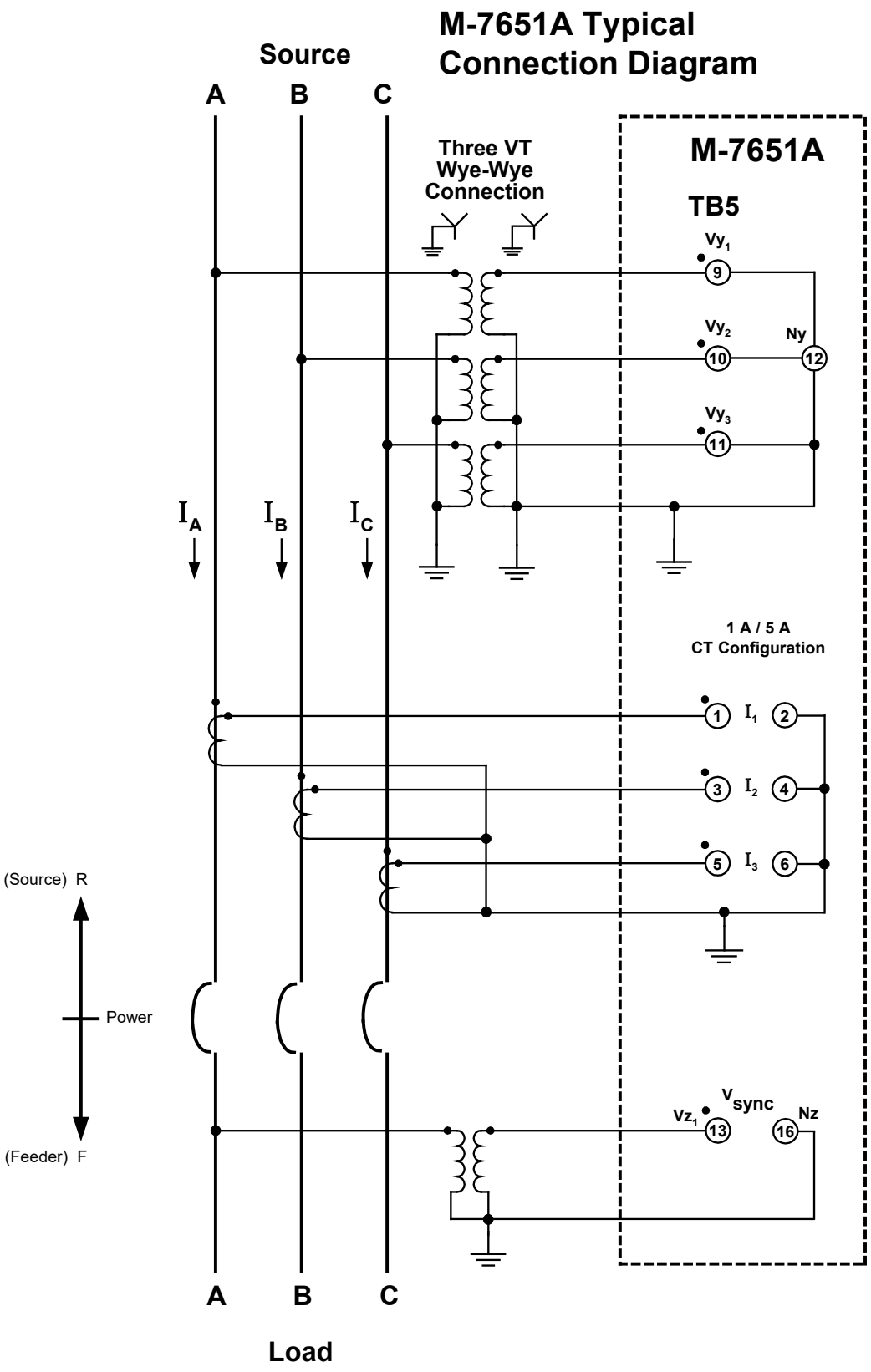


Figure 7-7 Three-Line Connection Diagram

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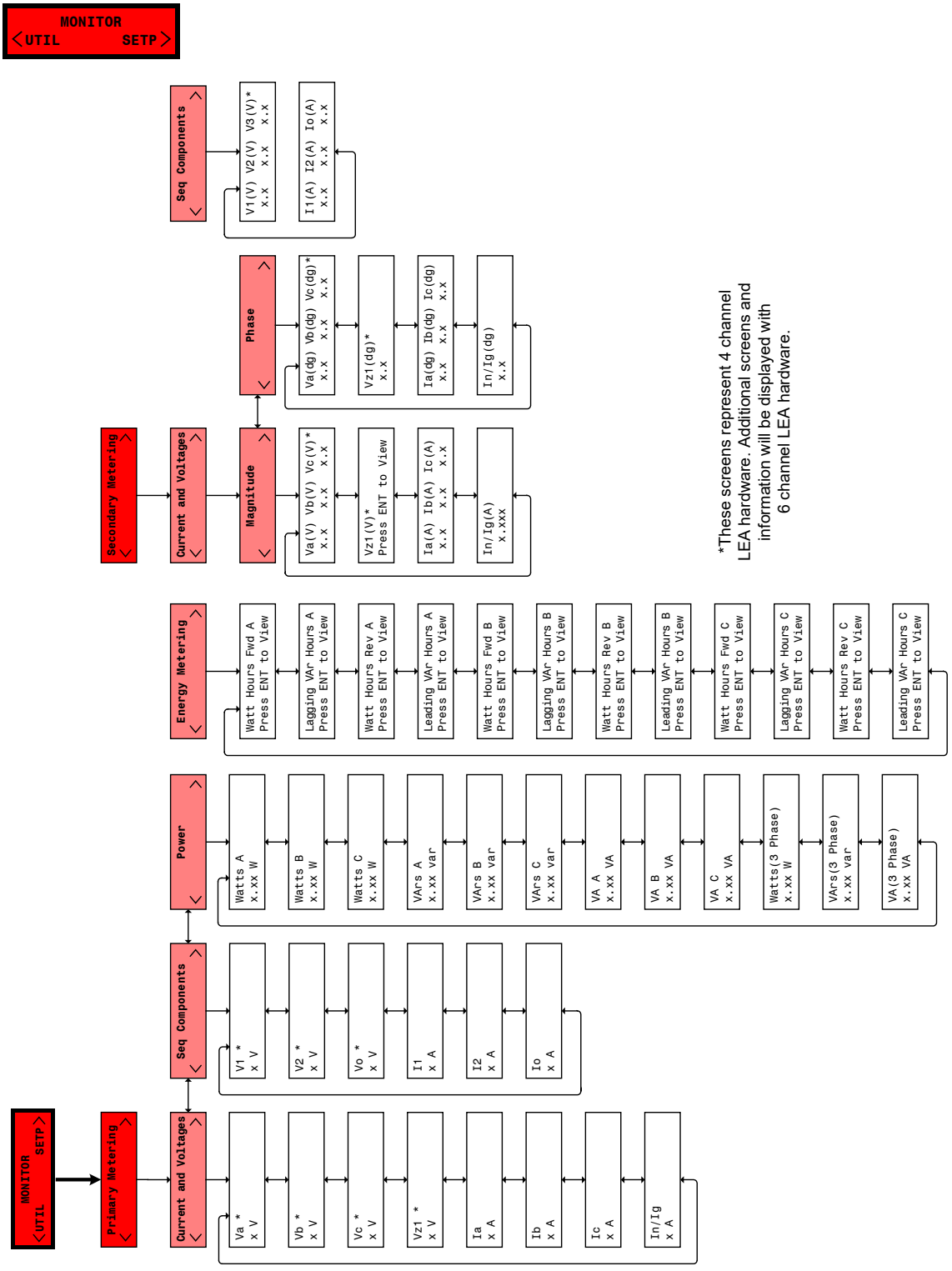
A HMI Menus

Figure A-1 Monitor Menu Flow ..... A–2 to A–4
Figure A-2 Setpoints Menu Flow A–5,A–6
Figure A-3 Configuration Menu Flow A–7
Figure A-4 Utilities Menu Flow A–8
Figure A-5 Communications Menu Flow ..... A–9 to A–11

■ **CYBER SECURITY NOTE:**
When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

HMI MONITOR Menu



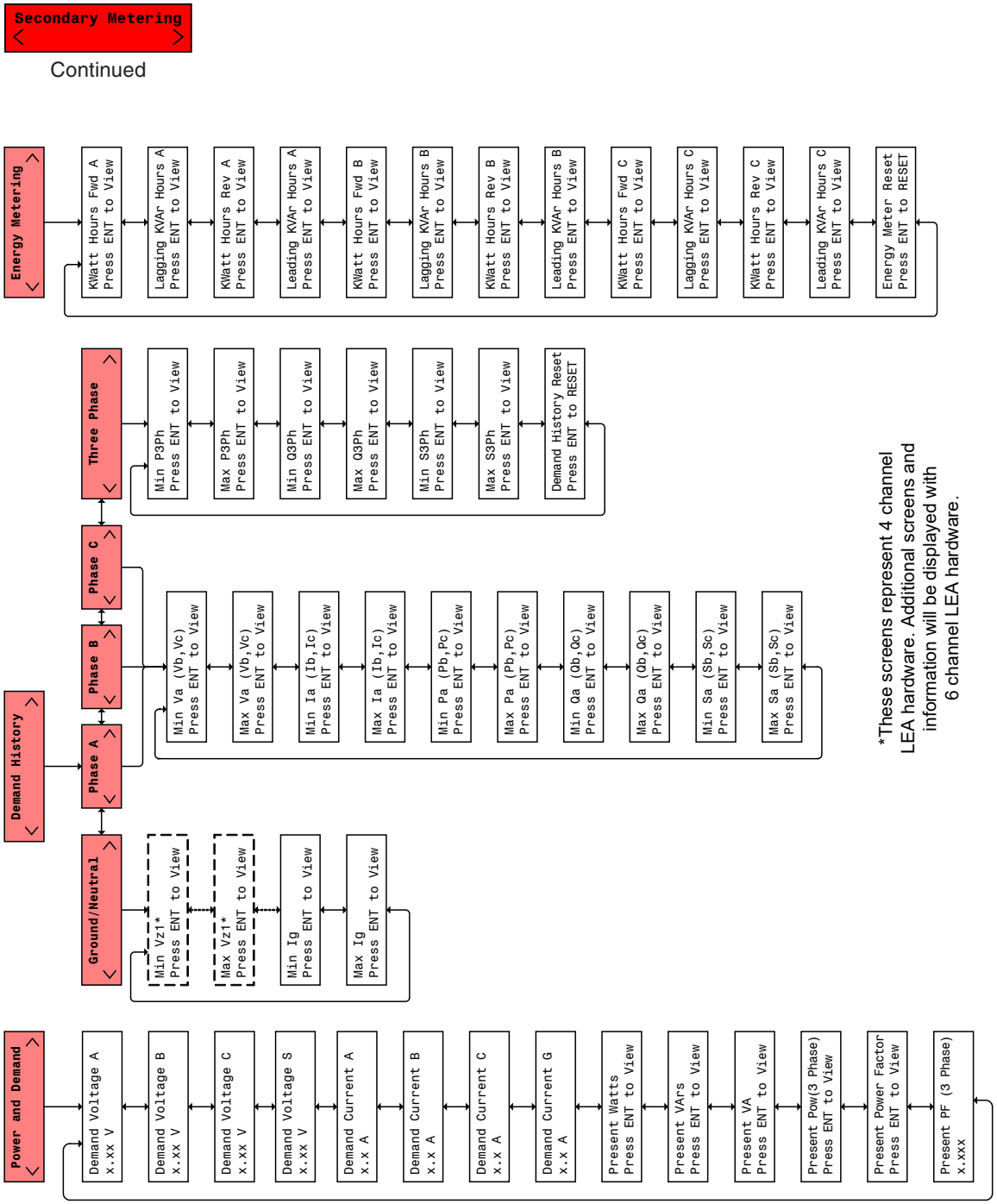
At any menu screen:

Press **EXIT** to go to the Menu Header.

Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-1 Monitor Menu Flow (1 of 3)

HMI MONITOR Menu (cont.)



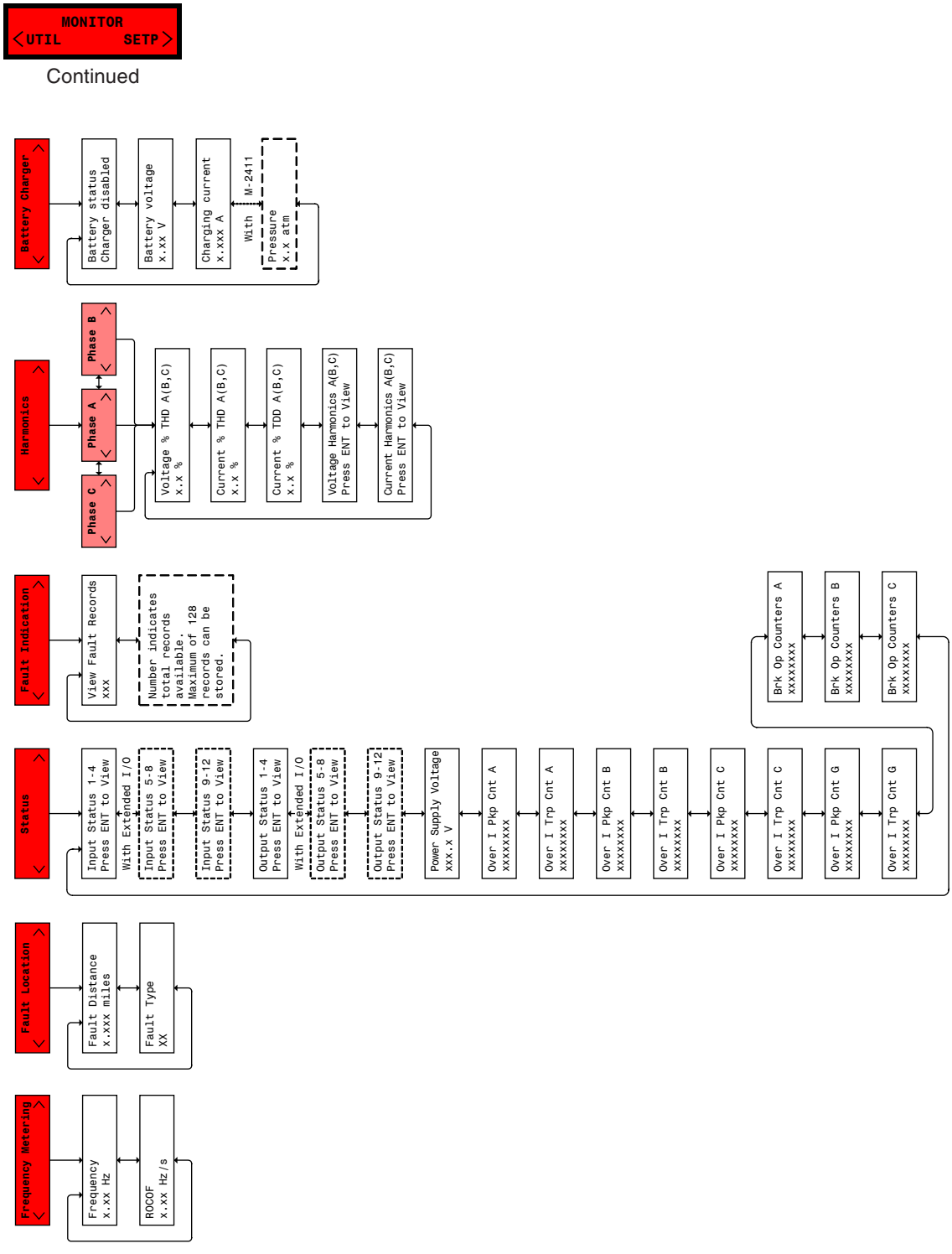
At any menu screen:

Press **EXIT** to go to the Menu Header.

Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-1 Monitor Menu Flow (2 of 3)

HMI MONITOR Menu (cont.)



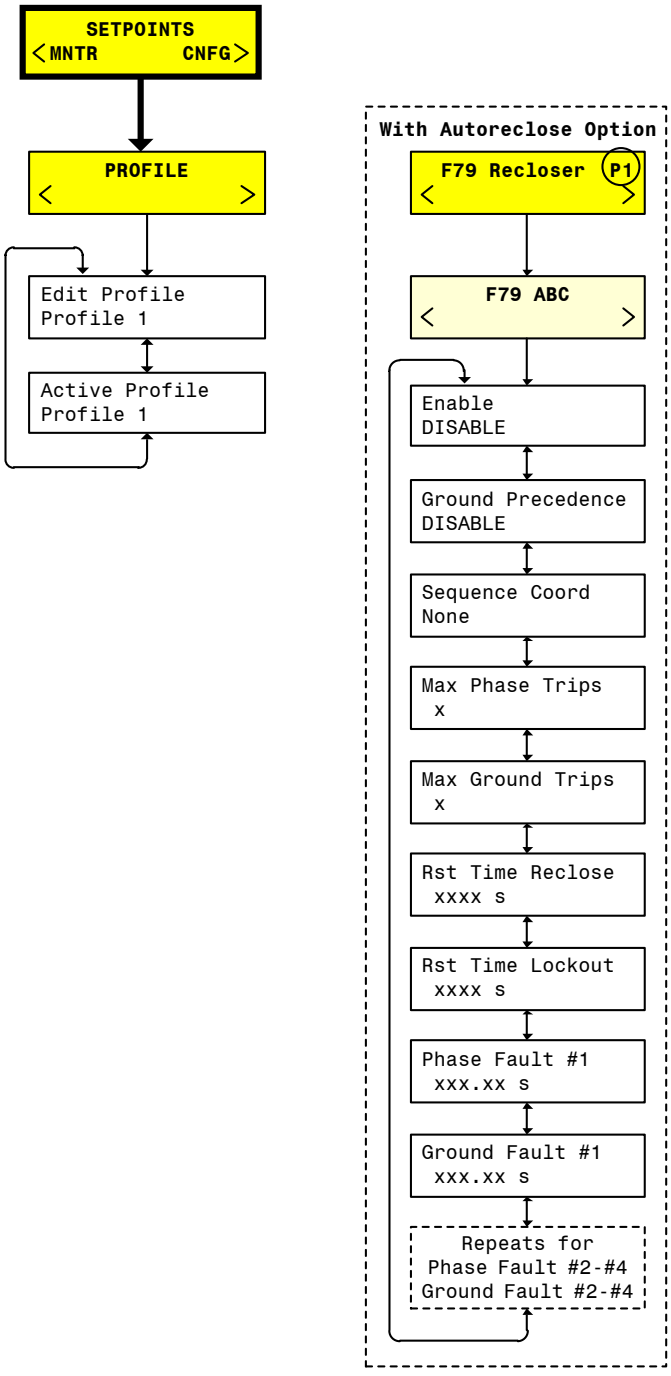
At any menu screen:

Press **EXIT** to go to the Menu Header.

Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-1 Monitor Menu Flow (3 of 3)

HMI SETPOINTS Menu

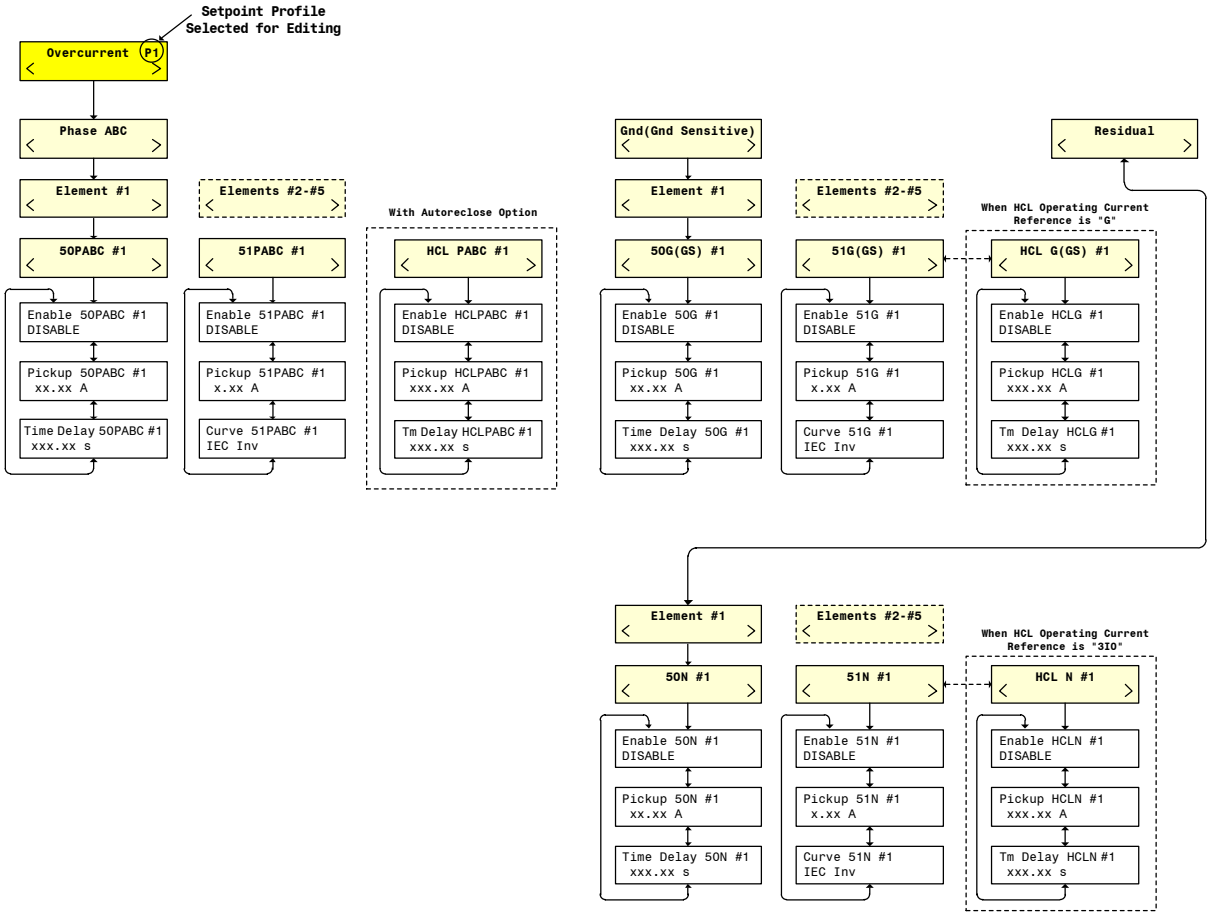


At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-2 Setpoints Menu Flow (1 of 2)

HMI SETPOINTS Menu (cont.)

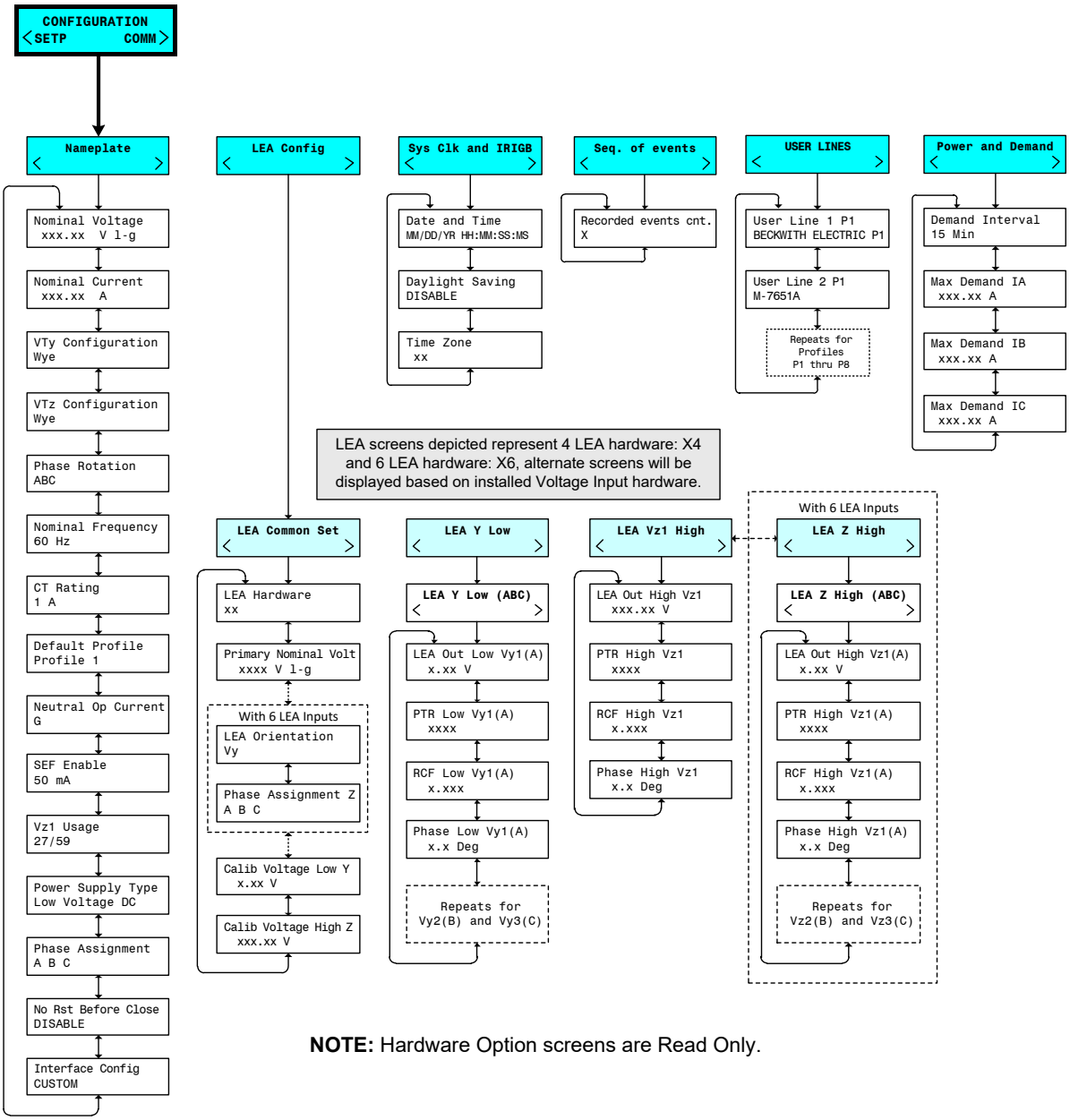
Continued



At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-2 Setpoints Menu Flow (2 of 2)

HMI CONFIGURATION Menu

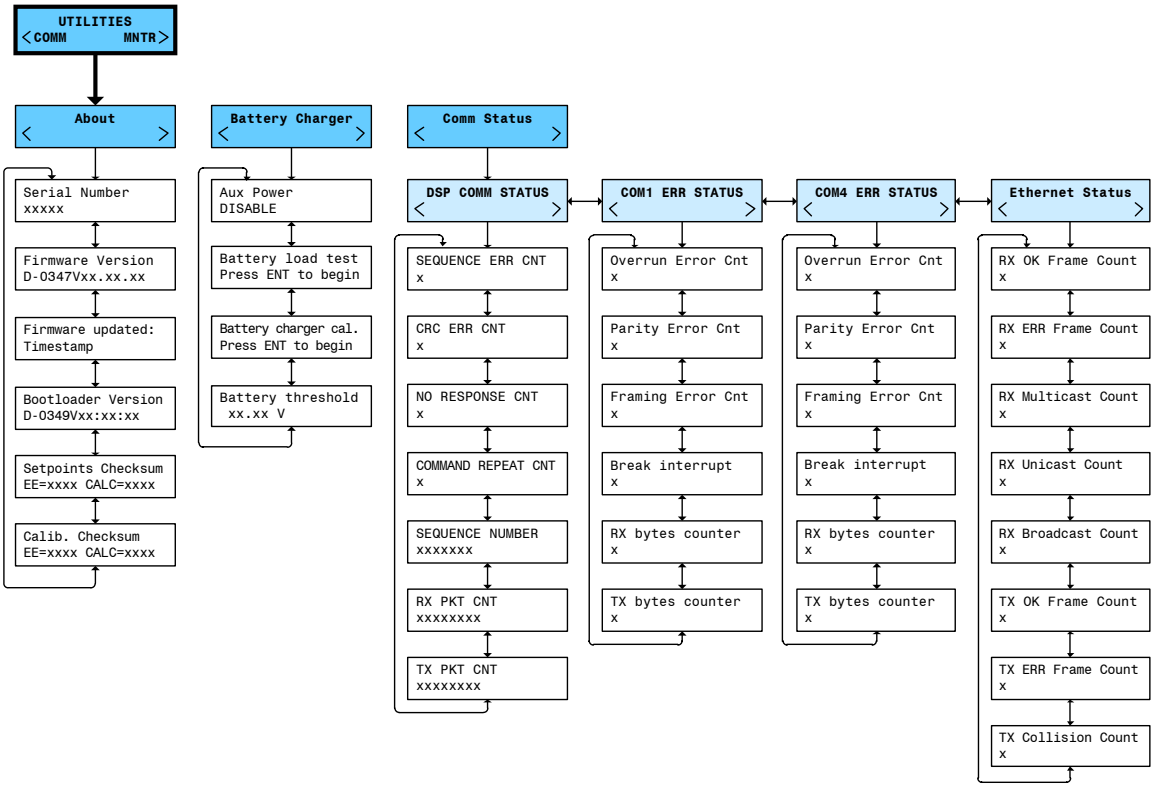


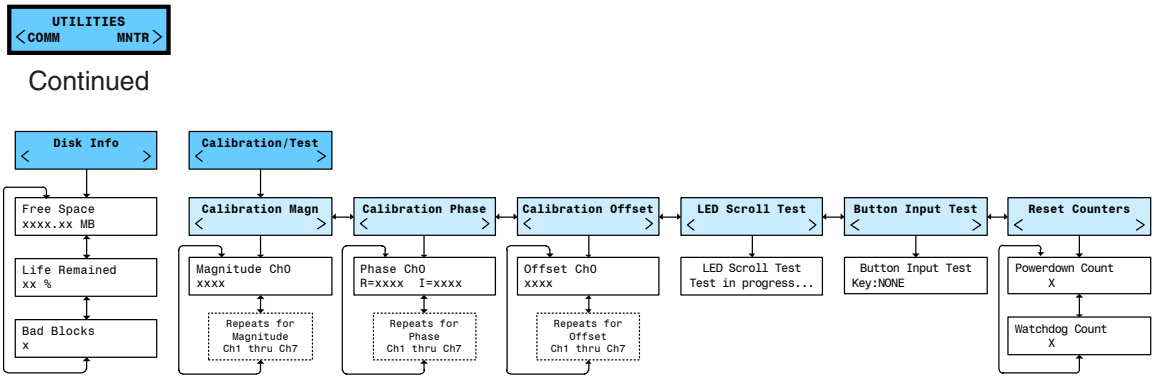
NOTE: Hardware Option screens are Read Only.

At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-3 Configuration Menu Flow

HMI UTILITIES Menu

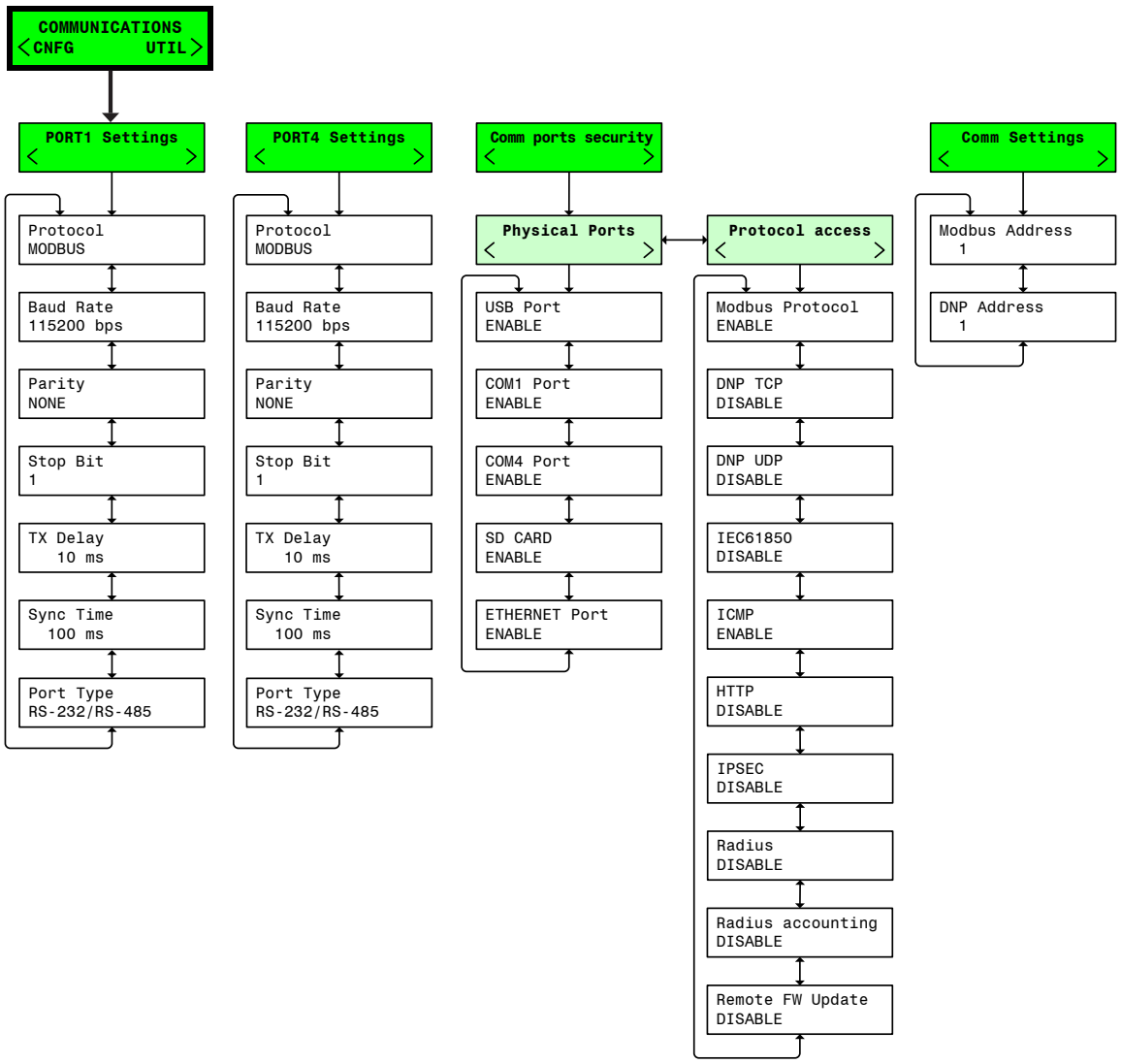




At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-4 Utilities Menu Flow

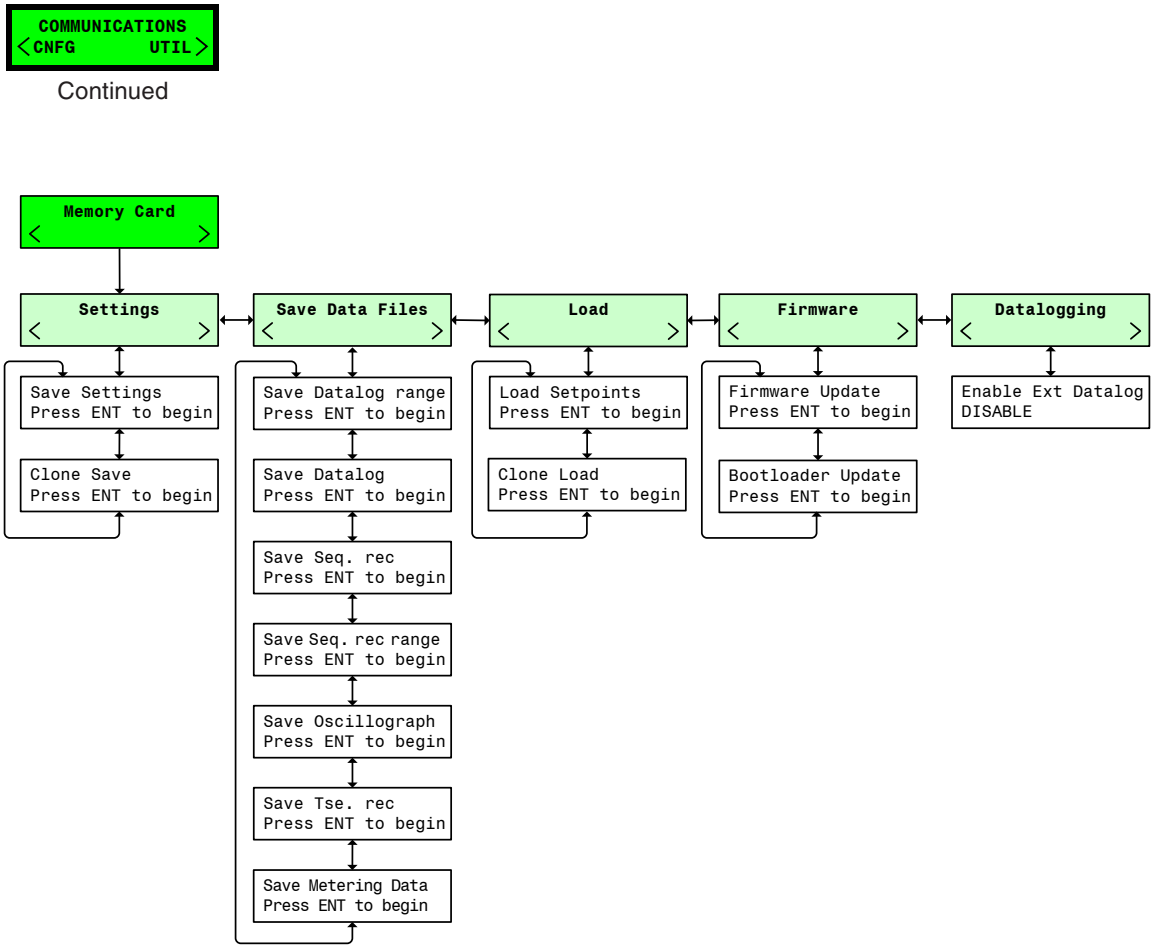
HMI COMMUNICATIONS Menu



At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-5 Communications Menu Flow (1 of 2)

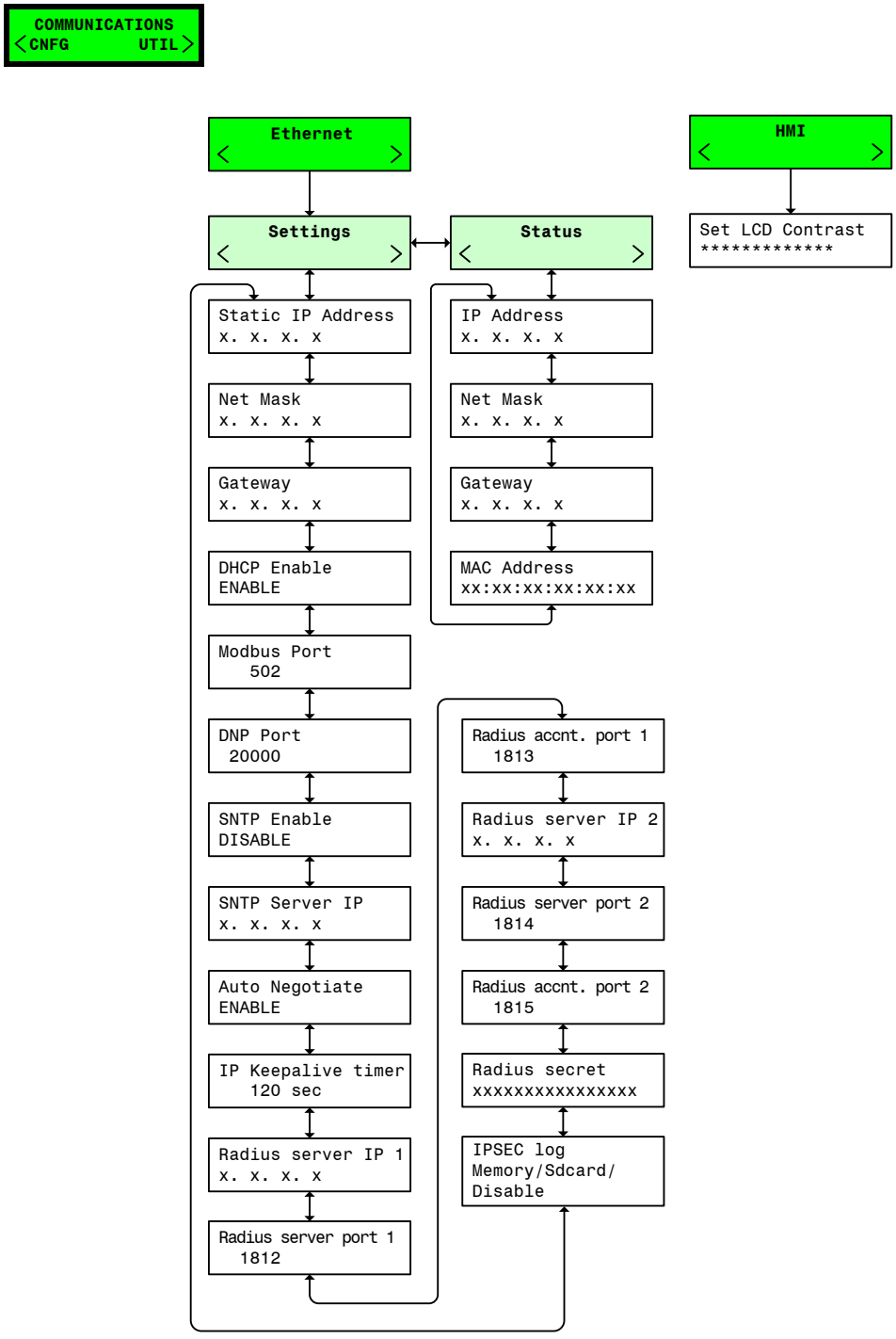
HMI COMMUNICATIONS Menu (cont.)



At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

Figure A-5 Communications Menu Flow (2 of 2)

HMI COMMUNICATIONS Menu (cont.)



At any menu screen:
Press **EXIT** to go to the Menu Header.
Press ⬅ or ➡ to move sideways to the adjacent Menu Header.

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B Relay I/O ConfigurationWorksheet

This Appendix contains a copy of the M-7651A D-PAC System Input/Output Configuration Table and is provided to define and record the blocking inputs and output configuration for the relay. For each function, check if **DISABLED** or **ENABLED**, then check the output contacts to be operated by the function. Also check the inputs designated to block the function operation.

Additional copies of the worksheet can be printed to record I/O configuration for up to 8 profiles. Examples of the suggested use of these forms are illustrated in **Chapter 5, Setpoints** and **Chapter 2, Operation**.

An interactive pdf Record Form is available for download from our website BeckwithElectric.com. This document may be used to record and save all configuration and setpoint settings.

■ **NOTE:** The M-7651A D-PAC is shipped with all functions disabled.

■ **CYBER SECURITY NOTE:**
When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
25 – Sync Check																														
25																														
27 – Undervoltage																														
27 #1 (ABC)																														
27 #2 (ABC)																														
27 #3 (ABC)																														
27 #4 (ABC)																														
27PP – Phase to Phase Undervoltage																														
27PP (ABC)																														
27Vz1 – Vz1 Undervoltage																														
27Vz1																														
32 – Directional Power																														
32 #1 (ABC)																														
32 #2 (ABC)																														
32 #3 (ABC)																														
32 #4 (ABC)																														
40 – Loss of Field																														
40 #1																														
40 #1 (VC)																														
40 #2																														
40 #2 (VC)																														

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 1 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
46DT – Negative Sequence Definite Time Overcurrent																														
46DT #1																														
46DT #2																														
46DT #3																														
46DT #4																														
46DT #5																														
46IT – Negative Sequence Inverse Time Overcurrent																														
46IT #1																														
46IT #2																														
46IT #3																														
46IT #4																														
46IT #5																														
47 – Negative Sequence Overvoltage																														
47																														
50BF – Breaker Failure																														
			Retrip Output												Input Initiate															
50BF																											–			
			Outputs												Blocking Inputs															
50P – Phase Instantaneous/Definite Time Overcurrent																														
50P #1 (ABC)																														
50P #2 (ABC)																														
50P #3 (ABC)																														
50P #4 (ABC)																														
50P #5 (ABC)																														

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 2 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
50N – Residual Instantaneous/Definite Time Overcurrent																														
50N #1																														
50N #2																														
50N #3																														
50N #4																														
50N #5																														
50G – Ground Instantaneous/Definite Time Overcurrent																														
50G #1																														
50G #2																														
50G #3																														
50G #4																														
50G #5																														
50GS – Sensitive Ground Instantaneous/Definite Time Overcurrent																														
50GS #1																														
50GS #2																														
50GS #3																														
50GS #4																														
50GS #5																														
51P – Phase Inverse Time Overcurrent																														
51P #1 (ABC)																														
51P #2 (ABC)																														
51P #3 (ABC)																														
51P #4 (ABC)																														
51P #5 (ABC)																														

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 3 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
51N – Residual Inverse Time Overcurrent																														
51N #1																														
51N #2																														
51N #3																														
51N #4																														
51N #5																														
51G – Ground Inverse Time Overcurrent																														
51G #1																														
51G #2																														
51G #3																														
51G #4																														
51G #5																														
51GS – Sensitive Ground Inverse Time Overcurrent																														
51GS #1																														
51GS #2																														
51GS #3																														
51GS #4																														
51GS #5																														
59 – Overvoltage																														
59 #1 (ABC)																														
59 #2 (ABC)																														
59 #3 (ABC)																														
59 #4 (ABC)																														
59PP – Phase to Phase Overvoltage																														
59PP (ABC)																														

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 4 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS												Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
59I – Peak Overvoltage																														
59I (ABC)																														
59Vz1 – Vz1 Overvoltage																														
59Vz1																														
59N – Residual Overvoltage																														
59N																														
67P – Phase Directional Overcurrent																														
67P #1 (ABC)																														
67P #2 (ABC)																														
67P #3 (ABC)																														
67P #4 (ABC)																														
67P #5 (ABC)																														
67Q – Negative Sequence Directional Overcurrent																														
67Q #1																														
67Q #2																														
67Q #3																														
67Q #4																														
67Q #5																														
67G – Ground Directional Overcurrent																														
67G #1																														
67G #2																														
67G #3																														
67G #4																														
67G #5																														

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 5 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
67GS – Sensitive Ground Directional Overcurrent																														
67GS #1																														
67GS #2																														
67GS #3																														
67GS #4																														
67GS #5																														
67N – Residual Directional Overcurrent																														
67N #1																														
67N #2																														
67N #3																														
67N #4																														
67N #5																														
81 – Frequency																														
81 #1																														
81 #2																														
81 #3																														
81 #4																														
81R – Rate of Change of Frequency																														
81R #1																														
81R #2																														
CLP – Cold Load Pickup																														
															52A	52B											Breaker Input Status			
CLP			N/A																											

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 6 of 7)

Profile ___

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS												Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
IPS – IPSlogic™																														
IPSlogic #1																														
IPSlogic #2																														
IPSlogic #3																														
IPSlogic #4																														
IPSlogic #5																														
IPSlogic #6																														
IPSlogic #7																														
IPSlogic #8																														
79 – Recloser Relay (Three Phase Ganged)																														
Function 79			N/A																											

Table B-1 Relay I/O Configuration Worksheet – Profile Setpoints (page 7 of 7)

Function	Enable	Disable	OUTPUTS												BLOCKING INPUTS													Virtual Input		
			1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	FL	V1	V2	V3
PSBC – IED Power Supply/Battery Charger Monitor																														
Automatic Test																														
TCM – Trip Circuit Monitor																														
															52A	52B					Trip Coil Input									
TCM															–	–											–			
																52B					Blocking Inputs									
CCM – Close Circuit Monitor																														
															52A	52B					Close Coil Input									
CCM															–	–											–			
															52A						Blocking Inputs									
60FL – VT Fuse Loss Detection																														
																					Input Initiate									
60FL																											–			
																					Blocking Inputs									
																											–			
THD/TDD – Total Harmonic Distortion / Total Demand Distortion																														
THD/TDD #1(ABC)																														
THD/TDD #1 (A)																														
THD/TDD #1 (B)																														
THD/TDD #1 (C)																														
THD/TDD #2(ABC)																														
THD/TDD #2 (A)																														
THD/TDD #2 (B)																														
THD/TDD #2 (C)																														

Table B-2 Relay I/O Configuration Worksheet – Common Setpoints

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C Self-Test Error Codes

26	FLASH configuration has invalid page size
27	FLASH access timeout
28	FLASH is missing configuration
29	FLASH configuration is invalid
30	FLASH configuration section is missing
31	FLASH configuration has invalid section range
32	FLASH configuration section is out of memory
33	FLASH configuration error
34	FLASH is out of memory
35	FLASH file system is out of memory
36	FLASH receive failed
37	FLASH PROGRAMMING ERROR
38	FLASH ACCESS ERROR
39	FLASH BUFFER ERROR
41	DNP CONFIGURATION OUT OF MEMORY
42	DNP MMS CONFIGURATION FAILED
43	FLASH FILE SYSTEM RESOURCES FAILED
44	LED MAP FILE NOT FOUND
45	LED MAP STATUS BIT MISSING
46	MISSING SETPOINT IN SPDB TABLE
47	SOE RECORDER INIT FAILED
48	MESSAGE LOG INIT FAILED
49	RAM DISK INIT FAILED
50	RAM DISK RESOURCES FAILED
51	INVALID MODBUS CHANNEL
52	ERROR IN SPDB DATABASE CONFIGURATION
53	SDCARD FAT MOUNT FAILED
54	OSCILLOGRAPH RECORDER HEADER MISMATCH
55	DATALOG RECORDER INIT FAILED
56	SPDB DATABASE HASH OUT OF MEMORY
57	ERROR DURING USER LOGOUT
58	PASSWORD FILE IS MISSING
59	ERROR IN PASSWORD FILE

Table C-1 Self-Test Error Codes (1 of 2)

60	BBRAM BATTERY FAILURE
61	BACKGROUND TASK FIFO ERROR
62	BACKGROUND TASK COMMAND POINTER IS NULL
63	OUT OF MEMORY DURING RSA INIT
64	IP SOCKET MUTEX ERROR
65	BBRAM RAMDISK INITIALIZATION FAILURE
66	MESSAGE LOG BUFFER OVERFLOW
67	DSP WATCHDOG ERROR
68	DSP CALIBRATION CHECKSUM ERROR
69	DSP SETPOINTS CHECKSUM ERROR
70	"MODBUS PORT" SETPOINT FAILURE
71	"GLOBAL PORTS ENABLE" SETPOINT FAILURE
72	EEPROM WRITE TIMEOUT
73	BOOTDATA IS CORRUPTED
74	BOOTDATA CHECKSUM ERROR
75	CONFIG FILE TYPE MISMATCH ERROR
76	DNP DTD FILE PARSE ERROR
77	"DNP PORT" SETPOINT FAILURE
100	ERROR LOCKING SPORT0 SEMAPHORE
101	NO RESPONSE FROM DSP VIA SPORT0
102	ERROR IN DSP RESPONSE
103	ERROR IN DSP METERING DATA
104	FAIL TO TRANSFER SETPOINTS TO DSP
200	IP SOCKETS ARE OUT OF MEMORY
201	IP SOCKET IS FULL
9000	UNAUTHORIZED PROGRAM FLASH ACCESS

Table C-1 Self-Test Error Codes (2 of 2)

D Inverse Time Curves

The M-7651A D-PAC offers over 50 different time curves plus four user programmable curves to facilitate coordination with other elements in the network. The phase or ground fast- and delay-curves can be set either with the user-designed curves or with the curve selection choices listed in Table D-1.

The M-7651A D-PAC supports the following curve selections:

Curve Category	Curve Selection
IEC Curves (IEC 60255-151)	Inverse, Very Inverse, Extremely Inverse
IEEE Curves (IEEE C37.112)	Moderately Inverse, Very Inverse, Extremely Inverse
Traditional Recloser Curves ■NOTE: (Newer curves are shown with the older curve designations in parentheses)	101 (A); 102 (1); 103 (17); 104 (N); 105 (R); 106 (4); 107 (L); 111 (8*); 112 (15); 113 (8); 114 (5); 115 (P); 116 (D); 117 (B); 118 (M); 119 (14); 120 (Y); 121 (G); 122 (H); 131 (9); 132 (E); 133 (C); 134 (Z); 135 (2); 136 (6); 137 (V); 138 (W); 139 (16); 140 (3); 141 (11); 142 (13); 151 (18); 152 (7); 161 (T); 162 (KP); 163 (F); 164 (J); 165 (KG); 200; 201; 202
US Curves	Moderately Inverse, Standard Inverse, Very Inverse, Extremely Inverse, Short Time Inverse
Definite Time	Definite Time
User-Designed Programmable Curves	Four Programmable Curves

Table D-1 M-7651A Curve Selection

Expression for Time Delay Setting – Operating time defined by IEC and ANSI/IEEE

IEC Equation	IEEE Equation
$t = TD\left[\frac{A}{M^P - 1}\right]$	$t = \frac{TD}{5}\left[\frac{A}{M^P - 1} + B\right]$ *(IEEE Equation Constants are defined at TD of 5)*

Where:

t = Relay operating time in seconds

TD = Time dial, or time multiplier setting

I = Fault current level in secondary amps

I_P = Tap or pickup current selected

B = Constant

p = Slope constant

A = Slope constant

$M = \frac{I}{I_P}$

Setting Time Delay on Overcurrent Relays

Table D-2 illustrates the ANSI/IEEE and IEC Constants for Overcurrent Relays.

IDMT Curve Description	Standard	p	A	B
Moderately Inverse	IEEE	0.02	0.0515	0.114
Very Inverse	IEEE	2	19.61	0.491
Extremely Inverse	IEEE	2	28.2	0.1217
Standard Inverse	IEC	0.02	0.14	-
Very Inverse	IEC	1.0	13.5	-
Extremely Inverse	IEC	2.0	80.0	-

Table D-2 ANSI/IEEE and IEC Constants for Overcurrent Relays

IPScom Inverse Time Curves Graphs

Inverse Time Curve Graphs are available from the Setpoints screens for all Inverse Time Overcurrent Functions in IPScom. The "View Graph" feature displays the curve graph based on the entered Time Multiplier (Dial), Time Adder and Minimum Response Time Adder. The graphs illustrated in Figure D-1 through Figure D-53 depict the supported curves with the following default settings:

- **TM –** Time Multiplier (Dial) = 1.00
- **TA –** Time Adder = 0.00 seconds
- **MRTA –** Minimum Response Time Adder = 0.00 seconds

IPScom also provides a tool for the user to create up to four user defined Custom Curves. See **Chapter 5 Setpoints** for detailed information.

CURVE EQUATIONS

IEC Curve Equations

IEC Curve Type	Operate Time	Reset Time	Figure
Inverse	$t = TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$	$t = TD \times \left[\frac{13.5}{1 - M^2}\right]$	Figure D-1
Very Inverse	$t = TD \times \left[\frac{13.5}{M - 1}\right]$	$t = TD \times \left[\frac{47.3}{1 - M^2}\right]$	Figure D-2
Extremely Inverse	$t = TD \times \left[\frac{80}{M^2 - 1}\right]$	$t = TD \times \left[\frac{80}{1-M^2}\right]$	Figure D-3

IEEE Curve Equations

IEEE Curve	Operate Time	Reset Time	Figure
Moderately Inverse	$t = TD\left[\frac{0.0515}{M^{0.02} - 1} + 0.114\right]$	$t = TD\left[\frac{4.85}{M^2 - 1}\right]$	Figure D-4
Very Inverse	$t = TD\left[\frac{19.61}{M^2 - 1} + 0.491\right]$	$t = TD\left[\frac{21.6}{M^2 - 1}\right]$	Figure D-5
Extremely Inverse	$t = TD\left[\frac{28.2}{M^2 - 1} + 0.1217\right]$	$t = TD\left[\frac{29.1}{M^2 - 1}\right]$	Figure D-6

US Curve Equations

US Curve	Operate Time	Reset Time	Figure
Moderately Inverse	$T = TD \times \left[0.0226 + \frac{0.0104}{M^{0.02} - 1}\right]$	$T = TD \times \left[\frac{1.08}{1 - M^2}\right]$	Figure D-7
Standard Inverse	$T = TD \times \left[0.180 + \frac{5.95}{M^2 - 1}\right]$	$T = TD \times \left[\frac{5.95}{1 - M^2}\right]$	Figure D-8
Very Inverse	$T = TD \times \left[0.0963 + \frac{3.88}{M^2 - 1}\right]$	$T = TD \times \left[\frac{3.88}{1 - M^2}\right]$	Figure D-9
Extremely Inverse	$T = TD \times \left[0.0352 + \frac{5.67}{M^2 - 1}\right]$	$T = TD \times \left[\frac{5.67}{1 - M^2}\right]$	Figure D-10
Short Time Inverse	$T = TD \times \left[0.00262 + \frac{0.00342}{M^{0.02} - 1}\right]$	$T = TD \times \left[\frac{0.323}{1 - M^2}\right]$	Figure D-11

IEC CURVES (IEC 60255-151)

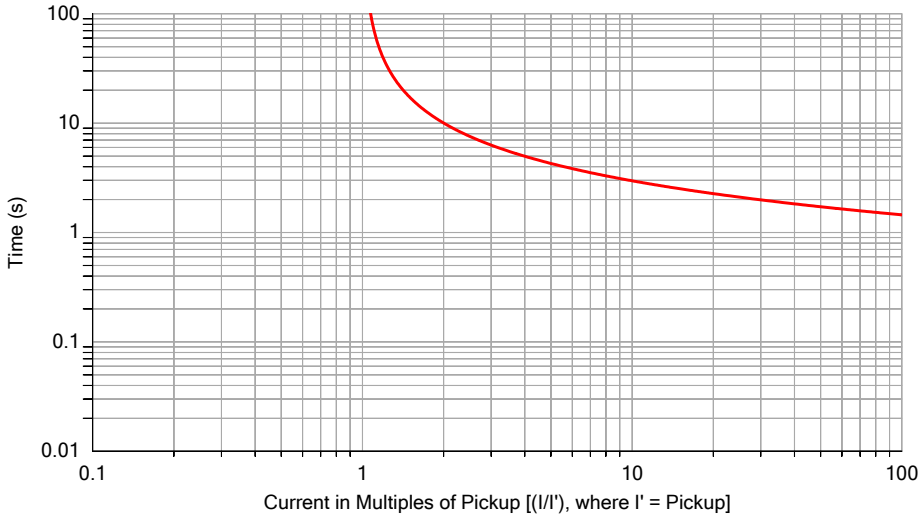

Figure D-1 IEC Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

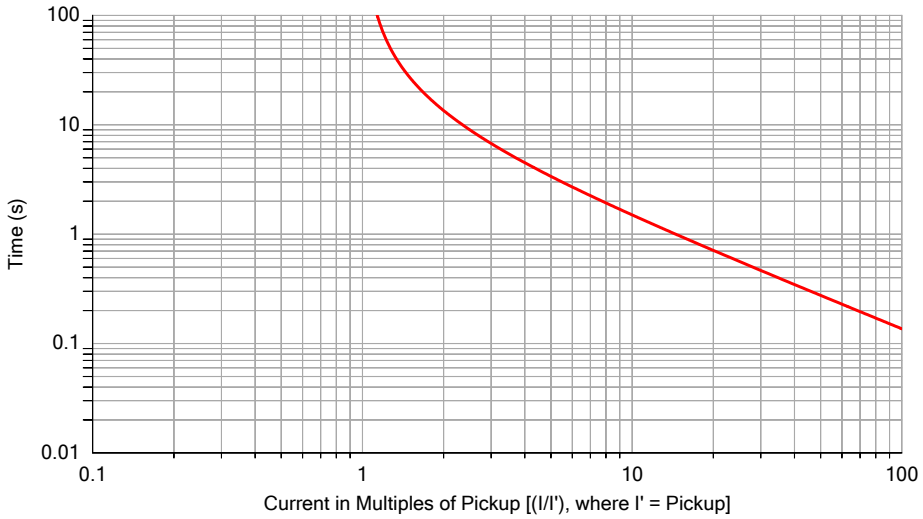

Figure D-2 IEC Very Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-3 IEC Extremely Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

IEEE CURVES (IEEE C37.112)

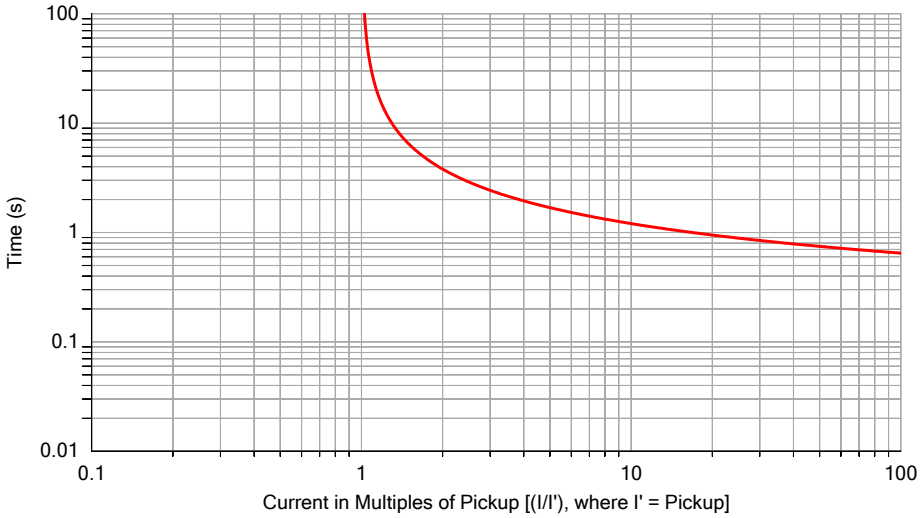

Figure D-4 IEEE Moderately Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

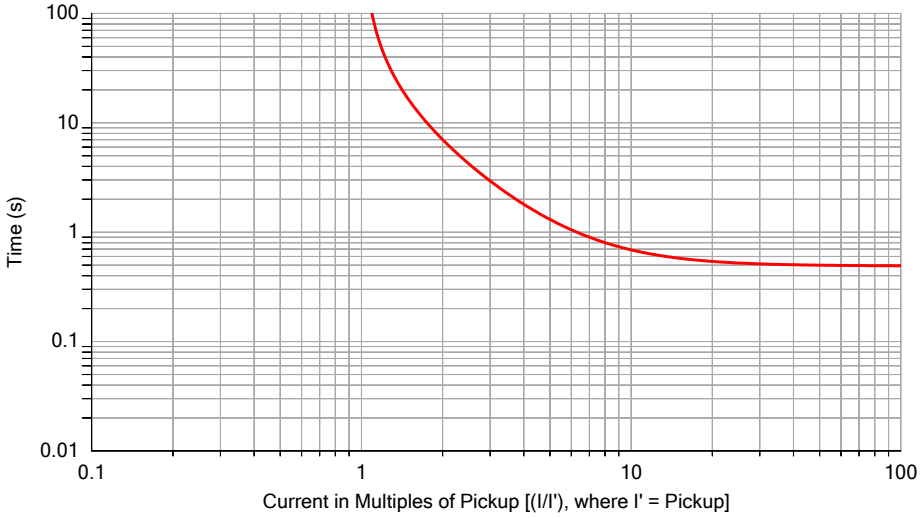

Figure D-5 IEEE Very Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

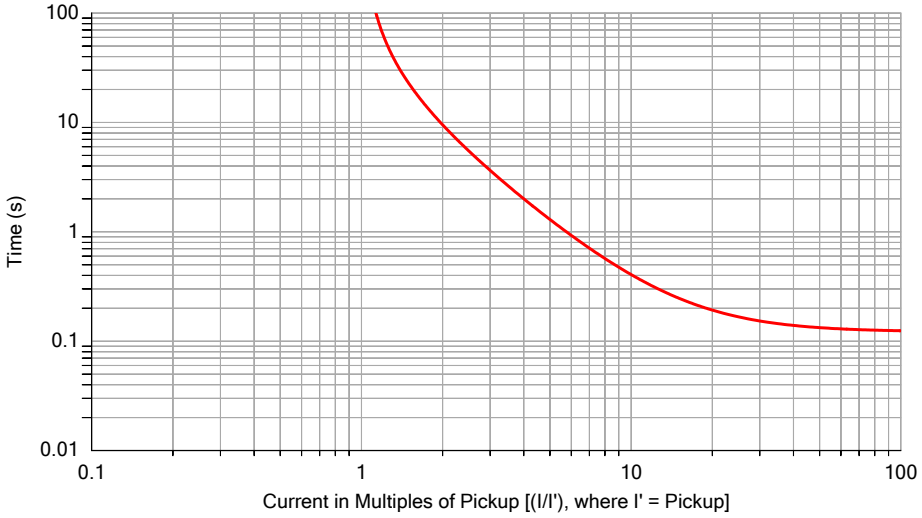

Figure D-6 IEEE Extremely Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

US CURVES

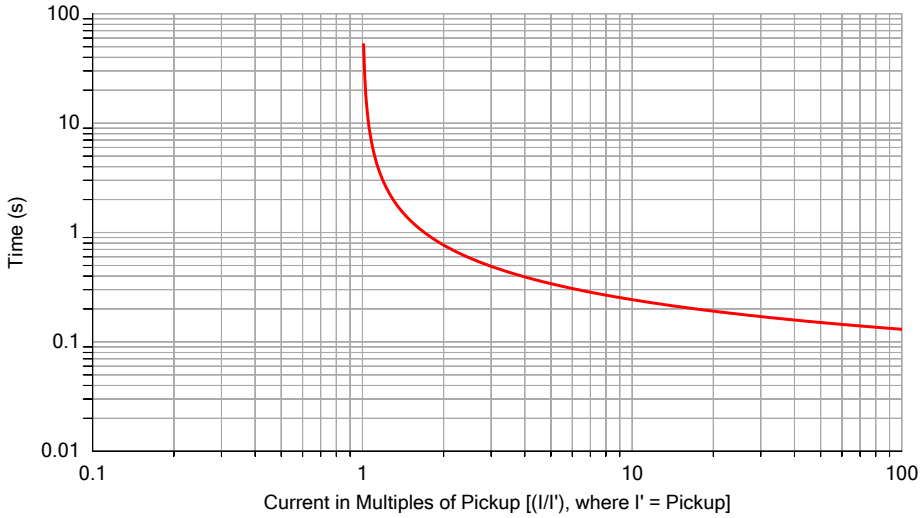

Figure D-7 US Moderately Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

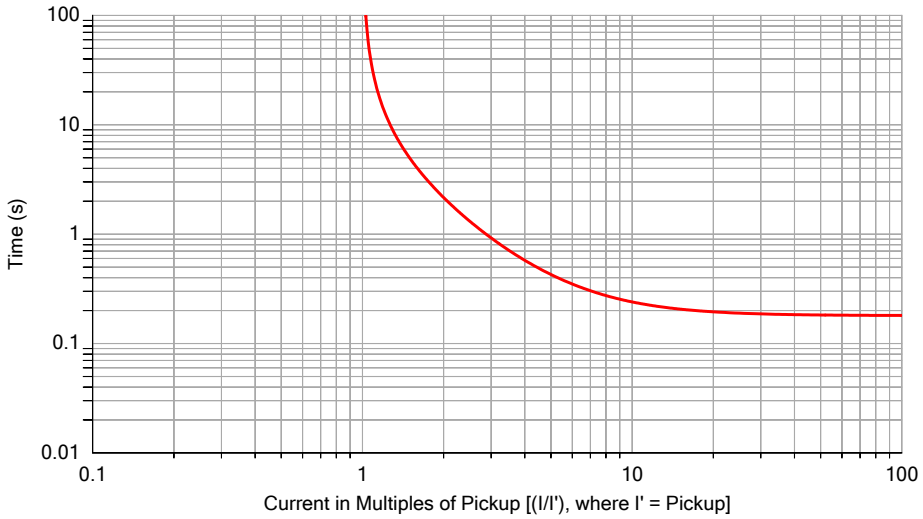

Figure D-8 US Standard Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

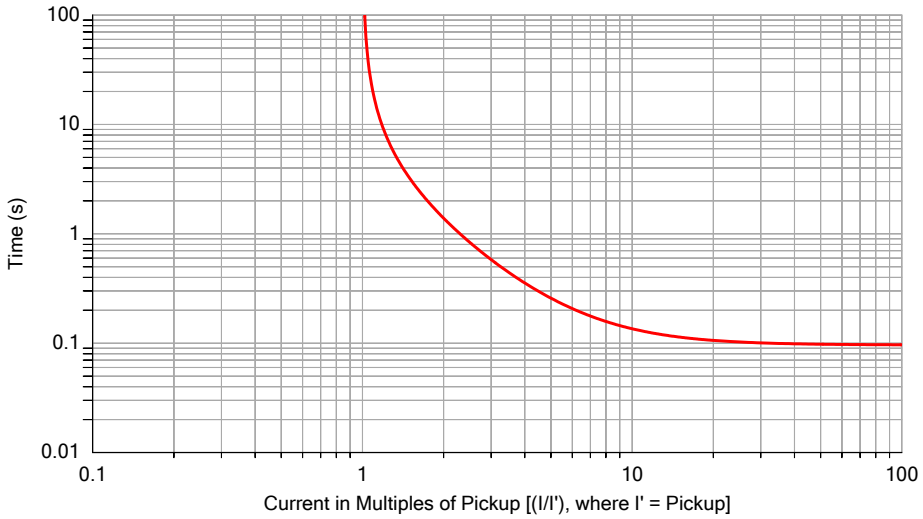

Figure D-9 US Very Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

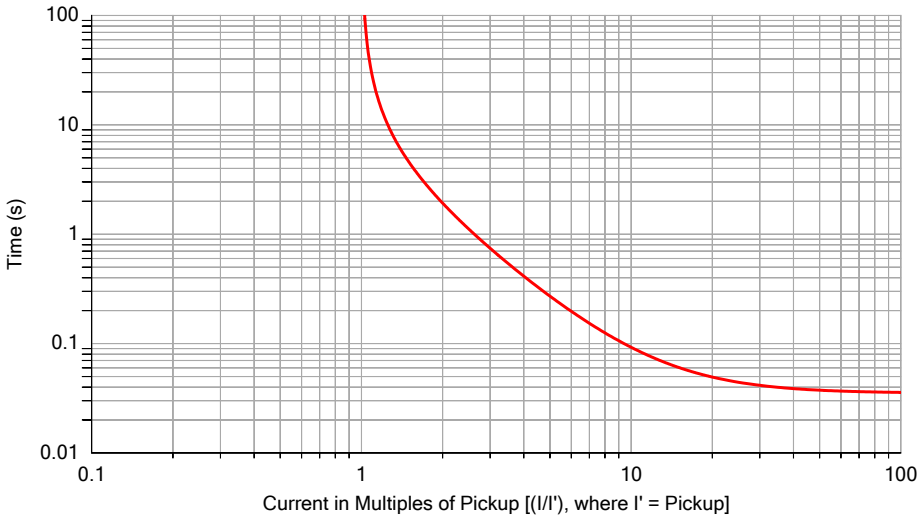

Figure D-10 US Extremely Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

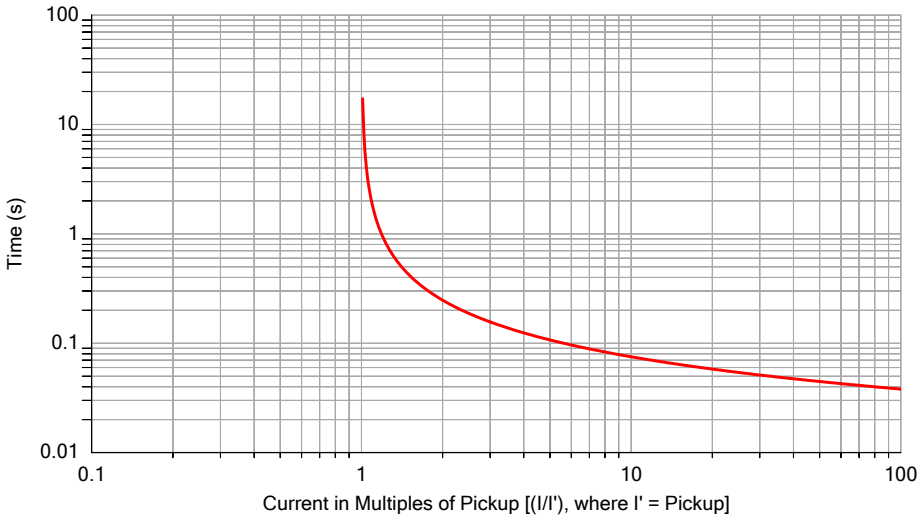

Figure D-11 US Short Time Inverse Curve (TM=1.00, TA=0.00, MRTA=0.00)

TRADITIONAL RECLOSER CURVES

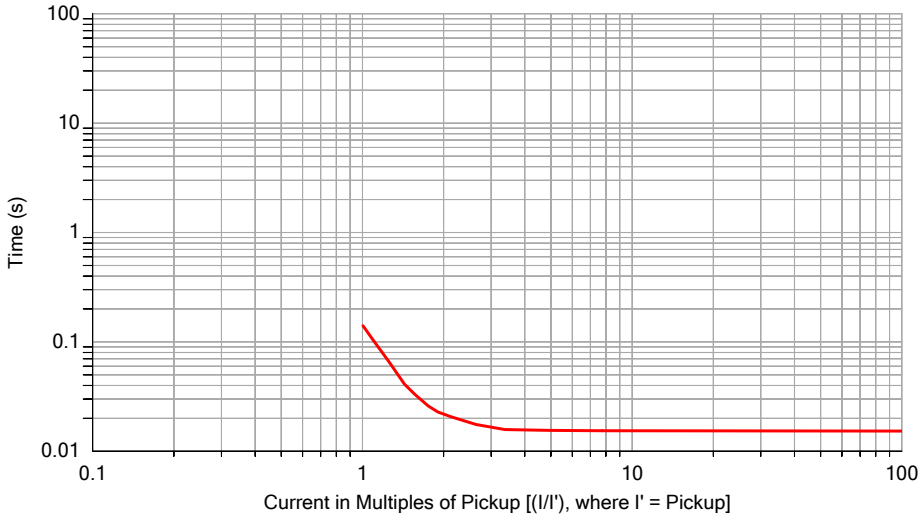

Figure D-12 Recloser Curve 101 (A) (TM=1.00, TA=0.00, MRTA=0.00)

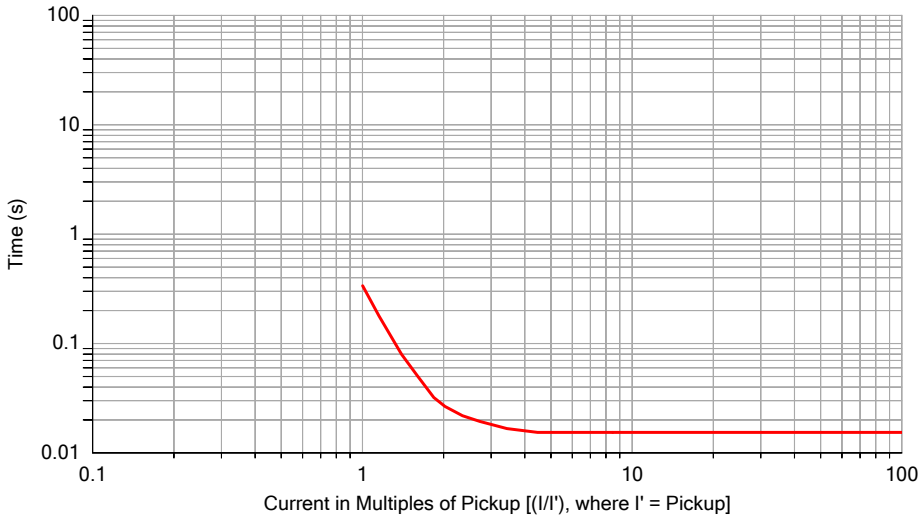

Figure D-13 Recloser Curve 102 (1) (TM=1.00, TA=0.00, MRTA=0.00)

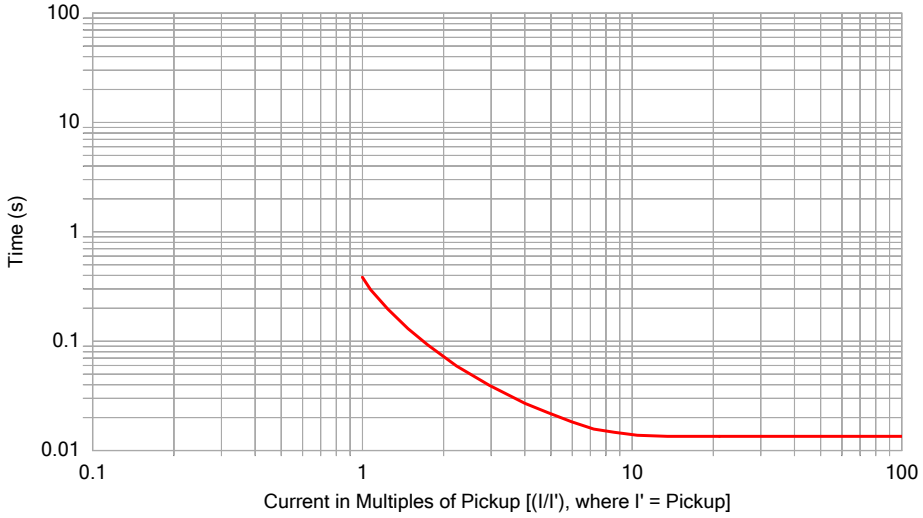

Figure D-14 Recloser Curve 103 (17) (TM=1.00, TA=0.00, MRTA=0.00)

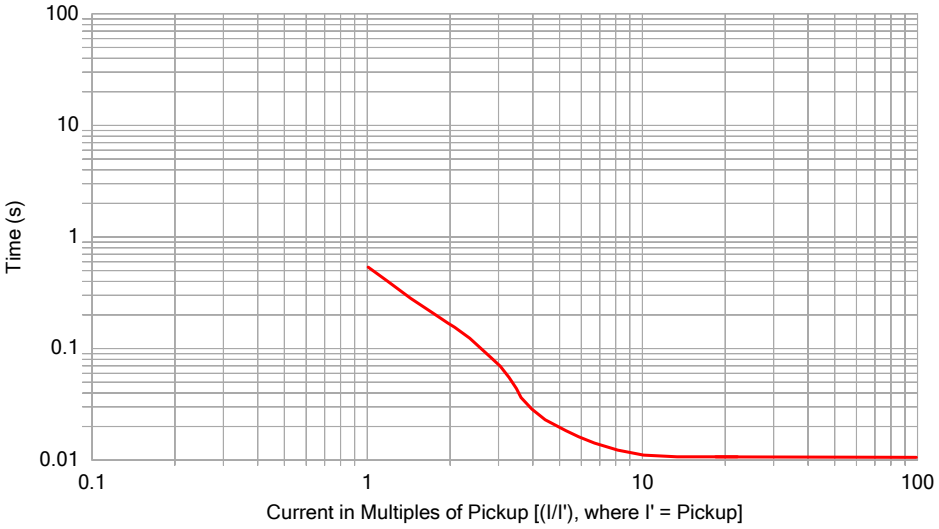

Figure D-15 Recloser Curve 104 (N) (TM=1.00, TA=0.00, MRTA=0.00)

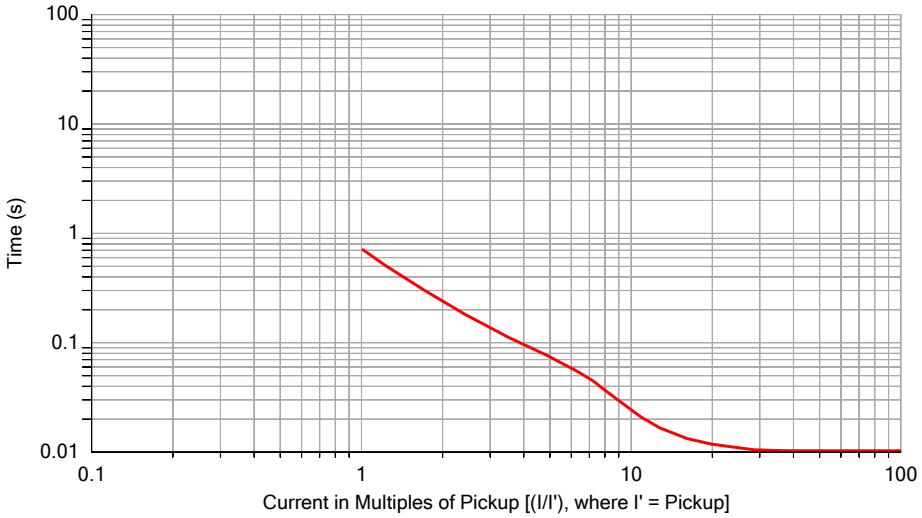

Figure D-16 Recloser Curve 105 (R) (TM=1.00, TA=0.00, MRTA=0.00)

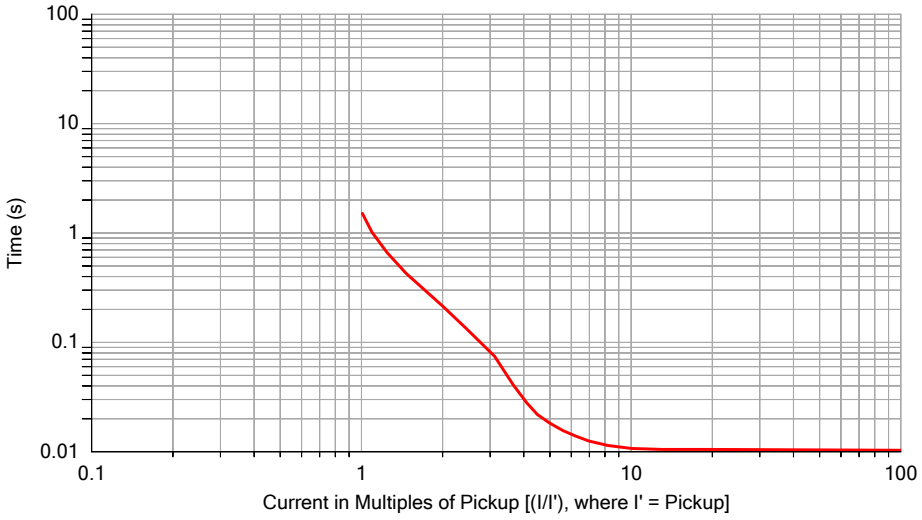

Figure D-17 Recloser Curve 106 (4) (TM=1.00, TA=0.00, MRTA=0.00)

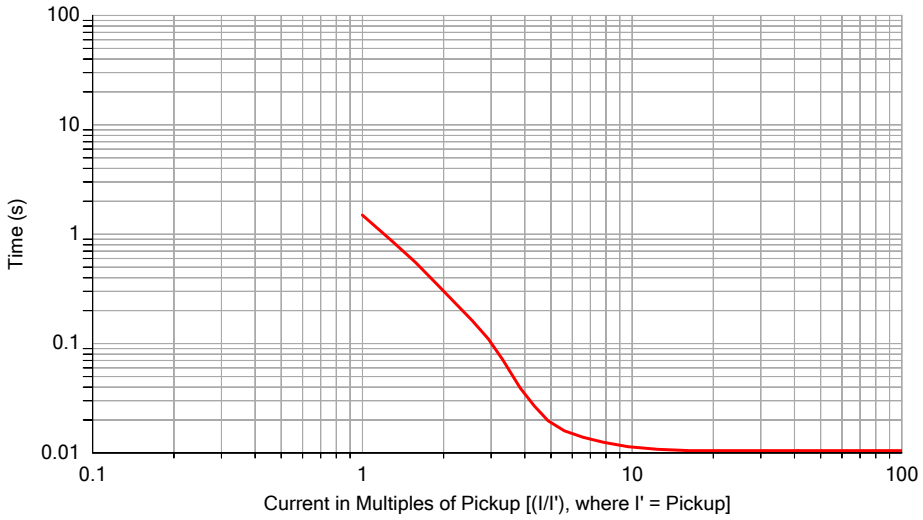

Figure D-18 Recloser Curve 107 (L) (TM=1.00, TA=0.00, MRTA=0.00)

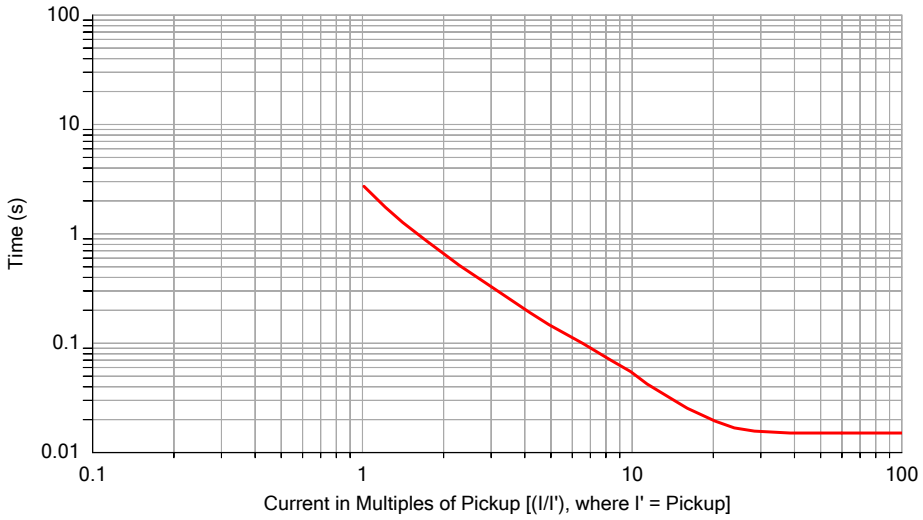

Figure D-19 Recloser Curve 111 (8) (TM=1.00, TA=0.00, MRTA=0.00)*

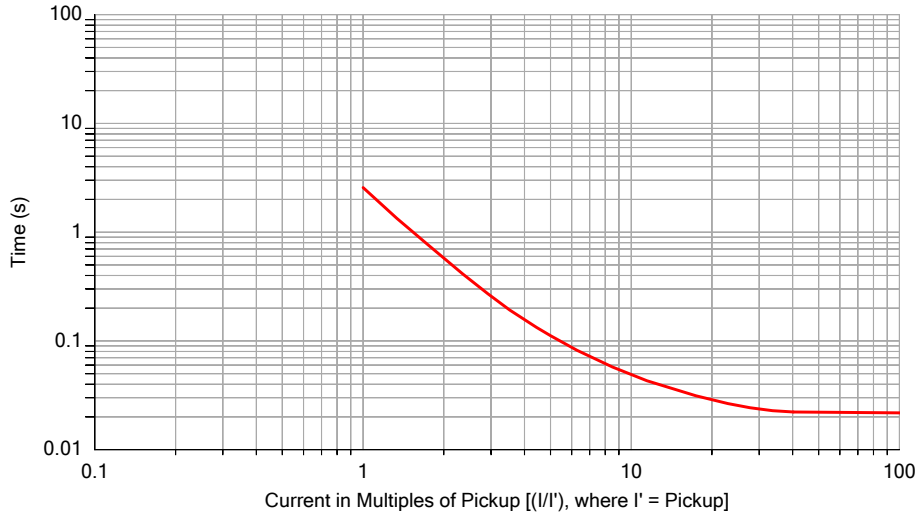

Figure D-20 Recloser Curve 112 (15) (TM=1.00, TA=0.00, MRTA=0.00)

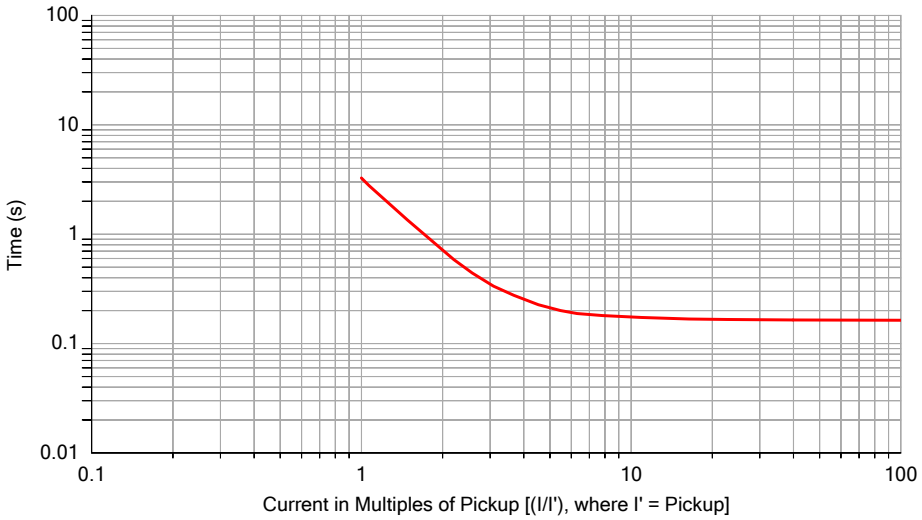

Figure D-21 Recloser Curve 113 (8) (TM=1.00, TA=0.00, MRTA=0.00)

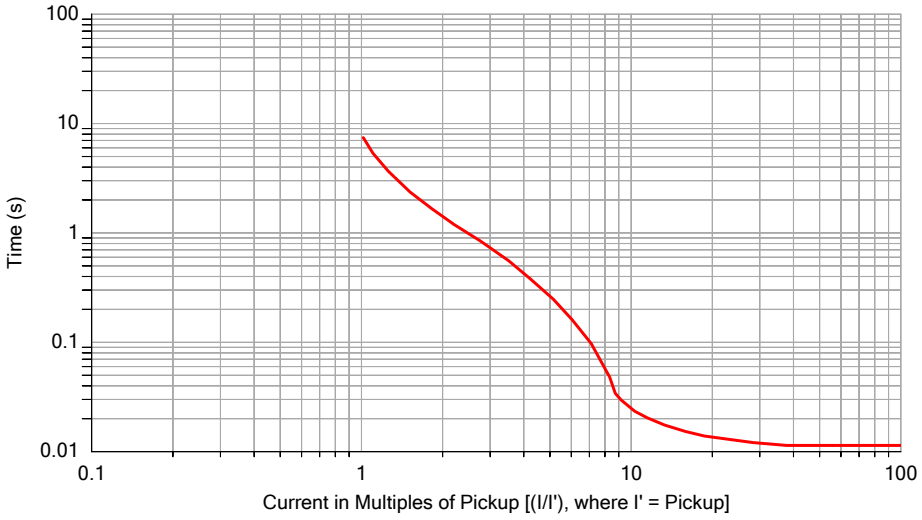

Figure D-22 Recloser Curve 114 (5) (TM=1.00, TA=0.00, MRTA=0.00)

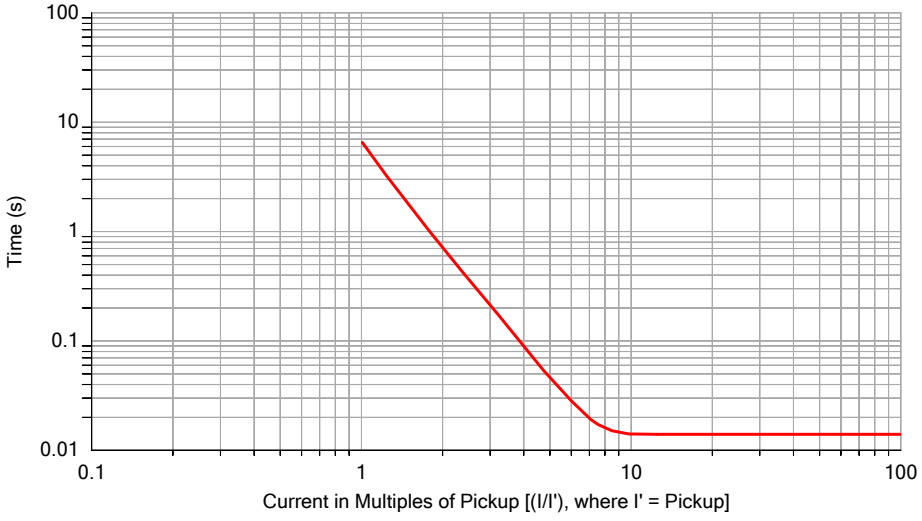

Figure D-23 Recloser Curve 115 (P) (TM=1.00, TA=0.00, MRTA=0.00)

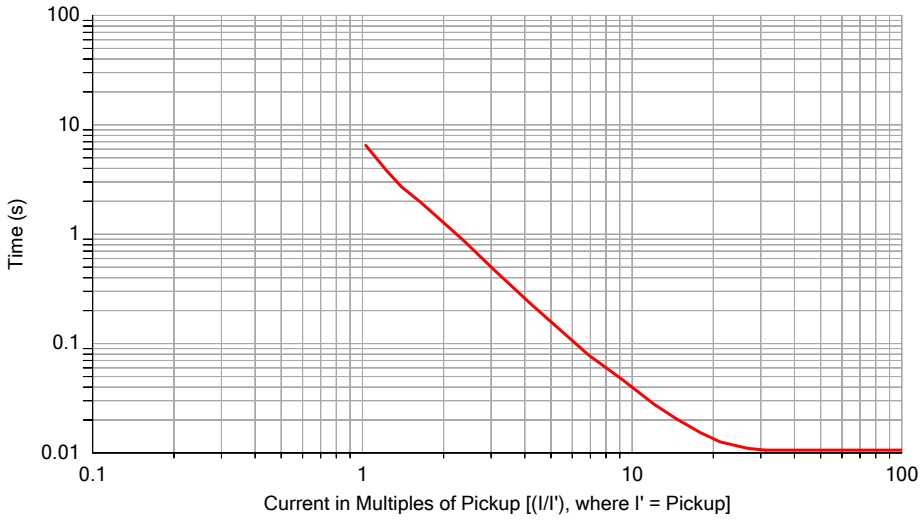

Figure D-24 Recloser Curve 116 (D) (TM=1.00, TA=0.00, MRTA=0.00)

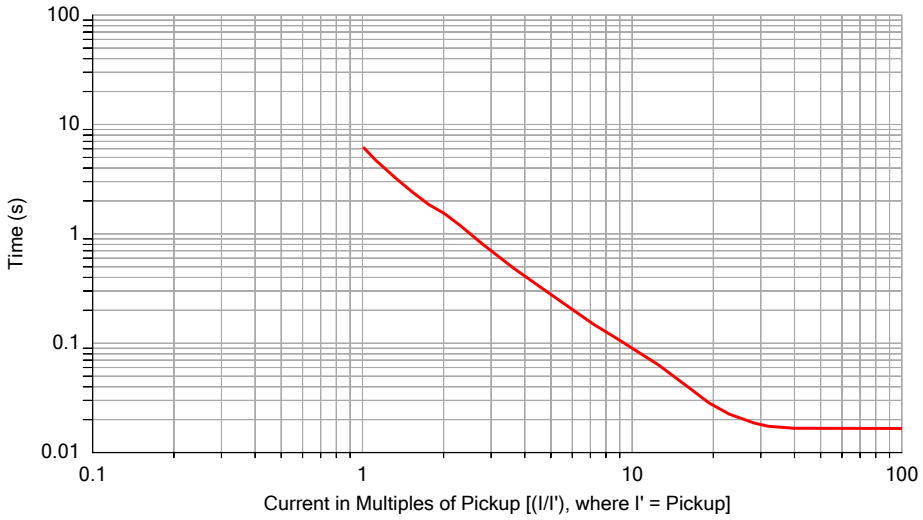

Figure D-25 Recloser Curve 117 (B) (TM=1.00, TA=0.00, MRTA=0.00)

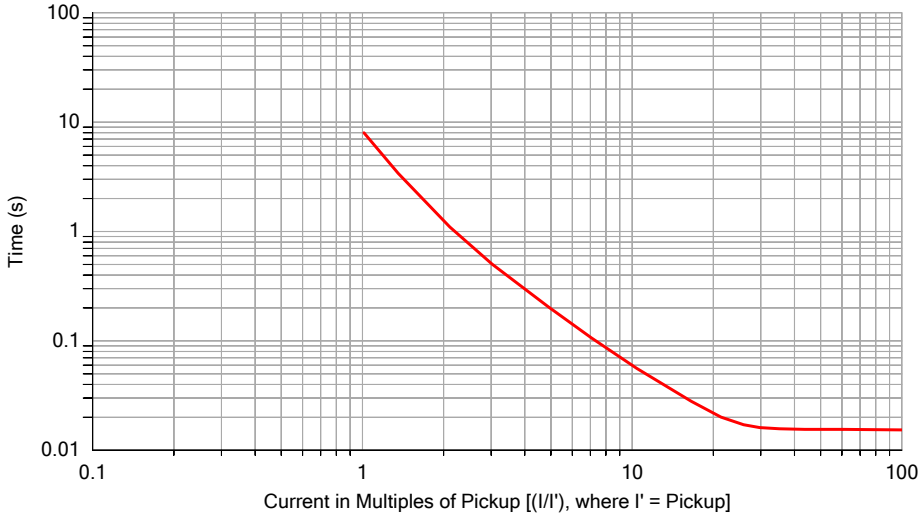

Figure D-26 Recloser Curve 118 (M) (TM=1.00, TA=0.00, MRTA=0.00)

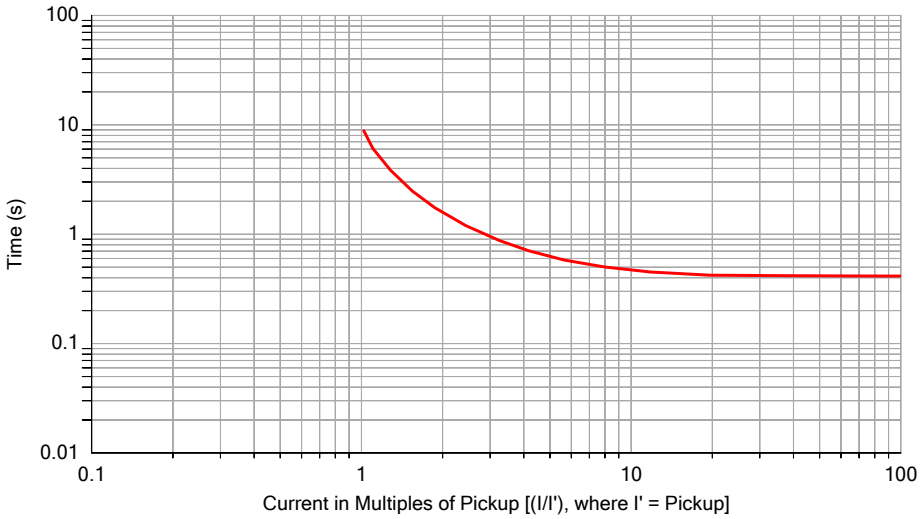

Figure D-27 Recloser Curve 119 (14) (TM=1.00, TA=0.00, MRTA=0.00)

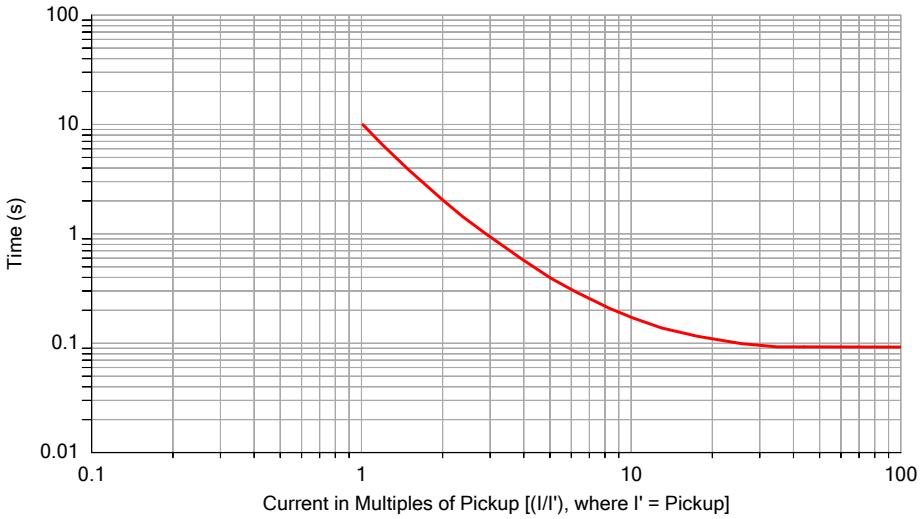

Figure D-28 Recloser Curve 120 (Y) (TM=1.00, TA=0.00, MRTA=0.00)

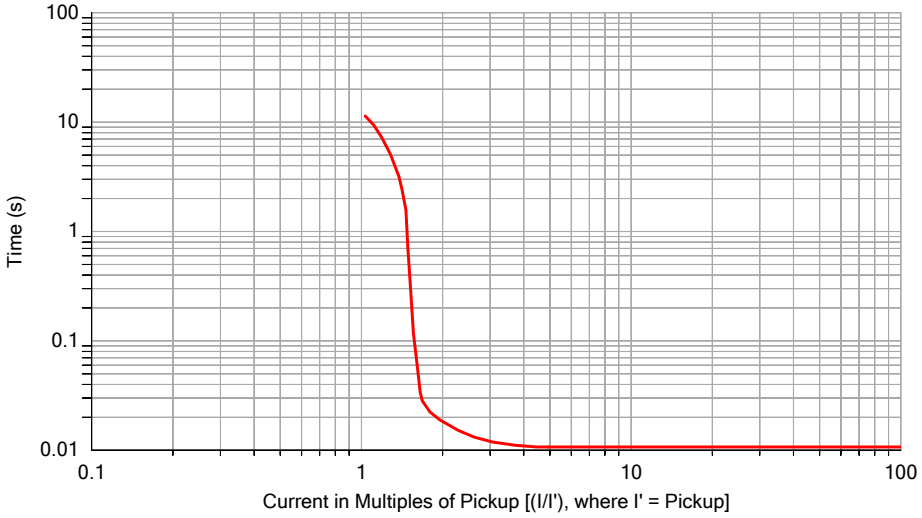

Figure D-29 Recloser Curve 121 (G) (TM=1.00, TA=0.00, MRTA=0.00)

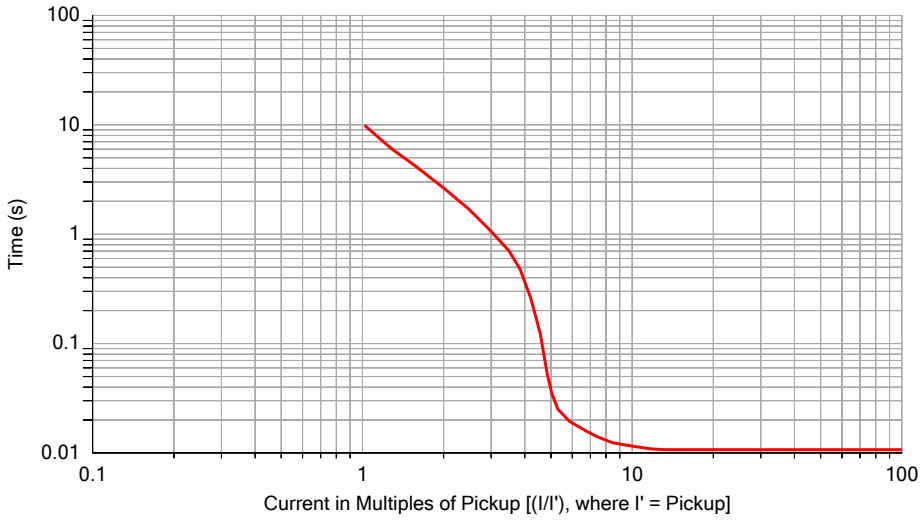

Figure D-30 Recloser Curve 122 (H) (TM=1.00, TA=0.00, MRTA=0.00)

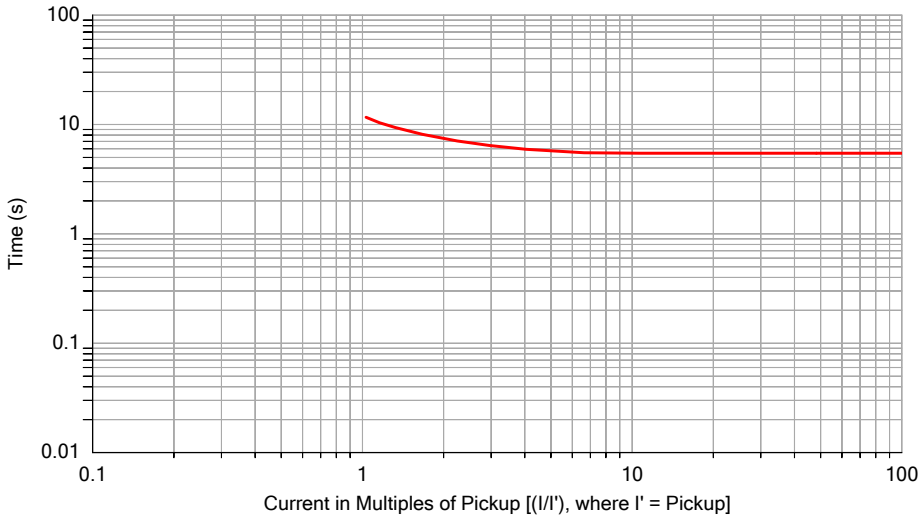

Figure D-31 Recloser Curve 131 (9) (TM=1.00, TA=0.00, MRTA=0.00)

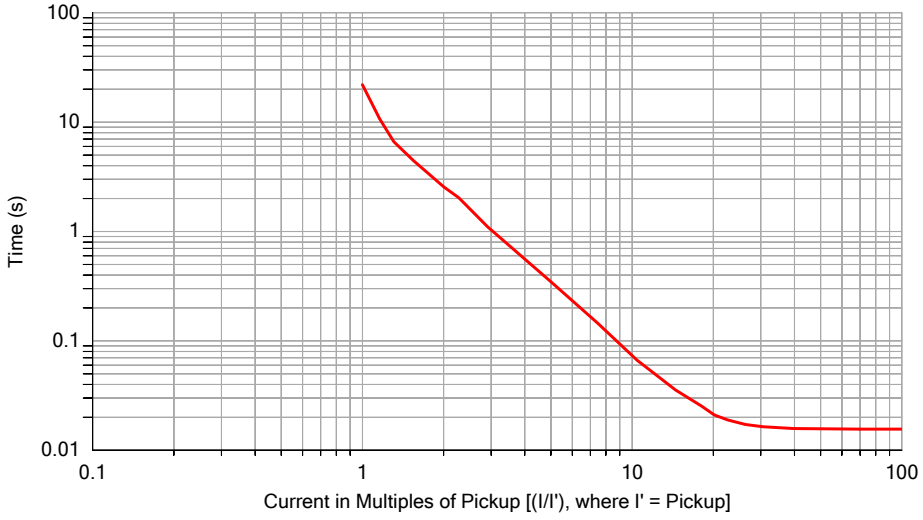

Figure D-32 Recloser Curve 132 (E) (TM=1.00, TA=0.00, MRTA=0.00)

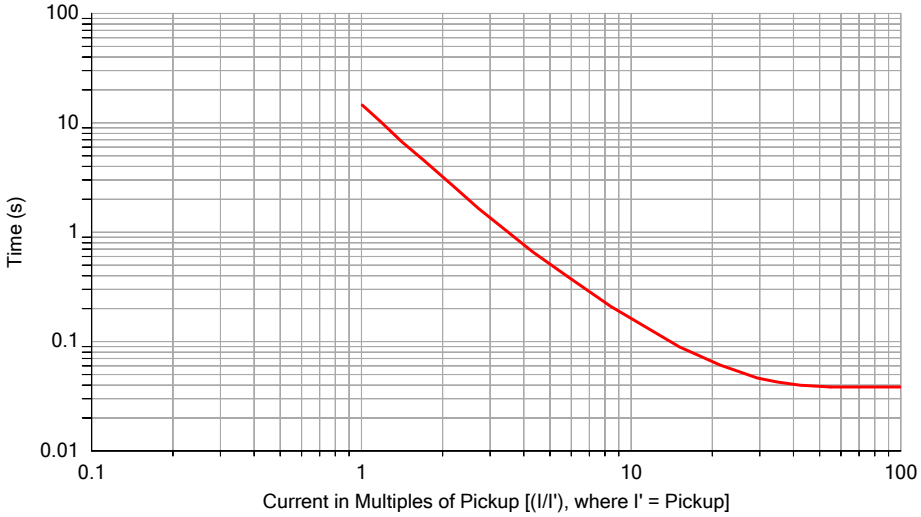

Figure D-33 Recloser Curve 133 (C) (TM=1.00, TA=0.00, MRTA=0.00)

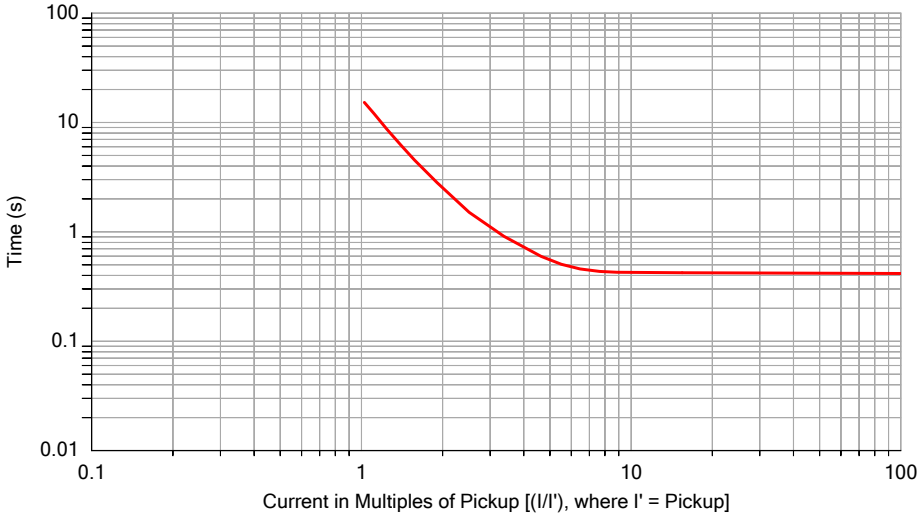

Figure D-34 Recloser Curve 134 (Z) (TM=1.00, TA=0.00, MRTA=0.00)

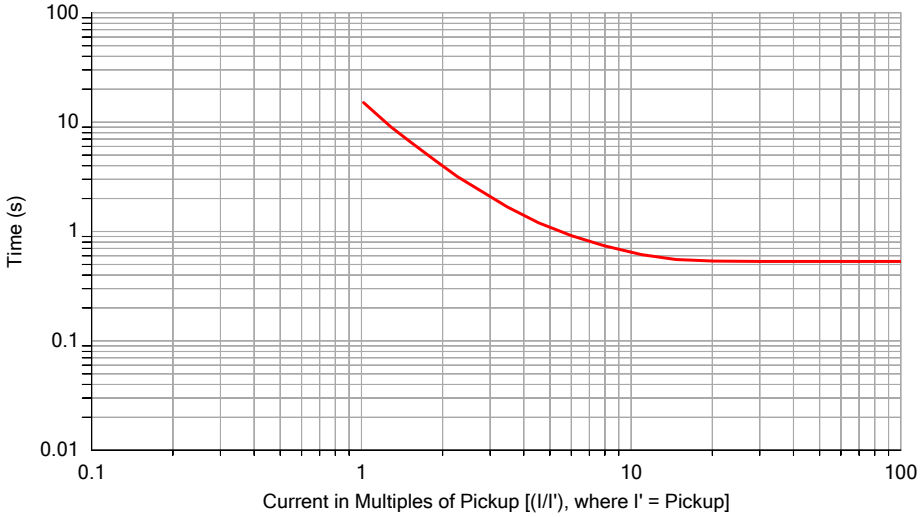

Figure D-35 Recloser Curve 135 (2) (TM=1.00, TA=0.00, MRTA=0.00)

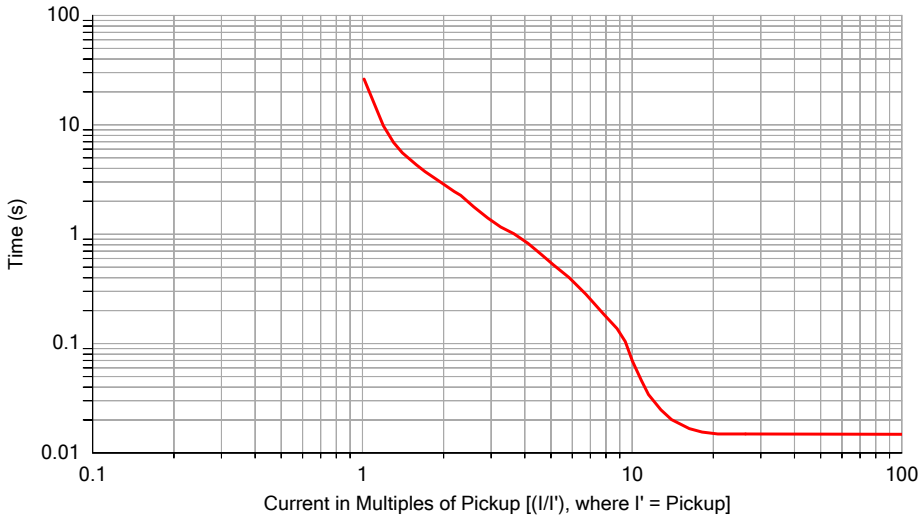

Figure D-36 Recloser Curve 136 (6) (TM=1.00, TA=0.00, MRTA=0.00)

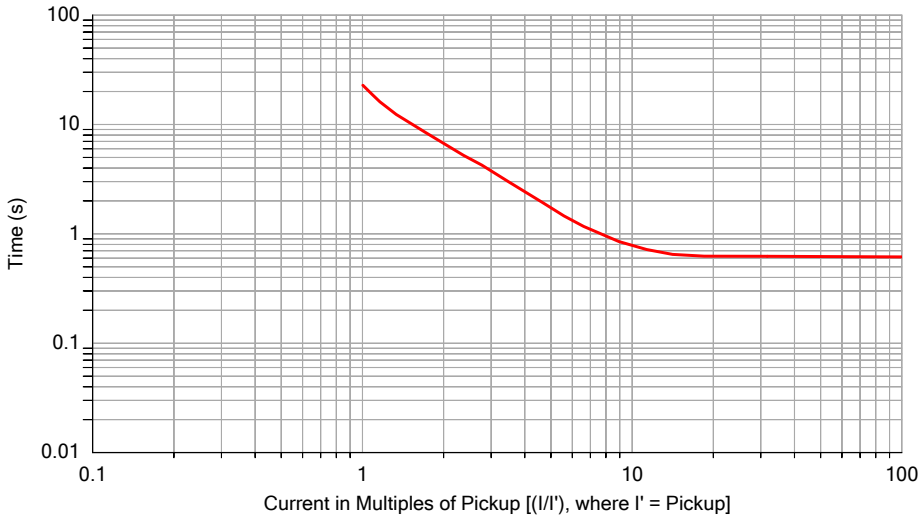

Figure D-37 Recloser Curve 137 (V) (TM=1.00, TA=0.00, MRTA=0.00)

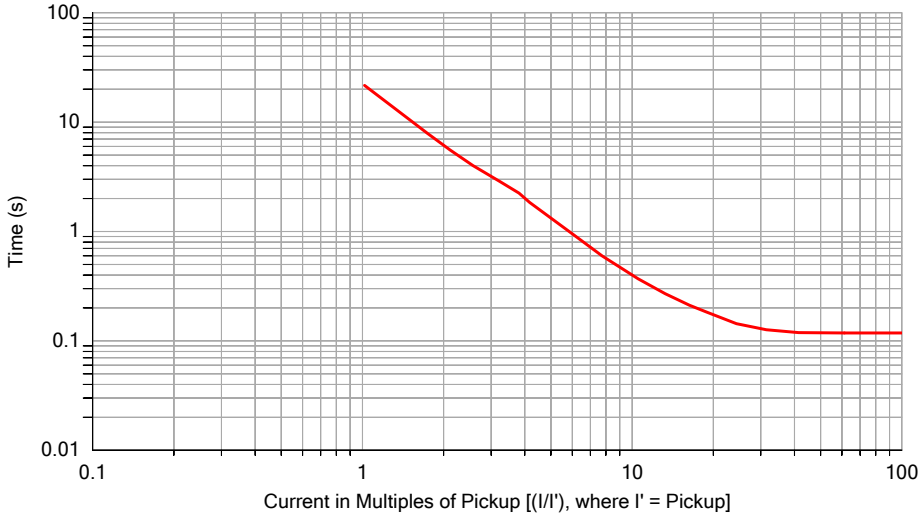

Figure D-38 Recloser Curve 138 (W) (TM=1.00, TA=0.00, MRTA=0.00)

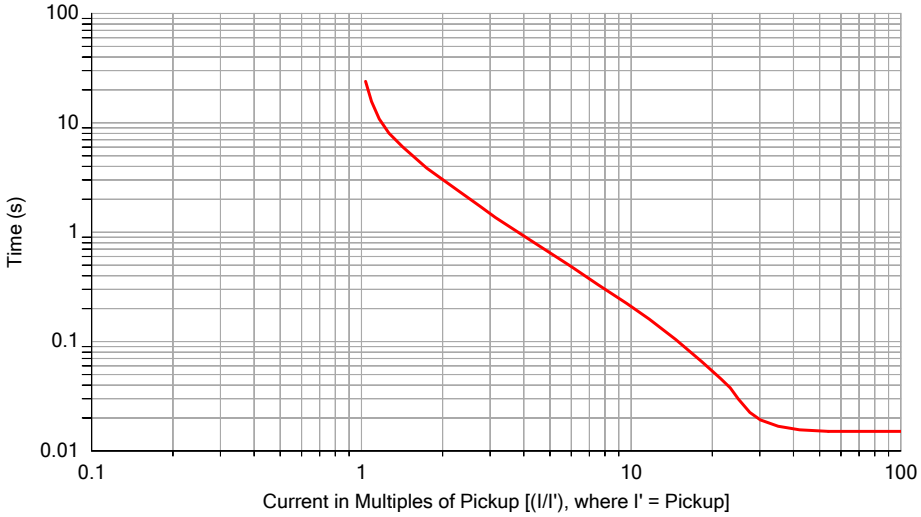

Figure D-39 Recloser Curve 139 (16) (TM=1.00, TA=0.00, MRTA=0.00)

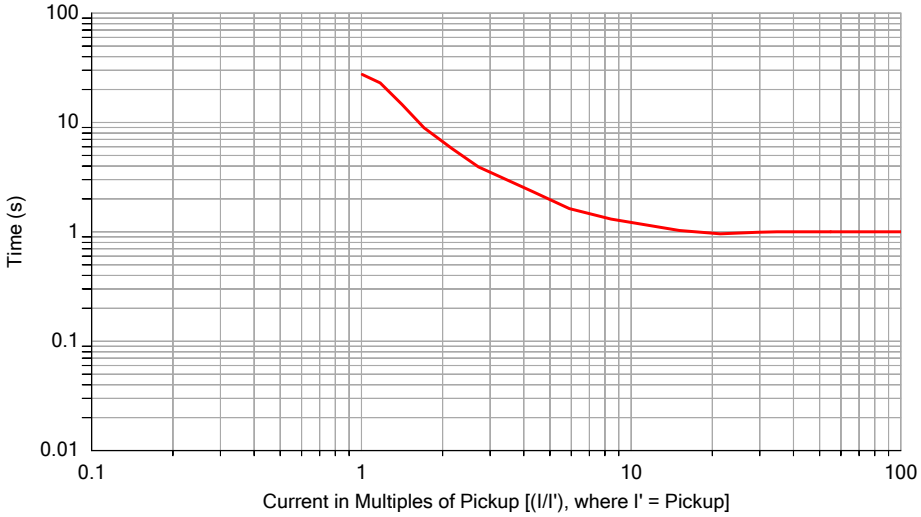

Figure D-40 Recloser Curve 140 (3) (TM=1.00, TA=0.00, MRTA=0.00)

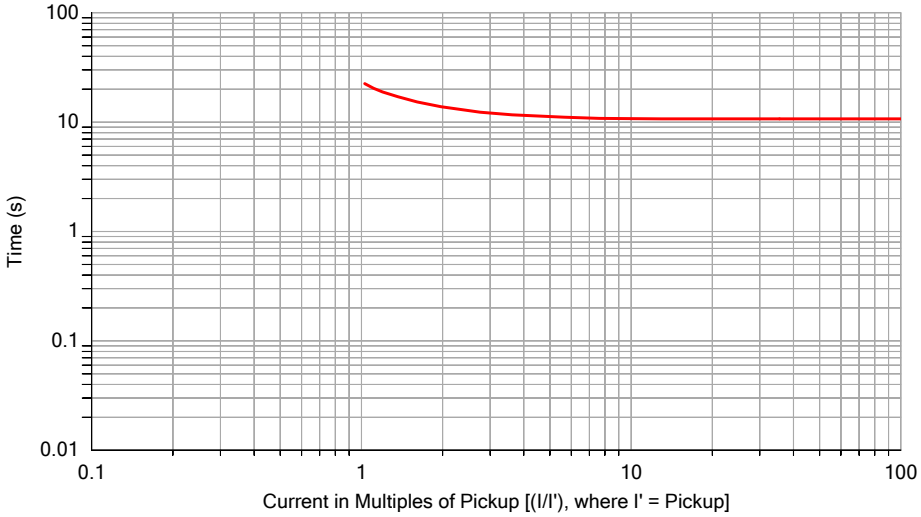

Figure D-41 Recloser Curve 141 (11) (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-42 Recloser Curve 142 (13) (TM=1.00, TA=0.00, MRTA=0.00)

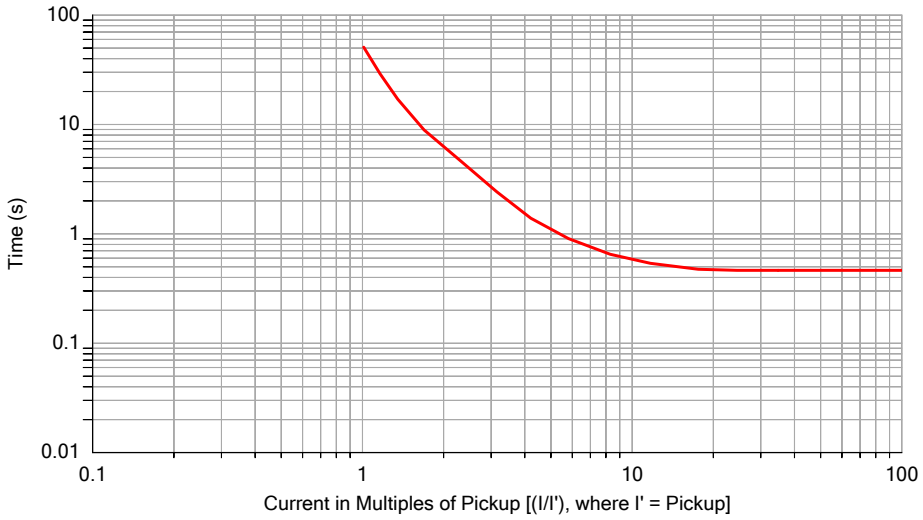

Figure D-43 Recloser Curve 151 (18) (TM=1.00, TA=0.00, MRTA=0.00)

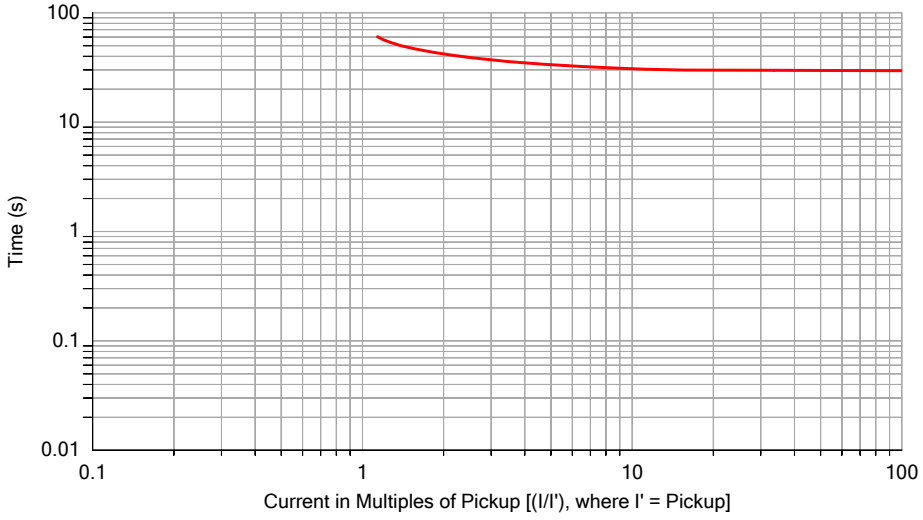

Figure D-44 Recloser Curve 152 (7) (TM=1.00, TA=0.00, MRTA=0.00)

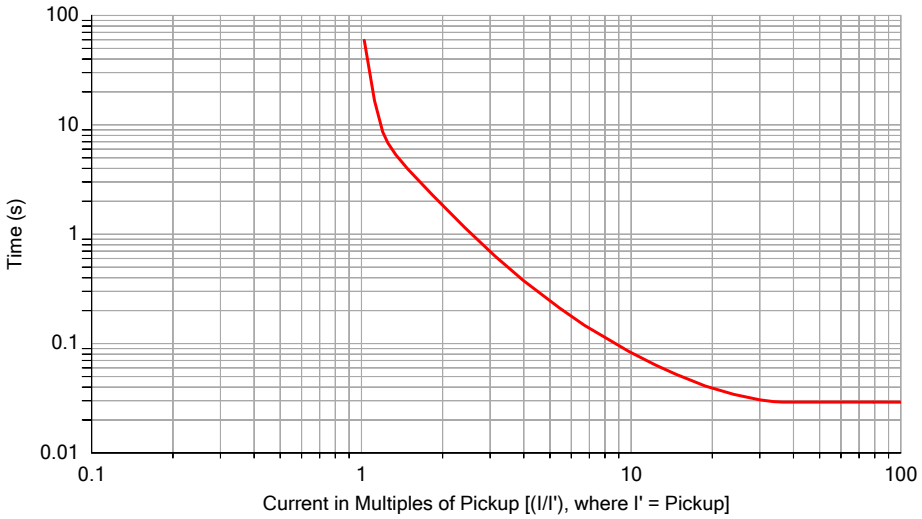

Figure D-45 Recloser Curve 161 (T) (TM=1.00, TA=0.00, MRTA=0.00)

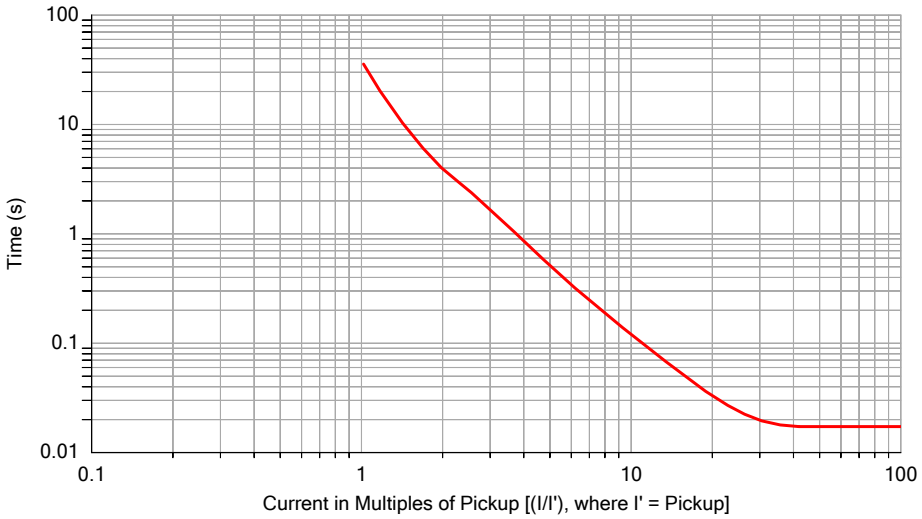

Figure D-46 Recloser Curve 162 (KP) (TM=1.00, TA=0.00, MRTA=0.00)

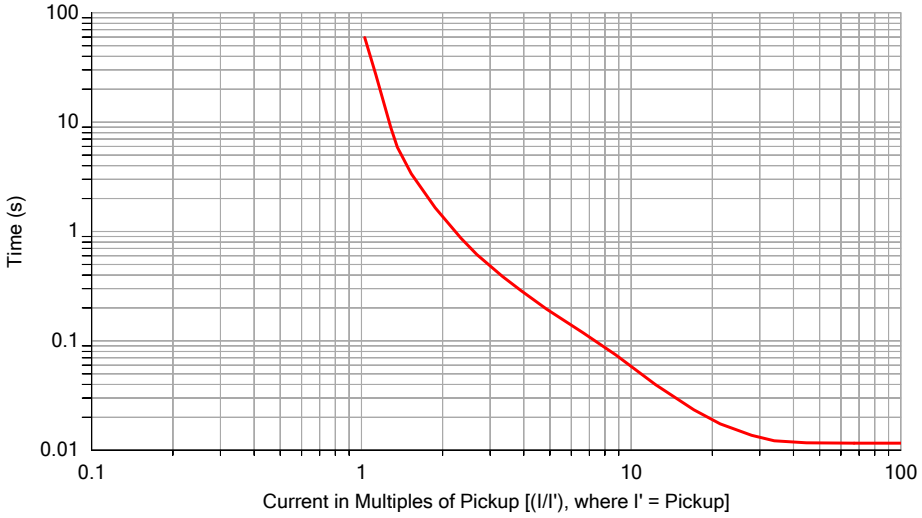

Figure D-47 Recloser Curve 163 (F) (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-48 Recloser Curve 164 (J) (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-49 Recloser Curve 165 (KG) (TM=1.00, TA=0.00, MRTA=0.00)

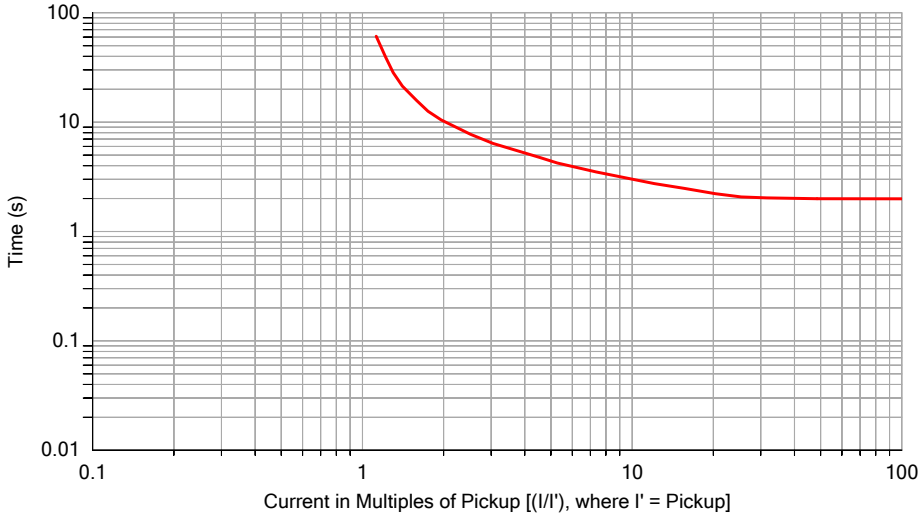

Figure D-50 Recloser Curve 200 (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-51 Recloser Curve 201 (TM=1.00, TA=0.00, MRTA=0.00)

Figure D-52 Recloser Curve 202 (TM=1.00, TA=0.00, MRTA=0.00)

DEFINITE TIME CURVE

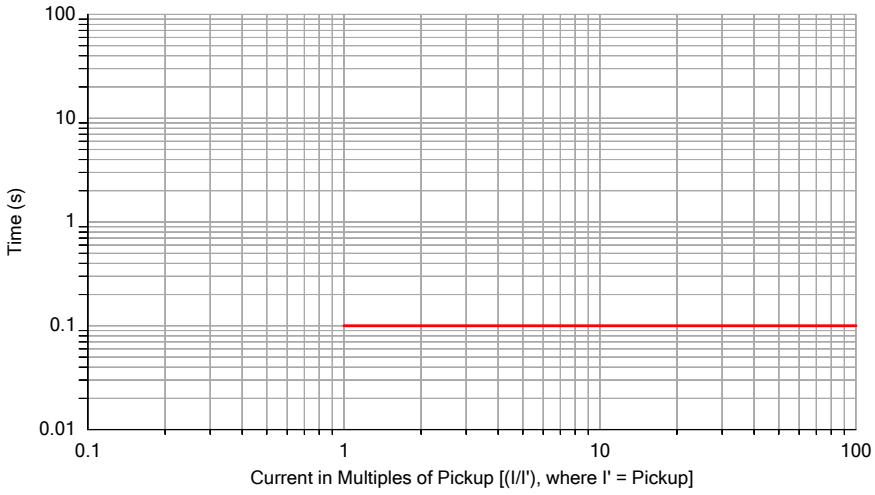

Figure D-53 Definite Time Curve (TM=1.00, TA=0.00, MRTA=0.00)

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E Utilizing DNP Configuration Editor

■ **CYBER SECURITY NOTE:**
When Cyber Security is enabled, access to any feature described in this Chapter is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

The DNP Configuration Editor includes the following features and functions:

Variations – The variation of an object gives a different representation of the same data point, such as the size of the object or whether or not the object has flag information. Accordingly, the Variations section will configure listed objects with the desired and supported variations.

Master Address used for Unsolicited responses – This address will be used as the address to send unsolicited responses.

Modem Unsolicit Setting – Applies to TIA-232 interface connected to an Ethernet Modem. TCP/IP and UDP/IP unsolicit settings are used when DNP is being deployed over an Ethernet network. The setting elements are described below:

- Allow Unsolicit: Determines whether unsolicited null responses will be sent when session comes online. If enabled, subsequent unsolicited responses will be enabled through function code 0x14 (Enable unsolicited responses) and disabled through function code 0x15 (Disable unsolicited responses). If "Allow Unsolicit" is disabled, then function codes 0x14 and 0x15 will be responded to with an error.
- Class 1 Max Delay (Sec): If unsolicited responses are enabled, this parameter specifies the maximum amount of time after an event in the corresponding class is received before an unsolicited response will be generated.
- Class 1 Max Events: If unsolicited responses are enabled, the parameter specifies the maximum number of events in the corresponding class to be allowed before an unsolicited response will be generated.
- Class 2 Max Delay (Sec): If unsolicited responses are enabled, this parameter specifies the maximum amount of time after an event in the corresponding class is received before an unsolicited response will be generated.
- Class 2 Max Events: If unsolicited responses are enabled, the parameter specifies the maximum number of events in the corresponding class to be allowed before an unsolicited response will be generated.

Choosing Points – The Available Points window is populated when a DNP source file is opened. The selection of points from the DNP window tabs can be accomplished by either individually selecting, dragging and dropping points in the Selected Points window or utilizing the "Copy All" feature. The Copy All feature only copies the points in the open tab to the Selected Points window. The "Remove All" feature removes all the points displayed in the Selected Points window for the tab that is open.

Search – The Search fields allow the user to search the Available Points as well as Selected Points for specific terms. Points containing these search terms are listed in numerical order.

Ordering Selected Points – Selected points can be reordered to match the users SCADA, RTU or Master setup by selecting, dragging and dropping the desired point within the Selected Points window.

Adding Dummy Points – The purpose of the Dummy Point is to allow the user to match other device DNP maps that contain points that are not supported in the control. This feature allows the user to communicate with the M-7651A D-PAC control when it is connected to an RTU that contains other brands of controls and eliminates the need to re-configure the RTU or the other controls.

To insert a Dummy point, select **Insert Dummy**. The Dummy Point will be inserted at the end of the Selected Points list. To move the Dummy Point, select, drag and drop the point at the desired location in the Selected Points list. The Dummy point will assume the Index Position and the remaining Selected Points will be modified to accommodate the Dummy Point.

Insert Offset – This allows an offset to be created in the DNP map without the point number being transmitted, thus providing the ability to construct a DNP profile that has non-consecutive point numbers within a group.

Editing Binary Input Points – The Binary Input "Value" and "Mask" values can be edited by double left clicking on the desired point Value or Mask elements. The default value for Value is TRUE, which means that the point will return a High or True when the item being monitored is active in the control. It can be changed to "FALSE" to match a SCADA Master if necessary. The "Mask" value defaults to "CLASS ONE" and defines what polling class type the point is mapped to. The Mask value can also be set to CLASS TWO or THREE by double left clicking on the desired point Mask element.

Editing Analog Input Points – The Analog Input "Deadband" and "Mask" values can be edited by double left clicking on the desired point Deadband or Mask elements. The Deadband can be set to define when the point will report by exception under the class type in the Mask setting. When the point value exceeds the deadband value, it will initiate a report by exception to the master. The "Mask" value defaults to "CLASS TWO" and defines what polling class type the point is mapped to. The Mask value can also be set to CLASS ONE or THREE by double left clicking on the desired point Mask element.

Editing Binary/Control Output Points – The Binary/Control Output Point "Crob", "Mask" and "Inverse" values can be edited by double left clicking on the desired point Crob, Mask or Inverse elements. The Crob (Control Relay Output Block) setting is used to define what control method will be used to operate the point. The possible settings for "Crob" are listed below:

- Latch On
- Latch Off
- Latch OnOff
- Latch OnOff_TC
- Pulse On
- Pulse Off
- Pulse OnOff
- Pulse OnOff_TC
- Paired Close
- Paired Trip
- Paired TripClose

The "Mask" value defaults to "CLASS ZERO" and defines what polling class type the point is mapped to. The Mask value can also be set to CLASS NONE by double left clicking on the desired point Mask element.

Inverse defines whether the command to be sent would be inverted, meaning that when TRUE is selected, sending a Trip, Close, etc will have the opposite effect. This was implemented due to variations seen in RTU manufacturer's implementation of direct control with DNP to allow full compatibility the widest possible number of RTU's.

Editing Analog Output Points – The Analog Output "Mask" value can be edited by double left clicking on the desired point Mask element. The "Mask" value defaults to "CLASS ZERO" and defines what polling class type the point is mapped to. The Mask value can also be set to CLASS NONE by double left clicking on the desired point Mask element.

Editing Counters – The Counters "Mask" value can be edited by double left clicking on the desired point Mask element. The "Mask" value defaults to "CLASS THREE" and defines what polling class type the point is mapped to. The Mask value can also be set to CLASS ZERO, CLASS ONE, CLASS TWO, CLASS NONE, CLASS ONE NOT CLASS 0, CLASS TWO NOT CLASS 0 or CLASS THREE NOT CLASS 0 by double left clicking on the desired point Mask element.

DNP Security – DNP authentication is now available and can be independently enabled in the DNP security tab for either serial or Ethernet (both TCP or UDP) interfaces.

The concepts of the Hashed Message Authentication Code (HMAC) and challenge-response as defined in the DNP3 specification for Secure Authenticate Version 2.0 document is employed.

When authentication is enabled, the following settings should be selected:

- HMAC Algorithm and Update key
- Challenge Response timeout
- Duration of session key
- Aggressive Mode
- Critical Request Function Codes

■ **NOTE:** Before IPScom allows a user to change the Update key, the user has to enter the old update key.

HMAC Algorithm and Update Key – The HMAC algorithm is either SHA1 (4 OCT) or SHA1(10OCT). An Update key is necessary to provide secure SESSION key negotiation. Once a SESSION key is obtained any subsequent challenge/response session will employ that session key. The Update key can be up to 32 hex characters (0123456789ABCDF) (128 bits).

Challenge Response Timeout – The range is from 0-100 seconds. This is the response time within which the control is expecting a response to a challenge.

Duration of Session Key – This duration must be configured in minutes (0-100) and in count 0-65535. This duration represents the maximum time or the maximum number of challenges a particular session key is used before key negotiation is again performed.

Aggressive Mode – Full challenge/response exchanges increase the number messages in the protocol, which affects throughput performance. Therefore, DNP Secure Authentication provides an aggressive mode in which the data from a single challenge can be used to authenticate many subsequent messages. The sender of the critical message includes the HMAC at the end of the critical message without having to be challenged. At least one challenge must occur, however, before aggressive mode can be used.

Critical Request Function Codes – This represents the function codes that will require authentication if selected. If none is selected, authentication will not be performed on any function code although authentication has been enabled.

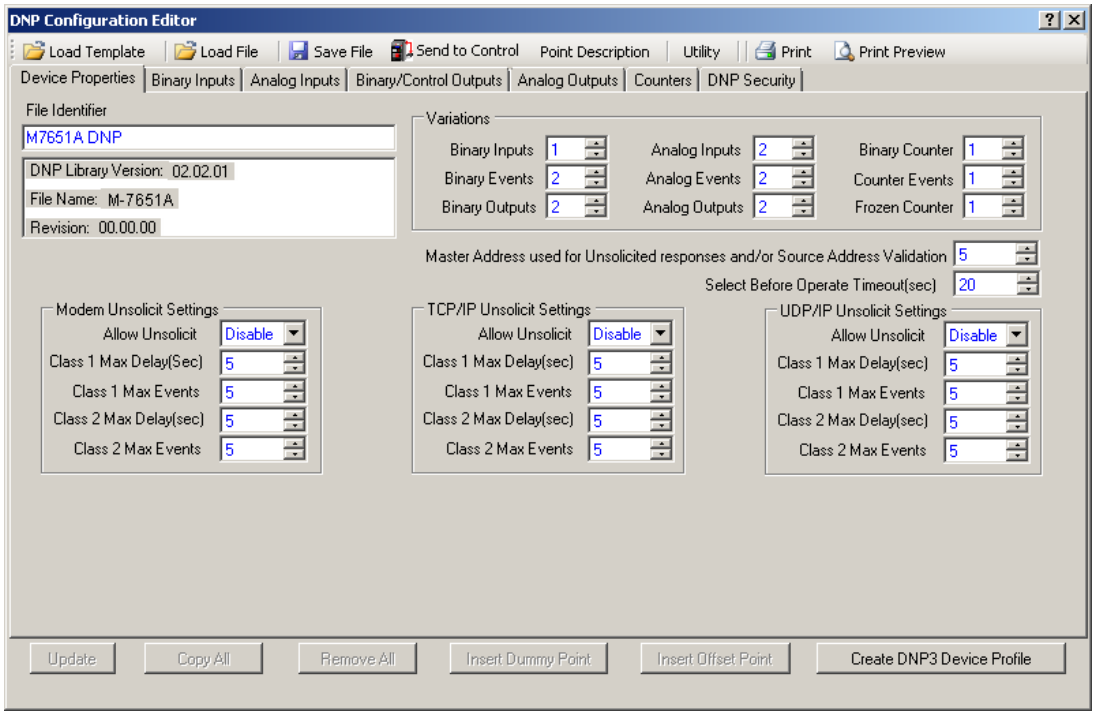

Figure E-1 DNP Configuration Editor Dialog Screen

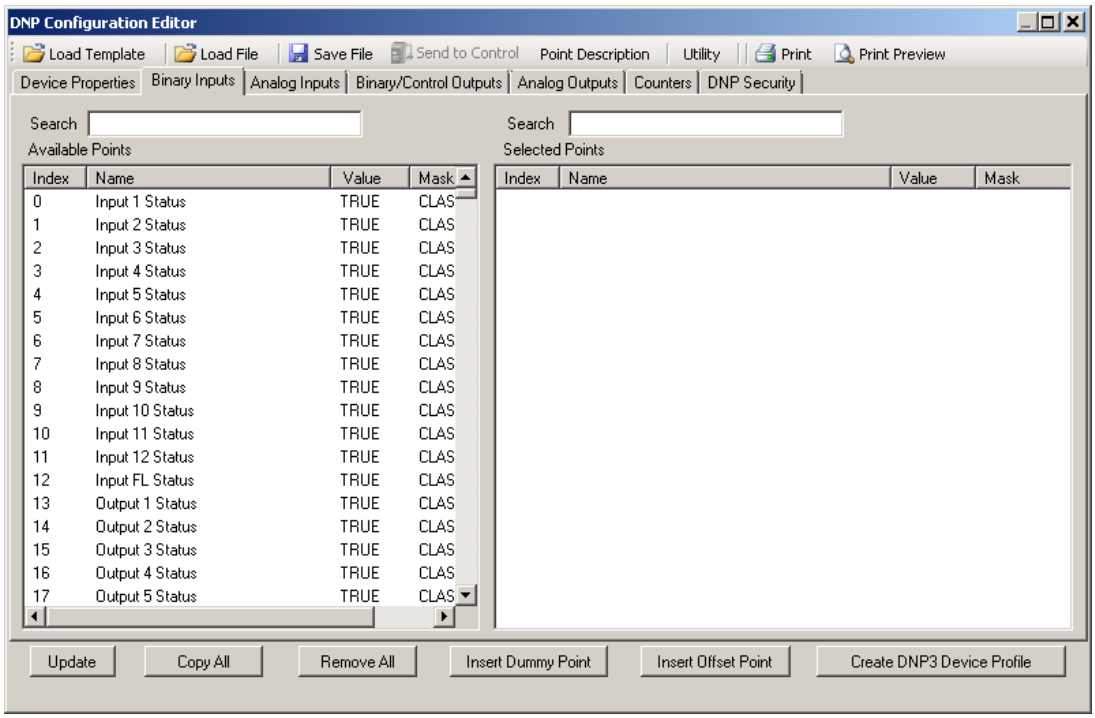

Figure E-2 DNP Configuration Editor Binary Inputs Dialog Screen

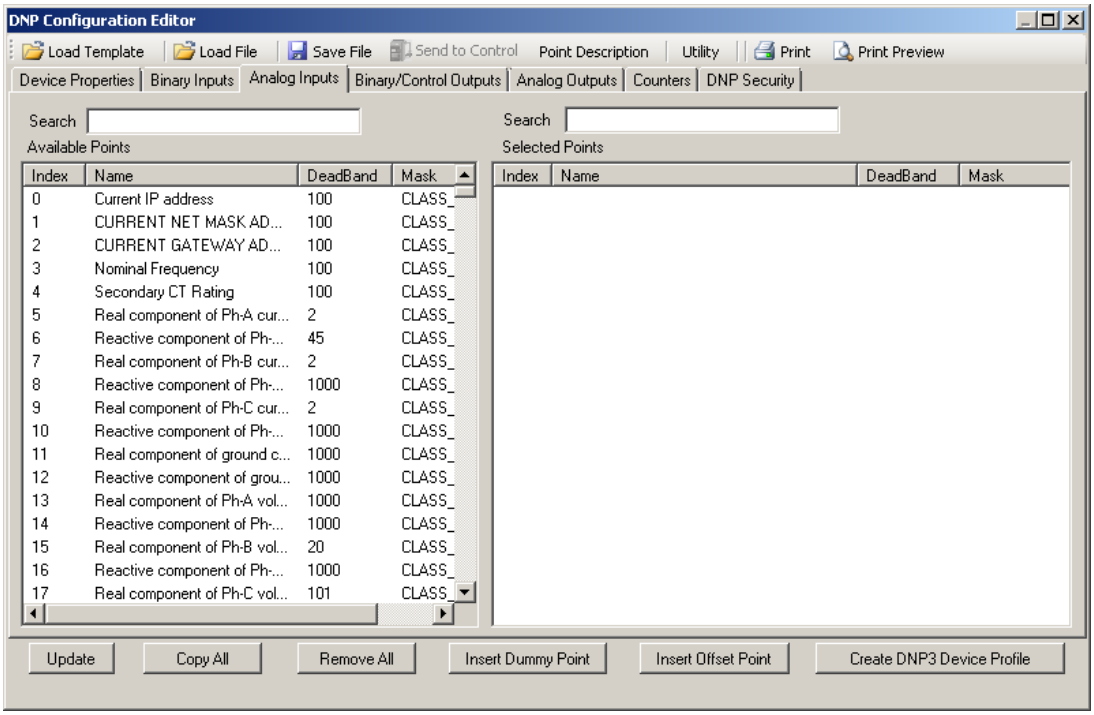

Figure E-3 DNP Configuration Editor Analog Inputs Dialog Screen

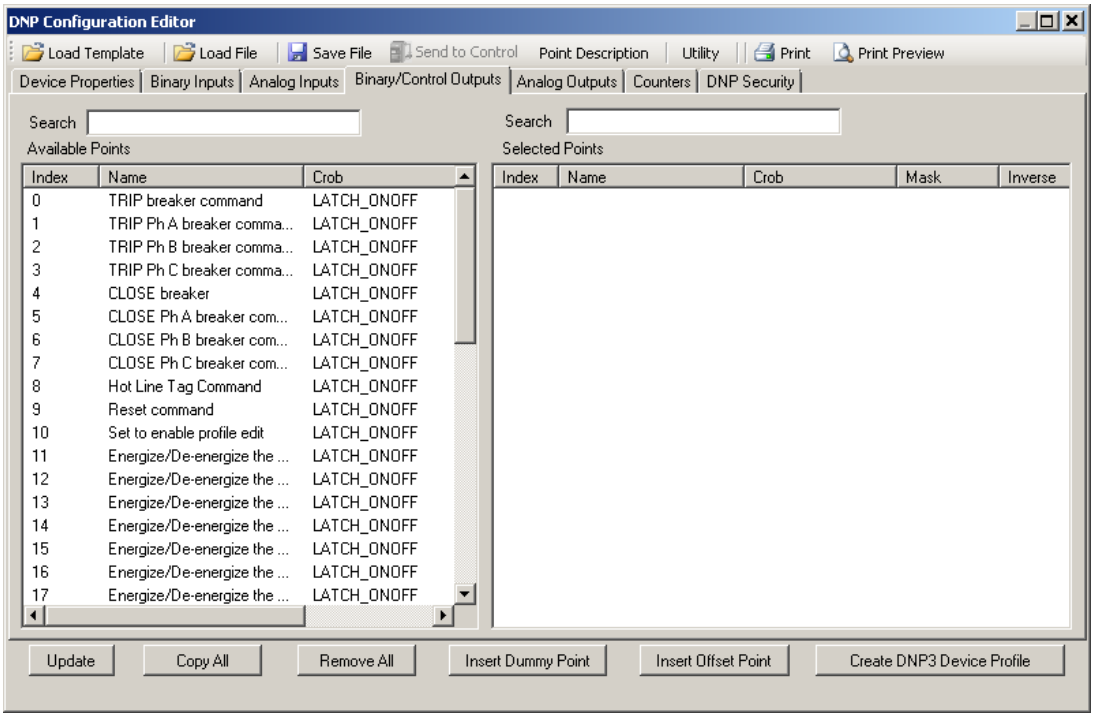

Figure E-4 DNP Configuration Editor Binary Control Outputs Dialog Screen

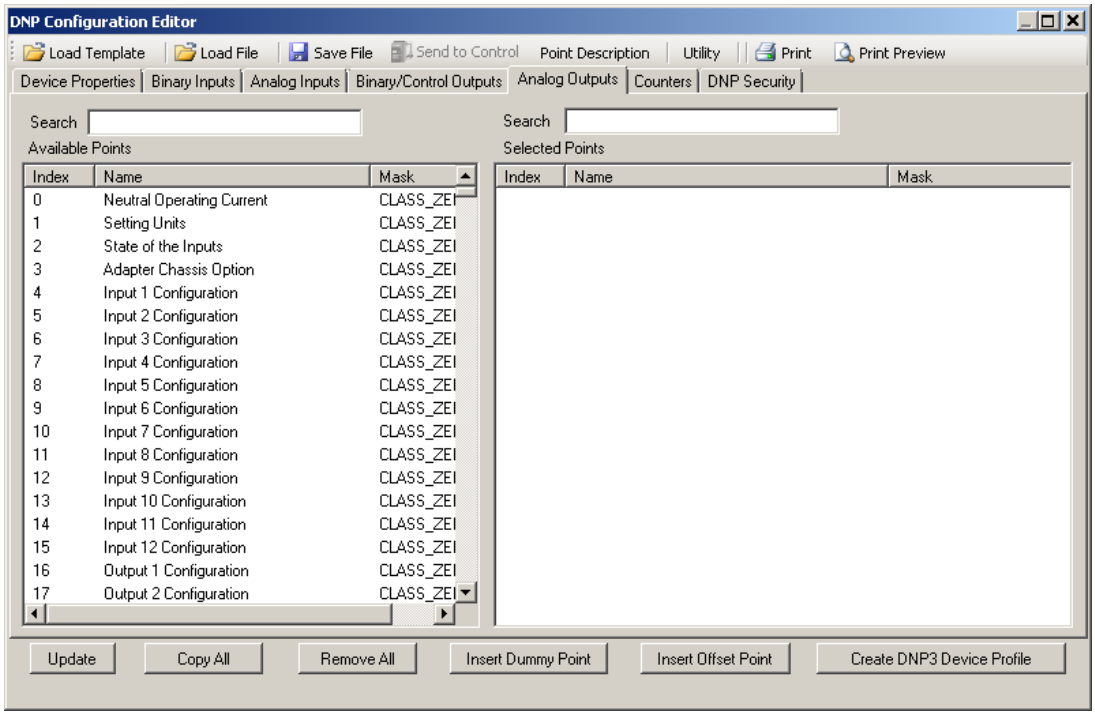

Figure E-5 DNP Configuration Editor Analog Outputs Dialog Screen

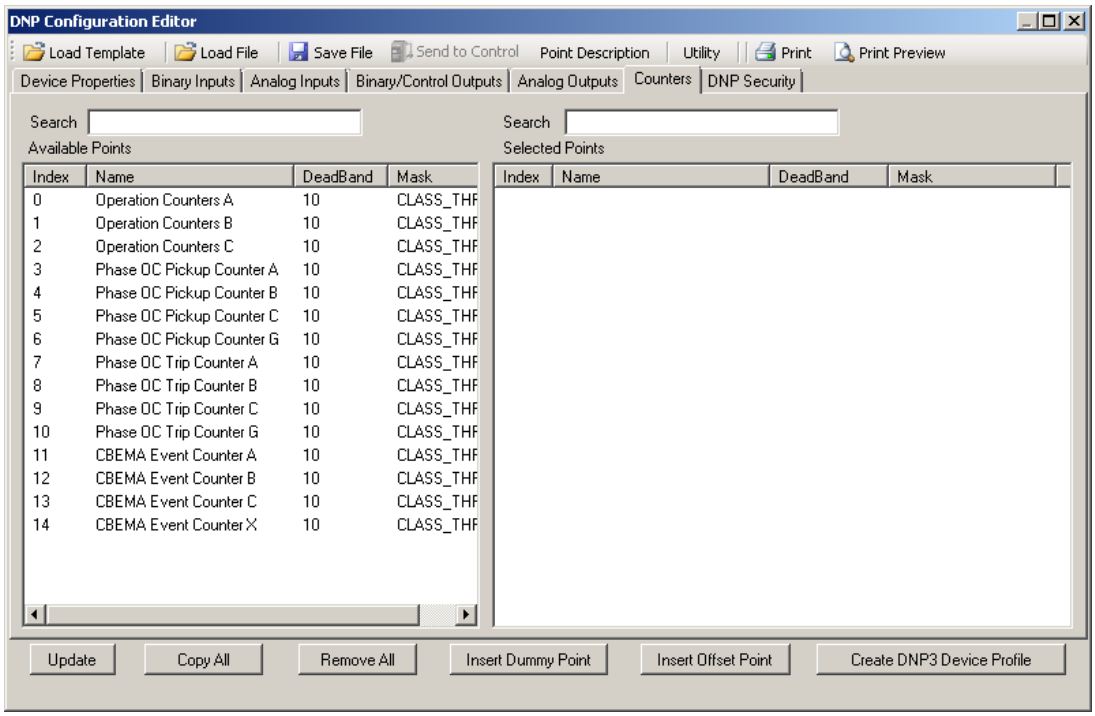

Figure E-6 DNP Configuration Editor Counters Dialog Screen

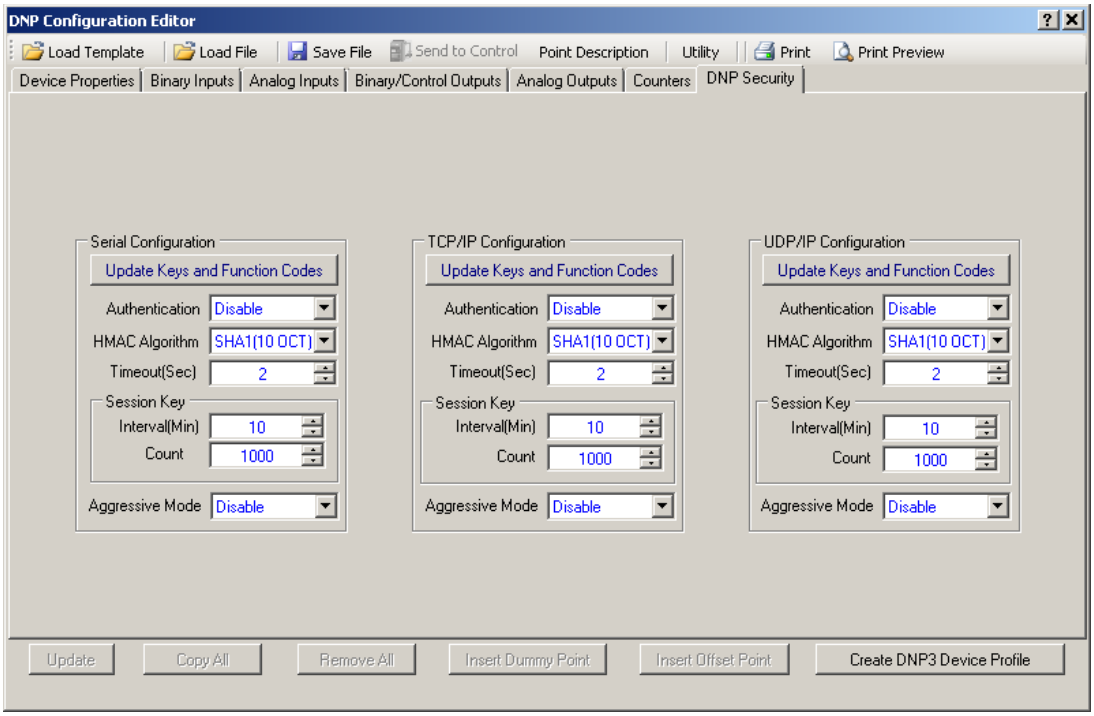

Figure E-7 DNP Configuration Editor Security Dialog Screen

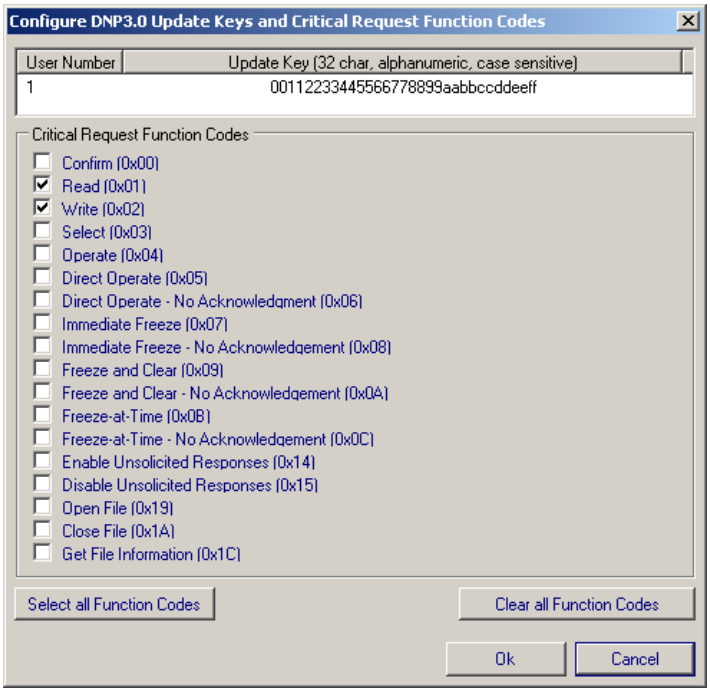

Figure E-8 DNP Configure Update Keys and Critical Request Function Codes Dialog Screen

Example of DNP Configuration Editor Use – The following sequence of steps provides an example of utilizing the DNP Configuration Editor.

1. From the IPScom S-7600 Communications Software Main Screen select **Communication/Protocol/DNP/DNP Configuration Editor**. IPScom will display the DNP Configuration Editor dialog screen (Figure E-1).
2. Select **Load Template/M-7651A Default** from the DNP Configurator menu bar. Select **Binary Inputs** tab, Figure E-2 is displayed. The Available Points list for each DNP Points Group tab will also be populated.
3. Select the Binary Input points you wish to include in the DNP map by selecting Copy All or dragging the desired point(s) to the Selected Points window.
4. Edit the Selected Points for each tab as necessary to match your SCADA, RTU or Master setup.
5. Select **Save File** from the DNP Configurator menu bar. IPScom will display a "Save As" dialog screen with a *.xml file extension.
6. Name the file and then select **Save**.
7. If IPScom is connected to the target control then the "Send to Control" menu item can be used as follows:
    a. Select **Send to Control**. IPScom will display the "Open File" dialog screen with a *.xml file extension.
    b. Select the file to be sent to the control, then select **Open**. IPScom will initiate the file transfer as indicated by the "Upload" status screen (Figure E-9), followed by a "DNP File sent successfully" confirmation screen (Figure E-10).

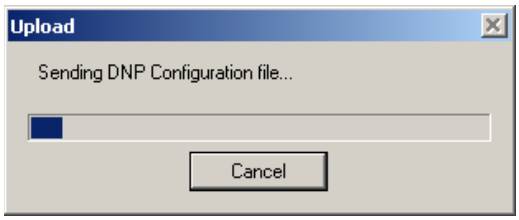

Figure E-9 Sending DNP Configuration File Status Screen

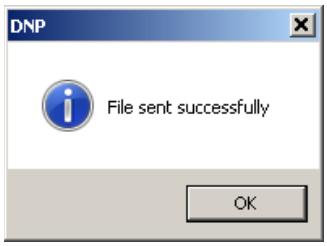

Figure E-10 DNP File Sent Successfully Confirmation Screen

F Cyber Security

Cyber Security F–1
IPsec/IKE Overview F–5
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Roles..... F–17
Audit Log..... F–18
Change Password..... F–20
Security Mode Setup F–21

CYBER SECURITY

■ CYBER SECURITY NOTE:
When Cyber Security is enabled, access to any feature described in this Section is subject to the Access Permissions Policy as designated by the Security Policy Administrator.

This section describes the security elements incorporated in the M-7651A D-PAC and the settings and configuration choices that are necessary to allow the M-7651A D-PAC to communicate securely over Virtual Private Networks (VPN).

The M-7651A D-PAC is compliant with the applicable requirements of:

- IEEE 1686™-2007 Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities
- IPsec/IKE
- Radius

IEEE 1686 Standard

The M-7651A D-PAC meets or exceeds the requirements established in IEEE Std 1686, IEEE Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities. Table F-1 represents the M-7651A D-PAC Table of Compliance (TOC).

Permissions

IEEE Standard 1686 for the most part defines the standards for User Name, Passwords and the Permissions associated with each user. The specific permission categories are listed in Table F-2 "Permissions Implemented for IEEE 1686 Standard".

Clause/ subclause	Clause/subclause Title	Status	Comment
5	IED cyber security features	Acknowledge	
5.1	Electronic access control	Comply	
5.1.1	Password defeat mechanisms	Comply	
5.1.2	Number of individual ID/ passwords supported	Exceed	Product provides for 32 individual ID/password combinations
5.1.3	Password construction exception uppercase and lowercase letters are Interchangeable.	Comply	
5.1.4	Authorization levels by Password	Comply	
5.1.4.1	View data	Comply	
5.1.4.2	View configuration settings	Comply	
5.1.4.3	Force values	Comply	
5.1.4.4	Configuration change	Comply	
5.1.4.5	Firmware change	Comply	
5.1.4.6	ID/password management	Comply	
5.1.4.7	Audit log	Comply	
5.1.5	Password display	Comply/Exception	Except on local LCD
5.1.6	Access time-out	Comply	
5.2	Audit trail	Comply/Exception	Can only view audit trail events on computer
5.2.1	Storage capability	Comply	
5.2.2	Storage record	Comply	
5.2.2.1	Event record number	Comply	
5.2.2.2	Time and date	Comply	
5.2.2.3	User ID	Comply	
5.2.2.4	Event type	Comply	
5.2.3	Audit trail event types	Comply	
5.2.3.1	Login	Comply	
5.2.3.2	Manual logout	Comply	
5.2.3.3	Timed logout	Comply	
5.2.3.4	Value forcing	Comply	
5.2.3.5	Configuration Access	Comply	
5.2.3.6	Configuration change	Comply	
5.2.3.7	Firmware change	Comply	

Table F-1 IEEE Std 1686 Table of Compliance (1 of 2)

Clause/ subclause	Clause/subclause Title	Status	Comment
5.2.3.8	Firmware change	Comply	
5.2.3.9	ID/password deletion	Comply	
5.2.3.10	Audit-log access	Comply	
5.2.3.11	Time/date change	Comply/Exception	Indicated as a forced value change
5.2.3.12	Alarm incident		
5.3	Supervisory monitoring and control		
5.3.1	Events	Exception	Done through use of DNP unsolicited events
5.3.2	Alarms	Exception	
5.3.2.1	Unsuccessful login attempt		
5.3.2.2	Reboot	Exception	However, users can deduce that a reboot has taken place by examining the DNP3.0 initialization bit being set followed by a DNP3.0 request for time.
5.3.2.3	Attempted use of unauthorized configuration software	Comply	A public encryption key shall be sent by the control to the client software upon request. This is used to authenticate whether the software is valid by encrypting the user id and password with the correct algorithm and key. This feature can enabled/ disabled by not choosing "Encrypted password" for access level.
5.3.3	Alarm point change detect	Comply	DNP 3.0
5.3.4	Event and alarm grouping	Comply/Exception	DNP 3.0 Class poll
5.3.5	Supervisory permissive control	Exception	(TBD)
5.4	Configuration software	Acknowledge	
5.4.1	Authentication	Comply	See 5.3.2.3
5.4.2	ID/password control	Exceed	Initially password is created by administrator. Once changed by the user, password cannot be read by anyone.
5.4.3	ID/password-controlled features	Comply	
5.4.3.1	View configuration data	Comply	
5.4.3.2	Change configuration data	Comply	
5.4.3.3	Full access	Comply	
5.5	Communications port access	Comply	
5.6	Firmware quality assurance	Comply	

Table F-1 IEEE Std 1686 Table of Compliance (2 of 2)

Permission Categories (Access Permitted)	Default Permissons (X = Permission Category Included in Default Permission Set)										
	View Data	View Setpoints	Change Setpoints	Read Files	View Config	Change Config	Firmware Update	Manage Users	View Audit Log	Remote Control	Change Date/Time
Monitor Data	X										
View setpoints		X									
Change setpoints		X	X								
View configuration					X						
Change configuration					X	X					
Datalog setup					X	X					
Datalog download				X							
SOE setup					X	X					
SOE download				X							
OSC setup					X	X					
OSC download				X							
Security events log									X		
Manage users*								X			
Firmware update							X				
Remote control										X	
Change Date/Time											X
Get LED file				X							
Write LED file											
Get Button file				X							
Write Button file											
Write Wakeup Screens											

*User can change own password without manage users permissions set

Table F-2 Permissions Implemented for IEEE 1686 Standard

IPSEC/IKE OVERVIEW

IPsec/IKE is supported directly by the M-7651A D-PAC. This section describes the essential principles that reside within IPsec/IKE.

Internet Protocol security (IPsec) uses cryptographic security services to protect communications over Internet Protocol (IP) networks. IPsec is a suite of protocols specified by the Internet Engineering Task Force (IETF) that add security to the IP layer of internet traffic.

Implementing IPsec in the M-7651A D-PAC secures internet traffic, including TCP and UDP packets. The important elements that are necessary to provide robust network data security include encryption and equally important authentication. Communication security cannot exist without a combination of both encryption, to prevent unauthorized monitoring of sensitive data, and authentication which validates the identity of all the parties involved in the communication scheme.

IPsec Establishment and Protocol

The original standard of IPsec/IKE uses IKE Version 1 (IKEv1). Although not supported in the M-7651A D-PAC IPsec suite, it is important to understand how IKEv1 operates since IKEv2 utilizes many concepts that reside in IKEv1.

IKEv1

The IPsec tunnel is established through two separate phases. The first phase, called Phase 1, ISAKMP SA (Security Association) establishment, establishes the authenticity of both ends to each other. It uses the IKE (Internet Key Exchange) protocol to create a shared key between both ends, in a manner that the unauthorized monitoring entity will not know the newly created shared key (using Diffie-Hellman exchange).

The shared key is used to perform the second phase negotiation, which is referred to as Phase 2 or IPsec SA establishment. Phase 2 is also performed by IKE, but establishes the parameters and security association for the IPsec tunnel. Both Phase 1 and Phase 2 are periodically repeated (i.e. every several hours), establishing new shared keys to ensure the strong security of the IKE data. IKE data is typically communicated between both endpoints using UDP packets sent to port 500. If there is a firewall in between the tunnel, it is important that UDP port 500 is forwarded to the proper endpoint. Figure F-1 provides a simple illustration of an IKE packet.

Figure F-1 IKE Packet Configuration

When the IPsec tunnel has been established (after Phase 1 and Phase 2), traffic between both ends of the tunnel is communicated using a special IP protocol that encapsulated the original, unsecured packets. Figure F-2 provides an illustration of the IPsec packets.

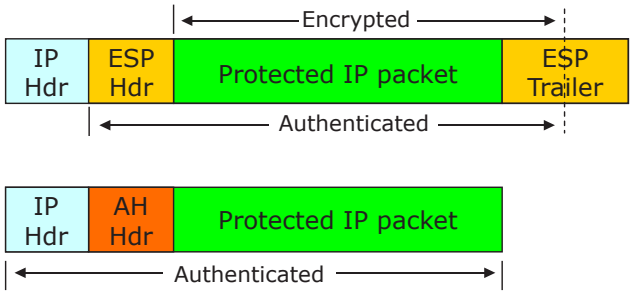


Figure F-2 ESP and AH Protocol IPsec Packet Examples

Normally, the ESP protocol is used, as it offers both encryption and authentication of the data from either endpoint. The AH protocol only offers authentication (i.e. the data is not fully protected), making it much less useful.

The creation and management of a security association is the most fundamental concept of the working of IKE and even IPsec. IKE can be considered the creator and manager of the SAs, while IPsec is the user of SAs.

IKEv2

In Phase 1, several messages are exchanged between the initiator and the receiver. The purpose of this phase is to generate the shared secret from which other keys will be computed and authenticate the communicating peers.

In IKEv2 there are only three sub-protocols in Phase 1 compared to eight sub-protocols in IKEv1. These are based on digital signatures (to be implemented later), MAC's (Message Authentication Code using pre-shared key), and EAP (Extensible Authentication Protocol) (not implemented).

Similar to IKEv1, Diffie-Hellman exponents and nonces are exchanged and used to compute several shared secret keys. The Phase 1 protocols establish an IKE SA (similar to IKEv1's ISAKMP SA) and a first child SA (similar to IKEv1's IPsec SA). Hence, contrary to IKEv1, an SA that can be used for IPsec (the child SA) is directly available after Phase 1.

In IKEv2 the Phase 2 SA is denoted as Child-SA which is created as a result of the Create-Child-SA request. This request may be launched by any of the parties once Phase 1 is completed. All messages in this phase are made secure due to the algorithms and keys negotiated in the first phase.

In addition, the Phase 2 in IKEv2 is known as Child Mode. The purpose of Child Mode is to re-key previous (IKE or child) SA's or to establish additional child SA's. IKEv2 is more efficient and requires less computing power.

RADIUS

Remote Authentication Dial In User Service (RADIUS) is a networking protocol that provides centralized Authentication, Authorization, and Accounting (AAA) management for computers to connect and use a network service. Authentication and Authorization RADIUS are described in RFC 2865 while Accounting is described by RFC 2866.

RADIUS is a client/server protocol that runs in the application layer, using UDP as transport. The following UDP ports are used:

- For Authentication and Authorization UDP port 1812 (previously 1645)
- For Accounting UDP port 1813 (previously 1646)

RADIUS serves three functions:

1. Authenticate users or devices before granting them access to a network
2. Authorize those users or devices for certain network services
3. Account for usage of those services

Password Authorization Mechanism

The M-7651A D-PAC includes the capability to use Authentication based on IEEE 1686. When IEEE 1686 password security is disabled, the RADIUS protocol although settable is not functional.

When Authentication, based on IEEE 1686 is implemented, then the full functionality of the RADIUS protocol is available. The following features are available if RADIUS is enabled:

- The M-7651A D-PAC provides local authentication capability if and ONLY if there is no other remote authentication server available to the device. Example of remote authentication server is the RADIUS server.

- The M-7651A D-PAC has the capability of being configured to use two remote authentication servers. Examples are 2 RADIUS servers. In case the primary server is down and not responding, the secondary server shall be used, and finally if both servers are down, the device shall fall back to the local server which is the IEEE 1686 password authentication.

The device is shipped with a default password file configured with one Super user ID and password. It is up to the end user to change this default password to ensure the security of the network. Usually the local password should match security policy of the RADIUS server.

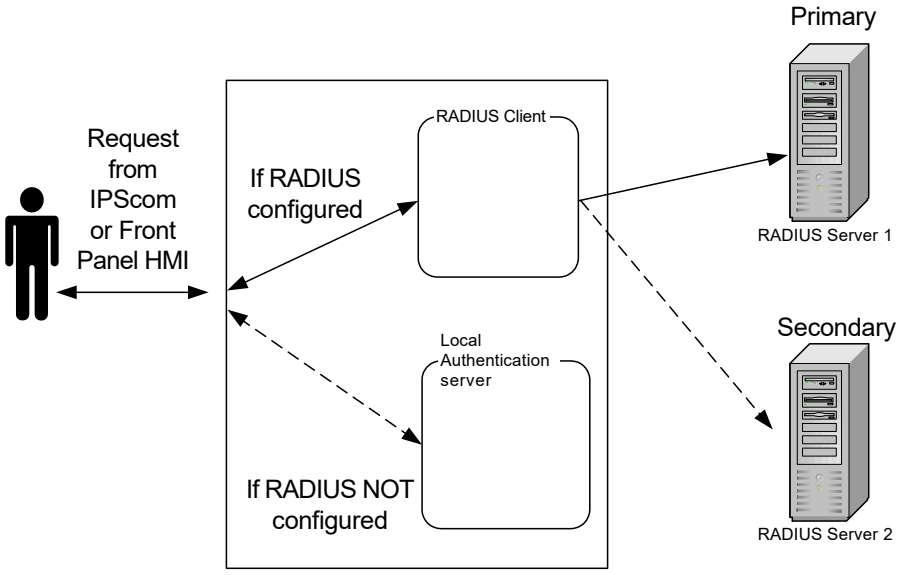


Figure F-3 RADIUS Server Configuration

Authentication and Authorization

The M-7651A D-PAC firmware includes the client and the Remote Access Server (RAS) component of the RADIUS protocol implemented. The M-7651A D-PAC sends a request to a RADIUS Server to gain access to a particular network resource using access credentials. The credentials are internally passed to the RAS.

In turn, the RAS sends a RADIUS Access Request message to the RADIUS server, requesting authorization to grant access via the RADIUS protocol. This request includes access credentials, typically in the form of user name and password provided by the user. The UDP port 1812 is used to communicate with the RADIUS server.

The RADIUS server checks that the information is correct using the defined authentication schemes. The User identification is verified along with the user's network address and user privileges.

The RADIUS server returns one of three responses to the client:

- Access Reject
- Access Challenge
- Access Accept

Access Reject – The user is unconditionally denied access to all requested network resources. Reasons may include failure to provide proof of identification or an unknown or inactive user account.

Access Challenge – Requests additional information from the user such as a secondary password. Access Challenge is also used in more complex authentication dialogs where a secure tunnel is established between the user device and the Radius Server in a way that the access credentials are hidden from the RAS.

Access Accept – The user is granted access. Once the user is authenticated, the RADIUS server will often check that the user is authorized to use the network service requested. A given user may be allowed to view data only, but not download files, for example. Again, this information may be stored locally on the RADIUS server, or may be looked up in an external source like LDAP or Active Directory.

Each of these three RADIUS responses may include a Reply-Message attribute which may give a reason for the rejection, the prompt for the challenge, or a welcome message for the accept.

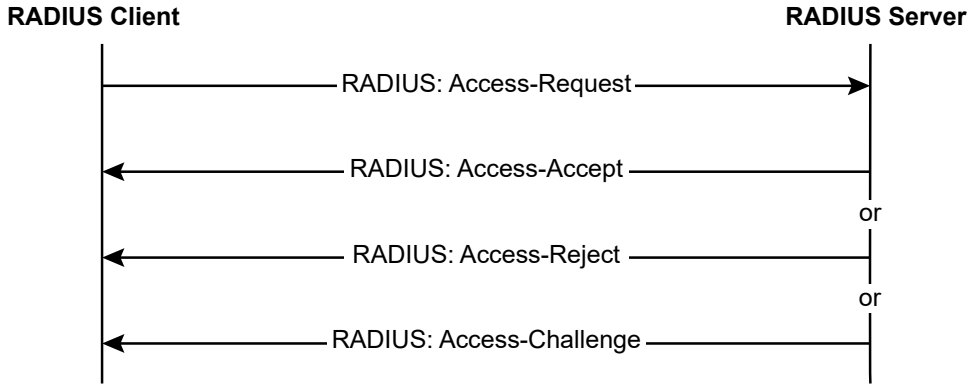


Figure F-4 RADIUS Authentication and Authorization Flow

Accounting

RADIUS Accounting Flow Accounting is described in RFC 2866. The UDP port 1813 is used to communicate with the RADIUS server for accounting purpose.

When network access is granted to the user by the client, an Accounting Start (a RADIUS Accounting Request packet containing an Acct-Status-Type attribute with the value "start") is sent by the client to the RADIUS server to signal the start of the user's network access. "Start" records typically contain the user's identification, network address, point of attachment and a unique session identifier.

Periodically, Interim Update records (a RADIUS Accounting Request packet containing an Acct-Status-Type attribute with the value "interim-update") may be sent by the client to the RADIUS server, to update it on the status of an active session. "Interim" records typically convey the setpoint changes by user.

Typically, the client sends Accounting-Request packets until it receives an Accounting-Response acknowledgement, using some retry interval.

In general the primary purpose of this data is to log user activity (Login/logout, setpoint changes, file transfer).

Channel ID	Description
0	USB interface
1	Comm interface on UART 0
2	Serial interface on UART 1
3	HMI interface
4	MODBUS Ethernet (starts from Channel 4 and may run through Channel 11 since the M-7651A D-PAC supports eight MODBUS Ethernet connections at a time)

CYBER SECURITY SETUP (IEEE STANDARD 1686) FROM IPSCOM

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Set Access Password Type** from the IPScom tool bar. IPScom will display the "Access Password Type" dialog screen (Figure F-5).

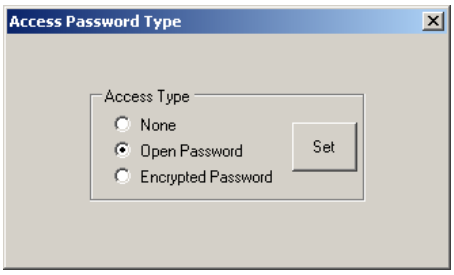


Figure F-5 Access Password Type Dialog Screen

■**NOTE:** The default User Name is "admin1"
The default password is "admin1@M76XX"

3. Select the desired Access Level:
   a. None – Cyber Security is not enabled. The user will not be prompted to enter a User Name and Password and will have access to ALL features and functions.
   b. Open Password – The password is not encrypted. This option should be chosen when IPScom is not the sole method of communication to the relay.
   c. Encrypted Password – The password is encrypted and is authenticated by the relay to allow the user to log on to the relay. However, this selection only controls password encryption for a user login. Setpoints files and passwords contained in Account Permissions files are encrypted.
4. Select **Set**. Based on the selection made, IPScom will display the applicable confirmation screen, either Figure F-6 or Figure F-7.

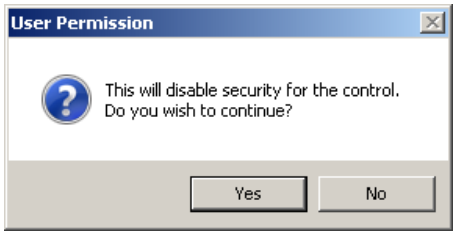


Figure F-6 Access Level "None" Confirmation Screen

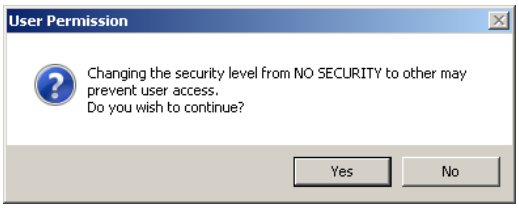


Figure F-7 Access Level "Open Password" or "Encrypted Password" Confirmation Screen

5. Select **Yes**. IPScom will display the following confirmation screen and will close communication with the relay.

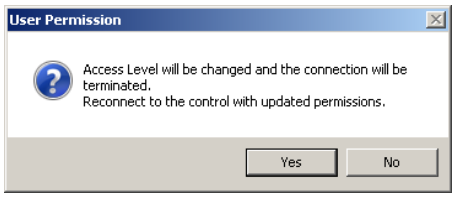


Figure F-8 Access Level Changed Confirmation Screen

6. Select **Yes**. If Cyber Security is enabled. the user will now be prompted to enter a valid User Name and Password to log on to a relay (Figure F-9).

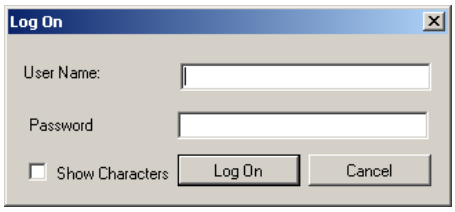


Figure F-9 Log On User Name and Password Dialog Screen

USER ACCOUNTS

■**NOTE:** The default User Name is "admin1"
The default password is "admin1@M76XX"

The relay contains default User Names, Passwords, and Roles. A user with the "Manage Users" permission can perform the following:

- Add/Delete a user
- Change the permissions associated with a user
- Assign a user to a specific Role
- Add/Delete a Role
- Open/Save/Save As, a ".bin" file
- Retrieve(Save As) and View an Audit Log ".bkp"

While the Manage Users permission allows the user to control all aspects of a User, the Manage Users permission does not allow changing or viewing a user's password beyond initially establishing the password when the User is created. However, the Manage Users permission can delete the user account, effectively canceling the password.

User Account information resides on the relay in flash memory. When retrieving (IPScom only) the data is saved to a file with a ".bin" file extension. The file contains all user(s) information for display and editing.

When initially establishing a password or when changing a password, the password syntax must conform to the following criteria:

- Minimum length must be 8 characters
- Maximum length is 20 characters
- Must include at least one uppercase letter
- Must include at least one lowercase letter
- Must include at least one number
- Must include at least one non-alphanumeric character (e.g. @, %, *, etc.)

IPScom presents the password criteria in red type in the "Change Password" (Figure F-25) and "Add User" (Figure F-20) dialog screens. As the criteria is met for the entered password, the "type" that states the criteria that has been met changes to black.

During "Retrieve Account Permissions from Control" and "Send Account Permissions to Control" operations, all User Account information is included. However, when a Password is changed, only the password is written to the relay.

■**NOTE:** The instructions presented in this section assume that the user has been granted the appropriate permissions (Manage Users) to access and make changes to the subject features and capabilities.

User Account Modification and Setup

The relay contains default User Accounts. The following instructions describe:

- Modifying Account Permissions retrieved from the relay
- Modifying an existing Account Permissions ".bin" file
- Setting up a new User Account in an Account Permissions file.

Modifying Account Permissions Retrieved from the Relay

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Retrieve Account Permissions from Control** from the IPScom tool bar. IPScom will display a "Binary File" Save As dialog screen (Figure F-10).

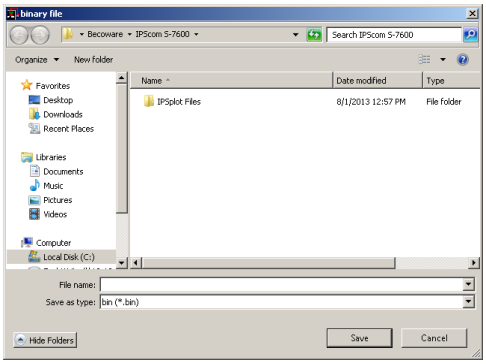


Figure F-10 Retrieve Account Permissions from Control Binary File Save As Screen

3. Choose the **Save As** location and enter the desired file name that will contain the Account Permissions retrieved from the relay.
4. Select **Save**. IPScom will save the named binary file that contains the relay Account Permissions to the selected location and display a confirmation screen.
5. Select **Utility/Manage Accounts/Manage Account Permissions** from the IPScom tool bar. IPScom will display a "Manage Account Permissions" dialog screen (Figure F-19).

6. From the Manage Account Permissions dialog screen menu bar select **File/Open**. IPScom will display the "Binary File" Open dialog screen (Figure F-11).

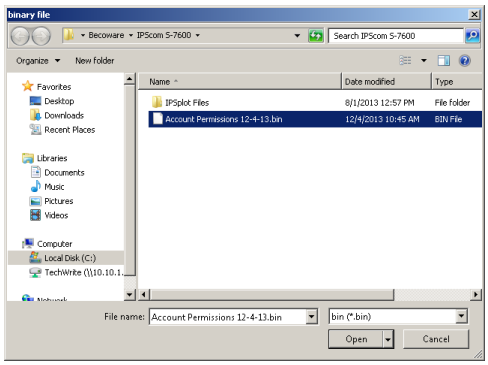


Figure F-11 Binary File Open Dialog Screen

7. Navigate to the file location and select the desired file name that contains the retrieved relay Account Permissions to be modified.
8. Select **Open**. IPScom will display a prompt for the User Name and Password associated with the selected file (Figure F-12).

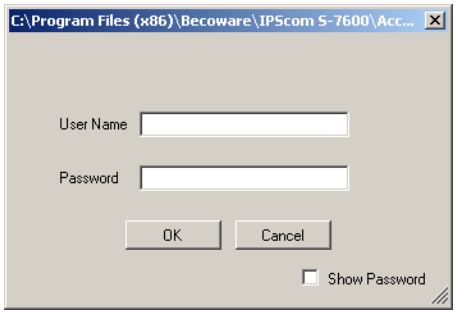


Figure F-12 User Name and Password Prompt

9. Enter the User Name and Password associated with the file, then select **OK**.
10. If the entered User Name and Password are rejected, then repeat Step 9.
11. If the entered User Name and Password are accepted for the target file, then IPScom will display a "Login Accepted" prompt (Figure F-13).

Figure F-13 Login Accepted Prompt Screen

12. Select **OK**. IPScom will open the selected binary file that contains the Account Permissions in the Manage Account Permissions dialog screen (Figure F-14).

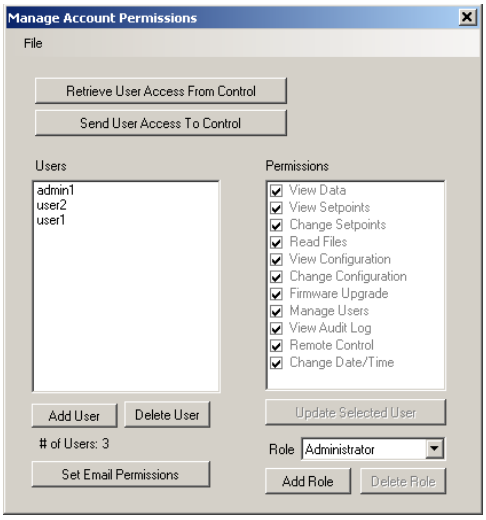


Figure F-14 Manage Account Permissions With Open Account Permissions File Dialog Screen

13. Select the **User** to be modified.
14. Select the desired Permissions for the User by either:
    - Checking or unchecking the desired Permissions
    - Selecting "Set Email Permissions" to automatically add the permissions required to access the E-mail Support feature:
        - View Data
        - View Setpoints
        - Read Files
        - View Configuration
        - Manage Users
        - View Audit Log
    - Selecting a **Role** with pre-defined Permissions from the Role dropdown menu (Figure F-15)

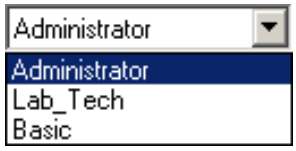


Figure F-15 Pre-defined Roles

15. When all permissions have been selected/deselected, then select **Update Selected User**. The original Binary File can be saved (File/Save) or saved to a different file name and/or location (File/Save As).
16. From the Manage Account Permissions dialog screen menu bar select **File/Save** or **Save As**. IPScom will display a "Send File" dialog screen to allow the user to save the file to the relay or to the computer (Figure F-16).

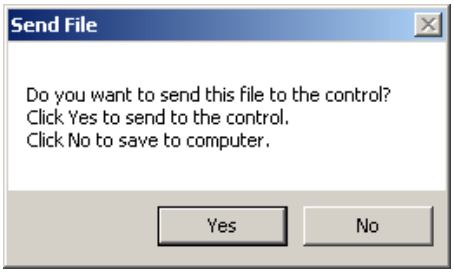


Figure F-16 Send User File Dialog Screen

17. Select **Yes** to send the User File to the relay. IPScom will display a confirmation screen (Figure F-17). Select **OK**, IPScom will close communications.

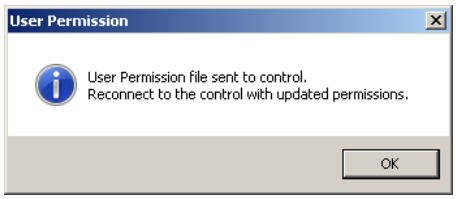


Figure F-17 User Permission File Sent to Control Confirmation Screen

18. Select **No** to save the User File to the computer. If **File/Save As** was selected, IPScom will display the "User Access File" Save As dialog screen (Figure F-18).

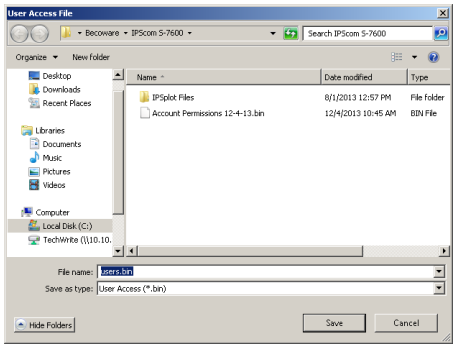


Figure F-18 User Access File Save As Dialog Screen

19. Select the name and location of the User Access file to be Saved As.
20. Select **Save**. IPScom will save the file to the selected location.
21. Record the User Name and Password associated with the saved file.

▲CAUTION: It is very important to record the User Name and Password associated with the saved file. The only way to access the file is to have the correct User Name and Password. In the case of writing the file to a relay, the relay will not be able to be accessed and will require the user to contact the factory to restore default User Name and Password.

Modifying Account Permissions in an Existing User Access ".bin" File

1. Start IPScom, select **Utility/Manage Accounts/Manage Account Permissions** from the IPScom tool bar. IPScom will display a "Manage Account Permissions" dialog screen (Figure F-19).

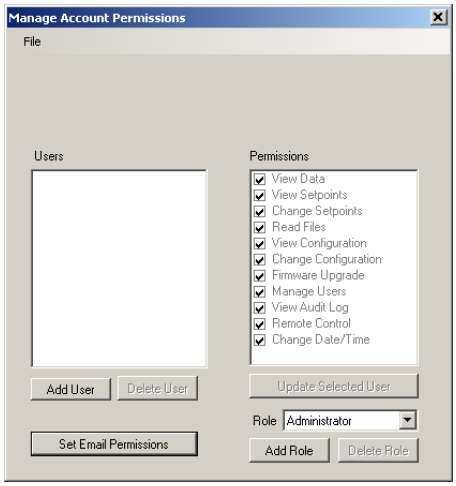


Figure F-19 Manage Account Permissions Dialog Screen

2. From the Manage Account Permissions dialog screen menu bar select **File/Open**. IPScom will display the "Binary File" Open dialog screen (Figure F-11).
3. Navigate to the file location and select the desired file name that contains the existing User Access ".bin" file to be modified.
4. Select **Open**. IPScom will display a prompt for the User Name and Password associated with the selected file (Figure F-12).
5. Enter the User Name and Password associated with the file, then select **OK**.
6. If the entered User Name and Password are rejected, then repeat Step 6.
7. If the entered User Name and Password are accepted for the target file, then IPScom will display a "Login Accepted" prompt (Figure F-13).
8. Select **OK**. IPScom will open the selected binary file that contains the Account Permissions in the Manage Account Permissions dialog screen (Figure F-14).
9. Select the **User** to be modified.
10. Select the desired Permissions for the User by either:
    - Checking or unchecking the desired Permissions
    - Selecting a **Role** with pre-defined Permissions from the Role drop down menu (Figure F-15)
11. When all permissions have been selected/deselected, then select **Update Selected User**. The original Binary File can be saved (File/Save) or saved to a different file name and/or location (File/Save As).
12. From the Manage Account Permissions dialog screen menu bar select **File/Save** or **Save As**. IPScom will display a "Send File" dialog screen to allow the user to save the file to the relay or to the computer (Figure F-16).
13. Select **Yes** to send the User File to the relay. IPScom will display a confirmation screen (Figure F-17). Select **OK**, IPScom will close communications.
14. Select **No** to save the User File to the computer. If **File/Save As** was selected, IPScom will display the "User Access File" Save As dialog screen (Figure F-18).
15. Select the name and location of the User Access file to be Saved As.
16. Select **Save**. IPScom will save the file to the selected location.
17. Record the User Name and Password associated with the saved file.

▲CAUTION: It is very important to record the User Name and Password associated with the saved file. The only way to access the file is to have the correct User Name and Password. In the case of writing the file to a relay, the relay will not be able to be accessed and will require the user to contact the factory to restore default User Name and Password.

Setting Up a New User Account in a User Access File

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Manage Account Permissions** from the IPScom tool bar. IPScom will display a "Manage Account Permissions" dialog screen (Figure F-19).
3. From the Manage Account Permissions dialog screen menu bar select **File/Open**. IPScom will display the "Binary File" Open dialog screen (Figure F-11).
4. Navigate to the file location and select the desired file name for the User Access ".bin" file that the New User Account is to be added to.
5. Select **Open**. IPScom will display a prompt for the User Name and Password associated with the selected file (Figure F-12).
6. Enter the User Name and Password associated with the file, then select **OK**.
7. If the entered User Name and Password are rejected, then repeat Step 6.
8. If the entered User Name and Password are accepted for the target file, then IPScom will display a "Login Accepted" prompt (Figure F-13).

9. Select **OK**. IPScom will open the selected binary file that contains the Account Permissions in the Manage Account Permissions dialog screen (Figure F-14).
10. Select **Add User**. IPScom will display the "Add User" dialog screen (Figure F-20).

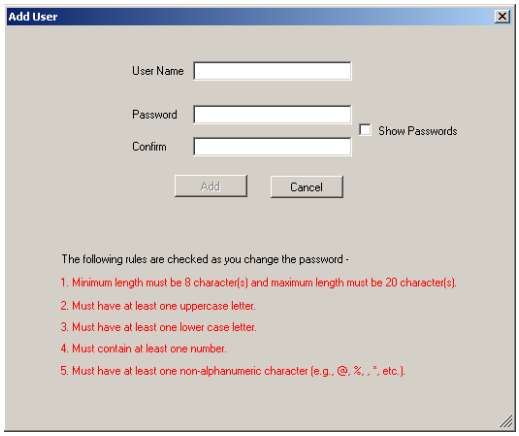


Figure F-20 Add User Dialog Screen

11. Enter a valid User Name and Password consistent with criteria presented in the User Accounts section earlier in this Section.

    IPScom presents the password criteria in red type. As the criteria is met for the entered password, the "type" that states the criteria that has been met changes to black.
12. When all Password criteria have been met, then select **Add**. IPScom will return to the "Manage Account Permissions" dialog screen (Figure F-14) and display the new User.
13. Select the new User, then select the desired Permissions by either:
    - Checking or unchecking the desired Permissions
    - Selecting a **Role** with pre-defined Permissions from the Role drop down menu (Figure F-15)
14. When all permissions have been selected/deselected, then select **Update Selected User**. The original Binary File can be saved (File/Save) or saved to a different file name and/or location (File/Save As).
15. From the Manage Account Permissions dialog screen menu bar select **File/Save** or **Save As**. IPScom will display a "Send File" dialog screen to allow the user to save the file to the relay or to the computer (Figure F-16).
16. Select **Yes** to send the User File to the relay. IPScom will display a confirmation screen (Figure F-17). Select **OK**, IPScom will close communications.
17. Select **No** to save the User File to the computer. If **File/Save As** was selected, IPScom will display the "User Access File" Save As dialog screen (Figure F-18).
18. Select the name and location of the User Access file to be Saved/Save as.
19. Select **Save**. IPScom will save the file to the selected location.
20. Record the User Name and Password associated with the saved file.

▲CAUTION: It is very important to record the User Name and Password associated with the saved file. The only way to access the file is to have the correct User Name and Password. In the case of writing the file to a relay, the relay will not be able to be accessed and will require the user to contact the factory to restore default User Name and Password.

ROLES

When the S-7600 IPScom is installed on the host PC, a Role file is created that contains the default Roles. Changes to existing Roles and creation of new Roles are captured in this file. However, Roles created on other IPScom PC installations may have different permissions for the same Role name. Adding and deleting "Roles" is accomplished from the "Manage Account Permissions" dialog screen (Figure F-19).

Retrieving Account Permissions from Relay

To Retrieve Account Permissions from the M-7651A D-PAC perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Retrieve Account Permissions from Control** from the IPScom tool bar. IPScom will display a "Binary File" Save As dialog screen (Figure F-10).
3. Choose the **Save As** location and enter the desired file name that will contain the Account Permissions retrieved from the relay.
4. Select **Save**. IPScom will save the named binary file that contains the relay Account Permissions to the selected location.

Sending Account Permissions to the Relay

To Send Account Permissions to the M-7651A D-PAC perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Send Account Permissions to the Control** from the IPScom tool bar. IPScom will display a "Binary File" Open dialog screen (Figure F-11).
3. Navigate to the file location and select the desired file name that contains the Account Permissions to be sent to the relay.
4. Select **Open**. IPScom will attempt to send the selected binary file that contains the relay Account Permissions to the target relay.
5. If IPScom returns a "Failed to send Users.bin file to Control" confirmation (Figure F-21), then select **OK** and repeat Steps 2 through Step 4.

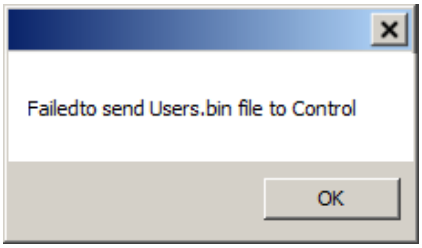


Figure F-21 Failed to Send Users.bin File to Control Confirmation Screen

6. If file transfer is successful, IPScom will display a "User Permission file sent to control" confirmation screen (Figure F-17). Select **OK**, IPScom will close communications.

   If any changes were made to the permissions that were sent to the relay, the changes will take effect the next time the user logs on to the relay.

AUDIT LOG

The Audit Log captures security events in the order in which they occur. The Audit Log can be retrieved and viewed in IPScom. The Audit Log is saved to the PC with a "*.bkp" file extension. The Audit Log can also be saved as Comma Separated Values file "*.csv".

Each Audit Log entry includes:

- Date (Month, Day, Year)
- Time (Hour, Minute, Second)
- User Name
- Event Description regarding:
  - USB interface
  - Comm interface on UART 0
  - Serial interface on UART 1
  - HMI interface
  - MODBUS Ethernet – MODBUS Ethernet starts from Channel 4 and may run through Channel 11 since the M-7651A D-PAC supports eight MODBUS Ethernet connections at a time.

Audit Log Retrieval, Viewing and Saving

The following sequence of steps describes retrieving, viewing and saving the Audit Log as a ".bkp" file.

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Audit Log/Retrieve** from the IPScom tool bar. IPScom will display the "Save As" dialog screen (Figure F-22) with the default "*.bkp" file extension.

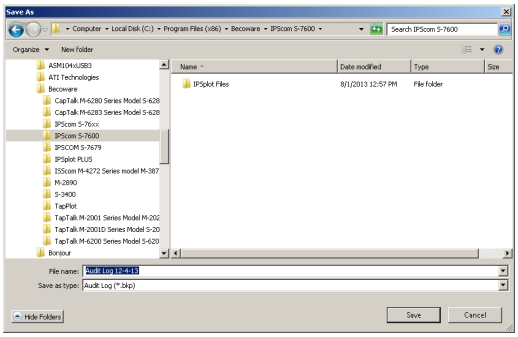


Figure F-22 Audit Log Save As Dialog Screen

3. Choose the **Save As** location and enter the desired file name that will contain the Audit Log retrieved from the relay.
4. Select **Save**. IPScom will display a confirmation dialog screen that confirms that the file has been saved.
5. Select **OK**. IPScom will display the Audit Log dialog screen(Figure F-24).

6. To view a previously saved Audit Log, select **Utility/Manage Accounts/Audit Log/View**. IPScom will display the "Audit Log file" Open dialog screen (Figure F-23) with the default "*.bkp" file extension.

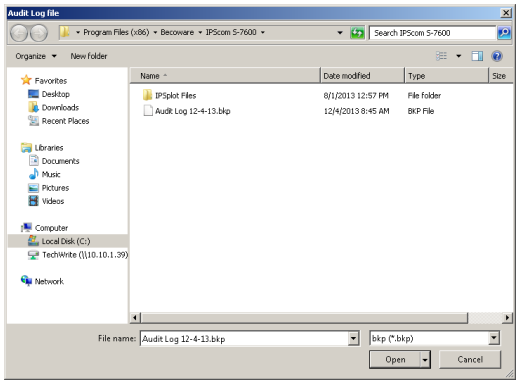


Figure F-23 Audit Log File Open Dialog Screen

7. Navigate to the file location and select the desired file name for the Audit Log to be viewed.
8. Select **Open**. IPScom will display the Audit Log Screen (Figure F-24).

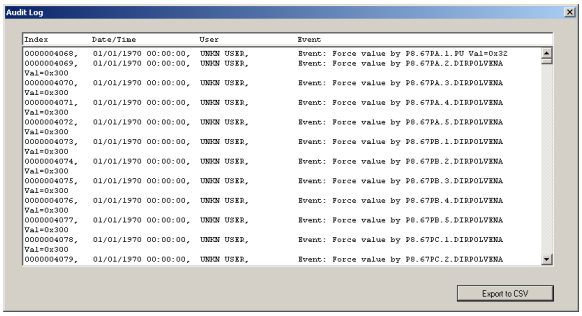


Figure F-24 Audit Log Screen

9. To save the displayed Audit Log to a "*.csv" formatted file select **Export to CSV**. IPScom will display a confirmation dialog screen that confirms that the file has been saved.

■**NOTE:** It may be necessary to select **View Hidden Folders** in Windows to locate the CSV file.

10. Select **OK**. IPScom will return to the Audit Log screen.

CHANGE PASSWORD

The Password associated with a specific User Name can only be changed by successfully connecting to the target relay. When **Change Password** is selected in the "Change Password" dialog screen (Figure F-25), only the new Password is written to the relay.

To change the Password for a specific User, proceed as follows:

1. Start IPScom, then establish communications with the target relay.
2. Select **Utility/Manage Accounts/Change Password** from the IPScom tool bar. IPScom will display a "Change Password" dialog screen (Figure F-25).

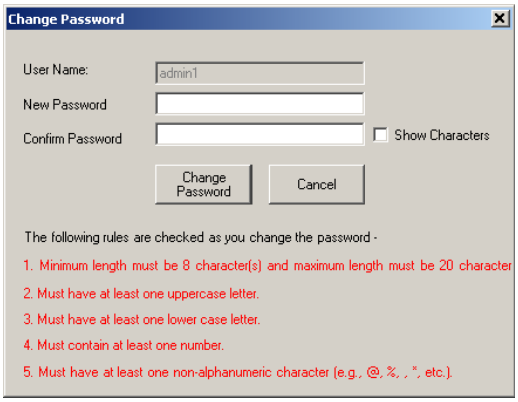


Figure F-25 Change Password Dialog Screen

3. Enter a valid Password consistent with criteria presented in the User Accounts section earlier in this Section.

   IPScom presents the Password criteria in red type. As the criteria is met for the entered password, the "type" that states the criteria that has been met changes to black.
4. Re-enter the desired Password to confirm the entered Password.
5. When all Password criteria have been met, then select **Change Password**. IPScom will display the "Changing Password" status screen (Figure F-26).

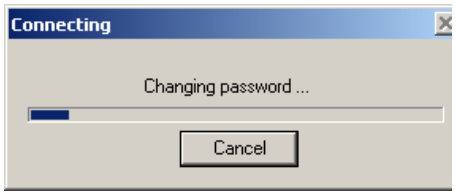


Figure F-26 Changing Password Status Screen

6. When the Password has been changed on the relay IPScom will display the "Password Changed Logout" confirmation screen (Figure F-27).

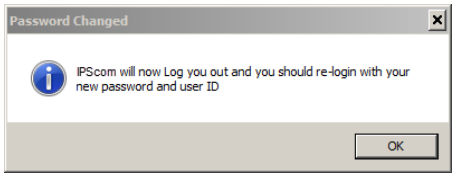


Figure F-27 Password Changed Logout Confirmation Screen

7. Select **OK**. IPScom will log the current user off the relay. In order to re-login to the relay the user must use the changed Password.

SECURITY MODE SETUP

■**NOTE:** The instructions presented in this section assume that IEEE Standard 1686 has been enabled and the user has been granted the appropriate permissions (Manage Users) to access and make changes to the subject features and capabilities.

Radius Configuration from IPScom

To set up the M-7651A D-PAC to apply the Radius elements of the Cyber Security scheme perform the following:

1. Obtain the following information from the Network Administrator:
   - Primary Server IP Address
   - Primary Server Authentication Port
   - Primary Server Accounting Port
   - Secondary Server IP Address
   - Secondary Server Authentication Port
   - Secondary Server Accounting Port
   - Secret Key
2. Start IPScom, then establish communications with the target relay.
3. Select **Communication/Setup/Communication Security/Radius Configuration** from the IPScom tool bar. IPScom will display a "Radius Configuration" dialog screen (Figure F-28).

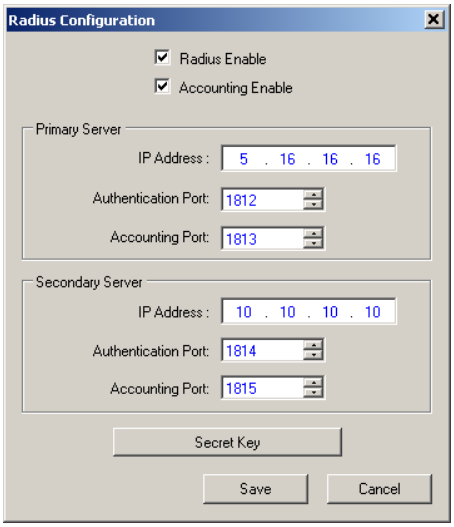


Figure F-28 Radius Configuration Dialog Screen

4. Enter the required settings in the Radius Configuration dialog screen.
5. From the Radius Configuration screen select **Secret Key**. IPScom will display the "Radius Configuration Key" dialog screen (Figure F-29).

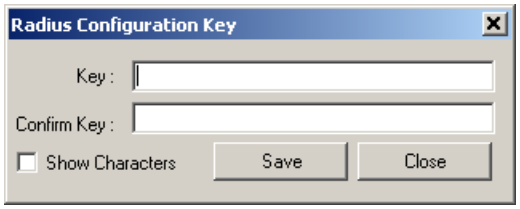


Figure F-29 Radius Configuration Key Dialog Screen

▲**CAUTION:** It is very important that the Configuration Key is entered correctly. In the event that it is not entered correctly and Radius is "Enabled" the Radius server will deny access to the relay because the Password will be encrypted in a way that the Radius server can not decrypt it properly.

6. Enter the Radius Configuration Key.
7. Select **Save**. IPScom will write the Radius Configuration settings to the relay.

Enable Radius Security from the HMI

1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".

```
    COMMUNICATIONS
<CNFG           UTIL>
```

2. Press **ENT** or **CNFG** once. The unit will display the following:

```
    PORT1 Settings
<                   >
```

3. Press **MNTR** or **COMM** as necessary until "Comm Ports Security" is displayed.

```
  Comm Ports Security
<                   >
```

4. Press **ENT** or **CNFG** once. The unit will display the following:

```
    Physical Ports
<                   >
```

5. Press **MNTR** or **COMM** as necessary until "Protocol Access" is displayed.

```
    Protocol Access
<                   >
```

6. Press **CNFG** as necessary, until the "Radius" menu item is displayed.

```
Radius
DISABLE
```

7. Press **ENT**. The following will be displayed.

```
Radius
DISABLE
```

8. Utilizing **SETP** or **CNFG** select **ENABLE**, then press **ENT**. The following will be displayed.

```
Radius
ENABLE
```

9. Press **SETP** or **CNFG** as necessary until "Radius accounting" is displayed.

```
Radius accounting
DISABLE
```

10. Press **ENT**. The following will be displayed.

```
Radius accounting
DISABLE
```

11. Utilizing **SETP** or **CNFG** select **ENABLE**, then press **ENT**. The following will be displayed.

```
Radius accounting
ENABLE
```

Radius Configuration from the HMI

■**NOTE:** Radius Server 1 (Primary Server) is setup in this example. The steps to setup Radius Server 2 (Secondary Server) are similar.

12. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".

```
     COMMUNICATIONS
<CNFG            UTIL>
```

13. Press **ENT** or **CNFG** once. The unit will display the following:

```
     PORT1 Settings
<                    >
```

14. Press **MNTR** or **COMM** as necessary until "Ethernet" is displayed.

```
        Ethernet
<                    >
```

15. Press **ENT** or **CNFG** once. The unit will display the following:

```
        Settings
<                    >
```

16. Press **CNFG** as necessary, until the "Radius server IP 1" menu item is displayed.

```
Radius server IP 1
 XX.  XX.  XX.  XX
```

17. Press **ENT**. The following will be displayed.

```
Radius server IP 1
 XX.  XX.  XX.  XX
```

18. Utilizing the arrow pushbuttons enter the desired Radius server IP address. Press **ENT**. The desired Radius server IP address will be displayed.

19. Press **CNFG** as necessary, until the "Radius server port 1" menu item is displayed.

```
Radius server port 1
  1812
```

20. Press **ENT**. The following will be displayed.

```
Radius server port 1
  1812
```

21. Utilizing the arrow pushbuttons enter the desired Radius server port.
    Press **ENT**. The desired Radius server port will be displayed.
22. Press **CNFG** as necessary, until the "Radius secret" menu item is displayed.

```
Radius secret
dfltsec
```

23. Press **ENT**. The following will be displayed.

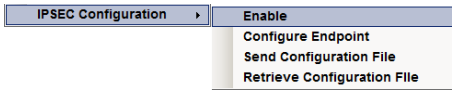
```
Radius secret
dfltsec
```

24. Utilizing the arrow pushbuttons enter the desired Radius secret key.
25. Press **ENT**. The desired Radius secret key will be displayed.

IPsec Configuration from IPScom

To set up the M-7651A D-PAC to apply the IPsec elements of the Cyber Security scheme perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Enable** from the **Communication/Setup/Communication Security/IPSEC Configuration** dropdown menu.



3. IPScom will display the "IPSec Enable" dialog screen (Figure F-30). Select **Enable IPSec**.

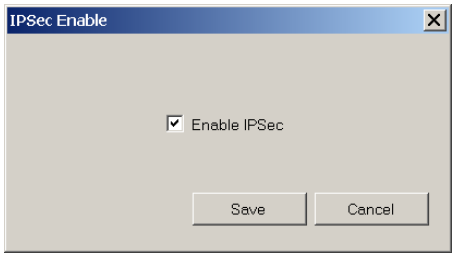


Figure F-30 IPSec Enable Dialog Screen

4. Select **IPSEC Configuration/Configure Endpoint**. IPScom will display the "Configure Endpoint" (Figure F-31) dialog screen which allows the user to add, edit, delete or save IPsec Endpoints.

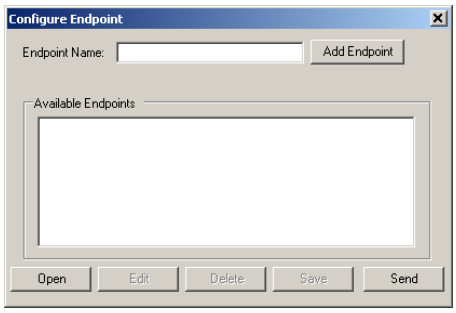


Figure F-31 IPsec Configure Endpoint Dialog Screen

5. Select an available Endpoint from the "Configure Endpoint" screen and then select **Edit**. IPScom will display the "IPsec General Settings" screen (Figure F-32) which allows the user to configure IPsec security settings, including IKE (Internet Key Exchange) Policy, IPsec Policy, Policy Lifetimes and Identities.
6. Enter the required settings in the IPsec General Settings dialog screen tabs (Figure F-33 through Figure F-35).

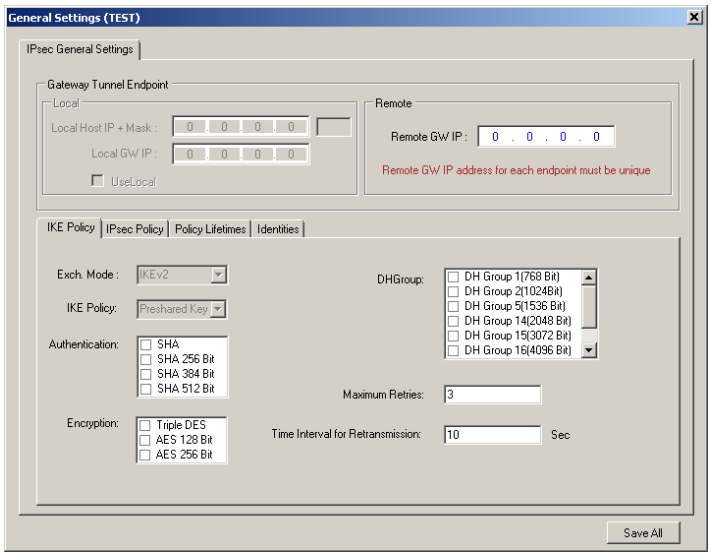


Figure F-32 IPsec General Settings Dialog Screen

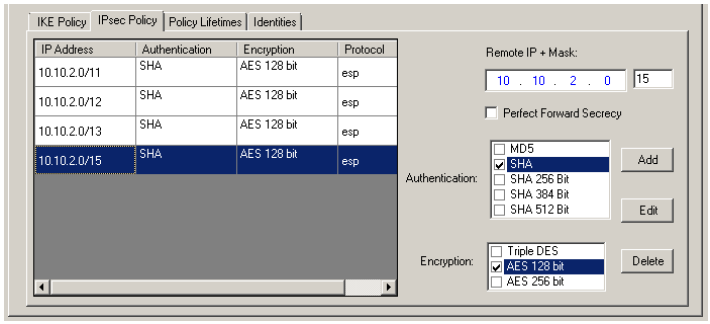


Figure F-33 IPsec General Settings "IPsec Policy" Tab

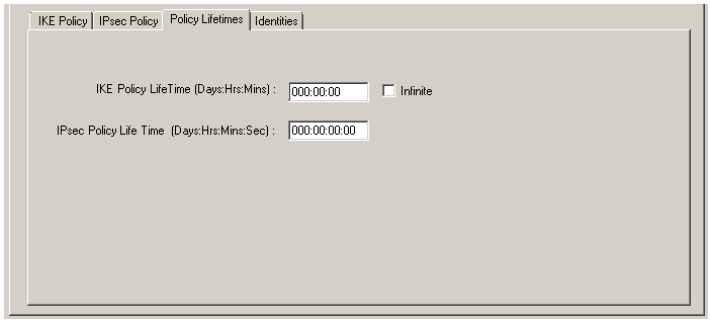


Figure F-34 IPsec General Settings "Policy Lifetimes" Tab

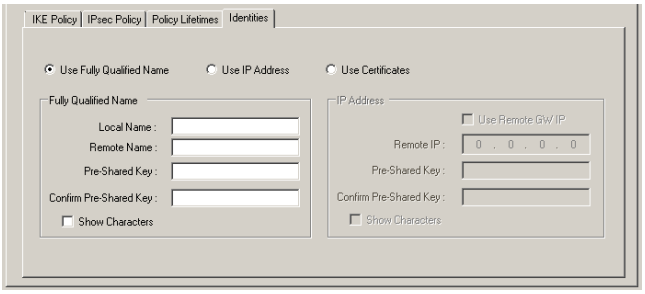


Figure F-35 IPsec General Settings "Identities" Tab

7. Select **Save All**. IPScom will display an Error Message alerting the user to any required settings which have not been entered (Figure F-36).

Figure F-36 IPsec Configuration Error Screen

8. If applicable, enter all required settings and select **Save All**.
9. Close the "General Settings" screen and return to the 'Configure Endpoint" dialog screen.
10. Add and/or edit any additional endpoints and select **Save**. IPScom will display the "Save As" dialog screen (Figure F-37) which allows the user to name and save the IPsec configuration file (*.ifg).

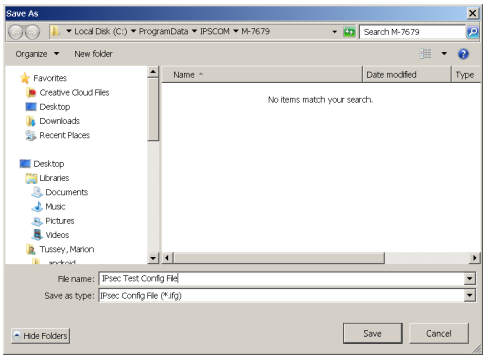


Figure F-37 IPsec Save As Dialog Screen

11. Enter the desired IPsec Configuration filename and select **Save**. IPScom will display a confirmation screen (Figure F-38).

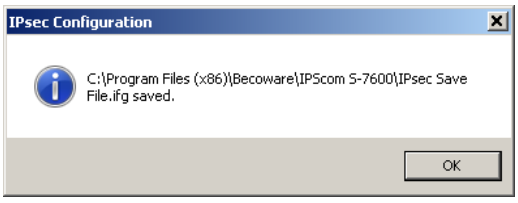


Figure F-38 IPsec Configuration File Saved Confirmation Screen

12. Select **OK**. IPScom will return to the "Configure Endpoint" screen.

■**NOTE:** IPsec configuration files may be sent to the control from the Configure Endpoint dialog screen.

Sending IPsec Configuration File to the Relay from IPScom

1. Start IPScom, then establish communications with the target relay.
2. Select **Communication/Setup/Communication Security/IPsec Configuration/ Send Configuration File** from the IPScom tool bar. IPScom will display a "IPsec Configuration File" Open dialog screen (Figure F-39).

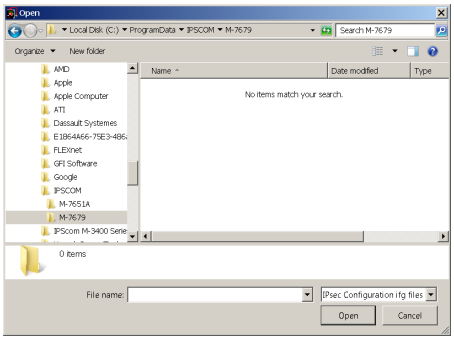


Figure F-39 IPsec Configuration File Open Dialog Screen

3. Select the desired file name that contains the IPsec Configuration to be sent to the relay.
4. Select **Open**. IPScom will send the selected file that contains the IPsec Configuration to the target relay.
5. IPScom will display a "IPsec Configuration File Sent to Control" confirmation screen (Figure F-40). Select **OK** IPScom will return to the main screen.

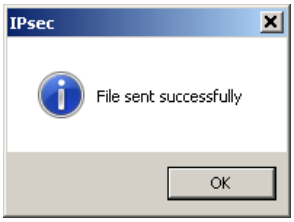


Figure F-40 IPsec Configuration File Sent to Control Confirmation Screen

Retrieving IPsec Configuration from the Relay

To retrieve the IPsec Configuration from the M-7651A D-PAC perform the following:

1. Start IPScom, then establish communications with the target relay.
2. Select **Communication/Setup/Communication Security/IPsec Configuration/ Retrieve Configuration File** from the IPScom tool bar. IPScom will display a "IPsec File" Save As dialog screen (Figure F-37).
3. Choose the **Save As** location and enter the desired file name that will contain the IPsec Configuration retrieved from the relay.
4. Select **Save**. IPScom will save the (*.ifg) file that contains the relay IPsec Configuration to the selected location and display a confirmation screen (Figure F-41).

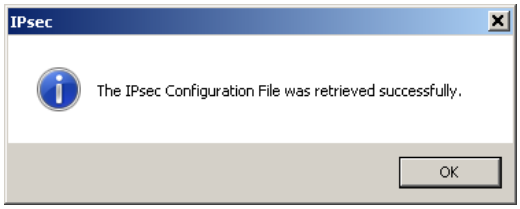
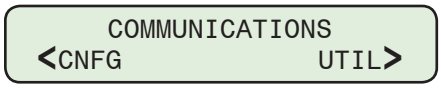


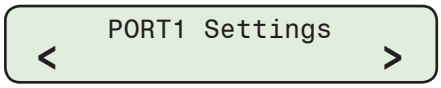
Figure F-41 IPsec Configuration File Retrieved Confirmation Screen

Enable IPsec Security from the HMI

1. Press **COMM** to wake the unit. The menu will advance to "COMMUNICATIONS".

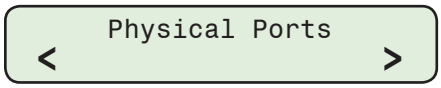


2. Press **ENT** or **CNFG** once. The unit will display the following:

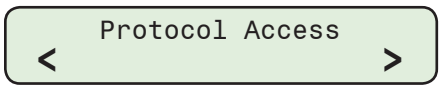


3. Press **MNTR** or **COMM** as necessary until "Comm Ports Security" is displayed.

4. Press **ENT** or **CNFG** once. The unit will display the following:

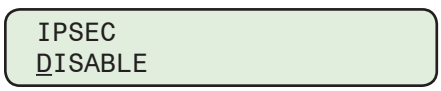


5. Press **MNTR** or **COMM** as necessary until "Protocol Access" is displayed.



6. Press **CNFG** as necessary, until the "IPSEC" menu item is displayed.

7. Press **ENT**. The following will be displayed.



8. Utilizing **SETP** or **CNFG** select **ENABLE**, then press **ENT**. The following will be displayed.

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Legal Information

Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringementof United States Letters Patent or rights accruing thereform or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of ten years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to peform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantibility and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

In no event shall the Seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of purchased power, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstances shall the Seller be liable for any personal injury whatsoever.

It is agreed that when the equipment furnished hereunder are to be used or performed in connection with any nuclear installation, facility, or activity, Seller shall have no liability for any nuclear damage, personal injury, property damage, or nuclear contamination to any property located at or near the site of the nuclear facility. Buyer agrees to indemnify and hold harmless the Seller against any and all liability associated therewith whatsoever whether based on contract, tort, or otherwise. Nuclear installation or facility means any nuclear reactor and includes the site on which any of the foregoing is located, all operations conducted on such site, and all premises used for such operations.

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BECKWITH ELECTRIC CO., INC.
6190 - 118th Avenue North • Largo, Florida 33773-3724 U.S.A.
PHONE (727) 544-2326 • FAX (727) 546-0121
marketing@beckwithelectric.com
www.beckwithelectric.com
ISO 9001:2015

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800-7651A D-PAC-IB-06 06/18
Printed in USA