Instruction Book

M-3520 Intertie Protection Relay

BECKWITH ELECTRIC CO. INC.

Intertie Protection M-3520

Integrated Protection System®

Unit shown with optional HMI and Target modules

- **Integrated Protection System for DR/DG Intertie, Providing:**
  - **Loss of parallel utility operation protections**
  - **Abnormal power flow protections**
  - **Comprehensive suite of phase and ground fault backed protections**
  - **Abnormal operating protections**
  - **Reconnect and Sync Check functions**

- **Microprocessor-based Intertie Protection Relay integrates protection, metering, monitoring and waveform capture**

- **Provides 18 base protective relay functions and 3 optional protective functions**

- **Local and remote serial communications capabilities, plus IRIG-B interface**

Standard Functions

- Sync check with Phase, ΔV and ΔF with deadline/deadbus options (25)
- Phase undervoltage (27) protection
- Neutral over/undervoltage (59G/27G) protection
- Sensitive dual-setpoint, reverse power detection (32)
- Sensitive negative-sequence overcurrent protection and alarm (46)
- Negative sequence voltage (47)
- Instantaneous overcurrent (50) protection
- Instantaneous neutral overcurrent (50G) protection
- Three-phase inverse time overcurrent (51V) with voltage control/voltage restraint
- Neutral inverse time overcurrent (51G) protection
- Phase overvoltage (59) protection
- Peak overvoltage (59I) protection
- VT fuse-loss detection and blocking (60FL)
- Directional inverse and definite time phase overcurrent (67)
- Directional inverse and definite time neutral overcurrent (67N)
- Reconnect enable (79)
- Over/Underfrequency (81 O/U)

Optional Functions

- Dual–zone phase distance protection for phase fault backup (21)
- Out of Step (78)
- Rate of change of frequency (81R)

Standard Features

- Eight programmable outputs and six programmable inputs
- Oscillograph recording
- 32-target storage
- Metering of all measured parameters
- Three communications ports (two RS-232, one RS-485)
- Standard 19" rack-mount design
- Removable printed circuit board and power supply
- Both 50 and 60 Hz models available
- Both 1 and 5 Amp rated CT inputs available
- M-3822 IPScom® Communications Software
- IRIG-B time synchronization

Optional Features

- Redundant power supply
- M-3915 Target Module
- M-3931 Human-Machine Interface Module
- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software
- 4-Wire RS-485 Connection

STANDARD FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Sync Check				
25	Phase Angle Window	0° to 90°	1°	±1°
	Upper Voltage Limit	60 to 140 V	1 V	±0.5 V or ±0.5%
	Lower Voltage Limit	40 to 120 V	1 V	±0.5 V or ±0.5%
	Delta Voltage Limit	1.0 to 50.0 V	0.1 V	±0.5 V
	Delta Frequency Limit	0.001 to 0.500 Hz	0.001 Hz	±0.0007 Hz or 5%
	Sync Check Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
	Dead Voltage Limit	0 to 60 V	1 V	±0.5 V
	Dead Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

Sync Check may be operated as a stand-alone function or supervised by 79 (reconnect). Various combinations of input supervised hot/dead closing schemes may be selected.

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Undervoltage				
27	Pickup #1, #2	5 to 180 V	1 V	±0.5 V or ±0.5% ±0.8 V or ±0.75%*
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

* When line-ground to line-line is selected.

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Neutral Undervoltage				
27G	Magnitude	5 to 180 V	1 V	±0.5 V or ±0.5%
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Reverse/Forward Power				
32	Pickup #1, #2	-3.000 to +3.000 PU	0.001 PU	±0.002 PU or 2%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	+16 Cycles or ±1%

The per-unit pickup is based on nominal VT secondary voltage and nominal CT secondary current settings. Single phase detection may be selected for line-to-ground connected VTs. This function can be selected as either overpower or underpower in the forward direction (positive setting) or reverse direction (negative setting).

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Negative Sequence Overcurrent				
46	**Definite Time** Pickup	0.10 to 20.00 A (0.02 to 4.00 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to + 3 Cycles or ±3%
	Inverse Time Pickup	0.50 to 5.00 A (0.10 to 1.00 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curves	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
Negative Sequence Overvoltage				
47	Pickup #1, #2	5 to 180 V	1 V	±0.5 V or ±0.5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

[†]Select the greater of these accuracy values. Values in parentheses apply to 1 Amp CT secondary rating.

STANDARD FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Instantaneous Phase Overcurrent			
50	Pickup	1.0 to 240.0 A (0.2 to 48.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	2 Cycles	—	±2 Cycles
	Instantaneous Neutral Overcurrent			
50G	Pickup	0.5 to 240.0 A (0.1 to 48.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	2 Cycles	—	±2 Cycles

The 50G can be supervised by the ground directional element (if 67N option is selected).

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Inverse Time Neutral Overcurrent			
51G	Pickup	0.25 to 12.00 A (0.05 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%

The 51G can be supervised by the ground directional element.

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Inverse Time Overcurrent, with Voltage Control or Voltage Restraint			
51V	Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%
	Voltage Control (VC) or Voltage Restraint (VR)	5 to 180 V Linear Restraint	1 V —	±0.5 V or ±5% —
	Overvoltage			
59	Pickup #1, #2	5 to 180 V	1 V	±0.5 V or ±0.5% ±0.8 V or ±0.75%*
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

* When line-ground to line-line is selected.

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Neutral Overvoltage			
59G	Pickup	5 to 180 V	1 V	±0.5 V or ±0.5%
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
	Peak Overvoltage			
59I	Magnitude	1.05 to 1.50 PU	0.01 PU	±0.03 PU*
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

Instantaneous voltage magnitude response; intended for ferroresonance protection.

*For fundamental (60 Hz/50 Hz) signal only. For distorted input signals, the accuracy degrades as the order of the harmonic signal increases. The accuracy applies to voltages below 180 V.

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†Select the greater of these accuracy values. Values in parentheses apply to 1 Amp CT secondary rating.

STANDARD FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
	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. VT fuse loss output can be initiated from internally generated logic or from input contacts.			
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
	Phase Directional Overcurrent			
	Definite Time*			
	Pickup	1.0 to 240.0 A (0.2 to 48.0 A)	0.1 A	±0.1 A or 3% (±0.02 A or 3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
(67)	**Inverse Time** Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%
	Phase Directional Element Maximum Sensitivity (Torque) Angle (MSA)	0° to 359°	1°	

High speed operation results when delay programmed for one cycle; response time = less than 1–1/2 cycles.

Directional sensing for 67DT or 67IT may be disabled. Sensitivity at MSA is 0.5 VA, uses Positive Sequence Voltage and current for polarization, prefault memory 8 cycles.

Device Number	Function	Setpoint Ranges	Increment	Accuracy[†]
	Residual Directional Overcurrent			
	Definite Time*			
	Pickup	0.5 to 240.0 A (0.1 to 48.0 A)	0.1 A	± 0.1 A or 3% (±0.02 A or ±3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
(67N)	**Inverse Time*** Pickup	0.25 to 12.00 A (0.05 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC Curves)	0.1 0.01	±3 Cycles or ±5%
	Ground Directional Element Max. Sensitivity Angle (MSA)	0 to 359°	1°	
	Polarization**	1 to 5	1	

Directional control for 67NDT or 67NIT may be disabled.

** *Polarization can be zero sequence, negative sequence, current (polarized) or dual polarized. Polarizations 1, 3 and 5 shall not be used with L-L and L-G to L-L VT selection. When using polarizations 4 or 5, MSA is not applicable and should be set to zero.*

[†]Select the greater of these accuracy values. Values in parentheses apply to 1 Amp CT secondary rating.

STANDARD FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Reconnect Enable Time Delay			
(79)	Reconnect Delay	2 to 65500 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

Reconnect timer starts when all outputs designated as trip outputs dropout.

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Frequency			
(81)	Pickup #1, #2, #3, #4	50.00 to 67.00 Hz 40.00 to 57.00 Hz*	0.01 Hz	±0.02 Hz
	Time Delay #1,#2, #3, #4	2 to 65,500 Cycles	1 Cycle	−2 to +3 Cycles or ±1%

The pickup accuracy applies to 60 Hz models at a range of 57 to 63 Hz, and to 50 Hz models at a range of 47 to 53 Hz. Beyond these ranges, the accuracy is ±0.1 Hz.

*This range applies to 50 Hz nominal frequency models.

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†Select the greater of these accuracy values. Values in parentheses apply to 1 Amp CT secondary rating.

OPTIONAL FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Phase Distance (dual–zone mho characteristic)			
21	Circle Diameter #1, #2	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω	±0.1 Ω or ±5% (±0.5 Ω or ±5%)
	Offset #1, #2	−100.0 to 100.0 Ω (−500.0 to 500.0 Ω)	0.1 Ω	±0.1 Ω or ±5% (±0.5 Ω or ±5%)
	Impedance Angle #1, #2	0° to 90°	1°	±1°
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%
	Out of Step (mho characteristic)			
78	Circle Diameter	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Offset	−100.0 to 100.0 Ω (−500.0 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Impedance Angle	0° to 90°	1°	±1°
	Blinder	0.1 to 50.0 Ω (0.5 to 250.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Trip on mho Exit	Enable/Disable		
	Pole Slip Counter	1 to 20	1	
	Pole Slip Reset	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Rate of Change of Frequency			
81R	Pickup #1, #2	0.10 to 20.00 Hz/Sec	0.01 Hz/Sec	±0.05 Hz/Sec or ±5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	+20 Cycles
	Negative Sequence Voltage Inhibit	0 to 99%	1%	±0.5%
	Nominal Settings			
	Nominal Voltage	60 to 140 V	1 V	—
	Nominal Current	0.5 to 6.00 A	0.01 A	—
	VT Configuration	Line-Line Line-Ground Line-Ground to Line-Line*		
	Seal-In Delay	2 to 8160 Cycles	1 Cycle	−1 to +3 Cycles or ±1%

*When line-ground to line-line is selected, the relay internally calculates the line-line voltage from the line-ground voltages for all voltage-sensitive functions. This line-ground to line-line selection should only be used to a VT nominal secondary voltage of 69 V (not 120 V).

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†Select the greater of these accuracy values. Values in parentheses apply to 1 Amp CT secondary rating.

Configuration Options

The M-3520 Intertie Protection Relay can be purchased with standard protective functions or as a base system with reduced functionality. The user can also select optional protective functions as required to expand the functionality of the Standard Protection System or Base System to satisfy specific application needs. The optional Human-Machine Interface (HMI) Module, Target Module, and redundant power supply are available for either configuration.

Metering

The relay provides metering of voltages (phase, neutral and sequence quantities), currents (phase, neutral and sequence quantities), real power, reactive power, power factor and impedance measurements.

Metering Accuracies are:

Voltage: ± 0.5 V or ± 0.5%, whichever is greater
         ±0.8 V or ±0.75%, whichever is greater (when line-ground to line-line is selected)

Current: 5 A rating, ± 0.1 A or ± 3%, whichever is greater
         1 A rating, ± 0.02 A or ± 3%, whichever is greater

Power   ± 0.01 PU or ± 2%, whichever is greater
(real and reactive)

Frequency: ± 0.02 Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models)

Oscillographic Recorder

The oscillograph recorder provides comprehensive data recording of all monitored waveforms, storing up to 170 cycles of data. The total record length may be user-configured for 1, 2, 3 or 4 partitions. The sampling rate is 16 times the power system nominal frequency (50 or 60 Hz). The recorder is triggered either via the designated status inputs, trip outputs, or via serial communications. When untriggered, the recorder continuously stores waveform data, keeping the most recent data in memory. When triggered, the recorder stores pre-trigger data, then continues to store data in memory for a user-defined, post-trigger delay period.

Target Storage

A total of 32 targets can be stored. Recorded information includes the type of function(s) operated, the functions picked up, input/output contact status, timer status, and phase and neutral currents at the time of trip.

Calculations

Current and Voltage Values: Uses discrete Fourier transform algorithm on sampled (16 times per cycle) voltage and current signals to extract fundamental frequency phasors for calculations.

Power Input Options

Nominal 110/120/230/240 V ac, 50/60 Hz, or nominal 110/125/220/250 V dc. Operates properly from 85 V ac to 265 V ac and from 80 V dc to 288 V dc; Withstands 300 V ac or 300 V dc for 1 second; Burden 20 VA at 120 V ac/125 V dc.

Nominal 24/48 V dc. Operates properly from 18 V dc to 56 V dc; Withstands 65 V dc for 1 second; Burden 25 VA at 24 V dc and 30 VA at 48 V dc.

Unit is available with an optional redundant power supply.

Sensing Inputs

Five Voltage Inputs: Rated nominal voltage of 60 V ac to 140 V ac, 60 Hz (50 Hz optional). Withstands 240 V continuous voltage and 360 V for 10 seconds. Source voltages may be line-to-ground or line-to-line connected. Phase sequence ABC/ACB is selectable. Voltage transformer burden less than 0.2 VA at 120 V ac.

Four Current Inputs: Rated current (I_R) of 5.0 A or 1.0 A (optional), 60 Hz (50 Hz optional). Withstands 2 I_R continuous current and 100 I_R for 1 second. Current transformer burden is less than 0.5 VA at 5 A (5 A option), or 0.3 VA at 1 A (1 A option).

Control/Status Inputs

The control/status inputs, INPUT1 through INPUT6, can be programmed to block any of the relay functions, trigger the oscillographic recorder or operate one or more outputs. The control/status inputs are designed to be connected to dry contacts and are internally wetted with a 24 V dc power supply. To provide breaker status LED indication on the front panel, the INPUT1 control/status input contact should be connected to the 52b breaker status contact.

Output Contacts

The eight programmable output contacts (six form 'a' and two form 'c'), the power supply alarm output contact (form 'b'), and the self-test alarm output contact (form 'c') are all rated as per ANSI/IEEE C37.90-1989 for tripping: make 30 A for 0.2 seconds, carry 8 A, break 6 A @ 120 V ac, break 0.1 A @ 125 V dc, inductive break 0.1 A.

Any of the relay functions can be individually programmed to activate any one or more of the eight programmable output contacts.

Target/Status Indicators and Controls

The **RELAY OK** LED reveals proper cycling of the microcomputer. The **BRKR CLOSED** LED illuminates when the breaker is closed (when the 52b contact is open). The **OSC TRIG** LED indicates that oscillographic data has been recorded in the unit's memory. The corresponding **TARGETS** LED will illuminate when any of the relay functions trip. Pressing and releasing the **TARGET RESET** pushbutton resets the **TARGET** LED if the conditions causing the operation have been removed. Pressing and holding the **TARGET RESET** pushbutton will allow elements or funcitons in pickup to be displayed. The **PS1** and **PS2** LEDs remain illuminated as long as power is applied to the unit and the power supply is operating properly. The **TIME SYNC** LED will illuminate when a valid IRIG-B signal is applied, and time synchronization has been established.

Communication

Communications ports include rear panel RS-232 and RS-485 ports, a front panel RS-232 port, and an IRIG-B port. The communications protocol implements serial, byte-oriented, asynchronous communication, and provides the following functions when used with the Microsoft® Windows™ compatible M-3822 IPScom® Communications Software package. MODBUS and BECO 2200 protocols are supported using:

- Setpoint interrogation and modification
- Time-stamped trip target information for the 32 most recent events
- Real time metering of all quantities measured
- Downloading of recorded oscillographic data (not available with MODBUS protocol)

IRIG-B

The relay can accept either modulated or demodulated IRIG-B time clock synchronization signal. The IRIG-B time synchronization information is used to correct the hour, minutes, seconds and milliseconds information.

Human-Machine Interface (HMI) Module (optional)

Local access to the relay is provided through an optional M-3931 HMI Module, allowing for easy to use, menu-driven access to all functions via a 6-button keyboard and a 2-line by 24 character alphanumeric display. Features of the HMI Module include the following:

- User-definable access codes providing three levels of security
- Interrogation and modification of setpoints
- Time-stamped trip target information for the 32 most recent events
- Real-time metering of all quantities measured

Target Module (optional)

An optional M-3915 Target Module provides 24 target and 8 output LEDs. Appropriate **TARGET** LEDs illuminate when the corresponding function trips. The targets can be reset with the **TARGET RESET** pushbutton if the trip conditions have been removed. The **OUTPUT** LEDs indicate the status of the programmable output contacts. The module connects to the M-3520 Intertie Protection unit.

Type Tests and Standards

M-3520 Intertie Protection Relay complies with the following tests and standards:

Voltage Withstand

Dielectric Withstand

IEC 255-5   3,500 V dc for 1 minute applied to each independent circuit to earth
3,500 V dc for 1 minute applied between each independent circuit
1,500 V dc for 1 minute applied to IRIG-B circuit to earth
1,500 V dc for 1 minute applied between IRIG-B to each independent circuit
1,500 V dc for 1 minute applied to RS-485 circuit (2-wire) to earth
1,500 V dc for 1 minute applied to RS-485 circuit (2-wire) to each independent circuit

Impulse Voltage

IEC 255-5   5,000 V pk, +/- polarity applied to each independent circuit to earth
5,000 V pk, +/- polarity applied between each independent circuit
1.2 X 50 μs, 500 Ohms impedance, three surges at 5 second intervals

Insulation Resistance

IEC 255-5   > 40 MegaOhms

Electrical Environment

Electrostatic Discharge Test

IEC 1000-4-2   Class 4 (8 kV) – point contact discharge

Fast Transient Disturbance Tests

IEC 1000-4-4   Class 4 (4 kV, 2.5 kHz)

Surge Withstand Capability

ANSI/IEEE   2,500 V pk-pk Oscillatory applied to each independent circuit to earth
C37.90.1   2,500 V pk-pk Oscillatory applied between each independent circuit
1989   5,000 V pk Fast Transient applied to each independent circuit to earth
5,000 V pk Fast Transient applied between each independent circuit

Radiated Susceptibility

ANSI/IEEE   25–1000 MHz @ 35 V/m
C37.90.2
1987

Output Contacts

ANSI/IEEE   Make 30 A for 0.2 seconds off for 15 seconds for 2,000 operations
C37.90.0

Atmospheric Environment

Temperature

IEC 68-2-1   Cold, –20° C for 96 hours
IEC 6-2-2   Dry Heat, +70° C for 96 hours
IEC 68-2-3   Damp Heat, +40° C @ 93% RH, for 96 hours

Mechanical Environment

Vibration

IEC 255-21-1   Vibration response Class 1, 0.5 g
                 Vibration endurance Class 1, 1.0 g

Compliance

UL Listed per 508 – Industrial Control Equipment.

CSA Certified per C22.2 No. 14-95-Industrial Control Equipment.

External Connections

External connection points and connection information are illustrated in Figures 1, 2, and 3, on the following pages.

Physical

Size: 19.00" wide x 5.21" high x 10.20" deep (48.3 cm x 13.2 cm x 25.9 cm)

Mounting: The unit is a standard 19", semiflush, 3-unit high, rack-mount panel design, conforming to ANSI/ EIA RS-310C and DIN 41494, Part 5 specifications. Vertical mounting is also available.

Contact Beckwith Electric for optional GE L-2/Westinghouse FT-41 retrofit panel vertical mounting details.

Approximate Weight: 17 lbs (7.7 kg)

Approximate Shipping Weight: 25 lbs (11.3 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.

See M-3520 Instruction Book, Appendix E, Layup and Storage for additional information.

Patent & Warranty

The M-3520 Intertie Protection Relay is covered by U.S. Patents 5,592,393 and 5,224,011.
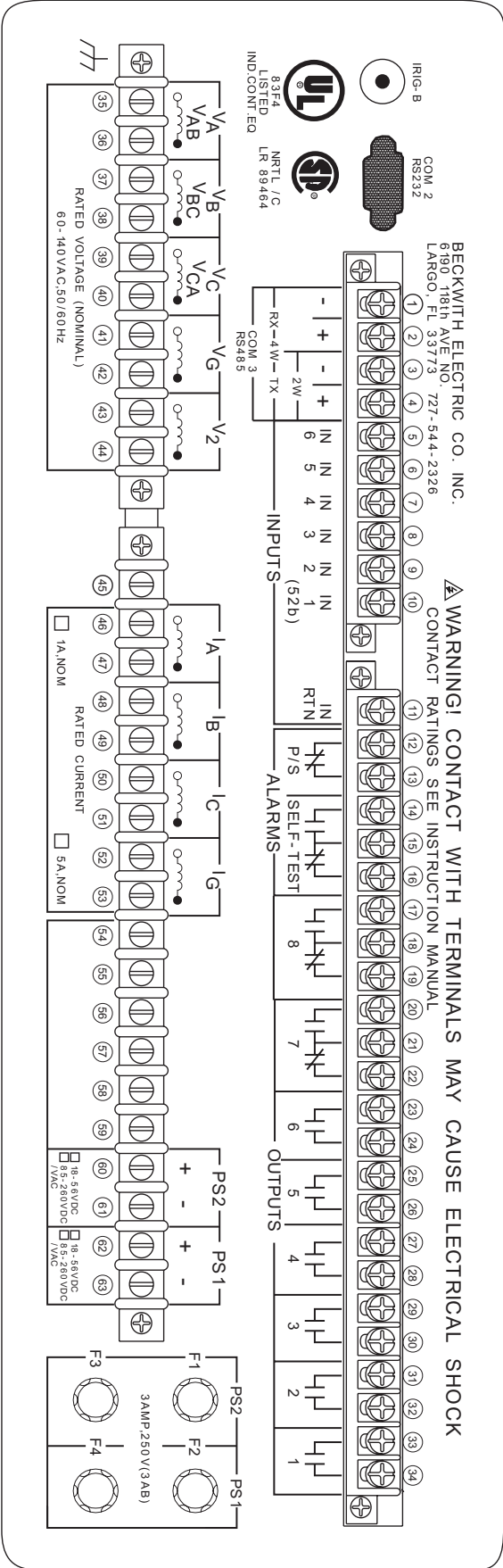
The M-3520 Intertie Protection Relay is covered by a five year warranty from date of shipment.

Specification subject to change without notice.

Figure 1 External Connections

■ **NOTES:**

1. Output contacts #1 through #4 contain special circuitry for high-speed operation, and close 4 ms faster than outputs #5 through #8. Outputs #1 through #6 are form "a" contacts (normally open), and Outputs #7 and #8 are form "c" contacts (center tapped "a" and "b" contacts).

2. To comply with UL and CSA listing requirements, terminal block connections must be made with #12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector. Wire insulation must be rated at 60°C minimum. Terminal block connections 1 through 34 must be tightened to 12 inch-pounds torque. Terminal block connections 35 through 63 must be tightened to 8 inch-pounds torque.

3. ONLY dry contacts must be connected to inputs (terminals 5 through 10 with 11 common) because these contact inputs are internally wetted. **Application of external voltage on these inputs may result in damage to the unit.**

4. All relays are shown in the de-energized state, and without power applied to the relay.

5. The power supply relay (P/S) is energized when the power supply is functioning properly.

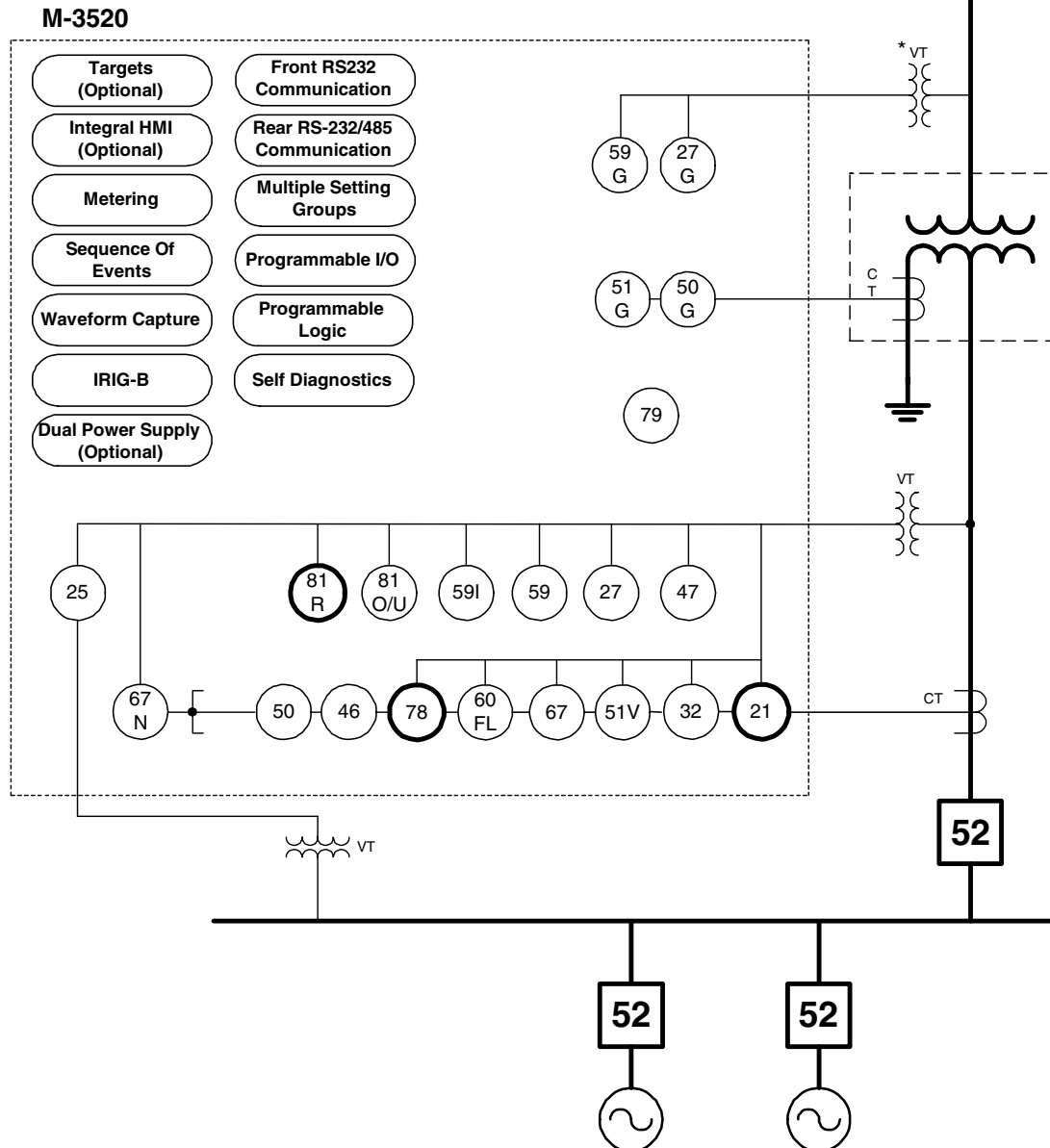6. The self-test relay is energized when the relay has performed all self-tests successfully.

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**M-3520
Typical
Connection Diagram**

This function is available as a standard protective function.

This function is available as a optional protective function.

Note: M-3520 may be purchased as a base protection system with 59, 27, 81O/U,79 and 60FL functions only.

**Utility
System**

M-3520

Targets (Optional)	Front RS232 Communication
Integral HMI (Optional)	Rear RS-232/485 Communication
Metering	Multiple Setting Groups
Sequence Of Events	Programmable I/O
Waveform Capture	Programmable Logic
IRIG-B	Self Diagnostics
Dual Power Supply (Optional)	

59 G   27 G

51 G   50 G

79

25   81 R   81 O/U   59I   59   27   47

67 N   50   46   78   60 FL   67   51V   32   21

52

52   52

■ **NOTE**: *Voltage Transformer (VT) connection may be either broken delta or single, line to ground VT depending on application (for ungrounded system).

Figure 2   Typical One-Line Connection Diagram

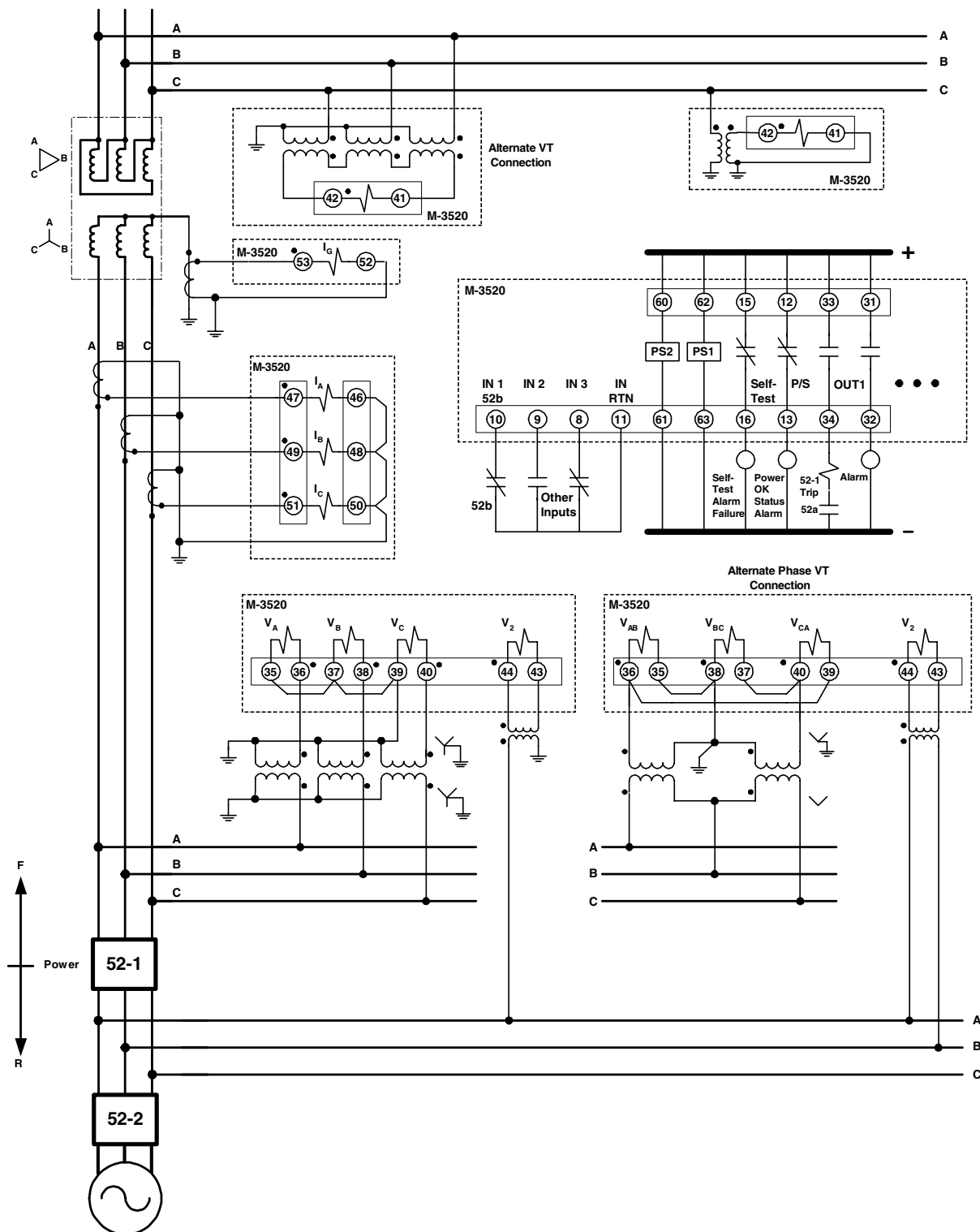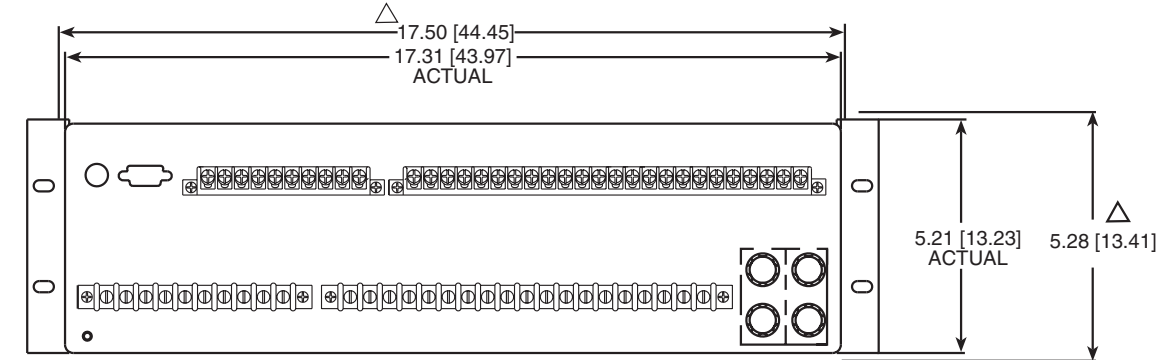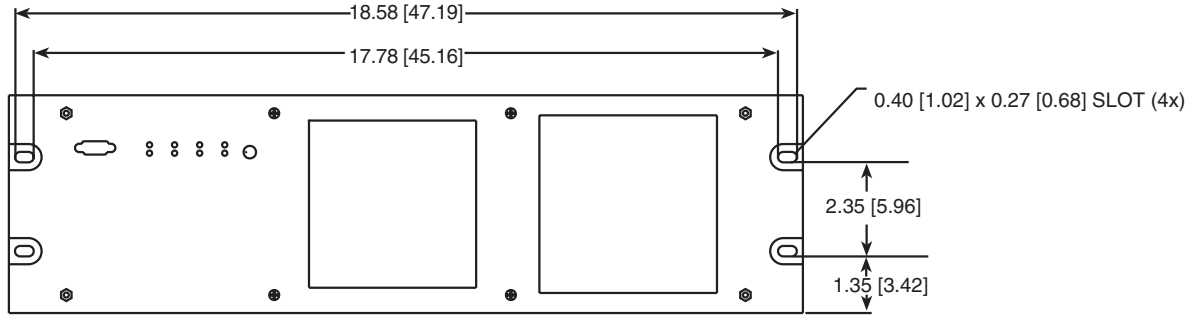## M-3520 Typical Three-line Connection Diagram

Figure 3   Typical Three–Line Connection Diagram

△ 17.50 [44.45]

17.31 [43.97]
ACTUAL

5.21 [13.23]
ACTUAL

△ 5.28 [13.41]

Rear View

△ RECOMMENDED CUTOUT WHEN RELAY IS
NOT USED AS STANDARD RACK MOUNT

10.20 [25.91]

19.00
[48.26]

18.58 [47.19]

17.78 [45.16]

0.40 [1.02] x 0.27 [0.68] SLOT (4x)

2.35 [5.96]

1.35 [3.42]

Standard 19" Horizontal Mount Chassis

■ **NOTE**: Dimensions in brackets are in centimeters.

Figure 4   Horizontal Mounting Dimensions
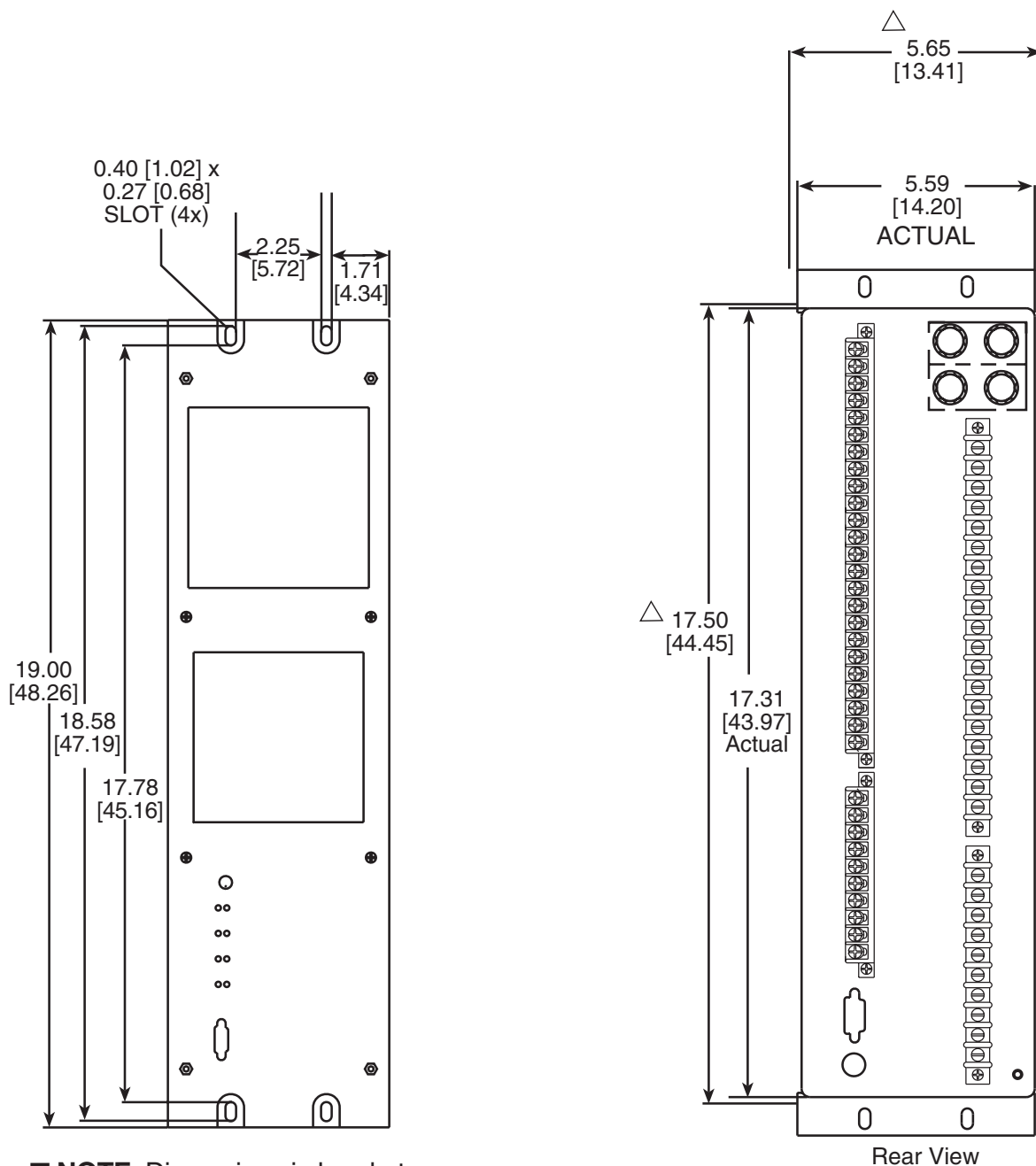
0.40 [1.02] x
0.27 [0.68]
SLOT (4x)

2.25 [5.72]   1.71 [4.34]

△ 5.65 [13.41]

5.59 [14.20]
ACTUAL

19.00 [48.26]

18.58 [47.19]

17.78 [45.16]

△ 17.50 [44.45]

17.31 [43.97] Actual

■ **NOTE**: Dimensions in brackets are in centimeters.

Rear View

△ RECOMMENDED CUTOUT WHEN RELAY IS NOT USED AS STANDARD RACK MOUNT

Optional Vertical Mount Chassis

Figure 5   Vertical Mounting Dimensions

800-3520-SP-14   10-07

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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Instruction Book

Chapter 6   Testing

Appendices

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Figures (cont'd)   **Page**

Figures (cont'd) **Page**

Tables (*cont.*)   **Page**

1 Introduction

1.1   Instruction Book Contents

This instruction book is divided into six major chapters and four appendices.

Chapter 1: Introduction

Chapter one contains a brief description of the six chapters and four appendices contained in this handbook. It enumerates the functional capabilities of the M-3520 Intertie Protection Relay and provides a list (see Table 1-1) of device functions. This chapter also describes the accessories that may be used in conjunction with application of the protective relay.

Chapter 2: Application

Chapter two contains specific information for the person or group responsible for the application of the relay. The information provided includes functional diagrams, connection diagrams for typical applications, instructions on configuration of the unit (enabling required functions), and output contact assignments/input blocking designation. This chapter also illustrates the definition of system quantities and required equipment characteristics, describes the individual function settings and oscillograph recorder setup.

Chapter 3: Operation (Front Panel)

This chapter is designed for the person or group responsible for the operation and direct setting and configuration of the relay, and is limited to installations using the HMI (Human-Machine Interface) Module. This chapter includes an introduction to the front panel controls, the function and operation of the keypad, the characteristics of the display, indicators, Target Module, and the communication ports. It further describes the procedures for entering all required data to the M-3520.

Also included in this chapter is a description of the operation of the monitoring status and metering quantities, and of viewing the target history. This chapter references appropriate forms for recording and communicating the described data to the parties responsible for operation and installation of the relay

Chapter 4: Operation (Computer)

This chapter provides information for the person or group responsible for the operation and direct setting and configuration of the relay via personal computer, using the IPScom® M-3822 Communications Software package. It includes installation, setup information, and procedures for entering all data required to operate the relay. Specific descriptions of the monitoring functions, status and metering quantities are also provided.

Chapter 5: Installation

This chapter provides all the mechanical information, including dimensions, external connections and equipment ratings required for physical installation of the relay. For reference, the Three-Line Connection Diagram is repeated from Chapter 2. A commissioning checkout procedure is outlined, using the HMI option and IPScom to check the external CT and VT connections. Other tests, which may be desirable at time of installation, are described in Chapter 6.

Chapter 6: Testing

This chapter provides step-by-step test procedures for each M-3520 function as well as the diagnostic mode procedures and the autocalibration procedure using the HMI.

Appendix A: Configuration Record forms

This appendix supplies a set of forms to record and communicate the inputs required for the proper operation of the M-3520, as well as forms illustrating "As Shipped" settings for all functions.

Appendix B: Communications

This appendix describes the communications equipment, the protocol used, the communication ports, and the port signals.

Appendix C: Self-test Error Codes

This appendix lists all the M-3520 error codes and their descriptions.

Appendix D: Inverse Time Curves

This appendix contains graphs of the four standard Inverse Time Curves and the four IEC overcurrent curves.

Appendix E: Layup and Storage

This appendix includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3520 Intertie Protection Relay.

1.2   M-3520 Intertie Protection Relay

The M-3520 Intertie Protection Relay (see Figure 1-1), is a microprocessor-based unit that uses digital signal processing technology to provide protection to the intertie between dispersed storage and generation (DSG) and a utility.

The M-3520 provides 17 standard and 3 optional protective relay functions (see Table 1-1). The nomenclatures of these functions are derived from the standards of ANSI/IEEE C37.2-1991, Standard Electric Power Systems Device Function Numbers.

Six control/status input contacts (located on rear side of unit) can be programmed to block any relay function and/or trigger the oscillograph recorder. Any of the functions or control/status input contacts can be individually programmed to activate one or more of the eight programmable output contacts.

STANDARD FUNCTIONS	DESCRIPTION
25	Sync Check
27	Undervoltage
59G/27G	Neutral Overvoltage/Undervoltage
32	Reverse/Forward Power
46	Negative Sequence Overcurrent
47	Negative Sequence Overvoltage
50	Instantaneous Overcurrent
50G	Instantaneous Neutral Overcurrent
51G	Inverse Time Neutral Overcurrent
51V	Inverse Time Overcurrent, with Voltage Control or Voltage Restraint
59	Overvoltage
59I	Peak Overvoltage
60FL	VT Fuse Loss Detection
67	Phase Directional Overcurrent
67N	Residual Directional Overcurrent
79	Reconnect Enable
81	Over/Under Frequency
OPTIONAL FUNCTIONS	DESCRIPTION
21	Phase Distance
78	Out of Step
81R	Rate of Change of Frequency

Table 1-1   M-3520 Device Functions

With the optional M-3931 Human-Machine Interface Module (HMI), all functions can be set or examined via a local, menu-driven 2-line by 24-character display. The HMI also provides the capability for local metering of various quantities, including phase, neutral, and sequence voltages and currents; power factor, real, reactive, and apparent power measurements, 32 most recent events.

Also included are self-test, self-calibration and diagnostic capabilities.

The function outputs can provide tripping and/or alarm contacts. Light Emitting Diodes (LEDs) are used for the targets to provide visual indication of a function operation. Three serial I/O ports provide remote communication capability.

A switching mode power supply provides the relay with the various power supply voltages required for operation. (A redundant power supply is available as an option.)

The serial interface ports, COM1 and COM2, are standard 9-pin RS-232 DTE-configured communications ports. The front-panel port, COM1, is used to locally set and interrogate the M-3520 via a portable computer. The second RS-232 port, COM2, is provided at the rear of the unit. An isolated RS-485 communication port, COM3, is also available at the relay's rear terminal block. The standard configuration of the RS-485 port is 2-wire, 4-wire must be specified at the time of purchase. Either rear-panel port, COM2 or COM3, can be used to remotely set and interrogate the M-3520 via a modem, network or direct serial connection. Detailed information on the use of the relay communications ports is provided in Appendix B, Communications, as well as Chapter 4, **Operation (Computer)**.

The unit provides up to 170 cycles of waveform data storage assignable to up to 4 events with selectable post-trigger delay. Once downloaded, the data can be analyzed using the optional M-3801D IPSplot® *PLUS* Oscillograph Analysis Software package.
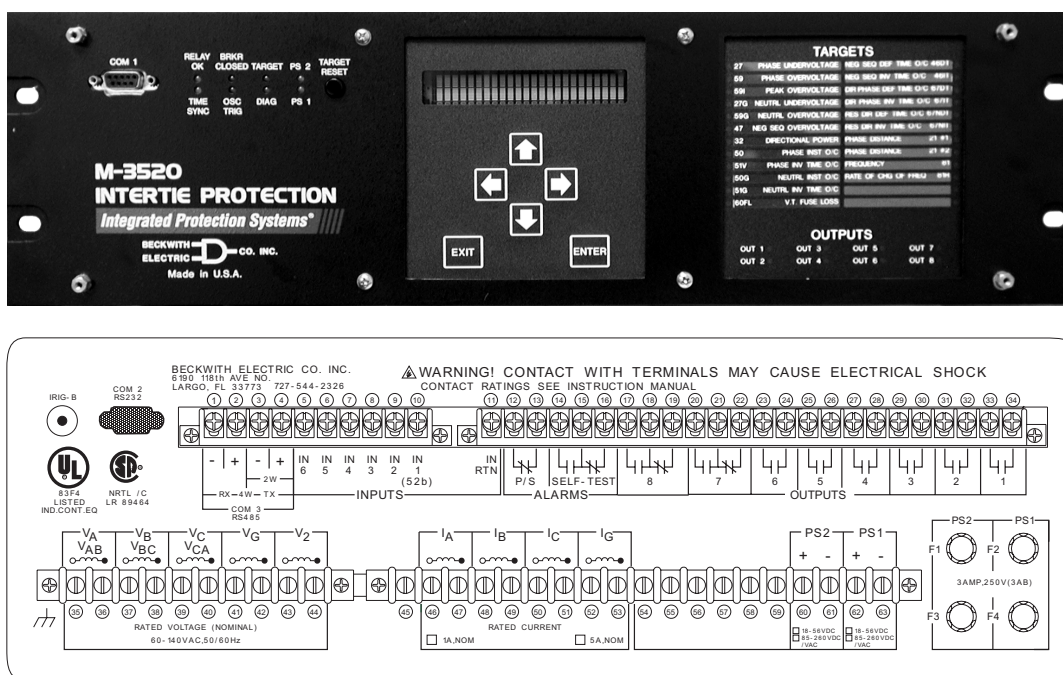
Figure 1-1   M-3520 Front and Rear Panels

1.3   Accessories

A copy of IPScom® communication software is shipped with each M-3520 Intertie Protection Relay. IPScom software will operate on an IBM PC-compatible computer running under Windows 95 or higher, providing remote access to the relay via either direct serial connection or modem. IPScom provides the following communication functions:

- Setpoint interrogation and modification
- Real-time metering and I/O status monitoring
- Stored target interrogation
- Recorded oscillograph data downloading
- Real time Phasor display

M-3915 Target Module

The optional target module shown in Figure 1-2 includes 24 individually labeled **TARGET** LEDs (Light Emitting Diodes) to target the operation of the functions on the front panel. Eight individually labeled **OUTPUT** LEDs will be lit as long as any output is picked up.

TARGETS

OUTPUTS

OUT 1 ○   OUT 3 ○   OUT 5 ○   OUT 7 ○

OUT 2 ○   OUT 4 ○   OUT 6 ○   OUT 8 ○
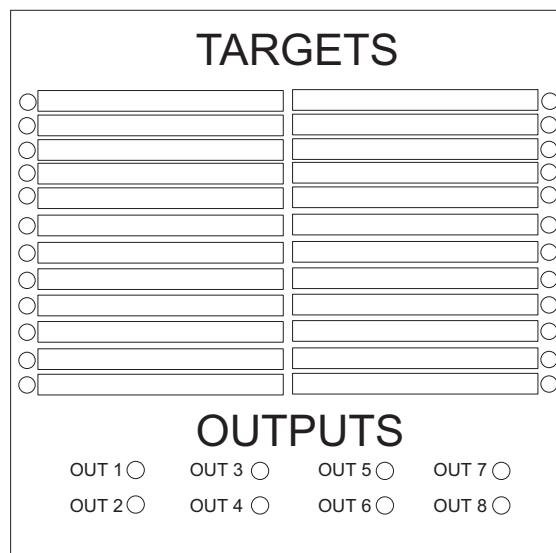
Figure 1-2   M-3915 Target Module

M-3931 Human-Machine Interface (HMI)

The optional HMI module, shown in Figure 1-3, provides a means to interrogate the M-3520 and to input settings, access data, etc. directly from the front of the relay. Operation of the HMI module is described in detail in Section 3.1, Front Panel Controls.
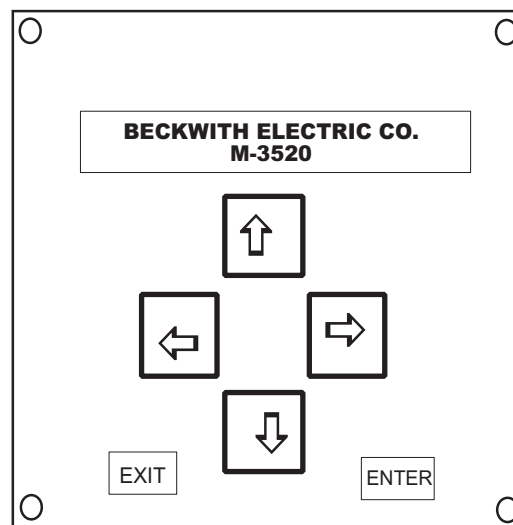
Figure 1-3   M-3931 Human-Machine Interface Module

M-3801D IPSplot® *PLUS* Oscillograph Analysis Software Package

The IPSplot *PLUS* Oscillograph Analysis Software runs in conjunction with IPScom software package on any IBM PC-compatible computer running Windows 95 or higher, to enable the plotting, analysis, and printing of waveform data downloaded from the M-3520 Intertie Protection Relay.

M-3933/M-0423 Serial Communications Cable

The M-3933 cable is a 10-foot RS-232 cable for use between the relay's rear-panel (COM2) port and a modem. This cable has a DB25 (25-pin) connector (modem) and a DB9 (9-pin) at the M-3520 end.

The M-0423 cable is a 10-foot null-modem RS-232 cable for direct connection between a PC and the relay's front-panel COM1 port or the rear COM2 port. This cable has DB9 (9-pin) connectors at each end.

M-3934 Redundant Low Voltage Power Supply

Redundant 24/48 VDC supply.

M-3935 Redundant High Voltage Power Supply

Redundant 110/250 VDC supply.

2 Application

2.1   Introduction

This chapter provides information for the person or group responsible for the application of the M-3520 Intertie Protection Relay. Individual relay functions can be programmed to activate any combination of eight output contacts (OUT1–8). Similarly, any relay function can be programmed to be blocked by any of six control/status inputs (IN1–6) or the internally generated VT Fuse Loss Status. The relay provides programmable setpoints for each relay function. Some relay functions provide two or more elements, each with a magnitude setting and associated time delay. Also, the relay includes the ability to use different I/O assignments for each element, if desired.

This chapter is designed to assist in the application aspects of the Intertie Protection system. Detailed information on the relay functions, configuration, setpoints, functional logic schemes, and oscillograph recorder is provided.

This chapter also specifies appropriate forms for recording and communicating the input settings to the parties responsible for operation and installation of the relay.

2.2   System Diagrams

**M-3520
Typical
Connection Diagram**

This function is available as a standard protective function.

This function is available as a optional protective function.

Note: M-3520 may be purchased as a base protection system with 59, 27, 81O/U,79 and 60FL functions only.

Utility System

M-3520

Targets (Optional)	Front RS232 Communication
Integral HMI (Optional)	Rear RS-232/485 Communication
Metering	Multiple Setting Groups
Sequence Of Events	Programmable I/O
Waveform Capture	Programmable Logic
IRIG-B	Self Diagnostics
Dual Power Supply (Optional)	

59 G   27 G

51 G   50 G

79

25

81 R   81 O/U   59I   59   27   47

67 N   50   46   78   60 FL   67   51V   32   21

52

52   52
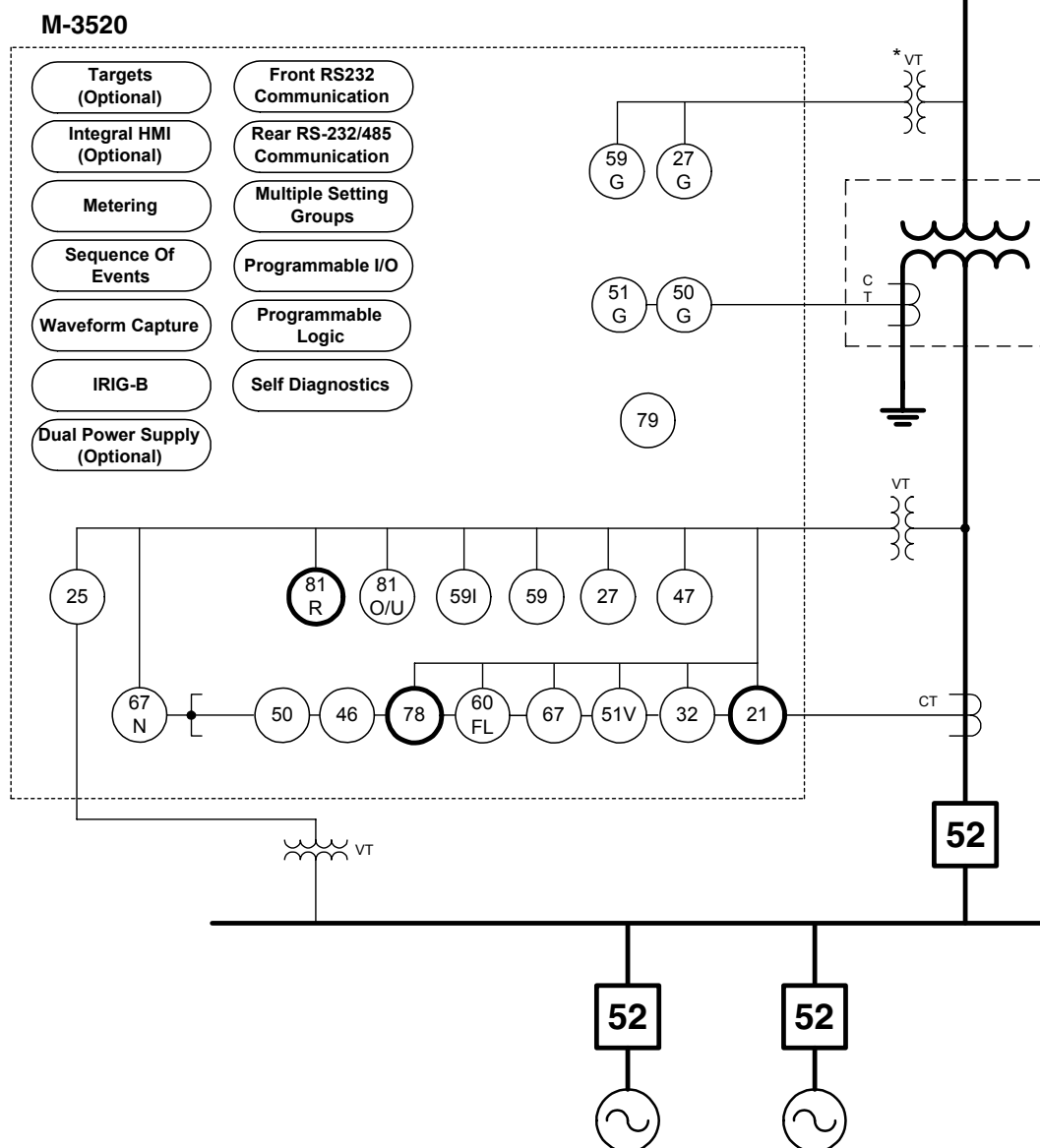
Figure 2-1   One-Line Functional Diagram

M-3520 Typical Three-line
Connection Diagram
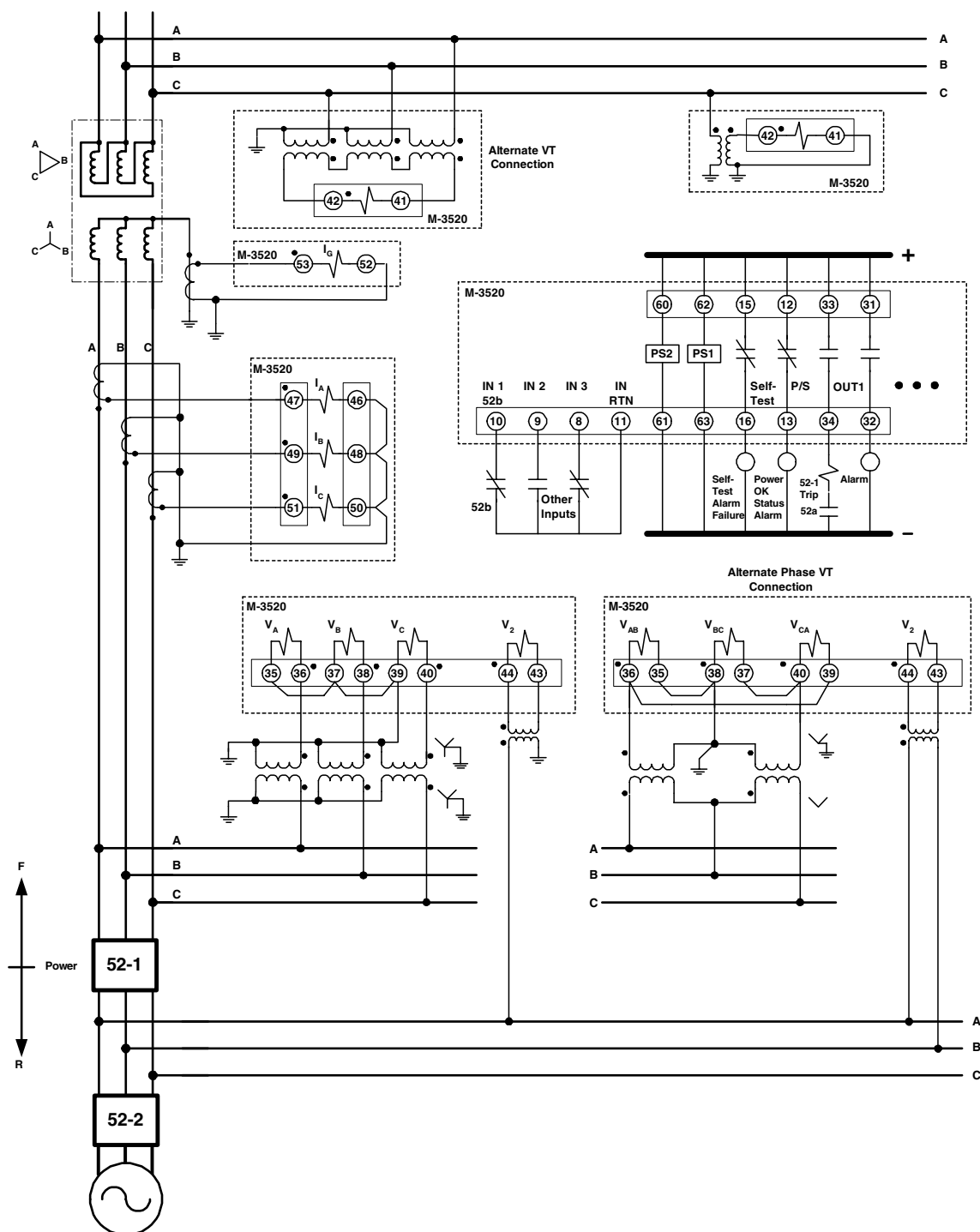
Figure 2-2 Three Line Connection Diagram

■ **NOTE:** Additional inputs and outputs can be selected by user.

2.3   Configuration

Functions

Configuring the M-3520 Intertie Protection Relay consists of enabling the relay functions to be used in a particular application. Once the output contacts (OUT1–8) are designated, each function will be receptive, according to the status inputs designated (IN1–6) to block the function.

Status inputs may also initiate other actions, such as triggering the Oscillograph Recorder. The status inputs and output contacts need to be chosen *before* configuring the individual functions. Both can be recorded on the **Relay Configuration Table** in Appendix A.

■ **NOTE:** At least one relay output must be selected to enable a function, otherwise the function is disabled.

Special Input/Output Considerations

Status input IN1 is preassigned to be the 52b breaker contact. The FL blocking input represents the internally generated fuse loss status.

Outputs 1–6 are form "a" contacts (normally open) and outputs 7 and 8 are form "c" contacts (center tapped "a" and "b" contacts).

Outputs 1–4 contain special circuitry which allow them to operate slightly faster than the other outputs.

Each output may be programmed for pulse operation. The seal-in time delay setting for the particular relay output determines the length of time that relay is energized when programmed for pulse operation.

■ **NOTE**: Output 8 has been especially designed to be used as the Reconnect output. Any protective function assigned to this output will not display a target LED if it operates.

```
27 #1 PHASE UNDERVOLTAGE
disable ENABLE
```

```
27 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
27 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

The following functions can be configured using enable/disable output, and status input blocking designations:

   +   21 Phase Distance zone #1, zone #2
   •   25 Sync Check
   •   27 Undervoltage #1, #2
   •   27G Neutral Undervoltage
   •   32 Reverse/Forward Power #1, #2
   •   46 Negative Sequence Overcurrent, Def, Inv
   •   47 Negative Sequence Overvoltage #1, #2
   •   50 Instantaneous Phase Overcurrent
   •   50G Instantaneous Neutral Overcurrent
   •   51G Inverse Time Neutral Overcurrent
   •   51V Inverse Time Overcurrent with Voltage Control or Voltage Restraint
   •   59 Overvoltage #1, #2
   •   59I Peak Overvoltage
   •   59G Neutral Overvoltage
   •   60FL VT Fuse Loss
   •   67 Phase Directional Overcurrent, Definite Time and Inverse Time
   •   67N Residual Directional Overcurrent, Definite and Inverse Time
   +   78 Out of Step
   •   79 Reconnect Enable
   •   81 Frequency: #1,#2, #3, #4
   +   81R Rate of Change of Frequency #1, #2

"•" denotes Standard function, "+" denotes Optional function

This designation is required for each relay function. After enabling the function the user is presented with the following two screens.

This screen assigns the blocking designations (up to six) for the enabled function. "OR" logic is used if more than one input is selected. If the "FL" is designated, the function will be blocked by the internally generated fuse loss status.

This screen assigns the output contacts (up to eight) for the particular relay function. If no output contacts are assigned, the function will be automatically disabled.

System Setup

The system setup consists of defining common information such as CT and VT ratios, nominal voltage and current ratings, VT configuration, phase rotation, etc. These parameters should be entered before proceeding to the configuration or setpoint and time delay settings for particular functions. The values or selections shown below are only examples. Record and communicate the following information using the Functional Configuration Record Form in Appendix A.

```
╭─────────────────────────────╮
│ NOMINAL VOLTAGE             │
│ _____    volts           │
╰─────────────────────────────╯
```

The secondary VT voltage when primary voltage is equal to the 1 per unit rating.

```
╭─────────────────────────────╮
│ NOMINAL CURRENT             │
│ _____    amps            │
╰─────────────────────────────╯
```

The secondary current of the phase CTs when the primary current is equal to the 1 per unit rating. Nominal voltage and current are used in the per unit power calculation.

```
╭─────────────────────────────╮
│ V.T. CONFIGURATION          │
│ LINE-LINE line-ground →     │
╰─────────────────────────────╯
```
```
╭─────────────────────────────╮
│ V.T. CONFIGURATION          │
│ ← line-gnd_to_line-line     │
╰─────────────────────────────╯
```

Indicates the VT Configuration. When **LINE-GROUND** is selected, functions 27 and 59 may operate for line-ground faults. If this is not desired, the **LINE-GND_TO_LINE-LINE** selection may be used. When **LINE-GND TO LINE-LINE** is selected, the relay internally calculates line-line voltages from line-ground voltages for all voltage-sensitive functions. This Line-Ground to Line-Line selection should be used only for a VT nominal secondary voltage of 69 V (not for 120 V). For this selection, the nominal voltage entered should be line-line nominal voltage, which is $\sqrt{3}$ times line-ground nominal voltage. The V2 connected VT must be configured line-ground if VT CONFIGURATION from above is **LINE-GROUND**. If VT configuration is **LINE-LINE** or **LINE-GND_TO_LINE-LINE**, then V2 must be configured line-line.

```
╭─────────────────────────────╮
│ SYNC-CHECK PHASE            │
│ A b c                       │
╰─────────────────────────────╯
```

Indicates selected phase for sync check (25) function.

```
╭─────────────────────────────╮
│ PHASE ROTATION              │
│ a-c-b A-B-C                 │
╰─────────────────────────────╯
```

Phase Rotation.

```
╭─────────────────────────────╮
│ PULSE RELAY                 │
│ o8 o7 o6 o5 o4 o3 o2 o1     │
╰─────────────────────────────╯
```

Indicates outputs chosen for pulse operation. When selected, output will remain energized for the time delay specified in the **RELAY SEAL-IN TIME** (see below), and then drop out. With pulse operation, the selected relay will drop out after the delay, even if the tripping function remains out of band.

```
╭─────────────────────────────╮
│ RELAY SEAL-IN TIME OUT1     │
│ _____    cycles          │
╰─────────────────────────────╯
```

Minimum time the output contact will remain picked up to ensure proper seal-in, regardless of the subsequent state of the initiating function. Individual Seal-In settings are available for all outputs.

```
ACTIVE INPUT OPEN/close
   i6 i5 i4 I3 i2 i1
```

Selects the active state of the six status inputs. When highlighted (uppercase), the active state is an open circuit. When lowercase, the active state is closed circuit (default)

```
DELTA-Y TRANSFORM
DISABLE enable
```

By enabling the **DELTA-Y TRANSFORM**, the relay will internally consider the 30° phase shift through the delta-wye unit transformer for 51V and 21 functions.

```
V.T. PHASE RATIO
    1.0:1
```

Ratio of the phase VT's

```
V.T. V2 RATIO
    1.0:1
```

Ratio of the V2 VT

```
V.T. NEUTRAL RATIO
    1.0:1
```

Ratio of the neutral VT

```
C.T. PHASE RATIO
    10.1:
```

Ratio of the phase CTs

```
C.T. NEUTRAL RATIO
    10:1
```

Ratio of the neutral CT

2.4   Setpoints and Time Settings

21 Phase Distance

The phase distance function, designed for system phase fault protection, is implemented as a two-zone mho characteristic. Three separate distance elements are implemented to detect AB, BC, and CA fault types. The diameter, offset, system impedance angle (relay characteristic angle), and definite time delay need to be selected for each zone for coordination with the system relaying in the specific application.

When the Dispersed Generation (DG) is connected to the system through a delta/wye transformer, proper voltages and currents (equivalent to the high side of the transformer) must be used in order for the relay to see correct impedances for system faults. By enabling the delta/wye transform feature (see Section 2.2, **System Diagrams**), the relay can internally consider the 30° phase shift through the delta-wye unit transformer, saving auxiliary VT costs.

	Direct-Connected		Delta/Wye Transformer Connected	
	VT Connection		VT Connection	
	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground
AB Fault	$\dfrac{V_{AB}}{I_a - I_b}$	$\dfrac{V_A - V_B}{I_a - I_b}$	$\dfrac{V_{BC} - V_{AB}}{(3)I_b}$	$\dfrac{V_B - V_0}{I_b}$
BC Fault	$\dfrac{V_{BC}}{I_b - I_c}$	$\dfrac{V_B - V_C}{I_b - I_c}$	$\dfrac{V_{CA} - V_{BC}}{(3)I_c}$	$\dfrac{V_C - V_0}{I_c}$
CA Fault	$\dfrac{V_{CA}}{I_c - I_a}$	$\dfrac{V_C - V_A}{I_c - I_a}$	$\dfrac{V_{AB} - V_{CA}}{(3)I_a}$	$\dfrac{V_A - V_0}{I_a}$

Table 2-1   Impedance Calculation
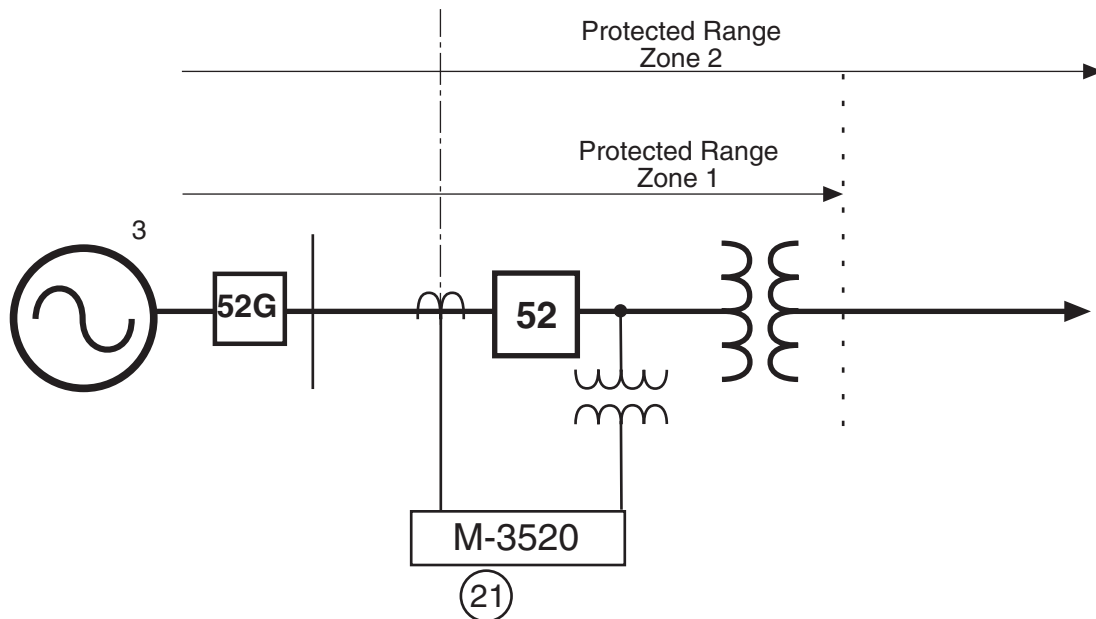
Figure 2-3   Phase Distance (21) Zones of Protection
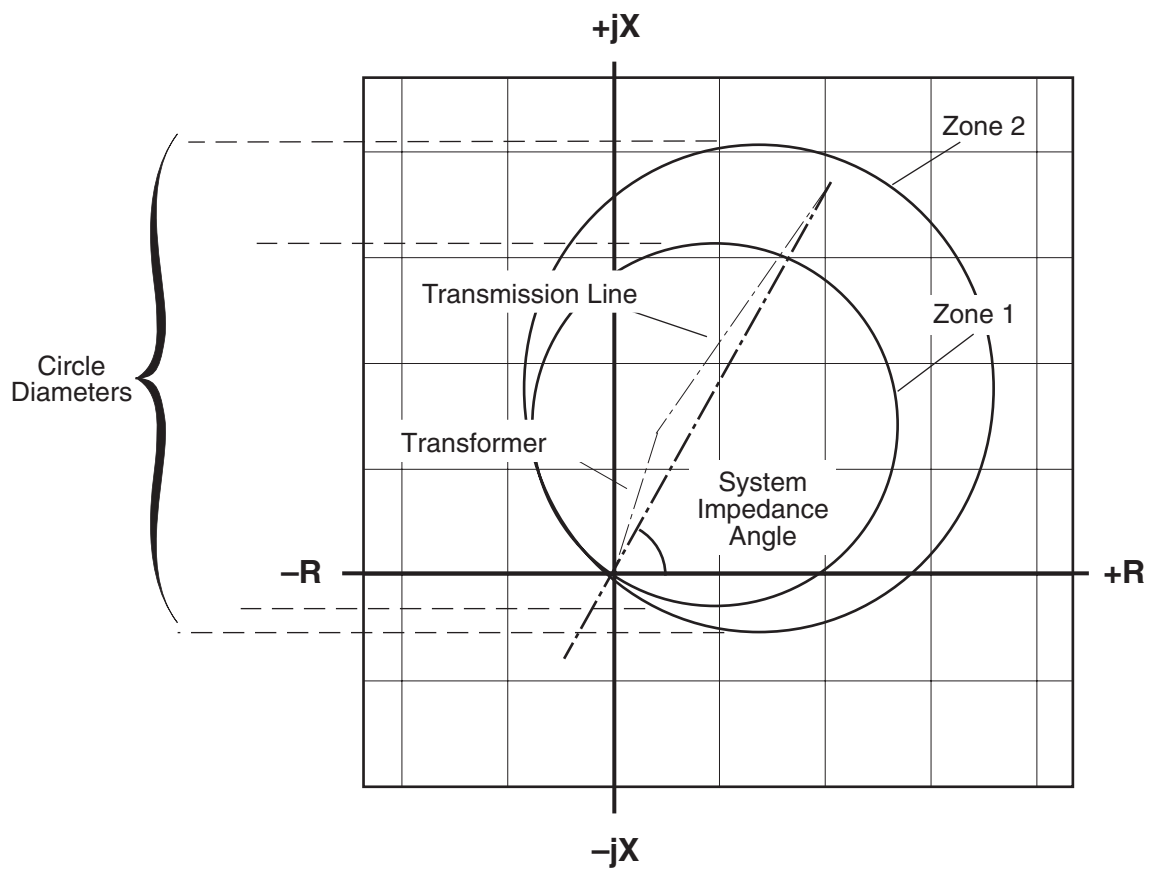
Figure 2-4   Phase Distance (21) Function Applied for System Phase Faults

All primary impedances (Z$_{PRI}$) must be reflected to relay quantities (Z$_{SEC}$). The primary ohms (Z$_{PRI}$) on the generator base needs to be multiplied by the ratio of the current transformer ratio (R$_C$) to the voltage transformer ratio (R$_V$).

$$Z_{SEC} = Z_{PRI} \; x \; (R_C \div R_V)$$

If this function is enabled, the following settings are applicable:

```
21 #1 DIAMETER
_____ Ohms
```

Typically, the first zone of protection is set to an impedance value in excess of the first external protective section (typically the transformer plus part of the transmission line) to ensure operation for faults within that protective zone (see Figure 2-4). The second #21 zone can be set for the second external section of protection on the system (typically transmission Zone 1 distance relays) plus adequate overreach.

```
21 #1 OFFSET
_____ Ohms
```

A negative or positive offset can be specified to offset the mho circle from the origin. This offset is usually set at zero.

```
21 #1 IMPEDANCE ANGLE
_____ Degrees
```

The impedance angle should be set as closely as possible to the actual impedance angle of the zone being protected.

```
21 #1 DELAY
_____ Cycles
```

The time delays are set to coordinate with the primary protection of those overreached zones and, when applicable, with the breaker failure schemes associated with those protective zones.

```
21 #2 DIAMETER
_____ Ohms
```

```
21 #2 OFFSET
_____ Ohms
```

```
21 #2 IMPEDANCE ANGLE
_____ Degrees
```

```
21 #2 DELAY
_____ Cycles
```

```
(21) - PHASE DISTANCE

  Circle Diameter: [    ]    0.1 Ohms  [◄][  ]              [►] 100.0 Ohms   #1
         Offset: [    ]  -100.0 Ohms  [◄][  ]              [►] 100.0 Ohms
Impedance Angle: [    ]         0°    [◄][  ]              [►] 90°
          Delay: [    ]      1 Cycle  [◄][  ]              [►] 8160 Cycles              Save

  ┌─────── OUTPUT ──────────@──┐  ┌──────── Blocking Input ───────┐
  │ 8☐  7☐  6☐  5☐  4☐  3☐  2☐  1☐ │  │ FL☐  6☐  5☐  4☐  3☐  2☐  1☐ │    Cancel
  └────────────────────────────┘  └───────────────────────────────┘

  Circle Diameter: [    ]    0.1 Ohms  [◄][  ]              [►] 100.0 Ohms   #2
         Offset: [    ]  -100.0 Ohms  [◄][  ]              [►] 100.0 Ohms
Impedance Angle: [    ]         0°    [◄][  ]              [►] 90°
          Delay: [    ]      1 Cycle  [◄][  ]              [►] 8160 Cycles

  ┌─────── OUTPUT ──────────@──┐  ┌──────── Blocking Input ───────┐
  │ 8☐  7☐  6☐  5☐  4☐  3☐  2☐  1☐ │  │ FL☐  6☐  5☐  4☐  3☐  2☐  1☐ │
  └────────────────────────────┘  └───────────────────────────────┘

        @ : WARNING, Function DISABLED until output selected!
```

Figure 2-5   M-3822 IPScom® for Windows™ Phase Distance (21) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(21) Phase Distance

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

25 Sync Check

The Synchronism (Sync) Check function is used to ensure that the voltage magnitude, phase angle and frequency of the Dispersed Generation (DG) (V2) and the utility system (V1) are within acceptable limits before the intertie breaker is closed.

The sync check function has phase angle, delta frequency, and delta voltage checks.

Phase Angle Check

The phase angle is considered OK when the selected sync phase voltage (V1) and DG voltage are within the Upper Volt Limit and Lower Volt Limit window and the measured phase angle is within the phase angle window.

Phase angle window is defined as twice the Phase Angle Limit setting. For example, if the Phase Angle Limit is set at 10 degrees, a phase angle window of 20 degrees exists between -10 degrees and +10 degrees. The basic diagram of the phase angle check is shown in Figures 2-6 and 2-7.

Delta Voltage and Delta Frequency Check

Delta voltage and delta frequency elements may be individually enabled or disabled, as desired. Delta voltage check will compare the absolute difference between the selected sync phase voltage (V1) and the measured DG voltage (V2) with the Delta Volt limit setting. Likewise, the delta frequency measures the frequency difference between V1 and V2 voltage signals. The logic diagram of the above is shown in Figures 2-6 and 2-7.

Dead Line/Dead Bus Check

The Dead Volt Limit defines the Hot/Dead voltage level used in deadline/dead bus closing schemes. When the measured V2 voltage is equal to or below the Dead Volt Limit, V2 is considered dead. When the measured V2 is above the Dead Volt Limit, V2 is considered hot. The opposite side of the breaker uses the positive sequence voltage measurement (V1 below) for 3-phase consideration in determining hot/dead detection. Different combinations of hot line/dead bus closings may be selected, depending on how the buses are referenced. The logic diagram of the deadline/dead bus scheme is shown in Figures 2-6 and 2-7.

The Dead V1, Dead V2, and Dead V1 & V2 enable are software switches used to enable the dead line/dead bus logic. Further conditioning can be performed on the dead detection logic by selecting one or more input contacts (Dead Input Enable) to control the enabled dead detection element. For example, if INPUT2 (I2) is selected under the Dead

Input Enable screen, and both the Dead V1 and Dead V2 elements are enabled, the dead check timer will start when INPUT2 is activated, and either V1 dead/V2 hot or V1 hot/V2 dead. This allows for external control of the desired dead closing scheme. Dead Input Enable selections are common to all dead detection elements. If no inputs are selected under the Dead Input Enable screen, and any dead element is enabled, the dead check timer will start immediately when the dead condition exists. The logic diagram in Figure 2-7 shows enabling/disabling of the dead line/dead bus scheme through contact inputs.

Eventually, the dead line/dead bus check, phase angle check, delta volt and delta frequency checks all combine through their appropriate timers and are directed to the programmed 25 output relay. The overall logic of the Sync Check (25) function is shown in Figure 2-7.

Supervision of 25 by 79

The Sync Check function (25) can be supervised by the reconnect enable (79) function. The "79 supervise 25" setting, if enabled, will hold both the dead check and sync check timers reset until the 79 timer expires. This, in effect, allows the 79 function to supervise the 25 operation. Neither the 25 nor the 79 function are considered "tripping" functions, and therefore do not generate target information by default.

▲ **CAUTION**: Outputs chosen for the 79 and 25 functions should not be selected as target outputs in the Target Setup section. Advanced programming using the IPSutil™ program allows user to redefine either or both the 25 and 79 functions as target outputs.

Delta V and Delta F Check Logic

With Delta V AND Delta F Enabled

$(V_1 - V_2) \leq$ Delta V Limit

AND

Delta V Is Enabled

Phase Angle Check Logic

$V1 \geq$ Lower Voltage Limit

AND

$V1 \leq$ Upper Voltage Limit

AND

$(F_1 - F_2) \leq$ Delta F Limit

AND

Delta F Is Enabled

AND

$V2 \geq$ Lower Voltage Limit

AND

AND

$V2 \leq$ Upper Voltage Limit

AND

Phase Angle OK

To Figure 2-7   1

Phase Angle $\leq$ Phase Limit

Delta V and Delta F Check Logic

With Delta V OR Delta F Enabled

$(V_1 - V_2) \leq$ Delta V Limit

AND

Delta V Is Enabled

OR

AND

$(F_1 - F_2) \leq$ Delta F Limit

AND

Delta F Is Enabled

Dead Line/ Dead Bus Check Logic

$V1_{pos} \leq$ Dead Limit

$V2 >$ Dead Limit

AND

Dead V1 Enabled

$V1_{pos} >$ Dead Limit

$V2 \leq$ Dead Limit

AND

OR

To Figure 2-7   2

Dead V2 Enabled

$V1_{pos} \leq$ Dead Limit

$V2 \leq$ Dead Limit

AND

Dead V1 & V2 Enabled

Dead Line/ Dead Bus Check Input Initiate Logic

$V1_{pos} \leq$ Dead Limit

$V2 >$ Dead Limit

AND

Dead V1 Enabled

AND

Dead Input Enable

Selected INPUT Is Activated

OR

To Figure 2-7   3

$V1_{pos} >$ Dead Limit

$V2 \leq$ Dead Limit

AND

AND

Dead V2 Enabled

Figure 2-6   Logic Diagrams

Sync Check (25) Function Logic
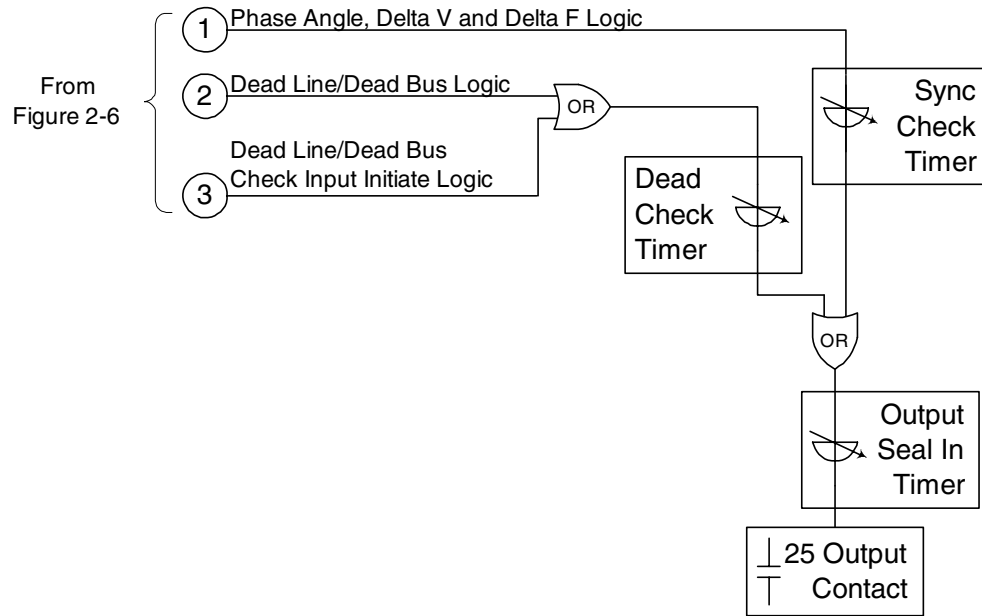
(79) Supervise (25) Function Logic
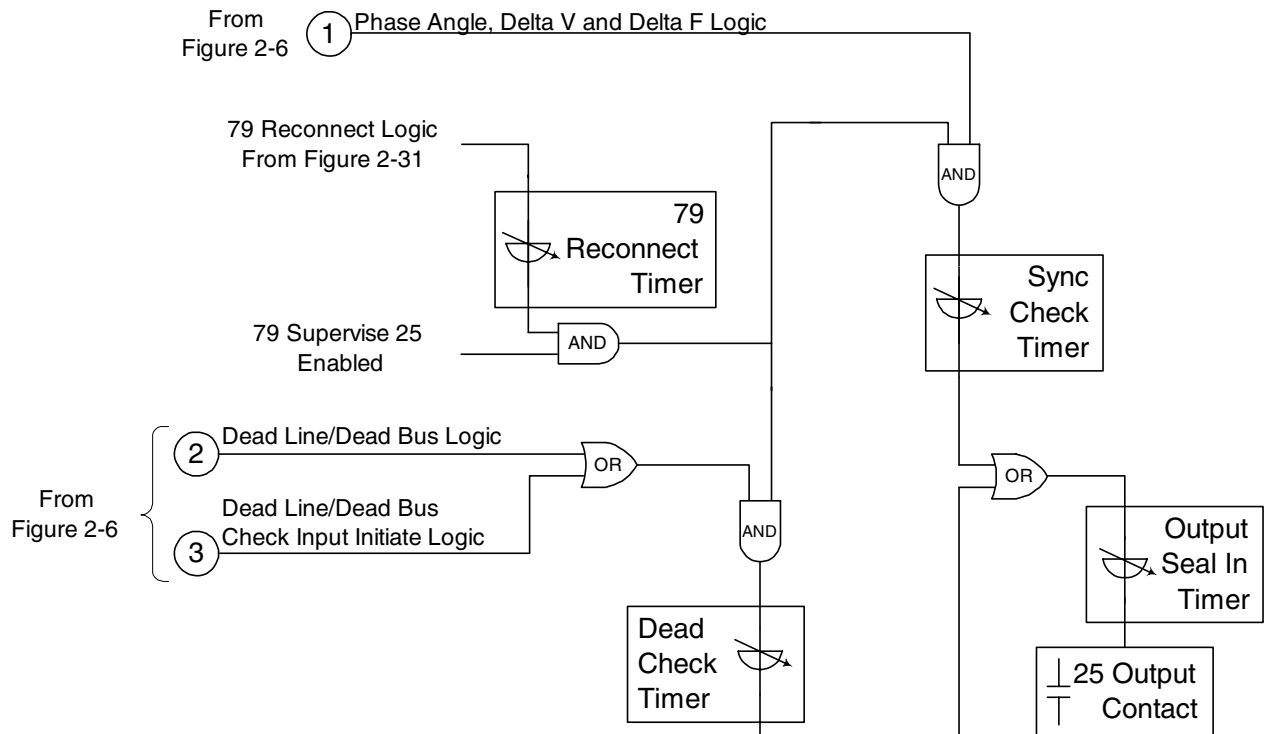
Figure 2-7   Function 25/79 Logic Diagrams

If this function is enabled, the following settings are applicable:

```
┌─────────────────────────────┐
│ 79 SUPERVISE 25             │
│ disable ENABLE              │
└─────────────────────────────┘
```
If enabled, 79 timer will control 25 function.

```
┌─────────────────────────────┐
│ 25 PHASE LIMIT              │
│ _____      Degrees       │
└─────────────────────────────┘
```
Phase angle setting.

```
┌─────────────────────────────┐
│ 25 UPPER VOLT LIMIT         │
│ _____ Volts              │
└─────────────────────────────┘
```
Upper voltage limit for voltage acceptance.

```
┌─────────────────────────────┐
│ 25 LOWER VOLT LIMIT         │
│ _____ Volts              │
└─────────────────────────────┘
```
Lower voltage limit for voltage acceptance.

```
┌─────────────────────────────┐
│ 25 SYNC CHECK DELAY         │
│ _____ Cycles             │
└─────────────────────────────┘
```
Sync check time delay.

```
┌─────────────────────────────┐
│ 25 DELTA VOLT               │
│ disable ENABLE              │
└─────────────────────────────┘
```
Delta voltage element.

```
┌─────────────────────────────┐
│ 25 DELTA VOLT LIMIT         │
│ _____ Volts              │
└─────────────────────────────┘
```
Delta voltage setting.

```
┌─────────────────────────────┐
│ 25 DELTA FREQUENCY          │
│ disable ENABLE              │
└─────────────────────────────┘
```
Delta frequency element.

```
┌─────────────────────────────┐
│ 25 DELTA FREQUENCY LIMIT    │
│ _____ Hz                 │
└─────────────────────────────┘
```
Delta frequency setting.

```
┌─────────────────────────────┐
│ 25 DEAD VOLT LIMIT          │
│ _____ Volts              │
└─────────────────────────────┘
```
Voltage less than this setting is defined as "DEAD"; above this setting as "HOT".

```
┌─────────────────────────────┐
│ 25 DEAD V1                  │
│ disable ENABLE              │
└─────────────────────────────┘
```
Enables Dead V1/Hot V2 setting.

```
┌─────────────────────────────┐
│ 25 DEAD V2                  │
│ disable ENABLE              │
└─────────────────────────────┘
```
Enables Hot V1/Dead V2 setting.

```
┌─────────────────────────────┐
│ 25 DEAD V1 & V2             │
│ DISABLE enable              │
└─────────────────────────────┘
```
Enables Dead V1/Dead V2 closing.

```
25 DEAD INPUT ENABLE
    i6 i5 i4 I3 i2 i1
```

Externally controlled dead closing.

```
25 DEAD DELAY
_____ Cycles
```

Dead delay timer setting.

---

(25) - SYNC CHECK

Phase Angle Window:	0° ◄▢ ▶ 90°		#1
Upper Voltage Limit:	60 V ◄▢ ▶ 140 V		
Lower Voltage Limit:	40 V ◄▢ ▶ 120 V		
Sync Check Delay:	1 Cycle ◄▢ ▶ 8160 Cycles		
Dead Voltage Limit:	0 V ◄▢ ▶ 60 V		
Dead Time Delay:	1 Cycle ◄▢ ▶ 8160 Cycles		

Delta Voltage: 1.0 V ◄▢ ▶ 50.0 V
○ Enable ◉ Disable

Delta Frequency: 0.001 Hz ◄▢ ▶ 0.500 Hz
○ Enable ◉ Disable

☐ Dead V1 Hot V2   ☐ Hot V1 Dead V2   ☐ Dead V1 Dead V2

☐ Supervised by Function 79

Input Initiate
FL☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

OUTPUT   @
8☐ 7☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

Blocking Input
FL☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

Save

Cancel

@ : WARNING, Function DISABLED until output selected!

Figure 2-8   M-3822 IPScom® for Windows™ Sync Check (25) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(25) Sync Check

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

27 Undervoltage, 3 Phase

Voltage is commonly suggested as an efficient means to protect against islanding. Notably, unless the DG includes very high-speed generator excitation response, the island case where load is greater than generation will result in a rapid drop of voltage. Except for those systems prone to ferroresonance, the voltage waveform will remain essentially sinusoidal, making the use of rms value of fundamental frequency component as the measurement for this function. An IEEE suggestion is that undervoltage relays be set at 90% to 95% of nominal voltage (in accordance with the lower limit allowed for supply to customers) with a 1 second time delay to prevent incorrect operation from a voltage dip caused by an external fault.

If this function is enabled, the following settings are applicable:

```
 27 #1 PICKUP
 _____ Volts
```

Relay volts are equal to the primary bus voltage divided by the VT ratio.

```
 27 #1 DELAY
 _____ Cycles
```

The operating time of the function.

```
 27 #2 PICKUP
 _____ Volts
```

```
 27 #2 DELAY
 _____ Cycles
```


Figure 2-9   M-3822 IPScom® for Windows™ Undervoltage (27) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(27) Undervoltage

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

32 Directional Power

Directional power protection is available in either the Reverse Overpower, Reverse Underpower, Forward Overpower or Forward Underpower configuration presented below. A power import and export convention that considers DG, Utility and the M-3520 perspectives is also included. The directional power function provides two power elements, each with a direction setting, magnitude setting and time delay, and configurable as an underpower or overpower element.

The directional power function provides protection against large power import or power export by an DG to a utility. Forward power is defined as power exported from an DG to a Utility, and reverse power is defined as power imported by an DG from a Utility (see Figures 2-1 and 2-2).

Two power elements are provided, each with a magnitude setting and time delay. The setting range is from –3.000 PU to 3.000 PU. The choice of the base PU is typically taken from the MVA rating of the interconnection transformer, the DG's aggregate generating capacity or some other value agreed upon by the DG and the utility. Normalized PU power flow measurements are based on the Nominal Voltage and Nominal Current setting, as shown in Section 2.3, Configuration.

If the DG is allowed to supply power to the Utility (export), the forward overpower function can be used to limit the amount of power flow into the Utility. The reverse underpower function can be used to ensure that the DG is importing a minimal amount of power from the utility, therefore providing a supplemental means of loss of parallel operation protection.

Configuration Process

The directional power elements are individually configured as follows:

1. Input the desired pick up value, positive (forward) or negative (reverse).

    a. *Positive pick up value* – Places the pick up point in the forward power area of the element, creating a forward power element.

    b. *Negative pick up value* – Places the pick up point in the reverse power area of the element, creating a reverse power element.

2. Select either Overpower or Underpower application:

    Overpower Mode

    a. *Reverse Overpower* – An increase in reverse power flow that exceeds the pick up value will cause a trip.

    b. *Forward Overpower* – An increase in forward power flow that exceeds the pick up value will cause a trip.

    Underpower Mode

    a. *Reverse Underpower Mode* – A decrease in reverse power flow that is below the pick up value will cause a trip.

    b. *Forward Underpower Mode* – A decrease in forward power flow that is below the pick up value will cause a trip.

▲ **CAUTION:** Proper CT polarity is important in defining the direction of power flow. Refer to Figure 2-2 for proper connections.

32 # 1 & #2 Pickup – If the pickup is set positive, the element is a forward power element. If the pickup is set negative, the element is a reverse power element.

32 #1 & #2 Delay – Power relays should be applied with a time delay to prevent mis-operation during power swing, heavy load pick up or heavy load rejection conditions.

REVERSE OVERPOWER

TRIP

NO
TRIP

Pick up

Reverse --- Relay --- Forward
Import --- DG --- Export
Export --- Utility --- Import

REVERSE UNDERPOWER

NO
TRIP

TRIP

Pick up

Reverse --- Relay --- Forward
Import --- DG --- Export
Export --- Utility --- Import

FORWARD OVERPOWER

NO
TRIP

TRIP

Pick up

Reverse --- Relay --- Forward
Import --- DG --- Export
Export --- Utility --- Import

FORWARD UNDERPOWER

TRIP

NO
TRIP

Pick up

Reverse --- Relay --- Forward
Import --- DG --- Export
Export --- Utility --- Import

Figure 2-10 Directional Power Configurations

If this function is enabled, the following settings are applicable

```
32 #1 PICKUP
_____ PU
```

```
32 #1 OVER/UNDER POWER
over_power under_power
```

```
32 #1 DELAY
_____ Cycles
```

```
32#1 THREE PHASE DETECT
disable ENABLE
```
This screen present if VT configuration is set Line-to-Ground.

```
32 #2 PICKUP
_____ PU
```

```
32 #2 OVER/UNDER POWER
over_power under_power
```

```
32 #2 delay
_____ Cycles
```

```
32 #2 THREE PHASE DETECT
disable ENABLE
```
This screen present if VT configuration is set Line-to-Ground.

Figure 2-11   M-3822 IPScom® for Windows™ Directional Power (32) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(32) Directional Power

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

46 Negative Sequence Overcurrent

The Negative Sequence Overcurrent function provides protection against possible damage due to unbalanced current conditions.

This function has a definite time element and an inverse time element. The definite time pickup value and operating time are normally associated with an alarm function. The inverse time element is usually associated with a trip function.

The inverse time function can be selected as one of the eight curve families: definite, inverse, very inverse, extremely inverse, and four IEC curves. The operator selects the pickup and time dial settings.

This protection must *not* operate for system faults that will be cleared by feeder/line relaying. This requires consideration of feeder line protection, bus differential, and breaker failure backup protections.

If this function is enabled, the following settings are applicable:

```
46DT PICKUP
_____ Amps
```

Negative sequence overcurrent pickup establishes the negative sequence overcurrent level above which the function timer will start.

```
46DT DELAY
_____ Cycles
```

This setting is the operating time of the function.

```
46IT PICKUP
_____ Amps
```

Negative sequence overcurrent pickup establishes the negative sequence overcurrent level above which the function timer will start.

```
46IT CURVE
DEF in vinv einv →
```

This setting selects, one of eight family of curves, as shown in Appendix D, Figures D-1 through D-8.

```
46IT TIME DIAL
_____
```

The appropriate curve in the selected family of curves is chosen here.

Figure 2-12 M-3822 IPScom® for Windows™ Negative Sequence Overcurrent (46) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(46) Negative Sequence Overcurrent

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

47 Negative Sequence Overvoltage
The Negative Sequence Overvoltage function 47
provides protection for voltage imbalance and
reverse phase sequence.

If this function is enabled, the following settings are applicable:

```
47#1 PICKUP
_____ Volts
```

A pickup setting in the range of 10 to 30 V can reliably
detect open phases and reverse phase sequence.

```
47#1 DELAY
_____ Cycles
```

A minimum time delay of 6 to 10 cycles will prevent
misoperation during switching transients.

```
47#2 PICKUP
_____ Volts
```

```
47#2 DELAY
_____ Cycles
```


Figure 2-13   M-3822 IPScom® for Windows™ Negative Sequence Overvoltage (47) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(47) Negative Sequence Overvoltage

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

50 Instantaneous Overcurrent, 3-Phase

The Instantaneous Phase (50) functions provide fast tripping times for high fault currents. The settings for 50 should be chosen such that they will not respond to faults on the adjacent system.

If this function is enabled, the following setting is applicable:

```
50 PICKUP
_____ Amps
```


Figure 2-14 M-3822 IPScom® for Windows™ Instantaneous Phase Overcurrent (50) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(50) Instantaneous Phase Overcurrent

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

50G Instantaneous Overcurrent, Neutral

The Instantaneous Neutral Overcurrent (50G) function provides fast tripping times for high fault currents. The settings for 50G should be chosen such that they will not respond to faults on the adjacent system.

If this function is enabled, the following settings are applicable:

```
50G PICKUP
_____ Amps
```

Pickup setting.

```
DIRECTIONAL ELEMENT
disable ENABLE
```

50G may be directionally controlled. See 67N function for maximum sensitivity angle and polarization setup.

Figure 2-15   M-3822 IPScom® for Windows™ Instantaneous Neutral Overcurrent (50G) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(50G) Instantaneous Neutral Overcurrent

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

51V Inverse Time Overcurrent, with Voltage Control or Voltage Restraint

Time overcurrent relays are basic to any protection scheme. This is the main function used to trip circuits selectively and to time coordinate them with other up or downstream devices. For this function, eight complete series of inverse time characteristics are included. The eight curve families to be chosen from are definite, inverse, very inverse, extremely inverse, and four IEC curves. The pickup and time dial settings are selected from the relay menu.

The curves available for use are shown in Appendix D, Figures D-1 through D-8. They cover a range from 1.5 to 20 times the tap. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the time at 20 times the pickup setting. The 51V function has voltage control or voltage restraint elements. Under certain conditions, the Dispersed Generation (DG) 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. The particular settings will be made by information from short-circuit (fault) studies and knowledge of the coordination requirements with other devices in the system that respond to time overcurrent.

When voltage restraint is selected, the tap setting of the 51VR is modified continuously according to the voltage inputs. The relay continues to operate independently of current decrement in the machine. The voltage restraint function is well-suited to small generators with relatively short time constants.

Voltage restraint is disabled when shipped from factory. When the generator is connected to the system through a delta/wye transformer, proper voltages (equivalent to the high-side of the transformer) should be used for the 51VR or 51VC element. The M-3520 can internally determine the equivalent high-side voltages of the delta/wye unit transformer, saving auxiliary instrument transformer costs. The voltage-current pairs used are shown in Table 2-2.

For voltage controlled operation, the function is not active unless the voltage is below the voltage control setpoint, which can be used to help confirm that the overcurrent is due to a system fault. When applied, most users will set voltage control in the range of 0.7 to 0.9 per unit rms voltage. Voltage control is disabled when shipped from the factory.

The various features of the 51V function, such as voltage control, voltage restraint, voltage transformations (for delta-wye unit transformers) are configurable.

■ **NOTE**: This function should be blocked by fuse loss if in the voltage control mode. Fuse loss blocking is not desirable for the restraint mode because the pickup is automatically held at 100% Tap Setting (see Figure 2-20) during fuse loss conditions, and will continue to operate correctly.

Generator Directly Connected			Generator Connected Through Delta/Wye Transformer		
Current	Voltage		Current	Voltage	
	L-N	L-L		L-N	L-L
I_A	$(V_A-V_C)/\sqrt{3}$	V_{AB}	I_A	V_A	$(V_{AB}-V_{CA})/\sqrt{3}$
I_B	$(V_B-V_A)/\sqrt{3}$	V_{BC}	I_B	V_B	$(V_{BC}-V_{AB})/\sqrt{3}$
I_C	$(V_C-V_B)/\sqrt{3}$	V_{CA}	I_C	V_C	$(V_{CA}-V_{BC})/\sqrt{3}$

Table 2-2   Delta/Wye Transformer Voltage–Current Pairs
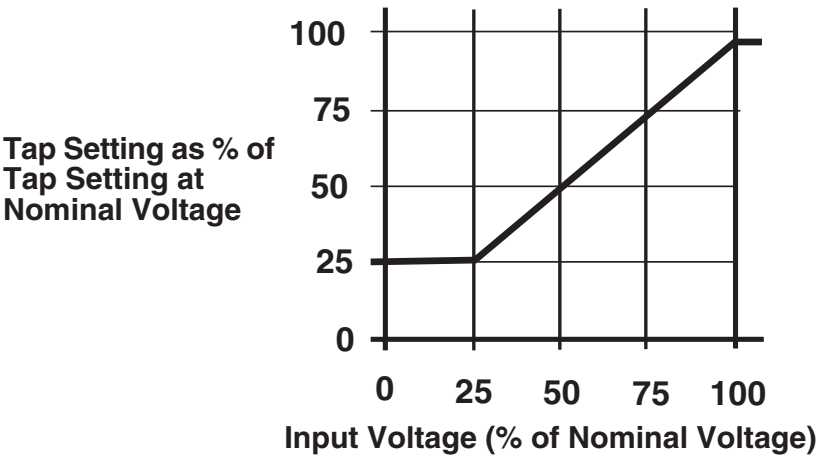
Figure 2-16   Voltage Restraint (51V) Characteristic

If this function is enabled, the following settings are applicable:

```
51V PICKUP
_____ Amps
```
Sets phase current pickup for 51V.

```
51V CURVE
DEF inv vinv einv →
```
Selects one of the eight inverse time curves as shown in Appendix D, Figures D-1 through D-8.

```
51V TIME DIAL
_____
```
The appropriate curve in the selected family of curves is chosen here.

```
51V VOLTAGE CONTROL
disable V_CNTL v_rstrnt
```
Restraint/control setting.

```
51V VOLTAGE CONTROL
_____ Volts
```
Voltage control level.

Figure 2-17   M-3822 IPScom® for Windows™ Inverse Time Overcurrent with Voltage Control/ Restraint (51V) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(51V) Inverse Time Overcurrent with Voltage Control/Restraint

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

51G Inverse Time Neutral Overcurrent

Neutral Inverse Time Overcurrent relay is used to trip circuits selectively for ground faults, and to time coordinate with up or down stream relays. For this function, eight complete series of inverse time characteristics are included. The eight curve families to be chosen are definite, inverse, very inverse, extremely inverse, and four IEC curves. The operator selects the time dial within each family setting and pickup setting through the M-3520 menu.

The curves available for use are shown in Appendix D, Figures D-1 through D-8. They cover a range from 1.5 to 20 times the pickup. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the time at 20 times the pickup setting.

If this function is enabled, the following settings are applicable:

```
51G PICKUP
_____ Amps
```

Sets ground current pickup.

```
51G CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves as shown in Appendix D, Figures D-1 through D-8.

```
51G TIME DIAL
_____
```

The appropriate curve in the selected family of curves is chosen here.

```
DIRECTIONAL ELEMENT
disable ENABLE
```

51G may be directionally controlled. See 67N function for maximum sensitivity angle and polarization setup.

Figure 2-18 M-3822 IPScom® for Windows™ Inverse Time Neutral Overcurrent (51G) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(51G) Inverse Time Neutral Overcurrent

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

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 a lightly loaded, islanded system. As the name implies, a system experiencing ferroresonance is in resonance, but the inductance is highly nonlinear, being variable as the transformer core cycles in and out of magnetic saturation. 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 nonsinusoidal 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 parameter setpoints in per unit of the peak of the nominal sinusoidal waveform. The per unit value is based on the nominal voltage setting. As an example, for a nominal voltage of 120 V, the one per unit instantaneous peak voltage is 120 x S2 = 170 V.

If this function is enabled, the following settings are applicable:

```
59I PICKUP
_____ PU
```

Typical pickup setting is between 1.3 to 1.5 PU.

```
59I DELAY
_____ Cycles
```

A time delay of 10 cycles provides fast protection and prevents misoperation during system disturbances.

Figure 2-19   M-3822 IPScom® for Windows™ Peak Overvoltage (59I) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(59I) Peak Overvoltage

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

59   Overvoltage, 3-Phase

Voltage is commonly suggested as an efficient means to protect against islanding. Notably, unless the Dispersed Generation (DG) includes very high-speed generator excitation response, the island case where load is less than generation will result in a rapid rise of voltage. Except for those systems prone to ferroresonance, the voltage waveform will remain essentially sinusoidal, making the use of rms value of the fundamental frequency component as the measurement.

IEEE suggests that the first setpoint (with a short time delay) be set up at 150% of the nominal voltage, and the second setpoint (with a long time delay) be set at 106 to 110% of the nominal voltage to prevent nuisance trips (*Intertie Protection of Consumer-Owned Sources of Generation, 3 MVA or Less*; IEEE Publication 88TH0224-6-PWR).

If this function is enabled, the following settings are applicable:

```
59 #1 PICKUP
_____ Volts
```
Pickup and Time Delay settings for 59 function. Set typically at 130% to 150%

```
59 #1 DELAY
_____ Cycles
```
Set typically at 3 to 6 cycles.

```
59 #2 PICKUP
_____ Volts
```
Set typically at 106% to 110%.

```
59 #2 DELAY
_____ Cycles
```
Set typically at 30 to 60 cycles.

Figure 2-20   M-3822 IPScom® for Windows™ Phase Overvoltage (59) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(59) Phase Overvoltage

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

59G/27G Overvoltage/Undervoltage, Neutral Circuit or Zero Sequence

The neutral Overvoltage/Undervoltage functions 59G/27G provide protection for ground faults on the system.

Applications of 59G/27G, shown in Figures 2-27 and 2-28, are for detecting ground faults on the utility side of the power transformer. Protection schemes are applied based on using one or three voltage transformers (VT).

If these functions are enabled, the following settings are applicable:

```
59G PICKUP
_____ Volts
```

```
59G DELAY
_____ Cycles
```

```
27G PICKUP
_____ Volts
```

```
27G DELAY
_____ Cycles
```


(59G) - NEUTRAL OVERVOLTAGE

Pickup: [   ]   5 V ◄[ ]   ▶ 180 V   #1
Delay: [   ]   1 Cycle ◄[ ]   ▶ 8160 Cycles

OUTPUT   @   Blocking Input
8☐ 7☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐   FL☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

Save

Cancel

@ : WARNING, Function DISABLED until output selected!

Figure 2-21   M-3822 IPScom® for Windows™ Neutral Overvoltage (59G) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(59G) Neutral Overvoltage

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

(27G) - NEUTRAL UNDERVOLTAGE

Magnitude: 5 V ◄☐ ▶ 180 V   #1   Save

Delay: 1 Cycle ◄☐ ▶ 8160 Cycles   Cancel

OUTPUT   @
8☐ 7☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

Blocking Input
FL☐ 6☐ 5☐ 4☐ 3☐ 2☐ 1☐

@ : WARNING, Function DISABLED until output selected!

Figure 2-22   M-3822 IPScom® for Windows™ Neutral Undervoltage (27G) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(27G) Neutral Undervoltage

COMMAND BUTTONS

Save　　　Saves all information to the relay.

Cancel　　Returns the user to the previous window; any changes to the displayed information are lost.

Ground Fault Detection using 59G and Broken-Delta VTs

The 59G may be used to detect system phase voltage unbalance in conjunction with three VTs. To do so, the VT secondaries are connected in "broken" delta; i.e., they are in delta except that one corner is open, and the 59G device is inserted, as illustrated in Figure 2-23.

In this case, voltage at 59G in Figure 2-24 will be zero so long as the three-phase voltages are balanced, but will rise above zero with any zero-sequence unbalanced condition, as will be expected with any real world utility ground fault.
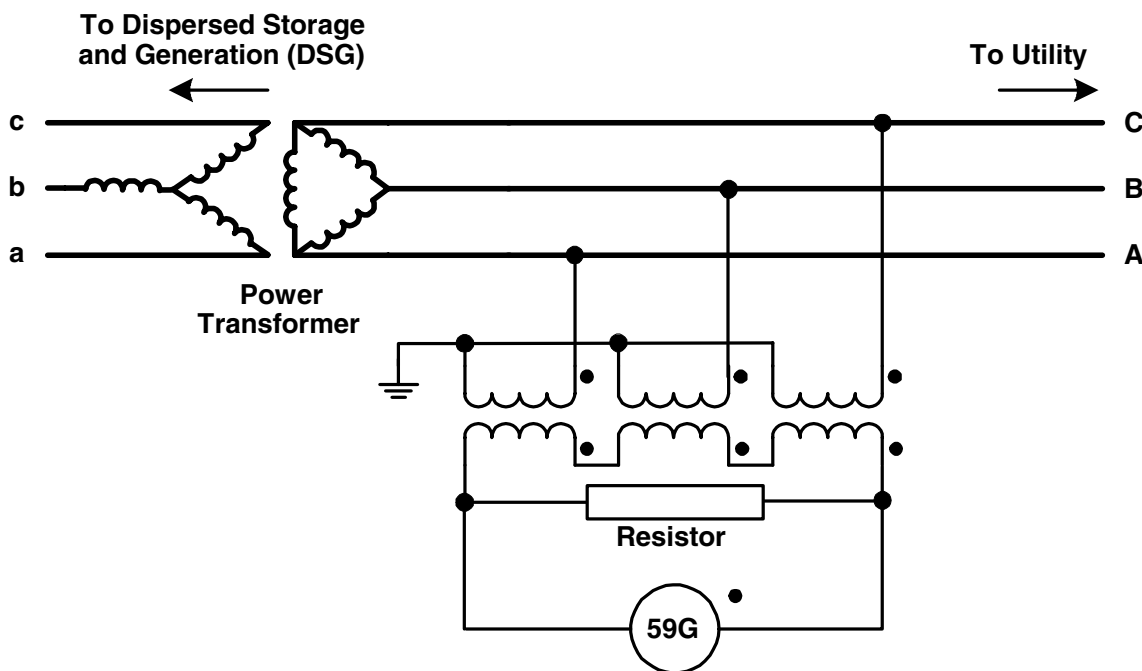
Figure 2-23   Ground Fault Detection Using 59G and Broken-Delta VTs

When the relay burden is small, the transformers in this scheme will be subject to ferroresonance and high voltage oscillations unless a shunt resistor is used. The shunt resistor will damp high transient voltage oscillations, and will usually hold peak values to less than twice normal crest voltage to ground (*Applied Protective Relaying*, Westinghouse Electric Corporation, 1982).

Typical Values	
VT Ratio	R
2400/120	250 Ω
4200/120	125 Ω
7200/120	90 Ω
14400/120	60 Ω

Table 2-3   Typical Shunt Resistor Values

Ground Fault Detection Using 27G and 59G with One VT

An alternate, but not recommended, scheme uses the 27G and 59G functions with one VT rated for line-to-line voltage, but connected from any one phase to ground as shown in Figure 2-24. This scheme will detect the most common line-to-ground faults in the following manner:

- A fault on the phase that includes the VT will pull that phase voltage low and initiate operation of the 27G function.

- A fault on either phase without the VT will result in line-to-line voltage (or $\sqrt{3}$ x normal line-to-neutral voltage) appearing at the VT, initiating operation of the 59G function.

For this scheme to work, the capacitance to ground of the lines must be fairly closely balanced and high enough to keep the neutral of the system at close to ground potential. The shunt resistor helps to minimize the chance of ferroresonance or neutral inversion. (*Applied Protective Relaying*, Westinghouse Electric Corporation, 1982.)

▲ Caution: This scheme should be used with caution since it can result in high overvoltages due to ferroresonance and neutral inversion.
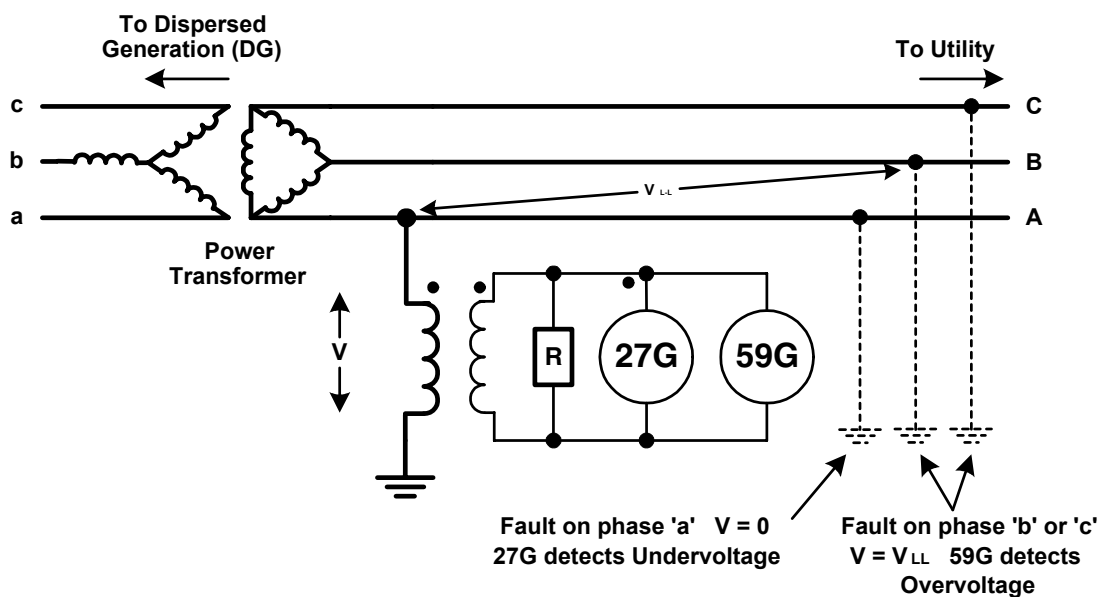
Figure 2-24   Ground Fault Detection Using 27G and 59G with One VT

60FL Fuse Loss

Since some functions may inadvertently operate when a VT fuse is blown, provisions are incorporated for both internal and external fuse loss detection. Functions which misoperate on VT fuse loss such as 21, 32, 51V, 67, and 67N can be programmed to disable during a VT fuse-loss condition. The status of the fuses can then be monitored using remote communications or locally if the optional M-3931 HMI Module is in service.

For internal detection of a fuse-loss condition, 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 VT inputs are being applied to the relay.

A timer, associated with the fuse loss logic, is available, to assure proper coordination for conditions which may appear as a fuse loss such as secondary VT circuit faults which will be cleared by local low voltage circuit action.

For the specific application where the above logic cannot be considered reliable (such as when current inputs to the relay are not connected, sustained positive sequence current during fault conditions is minimal, or negative sequence currents are not present during fault conditions), provision is made for disabling the 60FL Fuse Loss internal logic by not selecting "FL" from the 60FL Input Initiate choices.

Provision is also made in the relay to input external status contact(s) of other fuse loss detection protection. These external contacts may be input to any of the input contacts (IN1 to IN6) and programmed to initiate the 60FL function.

If this function is enabled, the following settings are applicable:

```
60FL INPUT INITIATE
FL i6 i5 i4 i3 i2 i1
```

The initiating inputs are user-designated. The operation of any of the externally-connected contacts (across these M-3520 inputs) will start the associated time delay to the 60FL function operation.

```
60FL DELAY
_____ Cycles
```

The time delay is to be set to coordinate for conditions which may appear as a fuse loss but will be corrected by other protection (such as a secondary VT circuit fault which will be cleared by low voltage circuit action).

Figure 2-25   M-3822 IPScom® for Windows™ Fuse Loss (60FL) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(60FL) Fuse-Loss Detection

COMMAND BUTTONS

Save   **Save**s all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

67 Phase Directional Overcurrent

For intertie protection applications, the phase directional overcurrent relay allows greater selectivity for utility system faults, since the directional element can be set to look directly towards the utility system. When the directional element is disabled, the 67DT operates like an instantaneous overcurrent. Likewise, the 67IT function operates like an inverse time overcurrent function (51) when its directional element is disabled. Special high-speed processing occurs when the 67DT time delay is set to minimum (1 cycle). A three-phase option on the 67DT function allows the 67DT to only respond to 3-phase faults. When three-phase detection is disabled, and any one phase current exceeds pickup, timing will begin. The directional elements are polarized from positive sequence voltage and positive sequence current. In order to obtain maximum sensitivity for fault currents, the directional element is provided with a maximum sensitivity angle adjustment (MSA). This setting is common to both the 67DT and 67IT elements. The directional detection algorithm is equipped with a pre-fault voltage memory of eight cycles to provide correct directional discrimination for bolted three-phase faults.
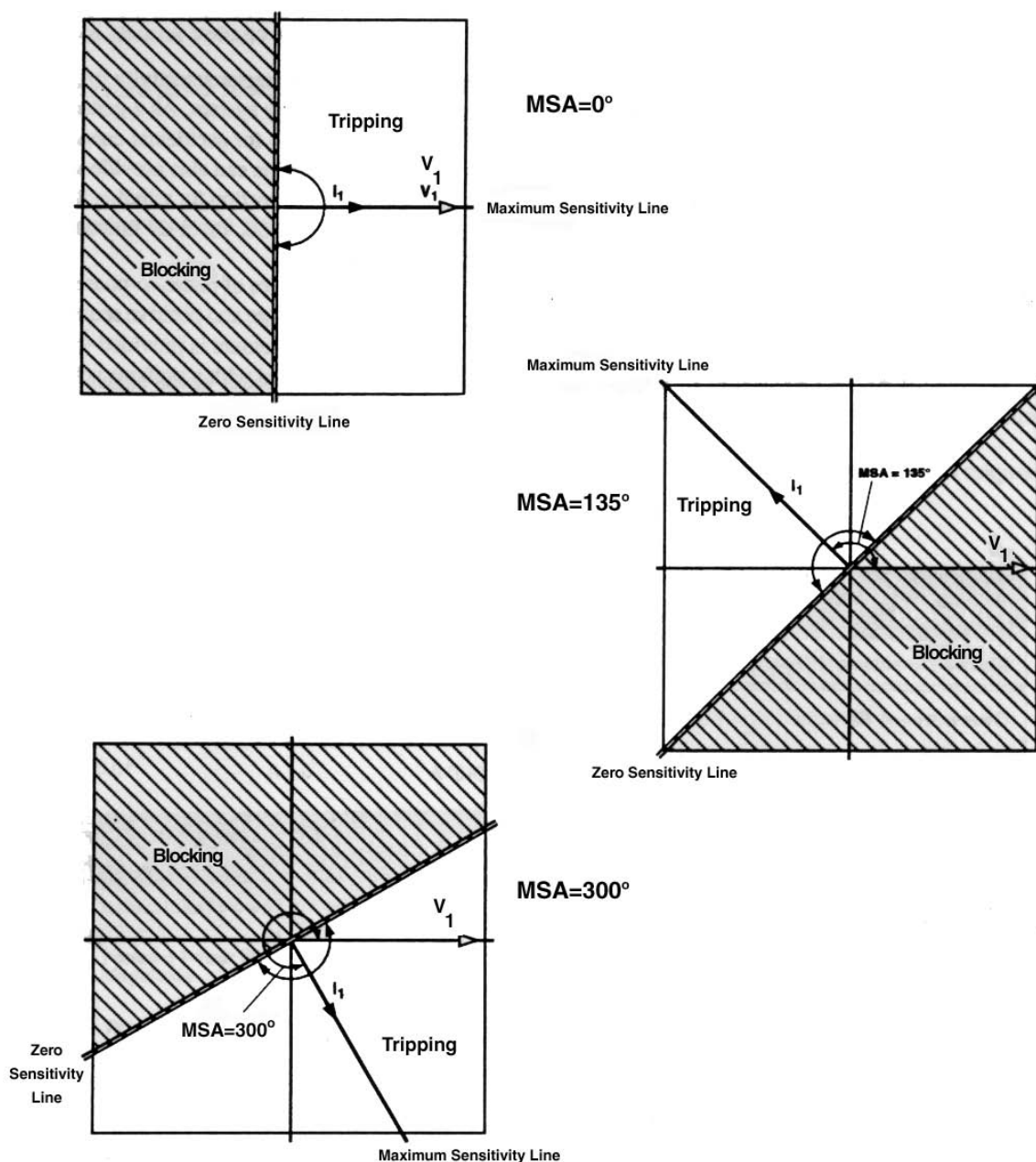
Figure 2-26   Phase Directional Overcurrent (67) Trip Characteristics

If this function is enabled, the following settings are applicable:

```
┌─────────────────────────┐
│ 67DT PICKUP             │
│ _____ Amps           │
└─────────────────────────┘
```

Pickup value for the 67DT element.

```
┌─────────────────────────┐
│ 67DT DIRECTIONAL ELEMENT │
│ disable ENABLE          │
└─────────────────────────┘
```

Directional discrimination enable. When disabled, this function will work like a standard overcurrent function (50DT).

```
┌─────────────────────────┐
│ 67DT THREE PHASE DETCT   │
│ DISABLE enable          │
└─────────────────────────┘
```

When enabled, all three phase currents must exceed the setpoint for the function to operate.

```
┌─────────────────────────┐
│ 67DT DELAY              │
│ _____ Cycles         │
└─────────────────────────┘
```

Time delay. When programmed for 1 cycle, high-speed operation results (.75 ±0.5 cycles).

```
┌─────────────────────────┐
│ 67IT PICKUP             │
│ _____ Amps           │
└─────────────────────────┘
```

Pickup value for the 67IT setting.

```
┌─────────────────────────┐
│ 67IT DIRECTIONAL ELEMENT │
│ disable ENABLE          │
└─────────────────────────┘
```

Directional discrimination enable. When disabled, this function will work like a standard inverse time overcurrent relay (51).

```
┌─────────────────────────┐
│ 67IT CURVE              │
│ def INV vinv einv →     │
└─────────────────────────┘
```

Curve Selection. Four standard curves and four IEC curves are available.

```
┌─────────────────────────┐
│ 67 IT TIME DIAL         │
│ _____                │
└─────────────────────────┘
```

Time Dial Setting.

```
┌─────────────────────────┐
│ 67 MAX SENSITIVITY ANGLE │
│ _____ DEGREES        │
└─────────────────────────┘
```

Used to polarize the directional elements. This setting is common to both the 67DT and 67IT when the directional elements are enabled.

(67) - PHASE DIRECTIONAL OVERCURRENT

Pickup: [_____]   1.0 Amp [◄][__]_____[►] 240.0 Amps | Def. Time |

Delay: [_____]   1 Cycle [◄][_]_____[►] 8160 Cycles

Three Phase Detection: ○ Enable   ◉ Disable

Phase Directional Element: ○ Enable   ◉ Disable

OUTPUT   @   Blocking Input
8 □ 7 □ 6 □ 5 □ 4 □ 3 □ 2 □ 1 □   FL □ 6 □ 5 □ 4 □ 3 □ 2 □ 1 □

| Save |

Pickup: [_____]   0.50 Amp [◄][__]_____[►] 12.00 Amps | Inv. Time |

Time Dial: [_____]   0.5 [◄][__]_____[►] 11.0

Curves
○ Definite Time   ◉ Inverse   ○ Very Inverse   ○ Extremely Inverse
○ IECI   ○ IECVI   ○ IECEI   ○ IECLTI

Phase Directional Element: ○ Enable   ◉ Disable

OUTPUT   @   Blocking Input
8 □ 7 □ 6 □ 5 □ 4 □ 3 □ 2 □ 1 □   FL □ 6 □ 5 □ 4 □ 3 □ 2 □ 1 □

Max Sensitivity: [_____]   0° [◄][__]_____[►] 359°

@ : WARNING, Function DISABLED until output selected!

| Cancel |

Figure 2-27   M-3822 IPScom® for Windows™ Phase Directional Overcurrent (67) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(67) Phase Directional Overcurrent

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

67N Residual Directional Overcurrent

The neutral directional overcurrent (67N) function provides protection from ground faults. This function includes an inverse time overcurrent element, and a directional element. The directional element may be polarized as five different types:

Type 1: $3V_0$ and $3I_0$, where V_0 and I_0 are zero-sequence voltage and zero sequence current calculated by the relay, using phase voltages and currents, respectively.

Type 2: V_G (broken delta voltage applied at the V_G input) and $3I_0$.

Type 3: $3V_2$ and $3I_2$, where V_2 and I_2 are negative sequence voltage and current, respectively.

Type 4: I_G and $3I_0$, where I_G is the neutral current (typically connected to the transformer neutral).

Type 5: Dual polarized with Type 1 or Type 4.

All types are designed to trip using $3I_0$ current.

Polarizations 1, 3, and 5 shall not be used with L-L or LG to L-L VT selection. When using polarizations 4 or 5, MSA is not applicable and should be set to zero.

■ **NOTE**: When I_G is connected as the residual current from phase CTs, type 4 and 5 must not be used.

If this function is enabled, the following settings are applicable:

```
67N PICKUP
_____ Amps
```
Pickup value for the 67N element.

```
67N DIRECTIONAL ELEMENT
disable ENABLE
```
Directional discrimination enable. When disabled, this function will work like a 51N.

```
67N DELAY
_____ Cycles
```
Time Dial setting.

```
67N MAX SENSITIVITY ANGLE
_____ Degrees
```

```
67NIT POLARIZATION
TYPE1 type2 type3 →
```
Used to polarize the directional elements. This includes polarizations 1, 2, and 3. For polarizations 4 and 5, the value should be set to zero. These settings are found under the RESIDUAL DIR SETUP screen.

Figure 2-28 M-3822 IPScom® for Windows™ Residual Directional Overcurrent (67N) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(67N) Residual Directional Overcurrent

COMMAND BUTTONS

Save   **Save**s all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

78 Out-of-Step

The Out-of-Step function (78) is used to protect the generator from out-of-step or pole slip conditions. Out-of-Step conditions can occur when faults are being cleared on the distribution system, and the DG accelerates as mechanical input exceeds electrical demand and synchronizing power is lost. This function uses one set of blinders, along with a supervisory MHO element. Ranges and increments are presented in Figure 2-30.

The pickup area is restricted to the shaded area in Figure 2-29, Out-of-Step Relay Characteristics, defined by the inner region of the MHO circle, the region to the right of the blinder A and the region to the left of blinder B. For operation of the blinder scheme, the operating point (positive sequence impedance) must originate outside either blinder A or B, and swing through the pickup area for a time greater than or equal to the time delay setting and progress to the opposite blinder from where the swing had originated. When this scenario happens, the tripping logic is complete. The output contact will remain closed for the amount of time set by the seal-in timer delay.

Consider, for example, Figure 2-29. If the out-of-step swing progresses to impedance $Z_0(t_0)$, the MHO element and the blinder A element will both pick up. As the swing proceeds and crosses blinder B at $Z_1(t_1)$, blinder B will pick up. When the swing reaches $Z_2(t_2)$, blinder A will drop out. If TRIP ON MHO EXIT option is disabled and the timer has expired ($t_2 - t_1 >$ time delay), then the trip logic is complete. If the TRIP ON MHO EXIT option is enabled and the timer has expired, then for the trip to occur the swing must progress and cross the MHO circle at $Z_3(t_3)$ where the MHO element drops out. Note the timer is active only in the pickup region (shaded area). If the TRIP ON MHO EXIT option is enabled, a more favorable tripping angle is achieved, which reduces the breaker tripping duty. The relay can also be set with a Pole Slip Counter. The relay will operate when the number of pole slips are greater than the setting, provided the Pole Slip Reset Time was not expired. Typically, the Pole Slip Counter is set to 1, in which case the Pole Slip Reset Time is not applicable.
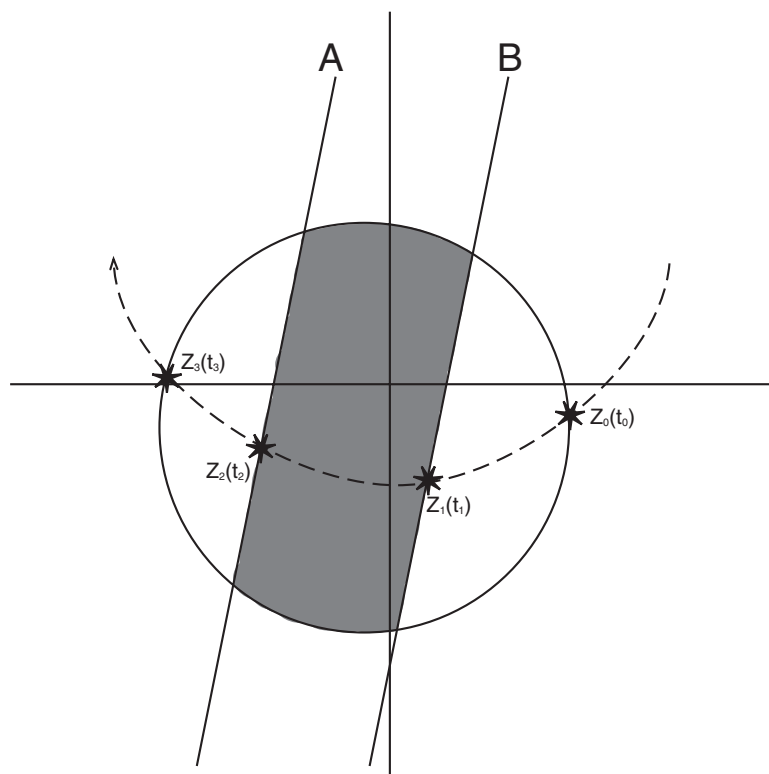
Figure 2-29 Out-of-Step Relay Characteristics

```
78 DIAMETER
_____ Ohms
```

```
78 OFFSET
_____ Ohms
```

A negative or positive offset can be specified to offset the mho circle from the origin.

```
78 BLINDER IMPEDANCE
_____ Ohms
```

The blinder impedance should be programmed less than the set diameter.

```
78 IMPEDANCE ANGLE
_____ Degrees
```

```
78 DELAY
_____ Cycles
```

```
78 TRIP ON MHO EXIT
disable enable
```

```
78 POLE SLIP COUNT
_____ slips
```

```
78 POLE SLIP RESET TIME
_____ Cycles
```

Figure 2-30 M-3822 IPScom® for Windows™ Out-of-Step (78) Setpoint Ranges

79 Reconnect Enable Time Delay

The reconnect relay is a permissive programmable output that may be set to close from 1 to 8160 cycles after all tripping functions are within limits. The 79 function is unique in that it is not considered a tripping function, and therefore if Output #8 is selected, it does not trigger target storage by default. The 79 function is enabled, and its output selected through the Relay Setpoints Screen, just as other functions. In addition to the time delay setting, the reconnect function monitors all functions that are programmed to trip. The reconnect relay will initiate timing when all outputs defined as trip outputs are not in a trip condition.

For example: If function 27#1 is programmed to output 5 (for alarm), 27#2 to output 1 (for trip), 81#1 to output 6 (for alarm), 81#2 to output 2 (for trip), 59G to output 2 (for trip), and 79 to output 8 (for reconnect), then OUT1 and OUT2 should be selected as output initiate. Schematic representation of this example is shown below:
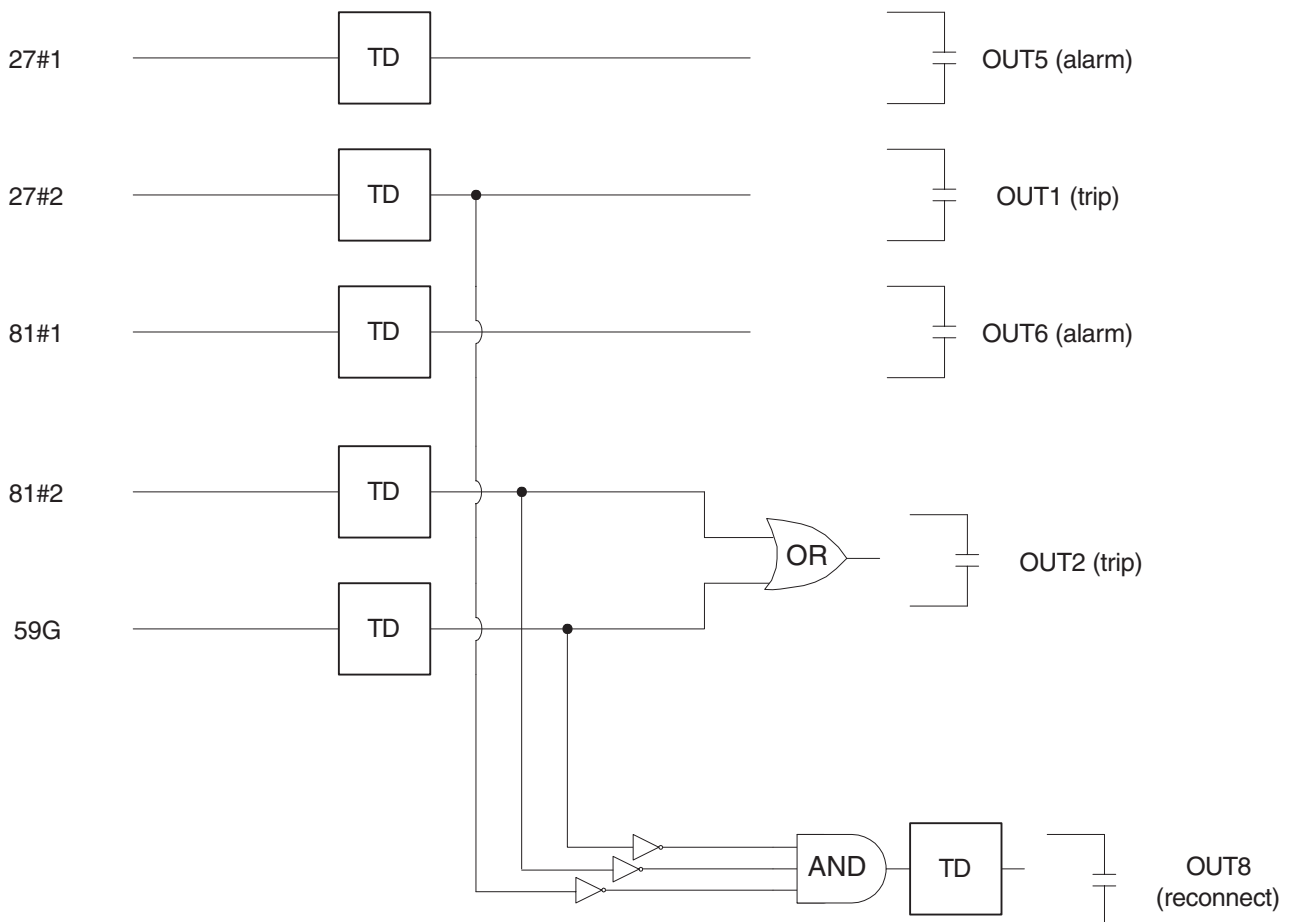
Figure 2-31   79 Function Logic Diagram

If this function is enabled, the following settings are applicable:

```
79 RECN INITIATE (TRIP)
o8 o7 o6 o5 o4 o3 O2 o1
```

Designated trip output selection. All trip outputs must drop out to start reconnect timer.

```
79 DELAY
_____ Cycles
```

Reconnect time delay.

Figure 2-32   M-3822 IPScom® for Windows™ Reconnect Enable Time Delay (79) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(79) Reconnect Enable Time Delay

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

81 Frequency

When Dispersed Generation (DG) is suddenly islanded, the frequency will quickly shift from 60.0 Hz (except for the improbable case of an exact generation and load match), making the measurement of frequency an excellent means to detect the island condition. If the only purpose is to detect the island condition, the frequency relay 81U and 81O can be set to operate at 59.5 Hz and 60.5 Hz, respectively (on a 60 Hz system), with a time delay of about 10 cycles.

A second school of thought advocates that the DG should definitely not be severed from the utility low frequency operation while the frequency remains as high as 59.5 Hz. This concept follows from the premise that if the drop in frequency is due to a major loss of system generation, it is at just this time that all available DG should be kept on-line to help prevent a complete system collapse. If this is the objective, it may be useful to set one underfrequency characteristic at 57.5 to 58.0 Hz with a very short time delay, but allowing a higher frequency, say 59.5 Hz, to be maintained for several seconds.
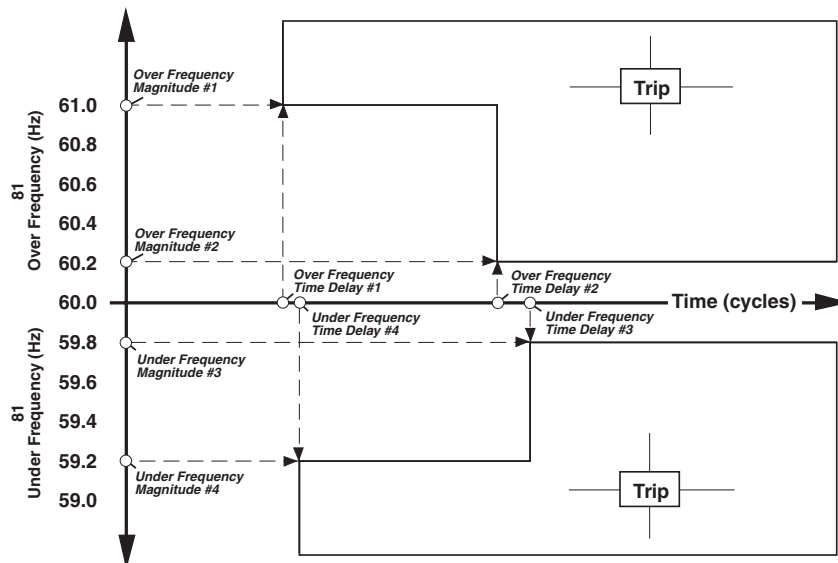
Figure 2-33   Typical Settings of 81 Function

If this function is enabled, the following settings are applicable:

```
81 #1 PICKUP
_____ Hz
```

```
81 #3 PICKUP
_____ Hz
```

```
81 #1 DELAY
_____ Cycles
```

```
81 #3 DELAY
_____ Cycles
```

```
81 #2 PICKUP
_____ Hz
```

```
81 #4 PICKUP
_____ Hz
```

```
81 #2 DELAY
_____ cycles
```

```
81 #4 DELAY
_____ Cycles
```

```
                              (81) - FREQUENCY

    ┌─────────────────────────────────────────────────────────┐
    │  Pickup:[    ]    50.00 Hz ◄│□                  ▶│ 67.00 Hz  [#1] │
    │  Delay: [    ]     2 Cycles ◄│□                  ▶│ 65500 Cycles  │
    │  ┌──────────────────────────┐ ┌──────────────────────────┐ │
    │  │       OUTPUT        @     │ │      Blocking Input      │ │
    │  │ 8□ 7□ 6□ 5□ 4□ 3□ 2□ 1□  │ │ FL□ 6□ 5□ 4□ 3□ 2□ 1□   │ │
    │  └──────────────────────────┘ └──────────────────────────┘ │
    └─────────────────────────────────────────────────────────┘

    ┌─────────────────────────────────────────────────────────┐
    │  Pickup:[    ]    50.00 Hz ◄│□                  ▶│ 67.00 Hz  [#1] │
    │  Delay: [    ]     2 Cycles ◄│□                  ▶│ 65500 Cycles  │
    │  ┌──────────────────────────┐ ┌──────────────────────────┐ │
    │  │       OUTPUT        @     │ │      Blocking Input      │ │
    │  │ 8□ 7□ 6□ 5□ 4□ 3□ 2□ 1□  │ │ FL□ 6□ 5□ 4□ 3□ 2□ 1□   │ │
    │  └──────────────────────────┘ └──────────────────────────┘ │
    └─────────────────────────────────────────────────────────┘     [ Save ]

    ┌─────────────────────────────────────────────────────────┐
    │  Pickup:[    ]    50.00 Hz ◄│□                  ▶│ 67.00 Hz  [#1] │
    │  Delay: [    ]     2 Cycles ◄│□                  ▶│ 65500 Cycles  │     [ Cancel ]
    │  ┌──────────────────────────┐ ┌──────────────────────────┐ │
    │  │       OUTPUT        @     │ │      Blocking Input      │ │
    │  │ 8□ 7□ 6□ 5□ 4□ 3□ 2□ 1□  │ │ FL□ 6□ 5□ 4□ 3□ 2□ 1□   │ │
    │  └──────────────────────────┘ └──────────────────────────┘ │
    └─────────────────────────────────────────────────────────┘

    ┌─────────────────────────────────────────────────────────┐
    │  Pickup:[    ]    50.00 Hz ◄│□                  ▶│ 67.00 Hz  [#1] │
    │  Delay: [    ]     2 Cycles ◄│□                  ▶│ 65500 Cycles  │
    │  ┌──────────────────────────┐ ┌──────────────────────────┐ │
    │  │       OUTPUT        @     │ │      Blocking Input      │ │
    │  │ 8□ 7□ 6□ 5□ 4□ 3□ 2□ 1□  │ │ FL□ 6□ 5□ 4□ 3□ 2□ 1□   │ │
    │  └──────────────────────────┘ └──────────────────────────┘ │
    └─────────────────────────────────────────────────────────┘

          @ : WARNING, Function DISABLED until output selected!
```

Figure 2-34   M-3822 IPScom® for Windows™ Frequency (81) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(81) Frequency

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

81R Rate of Change of Frequency

The Rate of Change of Frequency function can be used to detect islanding conditions. When the DG (Dispersed Generation) is islanded, the frequency either increases or decreases rapidly, depending upon the generator-load mismatch. If set far from Nominal Frequency, it may be difficult for over/underfrequency relay functions to detect islanding. The Rate of Change of Frequency function provides proper detection of islanding conditions under these circumstances.

The function also has an automatic disable feature, to disable 81R function during unbalanced faults and other system disturbances. This feature uses negative sequence voltage to block 81R function. When the measured negative sequence voltage exceeds the inhibit setting, the function 81R is blocked. The time delay and magnitude settings of 81R should be based on simulation studies, and the setpoint ranges are given in Figure 2-35 below.

If this function is enabled, the following settings are applicable:

```
81R #1 PICKUP
_____ Hz/s
```

```
81R #2 PICKUP
_____ Hz/s
```

```
81R #1 DELAY
_____ Cycles
```

```
81R #2 DELAY
_____ Cycles
```

```
81R NEG SEQ VOLT INHIBIT
    25%
```


Figure 2-35   M-3822 IPScom® for Windows™ Rate of Change of Frequency (81R) Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/(81R) Rate of Change of Frequency

COMMAND BUTTONS

Save   Saves all information to the relay.

Cancel   Returns the user to the previous window; any changes to the displayed information are lost.

2.5   Oscillograph Recorder

The oscillograph recorder provides comprehensive data recording of all monitored waveforms (voltage, current, control/status inputs and output contacts) at 16 samples per cycle. Oscillograph data can be downloaded using the communications ports to any IBM compatible PC running M-3822 IPScom® communications software. Once downloaded, the waveforms can be examined using M-3801D IPSplot® *PLUS* Oscillograph data analysis software.

The recorder can be triggered manually through serial communications using IPScom or automatically using programmed control/status inputs (IN1–6) or programmed output contact (OUT1–8) operation. When untriggered, the recorder continually records waveform data, keeping the most recent data in memory. The recorders memory may be partitioned into any one of the following:

- one 170 cycle record
- two 112 cycle records
- three 84 cycle records
- four 68 cycle records

When configured with a specific post trigger delay, the oscillographic record will show post-trip data in addition to pre-trip data, and keeps a snapshot of waveform data in its memory for downloading using IPScom.

■ **NOTE:** If more events or triggers occur before downloading than the number of partitions being used, the oldest record will be overwritten. Records are not retained if power to the relay is interrupted.

A post trigger delay of 5% to 95% may be specified. After triggering, the recorder will continue to store data for the programmed portion of the total record before rearming for the next record. For example, a setting of 80% will result in a record with 20% pre-trigger and 80% post trigger data.

The **OSC TRIG** LED on the front panel will indicate when oscillograph data has been recorded and is available for download.

The setup of the Oscillograph Recorder includes the following settings:

```
RECORDER PARTITIONS
   4
```

"Recorder Partitions" designates the number of partitions that the oscillograph recorder will use. Whenever this number is changed, the post-trigger delay is automatically reset to 5%

```
TRIGGER INPUTS
   I6 i5 i4 i3 i2 i1
```

The trigger inputs designate the control/status inputs whose operation will trigger the recorder to record an event. Operation is "OR"ed if more than one input is selected.

```
TRIGGER OUTPUTS
o8 o7 o6 o5 o4 o3 o2 o1
```

The trigger outputs are relay output contacts whose operation will trigger the recorder to record an event. Operation is "OR"ed if more than one output is selected.

```
POST TRIGGER DELAY
   5%
```

The post trigger delay assigns the amount, in percent, of the individual data record occurring after the trigger. The remaining portion consists of pre-trigger data.

2.6   Target History Recorder

The 32 most recent target events are stored in the unit's memory. A target is triggered whenever an output (designated as a trip output) operates.

The setup of the Target History Recorder includes the following setting:

```
TRIGGER OUTPUTS
o8 07 06 05 04 03 02 01
```

Designated tripping output. In this sample, O1–O7 are trip outputs, and o8 is used for reconnect.

2.7   IRIG-B Time Sync

The M-3520 Intertie Protection Relay has the ability to accept either a modulated or demodulated IRIG-B signal. The modulated signal is connected using the rear panel BNC connector, and is the default configuration.

A demodulated TTL level signal may also be used by connecting the signal source to two unused pins on the rear panel COM2 RS-232 connector (see table B-1). For demodulated operation, several jumpers need to be reconfigured (see Section 5.5, Circuit Board Switches and Jumpers).

When valid IRIG-B time information is received, the TIME SYNC LED is illuminated, and the hour, minute, and seconds of the on-board real-time clock (RTC) are corrected to the new IRIG-B time at five (5) minutes before the hour. Extended time information, accurate to 1 ms, is appended to all oscillograph and target time tags.

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3 Operation (Front Panel)

This chapter provides information on the operation of the optional M-3931 Human-Machine Interface Module (HMI) front panel controls to maneuver through the menus, enter values, set and interrogate the M-3520 Intertie Protection Relay.

3.1   Front Panel Controls

The relay has been designed to be set and interrogated locally with the optional M-3931 HMI. An integral part of this design is the layout and function of the front panel indicators and controls; see Figure 3-1, Front Panel.

The indicators and controls consist of a 2 x 24-character display, and a 6-button keypad. These controls are used by the operator to navigate the system menus, and to set and interrogate the unit. Detailed information on using these controls is provided in this chapter.

Alphanumeric Display

To assist the operator in setting and interrogating the relay, the display shows menus, which guide the operator to the desired function or setpoint value. These menus consist of two lines. The bottom line shows lower case abbreviations of each menu selection with the current menu selected and highlighted in uppercase. The top menu line provides a description of the current menu selection (see Figures 3-2 and 3-3).

While the unit is not in use, and has not operated, the user logo lines are blanked. If the unit has operated, the display cycles through a sequence of screens summarizing the operation status conditions (targets) until **ENTER** is pressed, at which time the first-level menu is displayed.

Screen Blanking

The display will automatically blank after exiting from the Main Menu, or from any screen after five (5) minutes of unattended operation. To wake up the display, the user must press any key except **EXIT**.

Arrow Buttons

The left and right arrow buttons are used to choose among menu selections shown on the display. When entering values, these buttons are used to select the digit (by moving the cursor) of the displayed setpoint that will be increased or decreased by the use of the up and down arrow buttons.

The up and down arrow buttons *only* increase or decrease input values, or change between upper and lower case inputs. Upper case inputs are active whereas lower case inputs are inactive. If the up or down arrow button is held in when adjusting numerical values, the speed of the increment or decrement is increased, after a small delay.

EXIT Button

Use the **EXIT** button to exit from a displayed screen to the immediately preceding menu. Any changed setpoint will not be saved if the selection is aborted via the **EXIT** button.

ENTER Button

The **ENTER** button is used to choose a highlighted menu selection, to replace a setpoint or other programmable value with the currently displayed value, or to select one of several displayed options, such as to **ENABLE** or **DISABLE** a function.

Target/Status Indicators and Controls

The target/status indicators and controls consist of the following LEDs: Power Supply (**PSI** and **PS2**) **RELAY OK**, the Oscillograph Recorder (**OSC TRIG**), **BREAKER CLOSED**, **TARGET**, **DIAGNOSTIC** and **TIME SYNC**

Power Supply (PS1 and PS2) LED.

The green power LED indicator(s) remains illuminated for the appropriate power supply whenever power is applied to the unit. Power supply PS2 is available as an option.

Relay OK LED

The green **RELAY OK** LED is controlled by the relay's microprocessor. A flashing **OK** LED indicates proper program cycling. The LED can also be programmed to illuminate continuously, if desired.

Oscillograph (OSC TRIG) Recorder LED

The **OSC TRIG** LED illuminates to indicate that oscillograph data has been recorded in the unit's memory.

Breaker (BRKR) CLOSED LED

The red **BRKR CLOSED** LED illuminates when the breaker status input (52b) is open.

Target Indicators and Target Reset

Normally, the 24 **TARGET** LEDs are not illuminated. Upon operation, LEDs corresponding to the cause(s) of the operation will light and stay illuminated until reset. The eight **OUTPUT** LED's will reflect the present state of the **OUT1**–**OUT8** output contacts. Pressing and releasing the **TARGET RESET** button will momentarily light all LEDs (providing a means to test them) and allows resetting of the **TARGET** LEDs if the condition causing the operation has been removed. Detailed information about the cause of the last 32 operations is retained in the unit's memory for access through the alphanumeric display via the **VIEW TARGET HISTORY** menu.

Pressing and holding the **TARGET RESET** button displays the present *pickup* status of the M-3520 functions on the target indicators.

Time Sync LED

The green **TIME SYNC** LED illuminates to indicate that the IRIG-B time signal is being received and validated.

Diagnostic LED (DIAG LED)

The diagnostic LED flashes upon occurrence of a detectable self-test error. The LED will flash the Error Code Number. For example, for error code 32, the LED will flash 3 times, followed by a short pause, and then 2 flashes, followed by a long pause, and then repeat. For units equipped with the HMI, the Error Code Number is also displayed on the screen.

Accessing Screens

To prevent unauthorized access to functions, the software allows assignment of access codes. If access codes have been assigned, the access code entry screen will be displayed after **ENTER** is pressed from the default message screen.

■ **NOTE**: The relay is shipped with the access code feature disabled.

The M-3520 has three levels of access codes, which determine the extent of access to M-3520 functions for each user. The higher the Level number, the greater access permitted.

Level **1** access - provides access to read setpoints, monitor status and view target history.

Level **2** access - provides all level 1 access, plus the ability to change setpoints.

Level **3** access - provides all level 1 & 2 access, plus the ability to change configuration parameters.

Each access code is a user defined 1 to 4 digit number. If the level 3 access code is set to 9999, the access code feature is disabled. When access codes are disabled, the access screens are bypassed. Access codes are altered by choosing the **ALTER ACCESS CODES** menu under **SETUP UNIT** menu. (These codes can only be altered by a level 3 user).

Default Message Screens

When the M-3520 is powered and unattended, user logo lines are blanked.

If a function has operated and not been reset, it will display the time and date of the operation and automatically cycle through screens for each applicable target. (This sequence is illustrated in Figure 3-2.) In either case, pressing **ENTER** will begin local mode operation, thereby displaying the access code entry screen, or if access codes are disabled, the first level menu will be displayed.

Serial Interfaces (COM1, COM2 and COM3)

The serial interface **COM1** port (front) and **COM2** port (rear) are standard 9-pin RS-232 DTE configured communications ports.

The **COM1** port will normally be used for local setting and interrogating of the relay via a portable computer running IPScom®. IPScom only supports communications using BECO 2200 protocol. **COM1** port protocol is fixed at BECO 2200. An additional **COM3** port (RS-485) is available at the rear terminal block. Either the **COM2** port or the **COM3** port will normally be used for remote setting and interrogation of the relay via a network, direct connection or permanently wired modem.

COM2 and **COM3** have the option of setting the protocol to BECO2200 or MODBUS. **COM1** communicates at a fixed 8 bits, no parity and 2 stop bits (8,N, 2 standard BECO 2200 settings). However, **COM2** and **COM3** have the option of set-

ting parity (none, odd or even) and stop bit (1, 2), if configured for MODBUS protocol. Detailed information on the use of the communications ports is provided in Appendix B, **Communications**.

The protocol description document and the communication data base document may be requested from the factory or from Beckwith's web site at www.beckwithelectric.com.

Communication Specifications

The following descriptions apply for use of MODBUS protocol:

1. MODBUS protocol is not supported on **COM1**.

2. Parity is supported on **COM2** and **COM3**; valid selections are 8,N,2; 8,O,1; 8,E,1; 8,N,1; 8,O,2; or 8,E,2.

3. ASCII mode is not supported (RTU only).

4. Standard baud rates from 300 to 9600 are supported.

5. Only the following MODBUS commands are supported:
    a. Read holding register (Function 03).
    b. Read input register (function 04)
    c. Force single coil (function 05)
    d. Preset single register (function 06).

6. MODBUS does not support oscillograph record downloading.

Figure 3-1 M-3520 Front Panel

Figure 3-2 Screen Message Menu Flow

VOLTAGE RELAY	CURRENT RELAY	FREQUENCY RELAY	POWER RELAY
VOLT curr freq pwr ➔	volt **CURR** freq pwr ➔	volt curr **FREQ** pwr ➔	volt curr freq **PWR** ➔

- 27 Phase Undervoltage
- 59 Phase Overvoltage
- 27G Neutral Undervoltage
- 59G Neutral Overvoltage
- 47 Neg Seq Overvoltage
- 59I Peak Overvoltage

- 50 Inst Overcurrent
- 51V Inv Time Overcurrent
- 50G Inst N Overcurrent
- 51G Inv Time N Overcurrent
- 46 Neg Seq Overcurrent
- 67 Directional Overcurrent
- 67N Dir Residual Overcurrent
- Neutral Directional Element

- 81 Frequency
- 81R Rate of Change Freq

- 32 Directional Power

PHASE DISTANCE RELAY	V.T. FUSE_LOSS RELAY	SYNC CHECK RELAY	RECONNECT RELAY
← **DIST** fuse sync	← dist **FUSE** sync	← dist fuse **SYNC**	← **RECONNECT** ➔

- 21 Phase Distance
- 78 Out of Step

- 60 V.T. Fuse Loss

- 25 Sync Check

- 79 Reconnect

CONFIGURE RELAY	SETUP SYSTEM	STATUS	VIEW TARGET HISTORY
← **CONFIG** sys stat ➔	← config **SYS** stat ➔	← config sys **STAT** ➔	← **TARGETS** osc_rec ➔

- Voltage Relay
- Current Relay
- Frequency Relay
- Power Relay
- Phase Distance Relay
- V.T. Fuse Loss Relay
- Sync Check Relay
- Reconnect Relay

- Nominal Voltage
- Nominal Current
- V.T. Configuration
- Sync-Check Phase
- Phase Rotation
- Pulse Relay
- Relay Seal-in Time
- Active Input State
- Delta-Y Transform
- V.T. Phase Ratio
- V.T. V2 Ratio
- V.T. Neutral Ratio
- C.T. Phase Ratio
- C.T. Neutral Ratio

- Voltage Status
- Current Status
- Frequency Status
- Power Status
- Impedance Status
- Sync Check Status
- In/Out Status
- Voltage Timer
- Current Timer
- Frequency Timer
- Power Timer
- Distance Timer
- Sync Check Timer
- Fuse Loss Timer
- Reconnect Timer
- Counters
- Time of Last Power Up
- Error Codes
- Checksums

- View Target History
- Clear Target History
- Target Setup

OSCILLOGRAPH RECORDER	COMMUNICATION	SETUP UNIT	EXIT LOCAL MODE
← targets **OSC_REC** ➔	← **COMM** setup exit	← comm **SETUP** exit	← comm setup **EXIT**

- View Record Status
- Clear Records
- Recorder Setup

- COM 1 Setup
- COM 2 Setup
- COM 3 Setup
- Communication Address
- Comm Access Code

- Software Version
- Serial Number
- Alter Access Codes
- User Control Number
- User Logo Line 1
- User Logo Line 2
- Clear Output Counters
- Clear Alarm Counter
- Date & Time
- Clear Error Codes
- Diagnostic Mode

Figure 3-3   Main Menu Flow

3.2 Initial Setup Procedure/ Settings

The relay is shipped with the initial configuration settings as listed in Appendix A, and recorded in the Record forms. Selected settings that are unique to the application may be recorded on the appropriate record form as calculated from Chapter 2, **Application.**

Setup Procedure

1. Connect power to the relay's rear power terminals, as marked on the rear panel's power supply label and as shown in Figure 5-4, External Connections.

2. Whenever initially powered up, the relay performs a number of self-tests to ensure its proper operation. During the self-tests, the display shows an "X" for each test successfully executed. If all tests are successful, the unit will briefly display the word **PASS**. Then it will cycle through a series of status screens, including the model number, software version number, serial number, date and time as set in the system clock, and the user logo screen will be displayed. (Figure 3-2 illustrates this sequence of screens.)

3. If any test should fail, the error LED will flash, an error code will be displayed and the relay will not allow operation to proceed. In such a case, the error code should be noted and Beckwith Electric contacted. A list of error codes and their descriptions are provided in Appendix C, **Error Codes**. Assuming that various voltage functions are enabled, and there are no voltage inputs connected, various voltage targets will be identified as having operated

4. If remote communication is used, the baud rate, address, and other parameters for the communication ports must be set. Refer to the instructions in subsection Communications Data (located at end of this procedure). Also refer to Chapter 4, **Operation (Computer)**, on M-3822 IPScom®.

5. To setup the unit with general information required, including altering access codes, clearing output counters, setting date and time, installing user logos, and other adjustments, refer to Setup Unit Data, in this section.

6. If desired, calibrate the unit following the calibration procedure described in subsection 6.3, Auto Calibration. For units without HMI, refer to Section 5.5, Circuit Board Switches & Jumpers.

■ **NOTE:** The relay has been fully calibrated at the factory using very precise and accurate test equipment. There is no need for recalibration before initial installation. Further calibration is only necessary if a component was changed and will be only as accurate as the test equipment used.

7. Finish relay configuration in the **SETUP SYSTEM** menu. This is the general system and equipment information required for relay operation. See Figure 3-4, Setup System Menu. This includes such items as CT and VT ratios, VT configurations, and Nominal values.

8. Enable the desired functions under the **CONFIGURE RELAY** menu.

■ **NOTE**: Disabling unused functions improves the response time of the indicators and controls.

9. Enter the desired setpoints for the enabled functions.

10. Enter the desired information for the oscillograph recorder.

11. Enter the desired information for the target recorder.

12. Install the relay and connect external input and output contacts according to the rear panel terminal block markings as shown in Figure 5-4, External Connections.

```
SETUP SYSTEM
← config SYS stat dmd →
```

```
NOMINAL VOLTAGE
VOLT curr vt sync phase→
```
```
NOMINAL VOLTAGE
120 Volts
```

```
NOMINAL CURRENT
volt CURR vt sync phase→
```
```
NOMINAL CURRENT
5.00 Amps
```

```
V.T. CONFIGURATION
volt curr VT sync phase→
```
```
V.T. CONFIGURATION
LINE-LINE line-ground →
```
```
V.T. CONFIGURATION
←line-gnd_to_ line-line
```

```
SYNC-CHECK PHASE
volt curr vt SYNC phase→
```
```
SYNC-CHECK PHASE
Ab bc ca
```

```
PHASE ROTATION
volt curr vt sync PHASE→
```
```
PHASE ROTATION
a-c-b  A-B-C
```

```
PULSE RELAY
← PULSE seal in y_dtx →
```
```
PULSE RELAY
o8 o7 o6 o5 o4 o3 o2 o1
```

```
RELAY SEAL-IN TIME
←pulse SEAL in d_ytx →
```
```
RELAY SEAL-IN TIME OUT 1
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 2
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 3
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 4
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 5
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 6
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 7
        30 Cycles
```
```
RELAY SEAL-IN TIME OUT 8
        30 Cycles
```

```
ACTIVE INPUT STATE
←pulse seal IN d_ytx →
```
```
ACTIVE INPUT OPEN/close
    i6 i5 i4 i3 i2 i1
```

```
DELTA-Y TRANSFORM
←pulse seal in D-YTX →
```
```
DELTA-Y TRANSFORM
DISABLE   enable
```

```
V.T. PHASE RATIO
← VT vt_v2  vt_n ct ct_n
```
```
V.T. PHASE RATIO
      1.0 :1
```

```
V.T. V2 RATIO
← vt VT_V2  vt_n ct ct_n
```
```
V.T. V2 PHASE RATIO
      1.0 :1
```

```
V.T. NEUTRAL RATIO
← vt vt_v2  VT_N ct ct_n
```
```
V.T. NEUTRAL RATIO
      1.0 :1
```

```
C.T. PHASE RATIO
← vt vt_v2 vt_n CT ct_n
```
```
C.T. PHASE RATIO
      10 :1
```

```
C.T. NEUTRAL RATIO
← vt vt_v2  vt_n ct CT_N
```
```
C.T. NEUTRAL RATIO
      10 :1
```

Figure 3-4   Setup System Menu

Communication Data

The general information that is required to complete the input data of this section includes:

- Baud rate for **COM1** and **COM2** communication ports. **COM3** uses the same baud rate as **COM2** (default) or **COM1** (jumper selectable).
- Communications address used to access multiple relays via a multidrop communication line.
- Communications access code (used for communication system security; entering an access code of 9999 disables the communication security feature).
- Communication protocol and dead sync time for **COM2** and **COM3.**
- Parity for **COM2** and **COM3** if MODBUS protocol is used.

Before entering the communication data, the Communication Data & Unit Setup Record (see Appendix A, Form A-1) should be completed.

Figure 3-5 is a sample of the Communication Data & Unit Setup Record Form. Refer to the column on the left for communication data. It is organized in the same order as in the relay menu.

The values shown in the Communication Data column of Figure 3-5 represent the default or "as shipped" values for these setpoints. Communication data for units purchased without the M-3931 HMI module may be altered by using the IPSutil™ utility package which is shipped with the IPScom® software package. Establishing communication with the relay using the default parameters is required before other setpoints may be altered.

Setup Unit Data

The general information that is required to complete the input data in this section includes:

- Access codes
- Control numbers
- Date and time
- User logo
- Diagnostic mode

Before entering the setup data, the Communication Data & Unit Setup Record (see Appendix A, Form A-1) should be completed.

Figure 3-5 is a sample of the Communication Data & Unit Setup Record Form. Refer to the two columns on the right for setup data.

The relay already contains factory settings for setup data, which can be used to familiarize the user with the **SETUP UNIT** menu.

Setup System

Information required in this section includes:

- Nominal Voltage and Current
- VT Configuration
- Sync-Check Phase
- Phase Rotation
- Pulse Relay
- Relay Seal-in Time
- Active Input State
- Delta-Y Transform
- VT Phase, Neutral and V2 Ratios
- CT Phase and Neutral Ratios

See Figure 3-4 for Sample Settings related to input for this Section. Settings are self explanatory, and are required for proper operation of the M-3520 relay.

Configure Relay Data

The relay is shipped with a certain group of standard functions (along with any purchased optional functions).Both standard and optional functions are fully configurable. (Unpurchased functions 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
- Output choices (OUT1–8)
- Input blocking choices (IN1–6 and/or fuse loss)

```
┌────────────────────────────────┐     ┌────────────────────────────────┐
│ COMMUNICATION                  │     │ SETUP UNIT                     │
│ ← COMM setup exit              │     │ ← comm SETUP exit              │
└────────────────────────────────┘     └────────────────────────────────┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM1 SETUP                   │ │   │ │ SOFTWARE VERSION             │ │   │ │ DATE AND TIME                │ │
  │ COM1 com2 com3 com_adr →     │       │ VERS sn access number →      │       │ ←TIME error diag             │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM1 BAUD RATE               │ │   │ │ SOFTWARE VERSION             │ │   │ │ DATE AND TIME                │ │
  │ ← baud_4800 BAUD_9600        │       │ D-0060V01.02.07              │       │ 01-JAN 2001 01:01:80         │
  └──────────────────────────────┘     │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM2 SETUP                   │ │   │ │ SERIAL NUMBER                │ │   │ │ DATE AND TIME                │ │
  │ com1 COM2 com3 com_adr →     │       │ vers SN access number →      │       │         01 Year              │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM2 BAUD RATE               │ │   │ │ SERIAL NUMBER                │ │   │ │ DATE AND TIME                │ │
  │ ← baud_4800 BAUD_9600        │       │           1                  │       │ JAN feb mar apr may →        │
│ └──────────────────────────────┘ │   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐                                             ┌──────────────────────────────┐
│ │ COM2 DEAD SYNC TIME          │ │                                         │ │ DATE AND TIME                │ │
  │          50 ms               │                                             │        1 Date                │
│ └──────────────────────────────┘ │                                         │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐                                             ┌──────────────────────────────┐
│ │ COM2 PROTOCOL                │ │                                         │ │ DATE AND TIME                │ │
  │ BECO2200 modbus              │                                             │ SUN mon tue wed thu →        │
  └──────────────────────────────┘                                           │ └──────────────────────────────┘ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘                                           ┌──────────────────────────────┐
                                                                             │ │ DATE AND TIME                │ │
                                                                               │        01 Hour               │
                                                                             │ └──────────────────────────────┘ │
                                                                               ┌──────────────────────────────┐
                                                                             │ │ DATE AND TIME                │ │
                                                                               │        01 Minutes            │
                                                                             │ └──────────────────────────────┘ │
                                                                               ┌──────────────────────────────┐
                                                                             │ │ DATE AND TIME                │ │
                                                                               │        02 Seconds            │
                                                                               └──────────────────────────────┘
                                                                             └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM3 SETUP                   │ │   │ │ ALTER ACCESS CODES           │ │   │ │ CLEAR ERROR CODES            │ │
  │ com1 com2 COM3 com_adr →     │       │ vers sn ACCESS number→       │       │ ← time ERROR diag            │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM3 BAUD RATE               │ │   │ │ ENTER ACCESS CODE            │ │   │ │ CLEAR ERROR CODES            │ │
  │ ← baud_4800 BAUD_9600        │       │ LEVEL1 level2 level3         │       │ PRESS ENTER KEY TO CLEAR     │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐     └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
│ │ COM3 DEAD SYNC TIME          │ │   │ │ LEVEL #1                     │ │
  │          50 ms               │       │           1111               │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COM3 PROTOCOL                │ │   │ │ LEVEL #2                     │ │
  │ BECO2200 modbus              │       │           2222               │
  └──────────────────────────────┘     │ └──────────────────────────────┘ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘     ┌──────────────────────────────┐
                                       │ │ LEVEL #3                     │ │
                                         │           9999               │
                                         └──────────────────────────────┘
                                       └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COMMUNICATION ADDRESS        │ │   │ │ USER CONTROL NUMBER          │ │   │ │ DIAGNOSTIC MODE              │ │
  │ com1 com2 com3 COM_ADR→      │       │ vers sn access NUMBER→       │       │ ← time error DIAG            │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COMMUNICATION ADDRESS        │ │   │ │ USER CONTROL NUMBER          │ │   │ │ PROCESSOR WILL RESET!        │ │
  │           1                  │       │           1                  │       │ ENTER KEY TO CONTINUE        │
  └──────────────────────────────┘     │ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐     ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
  ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COMMUNICATION ACCSS CODE     │ │   │ │ USER LOGO LINE 1             │ │
  │ ← ACCSS                      │       │ ←LOGO1 logo2 out alrm →      │
│ └──────────────────────────────┘ │   │ └──────────────────────────────┘ │
  ┌──────────────────────────────┐       ┌──────────────────────────────┐
│ │ COMMUNICATION ACCSS CODE     │ │   │ │ USER LOGO LINE1              │ │
  │           9999               │       │ BECKWITH ELECTRIC CO.        │
  └──────────────────────────────┘     │ └──────────────────────────────┘ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘     ┌──────────────────────────────┐
                                       │ │ USER LOGO LINE 2             │ │
                                         │ ←logo1 LOGO2 out alrm →      │
                                       │ └──────────────────────────────┘ │
                                         ┌──────────────────────────────┐
                                       │ │ USER LOGO LINE2              │ │
                                         │           M-3520             │
                                         └──────────────────────────────┘
                                       └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
                                       ┌ · · · · · · · · · · · · · · · · ┐
                                         ┌──────────────────────────────┐
                                       · │ CLEAR OUTPUT COUNTERS        │ ·
                                         │ ←logo1 logo2 OUT alrm →      │
                                       · └──────────────────────────────┘ ·
                                         ┌──────────────────────────────┐
                                       · │ CLEAR OUTPUT COUNTERS        │ ·
                                         │ PRESS ENTER KEY TO CLEAR     │
                                       · └──────────────────────────────┘ ·
                                       └ · · · · · · · · · · · · · · · · ┘
```

```
                                       ┌ · · · · · · · · · · · · · · · · ┐
                                         ┌──────────────────────────────┐
                                       · │ CLEAR ALARM COUNTERS         │ ·
                                         │ ←logo1 logo2 out ALRM →      │
                                       · └──────────────────────────────┘ ·
                                         ┌──────────────────────────────┐
                                       · │ CLEAR ALARM COUNTERS         │ ·
                                         │ PRESS ENTER KEY TO CLEAR     │
                                       · └──────────────────────────────┘ ·
                                       └ · · · · · · · · · · · · · · · · ┘
```

Figure 3-5   Communication Data & Unit Setup Menu

Setpoints and Time Settings
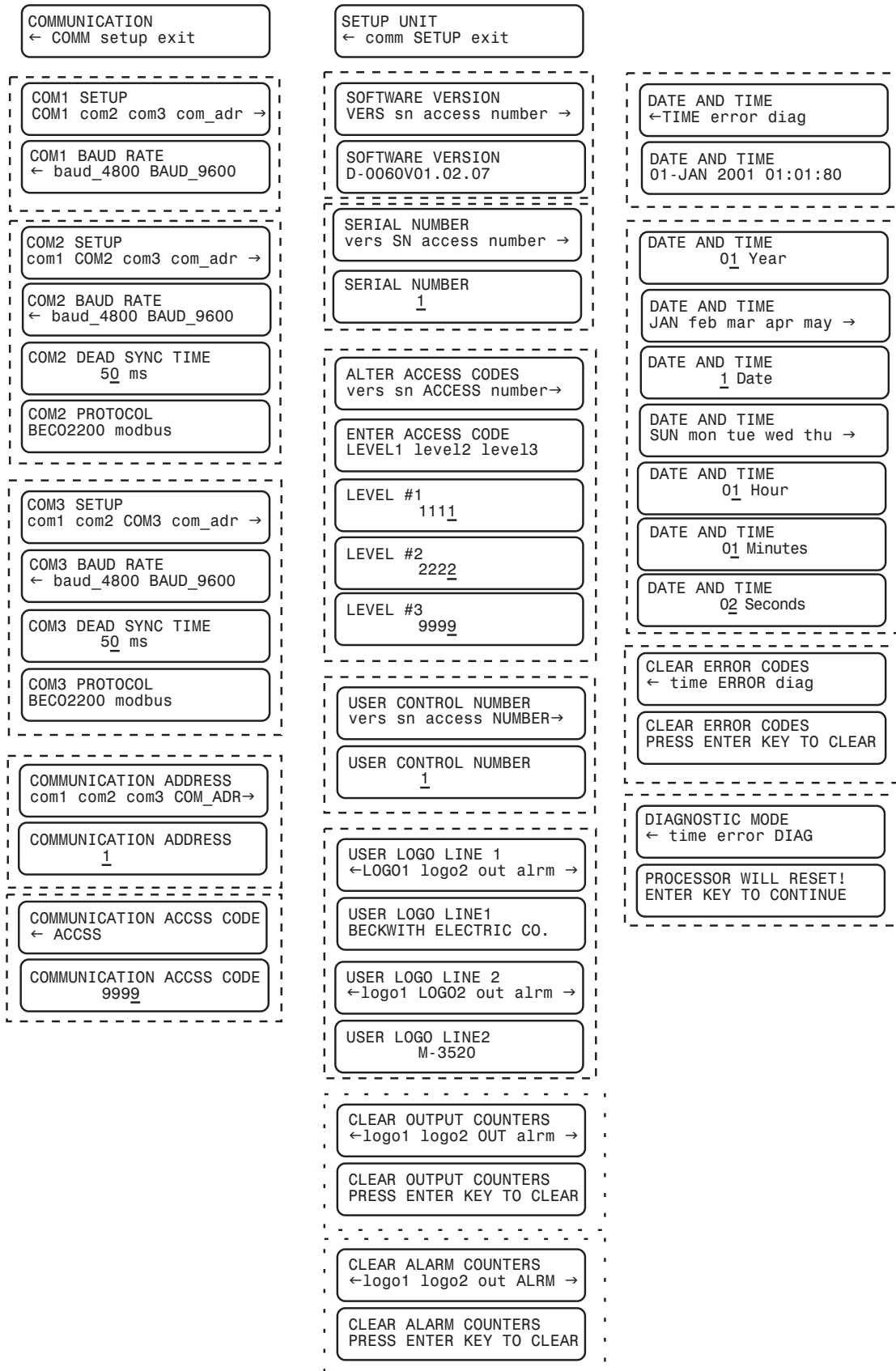
The general information that is required to complete the input data in this section includes individual relay function:

- Pickup settings (converted to relay quantities)
- Time delay settings
- Time dials and curves
- Power in PU, etc.

Input descriptions are detailed in Section 2.4, Setpoints and Time Settings. Make sure to complete the Setpoint & Timing Record Form in Appendix A before entering the setpoint and time setting data.

The relay already contains factory settings for setpoint and time setting data, which can be used to familiarize you with these menus.

Oscillograph Recorder Data

The oscillograph recorder provides comprehensive data recording of all monitored waveforms, storing up to 170 cycles of data. The total record length is programmable for one (170 cycles), two (112 cycles), three (84 cycles each), or four (68 cycles) event records. The oscillograph recorder is triggered either remotely, via designated status input signals or through relay output operations.

When untriggered, the recorder continuously records waveform data, keeping the data in buffer memory. When triggered, the recorder continues storing data for a period of time, as defined by the user, thereby keeping the most recent records in memory for downloading to a personal computer.

If more events or triggers occur than the number of records (partitions) designated before downloading of data, triggering the recorder overwrites the oldest of the event records. Be sure to complete the Setpoint & Timing Record Form in Appendix A before entering the oscillograph recorder settings.

The relay already contains factory settings for oscillograph recorder setup, which can be used to familiarize the user with the **OSCILLOGRAPH RECORDER** menu.

The HMI module allows the user to view time stamps for recorded events, and to clear all records in order to provide a fresh starting point for event triggering.

Target History Recorder

The **VIEW TARGET HISTORY** menu selection enables the user to review the targets for the previous 32 target conditions. A target is triggered whenever a designated output is operated or closed. The target history for each operation cycles continuously through a sequence of screens until **EXIT** is pressed. A target includes:

- pickup information which indicates any function which is timing,
- an indication whose function or functions have operated and timers expired,
- phase and ground currents at the time of trip, and individual phase element information at the time of the trigger, if the operating function was a 3-phase function,
- input and output status, and
- a time tag of the trigger.

The time tag of the trigger will be in the following format:

HH(Hours); MM(min); SS.xxx(seconds).

The xxx will be 000 if the IRIG-B signal is not connected or not synched. Otherwise, it will give seconds to the nearest thousands of a second.

CLEAR TARGET allows the user to clear all operation history for further target recording.

TARGET SETUP allows the user to select which outputs will trigger a target record. In most cases only tripping function outputs will be programmed to trigger targets. Outputs designated for reconnect or sync-check are usually not included in this set.

◼ **NOTE:** If a second function is used in an attempt to operate an output that has already operated, it will not trigger a new target since no new output has been operated or closed. If the second function operation closes a different unoperated output, a new target will be triggered. Targets are captured or recorded only when an output operates.

3.3   Checkout Status/Metering

The relay has two menu selections concerning monitoring status and demand values. This section describes the operation of these selections.

Status/Metering

Access the **STATUS** menu as follows:

1.   Press **ENTER** to bring up the main menu.

2.   Press the right arrow button until **STATUS** appears on the top line of the display.

3.   Press **ENTER** to access the **STATUS** submenu and begin the monitoring.

■ **NOTE:** Each category listed below is a submenu item. Pressing the **ENTER** button moves the item down within that menu, allowing monitoring of values within that submenu category. To exit a specific category and continue to the next menu category, press the **EXIT** button.

All metering values in this section (with the exception of power metering) are secondary level quantities.

The menu categories for monitored values are:

VOLTAGE STATUS

Phase voltages, neutral voltage, V2 voltage, positive sequence voltage, negative sequence voltage, zero sequence voltage

CURRENT STATUS

Phase currents, neutral current, positive sequence current, negative sequence current, zero sequence current

FREQUENCY STATUS

Frequency, Rate of change of frequency

POWER STATUS

Real power, Reactive power, Apparent power, Power factor

IMPEDANCE STATUS

SYNC CHECK STATUS

IN/OUT STATUS

Status of input and output contacts

The following timer status can also be monitored:

VOLTAGE TIMER

27, 27G, 47, 59, 59I, 59G

CURRENT TIMER

46, 50, 50G, 51G, 51V, 67

FREQUENCY TIMER

81, 81R

POWER TIMER

32

DISTANCE TIMER

21

SYNC CHECK TIMER

25

FUSE LOSS TIMER

60FL

RECONNECT TIMER

79

Timers for the inverse time functions are displayed in percentage where 100% corresponds to the full value of the integrating timer.

If the associated function time setting is less than 2 cycles, the indicated status will be less than actual. The following miscellaneous status can also be monitored:

COUNTERS   OUT1–8 plus alarm

TIME OF LAST POWER UP

ERROR CODES   Last error code log

3–12

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4 Operation (Computer)

This chapter contains information on configuring and interrogating the M-3520 Intertie Protection Relay using a personal computer running the M-3822 IPScom Communications Software package.

4.1   Installation and Setup

The IPScom Communications Software package runs under Microsoft® Windows 95 operating system, or later. This version of IPScom only supports communication using the BECO 2200 protocol.

IPScom is available on the following media (IBM PC-compatible format):

- CD-ROM
- Available for download from our website at www.beckwithelectric.com

The M-3822 IPScom software is not copy-protected and can be copied to a hard disk. For more information on your specific rights and responsibilities regarding the M-3822 IPScom software, refer to the licensing agreement enclosed with your software, or contact Beckwith Electric Co.

Hardware Requirements

IPScom will run on any IBM PC-compatible computer that provides at least the following:

- 8 Mb of RAM
- Microsoft Windows 95 or later
- CD-ROM
- One serial (RS-232) communication port

The M-3520 is provided with three serial communication ports. Two serial interface ports, COM1 and COM2 are standard 9-pin RS-232 DTE-configured ports. The front panel port, COM1, can be used as a temporary connection to locally set and interrogate the relay by computer. The second RS-232 COM2 port is provided at the rear of the unit.

An RS-485 configured port, COM3 is located at the rear terminal block of the unit. Either COM2 or COM3 can be used to remotely set and interrogate the relay using a modem, whereas all three ports may be used for direct serial connection.

■ **NOTE:** The RS-232 standard specifies a maximum cable length of 50 feet for RS-232 connections. Successful operation cannot be guaranteed for cable lengths exceeding this recommendation. Every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended.

Use of IPScom® and M-3520 Intertie Protection Relay using a Modem

In order to use IPScom to communicate with the relay using a modem, the following must be provided for the unit.

- Hayes-compatible external modem; 1200, 2400, 4800, or 9600 baud.
- Serial modem cable with 9-pin connector for the system and the applicable connector for the modem.

Similarly, the computer running IPScom must also have access to a Hayes-compatible internal or external modem. Pin-outs for communication cables are provided in Appendix B.

Use of IPScom and M-3520 Intertie Protection Relay using Direct Serial Connection

In order to use IPScom to communicate with the relay using direct serial connection, a serial "null modem" cable is required. The cable must be provided with a 9-pin connector (DB9P) for the system, and an applicable connector for the computer (usually DB9S or DB25S). Pin-outs for a null modem adapter are provided in Appendix B, **Communications**. A 10-foot, null modem RS-232 cable may be purchased from Beckwith Electric Co. (part number M-0423).

Installation

Before installing the IPScom program, make a copy of the software disks for archive purposes.

Figure 4-1   IPScom Program Icon

IPScom can be run from a hard disk. An installation utility (setup.exe) has been provided to make the process easier.

Installing IPScom

1. Insert software CD-ROM in your drive.

2. Select Run from the Start Menu.

3. In the Run dialog box, initiate software installation by typing either or **D:\Setup** or **other drive designation:\Setup**, depending on the drive in which the software is inserted.

4. The installation utility establishes a program folder (Becoware) and subdirectory (IPScom). After installation, the IPScom program item icon (see Figure 4-1) is located in Becoware. The application files are located on drive C, in the new subdirectory IPScom (C:\\Becoware\\Ipscom).

Installing IPSutil™

IPSutil is utility software used to program system-level parameters for units shipped without the M-3931 HMI Module. The IPSutil.exe file is automatically installed in the Becoware folder, along with the IPScom files, and does not require separate installation.

Installing the Modems

Using IPScom to interrogate, set or monitor the relay using a modem requires both a remote modem connected at the relay location and a local modem connected to the computer with IPScom installed.

The local modem can be initialized, using IPScom, by connecting the modem to the computer, and selecting the **COMM** menu in IPScom. Select **MODEM**, enter the required information, and finally select **INITIALIZE** from the expanded Communications dialog box. The following steps outline the initialized modem setup procedure.

1. Connecting the modem to the computer:

    a. If the computer has an external modem, use a standard straight-through RS-232 modem cable to connect the computer and modem (M-3933). If the computer has an internal modem, refer to the modem's instruction book to determine which communications port should be selected.

    b. The Hayes-compatible modem must be attached to (if external) or assigned to (if internal) the same serial port as assigned in IPScom®. While IPScom can use any of the four serial ports (COM1 through COM4), most computers support only COM1 and COM2.

    c. Connect the modem to the telephone line and power up.

2. Connecting the Modem to the Relay: Setup of the modem attached to the relay may be slightly complicated. It involves programming the parameters (using the AT command set), and storing this profile in the modem's nonvolatile memory.

    After programming, the modem will power up in the proper state for communicating with M-3520. Programming may be accomplished by using "Hyperterminal" or other terminal software. Refer to your modem manual for further information.

■ **NOTE:** The relay does not issue or understand any modem commands. It will not adjust the baud rate and should be considered a "dumb" peripheral. It communicates with 1 start, 8 data, and 1 stop bit.

    a. Connect the unit to an external Hayes-compatible modem by attaching a standard RS-232 modem cable to the appropriate serial communications port on both the unit and the modem.

    b. Connect the modem to the telephone line and power up.

The modem attached to the unit must have the following AT command configuration:

E0	No Echo
Q1	Don't return result code
&D3	On to OFF DTR, hang-up and reset
&S0	DSR always on
&C1	DCD ON when detected
S0=2	Answer on second ring

The following commands may also be required at the modem:

&Q6	Constant DTE to DCE
N0	Answer only at specified speed
W	Disable serial data rate adjust
\Q3	Bi-directional RTS/CTS relay
&B1	Fixed serial port rate
S37	Desired line connection speed

There are some variation in the AT commands supported by manufacturers of Hayes-compatible modems. Refer to the hardware user documentation for a list of supported AT commands and direction on issuing these commands.

Setting Up the M-3520 Intertie Protection Relay for Communication

The initial setup of the relay for communication must be completed by the optional M-3931 HMI Module or using direct serial connection using the default "As Shipped" communication parameters. Refer to Communication Data and Unit Setup "AS SHIPPED" form located in Appendix A, **Forms**.

For units shipped without the optional HMI Module, the communication parameters may be altered by first establishing communication using the default parameters and the IPSutil™ program.

IPSutil is an auxiliary program shipped on the same disk with the IPScom program. It is used exclusively for altering communication and setup parameters on units shipped without the M-3931 HMI Module.

■ **NOTE:** Communication is inhibited while the relay is in local mode (being accessed using the HMI). To ensure the M-3520 is available for remote communication, press **ENTER** at the **EXIT LOCAL MODE** menu item, or press the **EXIT** key several times to back out of the menu tree to the top level screen.

Multiple Systems Setup

The individual addressing capability of IPScom® and the relay allows multiple systems to share a direct or modem connection when connected using a communications-line splitter (see Figure 4-2). One such device enables 2 to 6 units to share one communications line.

▲ **CAUTION**: Units connected to a communications line splitter must have a unique communications address. If two or more units share the same address, corrupted communications will result.

Serial Multidrop Network Setup

Individual remote addressing also allows for communications through a serial multidrop network. Up to 32 relays can be connected using the same 2-wire or optional 4-wire RS-485 communications line.

Appendix B, Figure B-2 illustrates a setup of RS-232 Fiber Optic network, and Figure B-3 illustrates a 2-wire and 4-wire RS-485 network.

Other communication methods are possible using the M-3520 Intertie Protection Relay. 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.

Null Modem Cable for
Direct RS-232 Connection

IBM-Compatible PC

Communications-Line Splitter

M-3520

Address 6

Address 5

Address 4

Address 3   Up to six controls
can be used with a
Address 2   communications-line splitter.

Address 1

Integrated Protection
System
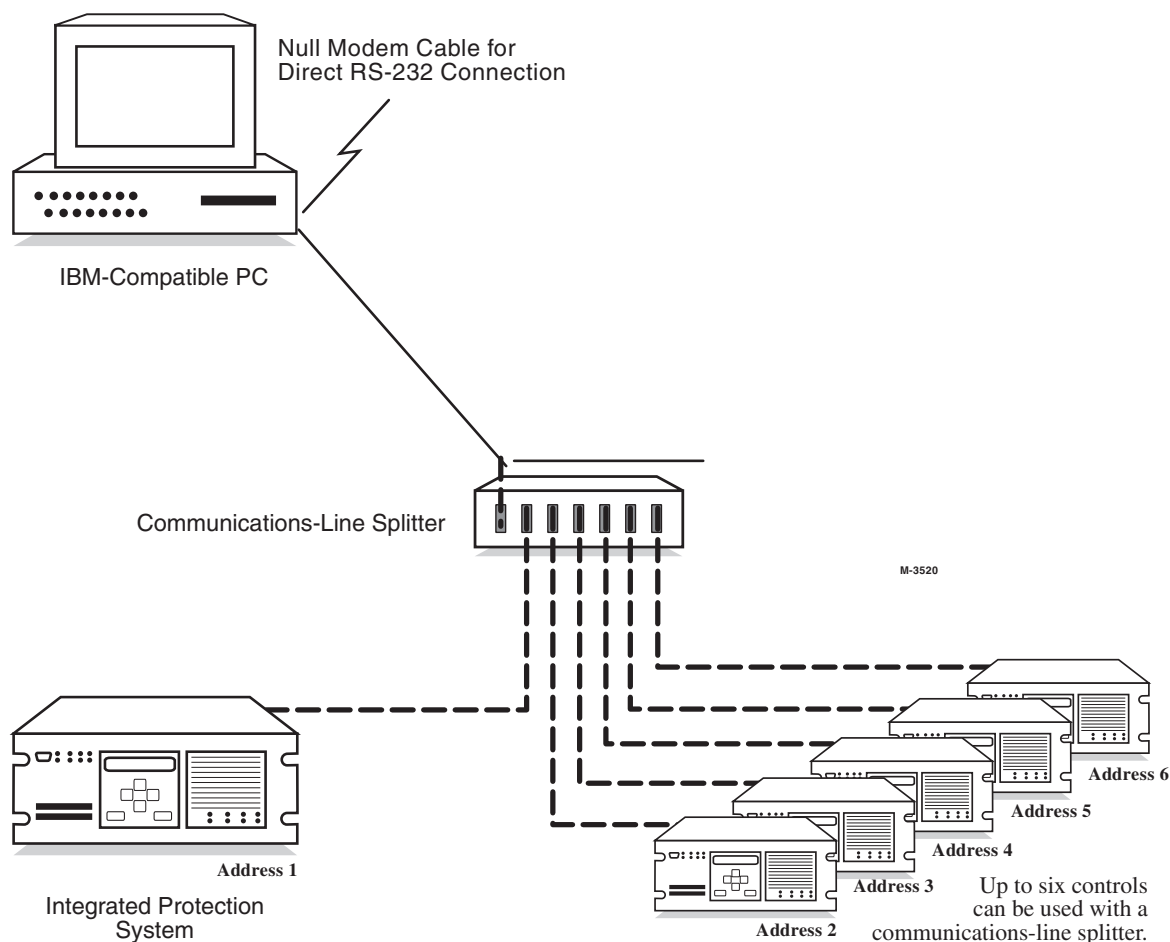
Figure 4-2   Multiple Systems Addressing Using Communications-Line Splitter

4.2   Operation

Activating Communications

After the relay has been set up, the modems initialized, and IPScom installed, communication is activated as follows:

1. Choose the IPScom icon from the Becoware folder.

2. The IPScom splash screen is displayed briefly, providing the software version number and copyright information. This information is also available by choosing the **About**... command from the **Help** menu.

3. Choose the **COMM** menu selection. Complete the appropriate information on the window for the relay to be addressed.

    a. If communication is through a modem, choose the Modem command button to expand the communications dialog box. Choose the desired relay location and choose **Dial** button. This action establishes contact and automatically opens the communication to the relay.

    b. If computer is serially connected through the front port, choose the **Open COM** button. This action establishes communications.

4. Enter any valid IPScom command(s) as desired.

5. To end communication when communicating by modem, choose the **Hang Up** command button from the expanded Communication dialog box. To close the communication channel when connected locally, choose the **Close COM** command button.

▬				IPScom				▼ ◆

File   Comm   Relay   Window   Help

| | | M-3520 | |

Window

Cascade
Tile
Arrange Icons
Close All

User Logo Lines
/ Unit Identifier

Relay Type

Unit Address

File

New
Open...
Close

Save
Save As...
Print
Printer Setup
Exit   Alt+F4

Help

Contents
Using Help
About...

Profile Info

Comm

Choosing the Comm menu sends you directly to the Communication dialog box.
From this dialog box, you have access to the port designation, baud rate, access
code, relay address, leased line identification, speaker volume, phone directory, and
modem dialing functions.

Setup System
Setpoints
Set Date/Time

Relay

Setup   ▶
Monitor   ▶
Targets   ▶
Oscillograph   ▶

Write File to Relay
Read Data From Relay

Primary Status
Secondary Status
Phase Distance
Phasor Diagram
Sync Scope
Out of Step
Function Status

Display
Reset LED
Clear History

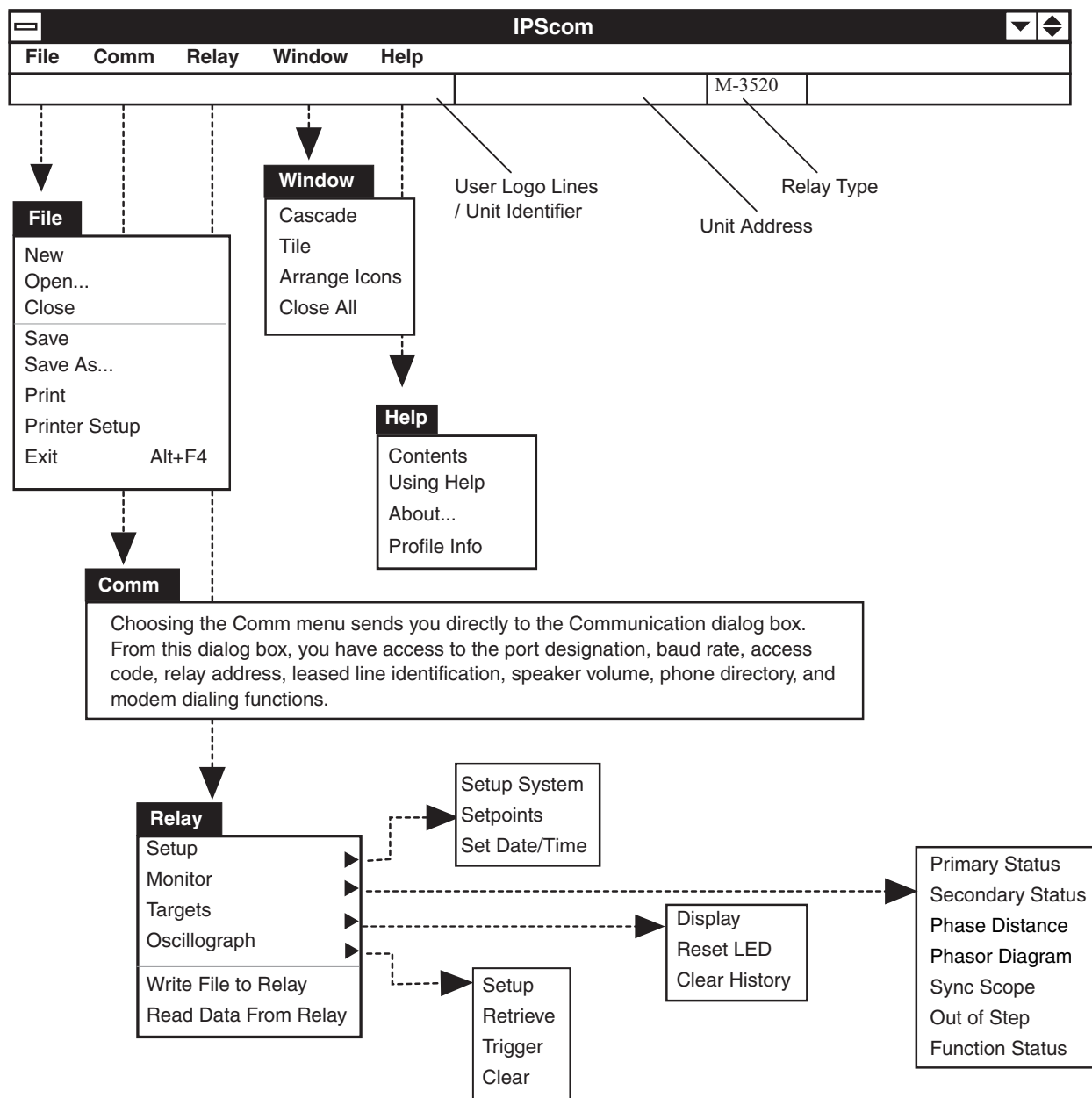Setup
Retrieve
Trigger
Clear

Figure 4-3   IPScom® Menu Selections

Overview

When IPScom is run, a menu and status bar is displayed (as shown below). This section describes each IPScom menu selection and explains each IPScom command in the same order as they are displayed in the software program. For detailed information on each dialog box field (function), refer to Chapter 2, **Application**.

When starting IPScom, the initial menu choices are the **File** menu or the **Comm** menu. The choice specifies whether the operator desires to write to an data file or to communicate directly with the relay.

File Menu

```
File
  New
  Open
  Close
  Save
  Save As...
  Print
  Printer Setup
  Exit              Alt +F2
```
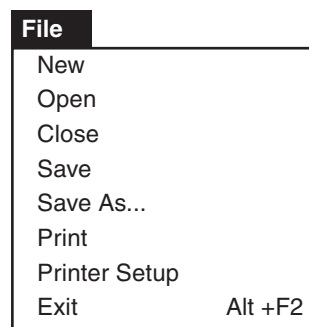
The **File** menu enables the user to create a new data file, open a previously created data file, close, print, and save the file. The IPScom® program can also be exited through the **File** menu.

Since IPScom can be used with several Beckwith protection systems in addition to the M-3520 Intertie Protection Relay, the format and contents of a file must be established depending on which protective system is being addressed. When not connected to one of the protection systems, using the **New** command, a new file is established with the New Device Profile dialog box (see Figure 4-5). Choosing the **OK** command button, allows the new data file to be named by using the **Save** or **Save As**...commands.

■ **NOTE:** By choosing the **New** command, unit and setpoint configuration values are based on factory settings specified for the profiled protection system.
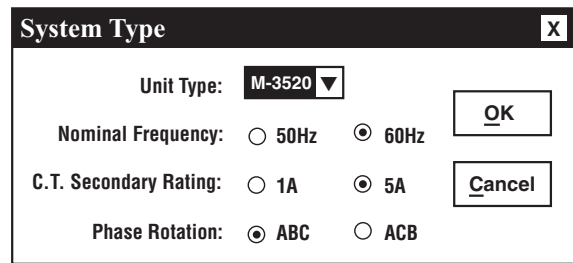


```
System Type                          X
      Unit Type:   [M-3520 ▼]
  Nominal Frequency:  ○ 50Hz    ◉ 60Hz       [ OK ]
 C.T. Secondary Rating: ○ 1A    ◉ 5A
    Phase Rotation:  ◉ ABC    ○ ACB          [ Cancel ]
```

Figure 4-4   New Device Profile Dialog Box

Path: File menu / New command

COMMAND BUTTONS

OK   Saves the currently displayed information.

Cancel   Returns you to the IPScom main window; any changes to the displayed information are lost.

The **Save** and **Save As**... commands allow re-saving a file or renaming a file, respectively. The **Open** command allows opening a previously created data file. With an opened data file, use the **Relay... Setup...** menu items to access the setpoint windows.

If communication can be established with a relay, it is always safer to use the **Read Data From Relay** command (found under the **Relay** menu) to update the PC's data file with the relay data. This file now contains the proper system type information, eliminating the need to set the information manually.

The **Print** and **Printer Setup** commands allow user to select printer options and print out all setpoint data from the data file or directly from the relay, if a relay is communicating with the PC. The **Exit** command quits the IPScom program.

Comm Menu

```
File   Comm   Relay   Window   Help
```

The **Communication** dialog box (see Figure 4-5) allows setup of the IPScom communication data to coordinate with the relay and, by choosing the **Modem** button, establishment of contact for remote locations. 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.

If communication is established through the modem, the **Dial** button should be pressed after the dial string is selected. If necessary, the **Initialize** button can be used to send the initialization string to the modem. If checked, the **Bring Up Terminal Window After Dialing** box provides an advanced

control on modem communications, such as communications where modem switch is involved at the remote site.

If the modem was not used to establish communication, press the **Open COM** button to start. If the relay has been defaulted with the communication access code 9999, a message

window will appear showing access level #3 was granted. Otherwise, another dialog box will appear to prompt the user to enter the access code in order to establish the communication. **Close COM** discontinues communication.
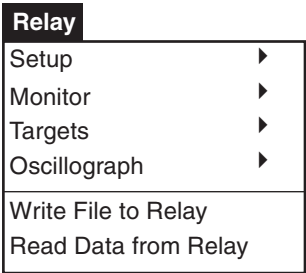

Figure 4-5   Communication Dialog Box

Path: Comm menu

COMMAND BUTTONS

Cancel   Returns you to the IPScom main window; any changes to the displayed information are lost.

Open COM   Initiates contact with the protective system, either by direct serial or modem communication.

Close COM   Breaks communication with the protective system, for both direct serial or modem communication.

Modem   Displays the expanded Communication dialog box.

Add   Displays the Add/Edit dialog box, allowing you to type a protective system's unit identifier, phone number, and communication address.

Edit   Displays the Add/Edit dialog box, allowing you to review and change the user lines (unit identifier), phone number, and communication address of a selected entry.

Delete   Deletes a selected entry.

Initialize   Allows you to send special setup or other AT commands directly to the modem.

Dial   Dials the entry selected from the directory.

Hang Up   Ends modem communication, allowing you to dial again.

Bring up   A built-in terminal window allows an
Terminal   interactive communication with modem
Window   and relay.
After Dialing

Relay Menu

Relay
Setup ▶
Monitor ▶
Targets ▶
Oscillograph ▶
Write File to Relay
Read Data from Relay

The **Relay** menu provides access to the windows used to set, monitor, or interrogate the relay. Four submenus are provided: **Setup, Monitor, Targets** and **Oscillograph** as well as two commands, **Write File To Relay** and **Read Data From Relay**.

Relay	
Setup ▶	Setup System
Monitor ▶	Setpoints
Targets ▶	Set Date/Time
Oscillograph ▶	
Write File to Relay	
Read Data from Relay	
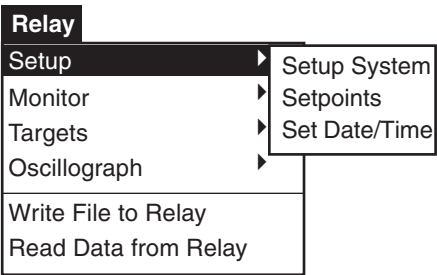
The **Setup** submenu provides three commands: **Setup System**, **Setpoints**, and **Set Date/Time**. The **Setup Relay** command displays a dialog box (see Figure 4-6) which allows the input of pertinent information regarding the system on which the relay is applied (see Section 2.3, Configuration, System Setup).

Figure 4-6   Setup System Dialog Box

Path: Relay menu / Setup submenu / Setup Relay window

SETUP SYSTEM COMMAND BUTTONS

Save   When connected to a protection system, sends the currently displayed information to the unit. Otherwise, saves the currently displayed information.

Cancel   Returns you to the IPScom® main window; any changes to the displayed information are lost.

■ **NOTE:** Checking the inputs for the Active Input Open parameter designates the "operated" state established by an *opening* rather than a closing external contact.

The **Setpoints** command displays the Relay Set-points dialog box (see Figure 4-7) from which the individual relay function dialog boxes can be accessed. Choosing a relay function button (#46, for example), will display the corresponding function dialog box (see Figure 4-8).

Figure 4-7   Relay Setpoints Dialog Box

Path: Relay menu / Setup submenu / Setpoints window

COMMAND BUTTONS

Display All   Opens the All Setpoints Table dialog box.

Configure   Opens the Configure dialog box.

Cancel   Saves the currently displayed information and returns to the IPScom main window.

Figure 4-8   Negative Sequence Overcurrent Setpoint Dialog Box

Path: Relay menu / Setup submenu / Setpoints window/ 46 command button OR 46 jump hotspot within All Setpoints Table or Configure dialog box

COMMAND BUTTONS

Save   When connected to a protection system, sends the currently displayed information to the unit. Otherwise, saves the currently displayed information and returns you to the Relay Setpoints, All Setpoints Table, or Configure dialog box.

Cancel   Returns you to the Relay Setpoints, All Setpoints Table, or Configure dialog box; any changes to the displayed information are lost.

The **Relay Setpoints** dialog box gives access to two additional dialog boxes: **All Setpoints Table** and **Configure**. Choosing the **Display All** command button displays the **All Setpoints Table** dialog box (see Fig. 4-9). This dialog contains a list of settings for each relay within a single window to allow scrolling through all relay setpoint configuration values.

Figure 4-9   All Setpoints Table Dialog Box

Path: Relay menu / Setup submenu / Setpoints window/ Display All command button

JUMP HOTSPOTS

` This window provides you with jump hotspots, identified by the hand icon, that take you to each relay dialog box and the Setup Relay dialog box. Exiting any of these dialog boxes will return you to the All Setpoints Table dialog box.

CONTROL MENU

Close   Returns you to the Relay Setpoints dialog box.

Move   Allows you to reposition the dialog box.

Choosing the **Configure** command button displays a dialog box (see Fig. 4-10), which contains a chart of programmed input and output contacts, in order to allow scrolling through all relay output and blocking input configurations. Both dialog boxes feature hotspots which allow the user to jump from a scrolling dialog box to an individual relay function dialog box and return to the scrolling dialog box again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog box from either scrolling dialog box.
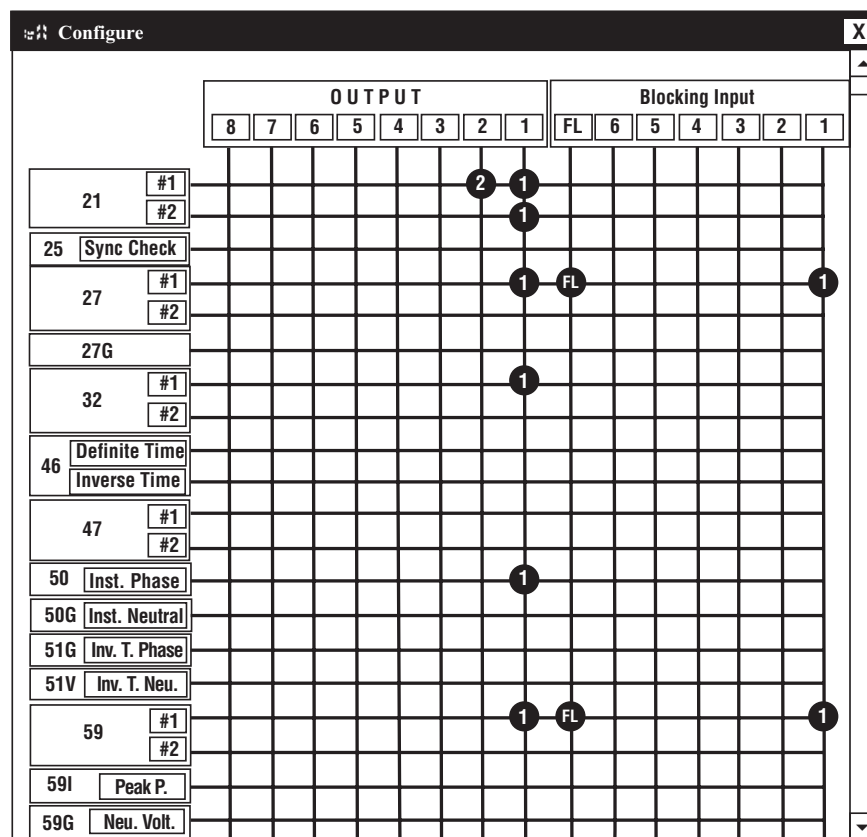
Figure 4-10   Configure Dialog Box

Path: Relay menu / Setup submenu / Setpoints window/ Configure command button

JUMP HOTSPOTS

This window provides you with jump hotspots, identified by the hand icon, that take you to each relay dialog box. Exiting any of these dialog boxes will return you to the Configure dialog box.

CONTROL MENU

Close   Returns you to the Relay Setpoints dialog box.

Move   Allows you to reposition the dialog box.

The **Set Date/Time** command (see Figure 4-11) allows system date and time to be set, or system clock to be stopped. This dialog box also displays an LED mimic to identify when the Sync Check is in use (preventing date/time from being changed by user).

```
┌──────────────────────────────────┐
│                                  │
│       SET UNIT DATE/TIME         │
│                                  │
│      ○ TIME SYNC.                │
│                                  │
│   ┌──────────────────────────┐   │
│   │        Stop Clock        │   │
│   └──────────────────────────┘   │
│                                  │
│  Date:  ┌──┐ ┌──┐ ┌──┐  ▲       │
│         │12│/│25│/│98│  ▼       │
│         └──┘ └──┘ └──┘           │
│                                  │
│  Time:  ┌──┐ ┌──┐ ┌──┐  ▲       │
│         │20│/│01│/│01│  ▼       │
│         └──┘ └──┘ └──┘           │
│                                  │
│   ┌───────────┐  ┌───────────┐   │
│   │   Save    │  │  Cancel   │   │
│   └───────────┘  └───────────┘   │
│                                  │
└──────────────────────────────────┘
```

Figure 4-11   Unit Date/Time Dialog Box

Path: Relay menu/ Setup submenu/ Set Date/Time Command
There is a blue Time Sync LED mimic on this dialog box (the LED is displayed as different shading on a monochrome monitor). When this LED is blue, the relay is synchronized with the IRIG-B signal and the Time field is grayed out, indicating that this field can't be changed. But the Date field can be changed (by editing and pressing **Save**).

When the LED is *not* blue, the relay is not time-synchronized and therefore, both the Date and Time fields can be changed.

The time field in the dialog box is not updated continuously. The time at which the dialog box was opened is the time that is displayed and remains as such. This is true whether the relay is synchronized with the IRIG-B signal or not.

COMMAND BUTTONS

Stop Clock   This toggles between start/stop, the relay clock. 'Stop' pauses, 'Start' resumes.

Cancel   Returns you to the IPScom® main window. Any changes to the displayed information is lost.

The **Monitor** submenu provides access for reviewing the present status of the M-3520's measured and calculated values, other real-time parameters and conditions as well as examining real-time and historical demand metering information (see Section 4.4, Checkout Status/Metering). A cascading menu appears, providing several command options as shown below.

```
┌─────────────────────────────────────────┐
│ Relay                                    │
├─────────────────────────────────────────┤
│ Setup                  ▶                 │
│ Monitor                ▶ ┌──────────────┐│
│ Targets                ▶ │ Primary Status││
│ Oscillograph           ▶ │ Secondary     ││
├──────────────────────────│ Status        ││
│ Write File to Relay      │ Phase Distance ││
│ Read Data from Relay     │ Phasor Diagram ││
│                          │ Sync Scope     ││
│                          │ Out of Step    ││
│                          │ Function Status││
└──────────────────────────└──────────────┘┘
```
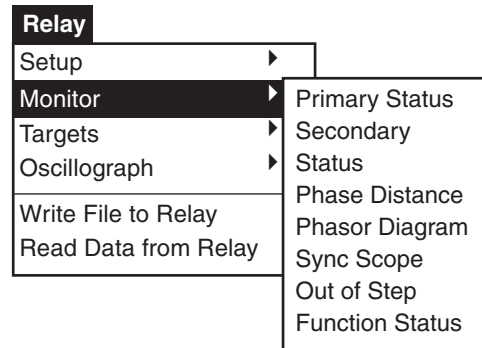
The **Targets** submenu provides three command options: **Display**, **Reset LED**, and **Clear**. The **Display** command displays the **Target** Dialog. This dialog box (see Figure 4-12) provides detailed data on target events, including time, date, function status, phase current values, and IN/OUT contact status at the time of trip. Individually recorded events may be selected within the dialog box and saved into a text file, or be printed out with optional added comments. The **Reset LED** is similar to pushing the **Target Reset** button on the relay's front panel, resetting current target(s) displayed on the relay. This command does not reset any target history.

The **Clear** command clears all stored target data.

Figure 4-13   Setup Oscillograph Recorder

Path: Relay/Oscillograph/Setup
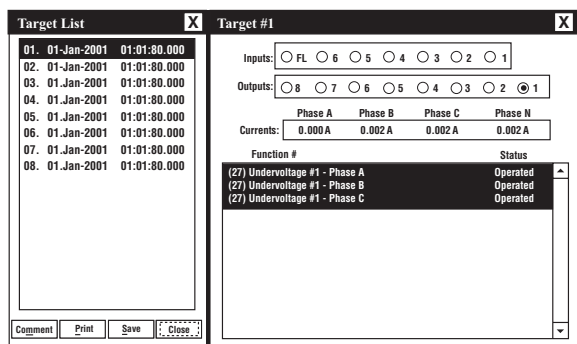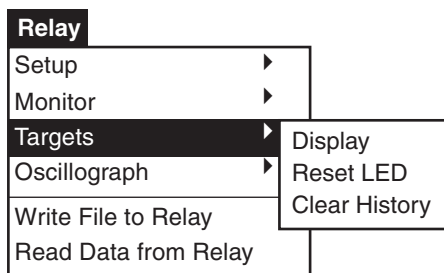
Figure 4-12   Target Dialog Box

Path: Relay menu / Targets submenu / Display command

COMMAND BUTTONS

Comment   Opens comment dialog box for annotation.

Print   Prints out selected target information, with comment.

Save   Saves selected target information, with comment, as a text file.

Close   Exits the currently displayed dialog box.
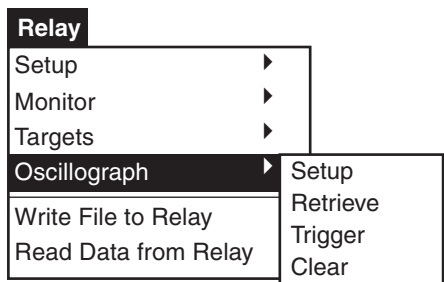
The **Oscillograph** submenu allows user to store data on selected parameters for review and plotting at a later time. The **Setup** command allows the user to set the number of partitions and triggering designations to be made. The **Retrieve** command downloads and stores collected data to a file; **Trigger** allows the manual triggering of the recorder; **Clear** erases the existing record. Run the optional M-3801A IPSplot® Oscillograph Analysis Software program to view the downloaded oscillograph files.

The **Write File To Relay** submenu is used to write the data to the M-3520 relay. The **Read Data From Relay** submenu is used to retrieve the data from the relay to the computer for display.

Window Menu
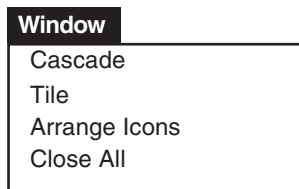
The **Window** menu enables the positioning and arrangement of any all IPScom® windows so that there is better access to available functions. This feature allows the display of several windows at the same time. Clicking on an inactive window activates that window.

Help Menu
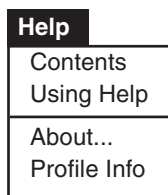
The **Help** menu will enable the user to access information about any IPScom menus or commands. **Contents** and **Using Help** commands are currently unavailable, and will display as greyed out.

The **About...** screen displays IPScom version and development information.

Profile Info allows the user to view or make notations for the relay setpoint data files.

4.3 Cautions

System and IPScom® Compatibility

Every attempt has been made to maintain compatibility with previous software versions. In some cases (most notably with older protection systems), compatibility cannot be maintained. If there is any question about compatibility, contact Beckwith Electric.

System Priority

System conflicts will not occur, as local commands initiated from the front panel receive priority recognition. While the unit is in local mode, communication using the serial ports is suspended. IPScom displays an error message to indicate this fact.

Time and Date Stamping

Time and date stamping of events is only as useful as the validity of the unit's internal clock. Under the **Relay** menu, the **Set Date/TIme** command allows you to manually set the unit's clock.

Echo Cancel

The **Echo Cancel** check box, under the **Comm** menu, 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.

Serial Port Connections

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.

4.4   Checkout Status/Metering
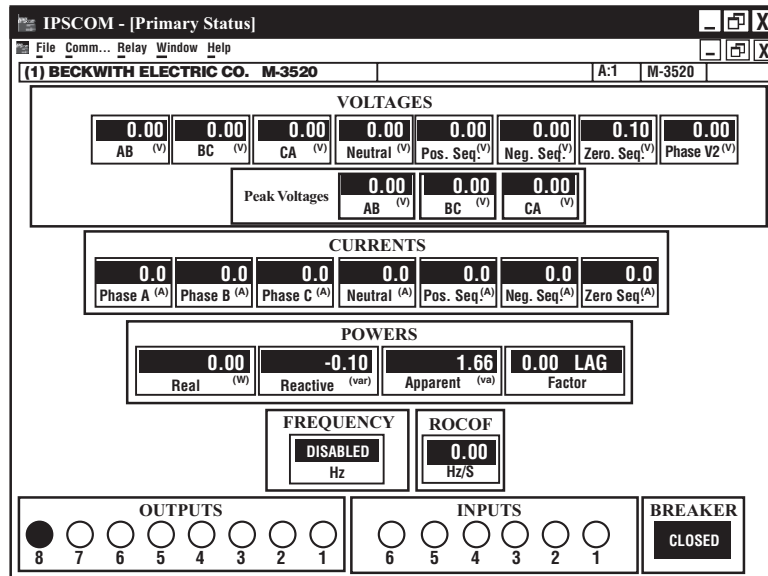
Figure 4-14   Primary Status Dialog Box

Path: Relay menu/Monitor submenu/ Primary Status window

These are calculated values based on the VT and CT inputs.
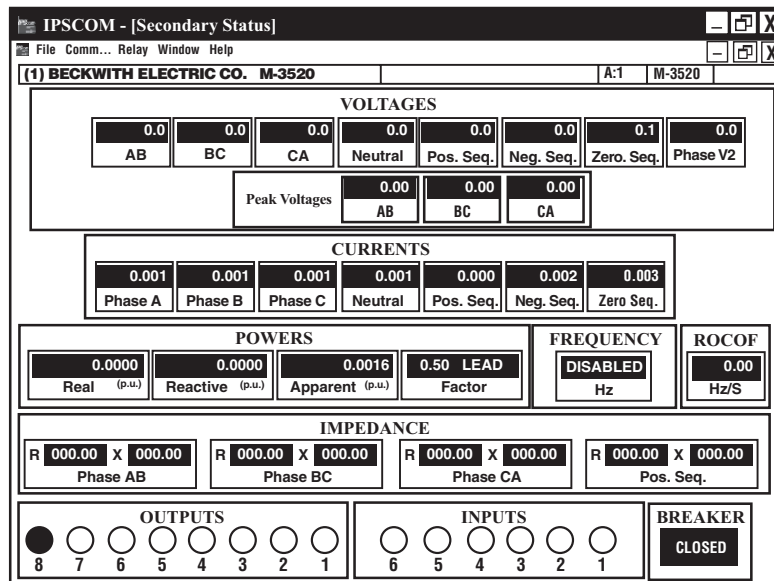
Figure 4-15   Secondary Status Dialog Box

Path: Relay menu / Monitor submenu / Secondary Status window
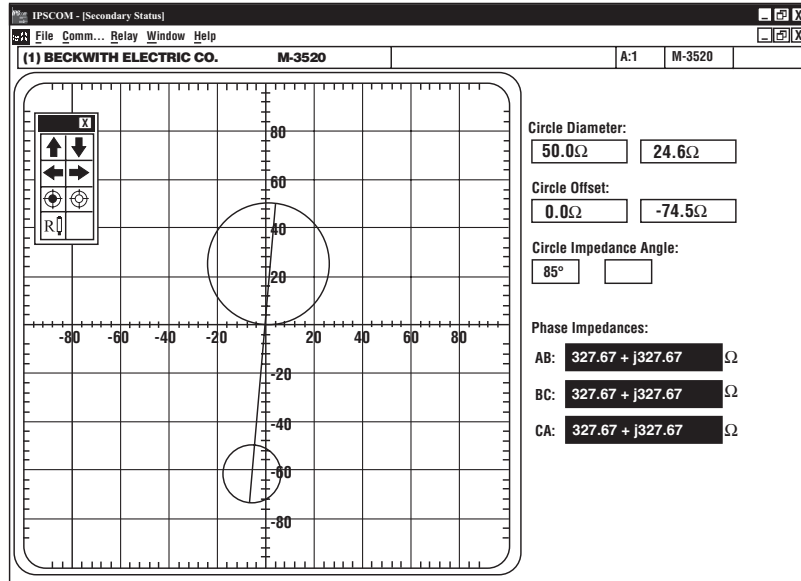
Figure 4-16   Phase Distance Dialog Box

Path: Relay menu / Monitor submenu / Phase Distance window

PHASE DISTANCE CONTROL BUTTONS

⬆   Move up the scope window

⬇   Move down the scope window

⬅   Move the scope window to the left

➡   Move the scope window to the right

⊕   Zoom In

⊕   Zoom Out

R   Refresh
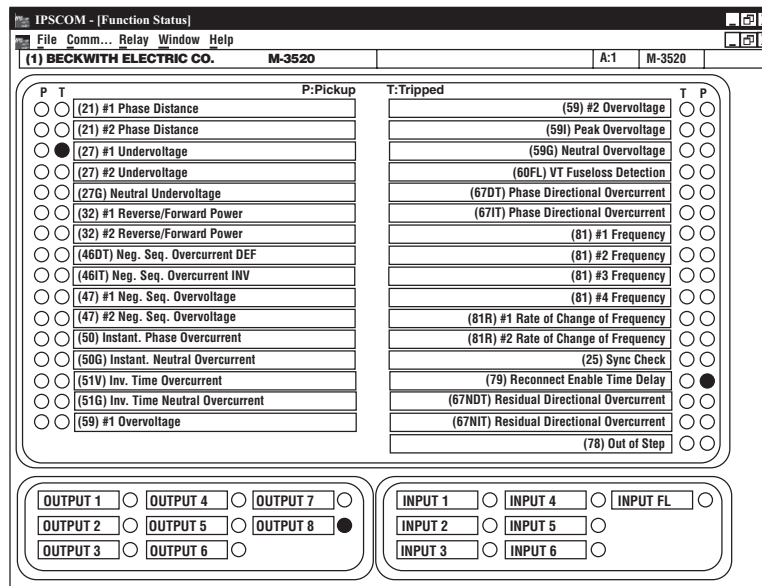
Figure 4-17   Function Status Dialog Box

Path: Relay menu /Monitor submenu / Function Status window

COMMAND BUTTONS

Close   Exits the currently displayed dialog box.

M-3520 Instruction Book
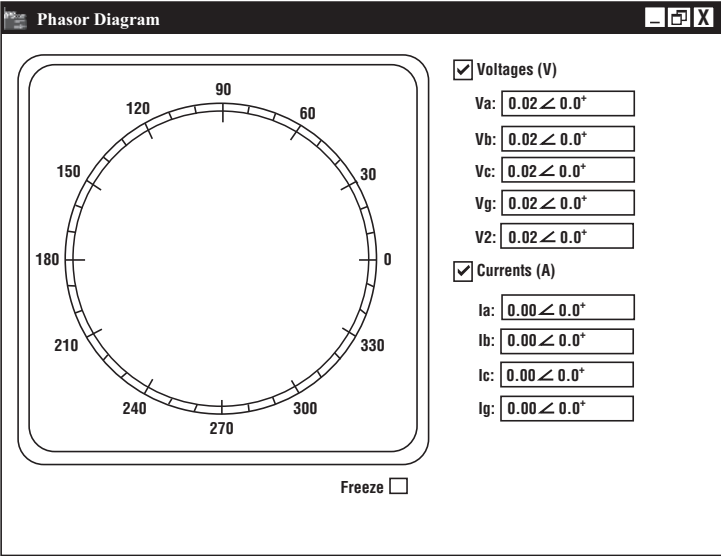
Figure 4-18   Phasor Diagram

Path: Relay menu/Monitor submenu/Phasor Diagram

COMMAND BOXES

Voltage – Select to display voltage signals.

Currents – Select to display current signals

Freeze – When checked, visible data will not be updated.
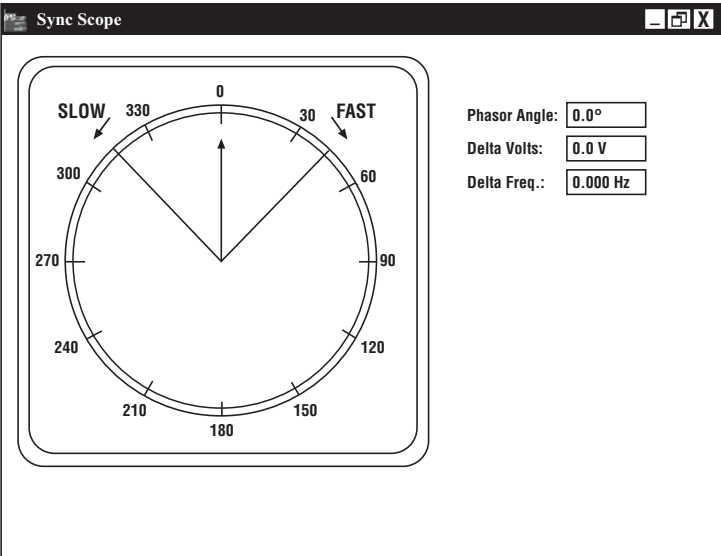
Figure 4-19   Sync Scope Screen

Path: Relay menu/Monitor submenu/Sync Scope
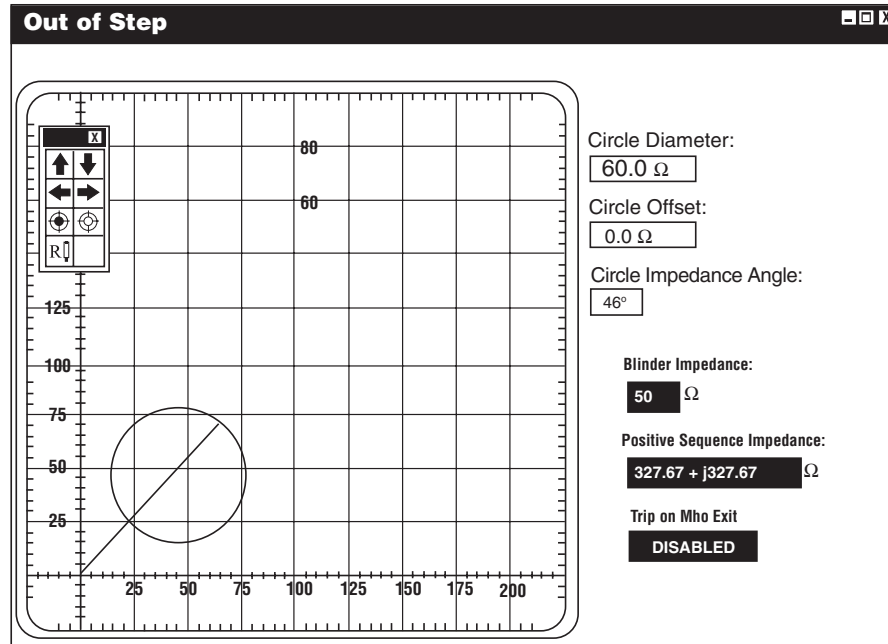
Figure 4-20   Out-of-Step Screen

4.5   Keyboard Shortcuts

Keyboard Shortcuts

SYSTEM KEYS

These keys can be used within Windows and IPScom®.

Alt-Tab	To switch between applications.
Ctrl-Esc	To open Task List dialog box.
Ctrl-Tab	To switch between windows.
Arrow Keys	To select an application or group icon.
First Character of Name	To select application or group icon.
Enter	To open selected group or run selected application.

MENU KEYS

These keys enable you to select menus and choose commands.

Alt or F10	To select or cancel selection of the Setup menu on the menu bar..
Left Arrow, Right Arrow	To move between menus.
Up Arrow, Down Arrow	To move between commands.
A character key	To choose the menu or command. The underlined character matches the one you type.
Enter	To choose the selected menu name or command.
Esc	To cancel the selected menu name, or to close the open menu.

DIALOG BOX KEYS

These keys are useful when working in a dialog box.

Alt-a character key	To move to the option or group whose underlined letter or number matches the one you type.
Arrow Keys	To move highlighted selections within list boxes.
Alt-Down Arrow	To open a list.
Spacebar	To select an item or cancel a selection in a list. Also to select or clear a check box.
Enter	To carry out a command.
Esc or Alt-F4	To close a dialog box without completing the command.

Table 4-1   Windows Keyboard Shortcuts

4.6   IPSutil™ Communications Software
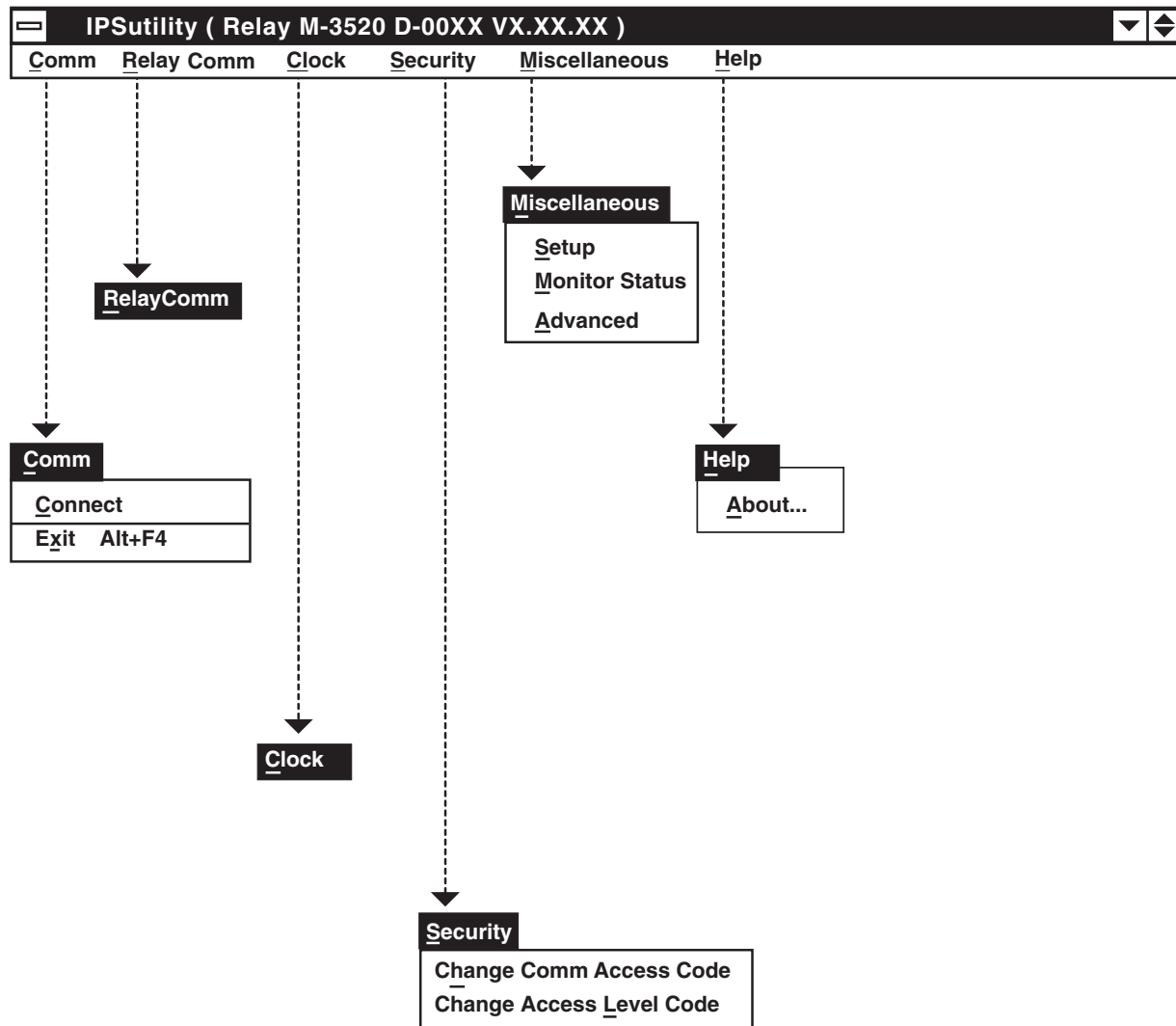
Figure 4-21   IPSutil Main Menu Flow

M-3890 IPSutil™

The M-3890 IPSutil Communication software package provides communication with the Beckwith Integrated Protection System® (IPS) for setting up the relays. Its main purpose is to aid in setting up IPS relays that are ordered without the optional front panel HMI interface.

⬤ **WARNING: The IPScom® and IPSutil programs are distributed on the same disk. The IPSutil program has the capability of overriding the security parameters set in the relay. It is recommended that you remove the IPSutil program from the IPScom disk and file it separately in a safe place, to be used by authorized people. For convenience, Beckwith Electric has distributed both programs on the same disk.**

Installation and Setup

IPSutil runs with the Microsoft® Windows operating system, version 3.1 or above, and is available in the following IBM PC-compatible format:

- one 3.5" double-sided, high-density (DS/HD 1.44 Mb) disk

Hardware Requirements

IPSutil will run on any IBM PC-compatible computer that provides at least the following:

- 8 Mb of RAM
- Microsoft Windows 95 or later
- one 3.5" double-sided, high-density (DS/HD 1.44 Mb) disk drive
- one serial (RS-232) communication port

Installation

An installation utility has been provided as a part of IPScom and IPSutil programs. After installation, the IPSutil can be run from the hard drive by choosing IPSUTIL.EXE.

System Setup

Connect a null modem cable from COM1 of the relay to the PC serial port. IPSutil supports COM1 port direct connection only. Modem connection is not supported. IPSutil program is not supported through COM2 or COM3 ports of the relay.

Overview

IPSutil helps in setting up IPS relays which were ordered without the optional front panel HMI

interface. Units delivered without HMI's are shipped with a set of factory default settings for various parameters that the end user may wish to change. While the utility program is directed to users that do not have HMI, users of HMI-provided relays can also use IPSutil to set various parameters. When the IPSutil is started, a warning window appears (See Figure 4-22).
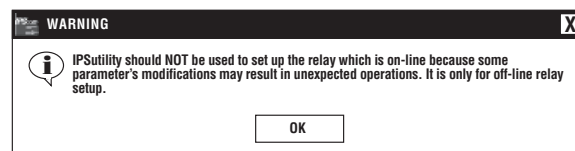
Figure 4-22 Warning Message

After the user accepts the warning, access is granted to the IPSutil main menu.

The following sections describe each IPSutil menu items.

Comm Menu

The **Comm** menu allows the user to connect to the relay. This is the first command that must be used to access the unit. After you click the **Connect** submenu item, the Communications dialog box is displayed (See Figure 4-23).
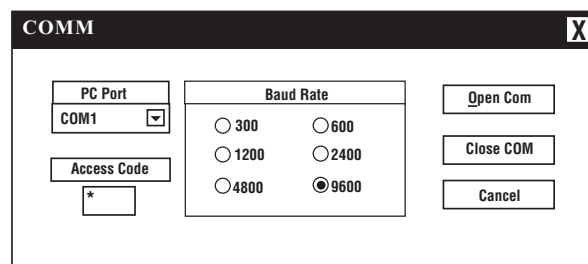
Figure 4-23 Communications Dialog Box

- Select the correct PC communication port where the null modem cable is connected for the relay.
- Select the baud rate of the relay. Factory default is 9600 baud.
- Select the access code resident in the relay. Factory default is 9999.
- Click "Open com" button.

The following message window will appear showing COM opened. Now, the title bar will display the relay model and the software version.

IPSutility **X**

M-3520
Com Opened.

OK

The **Exit** submenu allows you to quit IPSutil™. If the relay was connected, this submenu disconnects the relay. When the relay was connected, if you have made any changes for some parameters (for example, baud rate, phase rotation) the following message window appears.

IPSutility X

(i) Some parameter's changes require resetting the relay to become effective. Do you wish to reset the relay now?

OK   Cancel

Relay Comm

Comm	**Relay Comm**	Clock	Security	Miscellaneous	Help
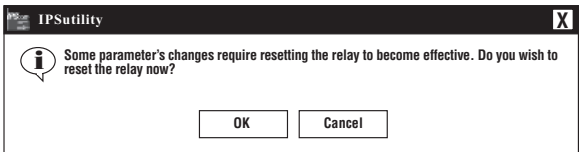
■ **NOTE:** If COM1 baud rate is changed and the relay is reset, the new baud rate must be used to communicate with COM1

When **Relay Comm** menu is selected, the **Relay Comm Port Settings** dialog box appears (See Figure 4-24). It allows you to set the relay communication ports COM1 or COM2/COM3 baud rate. For COM2/COM3, it allows you to set the protocol and dead synch time. Additionally, for COM2 and COM3, if you select MODBUS protocol, the dialog box allows you to enable the parity option.

Relay Comm Port Settings **X**

COM1 Baud Rate: 9600 ▼   **COM2/COM3 Baud Rate:** 9600 ▼

Communication Address: 1

COM2
 Beco 2200 ⦿   **MODBUS** ○
 Dead Sync Time: 50 ms
 1 ms ◄ [   ] ► 3000 ms
 Parity: ○ None ○ Even ○ Odd
 Stop Bits: ○ 1 Bit ⦿ 2 Bits

COM3
 Beco 2200 ⦿   **MODBUS** ○
 Dead Sync Time: 50 ms
 1 ms ◄ [   ] ► 3000 ms
 Parity: ○ None ○ Even ○ Odd
 Stop Bits: ⦿ 1 Bit ○ 2 Bits
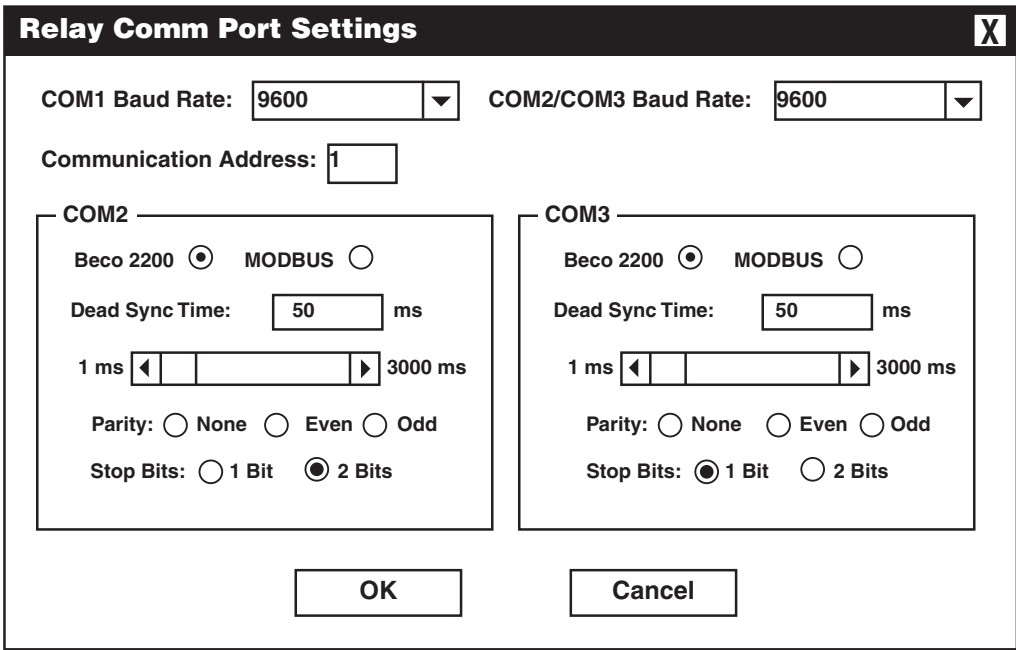
OK   **Cancel**

Figure 4-24   Relay Comm Port Settings

COMMAND BUTTONS

OK   Sends the currently displayed information to the relay.

Cancel   Returns you to the IPSutil main window. Any changes to the displayed information is lost.

Clock

Comm	Relay Comm	**Clock**	Security	Miscellaneous	Help

When the **Clock** menu is selected, the **Set Unit Date/Time** dialog box appears, allowing the user to start or stop the clock in the relay, and change the date or time (See Figure 4-25).

SET UNIT DATE/TIME

○ **TIME SYNC.**

Stop Clock

Date: 12 / 25 / 98 ▲▼

Time: 20 / 01 / 01 ▲▼

Save   Cancel

Figure 4-25   Unit Date/Time Dialog Box

COMMAND BUTTONS

Stop Clock   This toggles between start/stop the clock of the relay. The 'Stop' stops the clock in the relay. The 'Start' resumes the clock in the relay.

Save   When connected to the protection system, the date and time information on the display is sent to the relay.

Cancel   Returns you to the IPSutil main window. Any changes to the displayed information is lost.

There is a blue Time Sync LED mimic on this dialog box (the LED is displayed as different shading on a monochrome monitor). When this LED is blue, the relay is synchronized with the IRIG-B signal and the Time field is grayed out, indicating that this field can't be changed. But the Date field can be changed (by editing and pressing **Save**).

When the LED is *not* blue, the relay is not time-synchronized and therefore, both the Date and Time fields can be changed. The time field in the dialog box is not updated continuously. The time at which the dialog box was opened is the time that is displayed and remains as such. This is true whether the relay is synchronized with the IRIG-B signal or not. IPSutil is fully Y2K compliant.

Security Menu

Security

Change Comm Access Code

Change Level Access Code

The **Security** Menu allows you to set the communication access code and the level access codes for the relay.

■ **NOTE:**   Setting the access code to 9999 disables security.

The **Change Comm Access Code** allows you to assign new communication access code to the relay. The range of the access code is 1 to 9999. Note that the access code 9999 is a factory default. See Figure 4-26.

Change Comm Access Code   X

New Access Code: ****

Confirm New Access Code: ****

OK   Cancel

Figure 4-26   Change Communication Access Code Dialog Box

COMMAND BUTTONS

OK   Sends the currently displayed information to the relay.

Cancel   Returns you to the IPSutil™ main window. Any changes to the displayed information is lost.

The **Change Level Access Code** allows you to assign three different levels of access code for the relay functions accessibility. The range of the level access code is 1 to 9999. See Figure 4-27.

Change Level Access Code ⊠

	Level 1	Level 2	Level 3
New Level Access Code:	****	****	****
Confirm New Level Access Code:	****	****	****
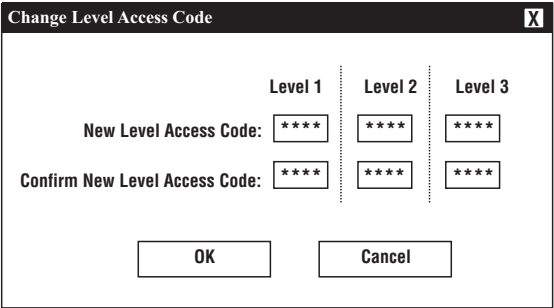
OK   Cancel

Figure 4-27   Change Level Access Code Dialog Box

COMMAND BUTTONS

OK   Sends the currently displayed information to the relay.

Cancel   Returns you to the IPSutil main window. Any changes to the displayed information is lost.

Miscellaneous Menu

Miscellaneous

Setup
Monitor Status
Calibration
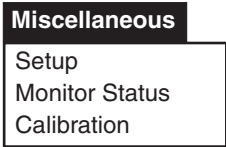
The **Miscellaneous** menu allows you to set and monitor some of the relay parameters.

The **Setup** feature (Figure 4-28) allows the user to change the Logo information, test outputs, assign communication address and user control number, phase rotation, **OK** LED flash mode in the relay. Note that the highest number used for the communication address is 255 and the highest control number allowed is 9999.

SETUP ⊠

User Logo

Line1:   BECKWITH ELECTRIC CO.

Line2:   M-3520

Output Test (Relay)

	8	7	6	5	4	3	2	1
OFF	◉	◉	◉	◉	◉	◉	◉	◉
ON	○	○	○	○	○	○	○	○

User Control Number: 1

OK LED Flash: ◉ Enable   ○ Disable

Phase Rotation: ◉ ABC   ○ ACB
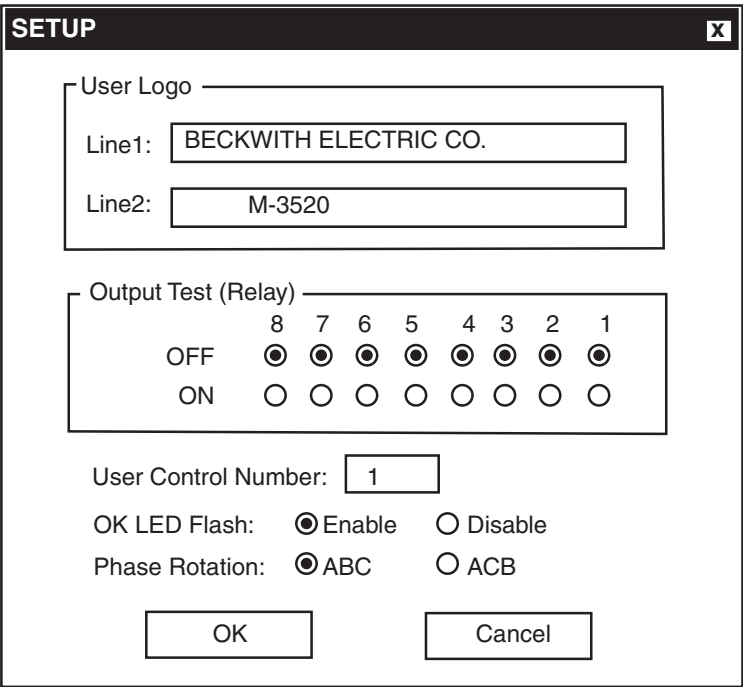
OK   Cancel

Figure 4-28   Setup Dialog Box

COMMAND BUTTONS

OK   Sends the currently displayed information to the relay.

Cancel   Returns you to the IPSutil main window. Any changes to the displayed information is lost.

5 Installation

5.1   General Information

■ **NOTE:** Prior to installation of the equipment, it is essential to review the contents of this manual to locate important data that may be of importance during installation procedures. The following is a quick review of the contents in the chapters of this manual.

It is suggested that terminal connections illustrated herein be transferred to station one-line wiring and three-line connection diagrams, station panel drawings and station DC wiring schematics.

If during the commissioning of the relay, additional tests are desired, refer to Chapter 6, **Testing**.

The operation of the M-3520 Intertie Protection Relay, including the initial setup procedure, is described in Chapter 3, **Operation (Front Panel)**. If the relay is not provided with an HMI module, refer to Chapter 4, **Operation (Computer).**

Section 3.1, Front Panel Controls, describes the front panel controls, and Section 3.2, Initial Setup Procedure/Settings describe the HMI setup procedure. The procedures contain specific instructions for entering the communications data, unit setup data, configure relay data, individual setpoints and time settings for each function, and oscillograph recorder setup information. A similar setup can be performed using IPScom® and IPSutil™ software packages.

5.2   Mechanical/Physical Dimensions

Figures 5-1 through 5-4 contain physical dimensions that may be required for mounting the unit to a rack.
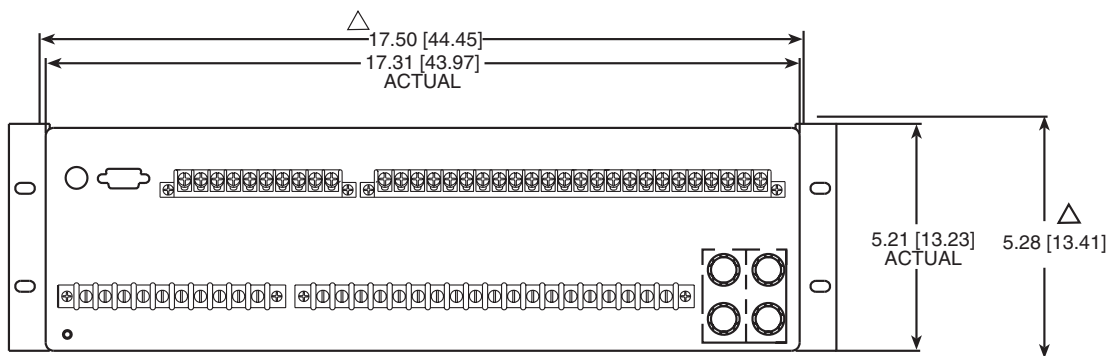
17.50 [44.45]

17.31 [43.97]
ACTUAL

5.21 [13.23]
ACTUAL

5.28 [13.41]

Rear View

△ RECOMMENDED CUTOUT WHEN RELAY IS
NOT USED AS STANDARD RACK MOUNT

10.20 [25.91]

19.00
[48.26]

18.58 [47.19]

17.78 [45.16]

0.40 [1.02] x 0.27 [0.68] SLOT (4x)

2.35 [5.96]

1.35 [3.42]
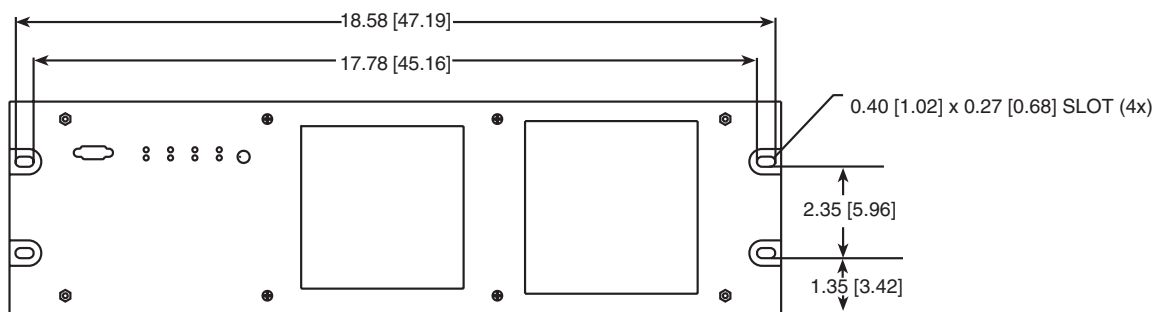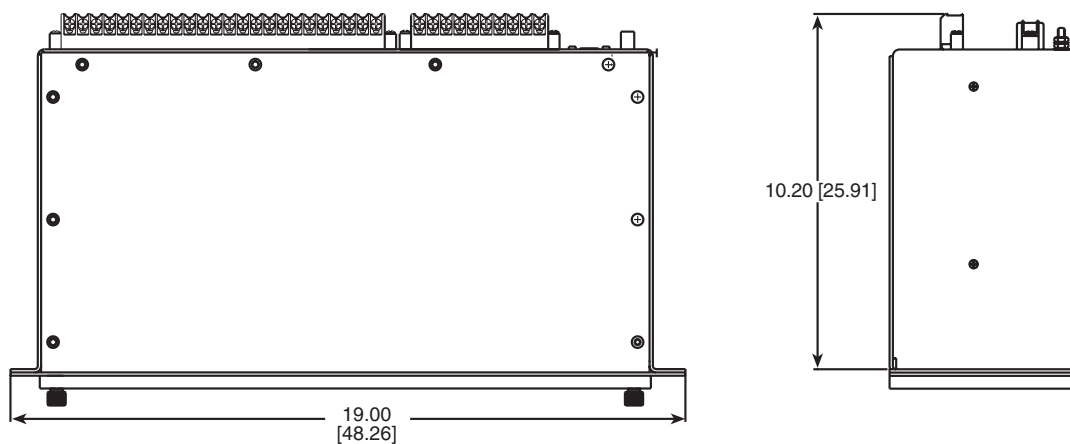
Standard 19" Horizontal Mount Chassis

■ **NOTE**: Dimensions in brackets are in centimeters.

Figure 5-1   M-3520 Mounting Dimensions – Horizontal Chassis
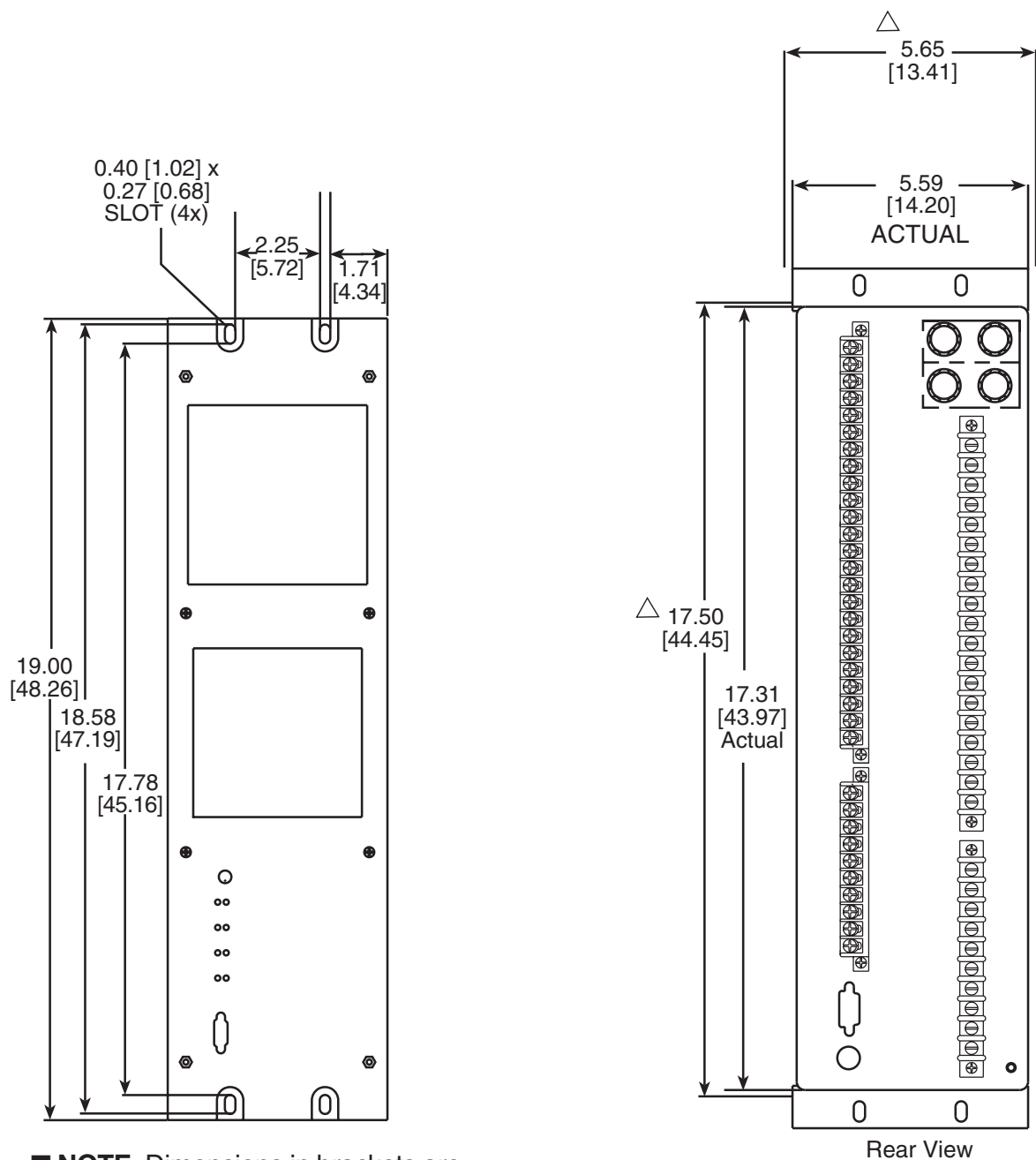
0.40 [1.02] x
0.27 [0.68]
SLOT (4x)

2.25
[5.72]

1.71
[4.34]

5.65
[13.41]

5.59
[14.20]
ACTUAL

19.00
[48.26]

18.58
[47.19]

17.78
[45.16]

17.50
[44.45]

17.31
[43.97]
Actual

■ **NOTE**: Dimensions in brackets are in centimeters.

Rear View

△ RECOMMENDED CUTOUT WHEN RELAY IS
NOT USED AS STANDARD RACK MOUNT

Optional Vertical Mount Chassis

Figure 5-2   M-3520 Mounting Dimensions – Vertical Chassis

.39
[0.99]

1.91
[4.85]

2.25
[5.71]

.261 [0.66]
Diameter
4 Holes

8.72
[22.15]

Recommended
Panel Cutout
Dimensions

18.21
[46.25]

19.00
[48.26]

2.80
[7.12]

2.80
[7.12]

8.72
[22.15]

***Max. Depth
of Unit:***
10.50
[26.67]

6.19
[15.72]

■ **NOTE:** Dimensions in
brackets are in centimeters.

Front View
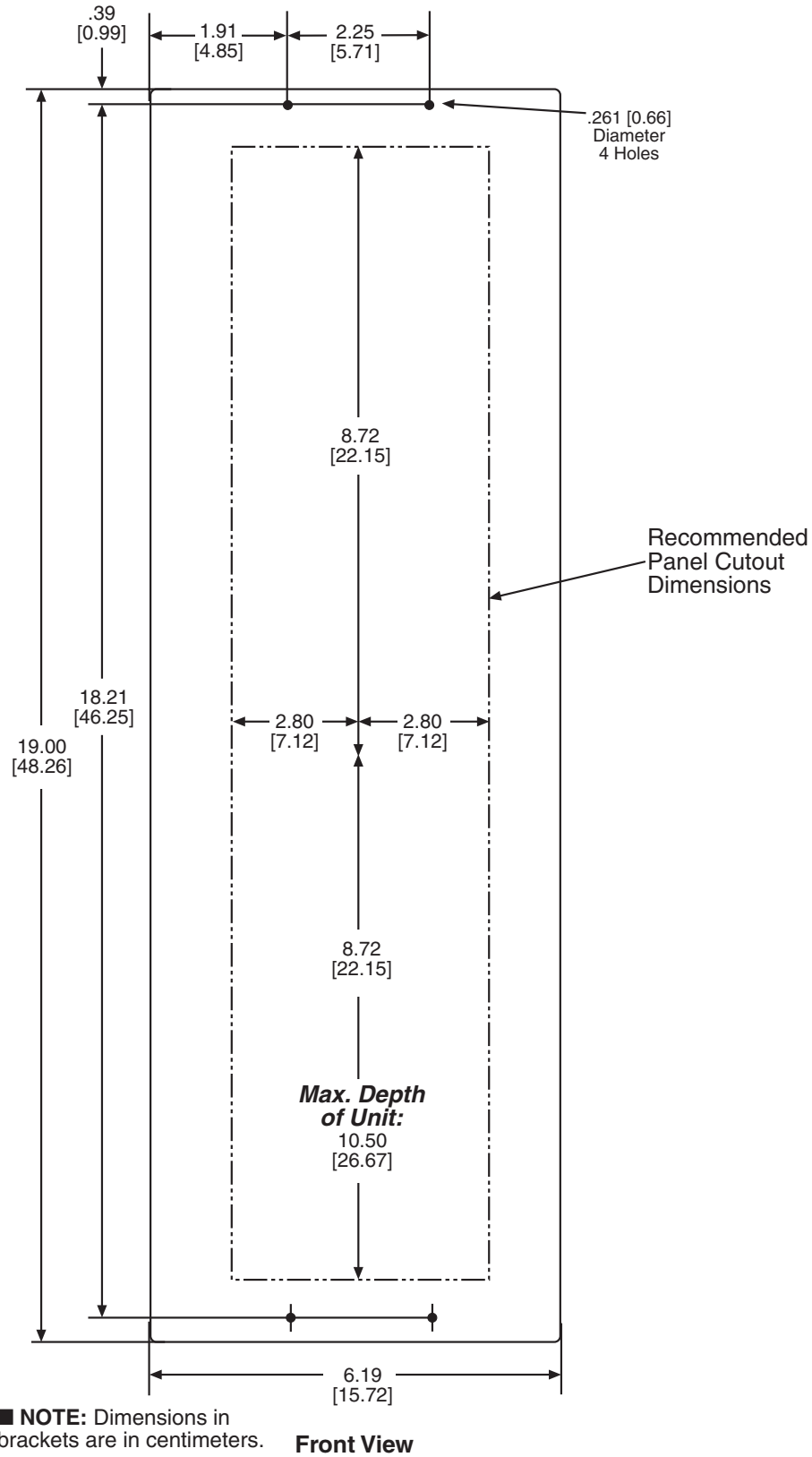
Figure 5-3 (H2) Mounting Dimensions

.75

6.13
[15.57]

1.04
[2.64]

5.56
[14.12]

.261 [0.66]
Diameter
6 Holes

8.72
[22.15]

Recommended
Panel Cutout
Dimensions

18.50
[46.99]

2.80
[7.12]

2.80
[7.12]

20.78
[52.78]

15.56
[39.52]

8.72
[22.15]

7.78
[19.76]

*Max. Depth
of Unit:*
10.50
[26.67]

2.60
[6.60]

1.14

7.63
[19.38]

Front View

■ **NOTE**: Dimensions in brackets
are in centimeters.
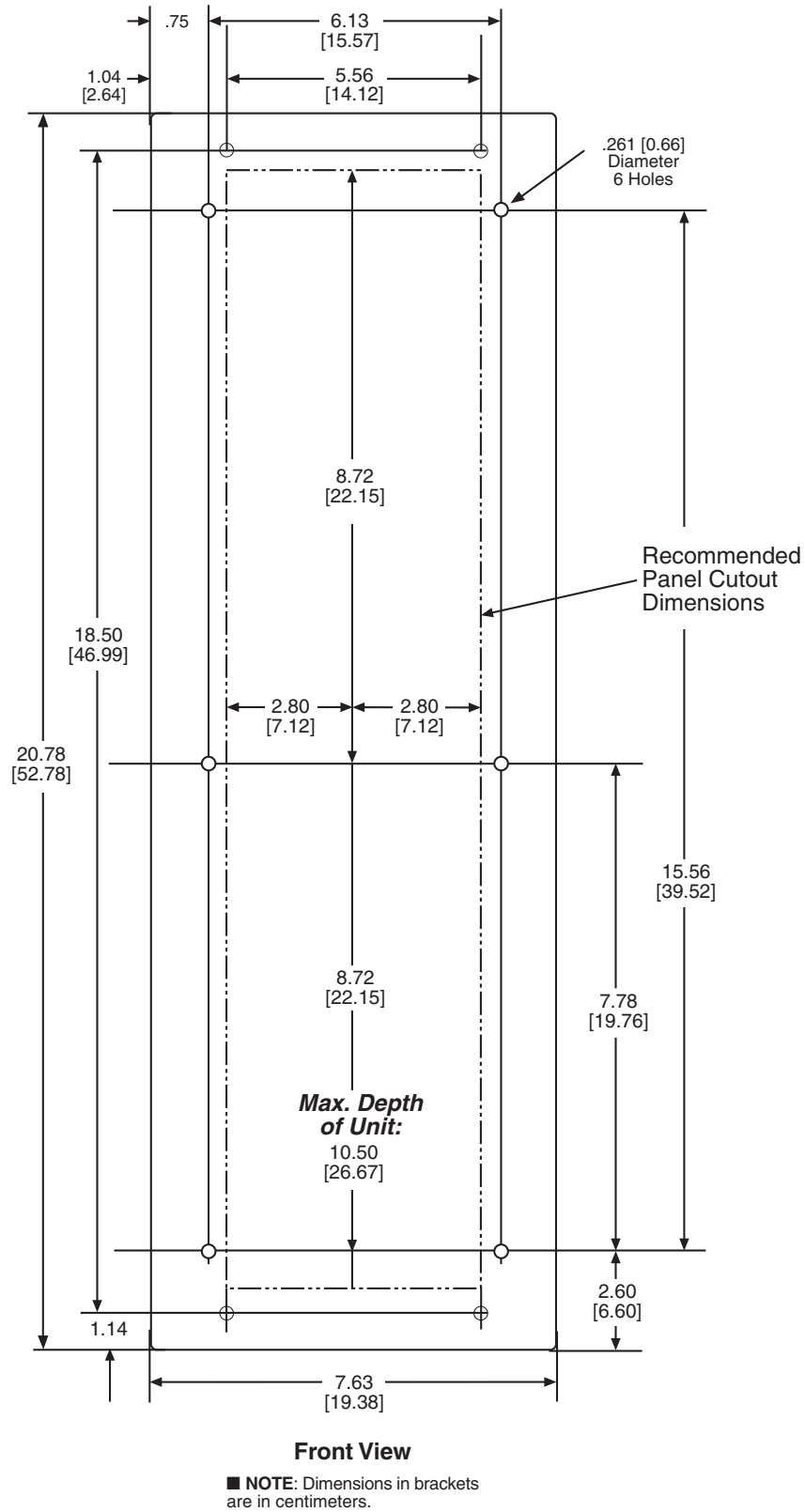
Figure 5-4   (H3) Mounting Dimensions for GE L-2 Cabinet

5.3   External   Connections

Figure 5-5 provides an explicit view of all the external contacts, com-munications points, and power fuses of the M-3520 Intertie Protection Relay.

■ **NOTE**:   Output contacts #1 through #4 are high-speed operation contacts. To fulfill UL and CSA requirements, terminal block connections must be made with No. 12 AWG solid or stranded copper wire inserted in an AMP #324915 or equivalent. The screws attaching the connector must be tightened to 8-inch pounds torque. Only dry contacts may be connected to **INPUTS** (terminals 5 through 10, with 11 common), because these contact inputs are internally wetted.

▲ **CAUTION:** Application of external voltages to the INPUT terminals may result in damage to the unit.
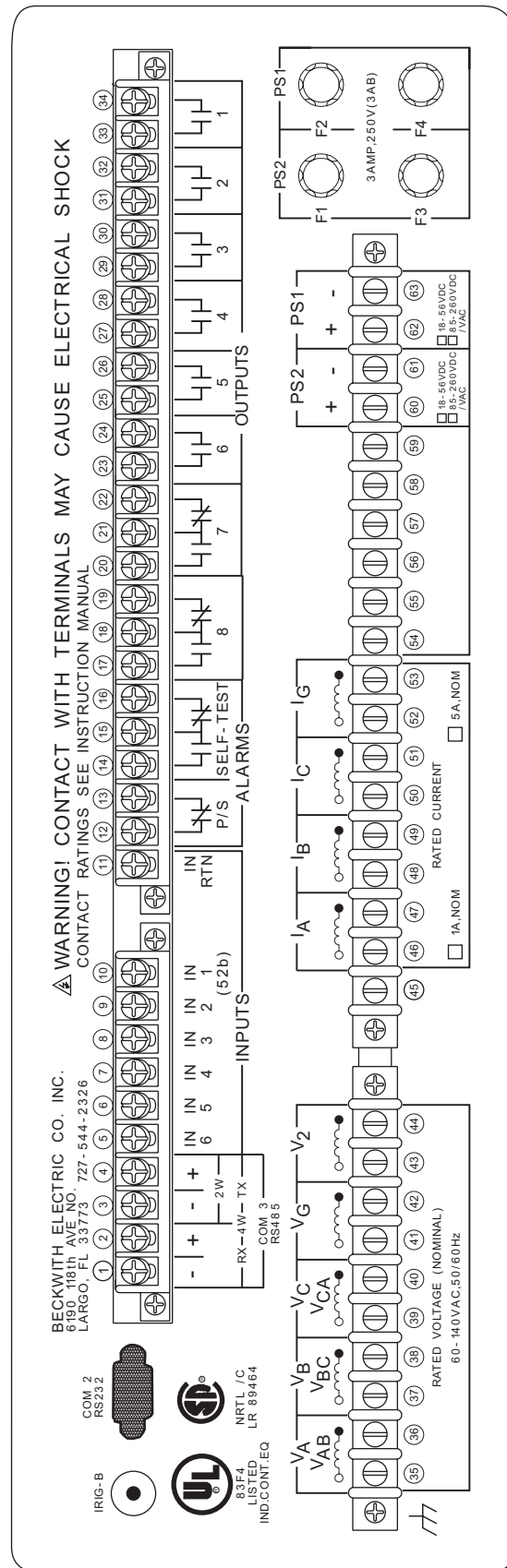
Figure 5-5   External   Connections

M-3520 Typical Three-line Connection Diagram
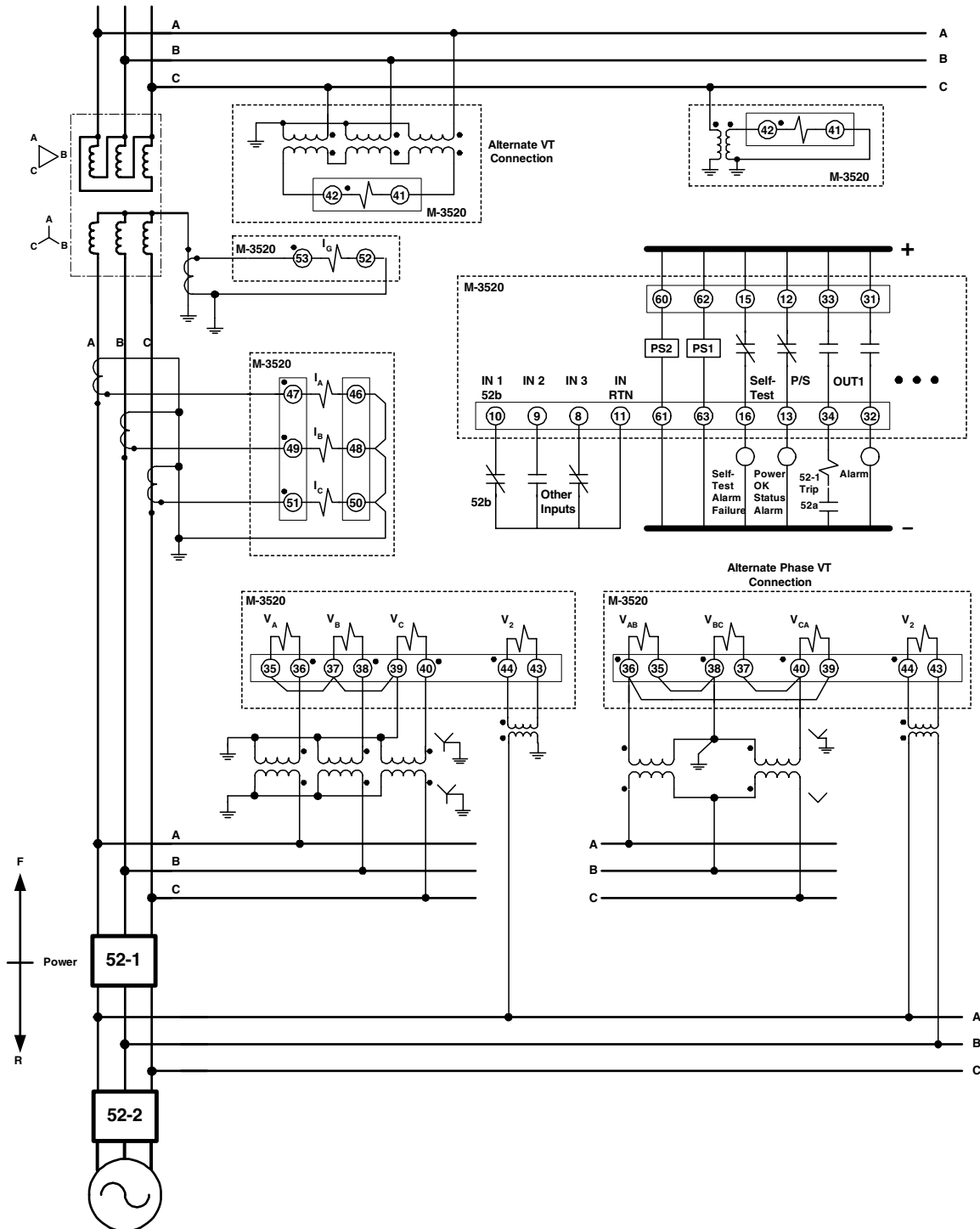
Figure 5-6   Three-Line Connection Diagram

5.4 Commissioning Checkout

During field commissioning, perform the following procedure to ensure that the CT and VT connections are correct.

1. On the keypad, press **ENTER**. After a short delay, the unit should display:

```
VOLTAGE RELAY
VOLT curr freq pwr →
```

2. Press the right arrow button until the unit displays:

```
STATUS
← config sys STAT →
```

3. Press **ENTER**. The unit should display:

```
VOLTAGE STATUS
VOLT curr freq powr      →
```

4. Press **ENTER** to display the phase voltages. The unit should display either $V_A V_B, V_C$, for line-to-ground connections or V_{AB}, V_{BC}, V_{CA}, for line-to-line connections). Use a voltmeter to compare these actual measurements. If there is a discrepancy, check for loose connections to the rear terminal block of the unit.

```
PHASE VOLTAGE
AB=     BC=     CA=
```

5. Press **ENTER** to display the peak phase voltage.

```
PEAK PHASE VOLTAGE (PU)
AB=    BC=     CA=
```

6. Press **ENTER** to display the neutral voltage. Neutral voltage should be $V_N=0$ Volts

```
NEUTRAL VOLTAGE
_____ Volts
```

7. Press **ENTER** to display V2 phase voltage.

```
PHASE VOLTAGE (V2)
_____ Volts
```

8. Press **ENTER** to display positive sequence voltage. The positive sequence voltage should be $V_{POS} \approx V_A \approx V_B \approx B_C \approx$ or $V_{AB} \approx V_{BC} \approx V_{CA}$.

```
POS SEQUENCE VOLTAGE
_____ Volts
```

9. Press **ENTER** to display negative sequence voltage. The negative sequence voltage should be $V_{NEG} \approx 0$.

```
NEG SEQUENCE VOLTAGE
_____ Volts
```

10. Press ENTER to display zero sequence voltage. The zero sequence voltage should be $V_{ZERO} \approx 0$.

```
ZERO SEQUENCE VOLTAGE
_____ Volts
```

■ **NOTE:** If negative sequence voltage shows a high value and positive sequence voltage is close to zero, the phase sequence may be incorrect. Proper phasing must be achieved to obtain proper readings. If phase sequence is incorrect, frequency related functions will not operate properly and the **FREQUENCY STATUS** menu will read **DISABLED**.

If positive, negative and zero sequence voltages are all present, check the polarities of VT connections and correct the connections to obtain proper polarities.

11. Press **EXIT**. The unit will display:

```
VOLTAGE STATUS
VOLT curr freq powr →
```

12. Press the right arrow once, so that the unit displays:

```
CURRENT STATUS
volt CURR freq powr →
```

13. Press **ENTER** to display line currents (I_A, I_B, I_C). Compare these currents with the measured values using a meter. If there is a discrepancy, check the CT connections to the rear terminal block of the unit. The unit should display:

```
PHASE  CURRENT
A=       B=        C=
```

14. Press **ENTER** for the unit to display neutral current. The neutral current should be near zero amperes.

```
NEUTRAL  CURRENT
_____  Amps
```

15. Press **ENTER** for the unit to display positive sequence current. The positive sequence current should be $I_{POS} \approx I_A \approx I_B \approx I_C$.

```
POS SEQUENCE  CURRENT
_____  Amps
```

16. Press **ENTER** for the unit to display negative sequence currents. Negative sequence current should be near zero amperes.

```
NEG SEQUENCE  CURRENT
_____  Amps
```

17. Press **ENTER** for the unit to display the zero sequence currents. The zero sequence should be $I_{ZERO} \approx 0.00$. If there is a significant amount of negative or zero sequence (greater than 25% of I_A, I_B, or I_C) then either the phase sequence or the polarities are incorrect. Modify connections to obtain proper phase sequence and polarity.

```
ZERO SEQUENCE  CURRENT
_____  Amps
```

18. Press **EXIT** for the unit to display :

```
CURRENT  STATUS
volt CURR freq powr  →
```

19. Press right arrow button once so that unit displays:

```
FREQUENCY  STATUS
volt curr FREQ powr  →
```

20. Press **ENTER** to display the nominal system frequency:

```
FREQUENCY  BUS 1
60.00 Hz
```

21. Press **ENTER** for the unit to display the rate of change frequency:

```
RATE OF CHANGE FREQUENCY
_____  Hz/Sec
```

22. Press **EXIT** for the unit to display

```
FREQUENCY  STATUS
volt curr FREQ powr  →
```

23. Press right arrow button once so that unit displays:

```
POWER  STATUS
volt curr freq POWR  →
```

24. Press **ENTER** to display real power and verify the correct polarity. The polarity should be positive for forward power and negative for reverse power. If the readings do not agree with actual conditions, check the polarities of the three low end CT's and /or the PT's and the CT and PT ratios.

```
REAL  POWER
_____  PU      _____  W
```

25. Repeat steps for the remaining metering quantities.

```
REACTIVE  POWER
_____  PU _____  VAr
```

```
APPARENT  POWER
_____  PU _____  VA
```

```
POWER  FACTOR
_____  Lag/Lead
```

5.5 Circuit Board Switches and Jumpers

JUMPER	POSITION	DESCRIPTION
J5	A to B	Demodulated IRIG-B TTL Signal on Pin 6
	B to C	Modulated IRIB-B signal BNC (Default Setting)
*J10 (200 ohm RS485/422 Termination Resistor)	A to B	Resistor Inserted (Terminated)
	B to C	COM3 Resistor Not Connected (Standby) (Default Setting)
J46	A to B	COM3 shares baud rate with COM1.
	B to C	COM3 shares baud rate with COM2(Default Setting)
*J58	A to B	Receiver continuously enabled.
	B to C	Receiver Disabled while transmitting. (Default Setting)
J60	A to B	Connects CD signal to Pin 1 of COM2 connector (Default Setting)
	B to C	Connects +15 V to Pin 9 of COM2 connector external
J61	Inserted	Connections -15 V to Pin 9 of COM2 connector external.
	Removed	Disconnects Pin 9 of COM2 connector (Default Setting) COM device

* Jumpers 10 and 58 are only available when the RS-485, 4-wire option is purchased.

Table 5-1 Jumper Settings

SWITCH POSITIONS				DESCRIPTION
1	2	3	4	**Switches should not be changed while power is applied to unit**
U	X	X	X	Up for dual Pwr Supply, down for single
	X			Not functional on M-3520
X	X	U	U	Run Mode
X	X	U	D	Factory Use Only
X	X	D	U	Initialize access codes and communication parameters to default values*.
X	X	D	D	Calibrate*,**
* Power down, set switch, then power up. After power up, the RELAY OKLED light remains off and DIAG LED will light lwhen operation has been satisfactorily completed. ** Power down, adjust, connect reference inputs, power up.				

Table 5-2 Switch Positions

Dip
Switch

J 46

J 5

J 10

J 58

J 60

J 61
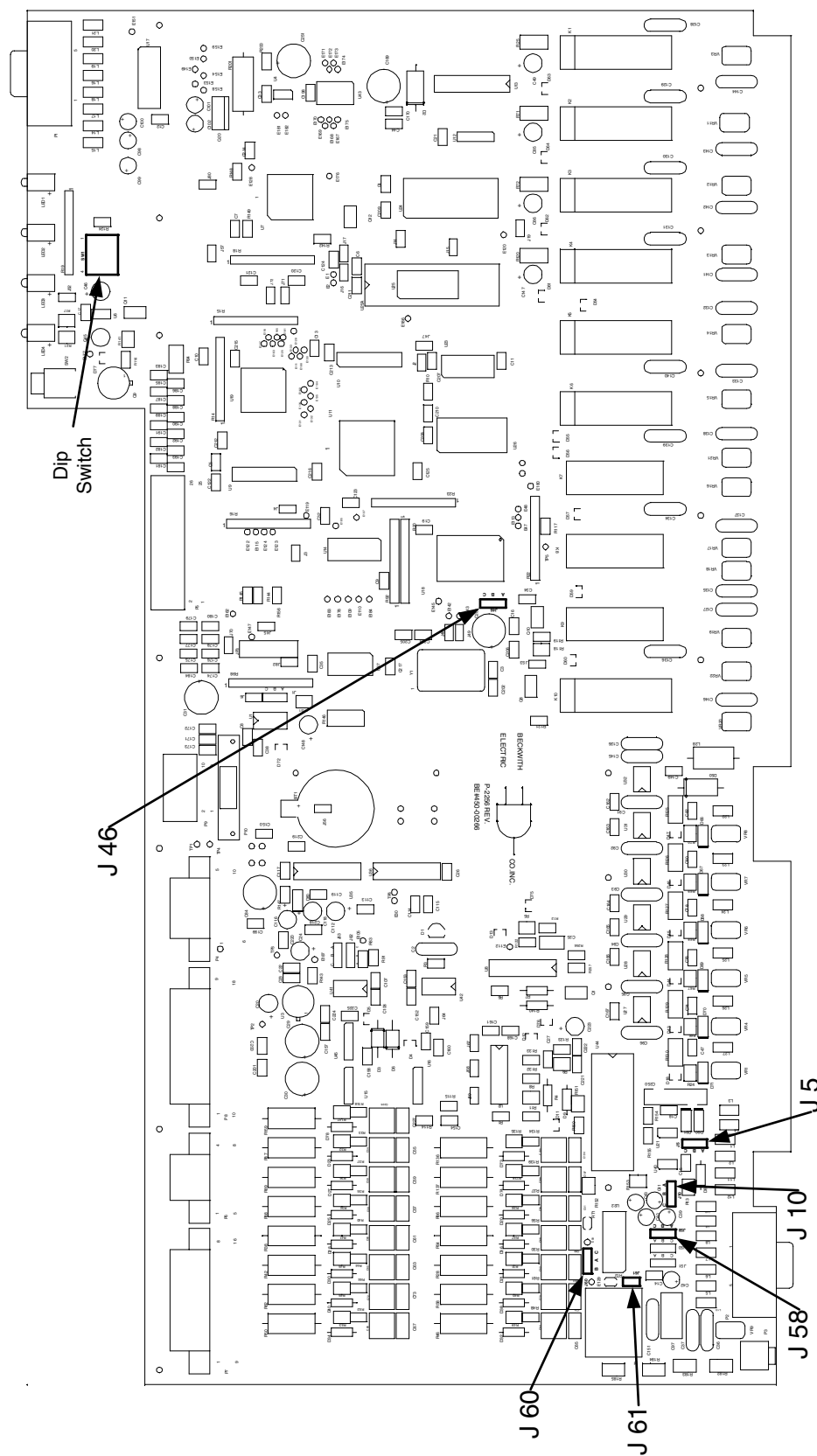
Figure 5-7   M-3520 Circuit Board

5–12

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6 Testing

6.1   Equipment and Test Setup

The M-3520 Intertie Protection Relay has been calibrated and fully tested at the factory. If calibration is necessary because of component replacement, follow the Auto-Calibration Procedure described in Section 6.3.

Automatic Calibration

■ **NOTE**:   If necessary, refer to Figures 6-2, 6-3, and 5-4 for reference to the **HMI** and **TARGETS** controls and LEDs, and rear connections.

Required Equipment

The following equipment is required to carry out the test procedures:

- Two Digital Multi-meters (DMM) with a 10 Amp current range. These are not required if using a Pulsar Universal Test System.

- One power supply for the relay, capable of supplying 120 V ac or 125 V dc for units with high voltage power supplies, or 24 V dc for units with Low Voltage power supplies.

- One 3-phase voltage source capable of 0 to 250 V ac. (Pulsar Universal Test System or equivalent.)

- One 3-phase current source capable of 0 to 25 Amps. (Pulsar Universal Test System or equivalent.)

- Electronic timer with a minimum accuracy of 8 ms. (Pulsar Universal Test System or equivalent.)

■ **NOTE:** A single-phase frequency tester may be used: 48 to 59.99 Hz for 60 Hz units; 38 to 49.99 Hz for 50 Hz units

Equipment Setup

▲ **CAUTION:** The proper voltage range for the relay is clearly marked underneath each of the power supply inputs.

1.   Connect power to the relay's power input terminals 62 and 63. The M-3520 may be configured with a high voltage power supply with a nominal voltage input of 110/120 /230/240 V ac or 110/125/220/ 250 V dc. The relay is also available with a low voltage power supply with nominal voltage input of 24/48 V dc, and a redundant power supply, which is available as an option.

2.   Connect the voltage and current inputs for each test procedure according to the configuration included with each test description and follow the outlined steps. It is recommended to disable any functions that may operate while performing tests on a particular function.

3.   Table 6-1 identifies the functions to disable.

FUNCTION BEING TESTED	FUNCTION TO DISABLE																				
	21	25	27	27G	32	46	47	50	50G	51V	51G	59	59I	59G	60FL	67	67N	78	79	81	81R
21															✓						
25			✓				✓					✓	✓							✓	
27		✓													✓				✓		
27G														✓					✓		
32			✓					✓		✓		✓	✓		✓				✓		
46								✓		✓									✓		
47			✓									✓							✓		
50										✓											
50G											✓										
51V								✓								✓					
51G																					
59															✓				✓		
59I												✓							✓		
59G				✓															✓		
60FL		✓			✓														✓		
67					✓		✓	✓		✓		✓									
67N			✓				✓	✓		✓		✓									
78	✓	✓								✓									✓		
79																					
81												✓							✓		✓
81R												✓							✓	✓	

Table 6-1   Functions to Disable When Testing

6.2   Diagnostic Test Procedures

The diagnostic procedures perform basic functional tests to verify the operation of the relay's front panel controls, LEDs, input and outputs, and communication ports. These tests are performed in diagnostic mode, which is entered in the following manner:

■ **NOTE:** The Diagnostic Mode is intended for bench testing the relay only. Do not use the diagnostic mode in relays that are installed in an active protection scheme.

For units with the optional HMI panel:

1. Press **ENTER** to begin main menu.

2. Press the right arrow button until **SETUP UNIT** appears in the top line of the display.

3. Press **ENTER** to access the **SETUP UNIT** menu.

4. Press the right arrow button until **DIAGNOSTIC MODE** appears in the display.

5. Press **ENTER**. A reset warning appears:

```
PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE
```

● **WARNING: ALL RELAY FUNCTIONS AND PROTECTION WILL BE INOPERATIVE WHILE THE RELAY IS IN DIAGNOSTIC MODE.**

6. Press **ENTER**. Unit will now reset and **DIAGNOSTIC MODE** will be temporarily displayed, followed by **OUTPUT TEST** (RELAY). This is the beginning of the diagnostic menu.

7. When testing in **DIAGNOSTIC MODE** is complete, press **EXIT** until the following message appears:

```
PRESS EXIT TO
EXIT DIAGNOSTIC MODE
```

8. Press **EXIT** again to exit **DIAGNOSTIC MODE**. The relay will reset and normal running mode will resume.

■ **NOTE**: Pressing any button other than **EXIT** will return the user to **DIAGNOSTIC MODE.**

Output Test (Relay)

The first step in testing the operation of the function outputs is to confirm the positions of the outputs in the unoperated or **OFF** position. This can be accomplished by connecting a DMM across the appropriate contacts and confirming open or closed contacts. The de-energized or **OFF** positions for each output is listed in Table 6-2, Output Contacts

Relay/Output Number	Normally Open Contact*		Normally Closed Contact	
1	33	34	N/A	N/A
2	31	32	N/A	N/A
3	29	30	N/A	N/A
4	27	28	N/A	N/A
5	25	26	N/A	N/A
6	23	24	N/A	N/A
7	21	20	21	22
8	18	17	18	19
9 (Self-Test)	15	14	15	16
10 (Power Supply)	N/A	N/A	13	12

"Normal" position of the contact corresponds to the OFF or de-energized state of the relay.

Table 6-2   Output Contacts

For units with optional HMI panel:

Enter Diagnostic Mode as previously outlined. Following completion of testing, the output contacts, can be turned **ON** in the following manner:

1. Press **ENTER**. The following is displayed:

```
RELAY NUMBER
      1
```

2. Press **ENTER**. The following is displayed:

```
RELAY NUMBER 1
     OFF on
```

3. Use the right button to highlight **ON** in uppercase letters, which signifies selection. The following is displayed:

```
RELAY NUMBER 1
     off ON
```

4. Press **ENTER**. **Output Relay #1** will energize. The following is displayed:

```
RELAY NUMBER
      1
```

5. Choose output numbers 2–8 by using the up and down arrow buttons to turn all relays or outputs to the energized or **ON** position. When each output is turned on, the appropriate **OUTPUT** LED turns on and stays on.

6. Use the DMM to verify the position of the output contacts in the "operate" or **ON** position. The readings should be the opposite of the initial reading above. All outputs should be returned to their initial de-energized or **OFF** positions. The **OUTPUT** LED's will extinguish when each output is turned off.

7. If Output Relay testing is complete, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Input Test (Status)

The **INPUT TEST** menu enables the user to determine the status of the individual status inputs.

For units with optional HMI panel:

Each input can be selected by its number using the up and down buttons. The status of the input will then be displayed.

INPUT NUMBER	RETURN TERMINAL	INPUT NUMBER
1 (52b)	11	10
2	11	9
3	11	8
4	11	7
5	11	6
6	11	5

Table 6-3   Input Contacts

1. When **OUTPUT TEST (RELAY)** is displayed press the right arrow to display the following:

```
INPUT TEST
output INPUT led target →
```

2. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
            1
```

3. Press **ENTER**. The following is displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

4. Connect **IN RTN**, terminal #11, to IN1, terminal #10.

5. Alternatively, if the input in step 4 above is being used in this application and external wiring is complete, the actual external status input contact can be manually closed. This will test the input contact operation *and* the external wiring to the input contacts. The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT CLOSED
```

6. Disconnect **IN RTN**, terminal #11, from **IN1**, terminal #10. The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

7. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
            1
```

8. Use the up button to go to the next input. Repeat the procedure using the contacts as shown in Table 6-3, Input Contacts.

9. When finished, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Status LED Test

The **STATUS LED TEST** menu enables the user to check the front panel LED's Individually.

Figure 6-1   Status LED Panel

For units with the optional HMI panel:

1. When **INPUT TESTS (STATUS)** is displayed, press the right arrow button until the following is displayed:

```
STATUS LED TEST
output input LED target →
```

2. Press **ENTER**. LED #1, **RELAY OK**, illuminates and the following is displayed:

```
STATUS LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for each of the 5 remaining LED's shown in Figure 6-1. The PS1 and PS2 LED's are not subject to this test.

4. When **STATUS LED** testing is complete, press **EXIT** to return to **DIAGNOSTIC MODE**.

Target LED Test

■ **NOTE:** This test is not applicable to units that are not equipped with the M-3915 Target Module.

The **TARGET LED TEST** menu allows the user to check the M-3915 Target Module LEDs individually.
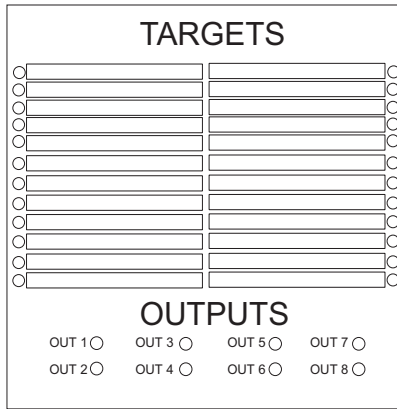
Figure 6-2 M-3915 Target Module

For units with the optional HMI panel:

1. When **STATUS LED TEST** is displayed, press the right button until the following is displayed:

```
TARGET LED TEST
output input LED target→
```

2. Press **ENTER**. Target LED #1 illuminates and the following is displayed:

```
TARGET LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for each of the remaining target and output LED's shown in Figure 6-2.

4. When **TARGET LED** testing is complete, press **EXIT** to return to **DIAGNOSTIC MODE**.

Expanded I/O Test

This function is not implemented at this time.

Button Test

■ **NOTE:** This test is only applicable to units that are equipped with the M-3931 HMI Module.

The **BUTTON TEST** menu selection allows the user to check the M-3931 HMI Module Keypad. As each button is pressed, its name is displayed.
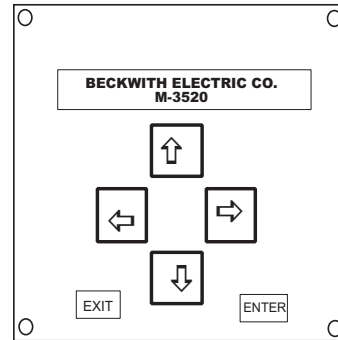
Figure 6-3 M-3931 Human-Machine Interface Module

1. When the **TARGET LED TEST** is displayed, press the right button until the following is displayed:

```
BUTTON TEST
← ex_io BUTTON disp →
```

2. Press and hold **ENTER**. The following is displayed:

```
BUTTON TEST
ENTER
```

3. Release **ENTER**. The following is displayed:

```
BUTTON TEST
     0
```

4. Repeat this test for each of the buttons on the keypad and the **TARGET RESET** button.

5. Press **EXIT** to exit from test.

■ **NOTE:** The **EXIT** button should be tested last. Notice the word **EXIT** is displayed temporarily before the test sequence is terminated.

Display Test

■ **NOTE:** This test is only applicable to units that are equipped with the M-3931 HMI Module.

The **DISPLAY TEST** menu selection enables the user to check the alphanumeric display. This test cycles through varying test patterns until the **EXIT** button is pressed.

1. When **BUTTON TEST** is displayed, press the right arrow button until the following is displayed:

```
SCREEN TEST
← ex_io button DISP →
```

2. Press **ENTER**. The unit will display a sequence of test characters until the **EXIT** button is pressed.

3. After the test has cycled completely through the characters, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Communication Tests

■ **NOTE:** These tests are only applicable to units that are equipped with the M-3931 HMI Module.

COM1 and COM2 Test

The **COM1** and **COM2 LOOPBACK TESTS** allow the user to test the front and rear RS-232 ports for proper operation. These tests require the use of a loop-back plug (see Figure 6-4).

The loop-back plug consists of a DB9P connector, with pin 2 connected to pin 3 and pin 7 connected to pin 8.

M-3520
COM1/COM2
DB9P

```
          1
RX      2 ┐
TX      3 ┘
          4
SGND    5
          6
RTS     7 ┐
CTS     8 ┘
          9
```
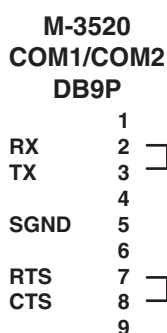
Figure 6-4   COM1/COM2 Loopback Plug

1. When **DISPLAY TEST** is displayed, press the right arrow button until the following is displayed:

```
COM1 LOOPBACK TEST
← COM1 com2 com3 com3 →
```

2. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loopback plug to **COM1**.

4. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
    19200 PASS...
```

5. Press **ENTER** to test each of the baud rates. When all baud rates have been tested, press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
       -DONE-
```

6. Press the right arrow until the following is displayed:

```
COM2 LOOPBACK TEST
← com1 COM2 com3 com3 →
```

7. Repeat steps 2-5 to test **COM2**.

COM3 Test (2-Wire)

The **COM3 ECHO TEST 2WIRE** allows the user to test the RS-485 rear terminal connections for proper operation.

■ **NOTE:** This test requires a PC with an RS-485 converter and terminal emulator software installed.

1. When **COM3 LOOPBACK TEST 4WIRE** is displayed, press the right arrow button until the following is displayed:

```
COM3 ECHO TEST 2WIRE
← com1 com2 com3 COM3 →
```

2. Press **ENTER**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
IDLING....9600, N, 8, 1
```

3. On the rear of the unit, connect a PC to the relay at terminals 3 (-) and 4 (+) using an RS-485 converter set for 2 wire operation. See Figure 6-5 for diagram.
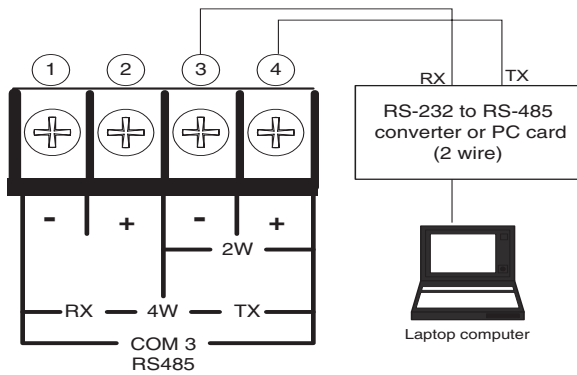
Figure 6-5 RS-485 2-Wire Testing

4. Set the following PC communications parameters:

Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
Duplex	Half

5. Open the terminal emulator program on the PC and open the COM port for the RS-485 converter.

6. Press a key on the PC keyboard. Verify that the character pressed shows temporarily on the display of the relay and appears on the PC monitor.

7. When communications has been verified, press **EXIT**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
     -DONE-
```

8. Close the COM port on the PC and exit the terminal emulator program.

COM3 Test (4-Wire)

■ **NOTE:** This test is only applicable to units that have the RS-485 4-Wire option installed.

The **COM3 LOOPBACK TEST 4WIRE** allows the user to test the RS-485 rear terminal connections for proper operation.

1. When **DISPLAY TEST** is displayed, press the right button until the following is displayed:

```
COM3 LOOPBACK TEST 4WIRE
← com1 com2 COM3 com →
```

2. Press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST 4 WIRE
CONNECT LOOPBACK PLUG
```

3. On the rear of the unit, connect a jumper from terminal 1 to terminal 3 and from terminal 2 to terminal 4. See Figure 6-6 for diagram.
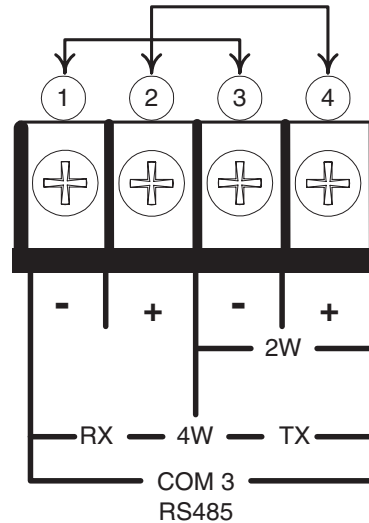
Figure 6-6 RS-485 4-Wire Testing

4. Press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST
     19200 PASS...
```

5. Press **ENTER** to test each of the baud rates. When all baud rates have been tested, press **ENTER**. The following is displayed:

```
COM3 LOOPBACK TEST
     -DONE-
```

Clock Test

1. When **COM3 ECHO TEST 4WIRE** is displayed, press the right arrow button until the following is displayed:

```
CLOCK TEST
← CLOCK led cal factory
```

2. Press **ENTER**. A display similar to the following is shown:

```
CLOCK TEST
03-JAN-1998 09:00:00.000
```

3. Press **ENTER** again to toggle the clock. If the clock is running, it will stop. If clock has stopped, it will start. The clock stop case is shown below.

```
CLOCK TEST
      -CLOCK START-
```

4. Press **ENTER** and verify the relay clock is running. A display similar to the following is shown with the seconds counting:

```
CLOCK TEST
03-JAN-1998 09:0035.000
```

5. Press **ENTER** again to stop the clock. The following is displayed:

```
CLOCK TEST
 -CLOCK STOP-
```

6. Press **ENTER** and verify the relay clock is stopped. A display similar to the following is shown with the seconds stopped:

```
CLOCK TEST
03-JAN-1998 09:01:80.000
```

■ **NOTE:** When the relay clock is stopped the seconds will be displayed as 80. If the unit is removed from service or is to be without power for long periods of time, the clock should be stopped to preserve battery life.

7. Repeat steps 2 and 3 to restart the clock.

Flash Relay OK LED

The **Flash Relay OK LED** function is provided to enabled or disable the flashing of the **Relay OK LED**. This function only has effect while the relay is in normal operating mode and will not be noticed while in **Diagnostic Mode**.

The operation of this function may be tested by completing the following steps:

1. When **CLOCK TEST** is displayed, press the right arrow button until the following is displayed:

```
FLASH RELAY OK LED
← clock LED cal factory
```

2. Press **ENTER**. The following is displayed:

```
FLASH RELAY OK LED
off    ON
```

■ **NOTE:** Please be advised that programming the **OK** LED to remain on indefinitely is not recommended. It is possible that the LED OK would remain lit even if the relay failed.

Factory Use Only

This function is provided to allow access by factory personnel.

```
FACTORY USE ONLY
← clock led cal FACTORY
```

6.3   Automatic Calibration

The relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to installation. Recalibration is only necessary if a component was changed.

For units with the optional M-3931 HMI:

⬤ WARNING: ALL RELAY FUNCTIONS AND PROTECTION WILL BE INOPERATIVE WHILE THE RELAY IS IN DIAGNOSTIC MODE

    1.   Navigate to the **Auto Calibration** function in the **Diagnostic Mode** menu. The following is displayed:

```
AUTO CALIBRATION
← clock led CAL factory
```

    2.   Press **ENTER**. The following is displayed:

```
CONNECT REFERENCE INPUTS
PRESS ENTER TO CALIBRATE
```

    3.   Connect all voltage inputs in parallel (V_A= V_B=V_C= V_2) and apply 120.00 (±0.01) V AC s0°. See Figure 6-7.

    4.   Connect all current inputs in series (I_A=I_B=I_C=I_N) and apply 5.00 (±0.01) Amps s0°. See Figure 6-8. For 1 Amp CT models, use 1.0 (±0.01) Amps s0°.

    5.   Press **ENTER** to start calibration. This process takes less than 5 seconds. The unit will display the following while the automatic calibration is in progress:

```
AUTO CALIBRATION
       -WAIT-
```

    6.   When the unit has completed calibration, the following will be displayed:

```
AUTO CALIBRATION
       -DONE-
```

    7.   The calibration can be checked by using the **Monitor Status** menu, see Section 3.3, **Checkout Status/Metering**.

For units without the optional M-3931 HMI:

It is possible to auto-calibrate Intertie Protection Relays that are not equipped with the optional M-3931 HMI. The procedure is similar to HMI equipped units:

    1.   Power down unit.

    2.   Refer to Figure 6-8 and place unit in calibrate mode by configuring the proper dip switches.

    3.   Connect all voltage inputs in parallel.

    4.   Connect all current inputs in series.

    5.   Power up unit.

    6.   **DIAG** LED will light when operation is complete.

    7.   Power down unit and return dip switches to normal position.
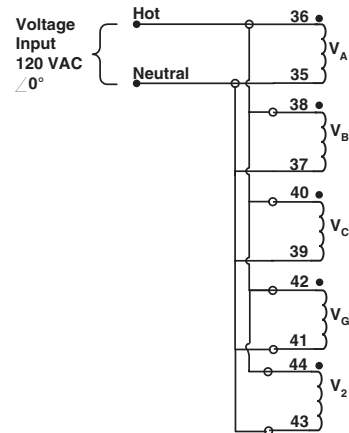
Figure 6-7   Voltage Calibration Configuration
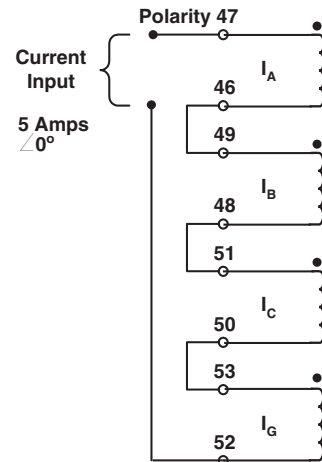
Figure 6-8   Current Calibration Configuration

6.4   Input Configurations

The phase angles shown here represent leading angles as positive and lagging angles as negative. Some manufacturers of test equipment use lagging angles as positive, in which case V_B=120 V AC$\angle$120° and V_C=120 V AC $\angle$240°. Other voltage and current phase angles should be adjusted in the same manner.
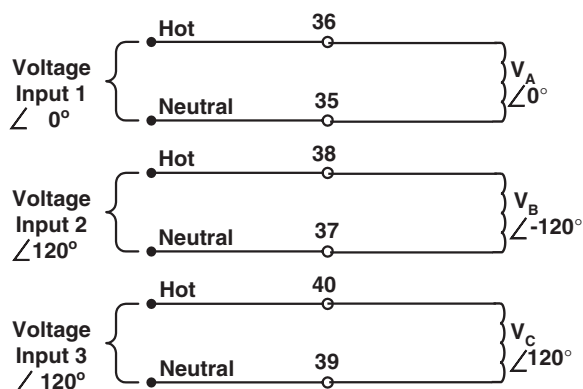
Figure 6-9   Voltage Inputs, Configuration V1
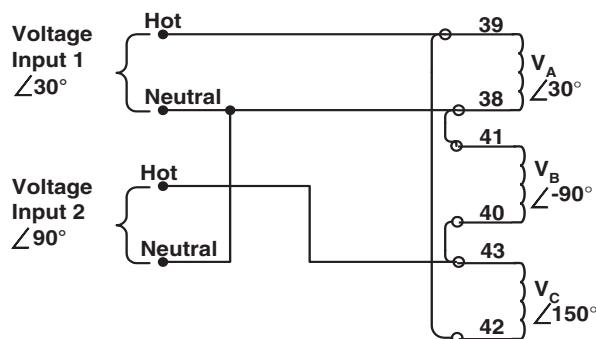
Figure 6-10   Voltage Inputs, Configuration V2
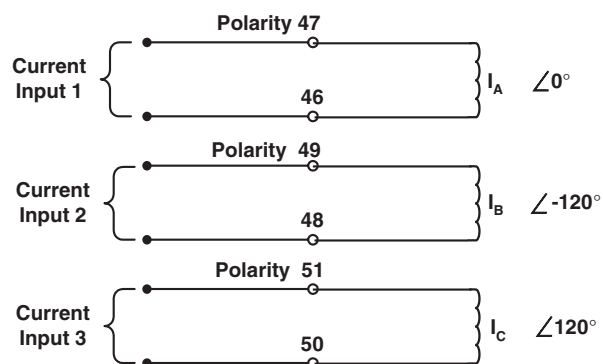
Figure 6-11   Current Inputs, Configuration C1
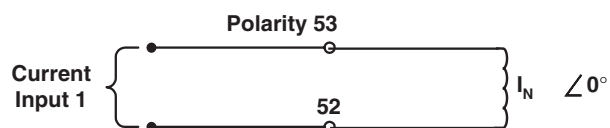
Figure 6-12   Current Inputs, Configuration C2
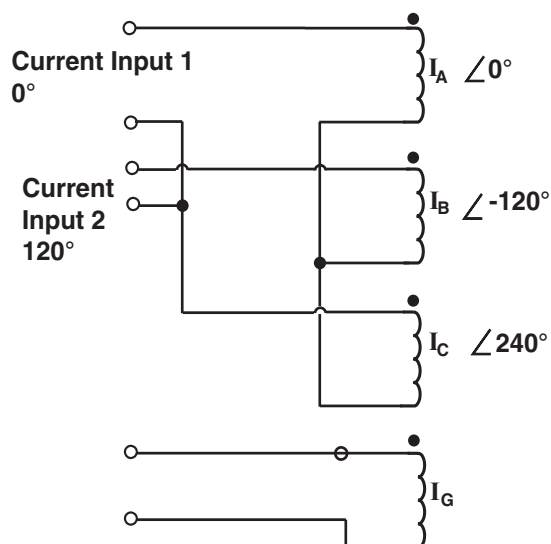
Figure 6-13   Current Inputs, Configuration C3

6.5   Functional Test Procedures

This section details the test quantities, inputs and procedures for testing each function of the M-3520 Intertie Protection 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 as specified in the test procedure.

In all test descriptions, a process for calculating input quantities to test the actual settings of the function will be given if needed. 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 with one set of input quantities that could cause confusion of operation of outputs or timers. The complete description of the method to disable or enable functions may be found in detail in Section 3.2, Configure Relay Data, or Chapter 4, **Operation (Computer)**. The complete description of the method to install setting quantities is found in detail in Section 3.2, Setpoints and Time Settings.

It is desirable to *record and confirm* the actual settings of the individual functions of the relay before beginning test procedures. Use the **FUNCTIONAL CONFIGURATION RECORD FORM** and the **SETPOINT AND TIMING RECORD FORM** found in Appendix A for recording settings.

The tests are described in this section in ascending function number order as in Chapter 2, **Application**. Depending on which functions are to be tested at a given time, an order may be determined with the aid of Table 6-1, Functions to Disable When Testing. This may result in fewer changes in connections and disable and enable operations.

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 illustrated at the beginning of this chapter.

■ **NOTE***:*   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.

It may be desirable to program all test settings in an alternate profile, or to save the relay settings in IPScom® to preserve a particular 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, Section 6.5, if desired.

■ **NOTE**:   Output 8 has been especially designed to be used as the Reconnect output. Any protective function assigned to this output will not display a target LED if it operates.

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Table 6-2 , Output Contacts.

It is suggested that copies of the following be made for easy referral during test procedures:

- Input Configurations - page 6–11
- Output Test (Relay)- page 6–4
- Relay Configuration Table - page A–2
- Setpoint & Timing Record Form - pages A–9 to A–12

21 Phase Distance (#1 or #2) Line to Line

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Diameter	C	Ohms	(0.1 to 100)
	1 Amp CT Rating			(0.5 to 500.0)
	Offset	O	Ohms	(–100 to 100)
	5 Amp CT Rating			(–500.0 to 500.0)
	Impedance Angle	A	Degrees	(0 to 90)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 60FL, 21 (1 or 2)		Disable	
	Delta-Y Transform		Disable	

■ **NOTE:** It would be efficient to disable the function with the higher "reach" (Diameter plus Offset) setting first (*lower current*), and test the lower reach setting operation, since the higher reach setting operation can be tested without disabling the lower setting.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect input in Configuration V1 and C1 as designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.

4. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as **R** ohms = (**C** ohms + **O** ohms) offset, **O**, usually set at zero ohms.
   b. Define "current" as **I** = ((Selected Voltage / S3) I **R** ohms). The voltage level may be selected based on the desired test current level.

5. *Pickup Test*: Set the three-phase voltages to the Selected Voltage value from step 4. Set the phase angle between the voltage and current inputs at (**A** –30°) degrees from setting above. Hold the **TARGET RESET** button in and slowly increase the three-phase currents until the appropriate **PHASE DISTANCE 21** LED light goes on, or the pickup indicator operates on the computer target screen. The level should be equal to **I** calculated in step 4 with the resulting impedance ±0.1 ohms or 5%. Release the **TARGET RESET** button and decrease the **INPUT CURRENTS**, and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.

6. *Time Test*: With output contacts connected to the timer, apply approximately 110% of the current (**I**) found in step 4, and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or 1%.

7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

21 Phase Distance (#1 or #2) Line to Ground

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Diameter	C	Ohms	(0.1 to 100)
	1 Amp CT Rating			(0.5 to 500.0)
	Offset	O	Ohms	(–100 to 100)
	5 Amp CT Rating			(–500.0 to 500.0)
	Impedance Angle	A	Degrees	(0 to 90)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	VT Configuration		Line-Ground	
	Function 60FL, 21 (1 or 2)		Disable	
	Delta-Y Transform		Disable	

■ **NOTE:** It would be efficient to disable the function with the higher "reach" (Diameter plus Offset) setting first (lower current), and test the lower reach setting operation, since the higher reach setting operation can be tested without disabling the lower setting.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect input in Configuration V1 and C1 as designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.

4. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as R ohms = (C ohms + O ohms) offset, O, usually set at zero ohms.
   b. Define "current" as I = ((Selected Voltage)IR ohms). The voltage level may be selected based on the desired test current level

5. *Pickup Test*: Set the three-phase voltages to the Selected Voltage value from step 4. Set the phase angle between the voltage and current inputs at (A) degrees from setting above. Hold the **TARGET RESET** button in and slowly increase the three-phase currents on the input until the appropriate **PHASE DISTANCE 21** LED light goes on, or the pickup indicator operates on the computer target screen. The level should be equal to I calculated in step 4 with the resulting impedance K0.1 ohms or 5%. Release the **TARGET RESET** button and decrease the **INPUT CURRENTS**, and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.

6. *Time Test*: With output contacts connected to the timer, apply approximately 110% of the current (I) found in step 4, and start timing. The contacts will close after D cycles within –1 to +3 cycles or 1%.

7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

25 Sync Check

VOLTAGE INPUTS:	See Below			
CURRENT INPUTS:	None			
TEST SETTINGS:	79 Supervise 25	Disable		
	Phase Angle Limit	PA	Degrees	(0 to 90)
	Voltage Limits			
	Upper Limit	UL	Volts	(60 to 140)
	Lower Limit	LL	Volts	(40 to 120)
	Sync Check Delay	SD	Cycles	(1 to 8160)
	Delta Volt	DV	Volts	(1.0 to 50.0)
	Delta Freq	DF	Hz	(0.001 to 0.500)
	Dead V1	See Below		
	Dead V2	See Below		
	Dead V1 & V2	See Below		
	Dead Input Enable	DIN	Input	(1 to 6)
	Dead Delay	DD	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 27 #1, #2	Disable		
	Function 47 #1, #2	Disable		
	Functions 59, 59I	Disable		
	Function 81 #1,2,3,4	Disable		

■ **NOTE**: The 25 function requires only one phase voltage and V2 for testing in the Line-to-Ground configuration. The phase voltage used for reference may be selected through the **System Setup** menu. The following tests will reference the phase voltage as V1, although any phase may be used for testing. Line-to-Line testing will follow the same procedures, with V1 representing the proper Line-to-Line phase input. Each test below can be performed using any of the three phases as a reference.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. ***Phase Angle Limit Test:*** Apply Nominal Voltage to V1 and V2, and establish a phase angle difference of more than **PA** +5°. Hold the **TARGET RESET** button in and slowly decrease the phase angle difference until Output **Z** LED operates or the pickup indicator operates on the computer target screen. The angle difference should be equal to **PA** ±1°. Release the **TARGET RESET** button and increase the angle difference, and the **OUTPUT** LED will go out.

4. ***Upper Voltage Limit Test:*** Apply voltage 5V higher than **UL** to both V1 and V2. Hold the **TARGET RESET** button in and slowly decrease the voltage on V1 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage should be equal to **UL** ±0.5V or ±0.5%. Release the **TARGET RESET** button and increase the voltage and the **OUTPUT** LED will go out. If desired, repeat the test using V2.

5. ***Lower Voltage Limit Test***: Apply voltage 5V lower than **LL** to both V1 and V2. Hold the **TARGET RESET** button in and slowly increase the voltage on V1 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage level should be equal to **LL** ±0.5V or ±0.5%. Relase the **TARGET RESET** button and decrease the voltage, and the **OUTPUT** LED will go out. If desired, repeat the test using V2.

6. ***Sync Check Time Delay Test***: Apply Nominal Voltage to V1 and V2, and establish a phase angle difference of more than **PA** +5°. With the output contacts connected to a timer, remove the phase angle difference and start timing. The contacts will close after **SD** cycles within –1 to +3 cycles or ±1%.

7.   ***Delta Voltage Test***: Set the Upper and Lower Voltage limits to their maximum and minimum values, respectively. Set V2 to 140 V and V1 to 80 V. Hold the **TARGET RESET** button in and slowly increase the voltage on V1 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage difference should be equal to ±0.5 V. Release the **TARGET RESET** button, and decrease the voltage, and the **OUTPUT** LED will go out. If desired, repeat the test using V2 with V1 at 140 volts.

8.   ***Delta Frequency Test:*** Set V1 and V2 to Nominal Voltage, and set the frequency of V1 to 0.05 lower than Nominal Frequency –**DF**. Hold the **TARGET RESET** button in, and slowly increase the frequency of V1 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The frequency difference level should be equal to **DF** ±0.0007 Hz or 5%. Release the **TARGET RESET** button and decrease the frequency, and the **OUTPUT** LED will go out. If desired, repeat the test using V2 with V1 at Nominal Frequency.

9.   ***Dead Volt Limit Test:***

   Dead V1 Test: Enable Dead V1 and disable Dead V2 (if enabled). Set V2 to Nominal Voltage, and V1 to **DVL** +5 V. Hold the **TARGET RESET** button in, and slowly decrease the voltage on V1 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage level should be equal to **DVL** ±0.5 V or ±5%. Release the **TARGET RESET** button and increase the voltage level and the **OUTPUT** LED will go out.

   Set V1 to Nominal Voltage, and decrease V2 below **DVL** and verify that the function does not operate.

   Dead V2 Test: Enable Dead V2 and disable Dead V1 (if enabled). Set V1 to Nominal Voltage, and V2 to **DVL** +5 V. Hold the **TARGET RESET** button in, and slowly decrease the voltage on V2 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage level should be equal to **DVL** ±0.5 V or ±5%. Release the **TARGET RESET** button and increase the voltage level and the **OUTPUT** LED will go out.

   Set V2 to Nominal Voltage, and decrease V1 below **DVL**, and verify that the function does not operate.

   Dead V1 and V2 Test: Enable Dead (V1 & V2) . Disable Dead (V1) and Dead (V2), if enabled. Set V1 and V2 to **DVL** +5 V. Hold the **TARGET RESET** button in, and slowly decrease the voltage on V1 and V2 until Output **Z** LED operates, or the pickup indicator operates on the computer target screen. The voltage level should be equal to **DVL** ±0.5 V or ±5%. Release the **TARGET RESET** button and increase the voltage level and the **OUTPUT** LED will go out.

   Set V1 to Nominal Voltage, decrease V2 below **DVL**, and verify that the function does not operate.

   Set V2 to Nominal Voltage, decrease V1 below **DVL**, and verify that the function does not operate.

10. ***Dead Input Enable Test***: Select one of the Dead Inputs (**DIN**) and activate it. Repeat step 9, verify that the function operates as in step 9. Deactivate the **DIN** and repeat step 9 once more. Verify that the function does not operate. Disable Dead Input feature when this step is complete.

11. ***Dead Timer Test:*** Enable Dead V1 & V2. Disable Dead V1 and Dead V2 (if enabled). Set V1 and V2 to **DVL** +5 V. With output contacts connected to a timer, remove V1 and V2 and start timing. The contacts will close within –1 to +3 cycles or ±1%.

12. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

27 Undervoltage, 3 Phase (#1 or #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:	Pickup	P	Volts	(5 to 180)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 60FL		Disable	
	Function 27#1 or #2		Disable	
	Functions 25, 79		Disable	

■ **NOTE**: If 27#1 and 27#2 have different pickup settings, it would be efficient to disable the one with the higher setting first and test the lower setting operation, since the higher setting operation could then be tested without disabling the lower.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.
2. Confirm settings to be tested.
3. Connect voltage input in Configuration V1 designated previously. Refer to Section 6.1, Equipment/Test Setup, for configuration. Set at Nominal Voltage.
4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly decrease the input voltage on phase A until the **27 PHASE UNDERVOLTAGE** LED illuminates, or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ± 0.5V or ±5%*. Release the **TARGET RESET** button and increase the input to the nominal voltage and the **OUTPUT** LED will extinguish. Press **TARGET RESET** button to remove targets.
5. *Time Test*: With output contacts connected to the timer, apply (**P**-1) Volts and begin timing. The contacts will close after **D** cycles within –1 or +3 cycles or ± 1%.
6. Test phases B and C by repeating steps 4 and 5.
7. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

* When both RMS and Line-to-Ground to Line-to-Line is selected, the accuracy is ± 0.8V or .75%.

27G Undervoltage, Neutral

VOLTAGE INPUTS:	See Below			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Volts	(5 to 180)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 59G, 79	Disable		

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect voltage input to V_G, terminals 41 & 42. Set at 105% of Pickup **P**.

4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly decrease the neutral voltage until **27G NEUTRL UNDERVOLTAGE** LED illuminates, or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5V or ±5%. Release the **TARGET RESET** button and increase the input to the nominal voltage and the **OUTPUT** LED will extinguish. Press **TARGET RESET** button to remove targets.

5. *Time Test*: With output contacts connected to the timer, apply (**P**-1) Volts and begin timing. The contacts will close after **D** cycles within –1 or +3 cycles or ±1%.

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

32 Directional Power, #1 or #2 (Line to Line)

VOLTAGE INPUTS:	Configuration V2			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Pickup	P	PU	(–3.00 to +3.00)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)

Function 32 (#1 or #2)   Disable
Functions 59, 59I, 60FL   Disable
Functions 27, 79. 50, 51V   Disable

■ **NOTE**: It would be efficient to disable the function with the lower pickup setting first and test the higher setting operation. Since the lower setting operation can be tested without disabling the higher setting, the 32 functions will be enabled when the tests are complete.

1. Disable functions as shown. See Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V2 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.

4. The level of current at which operation is to be expected for an individual power setting is as follows: Multiply the PU pickup value (**P** above) by the **Nominal Current**).

5. Set the three phase voltages to the **Nominal Voltage**.

6. *Pickup Test – Over Power*: Press and hold the **TARGET/OUTPUT RESET** pushbutton and slowly increase the three phase currents (*for negative or reverse power flow direction the phase angle of the phase currents are set at 180 degrees from the respective phase voltages*). Increase the currents until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the **Function Status** screen. The level of operation will be equal to that calculated in step 4, ±0.02 PU or ±2%.

7. *Pickup Test – Under Power*: Press and hold the **TARGET/OUTPUT RESET** pushbutton. *For negative or reverse power flow direction, the phase angle of the phase currents are set at 180 degrees from the respective phase voltages*. Start with a current calculated in Step 4, ±10%, then slowly decrease the current until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the Function Status screen.

8. Release the **TARGET/OUTPUT RESET** pushbutton and decrease the currents. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.

9. *Time Test*: With output contacts (**Z**) connected to stop the timer, apply approximately 110% of the pickup current and start timing. The contacts will close after **D** cycles within ±2 cycles.

10. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

32 Directional Power, #1 or #2 (Line to Ground)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:	Pickup	P	PU	(–3.00 to +3.00)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 or 8)
	Function 32 (#1 or #2)	Disable		
	Functions 27, 79, 50, 51	Disable		

■ **NOTE**: It would be efficient to disable the function with the lower pickup setting first and test the higher setting operation. Since the lower setting operation can be tested without disabling the higher setting, the 32 functions will be enabled when the tests are complete.

1. Disable functions as shown. See Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V2 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.

4. The level of current at which operation is to be expected for an individual power setting is as follows: Multiply the PU pickup value (**P** above) by the **Nominal Current**).

5. Set the three phase voltages to the **Nominal Voltage**.

6. *Pickup Test – Over Power*: Press and hold the **TARGET/OUTPUT RESET** pushbutton and slowly increase the three phase currents (*for negative or reverse power flow direction, the phase angle of the phase currents are set at 180 degrees from the respective phase voltages*). Increase the currents until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the Function Status screen. The level of operation will be equal to that calculated in step 4, ±0.02 PU or ±2%.

7. *Pickup Test – Under Power*: Press and hold the **TARGET/OUTPUT RESET** pushbutton. *For negative or reverse power flow direction, the phase angle of the phase currents are set at 180 degrees from the respective phase voltages.* Start with a current calculated in Step 4, ±10%, then slowly decrease the current until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the Function Status screen.

8. Release the **TARGET/OUTPUT RESET** pushbutton and decrease the currents. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.

9. *Time Test*: With output contacts **(Z)** connected to stop the timer, apply approximately 110% of the pickup current and start timing. The contacts will close after **D** cycles within ±2 cycles.

10. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

46DT Negative Sequence Overcurrent Definite Time

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C1 (MODIFIED)

TEST SETTINGS:	Pickup	P	Amps	(0.10 to 20.00)
	1 Amp CT Rating			(0.02 to 4.00)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 46 Inverse Time		Disable	
	Function 50		Disable	
	Functions 51V, 79		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect inputs in Configuration C1 (MODIFIED) designated previously. Refer to Section 6.4, Input Configurations for configurations. The modification to C1 is to exchange Current source 2 and 3 connections. Configuration will be Phase B current from source 3 and Phase C current from source 2.

■ **NOTE**: For proper testing use current below 3 times CT rating.

4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly increase the three-phase current until the **NEG SEQ DEF TIME O/C 46DT** LED illuminates or the pickup indicator operates on the computer screen The level of operation will be equal to Pickup Current **P** ±0.1 Amp (±0.02 for 1 Amp units) or ±3%, whichever is higher. Release the **TARGET RESET** button and decrease the three-phase current to a level below the Pickup Current **P** and the **OUTPUT** LED will extinguish. Press the **TARGET RESET** button to remove targets.

5. *Time Test*: With output contacts connected to the timer, apply three-phase current at least 1.1 times **P** and start timing. The operating time will be **D** cycles within −1 or +3 cycles or ±3%. Reduce applied current to 0 Amps

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

46IT Negative Sequence Overcurrent Inverse Time

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C1 (MODIFIED)			
TEST SETTINGS:	Pickup	P	Amps	(0.5 to 5.00)
	1 Amp CT Rating			(0.1 to 1.00)
	Standard Inverse Time Curves[1]:			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11.0)
	IEC Inverse Time Curves[1]:			
	IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.10)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 46 Inverse Time		Disable	
	Function 50		Disable	
	Function 51V, 79		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect inputs in Configuration C1 (MODIFIED) designated previously. Refer to Section 6.4, Input Configurations for configurations. The modification to C1 is to exchange Current source 2 and 3 connections. Configuration will be Phase B current from source 3 and Phase C current from source 2.

■ **NOTE**: For proper testing use current below 3 times CT rating.

4. **IEC Curve Testing**: Test current level may be chosen as a multiple of any level within the Pickup (**P**) range. Calculate the operating time for the applied current and appropriate Time Dial (**TD**) setting from the table below. Choose 4 or 5 test levels and calculate the operating times for each.

   Standard Curve Testing: The operating time will be read from Appendix D, Negative Sequence Current Inverse Time Curves for the applied current and appropriate Time Dial (**TD**) setting. The curve portions extending to lower than **P** current values are inactive and can be ignored.

5. **Time Test**: With output contacts connected to the timer, apply currents equal to the multiple of the Inverse Time Pickup (**P**) chosen in Step 4, and start timing. The operating time will be as calculated in step 4, ±3 cycles or ±5%.

IEC Class A Standard Inverse	**IEC Class B** Very Inverse	**IEC Class C** Extremely Inverse	**IEC Class D** Long Time Inverse
$t = TD \times \left[\dfrac{0.14}{M^{0.02} - 1} \right]$	$t = TD \times \left[\dfrac{13.5}{M - 1} \right]$	$t = TD \times \left[\dfrac{80}{M^2 - 1} \right]$	$t = TD \times \left[\dfrac{120}{M - 1} \right]$
Curve 5	*Curve 6*	*Curve 7*	*Curve 8*

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

47 Negative Sequence Overvoltage

VOLTAGE INPUTS: Configuration V1 (Modified)

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Pickup	P	Volts	(5 to 180)
Time Delay	D	Cycles	(1 to 8160)
Programmed Outputs	Z	Output	(1 to 8)
Function 59, 27, 79		Disable	

■ **NOTE:** Although no current input is required for the testing of the 47 function, it is suggested that Nominal Current be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests, they will need to also be disabled for the test and re-enabled after the tests are complete.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. The modification of V1 connection to to exchange voltage source V2 and V3 connections. The resulting configuration will be Phase B voltage, supplied from voltage source 3, and Phase C voltage, supplied from voltage source 2.

4. *Pickup Test*: Apply 3-phase voltage 5 volts below pickup **(P)**. Hold the **TARGET RESET** button in and slowly increase the voltage applied until the **47 NEG SEQ OVERVOLTAGE** LED lights or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5 volts or ±5%. Release the **TARGET RESET** button and decrease applied voltage, and the **OUTPUT** LED will go out. Press the **TARGET RESET** button again to remove targets.

5. *Time Test:* Apply voltage 10% less than pickup (**P**) to all three phases. With output contacts connected to a timer, apply **P** + 10% volts and start timing. The contacts will close after **D** cycles, within −1 to +3 cycles or ±3%.

6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

50 Instantaneous Phase Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Pickup	P	Amps	(1.0 to 240.0)
	1 Amp CT Rating			(0.2 to 48.0)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 51V		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect inputs in Configuration C1 designated previously. Refer to Section 6.4, Input Configurations, for configurations.

4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly increase the Phase A current until the **50 PHASE INST O/C** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1 A (±0.02 A for 1 Amp units) or ±3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish. Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases.

5. *Time Test*: With output contact (**Z**) connected to the timer, apply current 5% above pickup (**P**) and start timing. The operating time will be under 4 cycles.

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

50G Instantaneous Overcurrent, Neutral

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C2			
TEST SETTINGS:	Pickup	P	Amps	(0.5 to 240.0)
	1 Amp CT Rating			(0.1 to 48.0)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 51G		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect inputs in Configuration C2 designated previously. Refer to Section 6.4, Input Configurations, for configurations.

4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly increase the neutral current until the **50G NEUTRL INST O/C** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ± 0.1A (± 0.02 A for 1 Amp units) or ± 3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LED's will extinguish. Press **TARGET RESET** button to remove targets.

5. *Time Test*: With output contact (**Z**) connected to the timer, apply current 5% above pickup (**P**) and start timing. The operating time will be under 4 cycles.

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

51V Inverse Time Overcurrent, Phase

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	C1			
TEST SETTINGS:	Pickup	P	Amps	(0.50 to 12.00)
	1 Amp CT Rating			(0.10 to 2.40)
	Standard Inverse Time Curves:[1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11.0)
	IEC Inverse Time Curves:[1]			
	IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.10)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 50, 67		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect current inputs in Configuration C1 designated previously. Refer to Section 6.4, Input Configurations, for configurations.

4. Refer to Appendix D. Calculate test times for levels represented on the graphs. It is suggested that 4 or 5 test levels be chosen.

5. ***Time Test***: With output contacts connected to the timer, apply current used in calculations from step 4 and start timing. The operating time will be ±3 cycles or 5% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.

IEC Class A Standard Inverse	**IEC Class B** Very Inverse	**IEC Class C** Extremely Inverse	**IEC Class D** Long Time Inverse
$t = TD \times \left[\dfrac{0.14}{M^{0.02} - 1} \right]$	$t = TD \times \left[\dfrac{13.5}{M - 1} \right]$	$t = TD \times \left[\dfrac{80}{M^2 - 1} \right]$	$t = TD \times \left[\dfrac{120}{M - 1} \right]$
Curve 5	*Curve 6*	*Curve 7*	*Curve 8*

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. ***Voltage Control Test***: Input voltages at least 5% under the Voltage Control setting V.

   a. With output contacts connected to the timer, apply current equal to the chosen test level calculated in step 4 on phase A, and start timing. The operating time will be as read from the appropriate Inverse Curve Family and **K** (Time Dial) setting. Repeat this step for all test levels chosen. The curve portion extending to lower than 150% of **X** amps are inactive and can be ignored. The tested points verify the operating times of the function.

   b. The input voltage may be increased over the Voltage Control setting by at least 0.5 Volts, and the function will drop out.

7. ***Voltage Restraint Test:*** Input Nominal Voltages and test as in step 6 above (same current input values). Repeat step 6 above with reduced input voltage values and current reduced by an equivalent percentage as the voltage reduction.

8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

51G Inverse Time Residual Overcurrent, Neutral

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	C2			
TEST SETTINGS:	Pickup	P	Amps	(0.25 to 12.00)
	1 Amp CT Rating			(0.05 to 2.40)
	Standard Inverse Time Curves: [1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11.0)
	IEC Inverse Time Curves: [1]			
	IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.10)
	Programmed Outputs	Z	Output	(1 to 8)

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedures.

2. Confirm settings to be tested.

3. Connect current inputs in Configuration C2 designated previously. Refer to Section 6.4, Input Configurations, for configurations.

4. Refer to Appendix D. Calculate test times for levels represented on the graphs. Choose 4 or 5 test levels and calculate test times for each.

5. ***Time Test***: With output contacts connected to the timer, apply current used in calculations from step 4 and start timing. The operating time will be ± 3 cycles or 5% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.

IEC Class A Standard Inverse	**IEC Class B** Very Inverse	**IEC Class C** Extremely Inverse	**IEC Class D** Long Time Inverse
$t = TD \times \left[\dfrac{0.14}{M^{0.02} - 1} \right]$	$t = TD \times \left[\dfrac{13.5}{M - 1} \right]$	$t = TD \times \left[\dfrac{80}{M^2 - 1} \right]$	$t = TD \times \left[\dfrac{120}{M - 1} \right]$
Curve 5	*Curve 6*	*Curve 7*	*Curve 8*

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

59 Overvoltage, 3-Phase (#1 or #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:	Pickup	P	Volts	(5 to 180)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Functions 60FL , 79		Disable	
	Function 59 #1 or #2		Disable	

■ **NOTE**: If 59 #1 and 59 #2 have different pickup settings, it would be efficient to disable the one with the lower setting first and test the higher setting operation, since the lower setting operation could then be tested without disabling the higher setting.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 designated above. Refer to Section 6.1, Equipment/Test Setup for configuration. Set Voltages to Nominal voltage

4. *Pickup Test*: Hold the **TARGET RESET** button in and slowly increase the input voltage on phase A until **59 PHASE OVERVOLTAGE** LED light goes on, or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5 V or 5%. Release the **TARGET RESET** button and decrease the input voltages to nominal voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.

5. *Time Test*: With output contacts being connected to the timer, apply (**P**+1) Volts on phase A and start timing. The contacts will close after **D** cycles within −1 to +3 cycles or ±1%.

6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

 * When both RMS and Line-to-Ground to Line-to-Line is selected, the accuracy is ±0.8 V or ±.75%.

59I Peak Overvoltage, 3-Phase

VOLTAGE INPUTS:	V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P[1]	PU	(1.05 to 1.50)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Functions 59, 79		Disable	

■ **NOTE:** If function 59 settings are greater than the 59I setting being tested, it is not necessary to disable.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 designated above. Refer to Section 6.1, Equipment/Test Setup for configuration. Set voltages to Nominal Voltage.

4. *Pickup Test*: Hold the **TARGET RESET** button in, and slowly increase the voltage applied to Phase A until the **59I PEAK OVERVOLTAGE** LED goes on or the pickup indicator operates on the computer target screen. The level should be equal to **P** PU ± 0.3 PU. Release the **TARGET RESET** button and decrease the input voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets. This test may be performed on each phase, if desired.

5. *Time Test*: With output contacts being connected to the timer, apply (**P**+5) Volts and start timing. The contacts will close after **D** cycles within –1 to +3 cycles.

6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

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[1] *Accuracy of the function only applies to voltages below 180 Volts.*

59G Neutral Overvoltage

VOLTAGE INPUTS:	See Below			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Volts	(5 to 180)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	Output	(1 to 8)
	Functions 27G, 79	Disable		

1.   Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2.   Confirm settings to be tested.

3.   Connect voltage input to terminal numbers 41 and 42.

4.   *Pickup Test*: Hold the **TARGET RESET** button in and slowly increase the input Neutral voltage until **59G NEUTRL OVERVOLTAGE** LED illuminates or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5 V or 5%. Release the **TARGET RESET** button and decrease the input voltage and the **OUTPUT** LED's will extinguish. Press **TARGET RESET** button to remove targets.

5.   *Time Test*: With output contacts being connected to the timer, apply **P**+1 volts and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or 1%.

6.   If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

60 FL VT Fuse Loss Detection

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS: Time Delay   D   Cycles   (1 to 8160)

                         Programmed Outputs   Z   Output   (1 to 8)

                         Function 27, 32, 79   Disable

■ **NOTE:** It is necessary for "FL" to be designated as an initiating input (see Section 2.3 Setpoints and Time Settings, 60FL Fuse Loss) before this function can be tested.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 and C1 designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.

4. Adjust the three-phase voltage source to nominal volts, and the three-phase current source to nominal current.

5. *Time Test*: With output contacts connected to the timer, remove the A phase voltage input and start timing. The operating time will be **Y** cycles within –1 to +3 cycles and the **60FL V.T. FUSE LOSS** LED and output **Z** LEDs will light, or the pickup indicator operates on the computer target screen.

6. Reconnect the phase A voltage and press **TARGET RESET** button to remove targets.

7. Repeat steps 5 and 6 for phases B and C.

8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

67DT Phase Directional Overcurrent, Definite Time

VOLTAGE INPUTS:	V1			
CURRENT INPUTS:	C1			
TEST SETTINGS:	Pickup	P	Amps	(1.0 to 240.0)
	1 Amp			(0.2 to 48.0)
	Directional	See Below		
	Three Phase Detect	See Below		
	Delay	D	Cycles	(1 to 8160)
	MSA	MSA	Degrees	(0 to 359)
	Programmed Outputs	Z	Output	(1 to 8)

Function 32	Disable
Function 47 #1, #2	Disable
Functions 50, 51V, 59	Disable
Functions 67IT, 67NDT, 67NIT	Disable

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 and C1 designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.

4. *Single-Phase Pickup Test*: Disable Directional and Three-Phase Detect features, if enabled. Apply Nominal Voltage to all three phases. Apply current 10% less than pickup (**P**) to all three phases. Hold the **TARGET RESET** button in and slowly increase the current applied to phase A until the **DIR PHASE DEF TIME O/C 67DT** LED lights, or the pickup indicator operates on the computer target screen. The level should be equal to **P** amps ±0.1 Amps or ±3%. Release the **TARGET RESET** button and decrease phase A current and the **OUTPUT** LED will go out. Press the **TARGET RESET** button again to remove targets. If desired, repeat this test for both phase B and C currents.

5. *Three-Phase Pickup Test*: Enable the Three-Phase Detect feature and perform test #4 again to verify that the relay does not operate. Reset targets and apply Nominal Voltage to all three phases. Apply current 10% less than pickup (**P**) to all three phases. Hold the **TARGET RESET** button in and slowly increase the current applied to all phases until the **DIR PHASE DEF TIME O/C 67DT** LED lights, or the pickup indicator operates on the computer target screen. The level should be equal to **P** amps ±0.1 Amps or ±3%. Release the **TARGET RESET** button and decrease the applied current and the **OUTPUT** LED will go out.

6. *Directional Test*: Reset targets and apply Nominal Voltage to all three phases. Set the current angle to an angle more than 100° from **MSA**. Apply current 10% more than pickup (**P**) to all three phases. Hold the **TARGET RESET** button in and slowly swing the angle of the currents applied toward **MSA** until the **DIR PHASE DEF TIME O/C 67DT** LED lights, or the pickup indicator operates on the computer target screen. The angle should be equal to **A** –90° or +90°, depending to which side of **MSA** the current has been set. Release the **TARGET RESET** button and swing the current angle away from **MSA**, and the **OUTPUT** LED will go out.

7. *Timer Test*: Disable the Directional and Three-Phase Detect features, if enabled. Apply Nominal Voltage to all three phases. Apply current 10% less than pickup (**P**) to all three phases. With output contacts connected to a timer, apply **P**+10% Amps and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or ±3%.

8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

67IT Directional Overcurrent, Inverse Time

VOLTAGE INPUTS:	V1			
CURRENT INPUTS:	C1			
TEST SETTINGS:	Pickup	P	Amps	(0.5 to 12.0)
	1 Amp			(0.1 to 2.4)
	Directional	Disable		
	Standard Inverse Time Curves[1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 1.1)
	IEC Inverse Time Curves[1]			
	Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 11.0)
	MSA	MSA	Degrees	(0 to 359)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 32	Disable		
	Function 47 #1, #2	Disable		
	Functions 50, 51V, 59	Disable		
	Functions 67NIT	Disable		
	Function 67NDT	Disable		

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. *Pickup Test*: Refer to Appendix D, **Inverse Time Curves** and the table below in order to calculate test times for levels represented on the graphs. It is suggested that 4 or 5 test levels be chosen.

4. *Time Test*: With output contacts being connected to the timer, apply input current used in calculations from step 3 to all 3 phases and start timing. The operating time will be ±3 cycles or ±5% of the calculated time. Repeat this step for each test level chosen. The points tested verify the operation of this function.

IEC Class A	**IEC Class B**	**IEC Class C**	**IEC Class D**
Standard Inverse	Very Inverse	Extremely Inverse	Long Time Inverse
$t = TD \times \left[\dfrac{0.14}{M^{0.02} - 1} \right]$	$t = TD \times \left[\dfrac{13.5}{M - 1} \right]$	$t = TD \times \left[\dfrac{80}{M^2 - 1} \right]$	$t = TD \times \left[\dfrac{120}{M - 1} \right]$
Curve 5	*Curve 6*	*Curve 7*	*Curve 8*

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

5. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

[1]Either a Standard Curve or an IEC Curve must be selected.

67NDT Residual Directional Overcurrent, Definite Time

VOLTAGE INPUTS:	See Below			
CURRENT INPUTS:	See Below			
TEST SETTINGS:	Pickup	P	Amps	(0.50 to 240.0)
	1 Amp			(0.1 to 48.0)
	Directional	See Below		
	Time Delay	D	Cycles	(1 to 8160)
	MSA [c]	MSA	Degrees	(0 to 359)
	Polarization Type [c]			(1 to 5)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 27G, 32	Disable		
	Function 47 #1, #2	Disable		
	Functions 50, 51V, 59	Disable		
	Functions 67IT, 67NIT	Disable		

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Enable directional feature and connect inputs as listed in table below, for the polarization type selected for testing.

■ **NOTE**: This feature is designed for use with the Line-to-Ground VT configuration.

POLARIZATION TYPE	SETUP
1	Voltage Phases A, B, and C placed in parallel, and current phases A, B, and C placed in series.
2	Neutral volatge; current phases A, B, and C placed in series.
3	Balanced 3-phase voltages with full negative sequence and apply phase A current only.
4	Neutral current; current phases A, B, and C placed in series. This polarization type does not use Maximum Sensitivity Angle (MSA) feature, which is set at zero.
5	Either voltage phases A, B, and C in parallel, or neutral current in the trip region in reference to $3I_{ZERO}$ will give trip condition (see type 1 or 4).

4. ***Pickup Test***: Apply Nominal Voltage to all three phases. Apply current 10% less than pickup (**PI3**) to all three phases. Hold the **TARGET RESET** button in and slowly increase the current applied to all phases in the above table, until the **RES DIR DEF TIME O/C 67NDT** LED lights, or the pickup indicator operates on the computer target screen. The level should be equal to **PI3 Amps** ± 0.1A or ± 3%. Release the **TARGET RESET** button and decrease the applied current, and the **OUTPUT** LED will go out.

✜ *These settings are in a separate menu labeled Neutral Dir Setup.*

5. ***Directional Test***: Enable directional feature. Reset targets and apply Nominal Voltage to all three phases. Set the current angle to an angle more than 100° from **MSA**. Apply current 10% more than **P**I3, (**for type 3, use P**) to all three phases. Hold the **Target Reset** button in and slowly swing the angle of the currents applied towards the **MSA** until the **RES DIR DEF TIME O/C 67NDT** LED lights, or the pickup indicator operates on the computer target screen. The angle should be equal to A –90° or +90°, depending to which side of **MSA** the current has been set. Release the **TARGET RESET** button and swing the current angle away from the **MSA**, and the **OUTPUT** LED will go out.

■ **NOTE**: MSA is not used in type 4.

6. ***Time Delay Test***:   Disable the Directional and Three-Phase Detect features, if enabled. Apply Nominal Voltage to all three phases. Apply current 10% less than **P**I3, (**for type 3, use P**) to all three phases. With output contacts connected to a timer, apply **P**+10% Amps, and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or   ± 3%.

7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

67NIT Residual Directional Overcurrent, Inverse Time

VOLTAGE INPUTS:	See Below			
CURRENT INPUTS:	See Below			
TEST SETTINGS:	Pickup	P	Amps	(0.50 to 240.0)
	1 Amp			(0.1 to 48.0)
	Directional	See Below		
	Standard Inverse Time Curves[1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.05 to 11.0)
	IEC Inverse Time Curves[1]			
	Curve	C		(5 to 8)
	Time Dial	TD		(0.05 to 1.10)
	MSA[c]	MSA	Output	(0 to 359)
	Polarization Type[c]			(1 to 5)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 27G, 32	Disable		
	Function 47 #1, #2	Disable		
	Functions 50, 51V, 59	Disable		
	Functions 67IT, 67NDT	Disable		

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Enable directional feature and connect inputs as listed in table below for the polarization type selected for testing:

POLARIZATION TYPE	SETUP
1	Voltage Phases A, B, and C placed in parallel, and current phases A, B, and C placed in series.
2	Neutral volatge; current phases A, B, and C placed in series.
3	Balanced 3-phase voltages with full negative sequence and apply phase A current only.
4	Neutral current; current phases A, B, and C placed in series. This polarization type does not use Maximum Sensitivity Angle (MSA) feature, which is set at zero.
5	Either voltage phases A, B, and C in parallel, or neutral current in the trip region in reference to $3I_{ZERO}$ will give trip condition (see type 1 or 4).

4. Refer to Appendix D, **Inverse Time Curves**, and IEC table below to calculate test times for levels represented on the graphs. It is suggested that 4 or 5 test levels be chosen.

✢ *These settings are in a separate menu labeled Neutral Dir Setup.*

[1]Either a Standard Curve or an IEC Curve must be selected.

5. ***Time Delay Test***: Apply Nominal Voltage to voltage inputs, if any, as listed in table above. With output contacts connected to a timer, apply input current used in calculations from step 4 to current phases specified in table above, and start timing. The operating time will be ±3 cycles or ±5% of the calculated time. Repeat this step for each test level chosen. The points tested verify the operation of this function.

IEC Class A Standard Inverse	**IEC Class B** Very Inverse	**IEC Class C** Extremely Inverse	**IEC Class D** Long Time Inverse
$t = TD \times \left[\dfrac{0.14}{M^{0.02} - 1}\right]$	$t = TD \times \left[\dfrac{13.5}{M - 1}\right]$	$t = TD \times \left[\dfrac{80}{M^2 - 1}\right]$	$t = TD \times \left[\dfrac{120}{M - 1}\right]$
Curve 5	*Curve 6*	*Curve 7*	*Curve 8*

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

6. ***Directional Test***: Enable directional feature. Reset targets and apply Nominal Voltage to all three phases. Set the current angle to an angle more than 100° from **MSA**. Apply current 10% more than **P**I3, (**for type 3, use P**) to all three phases. Hold the **Target Reset** button in and slowly swing the angle of the currents applied towards the **MSA** until the **RES DIR INV TIME O/C 67NIT** LED lights, or the pickup indicator operates on the computer target screen. The angle should be equal to **A** −90° or +90°, depending to which side of **MSA** the current has been set. Release the **TARGET RESET** button and swing the current angle away from the **MSA**, and the **OUTPUT** LED will go out.

■ **NOTE**: MSA is not used in type 4.

7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

78 Out of Step

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Diameter	P	Ohms	(0.1 to 100)
	Offset	O	Ohms	(−100 to +100)
	Impedance Angle	A	Degrees	(0 to 90)
	Time Delay	D	Cycles	(1 to 8160)
	Blinder Impedance	B	Ohms	(0.1 to 50.0)
	Trip on MHO Exit	See Below		
	Programmed Output	Z		

Delta-Y Transform   Disable
Functions 21, 27, 27TN   Disable
Functions 32, 51V   Disable
Functions 81   Disable

■ **NOTE**: Use Figure 2-29 for reference. A stopwatch is required for this test.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 and C1 designated above. Refer to Section 6.1, Equipment/Test Setup for configurations. Adjust voltage and currents while monitoring the positive sequence impedance to a point similar to point Z_0 in Figure 2-29.

4. ***Pickup Test:*** Disable the **TRIP ON MHO EXIT** setting and set the delay, **D**, to a minimal setting. Press and hold the **TARGET RESET** button and sweep the current angle towards point Z_1. When the impedance passes through point Z_1, verify that the **OUT OF STEP 78** LED comes on or the function status indicator shows the function picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Continue to sweep the current angle to point Z_2, and verify output **Z** operates as point Z_2 is crossed, and resets after the seal-in time delay.

   Blocking on Stable Swing Test: Reset impedance to a point outside of the mho circle. Adjust voltages and currents to point Z_0. Press and hold the **TARGET RESET** button and sweep past point Z_1. Verify the **OUT OF STEP 78** LED comes on or the function status indicator shows the function picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Reverse sweep direction and sweep the current angle to point Z_1, and verify output **Z** does not operate and the **OUT OF STEP 78** LED goes out or the function status indicator shows the function reset on the **Monitor Function Status** screen as point Z_1 is crossed.

5. ***Pickup Test (Trip on mho Exit):*** Enable the **TRIP ON MHO EXIT** setting. Adjust voltages and currents to point Z_0. Press and hold the **TARGET RESET** button, and sweep the current angle towards point Z_1. When the impedance passes through point Z_1, verify that the **OUT OF STEP 78** LED comes on or the function status indicator shows that the function has picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Continue to sweep the current angle to point Z_2, and verify that output **Z** does not operate as point Z_2 is crossed. Sweep the impedance further towards point Z_3, and verify output **Z** operates as point Z_3 is crossed, and resets after the seal-in time delay.

79 Reconnect

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Time Delay	D	Cycles	(2 to 65,500)
	Reconnect Initiate	R		(1 to 8)
	Programmed Outputs	Z	Output	(1 to 8)

1. Confirm settings to be tested.

2. Connect inputs in Configuration V1 as designated previously. Refer to Section 6.4, Input Configurations for configuration.

3. Adjust the three-phase source to Nominal Voltage.

4. *Setup*: Remove the A phase voltage input to cause Function 27 to trip Output **R** (Output **R** will trip after Function 27 times out).

5. *Time Test*: With output contacts connected to the timer, reapply the A phase voltage input and start timing. The operation time will be D cycles within ±2 cycles.

6. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.

7. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

81 Frequency (#1, #2, #3, or #4)

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Hz	(50.00 to 67.00)
	50 Hz Relay			(40.00 to 57.00)
	Time Delay	D	Cycles	(2 to 65,500)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 59, 81 (#1, #2, #3, #4)		Disable	

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 designated previously. Refer to Section 6.4, Input Configurations for configuration.

4. *Pickup Test*: Set the voltages to the Nominal Frequency. Hold the **TARGET RESET** button in and slowly decrease the frequency on the input voltage(s) until the **FREQUENCY 81** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** Hz ± 0.02 Hz from 57 to 63 (47 to 53), otherwise the accuracy is ± 0.1 Hz. Return to nominal input frequency and the **OUTPUT** LED's will extinguish. Press **TARGET RESET** button to remove targets.

5. *Time Test*: With output contacts being connected to the timer, apply **P** ± 0.5 Hz and start timing. The operating time will be **D** cycles within –2 to +3 cycles or $\pm 1\%$.

6. Complete the testing for the remaining 81 functions by repeating steps 4 and 5, above.

7. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

81R Rate of Change of Frequency (#1, #2)

VOLTAGE INPUTS:	V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Hz/s	(0.10 to 20.00)
	Delay	D	Cycles	(1 to 8160)
	Negative Sequence Voltage Inhibit	N	%	(0 to 99)
	Programmed Outputs	Z	Output	(1 to 8)
	Function 59		Disable	
	Functions 79, 81		See Below	

■ **NOTE**: Testing of the 81R function requires a 3-phase voltage source capable of smoothly sweeping the frequency of all voltages at a variable rate, continuously.

1. Disable functions as shown. Refer to Section 3.2, Configure Relay Data, for procedure.

2. Confirm settings to be tested.

3. Connect inputs in Configuration V1 designated previously. Refer to Section 6.4, Input Configurations for configuration.

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 frequncy 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 below). 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. Conncet both of these outputs to an input with jumpers, and set the 81R function to block on this input. Set the time delays and seal-in times of the 81 functions to minimum. This will result in an operational window that is free of erroneous Hz/S measurements when the voltage source begins or ends the sweep.

F81#1 Block	81R Active Region	F81#2 Block

56.5 Hz	57.5 Hz	60 Hz	62.5 Hz	63.5 Hz
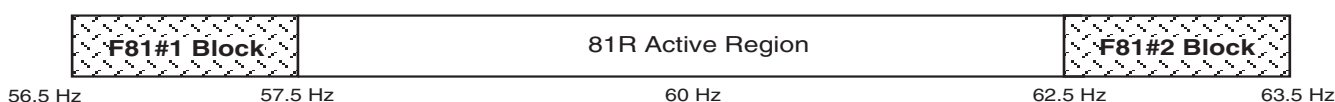
Using this setup, it is important to remember that the 81 elements being used will be operating in the 81R blocking regions, and the 81R contact operation must be distinguished from the 81 contacts.

5. ***Pickup Test:*** 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**) to all three phases.

   Hold the **TARGET RESET** button in and slowly decrease the sweep time until the **RATE OF CHG FREQ 81R** LED lights, or the pickup indicator operates on the computer target screen. The level should be equal to **P** ± 0.05 Hz/S or ± 5 %. Release the **TARGET RESET** button, and increase the sweep time, and the **OUTPUT** LED will go out.

6. ***Negative Sequence Voltage Inhibit Test***: Reset targets and apply Nominal Voltage to all three phases at a sweep rate 25% above **P**. Verify that the **RATE OF CHG FREQ 81R** LED lights, or the pickup indicator operates on the computer target screen. Swing the phase angle of a phase voltage and monitor the positive and negative sequence voltage levels. The **81R OUTPUT** should reset when the negative sequence voltage is **N**% ± 0.5% of the positive sequence voltage.

7.   ***Timer Test:*** Reset targets and apply Nominal Voltage to all three phases at a sweep rate 25% below **P**. With output contacts connected to a timer, apply a sweep rate 25% above **P** and start timing. The contacts will close after **D** cycles within –1 to +3 cycles, or ±3 %.

8.   If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

A Appendix A – Configuration Record Forms

This Appendix contains photocopy-ready forms for recording the configuration and setting of the M-3520 Intertie Protection Relay. The forms can be supplied to field service personnel for relay configuration, and kept on file for future reference. Examples of the suggested use of these forms are illustrated in Chapter 2, **Application** and Chapter 3, **Operation**.

A copy of the **Relay Configuration Table** (page A-2), discussed in Section 2.2, Configuration, Functions is provided to define and record the blocking inputs and output configuration for the relay. For each function; check if **DISABLED** or check the output contacts *to be operated by the function*, and check the inputs designated *to block the function operation.*

The Communication Data & Unit Setup Record Form reproduces the Communication and Setup unit menus. This form records definition of the parameters necessary for communication with the relay, as well as access codes, user logo (identifying) lines, date & time setting, and front panel display operation.

The Functional Configuration Record Form reproduces the Configure Relay menus (including the Setup Relay submenu) accessible via M-3822 IPScom® Communication Software or the optional M-3931 HMI front panel module. For each function or setpoint, refer to the configuration you have defined using the Relay Configuration Table, and circle whether it should be enabled or disabled, the output contacts it will activate, and the inputs that will block its operation.

The Setpoint & Timing Record Form allows recording of the specific values entered for each enabled setpoint or function. The form follows the main menu selections of the relay.

The "AS SHIPPED" data forms illustrate the factory settings of the relay.

EXAMPLES:

```
59 #1 PHASE OVERVOLTAGE
disable  enable
```

```
59 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
59 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
59 #1   PICKUP
_____ VOLTS
```

```
59 #1   DELAY
_____CYCLES
```

FUNCTION	D	OUTPUTS								FL	INPUTS					
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
21 #1																
21 #2																
25																
27 #1																
27 #2																
27G																
32 #1																
32 #2																
46DT																
46IT																
47 #1																
47 #2																
50																
50G																
51G																
51V																
59 #1																
59 #2																
59I																
59G																
60FL																
67DT																
67IT																
67NDT																
67NIT																
78																
79																
81 #1																
81 #2																
81 #3																
81 #4																
81R #1																
81R #2																

Check each box applicable : ✓   (See page A-1 for information on using this table.)

D Column = Function Disabled.   FL Column = Function blocked by fuse loss.

INPUTS Columns =Designated function blocking input(s)   OUTPUTS Columns =Designated function output(s)

Table A-1   Relay Configuration Table

KEY TO INPUT DATA RECORD FORMS

A.   All non-bold [   ] screens shown on forms require data inputs. Whatever is in that screen when **ENTER** button is pushed (see Figure A-1) will be installed in the M -3520 relay.

B.   All bold ruled [   ] screens are either menu screens which have horizontal choices (made with right - left arrows) or screens displaying a result of a choice previously made. Lightly shaded screens indicate separate functions.

C.   **Dotted** boxes [_ _ _] enclose screens which bound areas that the **ENTER** button will move within. In order to move out of one of the **dotted** boxes it is necessary to either push **EXIT** or make a menu choice change using the Right/Left arrow.

D.   The Up/Down arrows *only* adjust value or letter (lower/upper case) inputs – they do not move around within the menus.

E.   The Right/Left arrows are used *only* to make horizontally displayed choices. These can be either menu choices or input value digit choices. The previous choice or location in a menu is highlighted immediately.

F.   The **ENTER** button records the setting change and moves down *within* a menu. The operator will notice that after the last menu item, **ENTER** moves to the top of the same menu but does not change menu positions.

G.   Pushing **EXIT** at any time will exit the display screen to the last screen containing a horizontal choice. (Return to the preceding menu).
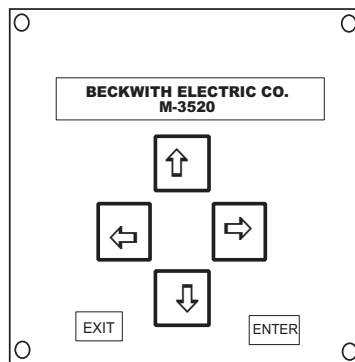
Figure A-1   Human-Machine Interface Module

H.   The symbol "←"or "→" in a screen indicates additional horizontal menu choices are available in the indicated direction. As previously described, the Right/Left arrows will move the operator to those additional choices.

   ■ **NOTE**: If a function is disabled, the input screens for that function will not be displayed.

```
COMMUNICATION
← COMM setup exit
```

```
COM1 SETUP
COM1 com2 com3 com_adr→
```

```
COM1 BAUD RATE
← baud_4800 baud_9600
```

```
COM2 SETUP
com1 COM2 com3 com-adr
```

```
COM2 BAUD RATE
← baud_4800 baud_9600
```

```
COM2 DEAD SYNC TIME
_____ MS
```

```
COM2 PROTOCOL
beco2200 MODBUS
```

```
COM2 PARITY
none odd even
```

```
COM3 SETUP
com1 com2 COM3 com-adr
```

```
COM3 DEAD SYNC TIME
_____ MS
```

```
COM3 PROTOCOL
beco2200 MODBUS
```

```
COM3 PARITY
none odd even
```

```
COMMUNICATION ADDRESS
com1 com2 com3 COM-ADR→
```

```
COMMUNICATION ADDRESS
_____
```

```
COMM ACCESS CODE
← ACCSS
```

```
COMM ACCESS CODE
_____
```

```
SETUP UNIT
← comm SETUP exit
```

```
SOFTWARE VERSION
VERS sn access number→
```

```
SOFTWARE VERSION
D-0060V01.XX.XX   7703
```

```
SERIAL NUMBER
vers SN access number→
```

```
SERIAL NUMBER
_____
```

```
ALTER ACCESS CODES
vers sn ACCESS number→
```

```
ENTER ACCESS CODE
LEVEL#1 level#2 level#3
```

```
LEVEL #1
_____
```

```
ENTER ACCESS CODE
level#1 LEVEL#2 level#3
```

```
LEVEL #2
_____
```

```
ENTER ACCESS CODE
level#1 level#2 LEVEL#3
```

```
LEVEL #3
_____
```

```
USER CONTROL NUMBER
vers sn access NUMBER→
```

```
USER CONTROL NUMBER
_____
```

```
USER LOGO LINE 1
←LOGO1 logo2 out alrm→
```

```
USER LOGO LINE 1
_____
```

```
USER LOGO LINE 2
←logo1 LOGO2 out alrm→
```

```
USER LOGO LINE 2
_____
```

```
CLEAR OUTPUT COUNTERS
←logo1 logo2 OUT alrm→
```

```
CLEAR OUTPUT COUNTERS
PRESS ENTER KEY TO CLEAR
```

```
CLEAR ALARM COUNTER
←logo1 logo2 out ALRM→
```

```
CLEAR ALARM COUNTER
PRESS ENTER KEY TO CLEAR
```

Figure A-2   Communication Data & Unit Setup Record Form (1 of 2)

```
DATE & TIME
← TIME error diag
```

```
DATE & TIME
01-JAN-2001 01:01:80
```

```
DATE & TIME
_____    YEAR
```

```
DATE & TIME
JAN feb mar apr may →
```

```
DATE & TIME
_____    DATE
```

```
DATE & TIME
SUN mon tue wed thu →
```

```
DATE & TIME
_____    Hour
```

```
DATE & TIME
_____    Minutes
```

```
DATE & TIME
_____    Seconds
```

```
CLEAR ERROR CODES
← time ERROR diag
```

```
CLEAR ERROR CODES
PRESS ENTER KEY TO CLEAR
```

```
DIAGNOSTIC MODE
← time error DIAG
```

```
PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE
```

■ **NOTE**: See Section 6.2, Diag-
nostic Test Procedures

Figure A-2   Communication Data & Unit Setup Record Form (2 of 2)   **A–5**

```
CONFIGURE RELAY
VOLTAGE_RELAY            →
```

```
CONFIGURE RELAY
← CURRENT_RELAY →
```

```
27 #1 PHASE OVERVOLTAGE
disable enable
```

```
27 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
27 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
27#2 PHASE UNDERVOLTAGE
disable enable
```

```
27 #2 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
27 #2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
59 #1 PHASE OVERVOLTAGE
disable enable
```

```
59 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
59 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
59 #2 PHASE OVERVOLTAGE
disable enable
```

```
59 #2 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
59 #2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
27G NEUTRAL UNDERVOLT
disable enable
```

```
27G BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
27G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
59G NEUTRAL OVERVOLT
disable enable
```

```
59G BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
59G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
47 #1 NEG SEQ OVERVOLT
disable enable
```

```
47 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
47 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
47 #2 NEG SEQ OVERVOLT
disable enable
```

```
47 #2 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
47 #2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
59I PEAK OVERVOLTAGE
disable enable
```

```
59I BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
59I RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
50 INST OVERCURRENT
disable ENABLE
```

```
50 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
50 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
51V OVERCURRENT INV
disable ENABLE
```

```
51V BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
51V RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
50G NTRL INST OVERCURRNT
disable ENABLE
```

```
50G BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
50G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

```
51G NTRL OVERCURRENT INV
disable ENABLE
```

```
51G BLOCK INPUT
fl i6 i5 i4 i3 i2 i1
```

```
51G RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

Figure A-3   Functional Configuration Record Form (1 of 3)

CONFIGURE RELAY
← CURRENT_RELAY →

46DT NEG SEQ CURRENT DEF
disable enable

46DT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

46DT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

46IT NEG SEQ CURRENT INV
disable enable

46IT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

46IT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

67DT DIR OVERCURRENT
disable enable

67DT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

67DT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

67IT DIR OVERCURRENT
disable enable

67IT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

67IT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

67NDT RESDL DIR OVERCURR
disable enable

67NDT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

67NDT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

67NIT RESDL DIR OVERCURR
disable enable

67NIT BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

67NIT RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

CONFIGURE RELAY
← FREQUENCY_RELAY →

81 #1 FREQUENCY
disable enable

81 #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81 #2 FREQUENCY
disable enable

81 #2 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81 #2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81 #3 FREQUENCY
disable enable

81 #3 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81 #3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81 #4 FREQUENCY
disable enable

81 #4 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81 #4 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81R #1 RATE OF CHNG FREQ
disable enable

81R #1 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81R #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

81R #2 RATE OF CHNG FREQ
disable enable

81R #2 BLOCK INPUT
fl i6 i5 i4 i3 i2 i1

81R #2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

Figure A-3   Functional Configuration Record Form (2 of 3)   **A–7**

```
┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ←  POWER_RELAY  →           │
└─────────────────────────────┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 32 #1 DIRECTIONAL POWER   │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 32 #1 BLOCK INPUT         │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 32 #1 RELAY OUTPUT        │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
│                               │
│ ╭───────────────────────────╮ │
│ │ 32 #2 DIRECTIONAL POWER   │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 32 #2 BLOCK INPUT         │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 32 #2 RELAY OUTPUT        │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ←PHASE_DISTANCE_RELAY  →    │
└─────────────────────────────┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 21 #1 PHASE DISTANCE      │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 21 #1 BLOCK INPUT         │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 21 #1 RELAY OUTPUT        │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
│                               │
│ ╭───────────────────────────╮ │
│ │ 21 #2 PHASE DISTANCE      │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 21 #2 BLOCK INPUT         │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 21 #2 RELAY OUTPUT        │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 78 OUT OF STEP            │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 78 BLOCK INPUT            │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 78 RELAY OUTPUT           │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ←V.T. FUSE_LOSS RELAY  →    │
└─────────────────────────────┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 60FL V.T. FUSE LOSS       │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 60FL BLOCK INPUT          │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 60FL RELAY OUTPUT         │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ←  SYNC_CHECK_RELAY  →      │
└─────────────────────────────┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 25 SYNC CHECK             │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 25 BLOCK INPUT            │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 25 RELAY OUTPUT           │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

```
┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ←  RECONNECT_RELAY  →       │
└─────────────────────────────┘
```
```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────────╮ │
│ │ 79 RECONNECT              │ │
│ │ disable enable            │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 79 BLOCK INPUT            │ │
│ │ fl i6 i5 i4 i3 i2 i1      │ │
│ ╰───────────────────────────╯ │
│ ╭───────────────────────────╮ │
│ │ 79 RELAY OUTPUT           │ │
│ │ o8 o7 o6 o5 o4 o3 o2 o1   │ │
│ ╰───────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

Figure A-3   Functional Configuration Record Form (3 of 3)

```
VOLTAGE RELAY
VOLT curr freq pwr →
```

```
27 PHASE UNDERVOLTAGE
PHASE_UNDER phase_over→
```
```
27 #1 PICKUP
_____ Volts
```
```
27 #1 DELAY
_____ Cycles
```
```
27 #2 PICKUP
_____ Volts
```
```
27 #2 DELAY
_____ Cycles
```

```
59 PHASE OVERVOLTAGE
phase_under PHASE_OVER→
```
```
59 #1 PICKUP
_____ Volts
```
```
59 #1 DELAY
_____ Cycles
```
```
59 #2 PICKUP
_____ Volts
```
```
59 #2 DELAY
_____ Cycles
```

```
27G NEUTRAL UNDERVOLTAGE
←NUTRL_UNDER nutrl_over→
```
```
27G PICKUP
_____ Volts
```
```
27G DELAY
_____ Cycles
```

```
59G NEUTRAL OVERVOLTAGE
←nutrl_under NUTRL_OVER→
```
```
59G PICKUP
_____ Volts
```
```
59G DELAY
_____ Cycles
```

```
47 NEG SEQ OVERVOLTAGE
← NEG_SEQ peak_over
```
```
47 #1 PICKUP
_____ Volts
```
```
47 #1 DELAY
_____ Cycles
```
```
47 #2 PICKUP
_____ Volts
```
```
47 #2 DELAY
_____ Cycles
```

```
59I PEAK OVERVOLTAGE
← neg_seq PEAK_OVER
```
```
59I PICKUP
_____ PU
```
```
59I DELAY
_____ Cycles
```

Figure A-4   Setpoint & Timing Record Form (1 of 4)

```
CURRENT RELAY
volt CURR freq pwr →
```

```
50 INST OVERCURRENT
INST inv
```

```
50 PICKUP
_____ Amps
```

```
51V INV TIME OVERCURRENT
inst INV
```

```
51V PICKUP
_____ Amps
```

```
51V CURVE
def inv vinv einv→
```

```
51V CURVE
← iec1 iec2 iec3 iec4
```

```
51V TIME DIAL
_____
```

```
51V VOLTAGE CONTROL
disable V_CNTRL v_rstrnt
```

```
51V VOLTAGE CONTROL
_____ VOLTS
```

```
50G INST OVERCURRENT
←NUTRL_INST nutrl_inv→
```

```
50G PICKUP
_____ Amps
```

```
50G DIRECTIONAL ELEMENT
disable enable
```

```
51G INV TIME OVERCURRENT
←nutrl_inst NUTRL_INV→
```

```
51G PICKUP
_____ Amps
```

```
51G CURVE
def inv vinv einv →
```

```
51G CURVE
← iec1 iec2 iec3 iec4
```

```
51G TIME DIAL
_____
```

```
51G DIRECTIONAL ELEMENT
disable enable
```

```
46 NEG SEQ OVERCURRENT
← NEG_SEQ dir n_dir
```

```
46DT PICKUP
_____ Amps
```

```
46DT DELAY
_____ Cycles
```

```
46IT PICKUP
_____ Amps
```

```
46IT CURVE
def inv vinv einv →
```

```
46IT CURVE
← iec1 iec2 iec3 iec4
```

```
46IT TIME DIAL
_____
```

```
67 DIR OVERCURRENT
← neg_seq DIR n_dir →
```

```
67DT PICKUP
_____ Amps
```

```
67DT DIRECTIONAL ELEMENT
disable enable
```

```
67DT THREE PHASE DETECT
disable enable
```

```
67DT DELAY
_____ CYCLES
```

```
67IT PICKUP
_____ Amps
```

```
67IT DIRECTIONAL ELEMENT
disable enable
```

```
67IT CURVE
def inv vinv einv →
```

```
67IT CURVE
← iec1 iec2 iec3 iec4
```

```
67IT TIME DIAL
_____
```

```
67 MAX SENSITIVITY ANGLE
_____ Degrees
```

Figure A-4   Setpoint & Timing Record Form (2 of 4)

FREQUENCY RELAY
volt curr FREQ pwr →

POWER RELAY
volt curr freq PWR →

67N DIR NEUTRAL OVERCURR
← neg_seq dir N_DIR

67NDT PICKUP
_____ Amps

67NDT DIRECTIONAL ELEMENT
disable enable

67NDT DELAY
_____ CYCLES

67NIT PICKUP
_____ Amps

67NIT DIRECTIONAL ELEMENT
disable enable

67NIT CURVE
def inv vinv einv →

67NIT CURVE
← iec1 iec2 iec3 iec4

67NIT TIME DIAL
_____

NEUTRAL DIR SETUP
← N_DIRSU

67N MAX SENSITIVITY ANGLE
_____ Degrees

67N POLARIZATION
type1 type2 type 3 →

67N POLARIZATION
← type4 type5

81 FREQUENCY
FREQ rcfreq

81 #1 PICKUP
_____ Hz

81 #1 DELAY
_____ Cycles

81 #2 PICKUP
_____ Hz

81 #2 DELAY
_____ Cycles

81 #3 PICKUP
_____ Hz

81 #3 DELAY
_____ Cycles

81 #4 PICKUP
_____ Hz

81 #4 DELAY
_____ Cycles

81 RATE OF CHNG FREQ
freq RCFREQ

81R #1 PICKUP
_____ Hz/s

81R #1 DELAY
_____ Cycles

81R #2 PICKUP
_____ Hz/s

81R #2 DELAY
_____ Cycles

81R NEG SEQ VOLT IN-
HIBIT
_____ %

32 DIRECTIONAL POWER
PWR

32 #1 PICKUP
_____ PU

32 #1 OVER/UNDER POWER
Over_Power   Under_Power

32 #1 DELAY
_____ Cycles

32 #2 PICKUP
_____ PU

32 #2 OVER/UNDER POWER
Over_Power   Under_Power

32 #2 DELAY
_____ Cycles

PHASE DISTANCE RELAY
← DIST fuse sync →

21 PHASE DISTANCE
DIST

21 #1 DIAMETER
_____ Ohms

21 #1 OFFSET
_____ Ohms

21 #1 IMPEDANCE ANGLE
_____ Degrees

21 #1 DELAY
_____ Cycles

21 #2 DIAMETER
_____ Ohms

21 #2 OFFSET
_____ Ohms

21 #2 IMPEDANCE ANGLE
_____ Degrees

21 #2 DELAY
_____ Cycles

Figure A-4   Setpoint & Timing Record Form (3 of 4)

```
┌─────────────────────────────────┐
│ V.T. FUSE LOSS RELAY            │
│ ← dist FUSE sync →              │
└─────────────────────────────────┘
```

```
│ ┌─────────────────────────────┐
│ │ 60FL V.T. FUSE LOSS         │
│ │ FUSE                        │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 60FL INPUT INITIATE         │
│ │ fl i6 i5 i4 i3 i2 i1        │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 60FL DELAY                  │
│ │ 3O Cycles                   │
│ └─────────────────────────────┘
```

```
│ ┌─────────────────────────────┐
│ │ SYNC CHECK RELAY            │
│ │ ← dist fuse SYNC →          │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 25 SYNC CHECK               │
│ │ SYNC                        │
│ └─────────────────────────────┘
```

```
┌──────────────────────┐    ┌──────────────────────────┐
│ 79 SUPERVISE 25      │    │ 25 DELTA VOLT             │
│ disable enable       │    │ disable enable            │
└──────────────────────┘    └──────────────────────────┘
┌──────────────────────┐    ┌──────────────────────────┐
│ 25 PHASE LIMIT       │    │ 25 DELTA VOLT LIMIT       │
│ _____ Degrees     │    │ _____ Volts            │
└──────────────────────┘    └──────────────────────────┘
┌──────────────────────┐    ┌──────────────────────────┐
│ 25 UPPER VOLT LIMIT  │    │ 25 DELTA FREQUENCY        │
│ _____ Volts       │    │ disable enable            │
└──────────────────────┘    └──────────────────────────┘
┌──────────────────────┐    ┌──────────────────────────┐
│ 25 LOWER VOLT LIMIT  │    │ 25 DELTA FREQUENCY LIMIT  │
│ _____ Volts       │    │ _____ Hz               │
└──────────────────────┘    └──────────────────────────┘
┌──────────────────────┐    ┌──────────────────────────┐
│ 25 SYNC CHECK DELAY  │    │ 25 DEAD VOLT LIMIT        │
│ _____ Cycles      │    │ _____ Volts            │
└──────────────────────┘    └──────────────────────────┘
```

```
┌─────────────────────────────────┐
│ 25 DEAD V1                      │
│ disable enable                  │
└─────────────────────────────────┘
```

```
│ ┌─────────────────────────────┐
│ │ 25 DEAD V2                  │
│ │ disable enable              │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 25 DEAD V1 & V2             │
│ │ disable enable              │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 25 DEAD INPUT ENABLE        │
│ │ i6 i5 i4 i3 i2 i1           │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 25 DEAD DELAY               │
│ │ _____ Cycles             │
│ └─────────────────────────────┘
```

```
┌─────────────────────────────────┐
│ RECONNECT RELAY                 │
│ ← RECONNECT →                   │
└─────────────────────────────────┘
```

```
│ ┌─────────────────────────────┐
│ │ 79 RECONNECT                │
│ │ RECN                        │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 79 RECN INITIATED (TRIP)    │
│ │ o8 o7 o6 o5 o4 o3 o2 o1     │
│ └─────────────────────────────┘
│ ┌─────────────────────────────┐
│ │ 79 DELAY                    │
│ │ _____ Cycles             │
│ └─────────────────────────────┘
```

Figure A-4   Setpoint & Timing Record Form (4 of 4)

COMMUNICATION
← COMM setup exit

COM1 SETUP
COM1 com2 com3 com_adr→

COM1 BAUD RATE
← baud_4800 BAUD_9800

COM2 SETUP
com1 COM2 com3 com-adr→

COM2 BAUD RATE
← baud_4800 BAUD_9800

COM2 DEAD SYNC TIME
50 ms

COM2 PROTOCOL
BECO2200 modbus

COM3 SETUP
com1 com2 COM3 com-adr→

COM3 DEAD SYNC TIME
50 ms

COM3 PROTOCOL
BECO2200 modbus

COMMUNICATION ADDRESS
com1 com2 com3 COM-ADR→

COMMUNICATION ADDRESS
1

COMM ACCESS CODE
← ACCSS

COMM ACCESS CODE
9999

SETUP UNIT
← comm SETUP exit

SOFTWARE VERSION
VERS sn access number→

SOFTWARE VERSION
D-0060V01.02.07   a3b7

SERIAL NUMBER
vers SN access number→

SERIAL NUMBER
1

ALTER ACCESS CODES
vers sn ACCESS number→

ENTER ACCESS CODE
LEVEL#1 level#2 level#3

LEVEL #1
1111

ENTER ACCESS CODE
level#1 LEVEL#2 level#3

LEVEL #2
2222

ENTER ACCESS CODE
level#1 level#2 LEVEL#3

LEVEL #3
9999

USER CONTROL NUMBER
vers sn access NUMBER→

USER CONTROL NUMBER
1

USER LOGO LINE 1
←LOGO1 logo2 out alrm→

USER LOGO LINE 1
BECKWITH ELECTRIC CO.

USER LOGO LINE 2
←logo1 LOGO2 out alrm→

USER LOGO LINE 2
    M-3520

CLEAR OUTPUT COUNTERS
←logo1 logo2 OUT alrm→

CLEAR OUTPUT COUNTERS
PRESS ENTER KEY TO CLEAR

CLEAR ALARM COUNTER
←logo1 logo2 out ALRM→

CLEAR ALARM COUNTER
PRESS ENTER KEY TO CLEAR

Figure A-5   Communication Data & Unit Setup – As Shipped (1 of 2)   **A–13**

```
┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┐
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │ ← TIME error diag       │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │ 01-JAN-2001 01:01:80    │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │       01 Year           │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │ JAN feb mar apr may →   │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │       01 Date           │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │ SUN mon tue wed thu →   │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │       01 Hour           │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │       01 Minutes        │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ DATE & TIME             │ │
│ │       01 Seconds        │ │
│ ╰─────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┘

┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┐
│ ╭─────────────────────────╮ │
│ │ CLEAR ERROR CODES       │ │
│ │ ← time ERROR diag       │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ CLEAR ERROR CODES       │ │
│ │ PRESS ENTER KEY TO CLEAR│ │
│ ╰─────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┘

┌─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┐
│ ╭─────────────────────────╮ │
│ │ DIAGNOSTIC MODE         │ │
│ │ ← time error DIAG       │ │
│ ╰─────────────────────────╯ │
│ ╭─────────────────────────╮ │
│ │ PROCESSOR WILL RESET!   │ │
│ │ ENTER KEY TO CONTINUE   │ │
│ ╰─────────────────────────╯ │
└─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─┘
```

■ **NOTE**: See Section 6.2, Diagnostic Test Procedures

Figure A-5   Communication Data & Unit Setup – As Shipped (2 of 2)

```
CONFIGURE RELAY
VOLTAGE_RELAY →
```

```
CONFIGURE RELAY
← CURRENT_RELAY →
```

```
CONFIGURE RELAY
← FREQUENCY_RELAY →
```

```
27#1 PHASE OVERVOLTAGE
disable ENABLE
```

```
27 #1 BLOCK INPUT
FL i6 i5 i4 i3 i2 I1
```

```
27 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1
```

```
27#2 PHASE UNDERVOLTAGE
DISABLE enable
```

```
59 #1 PHASE OVERVOLTAGE
disable ENABLE
```

```
59 #1 BLOCK INPUT
FL i6 i5 i4 i3 i2 I1
```

```
59 #1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1
```

```
59 #2 PHASE OVERVOLTAGE
DISABLE enable
```

```
27G NEUTRAL UNDERVOLT
-FUNCTION UNAVAILABLE-
```

```
59G NEUTRAL OVERVOLT
-FUNCTION UNAVAILABLE-
```

```
47 NEG SEQ OVERVOLT
-FUNCTION UNAVAILABLE-
```

```
59I PEAK OVERVOLTAGE
-FUNCTION UNAVAILABLE-
```

```
50 INST OVERCURRENT
-FUNCTION UNAVAILABLE-
```

```
51V OVERCURRENT INV
-FUNCTION UNAVAILABLE-
```

```
50G NTRL INST OVERCURRNT
-FUNCTION UNAVAILABLE-
```

```
51G NTRL OVERCURRENT INV
-FUNCTION UNAVAILABLE-
```

```
46 NEG SEQ CURRENT
-FUNCTION UNAVAILABLE-
```

```
67 PHASE DIR OVERCURRENT
-FUNCTION UNAVAILABLE-
```

```
67N RESIDUAL DIR OVERCUR
-FUNCTION UNAVAILABLE-
```

```
81 #1 FREQUENCY
DISABLE enable
```

```
81 #2 FREQUENCY
DISABLE enable
```

```
81 #3 FREQUENCY
DISABLE enable
```

```
81 #4 FREQUENCY
DISABLE enable
```

```
81R RATE OF CHNG FREQ
-FUNCTION UNAVAILABLE-
```

```
CONFIGURE RELAY
← POWER_RELAY →
```

```
32 DIRECTIONAL POWER
-FUNCTION UNAVAILABLE-
```

```
CONFIGURE RELAY
←PHASE_DISTANCE_RELAY→
```

```
21 #1 PHASE DISTANCE
-FUNCTION UNAVAILABLE-
```

Figure A-6   Functional Configuration –   As Shipped (1 of 2)   **A–15**

```
┌─────────────────────────────┐      ┌─────────────────────────────┐
│ CONFIGURE RELAY             │      │ CONFIGURE RELAY             │
│ ←V.T. FUSE_LOSS RELAY  →    │      │ ← RECONNECT_RELAY  →        │
└─────────────────────────────┘      └─────────────────────────────┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐      ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────╮ │      │ ╭───────────────────────╮ │
│ │ 60FL V.T. FUSE LOSS   │ │      │ │ 79 RECONNECT          │ │
│ │ disable ENABLE        │ │      │ │ disable ENABLE        │ │
│ ╰───────────────────────╯ │      │ ╰───────────────────────╯ │
│ ╭───────────────────────╮ │      │ ╭───────────────────────╮ │
│ │ 60FL BLOCK INPUT      │ │      │ │ 79 BLOCK INPUT        │ │
│ │ fl i6 i5 i4 i3 i2 I1  │ │      │ │ fl i6 i5 i4 i3 i2 i1  │ │
│ ╰───────────────────────╯ │      │ ╰───────────────────────╯ │
│ ╭───────────────────────╮ │      │ ╭───────────────────────╮ │
│ │ 60FL RELAY OUTPUT     │ │      │ │ 79 RELAY OUTPUT       │ │
│ │ o8 O7 o6 o5 o4 o3 o2 o1│ │      │ │ O8 o7 o6 o5 o4 o3 o2 o1│ │
│ ╰───────────────────────╯ │      │ ╰───────────────────────╯ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘      └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘

┌─────────────────────────────┐
│ CONFIGURE RELAY             │
│ ← SYNC CHECK RELAY  →       │
└─────────────────────────────┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│ ╭───────────────────────╮ │
│ │ 25 SYNC CHECK         │ │
│ │ -FUNCTION UNAVAILABLE-│ │
│ ╰───────────────────────╯ │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

Figure A-6   Functional Configuration Record Form – As Shipped (2 of 2)

```
┌─────────────────────────────┐      ┌─────────────────────────────┐
│ VOLTAGE RELAY               │      │ CURRENT RELAY               │
│ VOLT curr freq pwr →        │      │ volt CURR freq pwr →        │
└─────────────────────────────┘      └─────────────────────────────┘
```

```
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  27 PHASE UNDERVOLTAGE     │   │  50 INST OVERCURRENT       │   │  NEUTRAL DIR SETUP         │
│  PHASE_UNDER phase_over→   │   │  INST inv                  │   │  ← N_DIRSU                 │
│                           │   │                           │   │                           │
│  27 #1 PICKUP             │   │  FUNCTION(S) DISABLED      │   │  FUNCTION(S) DISABLED      │
│      108 Volts            │   │  SEE CONFIGURE MENU        │   │  SEE CONFIGURE MENU        │
│                           │   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
│  27 #1 DELAY             │
│      30 Cycles            │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  51V INV TIME OVERCURRENT  │
                                 │  inst INV                  │
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐   │                           │
│  59 PHASE OVERVOLTAGE      │   │  FUNCTION(S) DISABLED      │
│  phase_under PHASE_OVER→   │   │  SEE CONFIGURE MENU        │
│                           │   └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
│                           │
│  59 #1 PICKUP             │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│      132 Volts            │   │  50G INST OVERCURRENT       │
│                           │   │  ←NUTRL_INST nutrl_inv→    │
│  59 #1 DELAY             │   │                           │
│      30 Cycles            │   │  FUNCTION(S) DISABLED      │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  SEE CONFIGURE MENU        │
                                 └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  27G NEUTRAL UNDERVOLTAGE  │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  ←NUTRL_UNDER nutrl_over→  │   │  51G INV TIME OVERCURRENT  │
│                           │   │  ←nutrl_inst NUTRL_INV→    │
│  FUNCTION(S) DISABLED      │   │                           │
│  SEE CONFIGURE MENU        │   │  FUNCTION(S) DISABLED      │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  SEE CONFIGURE MENU        │
                                 └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  59G NEUTRAL OVERVOLTAGE   │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  ←nutrl_under NUTRL_OVER→  │   │  46 NEG SEQ OVERCURRENT     │
│                           │   │  ← NEG_SEQ dir n_dir       │
│  FUNCTION(S) DISABLED      │   │                           │
│  SEE CONFIGURE MENU        │   │  FUNCTION(S) DISABLED      │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  SEE CONFIGURE MENU        │
                                 └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  47 NEG SEQ OVERVOLTAGE    │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  ← NEG_SEQ peak_over       │   │  67 DIR OVERCURRENT         │
│                           │   │  ← neg_seq DIR n_dir →     │
│  FUNCTION(S) DISABLED      │   │                           │
│  SEE CONFIGURE MENU        │   │  FUNCTION(S) DISABLED      │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  SEE CONFIGURE MENU        │
                                 └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  59I PEAK OVERVOLTAGE      │   ┌ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┐
│  ← neg_seq PEAK_OVER       │   │  67N DIR NEUTRAL OVERCURR   │
│                           │   │  ← neg_seq dir N_DIR       │
│  FUNCTION(S) DISABLED      │   │                           │
│  SEE CONFIGURE MENU        │   │  FUNCTION(S) DISABLED      │
└ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘   │  SEE CONFIGURE MENU        │
                                 └ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ─ ┘
```

Figure A-7   Setpoint & Timing – As Shipped (1 of 2)

```
FREQUENCY RELAY
volt curr FREQ pwr →
```

```
81 FREQUENCY
FREQ rcfreq
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
81 RATE OF CHNG FREQ
freq RCFREQ
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
POWER RELAY
volt curr freq PWR →
```

```
32 DIRECTIONAL POWER
PWR
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
PHASE DISTANCE RELAY
← DIST fuse sync →
```

```
21 PHASE DISTANCE
DIST ostp
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
78 OUT OF STEP
dist OSTP
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
V.T. FUSE LOSS RELAY
← dist FUSE sync →
```

```
60FL V.T. FUSE LOSS
FUSE
```

```
60FL INPUT INITIATE
FL i6 i5 i4 i3 i2 i1
```

```
60FL DELAY
30 Cycles
```

```
SYNC CHECK RELAY
← dist fuse SYNC →
```

```
25 SYNC CHECK
SYNC
```

```
FUNCTION(S) DISABLED
SEE CONFIGURE MENU
```

```
RECONNECT RELAY
← RECONNECT →
```

```
79 RECONNECT
RECN
```

```
79 RECN INITIATED (TRIP)
o8 o7 o6 o5 O4 O3 O2 O1
```

```
79 DELAY
30 Cycles
```

Figure A-7   Setpoint & Timing – As Shipped (2 of 2)

FUNCTION	D	OUTPUTS								FL	INPUTS					
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
21 #1	✓															
21 #2	✓															
25	✓															
27 #1									✓	✓						✓
27 #2	✓															
27G	✓															
32 #1	✓															
32 #2	✓															
46DT	✓															
46IT	✓															
47 #1	✓															
47 #2	✓															
50	✓															
50G	✓															
51G	✓															
51V	✓															
59 #1									✓							✓
59 #2	✓															
59I	✓															
59G	✓															
60FL			✓													✓
67DT	✓															
67IT	✓															
67NDT	✓															
67NIT	✓															
78																
79		✓														
81 #1	✓															
81 #2	✓															
81 #3	✓															
81 #4	✓															
81R #1	✓															
81R #2	✓															

Check each box applicable : ✓   (See page A-1 for information on using this table.)

<u>D</u> Column = Function Disabled.   <u>FL</u> Column = Function blocked by fuse loss.

<u>INPUTS Columns</u> =Designated function blocking input(s)   <u>OUTPUTS Columns</u> =Designated function output(s)

Table A-2   M-3520 Configuration As Shipped

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B Appendix B – Communications

The M-3520 Intertie Protection Relay incorporates three serial ports for intelligent, digital communication with external devices. Equipment such as RTUs, data concentrators, modem, or computers can be interfaced for direct, on-line real time data acquisition and control.

Generally, all data available to the operator through the front panel of the relay, with the optional M-3931 HMI module is accessible remotely through the BECO 2200 data exchange protocol. This protocol document and the BECO 2200 M-3520 database-specified protocol document are available from the factory or our website at www.beckwithelectric.com.

The M-3822 IPScom® Communication Software package has been supplied for communication to any IBM compatible computer running under Microsoft® Windows 95 or higher.

The protocol implements serial, byte oriented, asynchronous communication, and can be used to fulfill the following communications functions:

- Real time monitoring of line status.
- Interrogation and modification of setpoints.
- Downloading of recorded oscillograph data.
- Reconfiguration of functions.

■ **NOTE:** The following restrictions apply for MODBUS protocol use:

1. MODBUS protocol is not supported on COM1

2. Parity is supported on COM2 and COM3 only, valid selections are 8,N,2; 8,O,1; 8,E,1; 8,N,1; 8,O,2; 8,E,2 . ASCII mode is not supported (RTU only)

3. Standard baud rates from 300 to 9600 are supported

4. Only the following MODBUS commands are supported:

   a. Read holding register (function 03)

   b. read input register (function 04)

   c. Force single coil (function 05)

   d. Preset single register (function 06)

6. MODBUS does not support oscillograph record downloading.

For detailed information on communications, refer to Chapter 4, **IPScom Computer Operation.**

Communication Ports

The M-3520 has both front and rear panel RS-232 ports, and a rear RS-485 port. The front and rear panel RS-232 ports are 9-pin (DB9S) connector configured as DTE (Data Terminal Equipment) per the RS-232C standard. Signals are defined in Table B-1.

The RS-485 port is assigned to the rear panel terminal block pins 1 through 4 (see Figure B-2). This can be configured for isolated RS-485 two-wire or non-isolated four-wire operation.

■ **NOTE**: Four-wire operation is only available as a non-isolated RS-485 supplied option.

Each communication port may be configured to operate at any of the standard baud rates (1200, 2400, 4800, and 9600). The RS-485 port shares the same baud rate with COM2 (or COM1 – see Section 5.3).

While the RS-232 communication ports do include some Electrostatic Discharge (ESD) protection circuitry, they are excluded from passing ANSI/IEEE C37.90.1-1998. Beckwith Electric recommends the use of RS-232 to fiber optic converters to avoid any question of surge-withstand capability.

A null modem cable (see Figure B-1) allows direct connection to a personal computer (PC), if desired.

CIRCUIT		SIGNAL	COM 1	COM 2
BB	RX	Receive Data	Pin 2	Pin 2
BA	TX	Transmit Data	Pin 3	Pin 3
CA	RTS	Request to Send	Pin 7	Pin 7
CB	CTS	Clear to Send		Pin 8
CD	DTR	Data Terminal Ready	Pin 4	Pin 4
CF	DCD	Data Carrier Detect		Pin 1
AB	GND	Signal Ground	Pin 5	Pin 5
		+15V		Pin 1*
		-15 V		Pin 9*
		IRIG-B (+)		Pin 6*
*OPTIONAL - see 5.5, Circuit Board Switches and Jumpers ± 15V (± 15%) @100 mA max.				

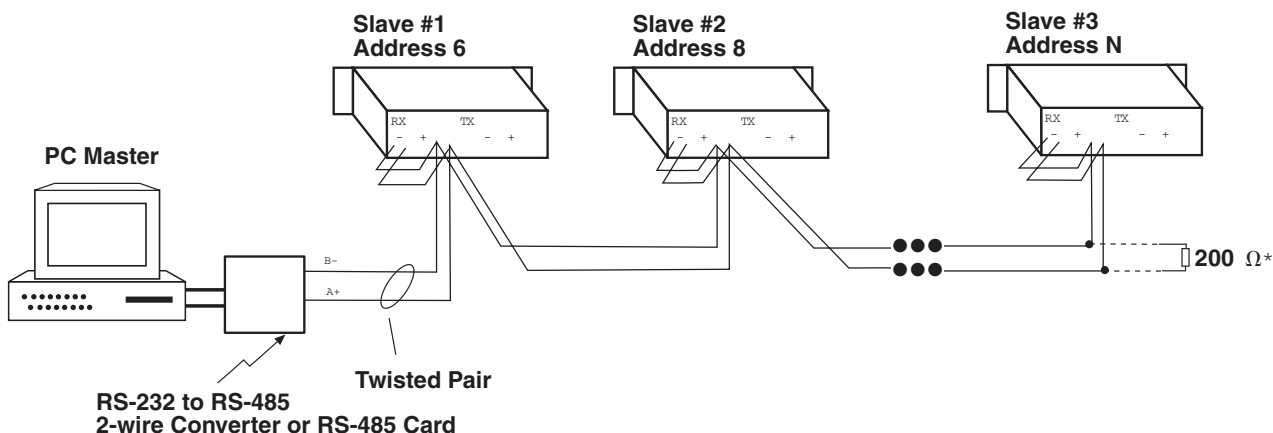*Table B-1   Communication Port Signals*
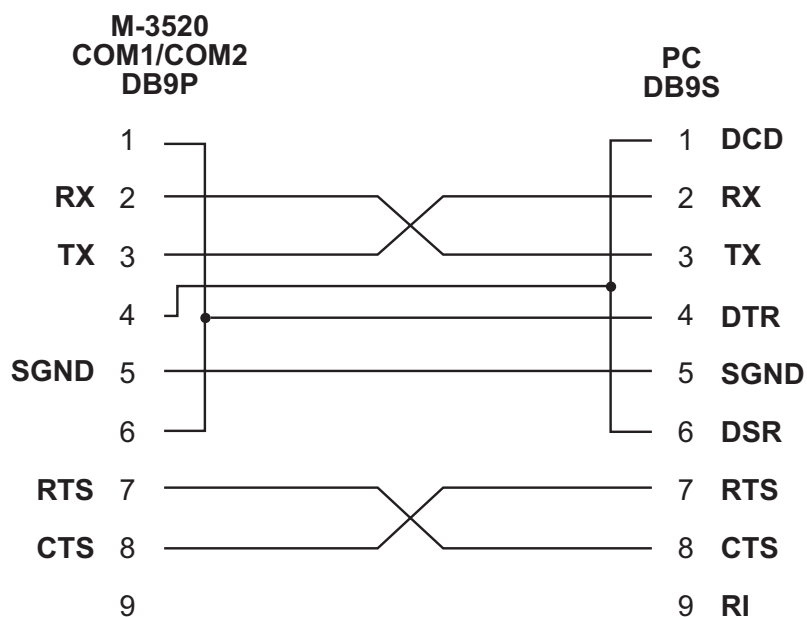
Figure B-1   Null Modem Cable

PC Master

IPScom running in "Echo Cancel" mode

25 pin or 9-25 pin
Straight-through Cable

DYMEC Fiber Optic
Link/Repeater

DCE
DTE

REP
OFF

T   R

Fiber Optic Cable

R   T   R   T   R   T

DCE
DTE

REP
OFF

DCE
DTE

REP
OFF

DCE
DTE

REP
OFF

Slave #1
Address 1

Slave #2
Address 2

Slave #3
Address 3

RS-232   RS-232   RS-232

9-25 pin Straight-through Cables
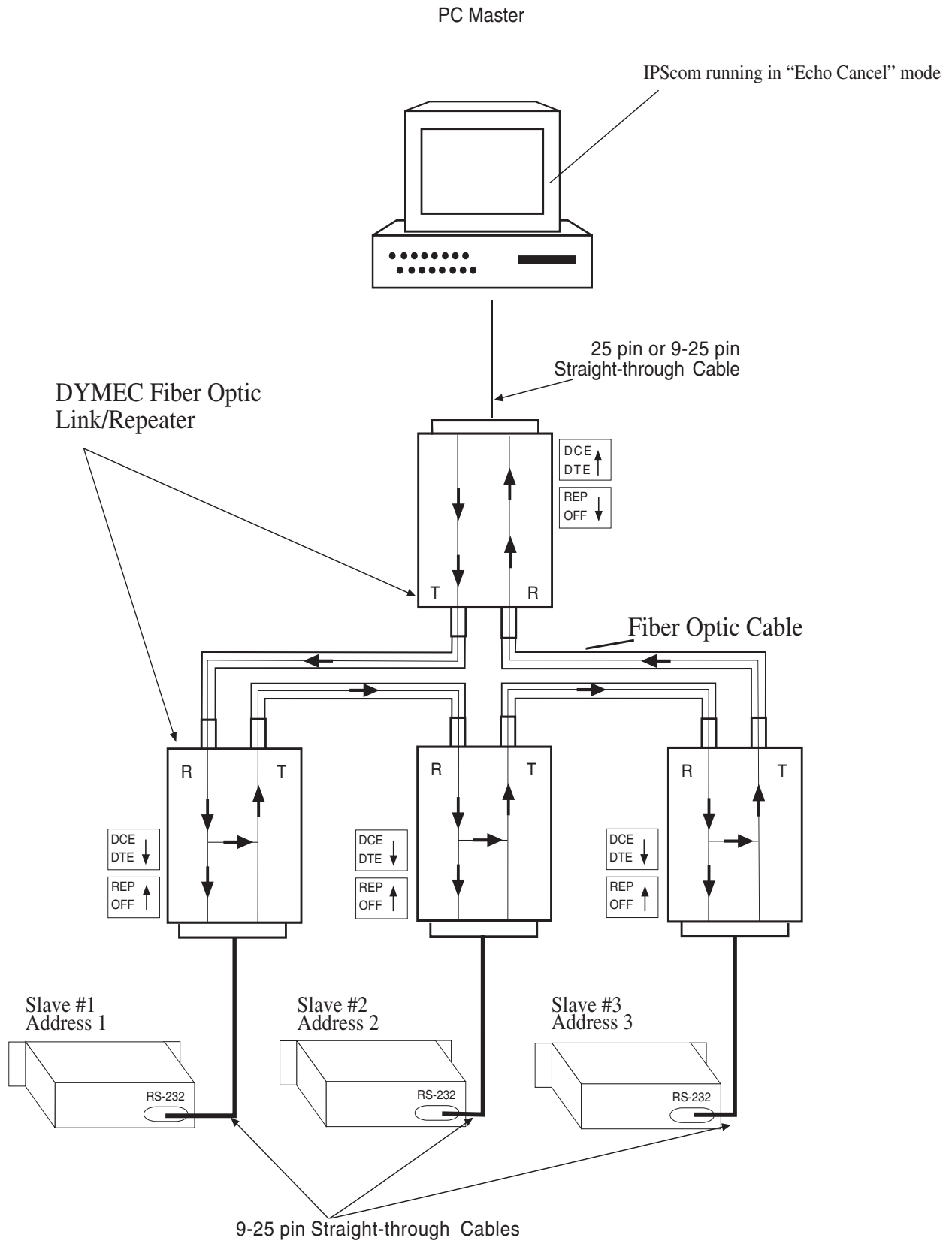
Figure B-2   RS-232 Fiber Optic Network

RS-485   4-Wire Network
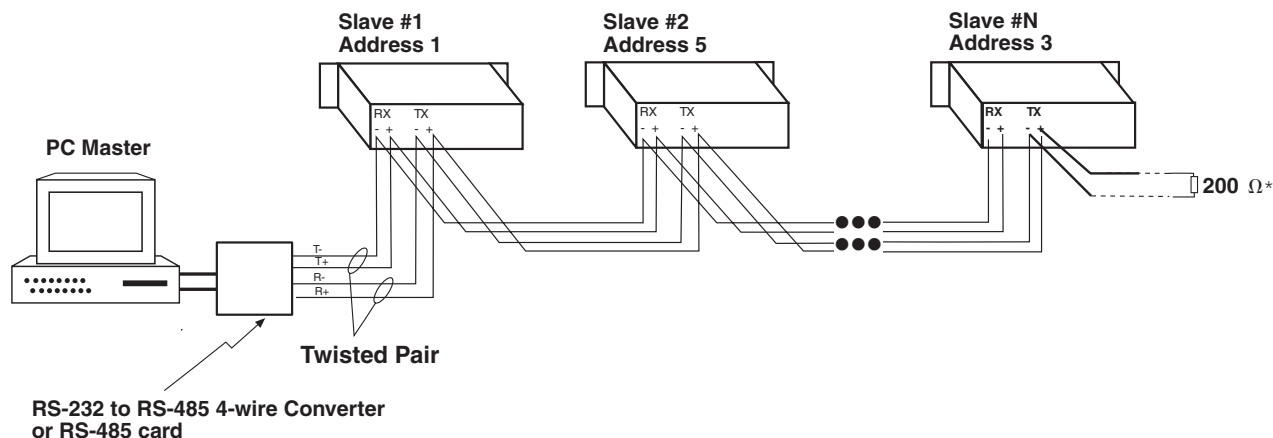
RS-485   2-Wire Network

▲ **CAUTION**: Due to the possibility of ground potential difference between units, the units should be mounted in the same rack. If this is not possible, fiber optics with the appropriate converters should be used for isolation. The two-wire topology is preferable to the four-wire, as circuitry within the relay provides some isolation. Four-wire operation is only available when the four-wire RS-485 option is selected at the time of purchase.

■ **NOTE**: Each address on the network must be unique. Only the last physical slave on the network should have the termination resistor installed.

Figure B-3   RS-485 Networks

C Appendix C – Error Codes

Error Code	Description
1	
2	Battery-backed RAM test fail
3	EEPROM write power-up fail
4	EEPROM read back power-up fail
5	Dual port RAM test fail
6	EEPROM write calibration checksum fail
7	EEPROM write setpoint calibration fail loss of power
8	EEPROM write setpoint checksum fail loss of battery backed RAM
9	DMA checksum/physical block fail
10	Oscillograph Memory Test fail
11	DSP external program RAM fail
12	DSP A/D convert fail
13	DSP ground channel fail
14	DSP reference channel fail
15	DSP PGA gain fail
16	DSP DSP<->Host interrupt 1 fail
17	DSP DSP <->Host interrupt 2 set fail
18	DSP DSP<->Host interrupt 2 reset fail
19	DSP program load fail
20	
21	
22	DSP DPRAM pattern test fail
23	EEPROM write verify error
24	BBRAM test error
25	Uninitialized EEPROM

Table C-1A   Error Codes

Error Code	Description
26	WARNING calibration checksum mismatch warning
27	WARNING setpoint checksum mismatch warning
28	WARNING low battery (BBRAM) warning
29	Supply/Mix PGA running test fail
30	
31	Unrecognized INTI interrupt code
32	Values update watchdog fail
33	Abort error
34	Restart error
35	Interrupt error
36	Trap error
37	Calibration running check fail
38	
39	
40	87 high speed interrupt noise
41	
42	
43	
44	Oscillograph buffer overflow
45	Oscillograph buffer underflow
46	Failure of DSP to calculate calibration phasors
47	Uncalibratable input (gain)
48	Uncalibratable input (phase)
49	
50	Stack overflow

Table C-1B   Error Codes

D

Appendix D – Inverse Time Curves

This Appendix contains Inverse Time Curve Families for M-3520 Intertie Protection Relay functions # 46, 51V, 51G, 67, and 67N.

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
1.50	0.69899	4.53954	3.46578	4.83520
1.55	0.64862	4.15533	3.11203	4.28747
1.60	0.60539	3.81903	2.81228	3.83562
1.65	0.56803	3.52265	2.55654	3.45706
1.70	0.53558	3.25987	2.33607	3.13573
1.75	0.50725	3.02558	2.14431	2.85994
1.80	0.48245	2.81566	1.97620	2.62094
1.85	0.46068	2.62673	1.82779	2.41208
1.90	0.44156	2.45599	1.69597	2.22822
1.95	0.42477	2.30111	1.57823	2.06529
2.00	0.41006	2.16013	1.47254	1.92006
2.05	0.37921	2.03139	1.37723	1.78994
2.10	0.38606	1.91348	1.29093	1.67278
2.15	0.37648	1.80519	1.21249	1.56686
2.20	0.36554	1.72257	1.12812	1.47820
2.30	0.35293	1.54094	1.01626	1.32268
2.40	0.34115	1.39104	0.92207	1.19250
2.50	0.33018	1.26561	0.84190	1.08221
2.60	0.31999	1.15945	0.77301	0.98780
2.70	0.31057	1.06871	0.71334	0.90626
2.80	0.30189	0.99049	0.66127	0.83527
2.90	0.29392	0.92258	0.61554	0.77303
3.00	0.28666	0.86325	0.57515	0.71811
3.10	0.28007	0.81113	0.53930	0.66939
3.20	0.27415	0.76514	0.50733	0.62593
3.30	0.26889	0.72439	0.47870	0.58700
3.40	0.26427	0.68818	0.45297	0.55196
3.50	0.26030	0.65591	0.42977	0.52032
3.60	0.25697	0.62710	0.40879	0.49163
3.70	0.25429	0.60135	0.38977	0.46554
3.80	0.25229	0.57832	0.37248	0.44175
4.00	0.24975	0.53904	0.34102	0.40129
4.20	0.24572	0.50641	0.31528	0.36564
4.40	0.24197	0.47746	0.29332	0.33460
4.60	0.23852	0.45176	0.27453	0.30741
4.80	0.23541	0.42894	0.25841	0.28346

■ **NOTE**: The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1A   M-3520 Inverse Time Overcurrent Relay Characteristic Curves

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
5.00	0.23266	0.40871	0.24456	0.26227
5.20	0.23029	0.39078	0.23269	0.24343
5.40	0.22834	0.37495	0.22254	0.22660
5.60	0.22684	0.36102	0.21394	0.21151
5.80	0.22583	0.34884	0.20673	0.19793
6.00	0.22534	0.33828	0.20081	0.18567
6.20	0.22526	0.32771	0.19511	0.17531
6.40	0.22492	0.31939	0.19044	0.16586
6.60	0.22360	0.31150	0.18602	0.15731
6.80	0.22230	0.30402	0.18187	0.14957
7.00	0.22102	0.29695	0.17797	0.14253
7.20	0.21977	0.29027	0.17431	0.13611
7.40	0.21855	0.28398	0.17090	0.13027
7.60	0.21736	0.27807	0.16773	0.12492
7.80	0.21621	0.27253	0.16479	0.12003
8.00	0.21510	0.26734	0.16209	0.11555
8.20	0.21403	0.26251	0.15961	0.11144
8.40	0.21300	0.25803	0.15736	0.10768
8.60	0.21203	0.25388	0.15534	0.10422
8.80	0.21111	0.25007	0.15354	0.10105
9.00	0.21025	0.24660	0.15197	0.09814
9.50	0.20813	0.23935	0.14770	0.09070
10.00	0.20740	0.23422	0.14473	0.08474
10.50	0.20667	0.22923	0.14180	0.07943
11.00	0.20594	0.22442	0.13894	0.07469
11.50	0.20521	0.21979	0.13615	0.07046
12.00	0.20449	0.21536	0.13345	0.06667
12.50	0.20378	0.21115	0.13084	0.06329
13.00	0.20310	0.20716	0.12833	0.06026
13.50	0.20243	0.20341	0.12593	0.05755
14.00	0.20179	0.19991	0.12364	0.05513
14.50	0.20119	0.19666	0.12146	0.05297
15.00	0.20062	0.19367	0.11941	0.05104
15.50	0.20009	0.19095	0.11747	0.04934
16.00	0.19961	0.18851	0.11566	0.04784
16.50	0.19918	0.18635	0.11398	0.04652
17.00	0.19881	0.18449	0.11243	0.04539
17.50	0.19851	0.18294	0.11102	0.04442
18.00	0.19827	0.18171	0.10974	0.04362
18.50	0.19811	0.18082	0.10861	0.04298
19.00	0.19803	0.18029	0.10762	0.04250
19.50	0.19803	0.18014	0.10679	0.04219
20.00	0.19803	0.18014	0.10611	0.04205

■ **NOTE**: The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1B   M-3520 Inverse Time Overcurrent Relay Characteristic Curves
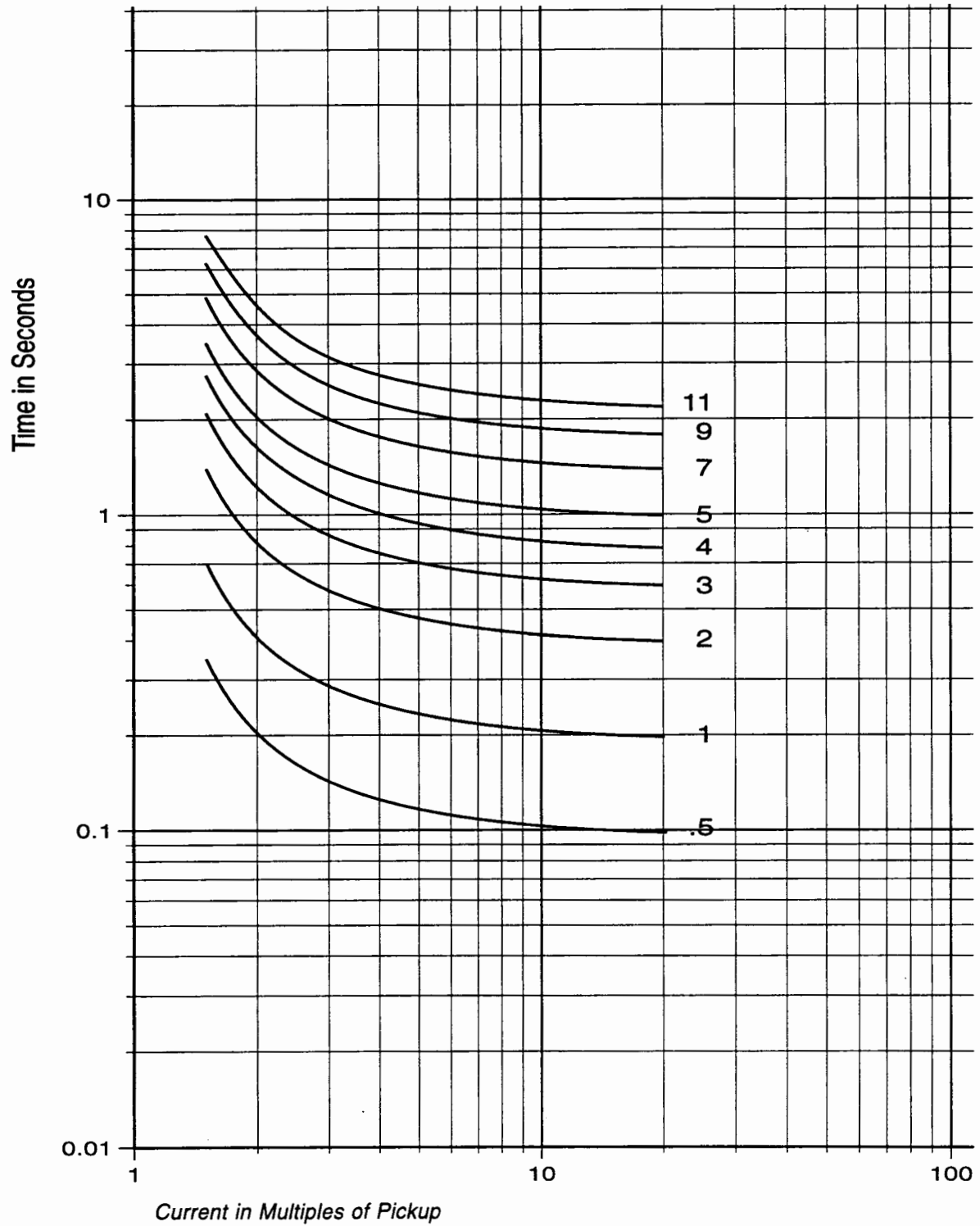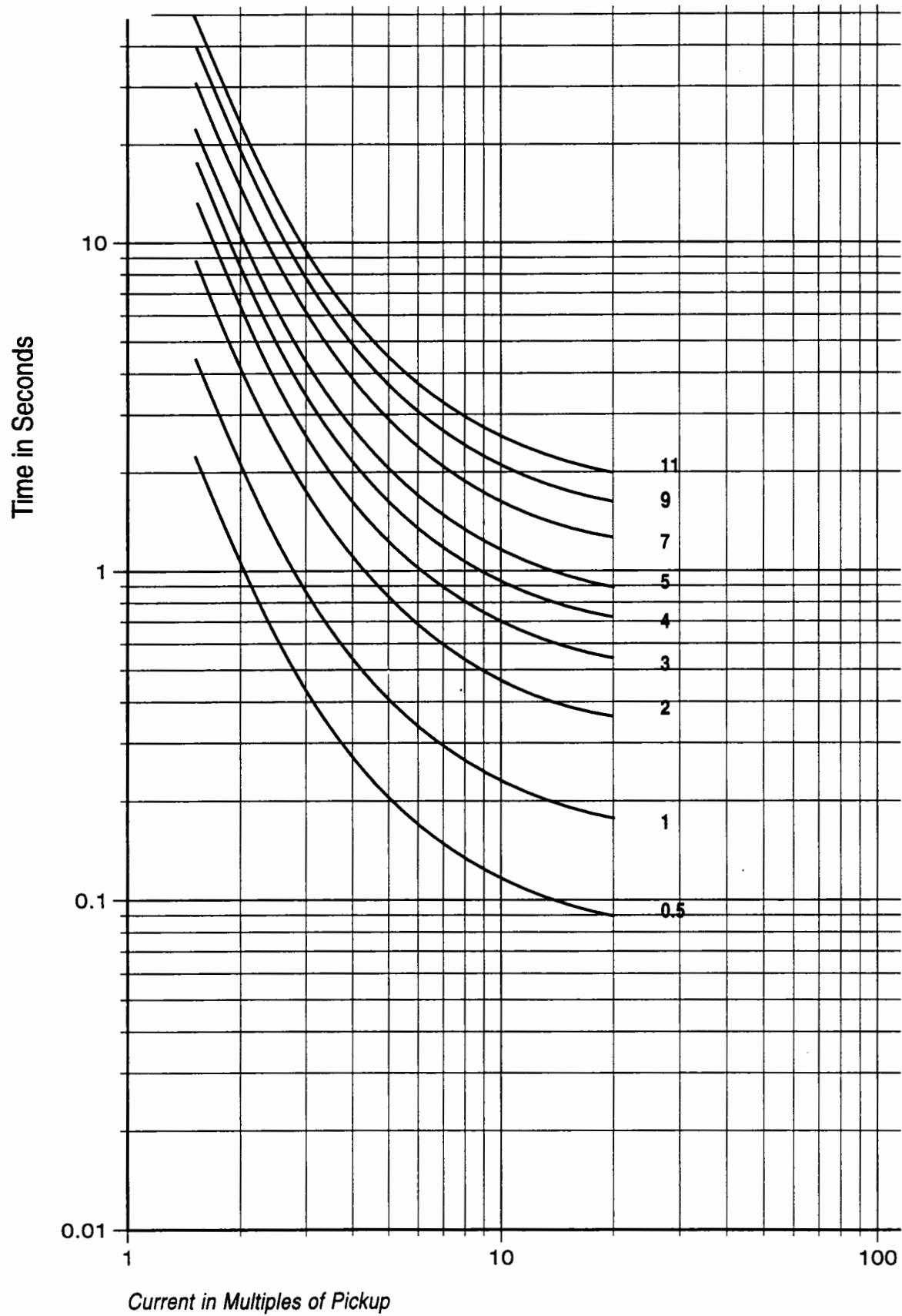
Figure D-1   Definite Time Overcurrent Curve

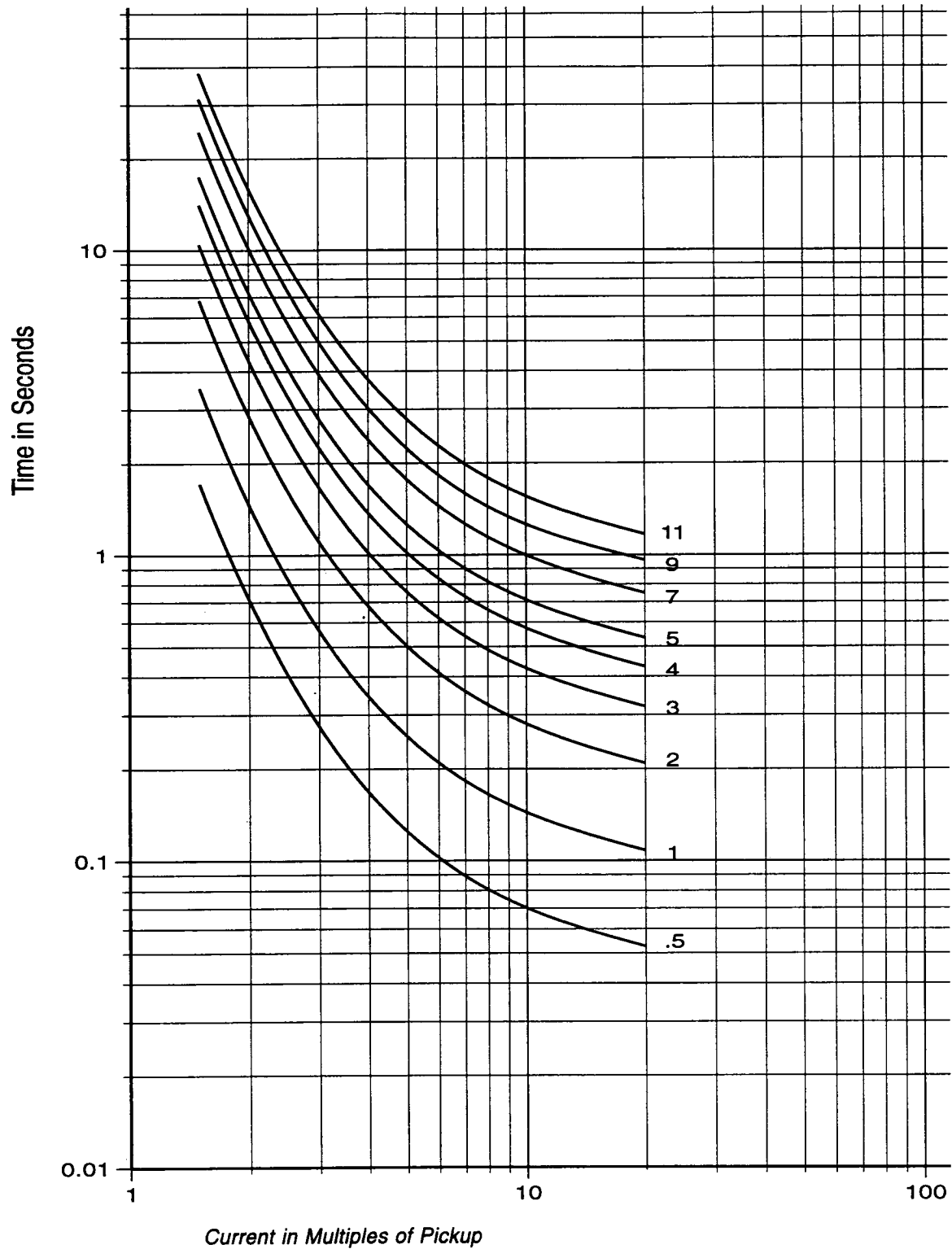*Figure D-2   Inverse Time Overcurrent Curve*

Figure D-3   Very Inverse Time Overcurrent Curve

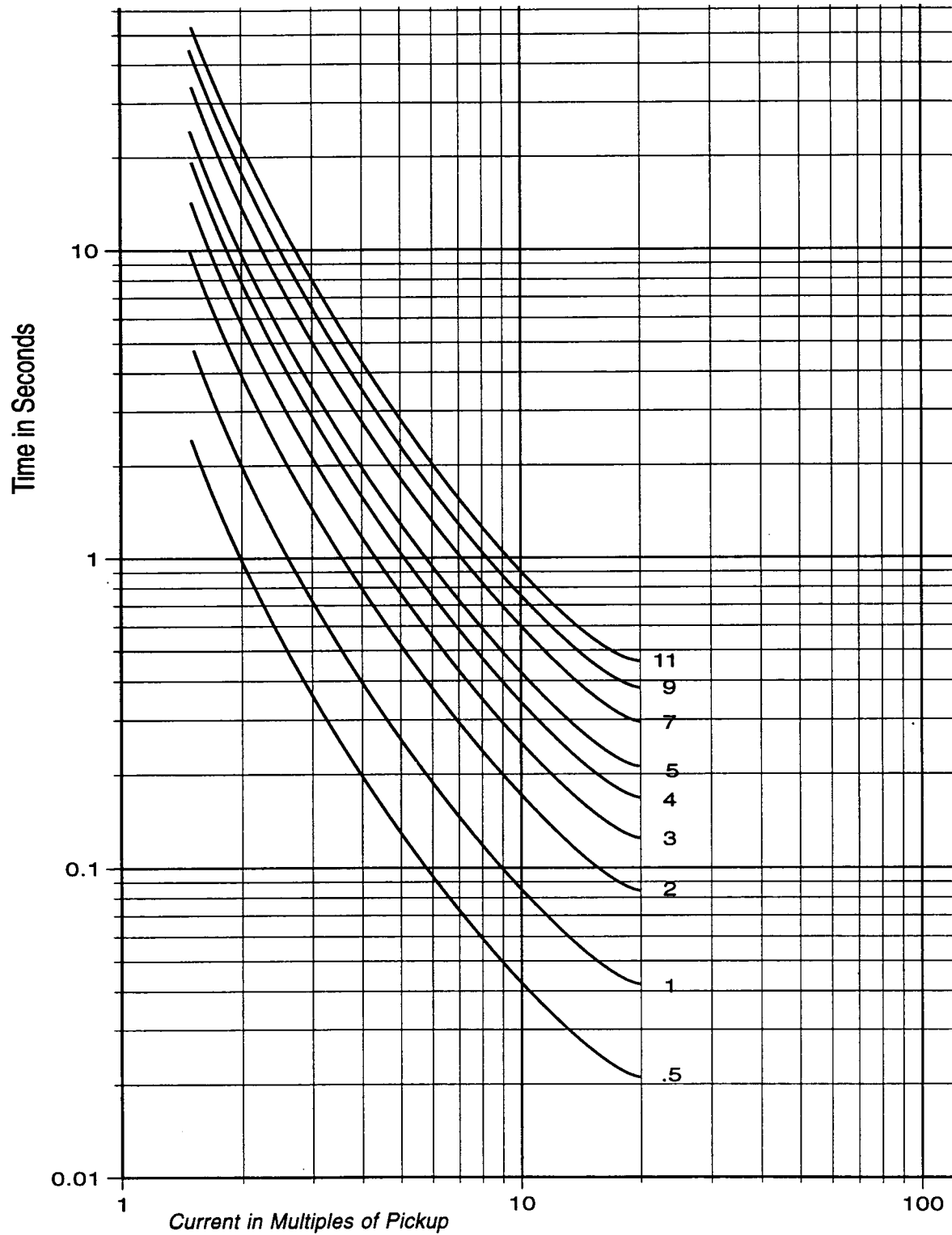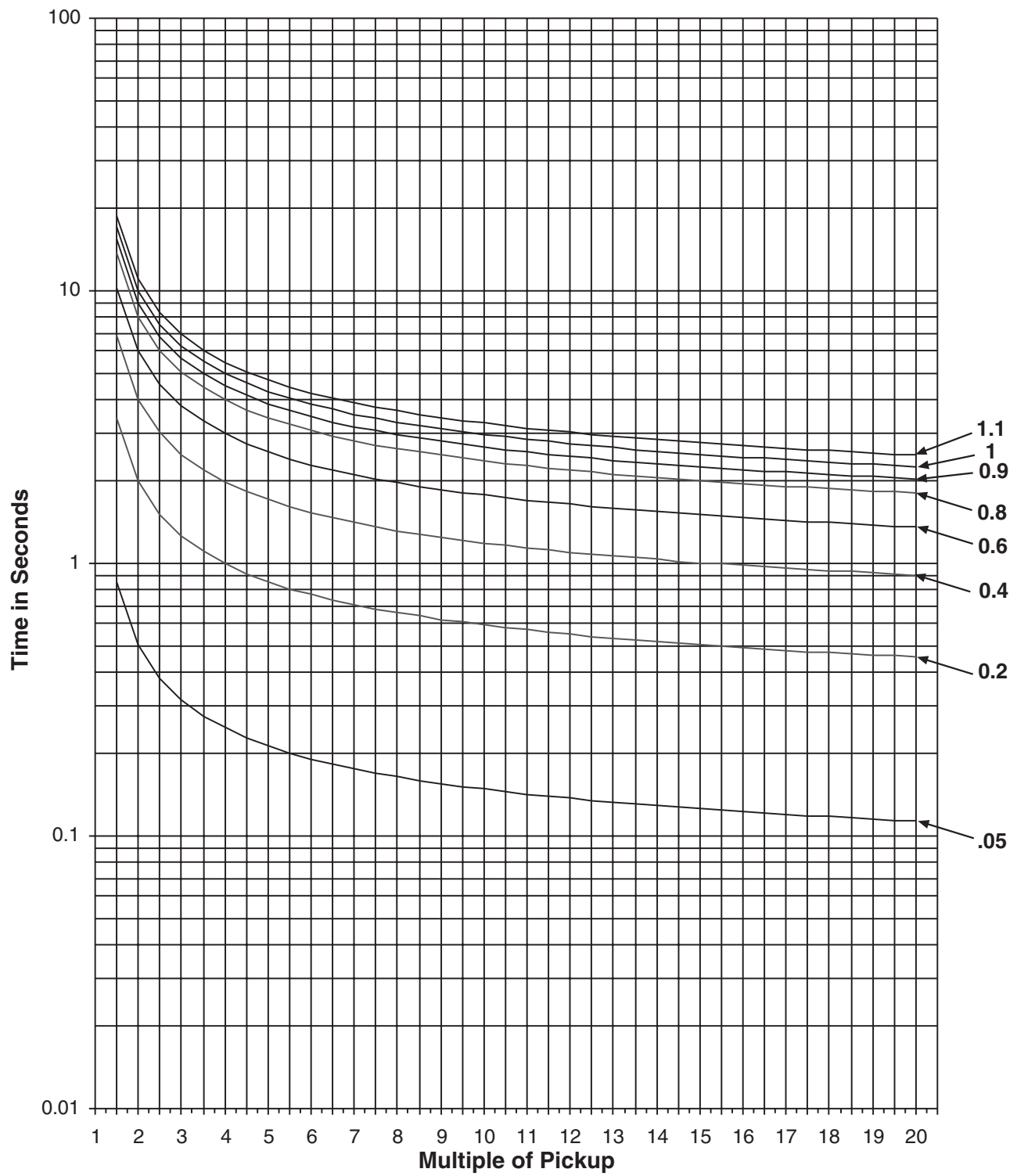*Figure D-4   Extremely Inverse Time Overcurrent Curve*

$$t=\text{TD x} \left[\frac{0.14}{M^{0.02} - 1} \right]$$
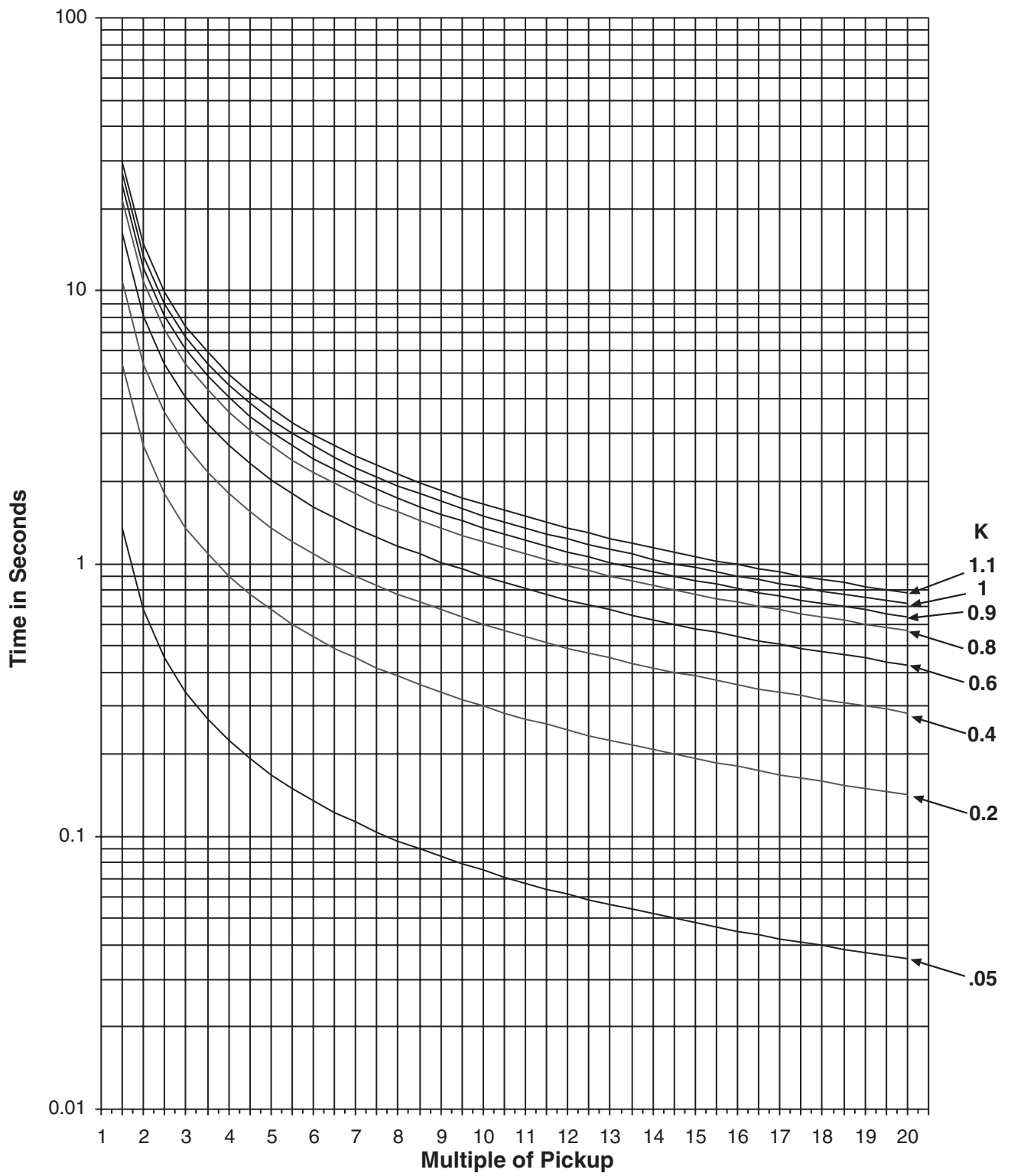
Figure D-5   IEC Curve #1   Inverse

$$t = TD \times \left[\frac{13.5}{M - 1} \right]$$

Figure D-6   IEC Curve #2 Very Inverse

$$t = TD \times \left[\frac{80}{M^2 - 1} \right]$$
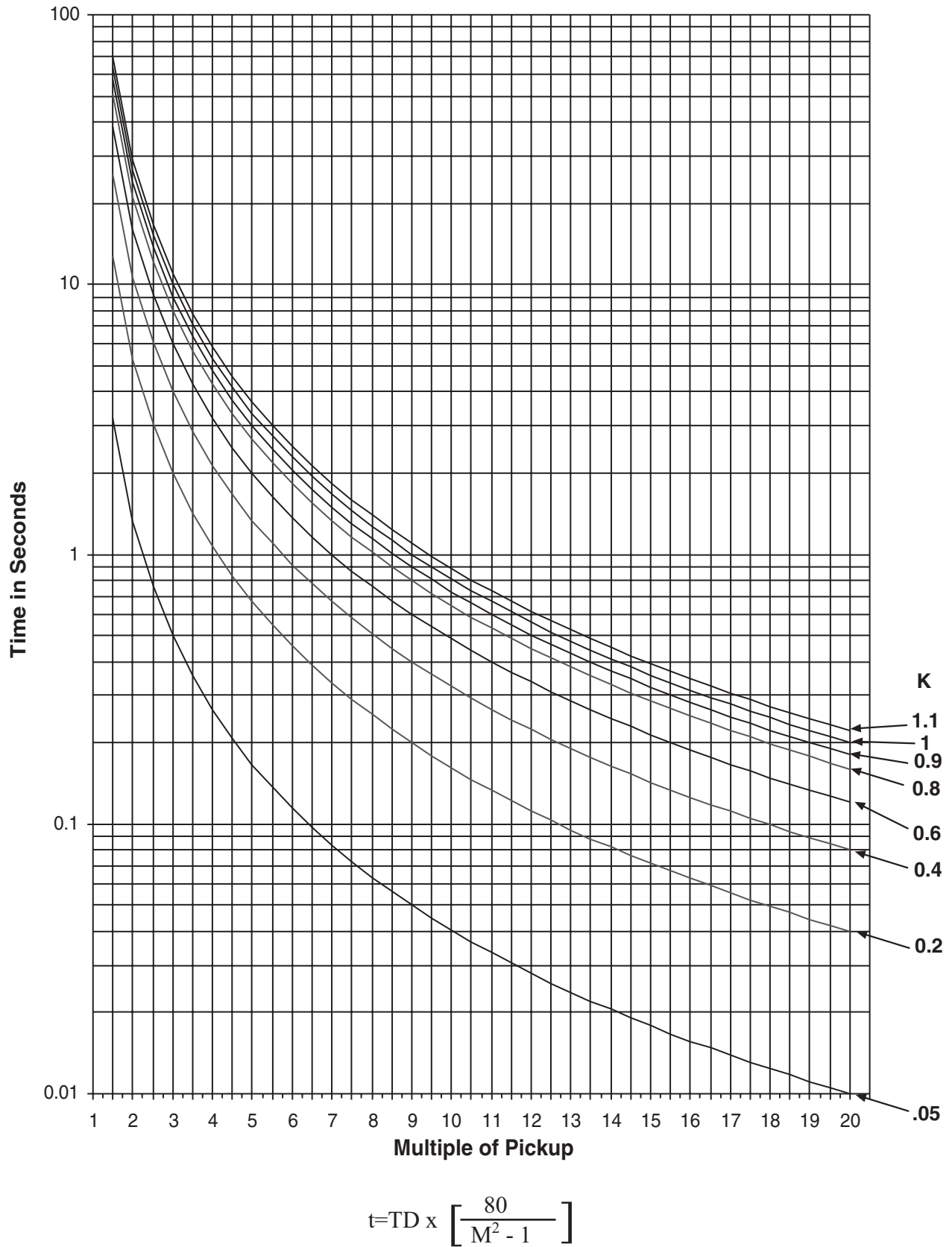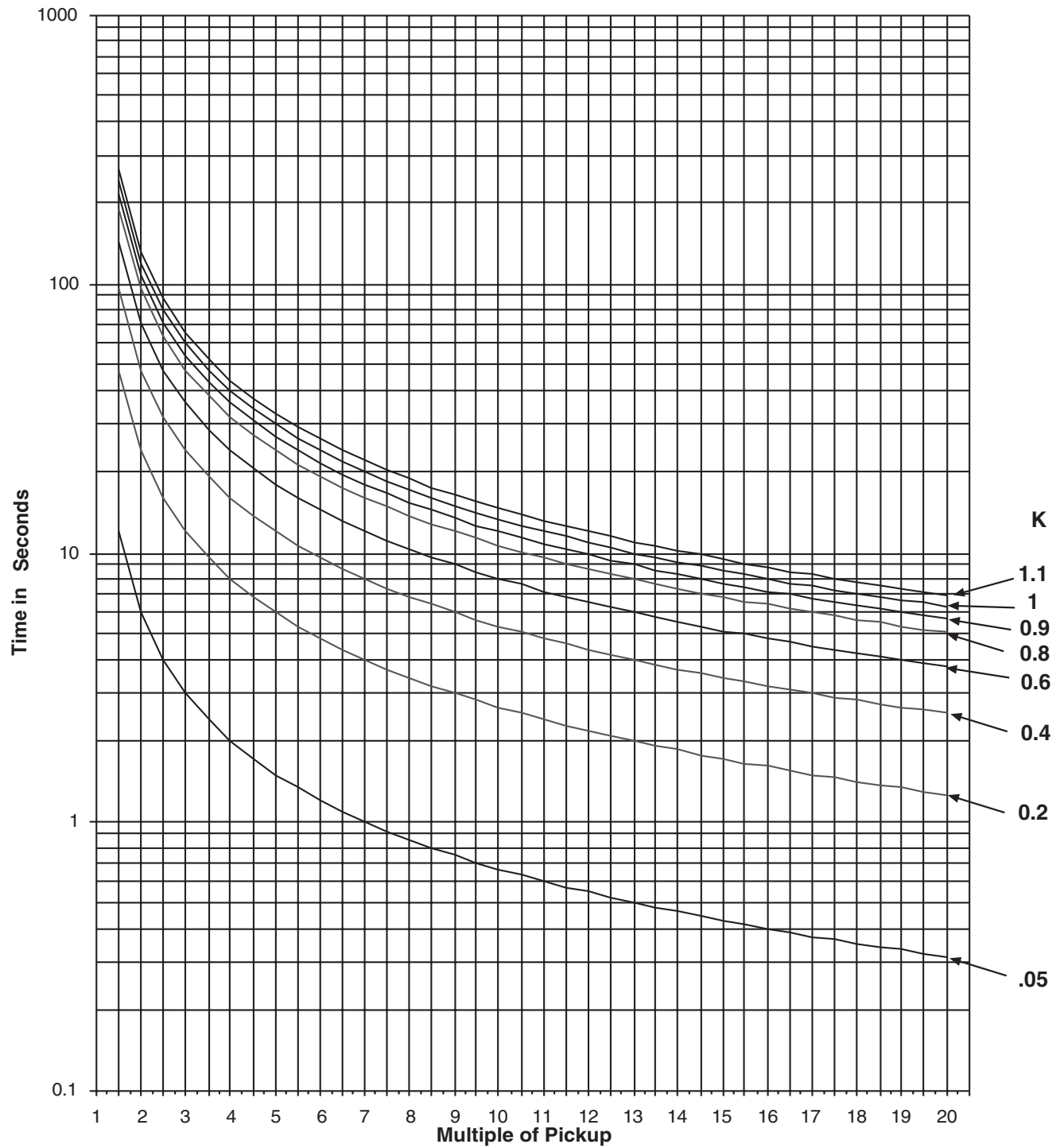
Figure D-7   IEC Curve #3 Extremely Inverse

$$t = TD \times \left[\frac{120}{M - 1} \right]$$

Figure D-8   IEC Curve #4 Long-Time Inverse

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E Appendix – Layup and Storage

Appendix E includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3520 Intertie Protection Relay.

Storage Requirements (Environment)

The recommended storage environment parameters for the M-3520 are:

- The ambient temperature where the M-3520 is stored is within a range of 5° C to 40° C

- The maximum relative humidity is less than or equal to 80% for temperatures up to 31° C, decreasing to 31° C linearly to 50% for relative humidity at 40° C.

- The storage area environment is free of dust, corrosive gases, flammable materials, dew, percolating water, rain and solar radiation.

Storage Requirements (Periodic Surveillance During Storage)

The M-3520 power supply contains electrolytic capacitors. It is recommended that power be applied to the relay (PS1 and optional PS2 redundant power supply when installed) every three to five years for a period of not less than one hour to help prevent the electrolytic capacitors from drying out.

Layup Configuration

The M-3520 includes a removable lithium battery backed TIMEKEEPER® module (Beckwith Electric component U25, Figure 5-7). The TIMEKEEPER module is the M-3520 real-time clock and also provides power to the unit's nonvolatile memory when power is not applied to the unit.

Layup of the M-3520 requires verifying that the system clock is stopped. The steps necessary to verify system clock status are as follows:

▲ **CAUTION:** Do not use the diagnostic mode in relays that are installed in an active protection scheme.

For units _with_ the optional HMI panel:

1. Verify that the Power Supply (PS) fuses are installed.

2. Determine the unit power supply rating by observing the check box below the PS terminals on the rear of the unit.

3. Apply power to the unit consistant with the rating determined in Step 2 (see Section 5.3 , External Connections). The unit will enter the selftest mode.

4. When the selftests are complete, then press **ENTER** to begin main menu.

5. Press the right arrow pushbutton until **SETUP UNIT** is displayed.

6. Press **ENTER** to access the **SETUP UNIT** menu.

7. Press the right arrow pushbutton until **DIAGNOSTIC MODE** is displayed.

8. Press **ENTER**. A reset warning will be displayed:

```
PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE
```

⬢ **WARNING: All relay functions and protection will be inoperative while the relay is in diagnostic mode.**

9. Press **ENTER**. Unit will now reset and **DIAGNOSTIC MODE** will be temporarily displayed, followed by **OUTPUT TEST** (RELAY). This is the beginning of the diagnostic menu.

10. Press the right arrow pushbutton until the following is displayed:

```
CLOCK TEST
← CLOCK led cal factory
```

11. Press **ENTER**. The following is displayed:

```
CLOCK TEST
03-JAN-1998 09:00:00.000
```

12. If the clock is running, press **ENTER** to stop the clock. The following is displayed:

```
CLOCK TEST
-CLOCK STOP-
```

■ **NOTE:** When the relay clock is stopped, the seconds will be displayed as 80.

13. Press **ENTER** and verify the relay clock is stopped. A display similar to the following is shown with the seconds stopped:

```
CLOCK TEST
03-JAN-09:01:80.000
```

14. When the clock has been verified to be stopped, then press **EXIT** until the following message appears:

```
PRESS EXIT TO
EXIT DIAGNOSTIC MODE
```

15. Press **EXIT** again to exit **DIAGNOSTIC MODE**. The relay will reset and normal running mode will resume.

■ **NOTE**: Pressing any button other than **EXIT** will return the user to **DIAGNOSTIC MODE.**

16. Remove power from the unit. The unit can now be placed in storage.

For units _without_ the optional HMI panel:

1. Verify that the Power Supply (PS) fuses are installed.

2. Determine the unit power supply rating by observing the check box below the PS terminals on the rear of the unit.

3. Apply power to the unit consistant with the rating determined in Step 2 (see Section 5.3 , External Connections). The unit will enter the selftest mode.

4. Install IPSutil™ Communications Software (see Section 4.6, IPSutil Communications Software) on a PC that includes the following:

    • Microsoft Windows™ 95 Operating System or above

    • Equipped with a serial port

5. Connect a null modem cable from COM1 of the relay to the PC serial port.

    IPSutil supports COM1 port direct connection only. IPSutil is not supported through COM2 or COM3 ports.

6. Open the IPSutil software.

7. Select "Comm" from the menu bar and then select "Connect". IPSutil will display the "Communication Dialog Screen" Figure 4-5.

8. Verify that the PC COM port that the null modem cable is connected to is selected in the "PC Port".

9. Select "Open COM", IPSutil will connect to the unit and then return to the IPSutil Main Screen.

10. Select "Clock" from the menu bar. IPSutil will display the "Unit Date/Time Dialog Screen Figure 4-11.

11. Verify that "Start Clock" is displayed, then proceed as follows:

    a. If "Start Clock" is displayed, then select "Save" and go to Step 12.

    b. If "Stop Clock" is displayed, then select "Stop Clock" and then select "Save".

12. Close communications with the unit by selecting "Comm" from the menu bar and then select "Exit".

13. Disconnect the null modem cable and then remove power from the unit. The unit can now be placed in storage.

Storage of the M-3520 greater than five years may require replacement of the lithium battery prior to placing the unit in service. Contact Beckwith Electric Customer Service for replacement procedure.

Legal Information

Patent

The units described in this manual are covered by U.S. Patents 5,592,393 and 5,224,011.

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 five 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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