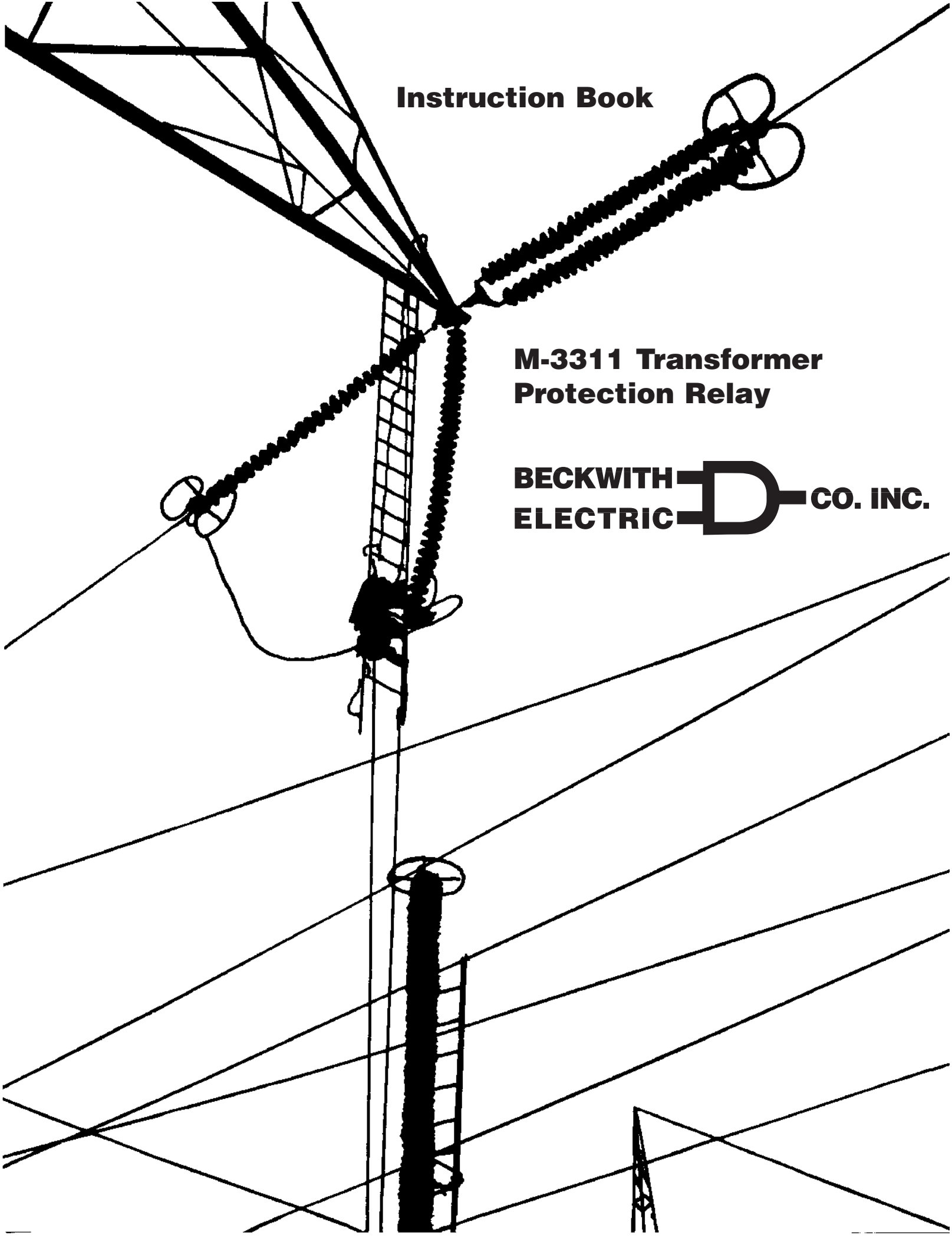
Instruction Book

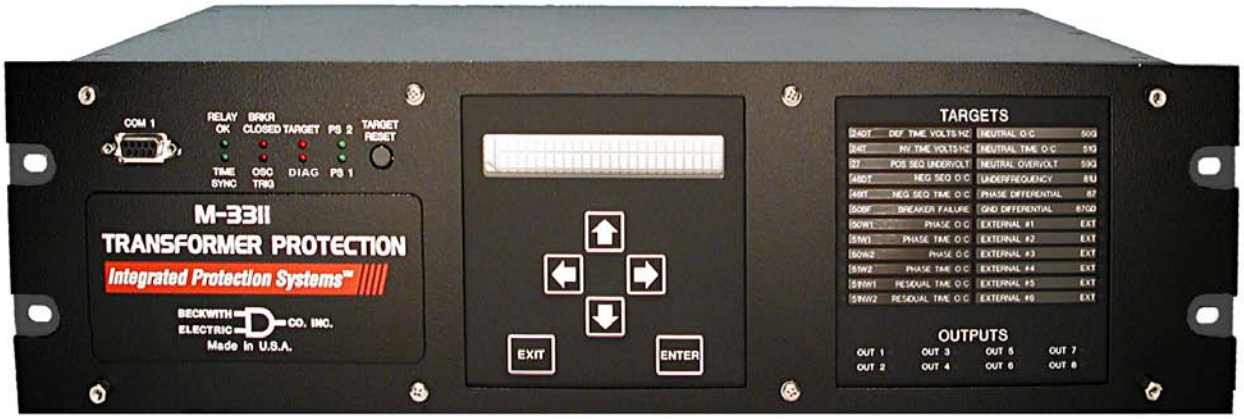


M-3311 Transformer Protection Relay

BECKWITH ELECTRIC CO. INC.

Transformer Protection M-3311

Integrated Protection System®



Unit shown with optional M-3931 HMI Module and M-3911 Target Module

- **For Transformers of All Sizes:**
  - **2 or 3 winding Transformers**
  - **Unit Wrapping of Generating Plants**
  - **Unit Protection of Other Electrical Apparatus and certain Bus Arrangements (including those with a transformer in the zone)**
- **Additional Applications: System Backup Protection, Load Shedding (voltage and frequency), Bus Protection, and individual Breaker Failure Protection for each winding input**

Standard Protective Functions

- Negative-sequence inverse time overcurrent (46)
- Winding thermal protection (49)
- Three winding instantaneous phase overcurrent (50)
- Breaker Failure (50BF)
- Instantaneous ground overcurrent (50G)
- Instantaneous residual overcurrent (50N)
- Three winding inverse time phase overcurrent (51)
- Inverse time ground overcurrent (51G)
- Inverse time residual overcurrent (51N)
- Three winding, phase differential (87T) and High Set instantaneous (87H)
- Ground differential (87GD)
- Six External input functions with individual timers

Optional Single-Phase Voltage Protection Package

- Overexcitation (24) V/Hz, two definite time and one inverse time elements
- Phase undervoltage (27) function for load shedding
- Ground Overvoltage (59G)
- Over/Underfrequency (81O/U)

Standard Features

- Four Setpoint Groups
- Eight programmable outputs and six programmable inputs
- Oscillographic recording
- 32-target storage
- Real time metering of measured and calculated parameters, including demand currents
- Two RS-232 and one RS-485 communications ports
- Standard 19" rack-mount design
- Removable printed circuit board and power supply
- 50 and 60 Hz models available
- 1 or 5 A rated CT inputs available
- M-3820B IPScom® Communications Software
- IRIG-B time synchronization
- Includes MODBUS, BECO 2200 and DNP 3.0 protocols

Optional Features

- Redundant Power Supply
- M-3911 Target Module
- M-3931 Human-Machine Interface (HMI) Module
- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software

STANDARD PROTECTIVE FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Negative Sequence Overcurrent			
	46W2/46W3			
	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%)
46	Time Delay	1 to 8160 Cycles	1 Cycle	–1 to +3 Cycles or ±1%
	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 Setting	0.5 to 11.0 0.05 to 1.10 (IEC curves)	0.1 0.01	±3 Cycles or ±5%
	Winding Thermal Protection			
49	Time Constant	1.0 to 999.9 minutes	0.1 minutes	
	Maximum Overload Current	1.00 to 10.00 A	0.01 A	±0.01 A
	Winding Select	W1 or W2 or W3		
	Instantaneous Phase Overcurrent (Dual elements per winding)			
	50W1/50W2/50W3			
50	Pickup #1, #2	1.0 to 100.0 A (0.2 to 20.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles or ±1%
	Breaker Failure			
	50BFW1/50BFW2/50BFW3			
50 BF	Pickup (phase)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A	±0.1 A or ±2% (±0.02 A or ±2%)
	50BFNW1/50BFNW2/50BFNW3			
	Pickup (residual)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A	±0.1 A or ±2% (±0.02 A or ±2%)
	Time Delay	1 to 8160 Cycles	1 Cycle	–1 to +3 Cycles or ±2%
	Instantaneous Ground Overcurrent			
	50GW2/50GW3			
50G	Pickup #1, #2	1.0 to 100.0 A (0.2 to 20.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles or ±1%

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

STANDARD PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Instantaneous Residual Overcurrent			
50N	**50NW1/50NW2/50NW3**			
	Pickup #1, #2	1.0 to 100.0 A (0.2 to 20.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±2 Cycles or ±1%
	Inverse Time Phase Overcurrent			
51	**51W1/51W2/51W3**			
	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 ±3%
	Inverse Time Ground Overcurrent			
51G	**51GW2/51GW3**			
	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 ±3%
	Inverse Time Residual Overcurrent			
51N	**51NW1/51NW2/51NW3**			
	Pickup	0.50 to 6.00 A (0.10 to 1.20 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%

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

STANDARD PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Phase Differential Current			
	87H			
	Pickup	5.0 to 20.0 PU	0.1 PU	±0.1 PU or ±3%
	Time Delay	1 to 8160 Cycles	1 Cycle	–1 to +3 Cycles or ±1%
	87T			
87	Pickup	0.10 to 1.00 PU	0.01 PU	±0.02 PU or ±5%
	Percent Slope #1	5 to 100%	1%	±1%
	Percent Slope #2	5 to 200%	1%	±1%
	Slope Break Point	1.0 to 4.0 PU	0.1 PU	—
	Even Harmonics Restraint (2nd and 4th)	5 to 50%	1%	±1%or ±0.1 A
	5th Harmonic Restraint	5 to 50%	1%	±1% or ±0.1 A
	Pickup at 5th Harmonic Restraint	0.10 to 2.00 PU	0.01 PU	±0.1 PU or ±5%
	CT Tap W1/W2/W3	1.00 to 10.00 (0.20 to 2.00)	0.01	—

Trip response for 87T and 87H (if time delay set to 1 cycle) is less than 1.5 cycles. Each restraint element may be individually disabled, enabled, or set for cross phase averaging.

	Ground Differential			
	87GDW2/87GDW3			
87 GD	Pickup	0.2 to 10.00 A (0.04 to 2.00 A)	0.01 A	±0.1 A or ±5% (±0.02 A or ±5%)
	Time Delay	1 to 8160 Cycles*	1 Cycle	–1 to +3 Cycles or ±1%
	CT Ratio Correction (R_c)	0.1 to 7.99	0.01	

**The Time Delay setting should not be less than 2 cycles.*
This function operates as a directional differential. If $3I_0$ is extremely small, directional element is disabled.

	External Functions			
	EXT #1— #6			
EXT	Input Initiate	In #1–#6	—	—
	Output Initiate	Out #1–#8	—	—
	Time Delay	1 to 65500 Cycles	1 Cycle	–1 to +3 Cycles or ±1%

Six functions are provided for externally connected devices to trip through the M-3311 to provide additional logic and target information. Any one or more of the input contacts (INPUT1 through INPUT6) or outputs (OUTPUT1 through OUTPUT8) can be programmed to activate designated output contacts after a selected time delay. In addition, these may be incorporated into logic schemes using BECO Logic.

OPTIONAL SINGLE-PHASE VOLTAGE PROTECTION PACKAGE

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Volts/Hz Overexcitation			
	Definite Time			
	Pickup #1, #2	100 to 200%	1%	±1%
	Time Delay #1, #2	30 to 8160 Cycles	1 Cycle	+25 Cycles
24	**Inverse Time**			
	Pickup	100 to 150%	1%	±1%
	Characteristic Curves	Inverse Time #1–#4	—	—
	Time Dial: Curve #1	1 to 100	1	—
	Time Dial: Curves #2–#4	0.0 to 9.0	0.1	—
	Reset Rate	1 to 999 Sec. (from threshold of trip)	1 Sec.	±.06 Seconds or ±1%

Pickup based on nominal VT secondary voltage and nominal system frequency. Accuracy applicable from 10 to 80 Hz, 0 to 180 V, and 100 to 150% V/Hz.

This function is applicable only when phase voltage input is applied.

	Phase Undervoltage			
27	Pickup	5 to 140 V	1 V	±0.5 V
	Inhibit Setting	5 to 140 V	1 V	±0.5 V
	Time Delay	1 to 8160 Cycles	1 Cycle	–1 to +3 Cycles or ±1%

This function is applicable only when phase voltage input is applied.

	Ground Overvoltage			
59G	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 Cycle or ±1%

This function is applicable only when voltage input from a broken delta VT is applied.

	Overfrequency/Underfrequency			
81 O/U	Pickup #1, #2, #3, #4	55.00 to 65.00 Hz 45.00 to 55.00 Hz*	0.01 Hz	±0.1 Hz
	Time Delay #1, #2, #3, #4	2 to 65,500** Cycles	1 Cycle	–1 to +3 Cycles or ±1%

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.
** This range applies to 50 Hz nominal frequency models.*
*** For 65,500 cycles, time delay setting phase voltage must be greater than 35 V ac.*
This function is applicable only when phase voltage of at least 27 V ac input is applied.

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

OPTIONAL SINGLE-PHASE VOLTAGE PROTECTION PACKAGE (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Nominal Settings			
	Nominal Voltage	60 to 140 V	1 V	—
	Nominal Current	0.5 to 6.00 A	0.01 A	
	VT Configuration	V_A, V_B, V_C, V_{AB}, V_{BC}, V_{CA}, V_G		
	Phase Rotation	ABC/ACB	—	—
	Number of Windings	2 or 3		
	Transformer/CT Connection	Standard IEEE/IEC or Custom Connections		
	Functions that can be Implemented with Overcurrent/Input-Output Connections			

Load Shedding
Can help prevent overloading of remaining transformers when a station transformer is out of service.

Bus Fault Protection
Provides high speed bus protection by combining digital feeder relay logic and transformer protection logic.

Feeder Digital Relay Backup
Provides backup tripping of feeder relays by combining the self test alarm output of the feeder relays with the transformer relay.

LTC fault blocking
Provides limited blocking of LTC during fault conditions.

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

Configuration Options

The M-3311 Transformer Protection Relay may be purchased as a fully configured two or three winding Transformer Protection System. The M-3311 can also be purchased with the Optional Single-Phase Voltage Protection Package to expand the system to satisfy specific application needs.

Multiple Setpoint Profiles (Groups)

The relay supports four setpoint profiles. This feature allows multiple setpoint profiles to be defined for different power system configurations. Profiles can be switched either manually using the Human-Machine Interface (HMI), communication, or by control/status inputs.

Metering

Metering of voltage, three-phase and neutral currents, and frequency. Phase voltage and current metering include sequence components.

Real Time Demand (interval of 15, 30 or 60 minutes), and Maximum Demand (with date and time stamp) metering of current.

Metering accuracies are:

Voltage:	±0.5 V or ±0.5%, whichever is greater (range 0 to 180 V ac)
Current:	5 A rating, ±0.1 A or ±3%, whichever is greater (range 0 to 14 A) 1 A rating, ±0.02 A or ±3%, whichever is greater (range 0 to 2.8 A)
Frequency	±0.1 Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models)

Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, storing up to 152 cycles of data. The total record length is user-configurable 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 by a designated status input, trip output, or using serial communications. When untriggered, the recorder continuously stores waveform data, thereby 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. The records may be analyzed using Beckwith Electric IPSplot® Oscillograph Analysis Software, and are also available in COMTRADE file format.

Target Storage

A total of 32 targets can be stored. This information includes the function(s) operated, the function(s) picked up, input/output contact status, time stamp, phase and ground currents.

Calculations

Current and Voltage Values: Uses discrete Fourier Transform (DFT) algorithm on sampled voltage and current signals to extract fundamental frequency phasors for M-3311 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 40 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.

Optional redundant power supply.

Sensing Inputs

One Voltage Input: Rated nominal voltage of 60 V ac to 140 V ac, 50/60 Hz. Withstands 240 V continuous voltage and 360 V for 10 seconds. Voltage input may be connected to phase voltage (L-G or L-L), or to a broken delta VT. Voltage transformer burden less than 0.2 VA at 120 V.

Eleven Current Inputs: Rated current (I_R) of 5.0 A or 1.0 A (optional), 50/60 Hz. Withstands 3 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, select a setpoint group, or to 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 status input contact must be connected to the 52b breaker status contact.

One separate input is provided for monitoring and reporting either breaker trip circuit or lockout relay trip circuit integrity (*anticipated for future release*).

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.

Breaker Monitoring

The Breaker Monitoring function calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current (selected as I^2t or It) passing through the breaker contacts during the interruption interval. The per-phase values are summed as an accumulated total for each phase, and then compared to a user-programmed threshold value. When the threshold is exceeded in any phase, the relay can activate a programmable ouput contact. The accumulated value for each phase can be displayed as an actual value.

Temperature Controller Monitoring

Any Temperature Controller equipped with a contact output may be connected to the M-3311 and controlled by the relay's BECO Logic function. Figure 1 is an example of a typical Temperature Controller Monitoring application.

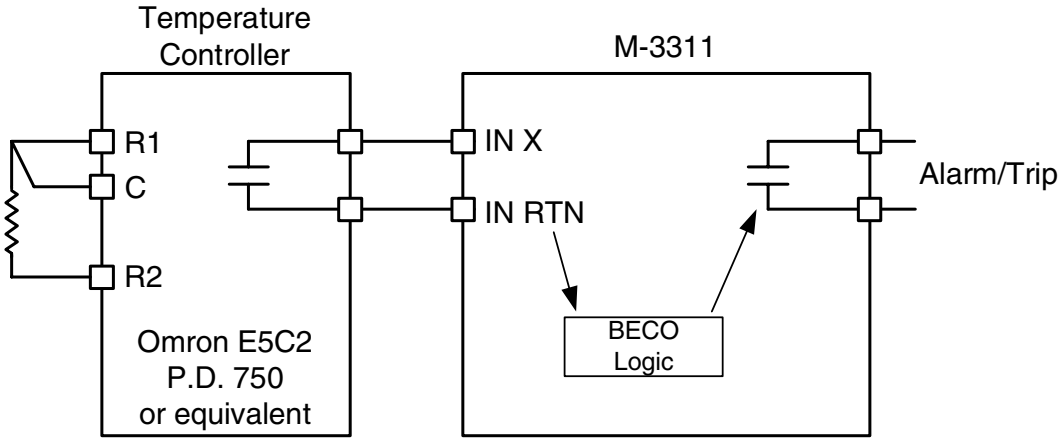


Figure 1 Typical Temperature Controller Monitoring Application

BECO Logic

This feature can be programmed utilizing the IPScom® communications software. IPScom takes the control/status inputs, outputs, and function status, and generates outputs by employing (OR, AND, NOR, and NAND) boolean logic.

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 **TARGET** LED will illuminate when any of the relay functions trip. Pressing and releasing the **TARGET RESET** button resets the **TARGET** LEDs if the conditions causing the operation have been removed. Pressing and holding the **TARGET RESET** button will allow elements or functions 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. **TIME SYNCH** LED illuminates when valid IRIG-B signal is applied and time synchronization has been established.

Communication

Communication ports include rear RS-232 and RS-485 ports, a front RS-232 port, and a rear IRIG-B port. The communications protocol implements serial, byte-oriented, asynchronous communication, providing the following functions when used with the Windows™-compatible M-3820B IPScom® Communications Software package. MODBUS, BECO 2200, and DNP 3.0 protocols are supported, providing:

- Interrogation and modification of setpoints
- Time-stamped trip target information for the 32 most recent events
- Real-time metering of all measured and calculated quantities, real-time monitoring of percentage differential characteristics, and vector displays of compensated and uncompensated phasors.
- Downloading of recorded oscillographic data

Detailed documentation on the above protocols is available on the Beckwith Electric website, at www.beckwithelectric.com

IRIG-B

The M-3311 accepts either modulated or demodulated IRIG-B time clock synchronization signals. The IRIG-B time synchronization information is used to correct the local calendar/clock and provide greater resolution for target and oscillograph time tagging.

HMI Module (optional)

Local access to the M-3311 is provided through an optional M-3931 Human-Machine Interface (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. The M-3931 module includes the following features:

- 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 measured and calculated quantities

Target Module (optional)

An optional M-3911 Target Module provides 24 target and 8 output LEDs. Appropriate target LEDs illuminate when the corresponding M-3311 function trips. The targets can be reset with the M-3311 **TARGET RESET** button if the trip conditions have been removed. The **OUTPUT** LEDs illuminate when a given programmable output is actuated.

M-3801D IPSplot® *PLUS* Oscillograph Analysis Software (optional)

M-3801D IPSplot *PLUS* Oscillograph Analysis Software enables the plotting and printing of M-3311 waveform data downloaded from the relay to any IBM-PC compatible computer.

Type Tests and Standards

M-3311 Transformer Protection Relay complies with the following type tests and standards:

Voltage Withstand

Dielectric Withstand

IEC 60255-5	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 between RS-485, to each independent circuit

Impulse Voltage

IEC 60255-5	5,000 V pk, +/- polarity applied to each independent circuit to earth
	5,000 V pk, +/- polarity applied between each independent circuit
	1.2 μs by 50 μs, 500 Ohms impedance, three surges at 1 every 5 seconds

Insulation Resistance

IEC 60255–5 > 40 MegaOhms

Electrical Environment

Electrostatic Discharge Test

IEC 61000-4-2 Class 4 (K8 kV) – point contact discharge

Fast Transient Disturbance Tests

IEC 61000-4-4 Class IV (±4kV, 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 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 @ 35V/m
C37.90.2

Output Contacts

ANSI/IEEE Make 30 A for 0.2 seconds, off for 15 seconds, for 2,000 operations
C37.90.0-1989, Section 6.7.1, Tripping Output Performance Requirements

Atmospheric Environment

Temperature

IEC 60068-2-1 Cold, –20° C for 96 hours

IEC 60068-2-2 Dry Heat, +70° C for 96 hours

IEC 60068-2-3 Damp Heat, +40° C @ 93% RH, for 96 hours

Mechanical Environment

Vibration

IEC 60255-21-1	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

M-3311 external connection points are illustrated in Figure 2, External Connections, on the following page.

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. Optional mounting is available.

Approximate Weight: 20.40 lbs (7.7 kg)

Approximate Shipping Weight: 28 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-3311 Instruction Book, Appendix E, Layup and Storage for additional information.

Patent & Warranty

The M-3311 Transformer Protection Relay has patents pending.

The M-3311 Transformer Protection Relay is covered by a five year warranty from date of shipment.

Specification subject to change without notice.

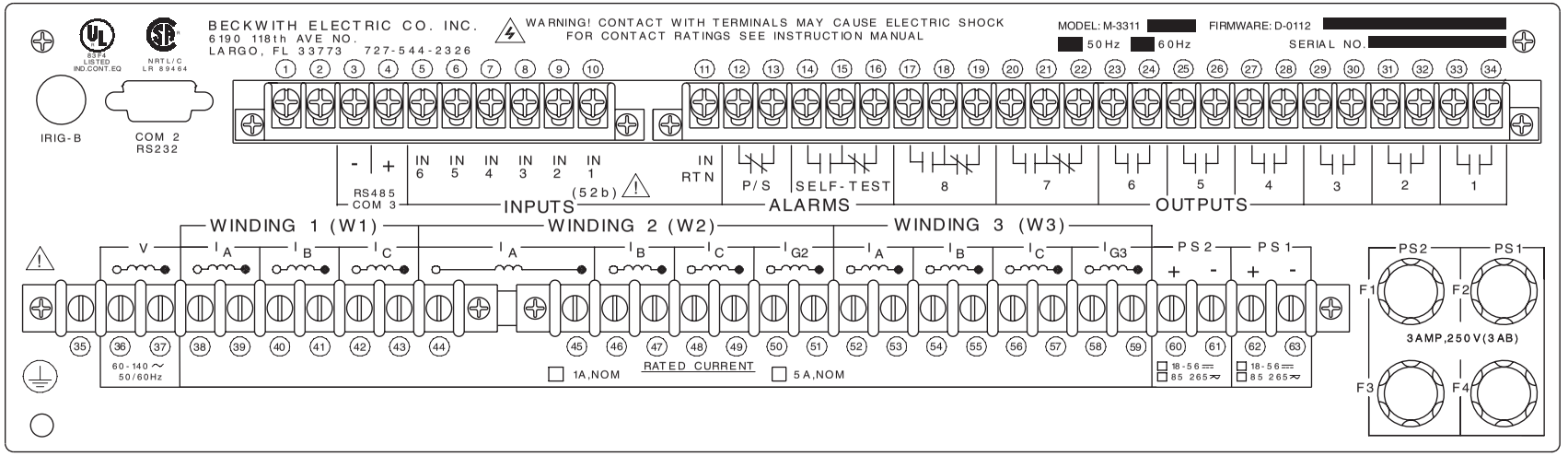


Figure 2 External Connections

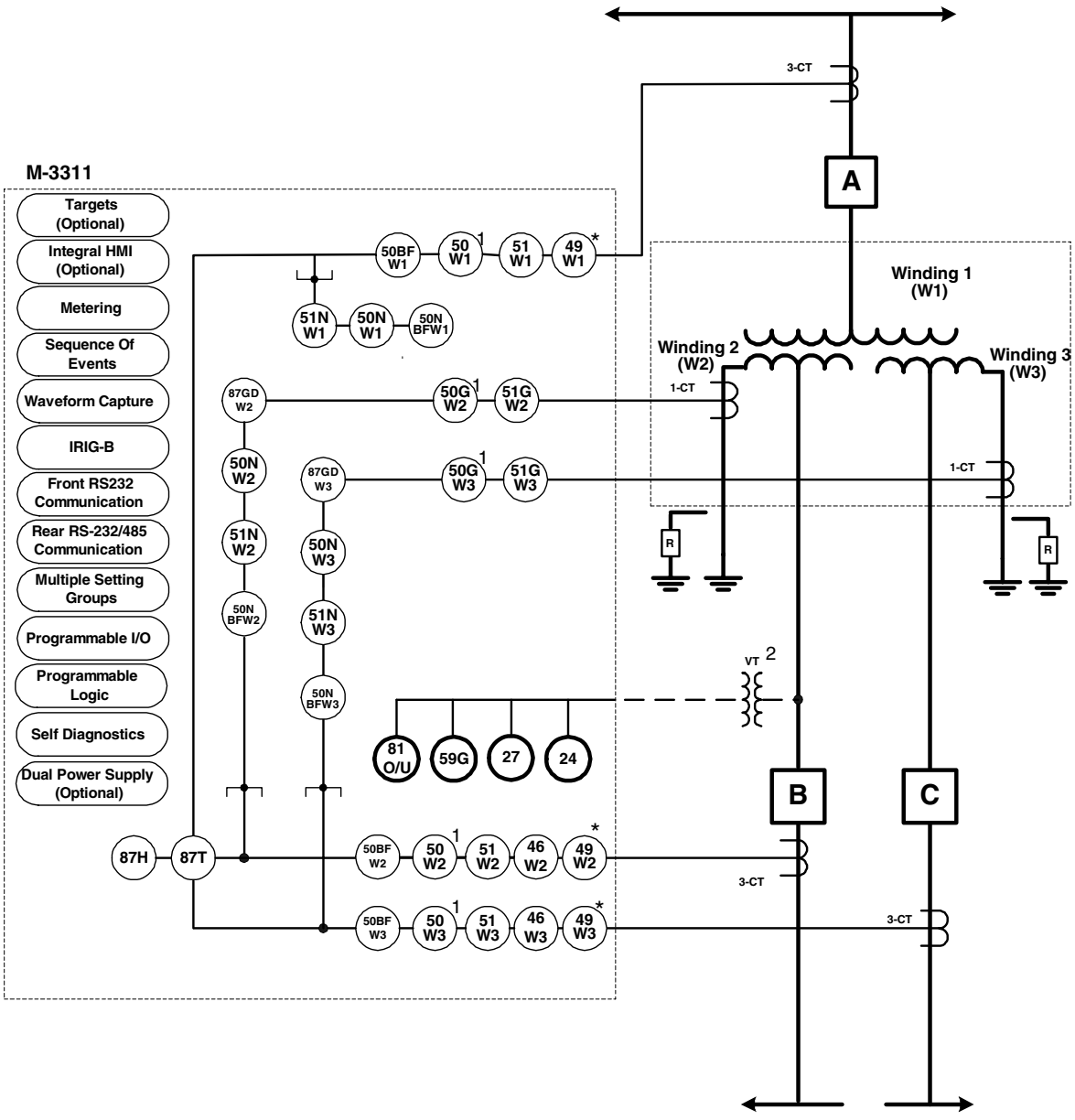
■ NOTES:

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 sensing 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.

M-3311 Typical Connection Diagram

This function is available as a standard protective function.

This function is available in the Optional Single-Phase Voltage Protection Package.



* Only one winding can be enabled at a time.

■ NOTES:

1. All 50 and 50G functions may be applied instantaneous or definite time, and are multiple (2) elements, each with individual pickup and time delay setpoints.
2. Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

Figure 3 Typical One-Line Connection Diagram

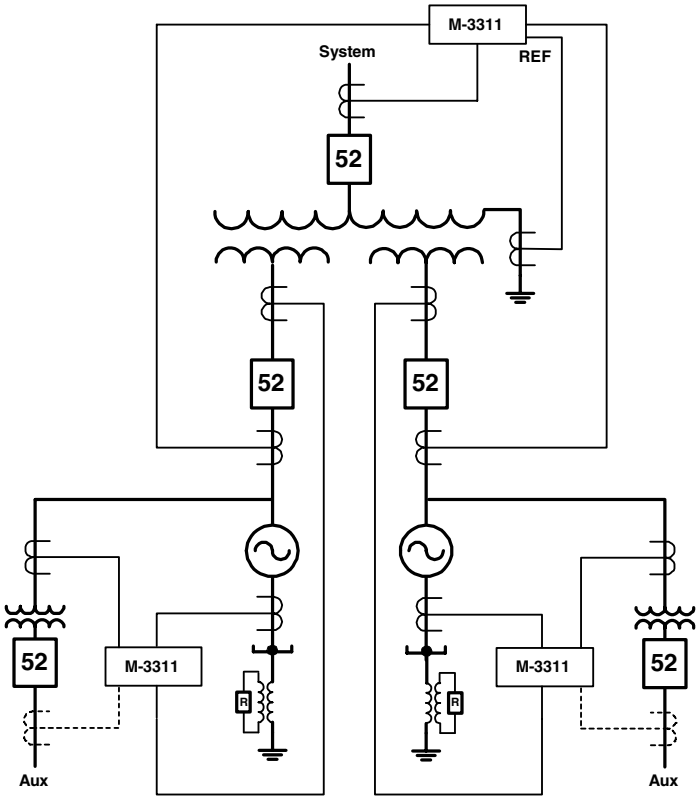


Figure 4 Dual Generator Power Plant Wrap

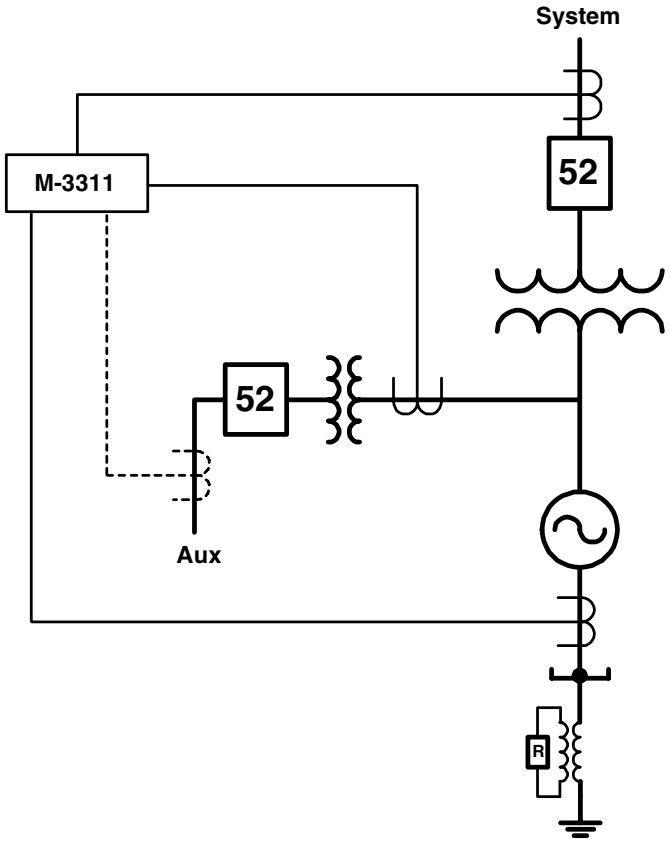


Figure 5 Generator Plant Unit Wrap

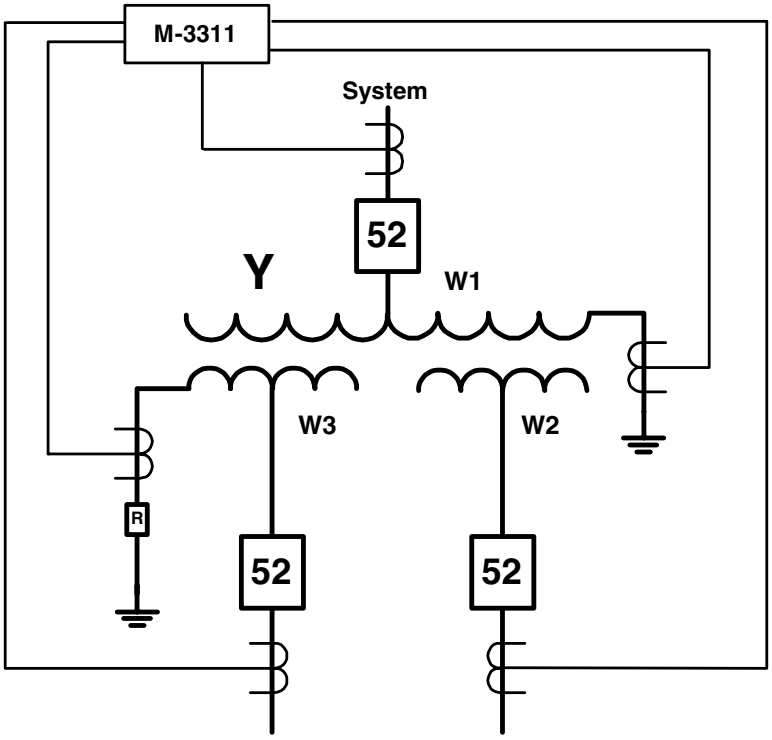


Figure 6 Three Winding Transformer with Shunt Reactor REF

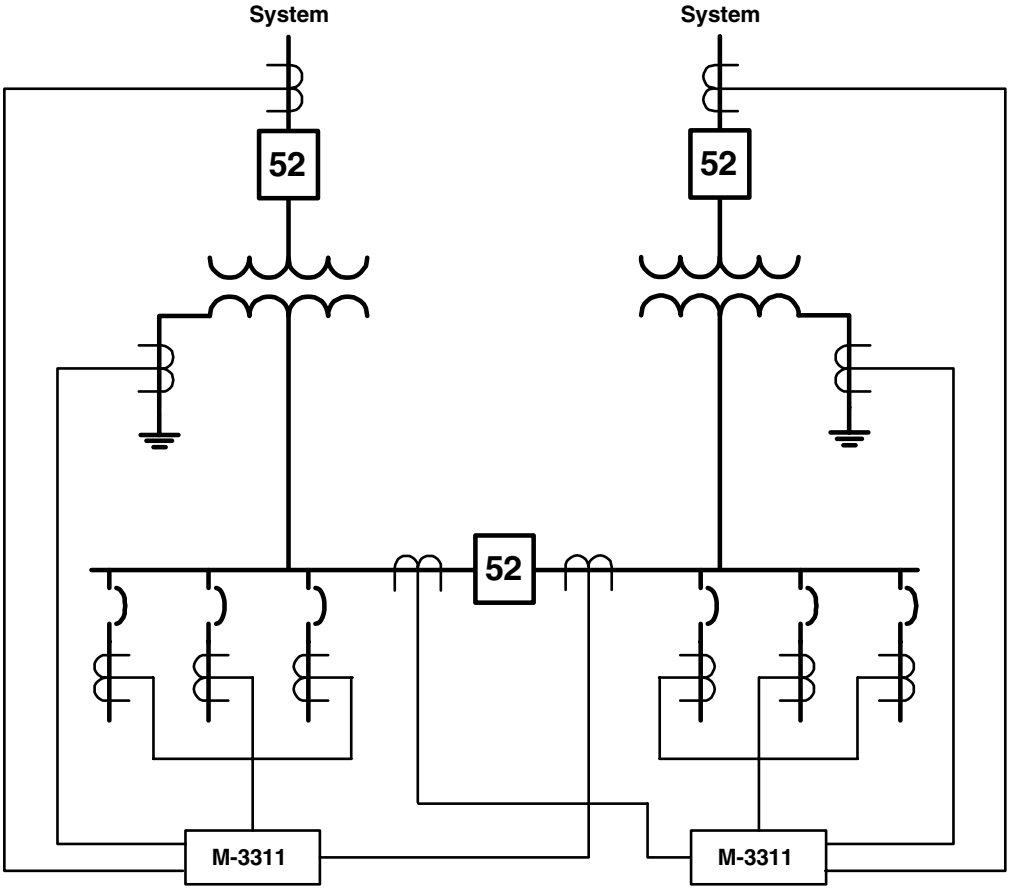


Figure 7 Main Tie Radial Substation

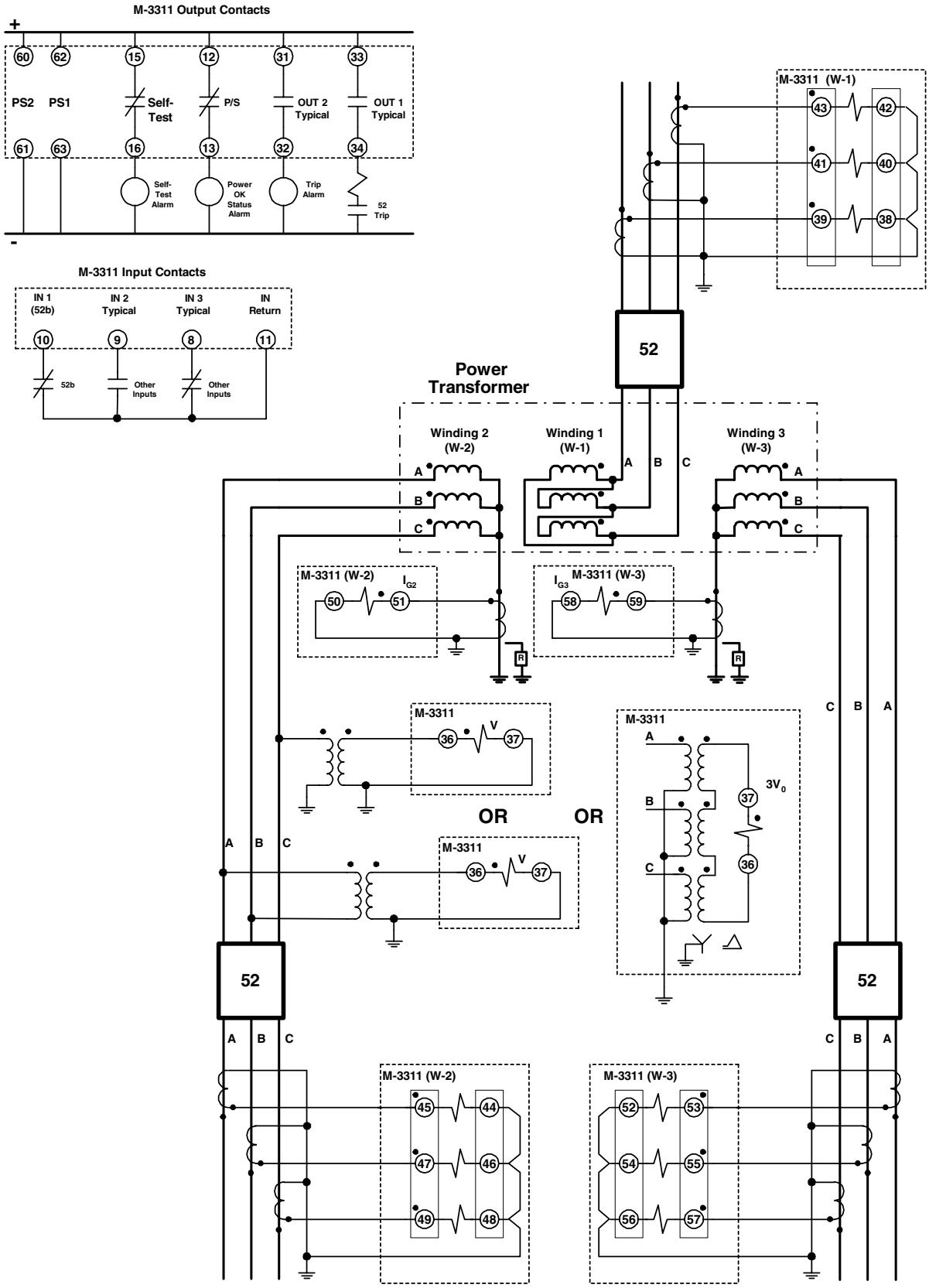
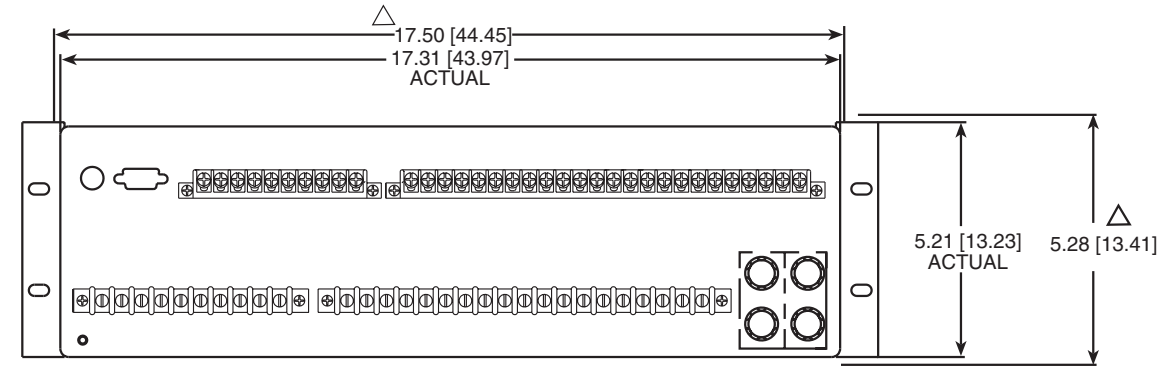
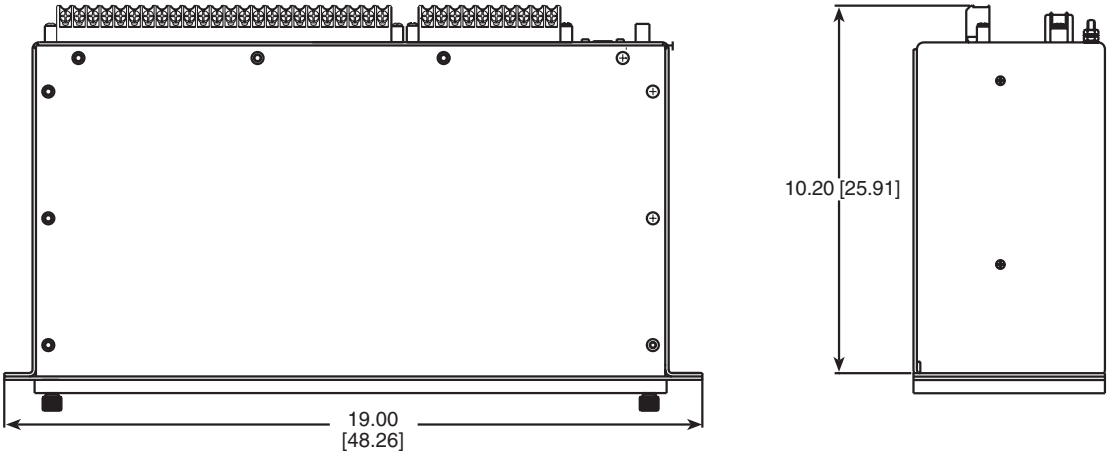


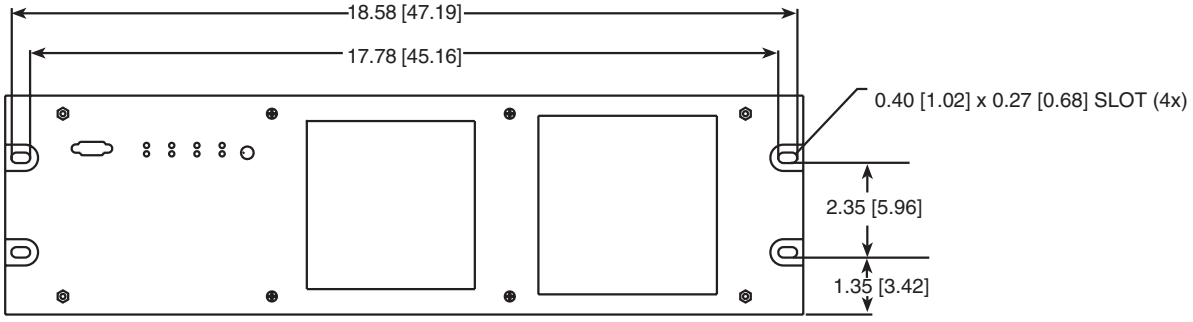
Figure 8 Typical Three-Line Connection Diagram



Rear View

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

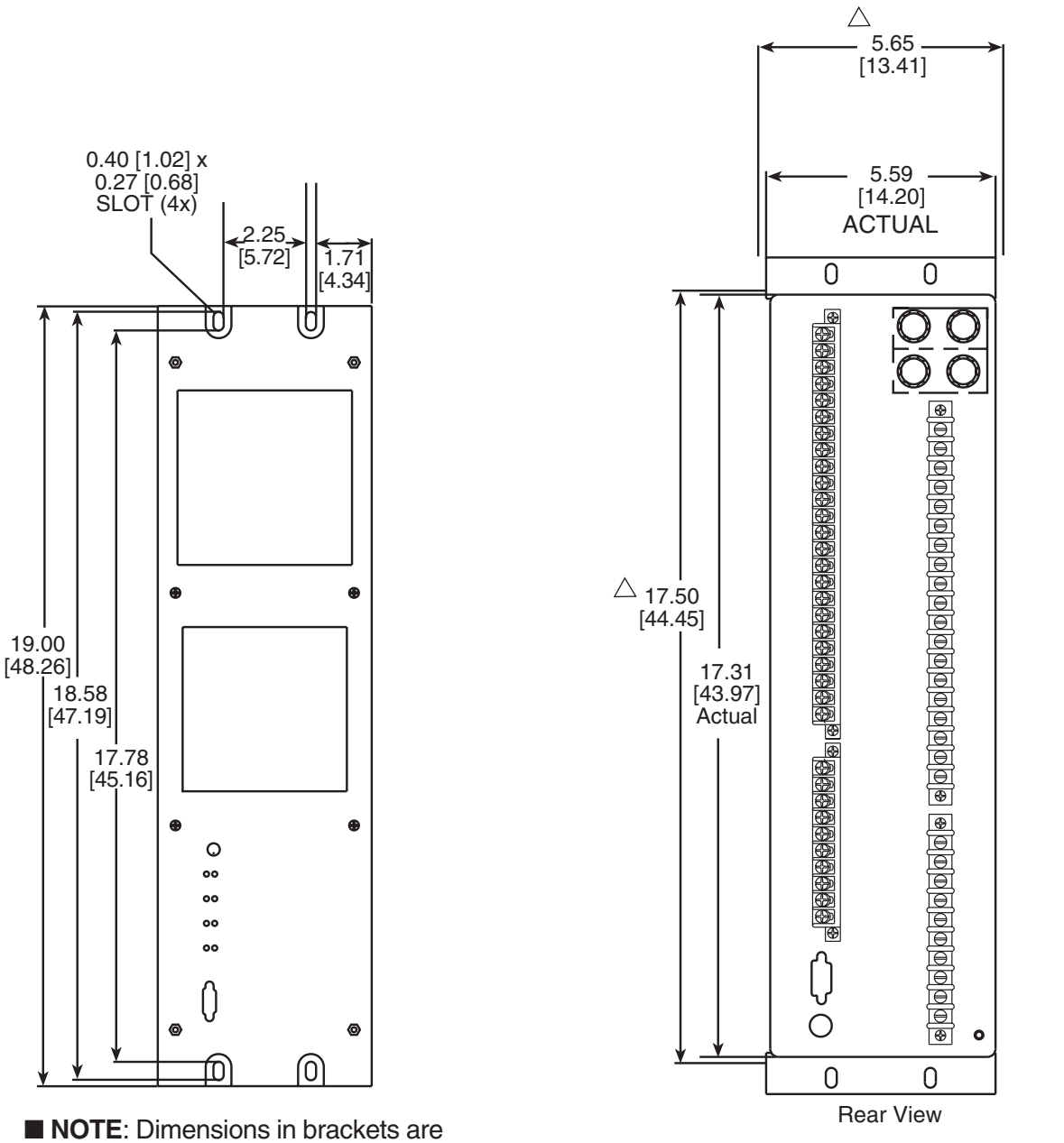




Standard 19" Horizontal Mount Chassis

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

Figure 9 Horizontal Mounting Dimensions



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

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

Optional Vertical Mount Chassis

Figure 10 Vertical Mounting Dimensions

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

800-3311-SP-04 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.

TABLE OF CONTENTS
M-3311 Transformer Protection
Instruction Book

Chapter 2 Application (*cont*)

Chapter 3 Operation (Front Panel)

Chapter 4 IPScom® Operation

Chapter 5 Installation

Chapter 6 Testing

Chapter 6 Testing (*cont*)

Appendices

Chapter 1 Introduction

Chapter 2 Application

Chapter 2 Application (*cont*)

Chapter 3 Operation (Front Panel)

Chapter 4 IPScom® Operation

Chapter 5 Installation

Chapter 6 Testing

Appendix A

Appendix B

Appendix D

This Page Left Intentionally Blank

1 Introduction

1.1 Instruction Book Contents

This instruction book includes six chapters and four appendices.

Chapter 1: Introduction

Chapter one contains a brief description of the six chapters and four appendices contained in this instruction book. It explains the functional capabilities of the M-3311 Transformer Protection Relay and provides a list of the device functions (see Table 1-1, M-3311 Device Functions). This chapter also describes the accessories that may be used in conjunction with application of the relay.

Chapter 2: Application

Chapter two contains specific information for the person or group responsible for the application of the M-3311 Transformer Protection Relay. The information provided includes functional diagrams and connection diagrams for typical application of the relay. It describes the configuring of the unit (choosing active functions), and how to assign output contacts and control/status inputs. This chapter also illustrates the definition of system quantities and equipment characteristics required by the relay, and describes the individual function settings and oscillograph recorder setup.

Chapter 3: Operation (Front Panel)

This chapter is intended for the person or group responsible for the operation and direct setting and configuration of the relay and is limited to the installations using the HMI (Human-Machine Interface) Module (M-3931). It includes an introduction to the front panel controls and the function and operation of the keypad, the characteristics of the display, the indicators and Target Module (M-3911), and the communication ports. It further describes the procedures for entering all the required data to the relay.

Included in this chapter is a description of how to access the status and metering quantities and how to view the target history. This chapter also references appropriate forms for recording the described data.

Chapter 4: IPScom® Operation

This chapter provides information for the person or group responsible for the operation and direct setting and configuring of the relay via personal computer, using the IPScom® M-3820B Communications Software package. It includes installation, setup information and procedures for entering all the 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 mechanical information, including dimensions, external connections and equipment ratings required for physical installation of the relay.

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: Testing**.

Chapter 6: Testing

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

Appendix A: Forms

This appendix includes forms to record the data values and settings required for the proper operation of the relay.

Appendix B: Communications

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

Appendix C: Error Codes

This appendix lists all error codes and their descriptions.

Appendix D: Inverse Time Curves

This appendix contains a graph of the four families of Inverse Time Curves for V/Hz applications, the four standard and the four IEC overcurrent curves are included.

Appendix E: Layup and Storage

This Appendix provides the recommended storage parameters, periodic surveillance activities and layup configuration.

1.2 M-3311 Transformer Protection Relay

The M-3311 Transformer Protection Relay, is a microprocessor-based unit that uses digital signal processing technology to protect a high voltage transformer from abnormal voltage and frequency, internal winding faults, system faults, negative sequence current, overloading, and overexcitation (V/Hz) disturbances. The M-3311 also provides system wide protection by implementing breaker failure, load shedding, bus fault and digital feeder relay backup protection capability.

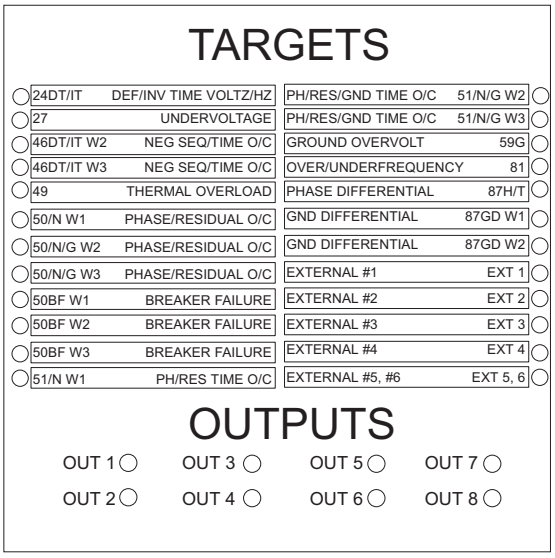


Figure 1-1 M-3911 Target Module

The relay provides 16 protective relay functions (see Table 1-1). The function nomenclature is derived from ANSI/IEEE C37.2-1991 standard, Standard Electric Power Systems Device Function Numbers.

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

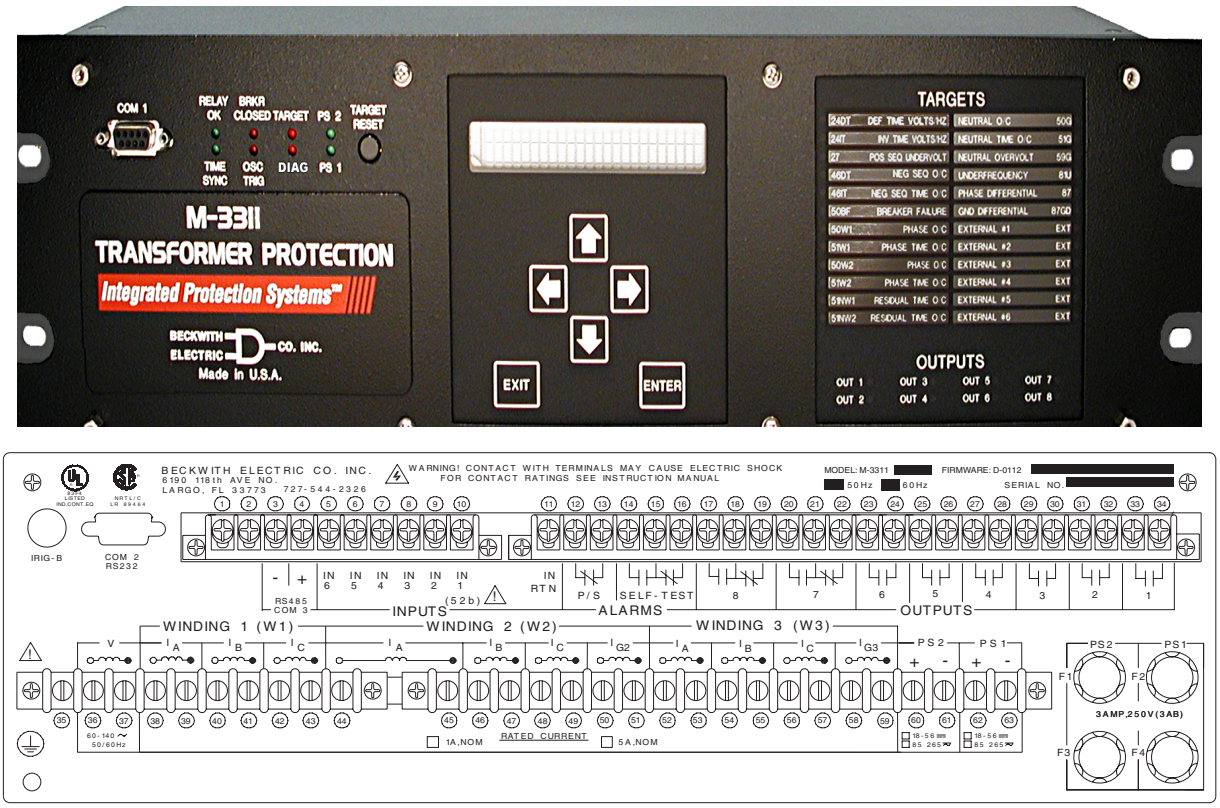


Figure 1-2 M-3311 Transformer Protection Relay

STANDARD FUNCTIONS	DESCRIPTION
46W2,3	Negative Sequence Overcurrent
49	Winding Thermal Protection (W1 or W2 or W3)
50W1,2,3	Instantaneous Phase Overcurrent
50BFW1,2,3	Breaker Failure
50GW2,3	Instantaneous Ground Overcurrent
50NW1,2,3	Instantaneous Residual Overcurrent
51W1,2,3	Inverse Time Phase Overcurrent
51GW2,3	Inverse Time Ground Overcurrent
51NW1,2,3	Inverse Time Residual Overcurrent
87	Phase Differential Current
87GDW2,3	Ground Differential
EXT	External Functions
OPTIONAL FUNCTIONS	**DESCRIPTION**
24	Volts per Hertz
27	Phase Undervoltage
59G	Ground Overvoltage
81O/U	Over/Under Frequency

Table 1-1 M-3311 Device Functions

With the optional M-3931 Human-Machine Interface Module (HMI), all functions can be set or examined from the local, menu-driven 2-line by 24-character display. The HMI also provides the M-3311 with local metering of various quantities, including phase and neutral currents, sequence currents and selected voltages.

The relay provides storage of time-tagged target information for the 32 most recent trip 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) represent 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-3311 using a portable computer. The second RS-232 port, COM2, is provided at the rear of the unit. An

isolated RS-485 communications port, COM3, is also available at the rear terminal block of the relay. Either rear-panel port, COM2 or COM3, can be used to remotely set and interrogate the relay 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, **IPScom® Operation**.

The unit provides up to 152 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-3801C IPSplot™ Oscillograph Analysis Software.

1.3 Accessories

Shipped as standard with each M-3311 unit is the IPScom® Communications Software. The IPScom communications software runs on an IBM PC-compatible computer running under Windows 95/98 or greater, providing remote access to the relay using 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 oscillographic data downloading
- Real time Phasor display

M-3911 Target Module

The optional target module shown in Figure 1-1 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 illuminated as long as any output is picked up.

M-3931 Human-Machine Interface (HMI)

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

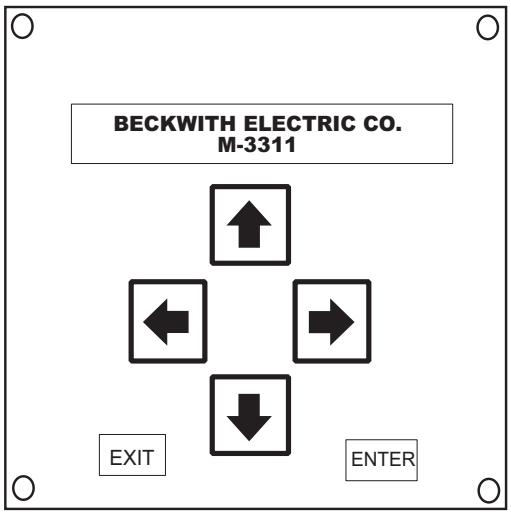


Figure 1-3 M-3931 Human-Machine Interface

M-3801C IPSplot™ Oscillograph Analysis Software Package

The IPSplot Oscillograph Analysis Software runs in conjunction with IPScom software package on any IBM PC-compatible computer running Windows 95/98 or greater, to enable the plotting and printing of waveform data downloaded from the M-3311 Transformer Protection Relay.

M-3933/M-0423 Serial Communications Cable

The M-3933 cable is a 10-foot straight-through RS-232 modem 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-3311 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 V dc supply.

M-3935 Redundant High Voltage Power Supply

Redundant 110/250 V dc supply.

2 Application

2.1 Introduction

This chapter provides information for the person or group responsible for the application of the M-3311 Transformer Protection Relay. Individual relay functions can be programmed to activate any combination of eight outputs (OUT1–8). Similarly, any relay function can be programmed to be blocked by any of six control/status inputs (IN1–6). 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. Up to four setpoint profiles (groups) may be programmed.

This chapter is designed to assist in the application aspects of the M-3311 Transformer Protection Relay. Detailed information on relay functions, configuration, setpoints, functional logic schemes, application to different transformer connections and use of the oscillograph recorder is provided.

This chapter also provides appropriate forms for recording input settings.

2.2 Configuration

Setpoint Profiles (Setting Groups)

Up to four setpoint profiles may be used. Each profile contains a function configuration and associated settings. One of the four profiles may be designated as the Active Profile which will contain the parameters that the relay will actively use. Only the Active Profile may be edited.

The Active Profile may be designated either manually using the HMI interface, by control/status input activation (input activated profiles enabled, see Table 2-1) or by remote communication.

A "copy profile" feature is available that copies an image of the Active Profile to any one of the other three profiles. This feature can speed up the configuration process. Consider, for example, a situation where a breaker will be removed from service. Two profiles will be used: an "In Service" profile (Profile 1) and an "Out of Service" profile (Profile 2).

Profile 2 will be identical to the "In Service" profile, with the exception of the overcurrent settings. Profile 1 is set to be the Active profile, and all setpoints entered. An image of Profile 1 will then be copied to Profile 2 with the Copy Active Profile command. Profile 2 is then selected as the Active Profile and the overcurrent setpoints modified.

Following the above procedure not only accelerates the configuration process, but also removes the possibility of errors if all setpoints are re-entered manually.

Functions

Configuring the relay consists of enabling the relay functions to be used in a particular application. Once the output contacts (OUT1–8) are designated, each function can be blocked if an associated control/status input has been designated to block the function.

Control/status inputs may also initiate actions, such as Breaker Failure Initiate, Trigger Oscillographic Recorder, Switch Setpoint Profile, or initiate an External Function. The configuration can be recorded on the **Relay Configuration Table** in Appendix A, **Forms**.

Special Considerations

Status input IN1 is pre-assigned to be the 52b breaker contact. IN5 and IN6 may be used to select setpoint profiles (with input activated profiles enabled).

Outputs 1–6 are form "a" contacts (normally open) and outputs 7 and 8 are form "c" contacts (center tapped "a" and "b" contacts). Output contacts 1–4 contain special circuitry for high-speed operation and pick up 4 ms faster than outputs 5–8. Function 87 outputs are recommended to be directed to OUT1 through OUT4 contacts.

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

+ 24 Volts/Hz Overexcitation: Definite Time #1, #2, Inverse Time
+ 27 Phase Undervoltage
- 46W2/W3 Negative Sequence Overcurrent: Definite Time, Inverse Time
- 49 Winding Thermal Protection (W1, W2, or W3)
- 50W1/W2/W3 Instantaneous Phase Overcurrent, #1, #2
- 50BFW1/W2/W3 Breaker Failure
- 50GW2/W3 Instantaneous Ground Overcurrent, #1, #2
- 50NW1/W2/W3 Instantaneous Residual Overcurrent, #1, #2
- 51W1/W2/W3 Inverse Time Phase Overcurrent
- 51GW2/W3 Inverse Time Ground Overcurrent
- 51NW1/W2/W3 Inverse Time Residual Overcurrent
+ 59G Ground Overvoltage, #1, #2
+ 81 Over/Under Frequency: #1,#2,#3, #4
- 87H Phase Differential Current, High-set
- 87T Phase Differential Current, Harmonic Restrained Percentage Differential
- 87GDW2/W3 Ground Differential
- External Functions: #1,#2,#3,#4,#5,#6

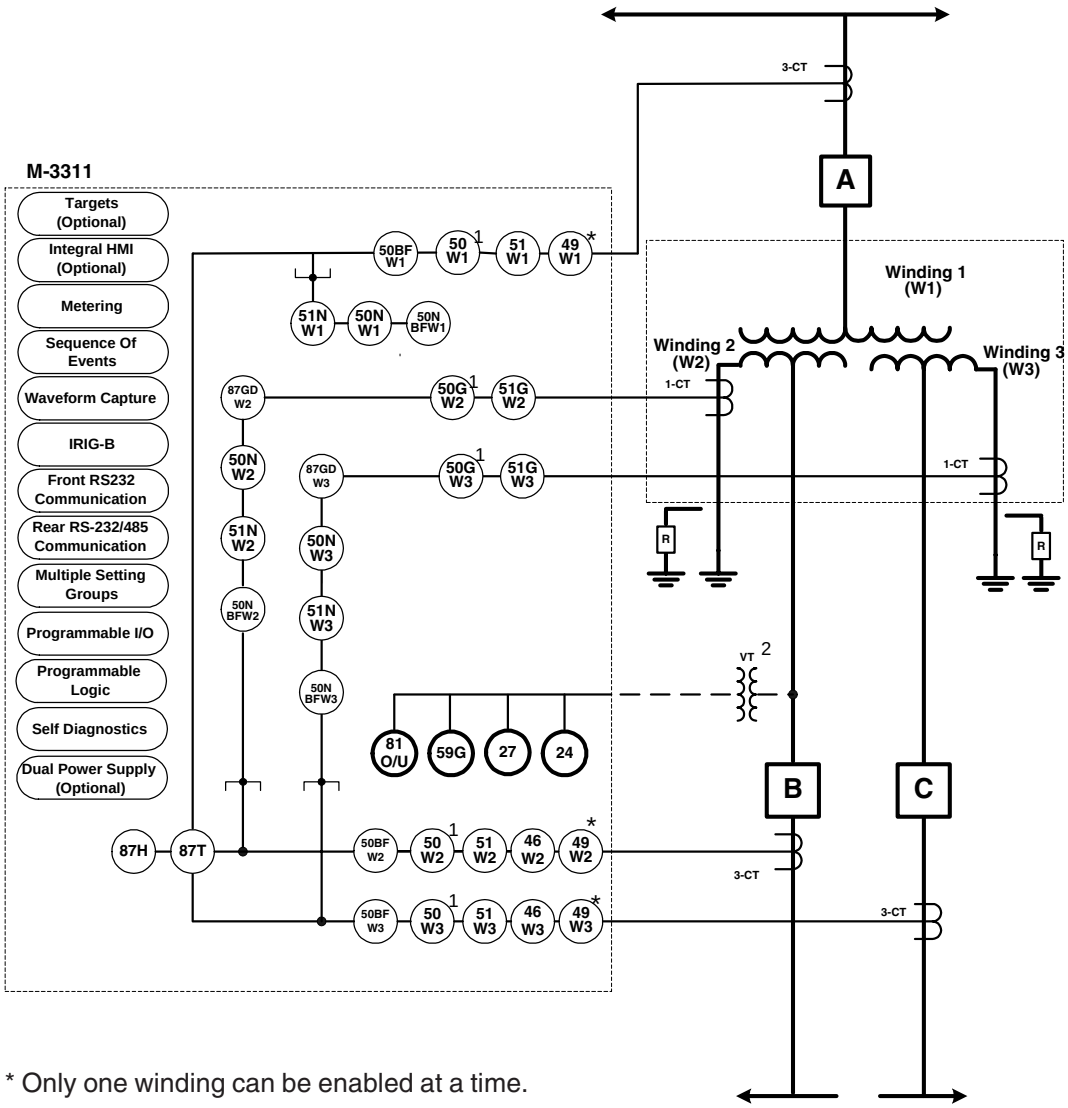
(+) = Denotes the Optional Single-Phase Voltage Protection Package Functions

2.3 System Diagrams

M-3311 Typical Connection Diagram

This function is available as a standard protective function.

This function is available in the Optional Single-Phase Voltage Protection Package.



* Only one winding can be enabled at a time.

Figure 2-1 One-Line Functional Diagram

■ NOTES:

1. All 50 and 50G functions may be applied instantaneous or definite time, and are multiple (2) elements, each with individual pickup and time delay setpoints.
2. Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

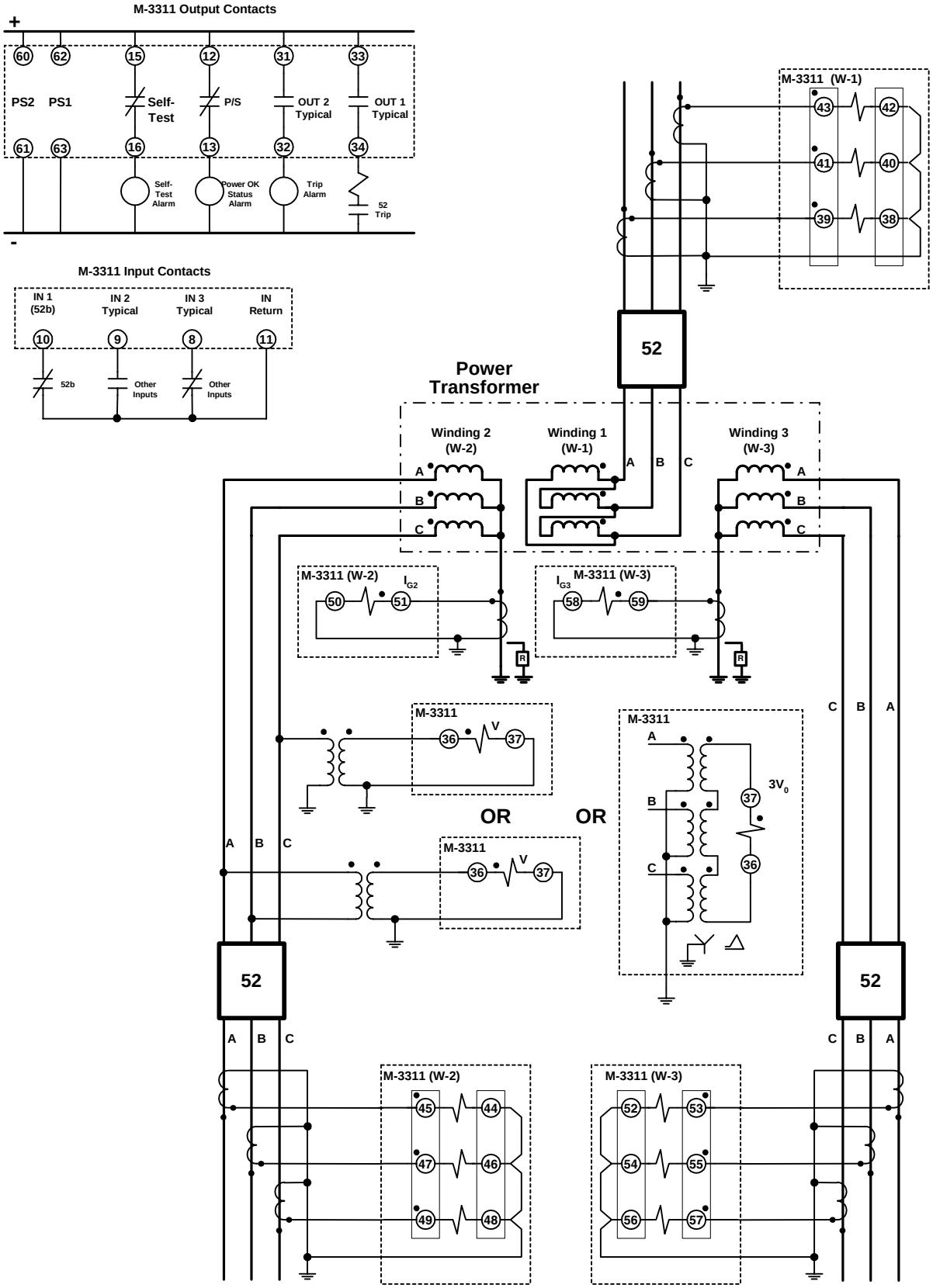


Figure 2-2 Three-Line Connection Diagram

2.4 System Setup

The system setup consists of defining common information like CT and VT ratios, nominal voltage rating, transformer connections, and which profile is the Active Profile, etc. Values are entered similar to other setpoints. System setup information is common to all profiles, and should be entered before configuration, setpoint, and time settings.

When INPUT ACTIVATED PROFILES are disabled, the Active Profile can be selected using the HMI or remote communication. When enabled, the Active profile is selected by the external connections of Input 5 and 6.

■ **NOTE:** Table 2-1 assumes ACTIVE INPUT STATE set to default setting (close circuit = TRUE).

Input 5	Input 6	SELECTION
Open	Open	Profile 1
Closed	Open	Profile 2
Open	Closed	Profile 3
Closed	Closed	Profile 4

Table 2-1 Input Activated Profile Logic

```
INPUT ACTIVATED PROFILES
disable ENABLE
```

If INPUT ACTIVATED PROFILES is disabled this screen allows manual selection of the Active Profile using the front panel or through communications.

```
ACTIVE SETPOINT PROFILE
 _____   1
```

Allows the user to manually select the Active Profile.

```
COPY ACTIVE PROFILE
TO_PROFILE_2          →
```

This screen initiates a copy of the Active Profile to any one of the other profiles.

```
NOMINAL VOLTAGE
120 Volts
```

The secondary VT voltage when primary voltage is equal to the rated transformer voltage (V trans rated/VT ratio). Range = 60–140 V; Increment 1 V.

```
V.T. CONFIGURATION
VAB vbc vac va vb vc vg
```

Indicates VT connection.

```
NUMBER OF WINDINGS
two three
```

If two winding is selected, then one of the three available windings must be disabled:

```
DISABLE WINDING
win1 win2 win3
```

The disabled winding will be removed from the differential calculation. However, the disabled winding may be utilized for other non-differential protection. See Section 2.7, Transformer Connections, for additional information.

```
CUSTOM XFM/CT CONNECTION
disable enable
```

▲ **CAUTION:** Changing from a standard Transformer/CT connection to the equivalent custom setting may cause the relay to momentarily trip when current is present.

If Custom XFM/CT Connection is DISABLED (standard transformer and CT configurations used), the relay automatically computes the phase and magnitude compensation required for the differential currents.

If Custom XFM/CT Connection is ENABLED, then the HMI will prompt the user to enter Transformer Phase Comp Type and CT PH/Mag Comp Type values for each winding. Zero Seq Comp will also be required to be enabled or disabled for each winding to complete this setting. See Section 2.7, Transformer Connections, for additional information.

```
W1 XFM PHASE COMP TYPE
     0
```

```
W2 XFM PHASE COMP TYPE
     0
```

```
W3 XFM PHASE COMP TYPE
     0
```

```
W1 CT PH/MAG COMP TYPE
     0
```

```
W2 CT PH/MAG COMP TYPE
     0
```

```
W3 CT PH/MAG COMP TYPE
     0
```

```
W1 ZERO SEQ COMP
disable enable
```

```
W2 ZERO SEQ COMP
disable enable
```

```
W3 ZERO SEQ COMP
disable enable
```

```
CT CONNECTION W1
←CON_W1 con_w2 con_w3→
```

```
CT CONNECTION W1
Y dab dac inv_y →
← inv_dab inv_dac
```

```
CT CONNECTION W2
←con_w1 CON_W2 con_w3→
```

```
CT CONNECTION W2
Y dab dac inv_y →
← inv_dab inv_dac
```

```
CT CONNECTION W3
←con_w1 con_w2 CON_W3→
```

```
CT CONNECTION W3
Y dab dac inv_y →
← inv_dab inv_dac
```

▲ **CAUTION:** Changing from a standard Transformer/CT connection to the equivalent custom setting may cause the relay to momentarily trip when current is present.

■ **NOTE**: When CT connection is chosen as delta, the relay calculates line currents using delta CT currents and the ground currents (for W2 and W3 only). The line currents (not delta currents) are displayed on the status screens (metering). The line currents are also used for 50, 51, and 46 functions.

The Standard configuration requires the CT connection to be defined as Wye, Delta-ab, Delta-ac, Inverse Wye, Inverse Delta-ab, or Inverse Delta-ac. See Section 2.7, Transformer Connection, for additional information.

```
XFM CONNECTION W1
←XFM_W1 xfm_w2 xfm_w3→
```

```
XFM CONNECTION W1
Y dab dac inv_y →
← inv_dab inv_dac
```

▲ **CAUTION:** Changing from a standard Transformer/CT connection to the equivalent custom setting may cause the relay to momentarily trip when current is present.

The Standard configuration requires the Transformer Winding Connection to be defined as Wye, Delta-ab, Delta-ac, Inverse Wye, Inverse Delta-ab, or Inverse Delta-ac. See Section 2.7, Transformer Connection for additional information.

```
XFM CONNECTION W2
←xfm_w1 XFM_W2 xfm_w3→
```

```
XFM CONNECTION W2
Y dab dac inv_y →
← inv_dab inv_dac
```

```
XFM CONNECTION W3
←xfm_w1 xfm_w2 XFM_W3→
```

```
XFM CONNECTION W3
Y dab dac inv_y →
← inv_dab inv_dac
```

```
PHASE ROTATION
← PHASE seal in vt →
```

```
PHASE ROTATION
a-c-b A-B-C
```

Indicates the phase rotation.

```
RELAY SEAL-IN TIME
← phase SEAL IN vt →
```

```
RELAY SEAL-IN TIME OUT1
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT2
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT3
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT4
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT5
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT6
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT7
 _____ Cycles
```

```
RELAY SEAL-IN TIME OUT8
 _____ Cycles
```

Seal-in time for output relays. Eight individual seal-in delays can be specified for each output relay.

```
ACTIVE INPUT OPEN/CLOSE
i6 i5 i4 i3 i2 I1
```

Selects the active state for the six control/status inputs. When highlighted (upper case), an open circuit activates the input. When lowercase, a closed circuit activates the input (default).

```
V.T. RATIO
←phase seal in VT→
```

Selects the active state for the six Control/Status inputs. When highlighted (upper case), an open circuit activates the input. When lowercase, a closed circuit activates the input (default).

```
V.T. RATIO
 _____________ :1
```

VT Ratio

```
W1 C.T. RATIO
←CT_W1 ct_w2 ct_w3→
```

```
W1 C.T. RATIO
 _____________ :1
```

```
W2 C.T. RATIO
←ct_w1 CT_W2 ct_w3→
```

```
W2 C.T. RATIO
 _____________ :1
```

```
W3 C.T. RATIO
←ct_w1 ct_w2 CT_W3→
```

```
W3 C.T. RATIO
 _____________ :1
```

CT Ratios

```
W2 C.T. GROUND RATIO
←CT_W2G ct_w3g→
```

```
W2 C.T. GROUND RATIO
 _____________ :1
```

```
W3 C.T. GROUND RATIO
←ct_w2g CT_W3G→
```

```
W3 C.T. GROUND RATIO
 _____________ :1
```

CT Ground Ratios

The relay will calculate the W2 and W3 line currents when a delta CT configuration is selected, as follows:

For Delta ab CTs:

Line Current $I_A = (I_{ab} - I_{ca} + (I_g/CTCF))/3$

Line Current $I_B = (I_{bc} - I_{ab} + (I_g/CTCF))/3$

Line Current $I_C = (I_{ca} - I_{bc} + (I_g/CTCF))/3$

where I_{ab}, I_{bc}, I_{ca} are the currents that enter the relay, and I_g is the measured ground current.

CTCF is given by $\frac{\text{CT Phase Ratio}}{\text{CT Ground Ratio}}$

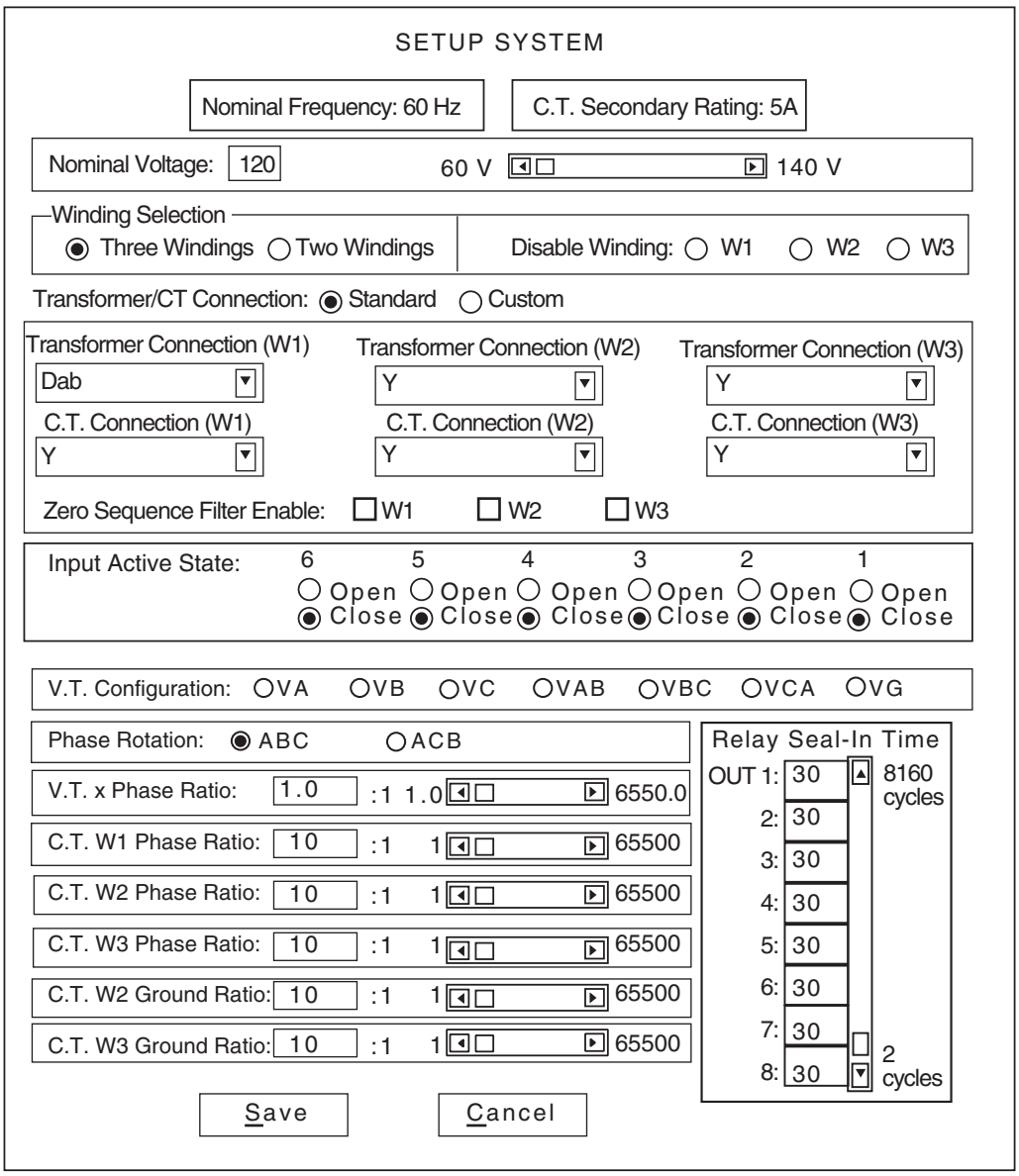


Figure 2-3 IPScom® Setup System Dialog

2.5 Setpoints and Time Settings

24 Volts/Hz Overexcitation

■ **NOTE:** Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

The 24 Volts-Per-Hertz (V/Hz) function provides over-excitation protection for the transformer. As the volts per hertz level rises above a transformer's limit, leakage flux increases. The leakage flux induces current in the transformer support structure causing rapid localized heating.

In power plant applications, over-excitation can occur due to sudden tripping of the generator as a result of faults and other abnormal conditions.

In Extra High Voltage (EHV) applications, an incorrectly switched line can lead to over-excitation at tapped transformers due to combined capacitance.

In transmission and distribution applications, sudden loss of load or improper capacitor/reactor switching may result in overexcitation.

This function provides two Definite Operating Time setpoints, four families of Inverse Time curves widely used in the industry (see Appendix D, Figures D1 to D4), and a linear reset rate programmable to match specific cooling characteristics of the transformer. The V/Hz function provides reliable measurements of V/Hz for a frequency range of 10–80 Hz.

When applied for generator and unit transformer protection, the first task in setting this relay function is to determine the desired protective levels and times. This can be accomplished by combining the V/Hz limit curves of the transformer and the associated generator on one graph and simplifying the result into one curve to coordinate with the protection.

Example of Transformer limits:

- Full Load V/Hz = 1.05 PU (HV terminals)
- No Load V/Hz = 1.10 PU (HV terminals)

■ **NOTE:** The curves must be on the same voltage base to be combined on one graph. An example is shown in Figure 2-4, Example of Capability and Protection Curves. The manufacturer of the generator and transformer will provide these over-excitation capability limits.

Depending on these characteristics, they can best be matched by one of the four families of inverse time curves, alone or in conjunction with definite time setpoints. Coordination of capabilities and protection is achieved when the time between the relay operation and the capability limit is sufficient for the breakers to open and de-energize the units. This coordination time is read vertically *between* the two curves at any given V/Hz value.

Figure 2-4, Example of Capability and Protection Curves, illustrates a composite graph of generator limits, transformer limits, a chosen inverse time curve, inverse time pickup, and definite time setpoint. While inverse time curve selection may provide more selective and sensitive protection, a traditional two-step protection scheme may be realized by using the two definite time functions (24DT #1 and #2), and disabling the inverse (24IT) element.

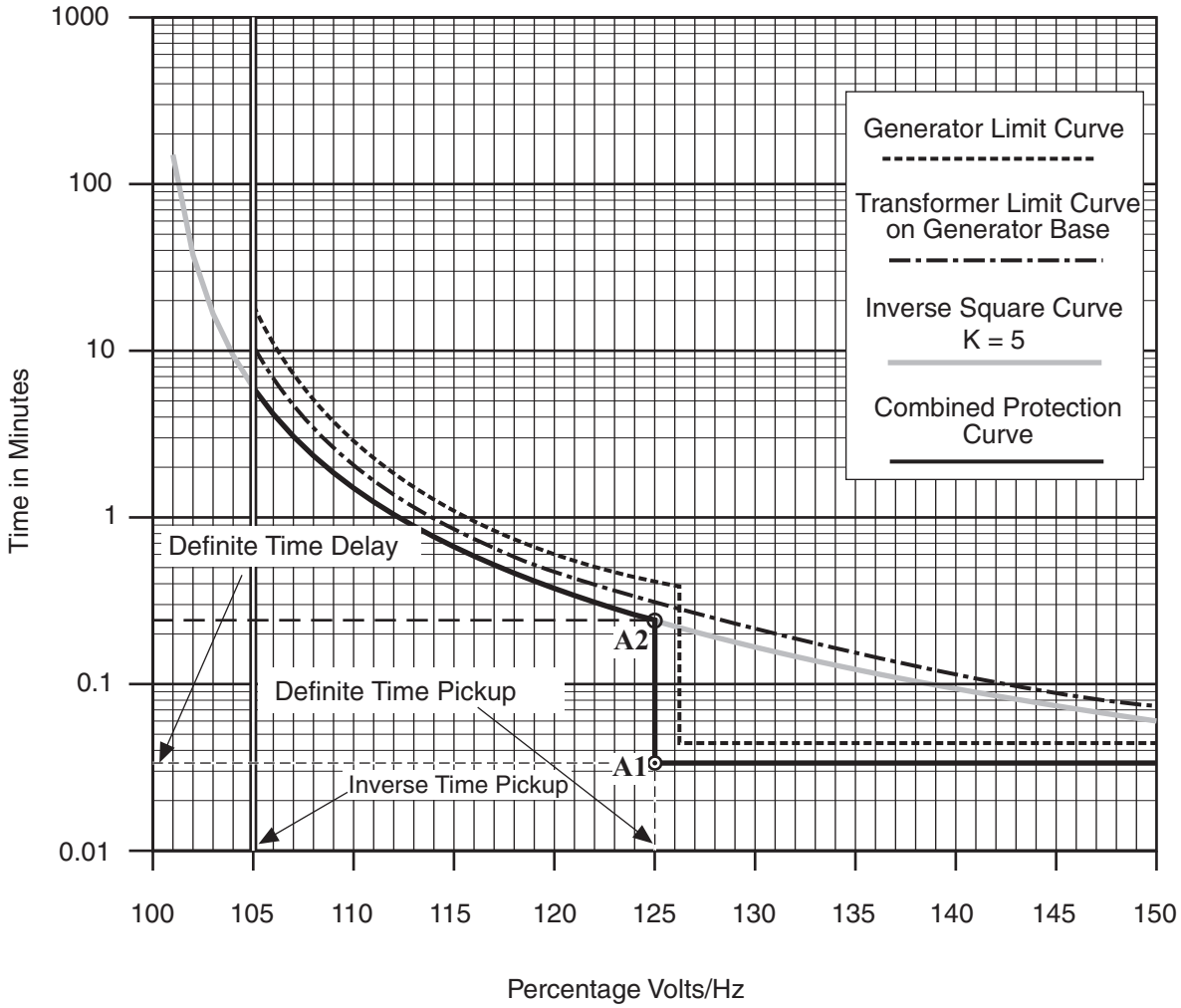


Figure 2-4 Example of V/Hz Capability and Protection Curves

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

```
24DT#1 PICKUP
 _____________ 110%
```

Definite time setpoint #1 establishes the V/Hz level above which the protection operating time will be fixed at the definite time delay #1 (See Figure 2-4). 100% is equal to nominal voltage at nominal frequency (50/60Hz). See Section 2.4, System Setup.

```
24DT#1 DELAY
360 Cycles
```

Delay time #1 establishes the operation time of the protection for all V/Hz values above the level set by definite time setpoint #1. Note that delay time #1 (A.1 in Figure 2-4) must be less than the operating time of the selected inverse curve at the definite time setpoint #1 V/Hz level (A.2 in Figure 2-4). Delay time A.1 becomes the definite minimum time for the inverse curve which prevents misoperation during transients. It is highly recommended that 24DT #1 be enabled along with 24IT function.

```
24DT#2 PICKUP
 _____________ 110%
```

Definite time setpoint #2 could be programmed to alarm, alerting the operator to take proper control action to possibly avoid tripping (may be used to trip). Time to operation at any V/Hz value exceeding Definite time setting #2.

```
24DT#2 DELAY
360 Cycles
```

```
24IT PICKUP
 _____________ 105%
```

As shown in Figure 2-4, the pickup value is the V/Hz value (in %) that the chosen inverse curve begins protective operation. Typical value is 105%.

```
24IT CURVE
CRV#1 crv#2 crv#3 crv#4
```

The appropriate curve *family* for this protection application is designated by circling the CRV #. These curves are shown in Appendix D, **Inverse Time Curves**. Note that the operating times are constant above 150% V/Hz values.

```
24IT TIME DIAL
 _________________ 9
```

The appropriate *curve* in the family is designated by the associated “K” value of the curve. These are shown in Appendix D, **Inverse Time Curves**.

```
24IT RESET RATE
200 Seconds
```

After any V/Hz excursion, cooling time must also be taken into account. If the unit should again be subjected to high V/Hz before it has cooled to normal operating levels, damage could be caused before the V/Hz trip point is reached. For this reason, a linear reset characteristic, adjustable to take into account the cooling rate of the unit, is provided. If a subsequent V/Hz excursion occurs before the reset characteristic has timed out, the time delay will pick up from the equivalent point (as a %) on the curve. The value entered here should be the time needed for the unit to cool to normal operating temperature if the V/Hz excursion time was just under the trip time.

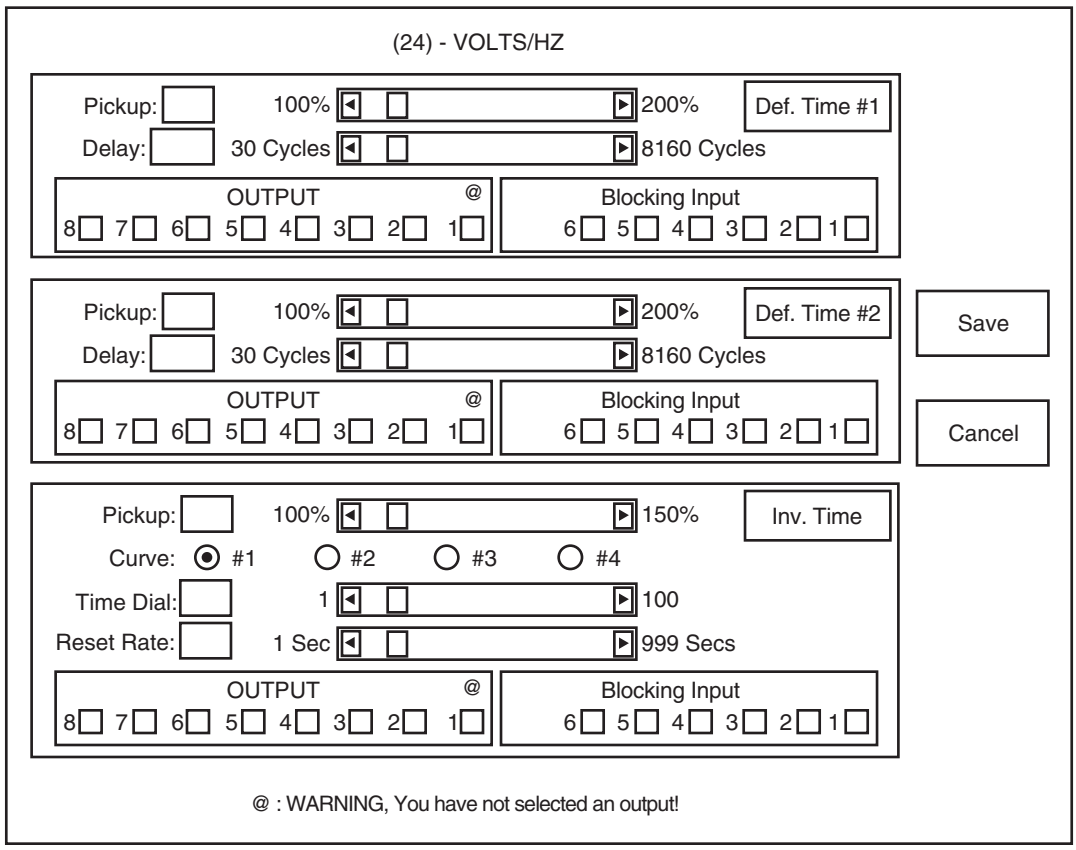


Figure 2-5 M-3820B IPScom® for Windows (24) Volts/Hertz Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/24 Volts per Hertz

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 Phase Undervoltage

■ **NOTE:** Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

The 27 Undervoltage function may be used to detect any condition causing long term undervoltage

This function is used to shed the transformer load when the power system does not have enough reactive support, similar to the Over/Underfrequency (81O/U) function.

The Inhibit setting of this function prevents it from operating during fault conditions.

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

27 PICKUP 108 Volts	Undervoltage pickup establishes the voltage level below which the function timer will start.
27 INHIBIT disable ENABLE	Enables or disables the undervoltage inhibit feature.
27 INHIBIT 108 Volts	Undervoltage inhibit establishes the voltage level below which the function will be disabled.
27 DELAY 30 Cycles	The operating time of the function.

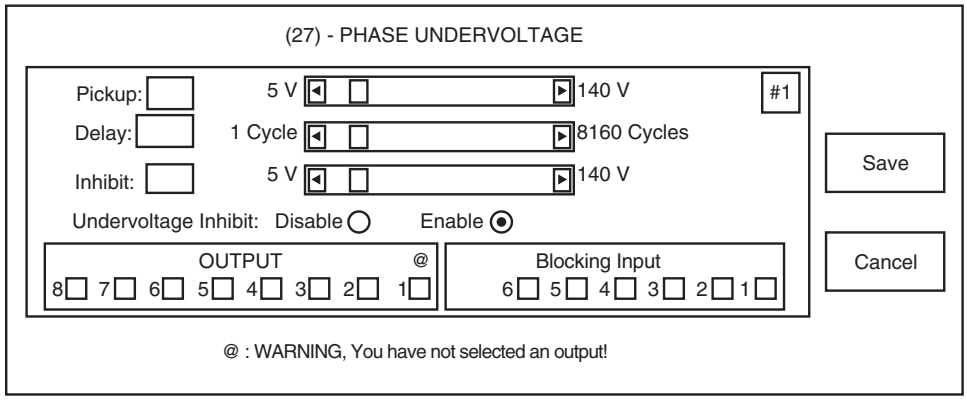


Figure 2-6 M-3820B IPScom® for Windows™ (27) Undervoltage Setpoint Ranges

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.

46 Negative Sequence Overcurrent

The 46 Negative Sequence Overcurrent function provides protection against possible damage due to unbalanced faults and open conductors.

The pickup setting of this function can be set below the system load for increased sensitivity for phase-to-phase fault backup of feeder protective relays.

This function has a definite time element and an inverse time element. The definite time pickup value and definite operating time are typically associated with an alarm function. The inverse time element is typically 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 coordination with feeder line protection, bus differential, and breaker failure backup protections.

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

```
46DTW2 PICKUP
    0.50 Amps
```

Winding 2 negative sequence overcurrent pickup establishes the negative sequence overcurrent level above which the definite time function timer will start.

```
46DTW2 DELAY
    120 Cycles
```

This setting is the operating time of the definite time function.

```
46ITW2 PICKUP
    1.00 Amps
```

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

```
46ITW2 CURVE
DEF inv vinv einv →
```

This setting selects one of eight families of curves, as shown in Appendix D, Figures D-5 through D-12.

```
46ITW2 TIME DIAL
    5.0
```

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

```
46DTW3 PICKUP
    0.50 Amps
```

These screens are applicable for Winding 3.

```
46DTW3 DELAY
    120 Cycles
```

```
46ITW3 PICKUP
    1.00 Amps
```

```
46ITW3 CURVE
DEF inv vinv einv →
```

```
46ITW3 TIME DIAL
    5.0
```

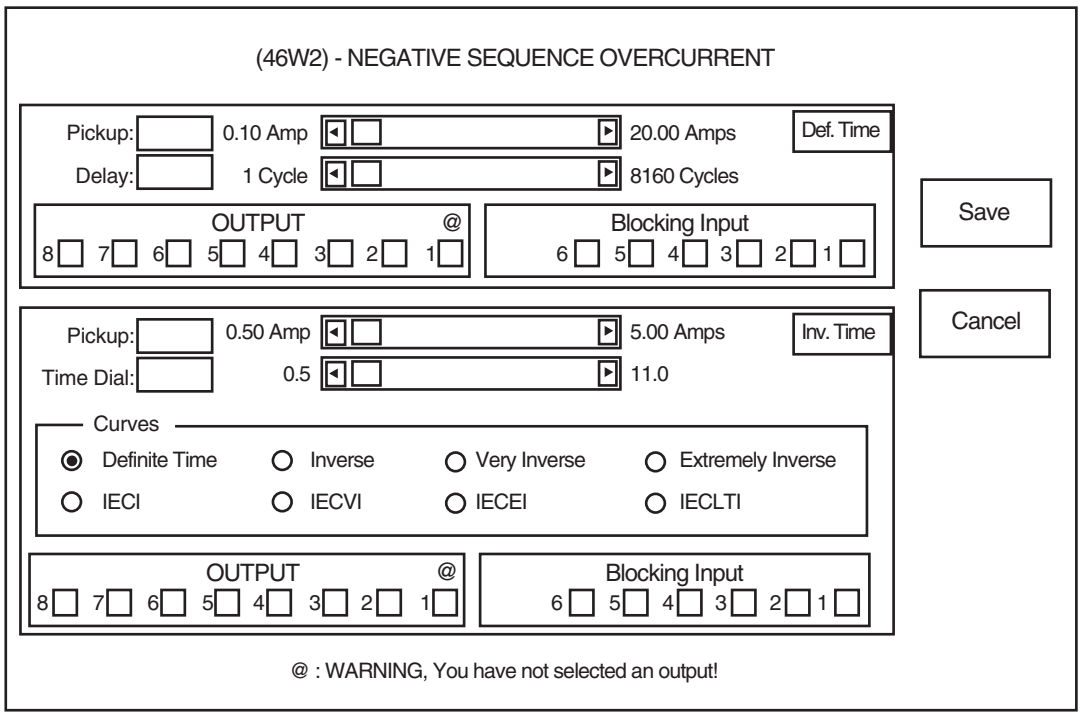


Figure 2-7 M-3820B IPScom® for Windows™ (46) Negative Sequence Overcurrent Setpoint Ranges

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

49 Winding Thermal Protection

The thermal overload function provides protection against possible damage during overload conditions. Temperature and overload monitoring of oil-filled transformers are carried out with the use of indicating thermostats (standard). The oil thermometer, which measures the top oil temperature, cannot be relied upon to detect short-time overloads beyond permissible limits.

Transformers without winding thermometers should have a thermal current protection with operating current/time characteristics that correspond to the current overload characteristic of the transformer windings. For transformers with winding thermometers, a thermal current protection will provide a back-up function for this monitoring device.

The 49 function uses the demand current as pre-load current, to protect the transformer following the IEC-255-8 standard:

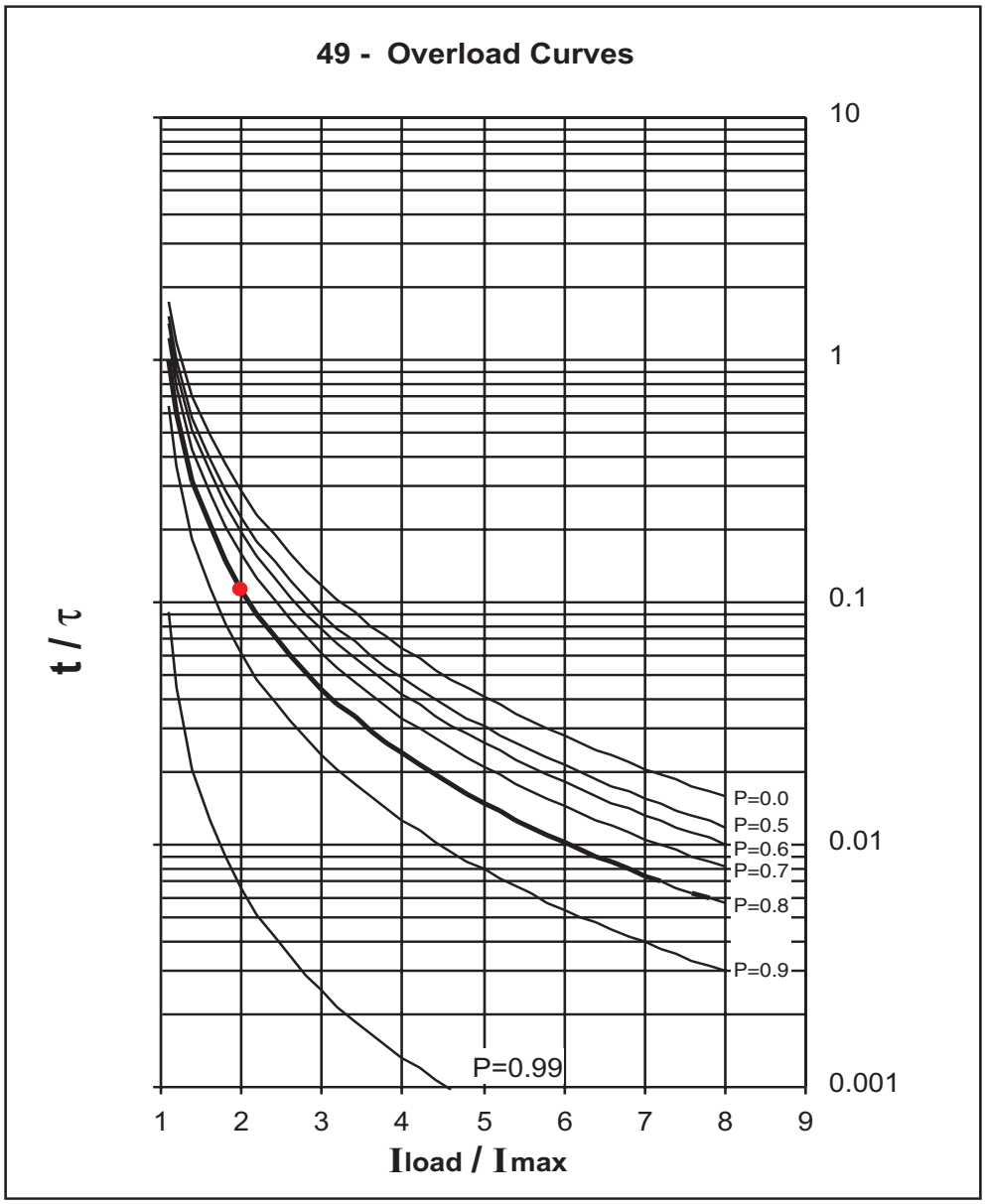
$$t = \tau \times I_n \quad \frac{(I_{load}/I_{max})^2 - (I_{preload}/I_{max})^2}{(I_{load}/I_{max})^2 - 1}$$

Where: t = time to trip
τ = time constant
I_{load} = relay current
$I_{preload}$ = pre-load current
I_{max} = maximum allowed continuous overload current

The pre-load current "$I_{pre\text{-}load}$" is the previous average current for the last 15 minutes, 30 minutes, or 60 minutes programmable into the demand metering.

The M-3311 includes four setpoint groups that can accommodate a power transformer's different MVA requirements. One setpoint group can be used for basic rating setpoints and others can be used to change to a second group of setpoints for use with higher ratings when forced cooling is required.

Example: If we consider that the transformer was working with 80% of its rating power prior to overload, then the current goes up to 2.0 times the maximum current (Iload/Imax=2.0). Selecting the curve P=0.8 (see Figure 2-8), we have t/τ=0.1133. If τ=30 minutes, then the time delay for this condition would be: t=0.1133 x 30=3.3999 minutes.



where: $P = \frac{I_{preload}}{I_{max}}$

Figure 2-8 49 Function Overload Curves

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

49 TIME CONSTANT 5.0 Min	Selects the time constant, 'τ'
49 MAX OVERLOAD CURRENT 2.00 Amps	Selects the maximum allowed continuous overload current.
49 WINDING SELECT win1 win2 win3	Select the winding to be used as the input.

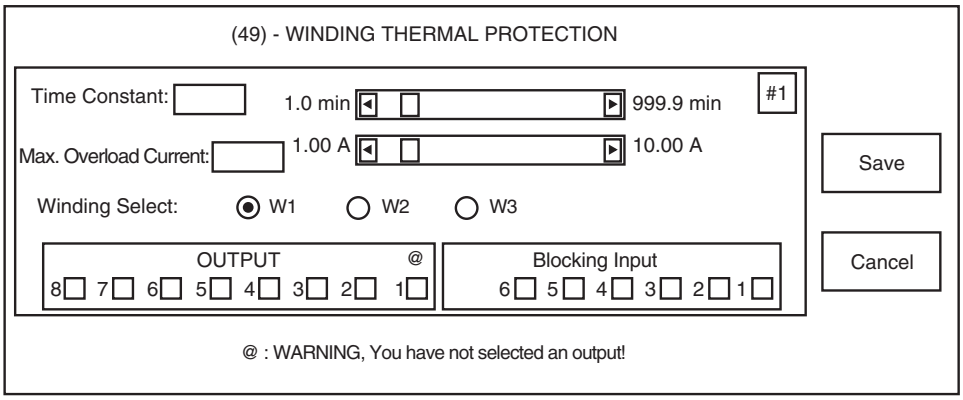


Figure 2-9 M-3820B IPScom® for Windows™ (49) Winding Thermal Protection Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/49 Winding Thermal Protection

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.

50BF Breaker Failure

The 50BF function is applicable when a transformer breaker is present. If enabled, the 50BF-Ph phase detector element is used for breaker failure and the 50BF-N provides breaker flashover protection (see Figure 2-10). This provides an additional Breaker Failure Initiate, which is active only when the breaker is open.

50BF-Phase Breaker Failure

When the M-3311 Transformer Protection Relay detects an internal transformer fault or an abnormal operating condition, it closes an output contact to trip the transformer breakers. Protection output contacts must be connected to trip the breakers required to isolate the transformer from the system. The breaker failure condition is detected by the continued presence of current in any one or more phases after a breaker trip command is issued.

Implementation of the transformer breaker failure function is illustrated in Figure 2-10. The breaker failure timer will be started whenever any one of the designated output contacts or the external programmed breaker failure initiate control/status inputs are activated. The breaker failure (TDOE) timer continues to time if any one of the phase currents is above the 50BF-Ph pickup setting.

50BF-Residual Element

This overcurrent relay is energized from the residual current, see Figure 2-1, One-Line Functional Diagram. This function is internally identical to the 50BF-Ph element and operates using residual (triple zero sequence) current.

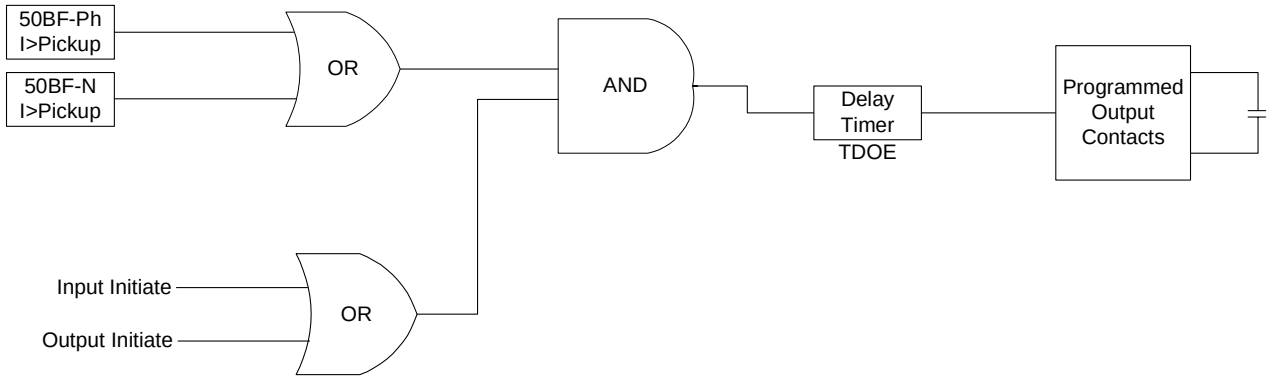


Figure 2-10 Breaker Failure Logic Diagram

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

50BFW1 PICKUP RESIDUAL 1.00 Amps	Sets 50BFW1 residual current pickup. 0.5A is a typical setting.
50BFW1 PICKUP PHASE 1.00 Amps	Sets 50BFW1 phase current pickup. 0.3 A is a typical setting.
50BFW1 INPUT INITIATE i6 i5 i4 i3 i2 I1	Designates the control/status inputs which will initiate the breaker failure timer.
50BFW1 OUTPUT INITIATE o8 o7 o6 o5 o4 o3 o2 O1	Designates the relay outputs which will initiate the breaker failure timer.
50BFW1 DELAY 30 Cycles	For transformer breaker failure use, the time delay should be set to allow for breaker operating time plus margin.

■ **NOTE:** These screens are also applicable for Windings 2 and 3.

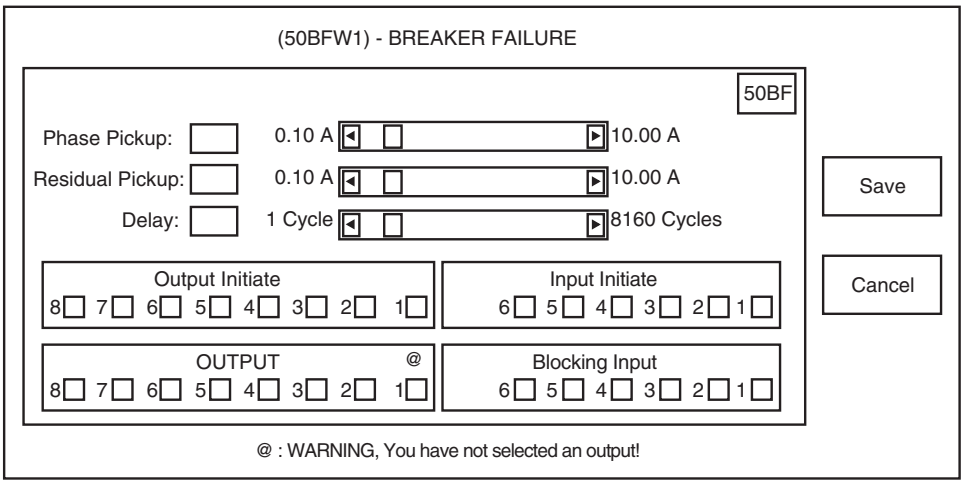


Figure 2-11 M-3820B IPScom® for Windows™ (50BF) Breaker Failure Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/50BFW1, W2, W3 Breaker Failure

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.

50/50G Instantaneous Overcurrent, Phase & Ground

The Instantaneous phase 50 and Instantaneous Ground 50G overcurrent functions provide fast tripping for high fault currents. The settings of both functions must be set such that they will not pickup for faults or conditions outside the immediate protective zone. Two phase elements (#1 and #2) are available on Winding 1, 2, and 3 for the 50 function, and Winding 2 and 3 for 50G function. For phase overcurrent functions, output is initiated when any individual phase A, B or C exceeds the pickup. These elements also allow the user to program several logic schemes described in Section 2.5, **Functional Logic Schemes.**

50W1#1 PICKUP 1.00 Amps	Sets ground pickup for instantaneous ground overcurrent.
50W1#1 DELAY 30 Cycles	Sets delay for instantaneous ground overcurrent.
50W1#2 PICKUP 1.00 Amps	Sets ground pickup for instantaneous ground overcurrent.
50W1#2 DELAY 30 Cycles	Sets delay for instantaneous ground overcurrent.
50GW2#1 PICKUP 1.00 Amps	Sets ground pickup for instantaneous ground overcurrent.
50GW2#1 DELAY 30 Cycles	Sets delay for instantaneous ground overcurrent.
50GW2#2 PICKUP 1.00 Amps	Sets ground pickup for instantaneous ground overcurrent.
50GW2#2 DELAY 30 Cycles	Sets delay for instantaneous ground overcurrent.

■ **NOTE:** These screens are also applicable for Windings 2 and 3 (Function 50G) or Winding 3 (Function 50).

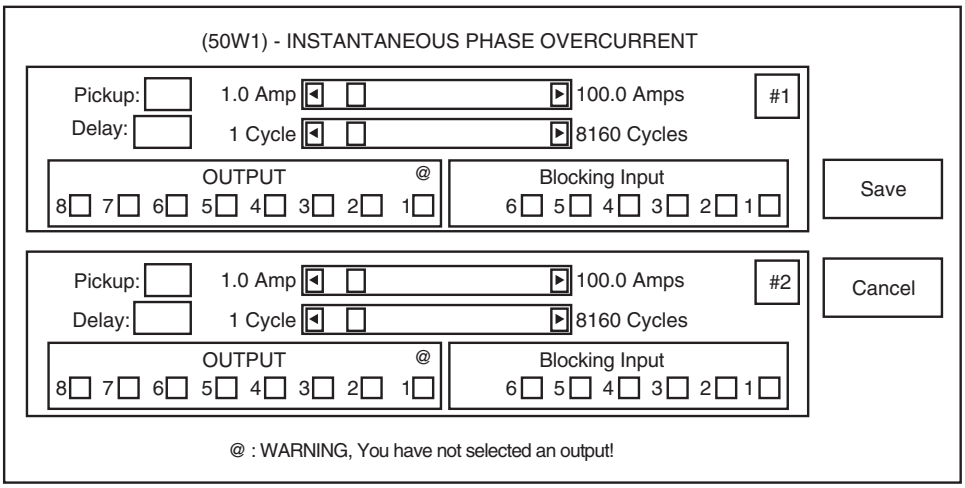


Figure 2-12 M-3820B IPScom® for Windows™ (50) Instantaneous Phase Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/50 W1, W2, W3 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.

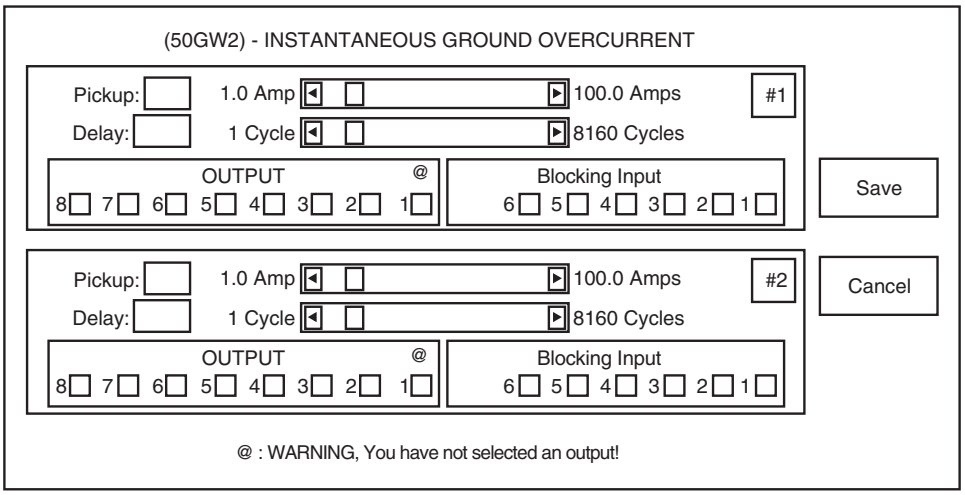


Figure 2-13 M-3820B IPScom® for Windows™ (50G) Instantaneous Ground Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/50G W2, W3 Instantaneous Ground 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.

50N Instantaneous Residual Overcurrent

The Instantaneous Residual (50N) overcurrent function provides fast tripping for high fault currents. Settings must be made in such a way as to prevent pickup for fault or conditions outside the immediate protective zone.

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

50NW1#1 PICKUP 1.00 Amps	Sets pickup for instantaneous residual overcurrent.
50NW1#1 DELAY 30 Cycles	Sets delay for instantaneous residual overcurrent.
50NW1#2 PICKUP 1.00 Amps	Sets pickup for instantaneous residual overcurrent.
50NW1#2 DELAY 30 Cycles	Sets delay for instantaneous residual overcurrent.

■ **NOTE:** These screens are also applicable for Windings 2 and 3.

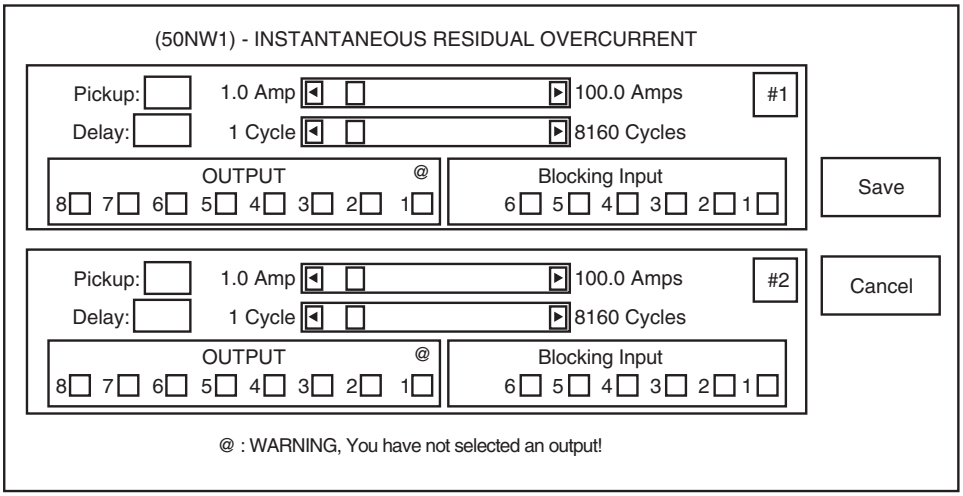


Figure 2-14 M-3820B IPScom® for Windows™ (50N) Instantaneous Residual Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/50NW1, W2, W3 Instantaneous Residual 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.

51 Inverse Time Phase Overcurrent

The 51 Inverse Time Phase Overcurrent function, one set per winding are used to trip circuits selectively and to time coordinate with up or down stream relays. For this function, eight complete series of inverse time tripping characteristics are included. The eight curve families to be chosen are definite, inverse, very inverse, extremely inverse, and four IEC curves. The time dial within each family setting and tap setting is selected through the relay menu.

The curves available for use are shown in Appendix D, **Inverse Time Curves**, Figures D-5 through D-12. 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 pickup setting.

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

```
51W1 PICKUP
    1.00 Amps
```

Sets phase current pickup for 51W1.

```
51W1 CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves as shown in Appendix D, Figures D-5 through D-12.

```
51W1 TIME DIAL
    5.0
```

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

■ **NOTE:** These screens are also applicable for Windings 2 and 3.

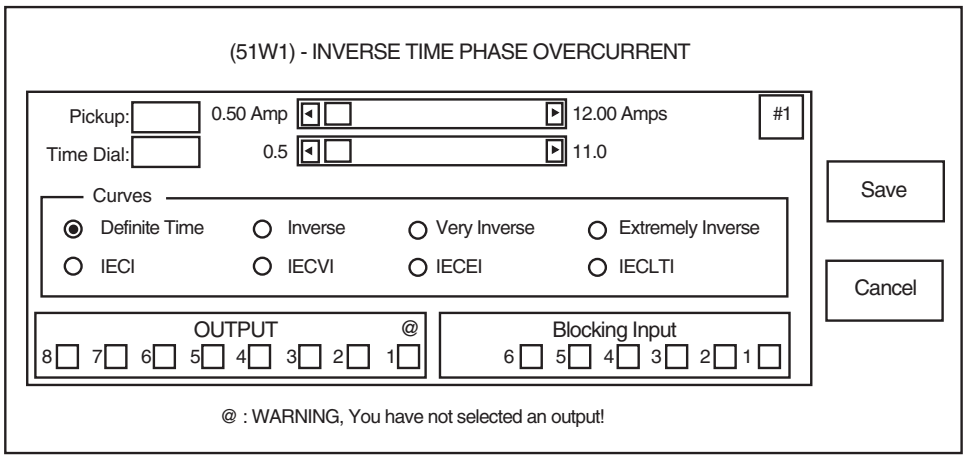


Figure 2-15 M-3820B IPScom® for Windows™ (51) Inverse Time Phase Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/51W1, W2, W3 Inverse Time 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.

51N Inverse Time Residual Overcurrent

The 51 Inverse Time Residual Overcurrent provides protection against ground faults. Since normal residual current is usually much lower than the full load phase current, this function can be set more sensitively than the phase overcurrent protection.

The curves available for use are shown in Appendix D, **Inverse Time Curves**, Figures D-5 through D-12. They cover a range from 1.5 to 20 times tap. For currents beyond 20 times the pickup setting, the relay operating time will remain the same as the time at 20 times pickup setting.

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

```
51NW1 PICKUP
    1.00 Amps
```

Sets phase current pickup for 51NW1.

```
51NW1 CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves, as shown in Appendix D, Figures D-5 through D-12.

```
51NW1 TIME DIAL
    5.0
```

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

■ **NOTE:** These screens are also applicable for Windings 2 and 3.

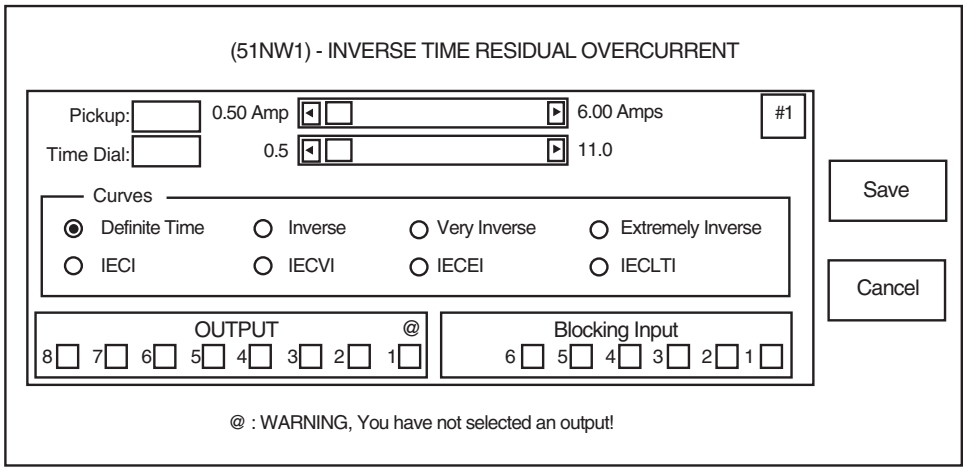


Figure 2-16 M-3820B IPScom® for Windows™ (51N) Inverse Time Residual Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/51N W1, W2, W3 Inverse Time Residual 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.

51G Inverse Time Ground Overcurrent

The 51G Inverse Time Ground Overcurrent function is used to trip circuits selectively and to time coordinate with up or downstream relays. For this function, eight complete series of inverse time neutral tripping 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 tap setting through the relay menu.

The curves available for use are shown in Appendix D, **Inverse Time Curves**, Figures D-5 through D-12. 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 pickup setting.

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

```
51GW2 PICKUP
    1.00 Amps
```

Sets residual pickup for 51G.

```
51GW2 CURVE
DEF inv vinv einv →
```

Selects one of the eight inverse time curves, as shown in Appendix D, **Inverse Time Curves**, Figures D-5 through D-12.

```
51GW2 TIME DIAL
    5.0
```

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

■ **NOTE:** These screens are also applicable for Winding 3.

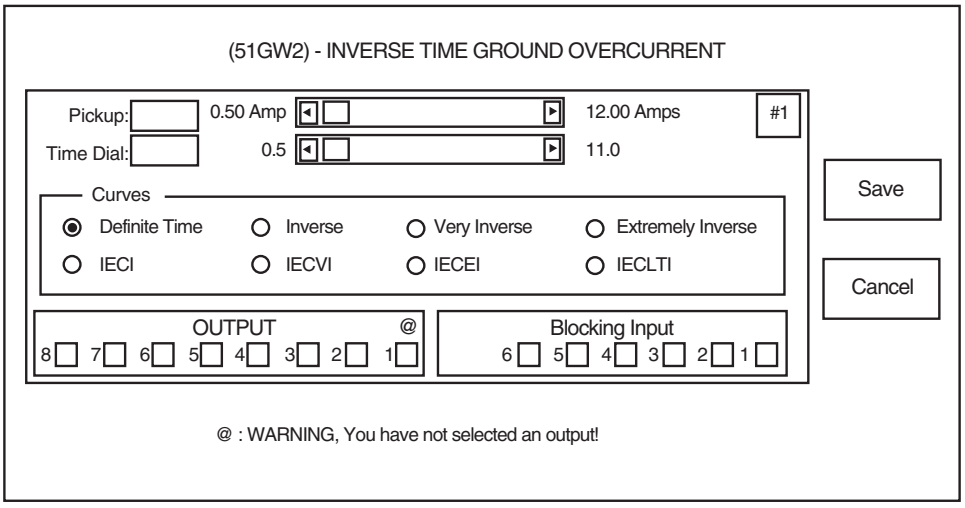


Figure 2-17 M-3820B IPScom® for Windows™ (51G) Inverse Time Ground Overcurrent Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/51GW2, W3 Inverse Time Ground 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.

59G Ground Overvoltage

■ **NOTE:** Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

The 59G Ground Overvoltage function provides protection for ground faults on the system.

Pickup setting for 59G should be set in such a way that it is higher than normal neutral voltage during unbalanced conditions. The time delay should be set to coordinate with downstream ground relaying.

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

59G#1 PICKUP 10 Volts	Sets voltage pickup for ground overvoltage.
59G#1 DELAY 30 Cycles	Sets delay for ground overvoltage.
59G#2 PICKUP 10 Volts	Sets voltage pickup for ground overvoltage.
59G#2 DELAY 30 Cycles	Sets delay for ground overvoltage.

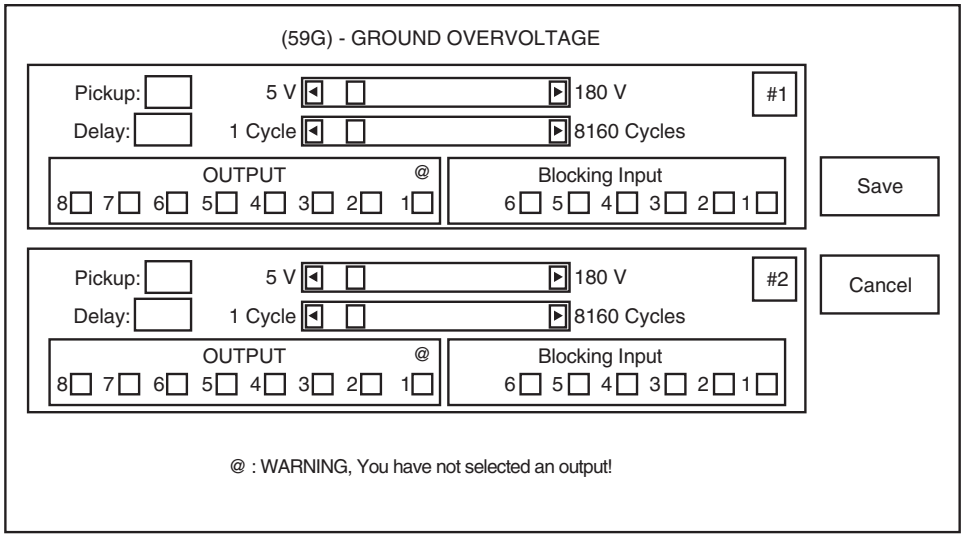


Figure 2-18 M-3820B IPScom® for Windows™ (59G) Ground Overvoltage Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/59G Ground 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.

81O/U Over/Underfrequency

■ **NOTE:** Only one voltage input is available for the M-3311. This can be a phase voltage input or voltage generated from a broken delta VT connection. 81O/U, 27, and 24 Functions are only available if the voltage input is connected to the phase voltage. If the voltage input is connected to phase voltage, Function 59G will be unavailable. Function 59G is only available if the voltage input is connected to a broken delta VT. If voltage input is connected to broken delta VT, Functions 81O/U, 27, and 24 will be unavailable.

The 81O/U Over/Underfrequency function provides protection against abnormal frequency. The Underfrequency function is typically used for load shedding applications. The frequency functions are automatically disabled when the input voltage is less than 5 volts.

When the frequency setpoint is selected as below the nominal frequency, the function operates as an underfrequency, otherwise, it operates as an overfrequency function.

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

```
81#1 PICKUP
    56.00 Hz
```

```
81#1 DELAY
    30 Cycles
```

```
81#2 PICKUP
    56.00 Hz
```

```
81#2 DELAY
    30 Cycles
```

```
81#3 PICKUP
    56.00 Hz
```

```
81#3 DELAY
    30 Cycles
```

```
81#4 PICKUP
    56.00 Hz
```

```
81#4 DELAY
    30 Cycles
```

The pickup and time delay setting for load shedding should be selected based on load frequency characteristics of the system.

A minimum time delay of 6 cycles is recommended to prevent relay operation during switching transients.

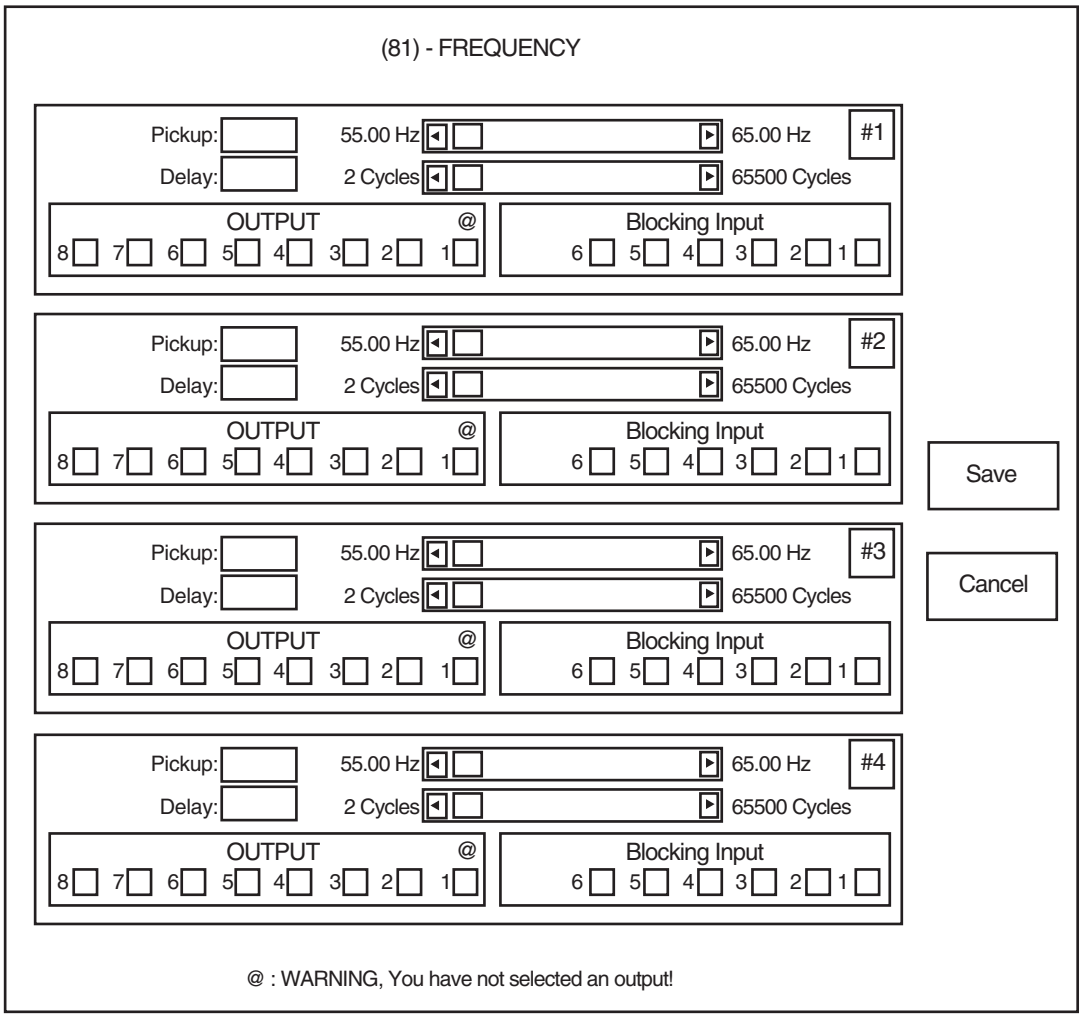


Figure 2-19 IPScom® for Windows™ (81O/U) Over/Underfrequency Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/81 Overfrequency/Underfrequency

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.

87 Phase Differential

87H Phase Differential Unrestrained High Set Overcurrent

The 87H Phase Differential Unrestrained High Set Overcurrent function is used to detect transformer internal winding faults with high currents. Unlike the 87T function, the 87H function is not blocked by harmonic restraint. The pickup for this function should be set above the worst case first peak of the inrush current. This prevents misoperation of the function due to magnetizing inrush current during switching on of the transformer. Typical pickup setting is between 8 to 12 PU. The per unit is based on the CT tap setting. The 87H is typically set with no intentional time delay (one cycle time delay setting corresponds to no intentional time delay).

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

```
87H PICKUP
    20.0 PU
```

High-set pickup setting.

```
87H DELAY
    2 Cycles
```

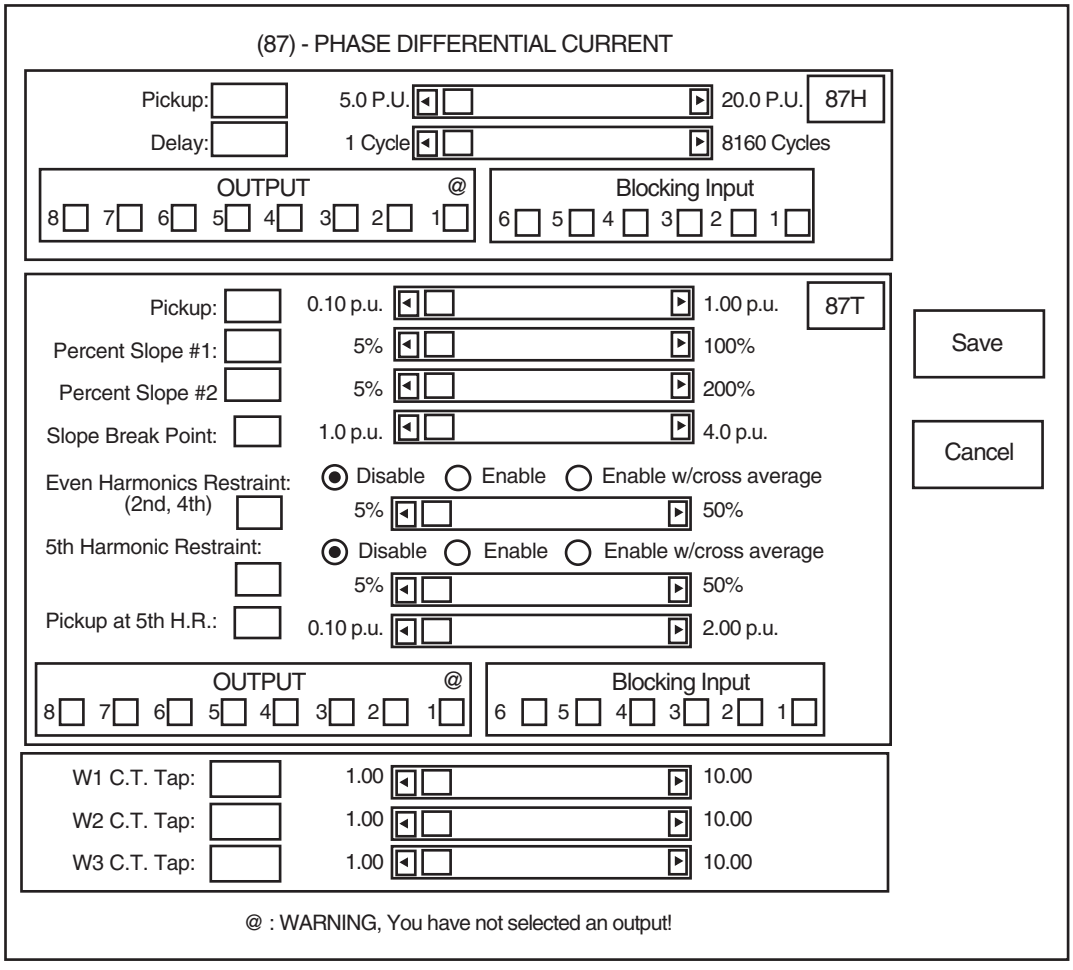


Figure 2-20 M-3820B IPScom® for Windows™ (87) Phase Differential Current Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/87 Phase Differential Current

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.

87 Phase Differential

■ **NOTE**: See Section 2.7 for detailed discussion on transformer connection applications for 87 function differential.

87T Phase Differential Restrained Overcurrent

The 87T Phase Differential function is a percentage differential function with dual adjustable slope characteristics (see Figure 2-22). This function provides protection for the transformer from internal winding faults. This function offers sensitive differential protection at low fault currents and tolerates larger mismatch of currents that can occur during high through fault current for greater security.

The 87T minimum pickup setting should be set to prevent operation of the 87T function due to transformer excitation current. Typical setting is 0.2 to 0.4 PU of tap setting.

Slope 1

The setting of Slope #1 should be set according to various possible errors:

1. Tapchanger operations in the power transformer (worst case ± 10%).
2. CT mismatch due to ratio errors. Errors can be as high as ± 10%.

A typical Slope #1 setting of 30 to 40% prevents misoperation due to above errors.

Slope 2

For heavy faults outside the differential zone, CT saturation can occur. Factors such as residual magnetism in the CT core, CT characteristic mismatch and burden mismatch can contribute large differential currents during this condition. Slope #2 should be set higher than Slope #1. It can provide security against misoperation during high through fault currents. A typical Slope #2 setting is 60 to 100%.

Even Harmonic Restraint

Transformer magnetizing inrush currents contain significant amounts of 2nd and some 4th harmonic currents. This inrush can cause undesirable trips and delay putting a transformer into service. The even harmonic restraint keeps it from operating during a magnetizing inrush condition. Magnetizing inrush current is distinguishable from fault current by harmonic components. The M-3311 Transformer Protection Relay can be set to restrain if the level of even harmonic current is above a set percentage of fundamental.

The harmonic currents are calculated from the differential current in the windings. The amount of even harmonic current (Id_{24}) in PU can be found by using the formula:

$$Id_{24} \quad \sqrt{Id_2{}^2 \quad Id_4{}^2}$$

where Id_2 and Id_4 are second and fourth harmonic currents in PU, respectively.

The percentage of even harmonics is found by the ratio Id_{24}/Id_1: If this number is above the even harmonic restraint setpoint, function 87T will restrain from operation.

The amount of even harmonics present in the transformer inrush currents depends upon the magnetizing characteristics of the transformer core and residual magnetism present in the core. A setting in the range of 10 to 15% can provide security against misoperations during magnetizing inrush conditions.

Modern transformers tend to have low core losses and very steep magnetizing characteristics. When the relay is applied to this type of transformers, the even harmonic setting should be set around 10% (in some cases, the setting may be lower than 10%). Older transformer designs tend to have higher amounts of even harmonics, where a setting of 15% or greater can provide security against misoperation during magnetizing inrush conditions.

The setting of the even harmonic restraint should be set to a low enough value to provide security against misoperation during transformer magnetizing inrush current and it should not be lower than the amount of even harmonics generated during internal fault conditions with CT saturation so as not to compromise reliability for heavy internal fault detection.

Fifth Harmonic Restraint

Transformer over-excitation produces a high amount of excitation current, which will appear as a differential current to the 87T function. The Fifth Harmonic restraint function can prevent misoperation of the 87T function by shifting the minimum pickup to a higher value (typically set at 150 to 200% of 87T minimum pickup), during transformer over-excitation conditions.

The over-excitation condition is detected by the presence of Fifth Harmonic component as a percentage of fundamental component of differential current above a set value.

The amount of Fifth Harmonic depends on the transformer core magnetizing characteristics. A setting of 30% is adequate to discriminate over-excitation from other conditions.

Cross Phase Averaging

Cross phase averaging is used to average the harmonics of all three phases to provide restraint of phases which may not have enough harmonics. Cross phase average, when enabled, provides security against misoperation during magnetizing inrush. However, it may slightly delay the relay operation for internal faults. The level of cross phase average current may be found using the following equations.

Even Harmonic Cross Phase Average:

$$Id_{CPA24} = \sqrt{IAd_{24}^2 + IBd_{24}^2 + ICd_{24}^2}$$

Fifth Harmonic Cross Phase Average:

$$Id_{CPA5} = \sqrt{IAd_{5}^2 + IBd_{5}^2 + ICd_{5}^2}$$

When enabled, the above averages are used along with fundamental component of differential current in each of the phases to calculate the harmonic percentages.

It is recommended to enable the cross phase average for even harmonic restraint, and disable the cross phase average for 5th harmonic restraint.

87T W1, W2 and W3 CT Tap Settings

The 87TW1, W2 and W3 CT tap settings are used to convert the W1, W2 and W3 current in terms of P.U. These settings are provided to compensate for CT ratio mismatch for 87T and 87H functions. These should be calculated as follows:

87T CT Tap Settings For W1, W2, & W3

$$87\ CT\ Tap_{WN} = \frac{MVA \times 10^3}{\sqrt{3} \times kVL\text{-}L \times CTR_{WN}}$$

where W_N is the winding number.

CT Tap Setting Calculation Example

Based on the transformer example in Figure 2-21, the CT tap calculations are presented below.

Since the $\sqrt{3}$ magnitude compensation for Delta connected CT's is already taken into account in the relay calculation, the same equation is used to calculate each CT Tap setting.

$$87\ CT\ Tap_{W1} = \frac{392.8\ MVA \times 10^3}{\sqrt{3} \times 17.1\ kV \times 1600} = 8.29$$

$$87\ CT\ Tap_{W2} = \frac{392.8\ MVA \times 10^3}{\sqrt{3} \times 17.1\ kV \times 1600} = 8.29$$

$$87\ CT\ Tap_{W3} = \frac{392.8\ MVA \times 10^3}{\sqrt{3} \times 161\ kV \times 400} = 3.52$$

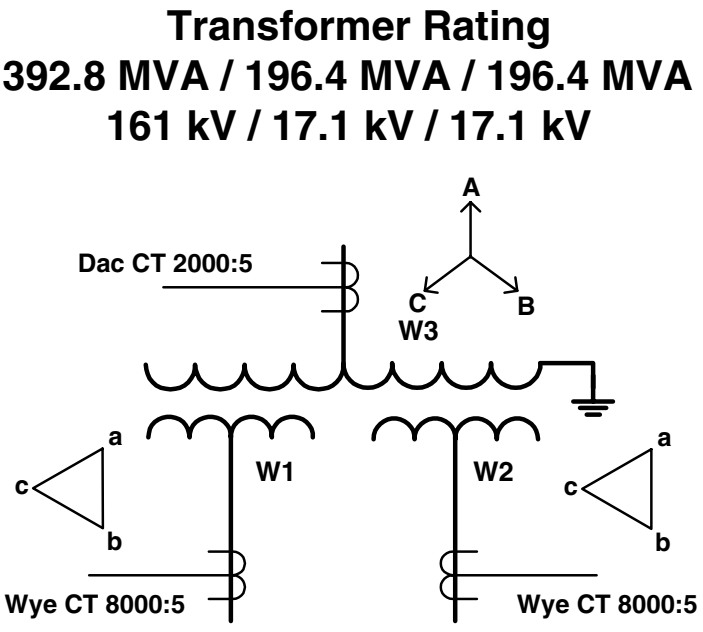
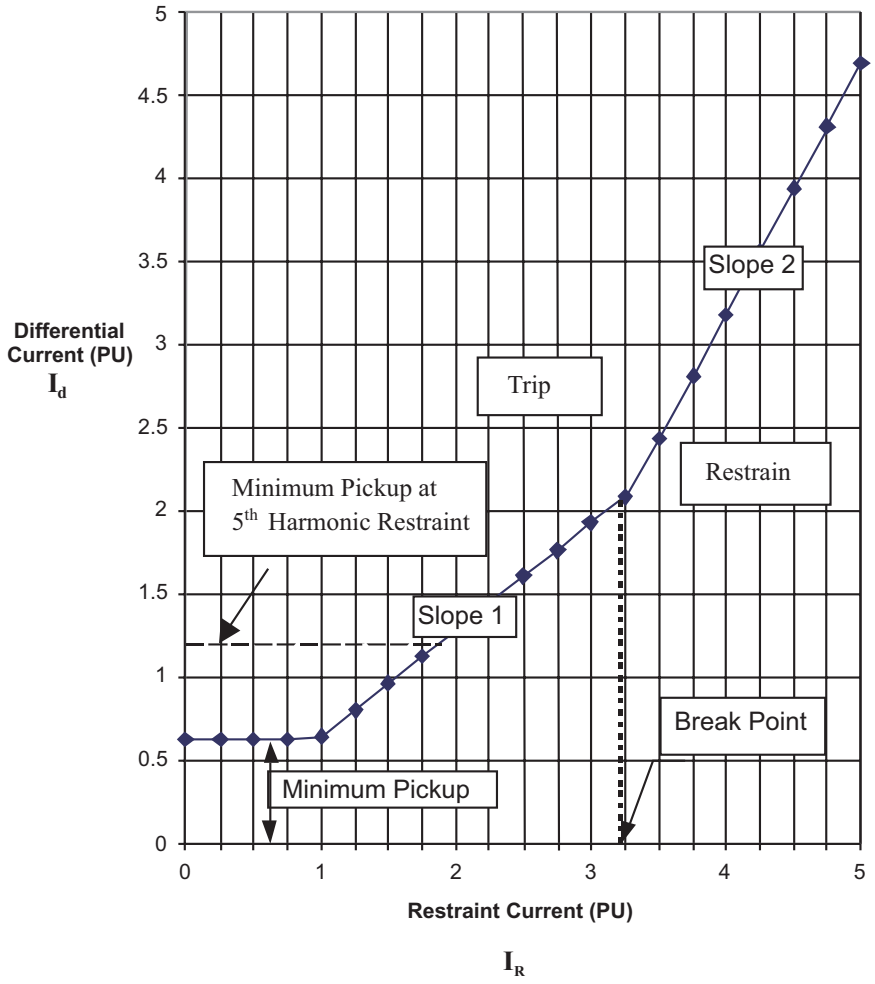


Figure 2-21 Transformer CT Tap Setting Example



where

$$I_R = \frac{\Sigma \left(|I_{AW1}| + |I_{AW2}| + |I_{AW3}| \right)}{2}$$

$$I_d = \Sigma \left(\bar{I}_{AW1} + \bar{I}_{AW2} + \bar{I}_{AW3} \right)$$

Figure 2-22 87T Programmable Dual Slope Percentage Restraint Characteristic

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

See previous pages for more information on these settings.

```
87T PICKUP
    0.50 PU
```

```
87T SLOPE #1
    25%
```

```
87T SLOPE #2
    75%
```

```
87T SLOPE BREAKPOINT
    2.0 PU
```

```
87T EVEN RESTRAINT
disable enable CROSS_AVG
```

```
87T EVEN RESTRAINT
    10%
```

```
87T 5TH RESTRAINT
disable enable CROSS_AVG
```

```
87T 5TH RESTRAINT
    10%
```

```
87T PICKUP@5TH RESTRAINT
    0.75 PU
```

```
87 W1 C.T.TAP
    1.00
```

```
87 W2 C.T. TAP
    1.00
```

```
87 W3 C.T. TAP
    1.00
```

87GD Ground Differential

The 87GD ground differential element may provide sensitive ground fault protection on winding 2 or winding 3.

The relay provides a CT Ratio Correction which removes the need for auxiliary CTs when the phase, winding 2 or winding 3 and their ground CT ratios are different.

The directional element calculates the product ($-3I_0 I_G \text{Cos}\phi$) for directional indication. The relay will operate only if I_0 (zero sequence current derived from the phase CTs) and I_G (Ground current from the Ground CT) have the opposite polarity, which is the case for internal transformer faults.

The advantage of directional element is that it provides security against ratio errors and CT saturation during faults external to the protected transformer.

The directional element is inoperative if the residual current ($3I_0$) is approximately less than 140 mA (approx., based on 5 A CT rating). For this case, the algorithm automatically disables the directional element and the 87GD function becomes non-directional differential. The pickup quantity is calculated as the difference between the corrected triple zero sequence current ($RC3I_0$) and the ground current (I_G). The magnitude of the difference ($RC3I_0 - I_G$) is compared to the function pickup setting.

In order to use the 87GD function, Winding 2 and Winding 3 CTs must be connected wye.

The 87GD function is automatically disabled if the ground current is less than 200 mA (based on a 5 A rating).

For security purposes during external phase fault currents causing CT saturation, this function is disabled any time the value of I_G is less than approximately 0.20 amps.

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

```
87GDW2 PICKUP
   0.2 Amps
```

```
87GDW2 DELAY
   6 Cycles
```

```
87GDW2 C.T. RATIO CORR.
   1.00
```

■ **NOTE:** For higher values of CT Ratio correction, noise may create substantial differential current making higher settings desirable.

▲**CAUTION:** DO NOT set the Delay to less than 2 cycles. In order to prevent mis-operation during external faults with CT saturation conditions, a time delay of 6 cycles or higher is recommended.

CT Ratio Correction Factor (CTRCF) = $\dfrac{\textit{Phase C.T. Ratio}}{\textit{Ground C.T. Ratio}}$

■ **NOTE:** These screens are also applicable for Winding 3.

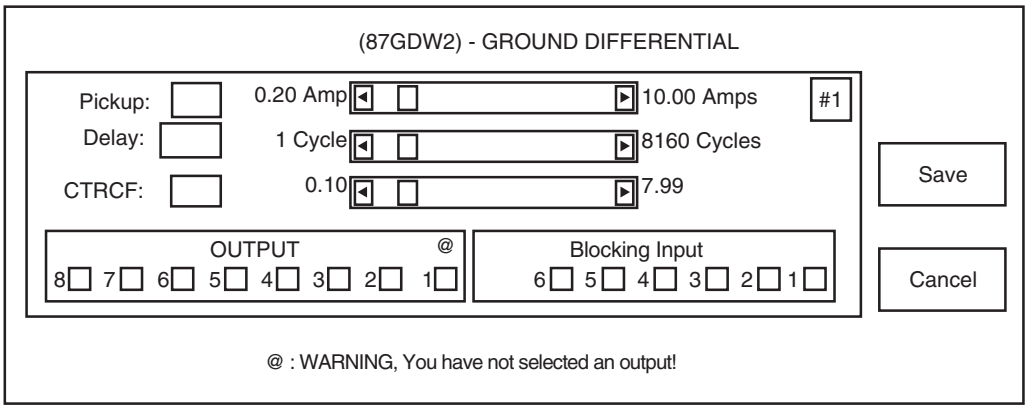


Figure 2-23 M-3820B IPScom® for Windows™ (87GD) Ground Differential Current Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/87GD W2, W3 Ground Differential Current

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.

Breaker Monitoring

The Breaker Monitoring feature calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current or current squared passing through the breaker contacts during the interruption period. The per-phase values are added to an accumulated total for each phase, and then compared to a user-programmed threshold value. When the threshold is exceeded in any phase, the relay can set a programmable output contact. The accumulated value for each phase can be displayed as an actual value. The integration starts after a set time delay from the initiate point to account for the time it takes for the breaker to start opening its contacts. The integration continues until the current drops below 0.1 PU or 10 cycles, whichever occurs first.

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

```
BRKRW1 PICKUP
  1000 kA^2-cycles
```

Pickup setting for BM W1.

```
BRKRW1 INPUT INITIATE
  i6 i5 i4 i3 i2 i1
```

```
BRKRW1 OUTPUT INITIATE
 08 07 06 05 04 03 02 01
```

```
BRKRW1 DELAY
  10.0 Cycles
```

Time delay until breaker contacts start to open.

```
BRKRW1 TIMING METHOD
  it i2t
```

Selects integration timing method. (IT or I^2t)

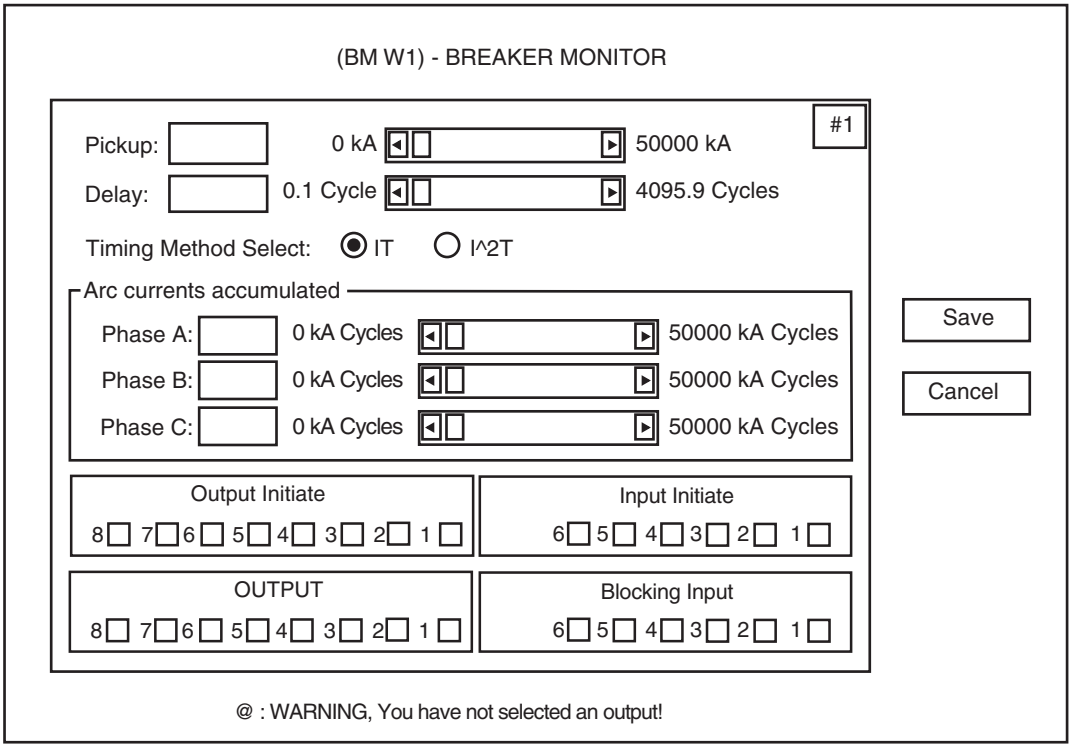


Figure 2-24 M-3820B IPScom® for Windows™ Breaker Monitor Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/Breaker Monitoring

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.

External Functions/BECO Logic

The relay provides six External Functions and associated BECO logic. The External Functions can be used to allow external devices to trip through the relay, providing additional target information for the external device. More importantly, these functions can be used in conjunction with BECO Logic to expand the capability of the relay by allowing the user to define customized operating logic.

Programming the BECO Logic can only be implemented through IPScom®. The BECO Logic cannot be programmed using the Human-Machine Interface (HMI). The six External Functions can be activated using the HMI, but with limited logic capability. When activated using the HMI, the settings indicated below are applicable. The initiating input can be any external device connected to IN1*–IN6.

■ **NOTE**: *IN1 is pre-designated as the Breaker contact input.

Settings applicable when this function is enabled using the HMI:

```
EXT#1 INPUT INITIATE
    i6 i5 i4 i3 i2 i1
```

The initiating inputs are user designated for each enabled external function. The activation of one or more of the external contacts will start operation of the external function timer.

```
EXT#1 OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1
```

The initiating outputs can also be set to start the external functions timer. This aids in setting up special logic schemes as the output contact does not have to be routed back to the input. This also saves inputs as well as speeds up the triggering process as the output contact delay and input de-bounce delay no longer enter the equation.

```
EXT#1 DELAY
    30 Cycles
```

Each enabled external function requires a time delay setting. Complete settings for each of the 5 remaining external contacts (screens not shown).

■ **NOTE:** These screens are also applicable for External Functions #2, 3, 4, 5, and 6.

The following is an example of how to program an external function, when programming using the HMI (see Figure 2-25):

- Initiating inputs are IN2 or IN5
- Initiating output is OUT4
- Blocking input is IN3
- External function output is OUT6
- Time Delay of 30 cycles

The only logical limitation is that the same status input cannot be designated as both an initiating input and a blocking input. The connection for the external device to the input contacts is illustrated in Chapter 5, Figure 5-5, M-3311 External Connections, and Chapter 6, Table 6-3, Input Contacts.

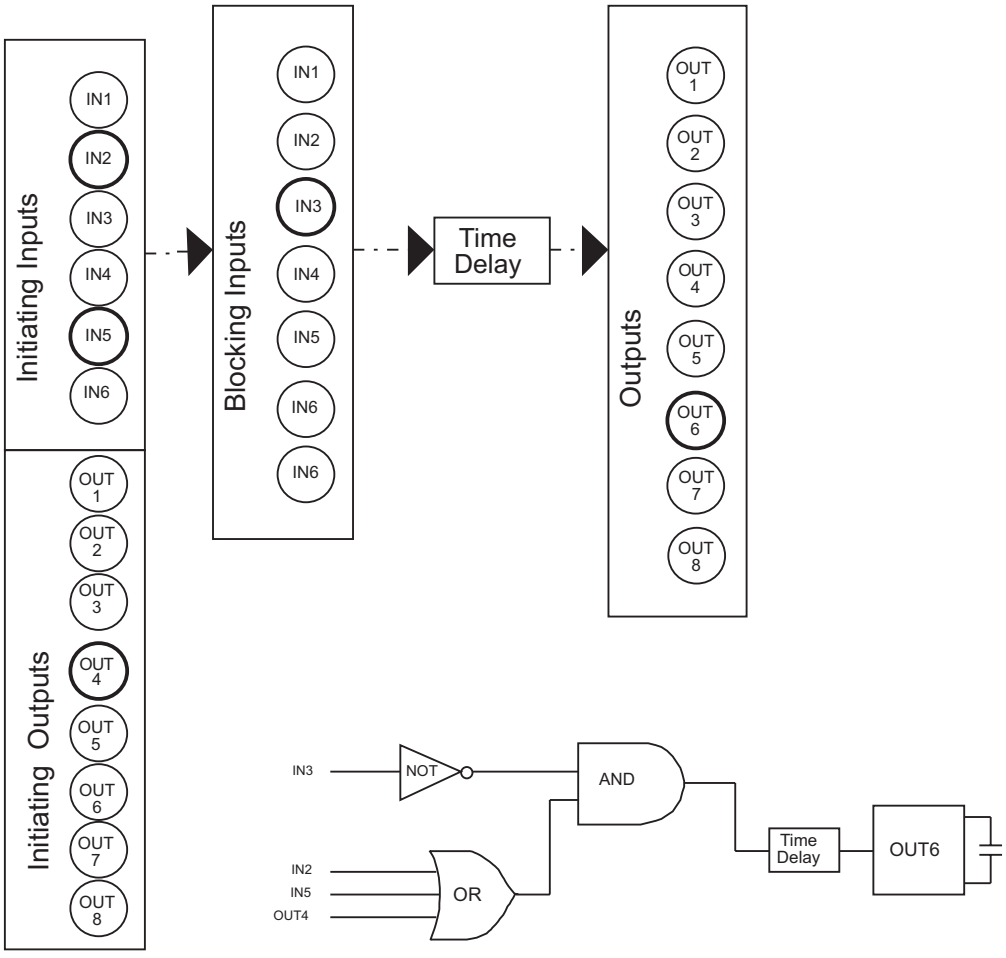


Figure 2-25 External Function Setup

Settings and Logic Applicable when External Function(s) programmed using IPScom®

There are four initiating input sources: Initiating Outputs, Initiating Function Trips (including the External Functions themselves), Initiating Inputs, and initiation using the Communication Port. The only limitation is that an External Function may not be used to initiate itself. There are two blocking input sources: Blocking Inputs and blocking using the Communication Port.

The IPScom External Function programming screen and Initializing Function Trip Selection screens are shown in Figure 2-26 and 2-27, respectively.

The activation state of the input function selected in the Initiating Function Trip dialog (Figure 2-26) is the Tripped state, not Pickup. If the user requires an initiating input that indicates a Pickup status, this can be achieved. Since most functions have multiple setpoints, the second setpoint can be set with no intentional time delay, and used as the initiating input. The desired time delay for security considerations can be obtained in the External Function time delay setting.

The External Function can be programmed to perform any or all of the following tasks:

- Change the Active Setting Profile
- Close an Output Contact
- Be activated for use as an input to another External Function

Since there are six External Functions per setting profile, depending on the number of different relay settings defined, the scheme may provide up to 24 different logic schemes. The BECO Logic is illustrated in Figure 2-25, and the IPScom® External Function programming screen is shown in Figure 2-27.

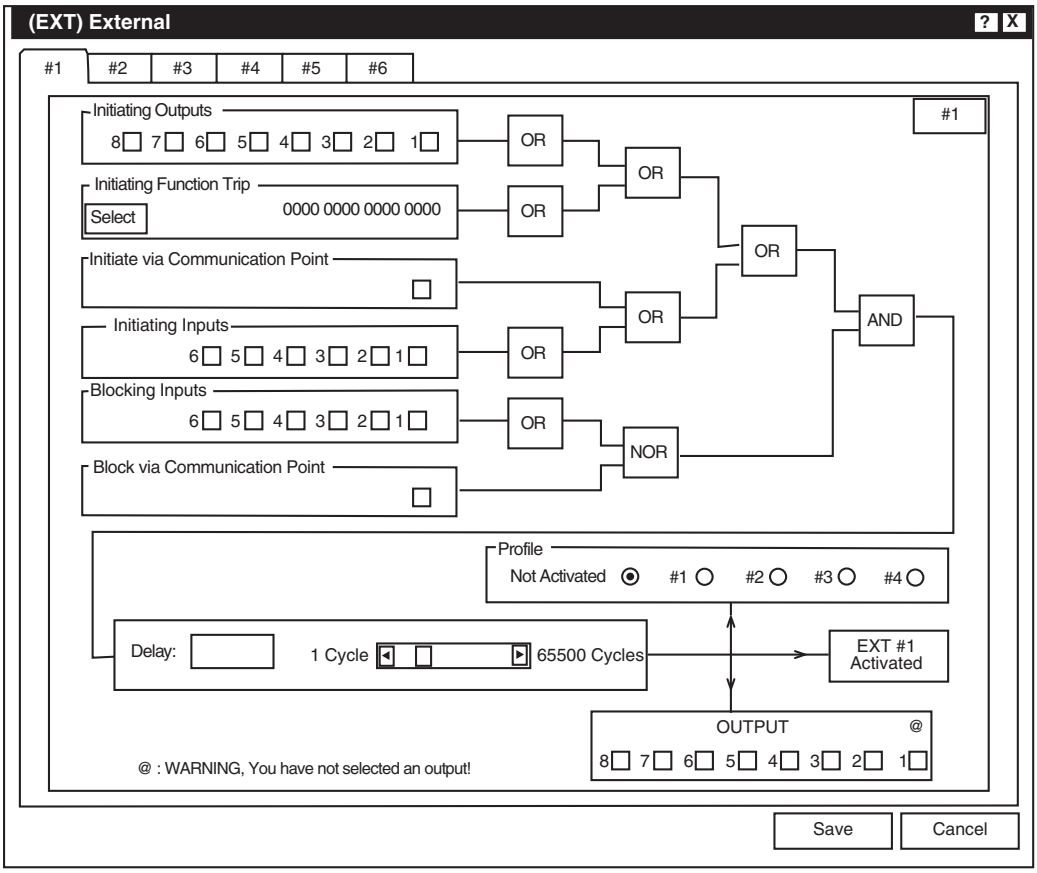


Figure 2-26 M-3820B IPScom® for Windows™ (EXT) External Functions Setpoint Ranges

Path: Relay Menu/Setup/Setpoints/External

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.

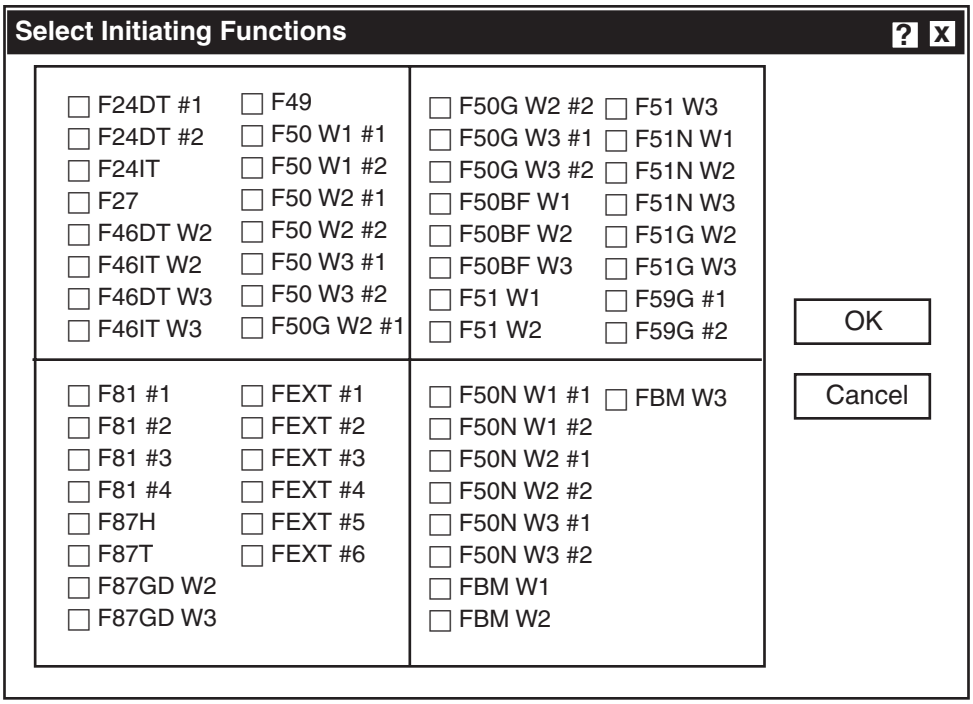


Figure 2-27 Select Initiating Functions Screen

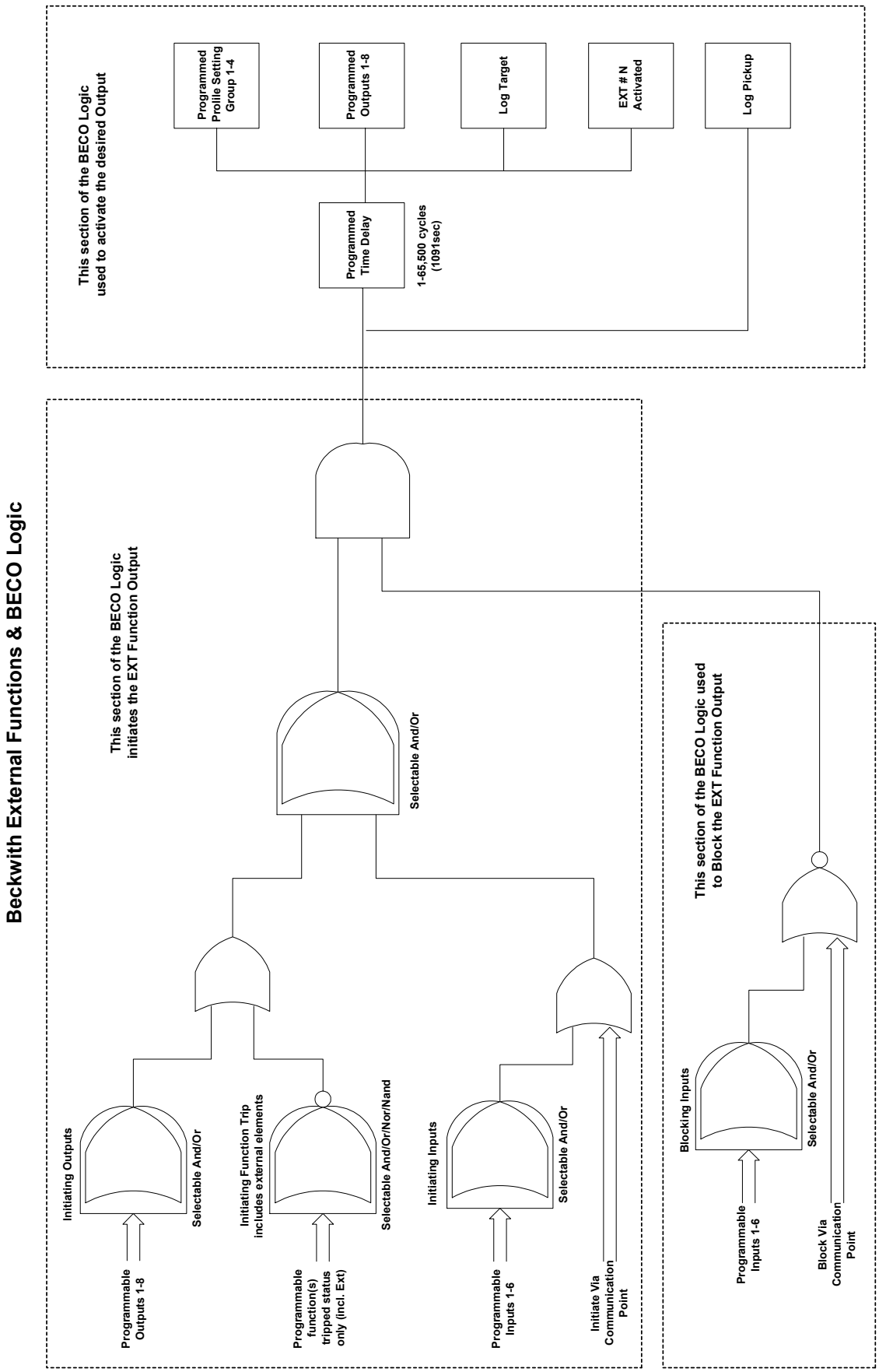


Figure 2-28 External Functions and BECO Logic Diagram when Using IPScom®

2.6 System Applications and Logic Schemes

Bus Fault Protection

Digital feeder and transformer protection logic can be combined together to provide high-speed bus fault protection. The 50W2 function will act as a delayed overcurrent detector (see Figure 2-29). A fault detected from any feeder relay will activate a programmable input on the relay. This input will block the 50W2 function from operating under normal feeder trip conditions. If a fault occurs on the bus connected to winding 2 and none of the feeder relays have tripped, the 50W2 function will then proceed to trip the breaker after the specified time delay.

Example

Function 50W2 #1 is programmed with the following I/O settings: trip Output #2, time delay setting of 7 cycles for proper coordination, and IN4 is set as a Blocking Input. This application requires no special logic. In this configuration all feeder relay output contacts will be in parallel on IN4.

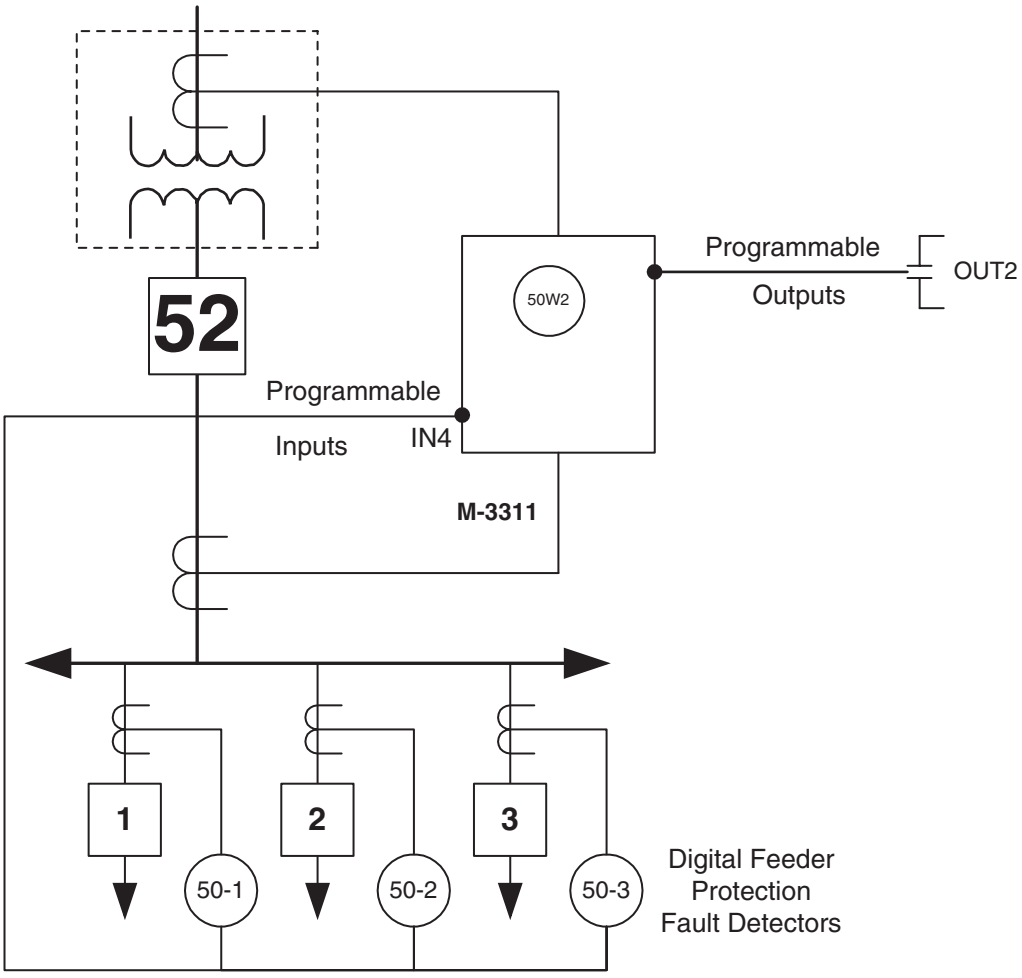


Figure 2-29 Bus Fault Protection Scheme

Backup for Digital feeder Relay Failure

The M-3311 Transformer Protection Relay can provide backup for digital feeder relays (see Figures 2-30 and 2-31). The backup feature is initiated by the closure of a feeder relay's self-test error contact. This scheme assumes that some sort of contact multiplying is done on the self-test outputs. A multiplied, normally open self-test contact can be paralleled with all feeder relays to initiate the backup feature.

Example

In this example, the Negative Sequence Overcurrent (46) function is used to provide the backup protection. Use of the 46 function allows for sensitive backup protection independent of the load current. If the 51 function is used, it must be set to coordinate with the load current and results in less sensitive protection.

This application requires no special logic to implement. The scheme is enabled using the 46 function basic settings through a user-selected control input, configured such that the 46 function is blocked by an open contact. The parallel contacts from the feeder self-test are wired to that input (see Figure 2-31). The negative sequence function is set to coordinate with the downstream devices of the feeders on the protected bus.

With no feeder alarms, the paralleled self-test alarm contacts will all be open, and the Negative Sequence Overcurrent function blocked. When a feeder relay fails and its self-test contact closes, the Negative Sequence overcurrent function is enabled (unblocked), and the contact stream establishes a trip path to the failed relay breaker trip circuit. The Negative Sequence relay will then provide backup protection to the failed relay circuit.

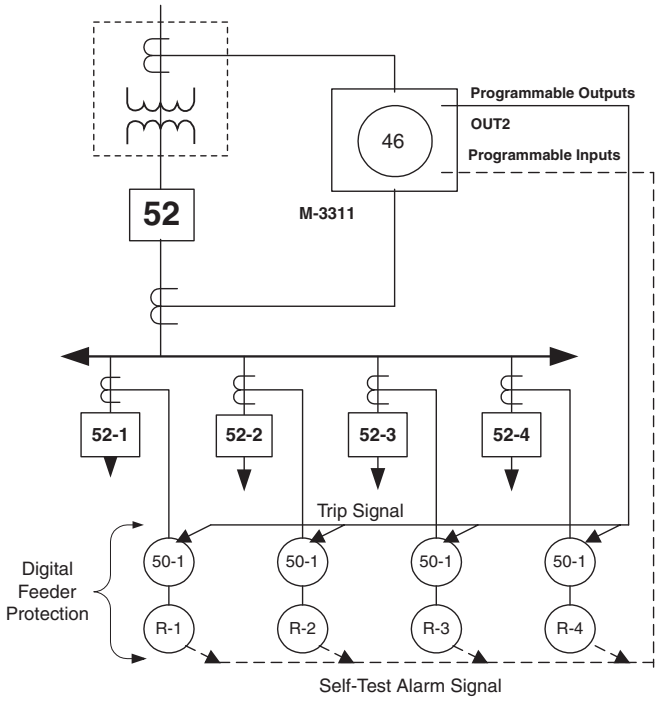


Figure 2-30 Digital Feeder Relay Backup Scheme

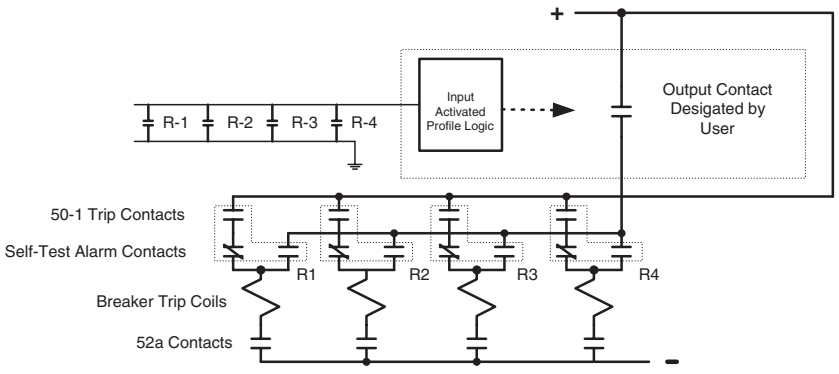


Figure 2-31 Feeder Backup Logic

Load Shedding

Description

In stations where there are two or more transformers (see Figure 2-32), usually there is a normally open tie breaker on the secondary side. If one of the transformers is removed from the system, the tie breaker closes and the remaining transformers will pick up the entire station load. To prevent the remaining transformer(s) from overloading, an overcurrent load shedding is used to remove some of the load if it exceeds a predefined level.

The External functions can provide a cascading time delay feature that can be used for this load shedding configuration. The 52b contact is wired to a relay input, which is programmed to block the 50W2 function. The output of the 50W2 function is programmed to initiate the External functions that are associated with the load shedding configuration. Each External function output is used to trip a corresponding feeder load or initiate voltage reduction.

Example

The function 50W2 #1 basic settings provide the first load shedding step. The tie CB 52b contact wired in parallel with the 52a contacts of the low side transformer breakers are programmed as a control input (IN2). They are configured such that the 50W2 #1 function is blocked by the closed contacts. Closing of the Bus Tie Breaker (opens 52b contact) in conjunction with the opening of one of the low side breakers (opens a 52a contact) enables (unblocks) the 50W2 #1 function.

The 50W2 #1 is programmed to Output #2, providing the first load shedding step. Output #2 is programmed as an “Initiating Output” in the External Function Logic providing additional load shedding steps (see Figure 2-33). Each External function is programmed with a different time delay setting.

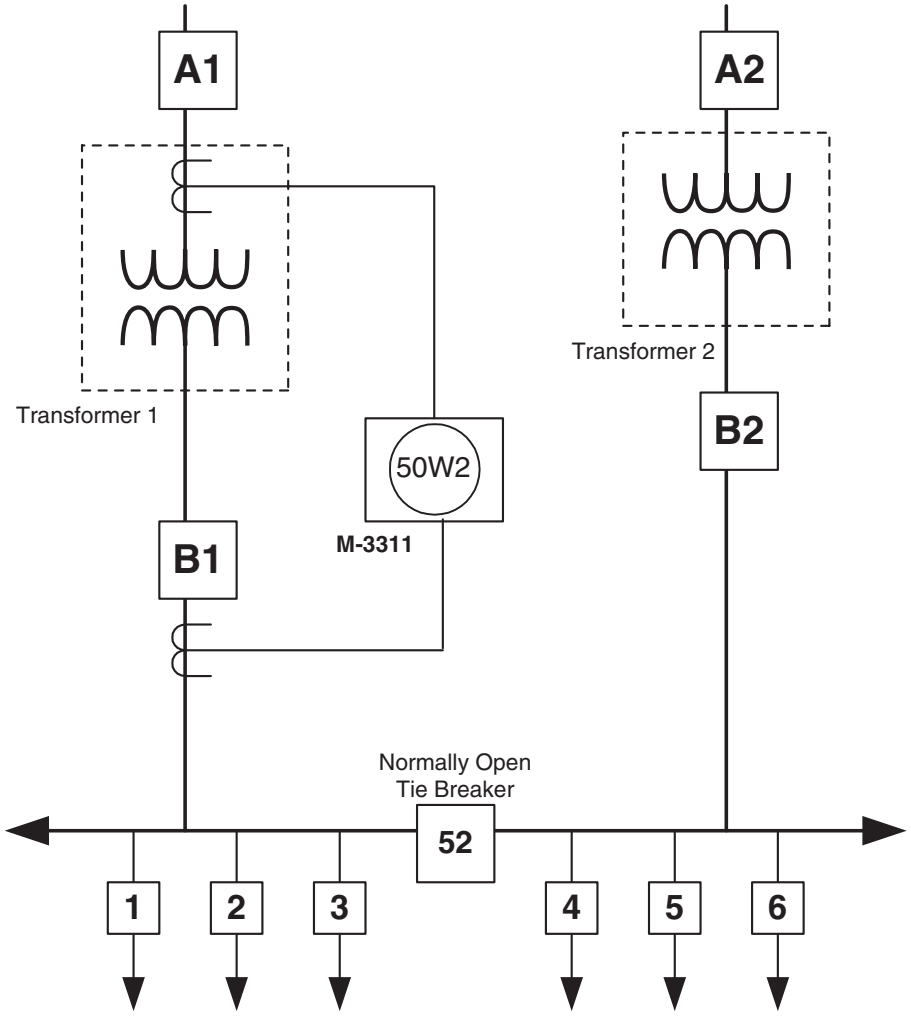


Figure 2-32 Two Bank Load Shedding Scheme

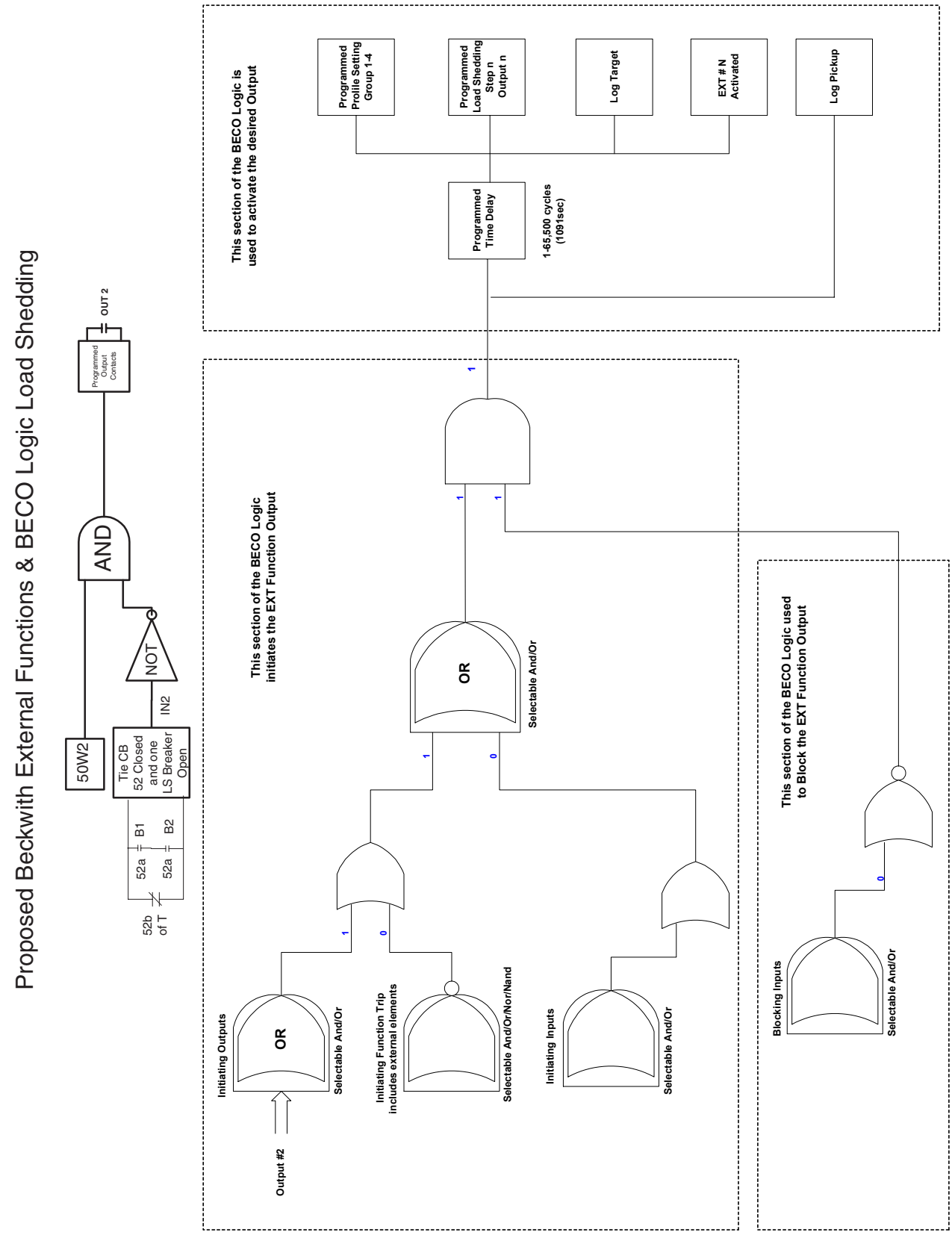


Figure 2-33 Load Shedding Logic

LTC Blocking During Faults

Description

The relay contains logic to block load Tapchangers from operating during feeder fault conditions (see Figure 2-34). Blocking LTC operation during feeder faults can prevent excessive tap changes, reduce contact wear and provide more predictable trip coordination. The blocking contact can be wired to the Auto Disable input (Beckwith M-2270/M-2001B Tapchanger control, for example) or wired in series with the motor power for the Tapchanger.

Example

Function 50W1 #2 is programmed to trip on OUT7 with a pickup of 2X transformer nameplate rated current. The seal-in delay of OUT7 is programmed to 3000 cycles (50 seconds). The normally closed contact of OUT7 is wired to the Auto Disable input of a Beckwith Electric M-2270/M-2001A Tapchanger control. This application requires no special logic.

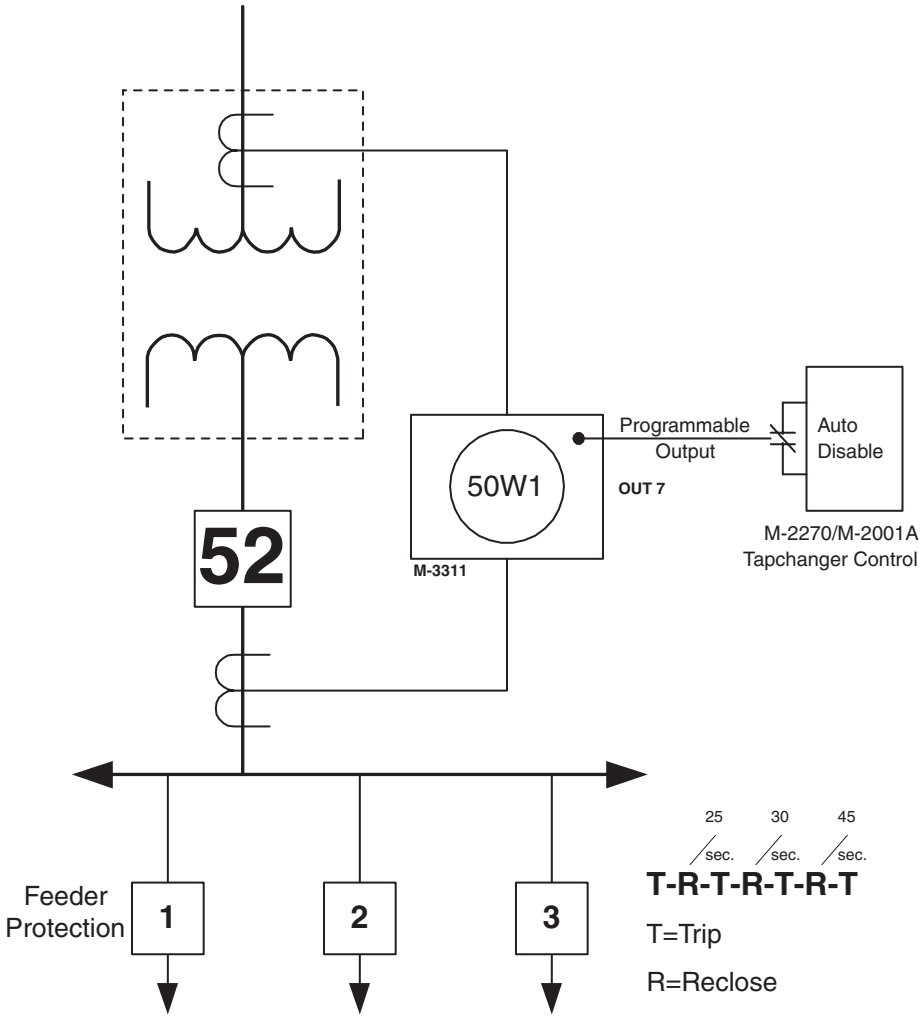


Figure 2-34 LTC Blocking Scheme During Faults

2.7 Transformer Connections

Transformer Winding Selection

The M-3311 can be applied in either a two or three winding transformer differential application. For applications where a two winding differential is required, the user can set the relay system configuration for **Two Winding** and designate the winding current that will be disabled in the 87 Phase Differential Current function.

Only the current input to the 87 function of the disabled winding is not functional. All other functions associated with the disabled winding may be enabled if desired. If the application requires a separate overcurrent function, the user may enable the desired overcurrent functions.

Transformer and CT Configuration

The M-3311 includes Standard and Custom methods of defining the transformer winding and CT configurations. The Standard and Custom Configuration options are made available by selecting either **Disable** or **Enable** for the **Custom Mode for Transformer and CT Connection**.

Standard Transformer and CT Configuration

The standard transformer and CT configuration selections consist of six connections for each transformer winding and CT configuration. The selectable configurations are:

- Wye
- Delta-ab
- Delta-ac
- Inverse Wye
- Inverse Delta-ab
- Inverse Delta-ac

When the user selects from these connection combinations, the relay automatically computes the phase and magnitude compensation required for the differential currents. The general expression for the compensation is given below.

$$\begin{pmatrix} I_A\,CompW_n \\ I_B\,CompW_n \\ I_C\,CompW_n \end{pmatrix} = ConnectType(W_N) \begin{pmatrix} I_A\,W_n \\ I_B\,W_n \\ I_C\,W_n \end{pmatrix}$$

Where:

- I_AW_n, I_BW_n, and I_CW_n are the uncompensated currents entering/exiting winding “n” of the transformer.
- $I_A\,CompW_n$, etc. are the compensated phase currents after being multiplied by the 3x3 matrix ConnectType(N).
- The ConnectType(N) is a discrete number representing the number of 30 degree increments a balanced set of currents with abc phase rotation will be rotated in a counterclockwise rotation.

  Types 0–11 correspond to phase shifts of; 0°, 30°, 60°, …, 330° with a magnitude gain of 1.

  Types 13–23 correspond to phase shifts of; 0°, 30°, 60°, …, 330° with a magnitude gain of $1/\sqrt{3}$.

The compensation calculation uses a counter clockwise rotation from zero. Therefore a Delta-ab transformer (defined as 30 degree leading) has a compensation phase angle shift of 330°, (11x30°). The Delta-ac transformer (defined as 30° lagging) has a compensation phase angle shift of 30°, (1x30°). For a system with acb phase rotation, the compensation calculation uses a counterclockwise rotation. For users more familiar with the IEC transformer configuration nomenclature, a comparison between the IEC definitions and the Beckwith connections is provided in Table 2-2. An example of a ConnectType(1) or 30° compensation matrix is illustrated below.

$$\begin{pmatrix} I_ACompW_n \\ I_BCompW_n \\ I_CCompW_n \end{pmatrix} = \begin{pmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{pmatrix} \begin{pmatrix} I_AW_n \\ I_BW_n \\ I_CW_n \end{pmatrix}$$

Phase Angle Shift - Standard Connections

All inputs are compensated against a Reference Vector of zero degrees. The six standard connections referenced previously result in 6 compensation types for each transformer winding and 12 compensation types for each CT. The transformer compensation types are; 0, 1, 5, 6, 7, and 11, which correspond to 30 degree phase shift multiples of; 0°, 30°, 150°, 180°, 210°, and 330°, all with a gain of one.

The CT compensation types consist of those compensation types listed above and types 13, 17, 19, and 23. Type 13, 17, 19 and 23 correspond to 30 degree phase shift multiples of; 30°, 150°, 210°, and 330°, but with a magnitude gain of $1/\sqrt{3}$.

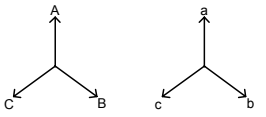
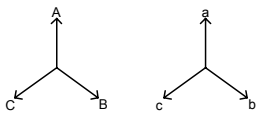
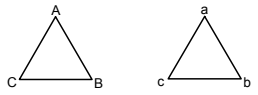
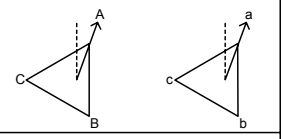
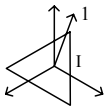
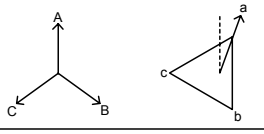
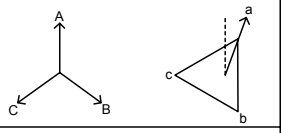
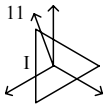
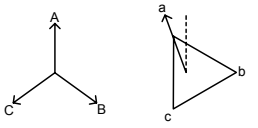
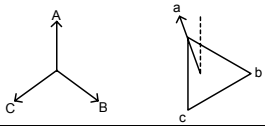
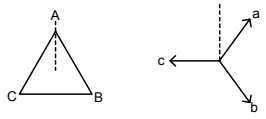
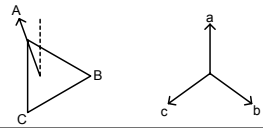
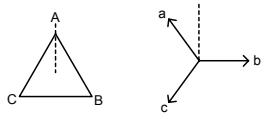
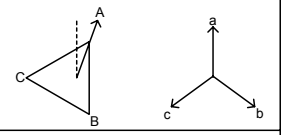
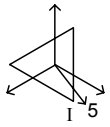
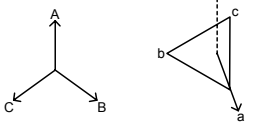
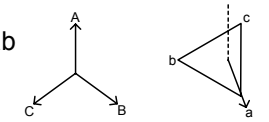
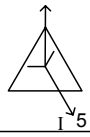
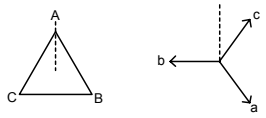
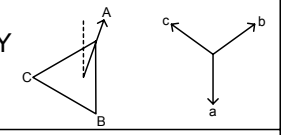
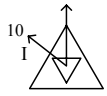
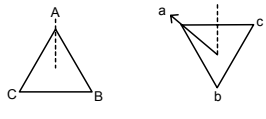
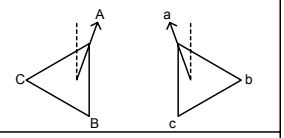
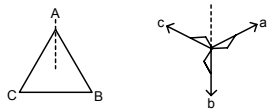
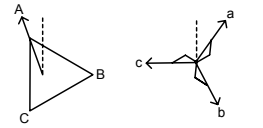
IEC Connection Description	Symbol	Beckwith Standard Connection Description	Symbol	Beckwith Custom Input Value	Symbol
Yy0		YY		Y Y 0 0	
Dd0		Dac Dac		Dac Dac 1 1	
Yd1		Y Dac		Y Dac 0 1	
Yd11		Y Dab		Y Dab 0 11	
Dy1		Dab Y		Dab Y 11 0	
Dy11		Dac Y		Dac Y 1 0	
Yd5		Y Inverse Dab		Y Inverse Dab 0 5	
Dy5		Dac Inverse Y		Dac Inverse Y 1 5	
Dd10		Dac Dab		Dac Dab 1 11	
Dz2		Dab Custom		Dab Wye 11 1	

Table 2-2 Transformer Connections

When the standard connection options are used, the transformer and CT phase angle shifts are combined and the **ConnectType** returns the correct combined phase angle shift. The MagnitudeCT will compensate for the $\sqrt{3}$ associated with delta connected CT's. The shift and magnitude compensation is defined in Table 2-3. Using a reference angle of zero degrees, the Phase A Winding phase angle shift is obtained as follows:

ConnectType (W_n) = ConnectXfm (Type) + ConnectCT (Type)

MagnitudeCT (W_n) = ConnectCT (Type)

Where:

ConnectXfm is the connection of any transformer winding

ConnectCT is the connection of any CT

If the transformer connection is a Delta-ac/Delta-ab/Inverse wye with Wye/Delta-ab/Delta-ac CT's, the resulting phase angle compensation shifts and CT magnitude compensation are:

ConnectType (W1) = ConnectXfm (Delta-ac) + ConnectCT (Wye)

ConnectType (W1) = 1 + 0 = 1 connect type 1 or 30°

ConnectType (W2) = ConnectXfm (Wye) + ConnectCT (Delta-ab)

ConnectType (W2) = 0 + 11 = 11 connect type 11 or 330°

MagnitudeCT(W2) = ConnectCT (Delta-ab)

MagnitudeCT(W2) = 23 = $1/\sqrt{3}$

ConnectType (W3) = ConnectXfm (Inverse Wye) + ConnectCT (Delta-ac)

ConnectType (W3) = 6 + 1 = 7 connect type 7 or 210°

MagnitudeCT(W3) = ConnectCT (Delta-ac)

MagnitudeCT(W3) = 13 = $1/\sqrt{3}$

If any transformer winding is a wye with a wye CT, the ConnectType is returned as 0, (or 0°), the relay automatically eliminates the zero sequence current.

Phase Angle Shift - Custom Connections

For configurations not available in the standard six selections, a Custom Configuration selection is available. The transformer phase compensation is similar to the Standard Configuration selection. However, the transformer phase shift compensation angle does not include the CT compensation phase shift. In the Custom Mode For Transformer and CT Connection, the user must input the actual compensation number as defined in the Custom Configuration Table. The CT phase and magnitude compensation are entered as one input using the selection from Table 2-4. For reference, examples of the transformer phase shift ConnectType numbers are indicated in Table 2-2, under the Custom column.

Transformer & CT Phase Compensation			CT Phase/Magnitude Compensation		
CCW Increment #	Compensation	Beckwith Connection	CCW Increment #	Compensation	Beckwith Connection
0	$1 \angle 0^o$	Wye	13	$1/\sqrt{3}$	Delta-ac
1	$1 \angle 30^o$	Delta-ac	17	$1/\sqrt{3}$	Inverse Delta-ab
5	$1 \angle 150^o$	Inverse Delta-ab	19	$1/\sqrt{3}$	Inverse Delta-ac
6	$1 \angle 180^o$	Inverse Wye	23	$1/\sqrt{3}$	Delta-ab
7	$1 \angle 210^o$	Inverse Delta-ac			
11	$1 \angle 330^o$	Delta-ab			

Table 2-3 Standard Transformer and CT Configuration Options

Transformer Phase Compensation			CT Phase/Magnitude Compensation		
CCW Increment #	Compensation	Beckwith Connection	CCW Increment #	Compensation	Beckwith Connection
0	$1 \angle 0^o$	Wye	0	$1 \angle 0^o$	Wye
1	$1 \angle 30^o$	Delta-ac	1	$1 \angle 30^o$	
2	$1 \angle 60^o$		2	$1 \angle 60^o$	
3	$1 \angle 90^o$		3	$1 \angle 90^o$	
4	$1 \angle 120^o$		4	$1 \angle 120^o$	
5	$1 \angle 150^o$	Inverse Delta-ab	5	$1 \angle 150^o$	
6	$1 \angle 180^o$	Inverse Wye	6	$1 \angle 180^o$	Inverse Wye
7	$1 \angle 210^o$	Inverse Delta-ac	7	$1 \angle 210^o$	
8	$1 \angle 240^o$		8	$1 \angle 240^o$	
9	$1 \angle 270^o$		9	$1 \angle 270^o$	
10	$1 \angle 300^o$		10	$1 \angle 300^o$	
11	$1 \angle 330^o$	Delta-ab	11	$1 \angle 330^o$	
			12	$1/\sqrt{3} \angle 0^o$	
			13	$1/\sqrt{3} \angle 30^o$	Delta-ac
			14	$1/\sqrt{3} \angle 60^o$	
			15	$1/\sqrt{3} \angle 90^o$	
			16	$1 \sqrt{3} \angle 120^o$	
			17	$1/\sqrt{3} \angle 150^o$	Inverse Delta-ab
			18	$1/\sqrt{3} \angle 180^o$	
			19	$1/\sqrt{3} \angle 210^o$	Inverse Delta-ac
			20	$1/\sqrt{3} \angle 240^o$	
			21	$1/\sqrt{3} \angle 270^o$	
			22	$1/\sqrt{3} \angle 300^o$	
			23	$1/\sqrt{3} \angle 330^o$	Delta-ab

Table 2-4 Custom Transformer and CT Configuration

Calculation of Differential & Restraint Currents

The M-3311 uses the following algorithms for calculating the restraint and differential currents.

I restraint: $$I_R = \Sigma \frac{|I_{AW1}| + |I_{AW2}| + |I_{AW3}|}{2}$$

I differential: $$I_d = \Sigma \; \bar{I}_{AW1} + \bar{I}_{AW2} + \bar{I}_{AW3}$$

The differential current (I_d) under normal load conditions should equal zero. As indicated by the operate equation, the currents must be correctly defined as entering/exiting the relay terminals. When the transformer CT polarity markings are located away from the transformer input terminals, the correct connection of the CT leads to the relay has the CT leads with the polarity mark connected to the relay input terminals with polarity mark. If a transformer CT polarity marking is toward the transformer input terminals, the Inverse CT connection should be chosen, or the CT leads should be reversed at the relay terminals. Illustrations of the proper CT input connections marking are provided in the following examples.

M-3311 Connection Examples

Figure 2-33 illustrates a typical transformer differential application in a power plant. The connections and input settings required for the GSU, (Generator Step Up) and Auxiliary transformers are reviewed in detail.

Auxiliary Transformer Example

The Auxiliary Transformer is a Delta/Wye/Wye with resistance grounded wye windings, and Wye/Wye/Wye CT's. The IEC definition of the windings is Dy11y11. The Beckwith standard connection is a Delta-ac/Wye/Wye. The correct connection of the CT leads is shown in Figure 2-35. If the transformer CT polarity markings are located away from the transformer input terminals, the correct connection of the CT leads to the relay has the CT leads with the polarity mark connected to the relay input terminals with polarity mark.

If the standard transformer configuration option is selected the configuration input selections are:

Transformer Configuration W1 = Delta-ac

Transformer Configuration W2 = Wye

Transformer Configuration W3 = Wye

CT Configuration W1 = Wye

CT Configuration W2 = Wye

CT Configuration W3 = Wye

If the custom configuration option is selected, the input settings are illustrated in Figure 2-36. The settings are:

Transformer W1 Setting = 1

Transformer W2 Setting = 0

Transformer W3 Setting = 0

CT W1 Setting = 0

CT W2 Setting = 0

CT W3 Setting = 0

GSU Transformer Example

The GSU transformer illustrated in the example is a Wye/Delta/Delta with a resistance grounded wye winding and Delta-ac/Wye/Wye CT's. The IEC definition of the transformer is Yd1d1. The Beckwith standard connection is a Wye/Delta-ac/Delta-ac. The application requires an 87GD (Ground Differential) function for the wye winding. Since only Winding 2 and Winding 3 in the M-3311 have an 87GD the wye winding must be assigned to one of these winding inputs.

In the example illustrated in Figure 2-37, the wye winding was assigned to the M-3311 winding number 3. Any transformer winding may be assigned to any relay input winding as long as the polarity marking criteria discussed previously is followed.

If the standard transformer configuration option is selected the configuration input selections are:

Transformer Configuration W1 = Delta-ac

Transformer Configuration W2 = Delta-ac

Transformer Configuration W3 = Wye

CT Configuration W1 = Wye

CT Configuration W2 = Wye

CT Configuration W3 = Delta-ac

If the custom configuration option is selected, the input settings are illustrated in Figure 2-38. The settings are:

Transformer W1 Setting = 1

Transformer W2 Setting = 1

Transformer W3 Setting = 0

CT W1 Setting = 0

CT W2 Setting = 0

CT W3 Setting = 13

CONNECTION EXAMPLES

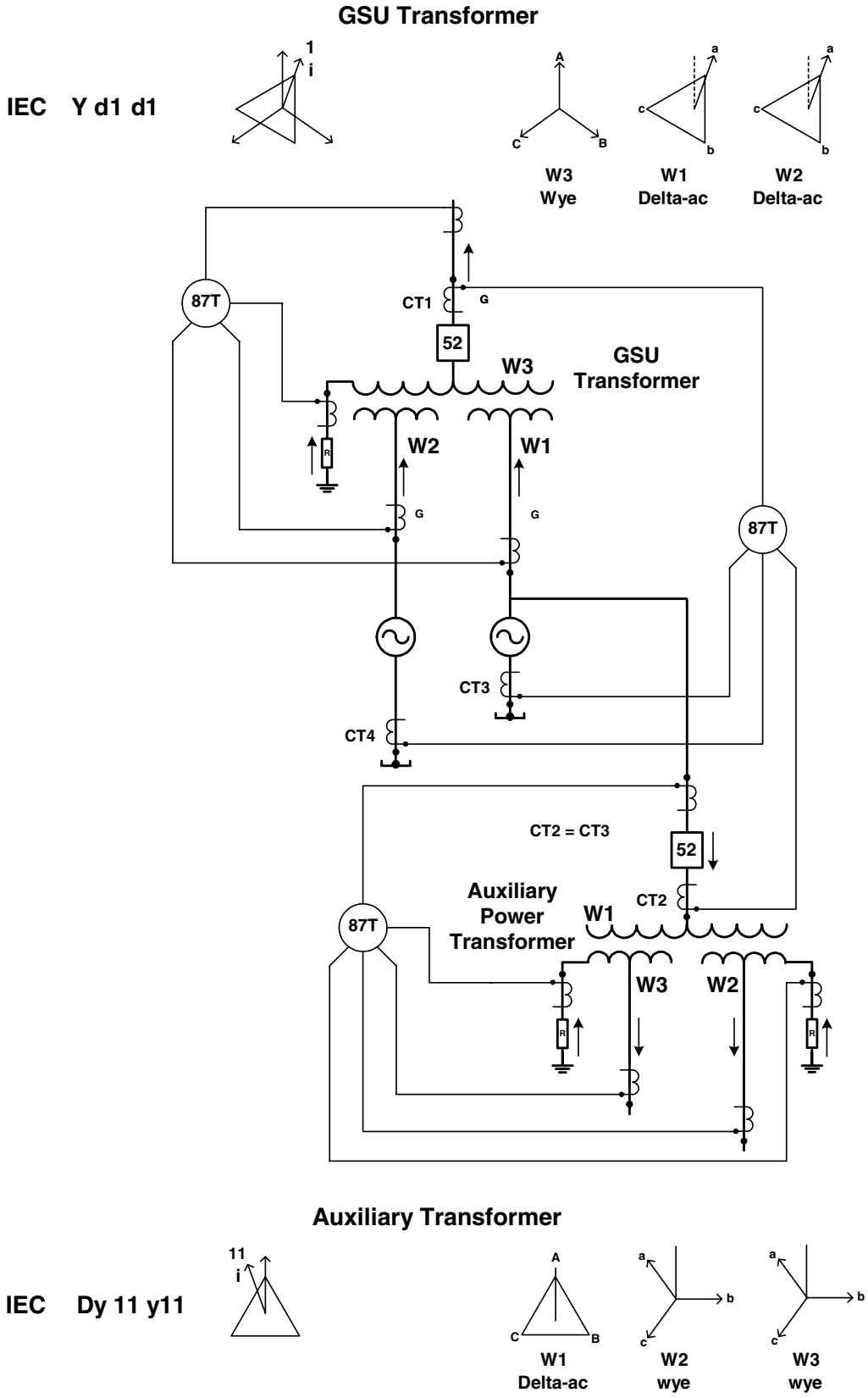


Figure 2-35 Typical Transformer Differential Application

AUXILIARY TRANSFORMER EXAMPLE

Beckwith Delta-ac/Wye/Wye with Wye/Wye/Wye CTs

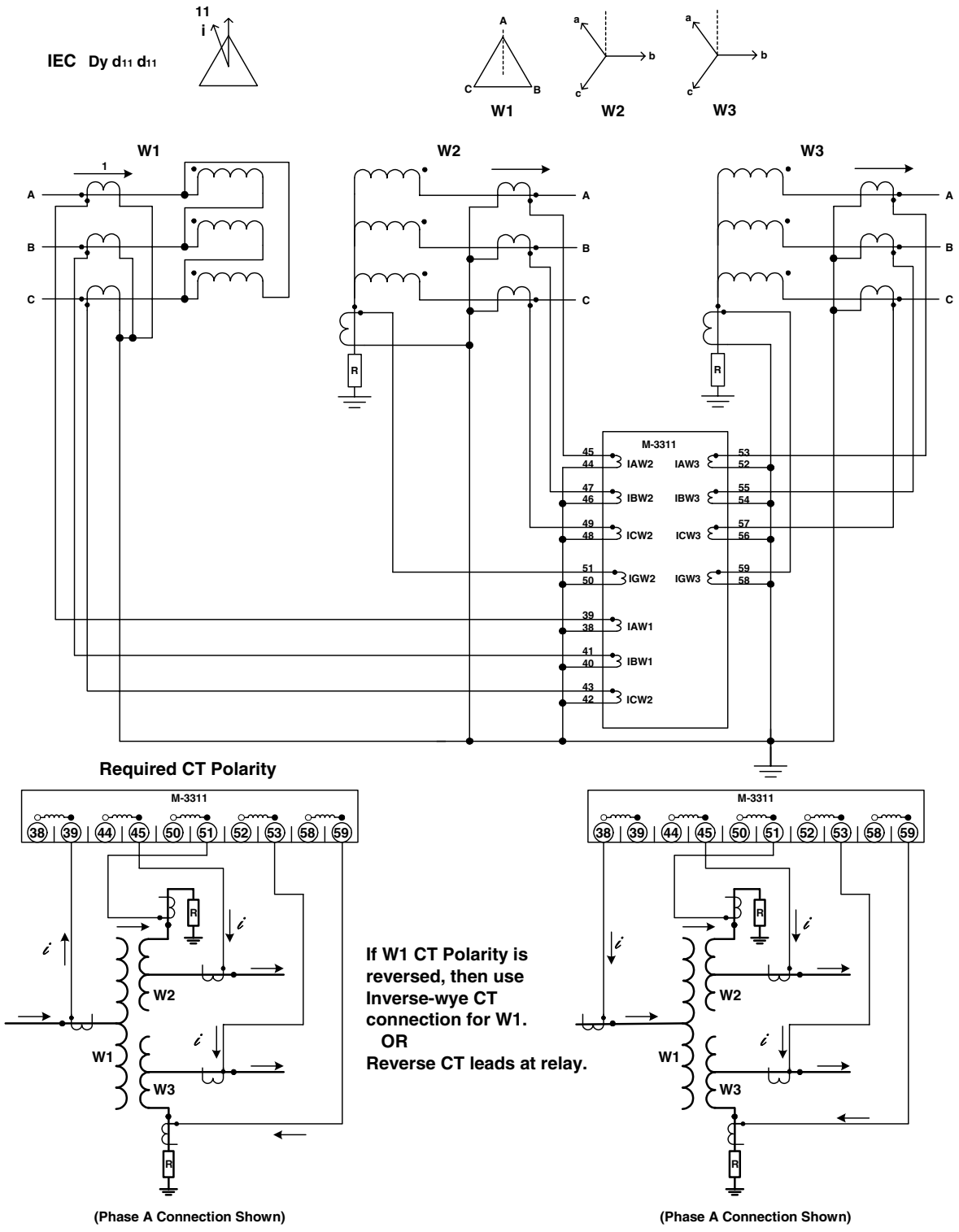


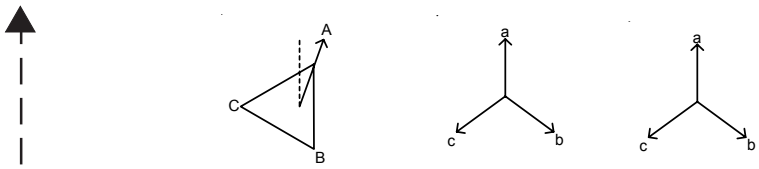
Figure 2-36 Delta-ac/Wye/Wye CT Connection Diagram

AUXILIARY TRANSFORMER EXAMPLE

Beckwith: Delta-ac/Y/Y

IEC Description: D y11 y11

REF Winding



Winding	#1	#2	#3
Winding Type	Dac	y	y
CT Type	Y	Y	Y
Line Current in Degrees ∠°	30°	0°	0°
Phase Compensation	To ref winding		
CCW Rotation	30°	0°	0°
Relay Phase Setting	1	0	0
CT Compensation			
Phase Degrees	0°	0°	0°
Magnitude	no	no	no
Combined Compensation	1 ∠ 0°	1 ∠ 0°	1 ∠ 0°
Relay CT Setting	0	0	0
Zero Sequence Filter	Enable ☒	Disable ☐	

Zero Sequence Filtering is applicable for grounded wye winding with wye connected CTs. Otherwise, zero sequence currents could appear in this input to relay but in no other, causing possible false trip during an external fault.

Figure 2-37 Custom Settings for Delta-ac/Wye/Wye

GSU TRANSFORMER EXAMPLE

Beckwith Wye/Delta-ac/Delta-ac with Delta-ac/Wye/Wye CTs

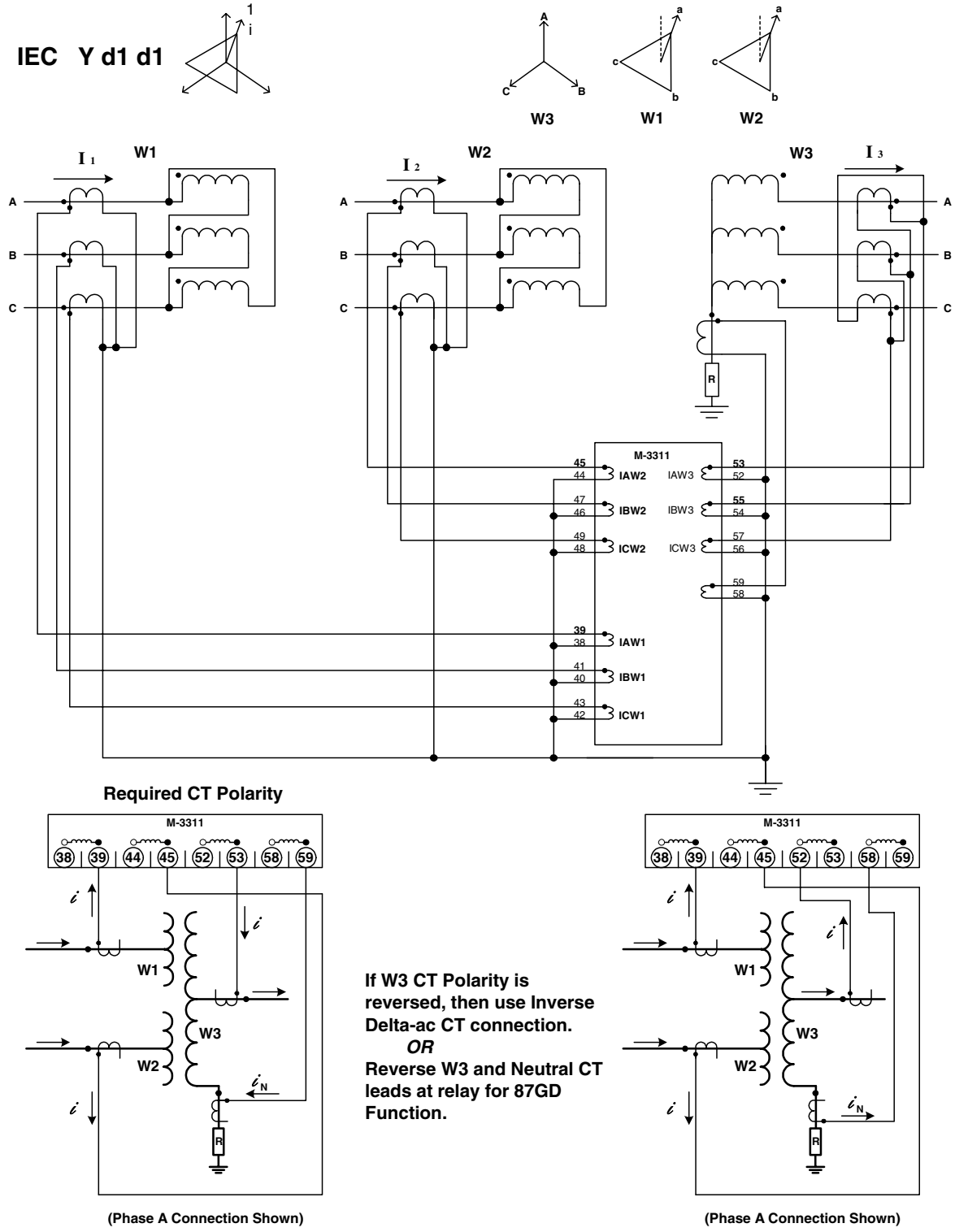
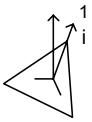


Figure 2-38 Wye/Delta-ac/Delta-ac CT Connection Diagram

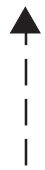
GSU TRANSFORMER EXAMPLE

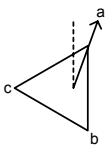
Beckwith: Y/Delta-ac/Delta-ac

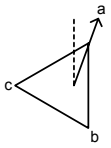


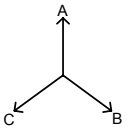
IEC Description: Y d1 d1

REF Winding









Winding	#1	#2	#3
Winding Type	dl	dl	Y0
CT Type	Y	Y	Dac
Line Current in Degrees ∠°	30°	0°	0°
Phase Compensation	To ref winding		
CCW Rotation	30°	30°	0°
Relay Phase Setting	1	1	0
CT Compensation			
Phase Degrees	0°	0°	30°
Magnitude	no	no	$1/\sqrt{3}$
Combined Compensation	$1 \angle 0°$	$1 \angle 0°$	$1/\sqrt{3} \angle 30°$
Relay CT Setting	0	0	13
Zero Sequence Filter	Enable ☐	Disable ☒	

Zero Sequence Filtering is applicable for grounded wye winding with wye connected CTs. Otherwise, zero sequence currents could appear in this input to relay but in no other, causing possible false trip during an external fault.

Figure 2-39 Custom Settings for Wye/Delta-ac/Delta-ac

2.8 Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms (voltage, current, control/status inputs and outputs) at 16 samples per cycle. Oscillograph data can be downloaded via the communications ports to any IBM compatible PC running M-3820B IPScom® Communications Software. Once downloaded, the waveforms can be examined using M-3821 IPSplot® Oscillograph Data Analysis Software, or viewed in COMTRADE file format.

The recorder can be triggered manually through serial communications using IPScom or automatically using programmed 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:

- one 152 cycle record,
- two 104 cycle records,
- three 72 cycle records, or
- four 56 cycle records.

When triggered with a specific post trigger delay, the recorder continues recording for the delay period and keeps a snapshot of waveform data in its memory for downloading via 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 re-arming for the next record. For example, a setting of 80% will result in a record with 20% pre-trigger and 80% post trigger data.

■ **NOTE:** In most cases, the most desirable data to record will occur before the triggering event, such as a breaker opening or protection operation.

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
```

This 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% and all stored records are cleared.

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

The trigger inputs designate the contact 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.

This Page Left Intentionally Blank

3 Operation (Front Panel)

This chapter contains information that describes the operation of the optional M-3931 Human-Machine Interface Module (HMI) front panel controls. The HMI provides the means to maneuver through the menus, enter values, set and interrogate the M-3311 Transformer 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.

The M-3931 HMI module consists of a 2 x 24-character alphanumeric display and a 6-pushbutton keypad. The controls are used to navigate through the system menus, and to set or interrogate the unit. Detailed information regarding the use of these controls is provided in this chapter.

Alphanumeric Display

The alphanumeric display presents interactive menus that guide the user to the desired function or display. The top line of the display presents a description of the current menu selection. The bottom line presents lower case abbreviations for each selectable item. The current selected menu item on line two is presented in upper case letters (See Figure 3-2, Main Menu Flow).

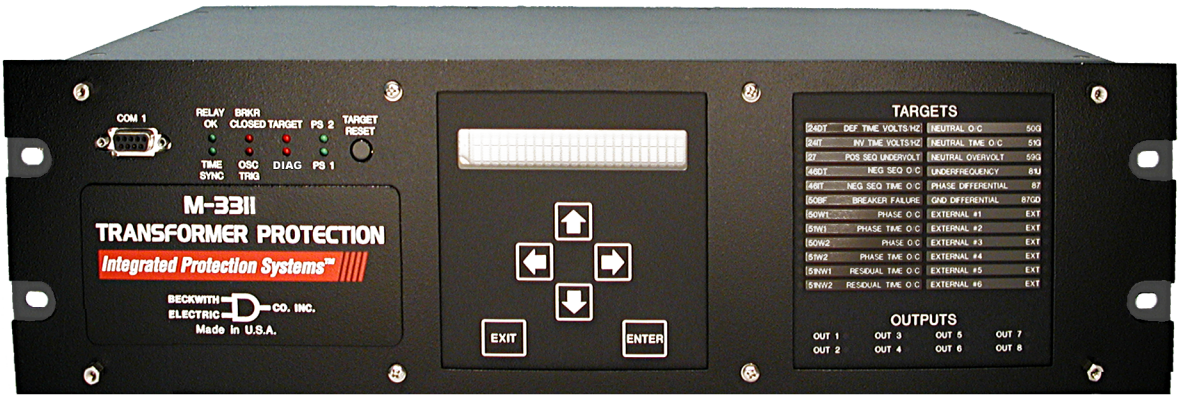


Figure 3-1 M-3311 Front Panel

■ **NOTE**: Unit shown with optional HMI and Target modules.

When the unit is monitoring system conditions and has not detected an event, the user logo lines are blanked. Upon detection of an event, 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 5 minutes of unattended operation. To wake up the display the user must press any key except **EXIT**.

Arrow Pushbuttons

The left and right arrow pushbuttons are used to navigate through the available menu options and also to enter alphanumeric values. To enter values, use the left and right arrow pushbuttons to select the desired digit (by moving the cursor). The displayed value can then be increased or decreased by the use of the up and down arrow pushbuttons.

The up and down arrow pushbuttons *will only* increase or decrease input values, or change, between upper and lower case inputs.

If the up or down arrow pushbutton is held in the depressed position when adjusting numerical values, the speed of the increment or decrement is increased, after a small delay.

EXIT Pushbutton

The **EXIT** pushbutton is used to exit from the currently displayed menu to the immediately preceding menu. Any changes to a setpoint will not be saved if the selection is aborted by depressing the **EXIT** pushbutton.

ENTER Pushbutton

The **ENTER** pushbutton is used to initiate a highlighted menu selection, to save a setpoint value or other programmable value, or to select one of several displayed options, such as to **ENABLE** or **DISABLE** a function.

Status Indicators

Status indicators consist of the following LEDs:

- Power Supply, **PS1** and **PS2**
- **RELAY OK**
- Oscillograph Recorder Trigger, **OSC TRIG**
- Breaker Closed, **BRKR CLOSED**
- **TARGET**
- Diagnostic, **DIAG**
- Time Synchronize, **TIME SYNC**

Power Supply (PS1) and (PS2) LEDs

The green power LED indicator (for the appropriate power supply) will be illuminated whenever power is applied to the unit and the power supply is functioning properly. 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.

Oscillograph Recorder Trigger (OSC TRIG) LED

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

Breaker Closed (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 *pick up* status of the relay 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)

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.

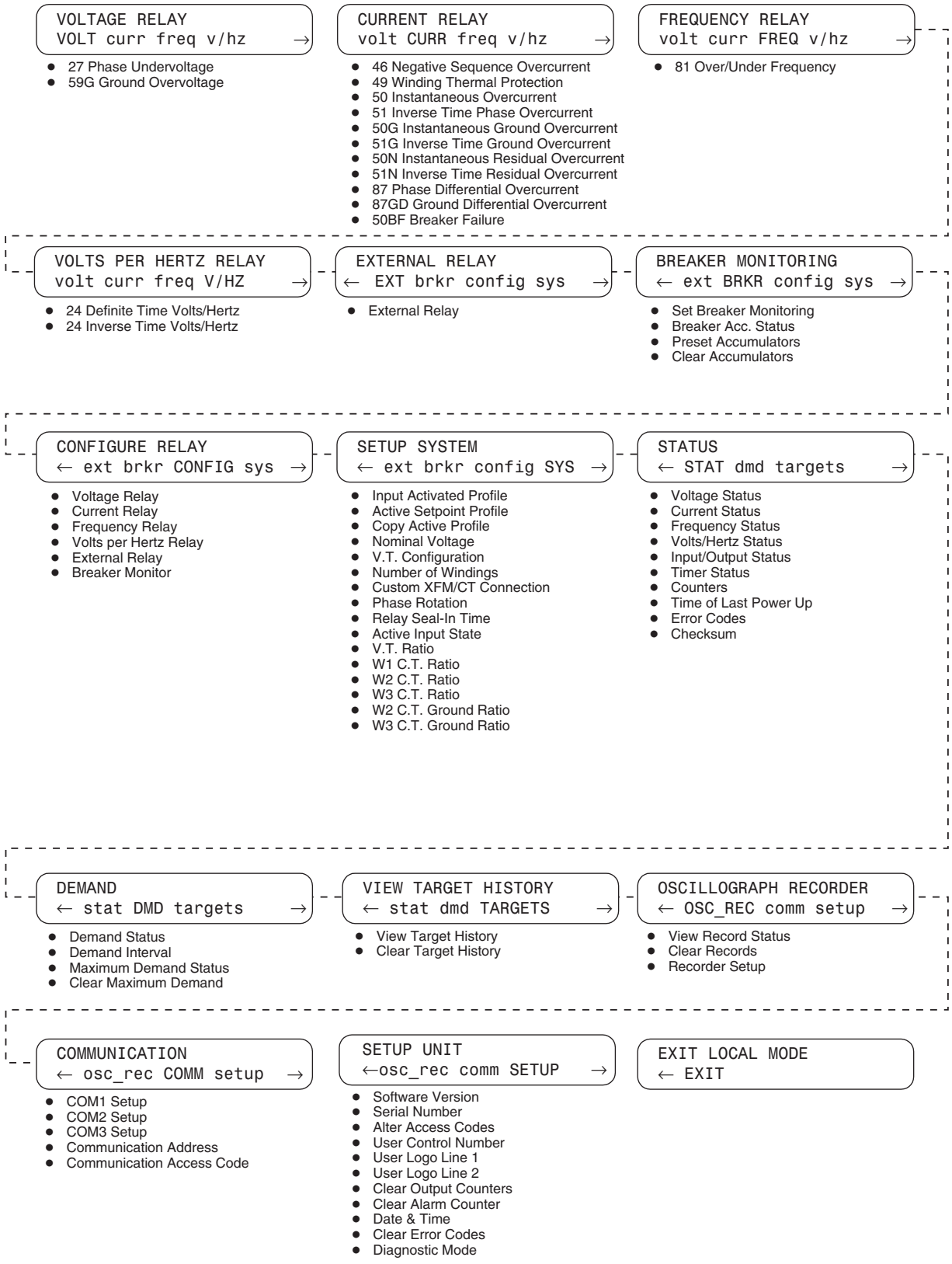


Figure 3-2 Main Menu Flow

Accessing Screens

To prevent unauthorized access to the relay functions, the relay includes the provision for assigning 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. The relay is shipped with the access code feature disabled.

The relay has three levels of access codes. Depending on the access code each level holds, users have varying levels of access to the relay functions.

Level 3 Access: provides access to all M-3311 configuration functions and settings.

Level 2 Access:provides access to read & change setpoints, monitor status and view target history.

Level 1 Access: provides access to read setpoints, monitor status and view target history.

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-3311 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 3-3. 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.

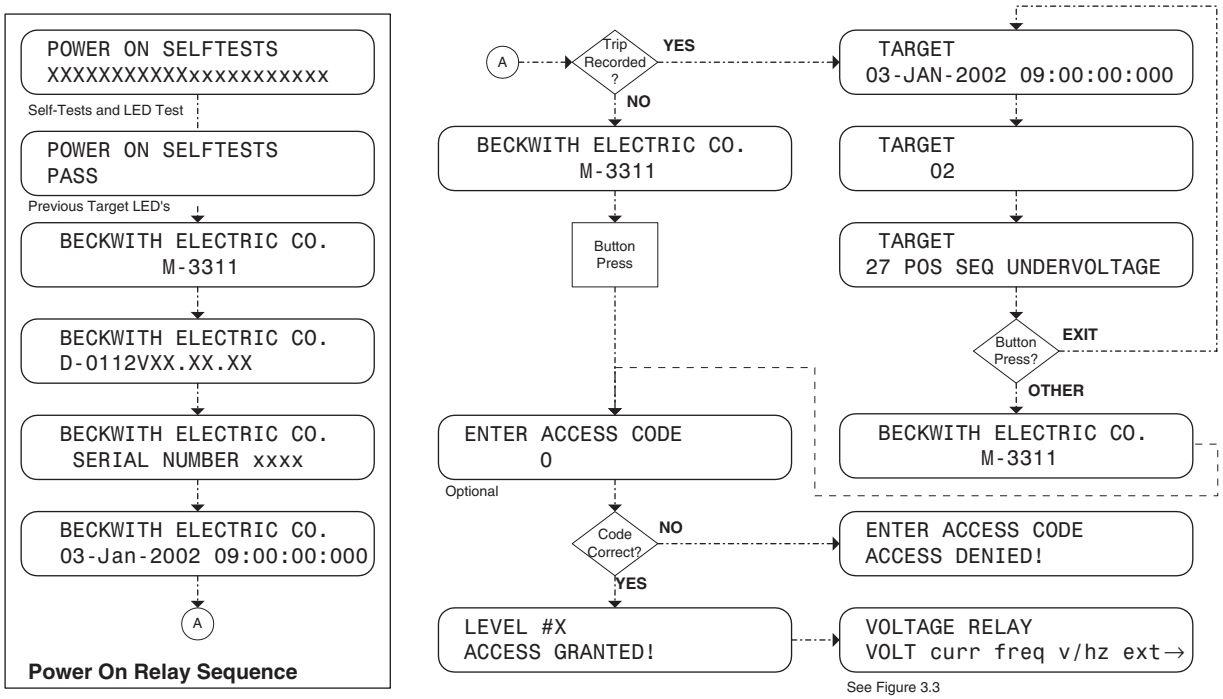


Figure 3-3 Message Flow

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 M-3311 using 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 M-3311 via a network, direct connection or permanently wired modem.

COM2 and **COM3** have the option of setting the protocol to BECO 2200, MODBUS or DNP3.0. **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 setting parity (none, odd or even) and stop bits (1 or 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, 1; 8,O,1; 8,E, 1; 8, N, 2; 8, O, 2; 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 supports oscillograph record downloading in COMTRADE file format.

DNP3.0 does not support oscillograph record downloading.

3.2 Initial Setup Procedure/ Settings

The relay is shipped with the initial configuration settings as listed in Appendix A (see Figure A-4, Functional Configuration Record Form – As Shipped, Figure A-2, Communication Data & Unit Setup - As Shipped, Figure A-3, Setpoint and Timing Record Form – As Shipped, and Table A-2, Relay Configurations – As Shipped) 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 5.5, External Connections.
2. When initially powered up, the M-3311 performs a number of self-tests to ensure its proper operation. During the self-tests, an "X" is displayed for each test successfully executed. If all tests are successful, the unit will briefly display the word **PASS**. Then, 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 3-3 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 the factory 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 Section 3.2, Communications Data (located at end of this procedure). Also refer to Chapter 4, **Operation** (Computer), on M-3820B IPScom® Communications Software.
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 Section 3.2, Setup Unit Data.

■ **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.

6. If desired, calibrate the unit following the calibration procedure described in subsection 6.3, Auto Calibration. For units without HMI, refer to Section 5.3, Circuit Board Switches & Jumpers.
7. Finish relay configuration in the **SETUP SYSTEM** menu (see Figure 3-4). This is the general system and equipment information required for the operation of the relay. This includes such items as CT and VT ratios, VT configurations, transformer connections and Nominal values. See Section 3.2, Setup System.
8. Enable the desired functions under the **CONFIGURE RELAY** menu. See Section 3.2, Configure Relay Data .

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

9. Enter the desired setpoints for the enabled functions. See Section 3.2, Setpoints and Time Settings.
10. Enter the desired information for the oscillograph recorder. See Section 3.2, Oscillograph Recorder Data.
11. Install the M-3311 and connect external input and output contacts according to the rear panel terminal block markings as shown in Figure 5.4, External Connections.

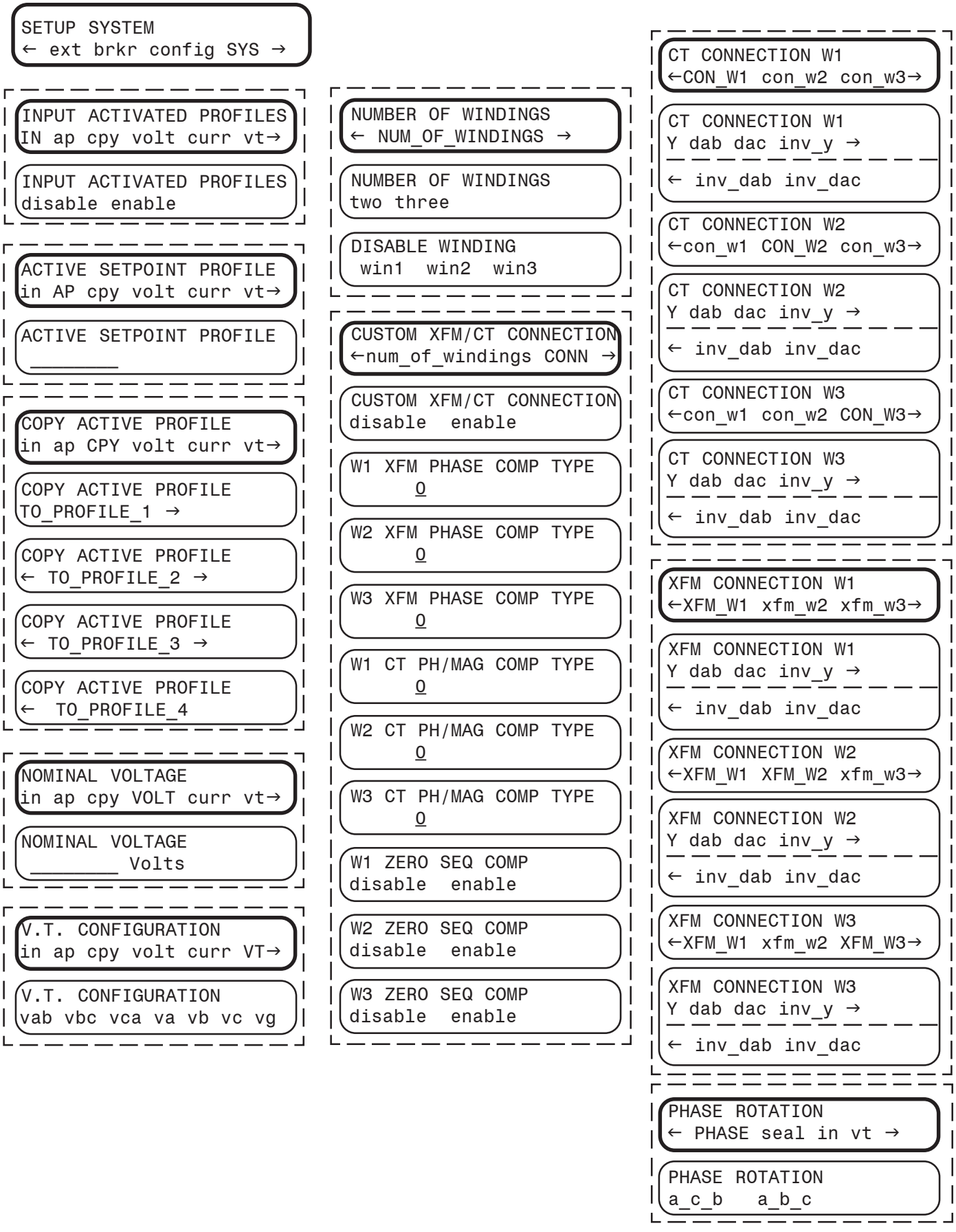


Figure 3-4 Sample of System Setup Menus

Communication Data

■ **NOTE**: Communication settings are not considered part of the setpoint profiles. Communication settings are common to all profiles.

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** (software selectable)
- communications address used to access multiple relays using a multi-drop 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
- Stop bits for **COM2** and **COM3** if MODBUS protocol is used.

Before entering the communication data into the relay, 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 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

■ **NOTE**: **UNIT SETUP** settings are not considered part of the setpoint profiles. Unit Setup settings are common to all profiles.

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 into the M-3311, 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. It is organized in the same order as in the relay menu.

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

Setup System

■ **NOTE**: Setup System settings are not considered part of the setpoint profiles. Setup System settings are common to all profiles.

Information required in this section includes:

- Input Activated Profiles
- Active Setpoint Profile
- Nominal Voltage and Current
- VT Configuration
- Transformer Connection
- CT Connection
- Phase Rotation
- Relay Seal-In Time
- Active Input State
- VT Phase and Ground Ratios
- CT Phase and Ground Ratios

See Figure 3-4 for Sample Settings related to input for this Section. The Active Setpoint Profile screen shows the profile presently selected for operation. This profile number can be altered to manually select a different profile, only if the Input Activated Profiles setpoint is set to **DISABLE**. Other settings are self-explanatory, and are required for proper operation of the relay.

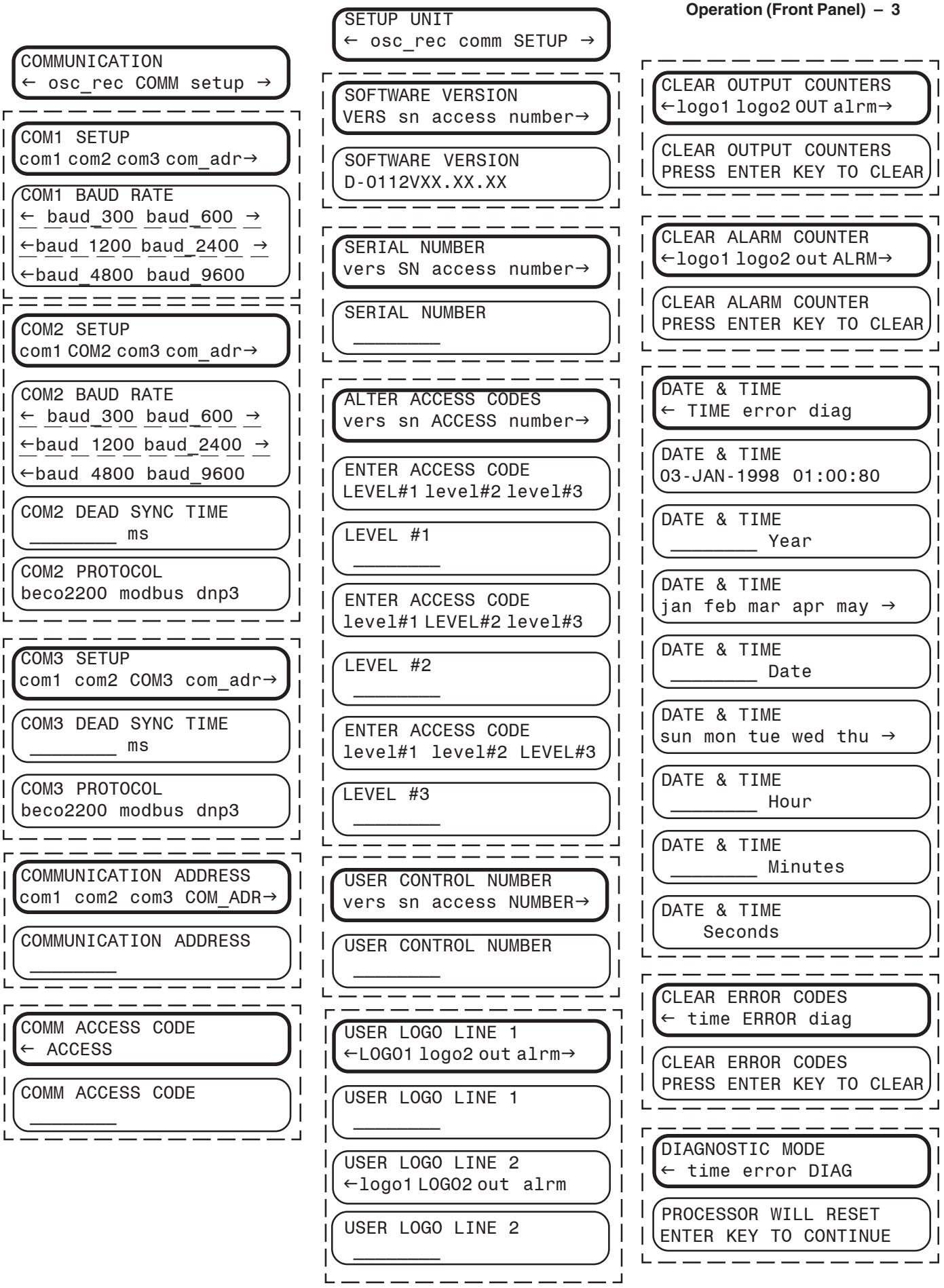


Figure 3-5 Sample of Communication Data & Unit Setup Record

Configure Relay Data

The relay is shipped with a certain group of standard functions, including other optional functions, as purchased. Both of these groups define a configurable set of functions. Only members of this set may be enabled/disabled by the end user. (Optional functions not purchased cannot be enabled.)

Functions designated as **DISABLED** are inactive and will not be available for tripping. All menus associated with inactive functions will be unavailable.

The general information required to complete the input data on this section includes:

- Enable/disable function
- Output choices (OUT1–8)
- Input blocking choices (IN1–6)

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

Input descriptions are detailed in Section 2.5, **Setpoints and Time Settings**. Make sure to complete the Setpoint & Timing Record Form in Appendix A before entering the setpoint and time setting data into the relay.

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 152 cycles of data. The total record length is programmable for one (152 cycles), two (104 cycles), three (72 cycles each), or four (56 cycles each) event records. The oscillograph recorder is triggered either remotely or via designated status input signals or 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. Make sure to complete page two of the Setpoint & Timing Record Form in Appendix A before entering the oscillograph recorder settings into the relay.

■ **NOTE:** Oscillograph recorder settings are not considered part of the Setpoint Profile. Recorder settings are common to all profiles.

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

The Oscillograph recorder data can be cleared via the HMI Module to provide a fresh starting point for event triggering.

Demand Metering Data

Setup of the Demand Metering subsystem consists of setting the Demand Interval. Integrating times of 15, 30, or 60 minutes may be set. The maximum Recorded Demand Peaks should also be cleared before commissioning.

3.3 Checkout Status/Metering

The relay has two menu selections concerning monitoring statuses 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 pushbutton until **STATUS** appears on the top line of the display.
3. Press **ENTER** to access the **STATUS** submenu and begin the monitoring.

Each category listed below is a submenu item. Pressing the **ENTER** pushbutton 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** pushbutton.

■ **NOTE**: All metering values in this section are secondary level quantities.

The menu categories for monitored values are:

VOLTAGE STATUS – Phase voltage or ground (depending on VT configuration)

CURRENT STATUS – Winding 1, 2 & 3 phase currents, ground current (W2 & W3), restraint current, differential current fundamental, differential current 2nd harmonic, differential current 4th harmonic, differential current 5th harmonic, ground differential current (W2 & W3), positive sequence current (W1, W2, & W3), negative sequence current (W1, W2, & W3), zero sequence current (W1, W2, & W3)

FREQUENCY STATUS – Frequency

VOLTS /HZ STATUS – Volts per Hertz

IN/OUT STATUS – status of input and output contacts

The following timer status can also be monitored:

CURRENT TIMER – 24IT, 46IT W2/W3, 51 W1/W2/W3, 51G W2/W3, 51N W1/W2/W3

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 – Displays DD-MM-YY hours/min/sec

ERROR CODES – Last 4 error code log; reset location, etc.

CHECKSUM – calibration, setpoints, ROM

DEMAND STATUS

Demand Interval

Time integrated primary metering values, based on the chosen demand integration interval (15 min, 30 min, or 60 min), as well as the time-tagged peak reading are available for viewing.

■ **NOTE**: All metering values in this section are primary level quantities.

Maximum Demand Status

Monitored values include:

- Winding 1, 2, & 3 Phase Currents
- Winding 2 & 3 Ground Current

Maximum values include time-tagged values for all the above quantities.

View Target History

The **VIEW TARGET HISTORY** menu selection enables the user to review the targets for the previous 32 target conditions. A target is triggered whenever an 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
- a time tag of the triggered target

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.

The final selection allows the user to clear all operation history for further target recording.

■ **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.

This Page Left Intentionally Blank

4 IPScom® Operation

This chapter contains information on configuring and interrogating the M-3311 Transformer Protection Relay using a personal computer running the M-3820B IPScom Communications Software.

4.1 Installation and Setup (M-3820B IPScom)

The IPScom Communications Software package runs with Microsoft® Windows 95 operating system, or later. This version of IPScom supports communication using the BECO 2200 protocol. IPScom is available on CD-ROM.

M-3820B IPScom software is not copy-protected and may be copied to your hard disk. For more information on your specific rights and responsibilities regarding the 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:

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

The relay 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-3311 Transformer Protection Relay using a Modem

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

- 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 an internal or external modem. Pin-outs for communication cables are provided in Appendix B, **Communications**.

Use of IPScom and M-3311 Transformer Protection Relay using a Direct Serial Connection

To use IPScom to communicate with the relay using a direct serial connection, a serial "null modem" cable is required. The cable must be provided with a 9-pin connector (DB9P) for the relay, 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 (part number M-0423) may be purchased from Beckwith Electric Co.

Installing IPScom

1. Insert the software into your CD-ROM/ Floppy drive.
2. Select Run from the Start Menu.
3. In the Run dialog box, initiate the software installation by typing either *D:\Setup* or *Other Drive:\Setup*, depending on the drive in which the software is inserted.
4. The installation utility establishes a program folder (Becoware) and subdirectory (M-3820B). After installation, the IPScom program item icon (see Figure 4-1) is located in the Becoware program folder. The application files are located on drive C, in the new subdirectory named IPScom.

Figure 4-1 IPScom Program Icon

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 installed in the Becoware folder, along with the IPScom files.

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 select **INITIALIZE** from the expanded Communications dialog box. The following steps outline the initialized modem setup procedure.

Connecting the modem to the computer

1. 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. The 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 **COM 4**), most computers support only **COM1** and **COM2**.
2. Connect the modem to the telephone line and apply power.

Connecting the Modem to the Relay

Setup of the modem attached to the M-3311 Transformer Protection 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 initialize in the proper state for communicating with the relay. 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.

1. Connect the unit to an external modem by attaching a standard RS-232 modem cable to the appropriate serial communications port on both the unit and the modem.
2. 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 modems. Refer to the hardware user documentation for a list of supported AT commands and direction on issuing these commands.

Setting Up the Relay for Communication

■ **NOTE:** Communication is inhibited while the relay is in local mode (being accessed using the HMI). To ensure that the relay 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.

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.

Multiple Systems Setup

▲ **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.

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

Serial Multidrop Network Setup

Individual remote addressing also allows communications through a serial multidrop network. Up to 32 relays can be connected using the same 2-wire RS-485 communications line. See Appendix B, **Communications**. Figure B-2 illustrates a setup of RS-232 Fiber Optic network, and Figure B-3 illustrates a 2-wire RS-485 network.

Other communication methods are possible using the 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.

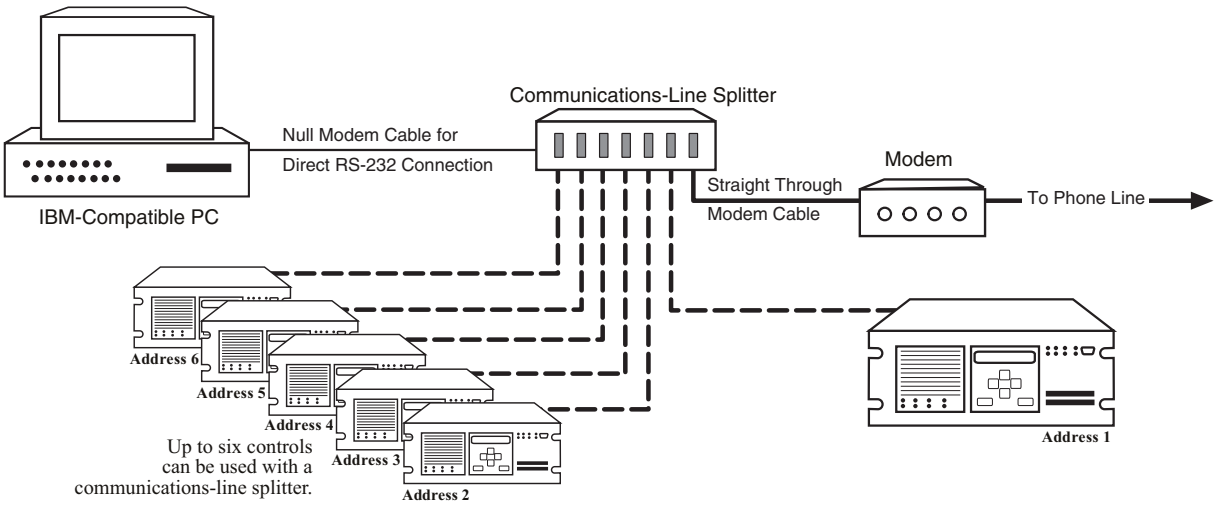


Figure 4-2 Multiple Systems Addressing Using Communications Line Splitter

4.2 Operation

Activating Communications

After the M-3311 Transformer Protection Relay has been set up, the modems initialized, and IPScom® installed, communication is activated as follows:

1. Choose the IPScom icon from the Becoware group on the Program menu.
2. The IPScom flash screen is displayed briefly, providing the software version number.
3. Choose the **COMM** menu. Complete the appropriate information in the window to address the relay.
4. If communicating using a modem, proceed as follows:
   a. Select Modem to expand the Communciations dialog box.
   b. Determine if the desired location/ phone number is listed.
   c. If the desired location/phone number is listed, then verify relay acces code and address are correct for this location.
   d. If the desired location/phone number is not listed, then input the access code, address and location/phone number, and select **Add**.
   e. Select **Dial**. IPScom will establish communications with the relay.
5. Enter any valid IPScom command(s) as desired.
6. To end communication when communicating by modem, choose **Hang Up** from the expanded Communication dialog box.

   To close the communication channel when connected locally, choose the **Close COM** command button.

Overview

When IPScom is run, a menu and status bar is displayed (see Figure 4-3). This section describes each IPScom menu selection and explains each IPScom command in the order they are displayed in the software program. For detailed information regarding each function dialog box field, refer to Chapter 2, **Application**.

When starting IPScom, the initial menu choices are the **FILE** menu, **COMM** menu, or **HELP** menu. The choice specifies whether the operator desires to write to a data file, communicate directly with the relay, or obtain information about the relay.

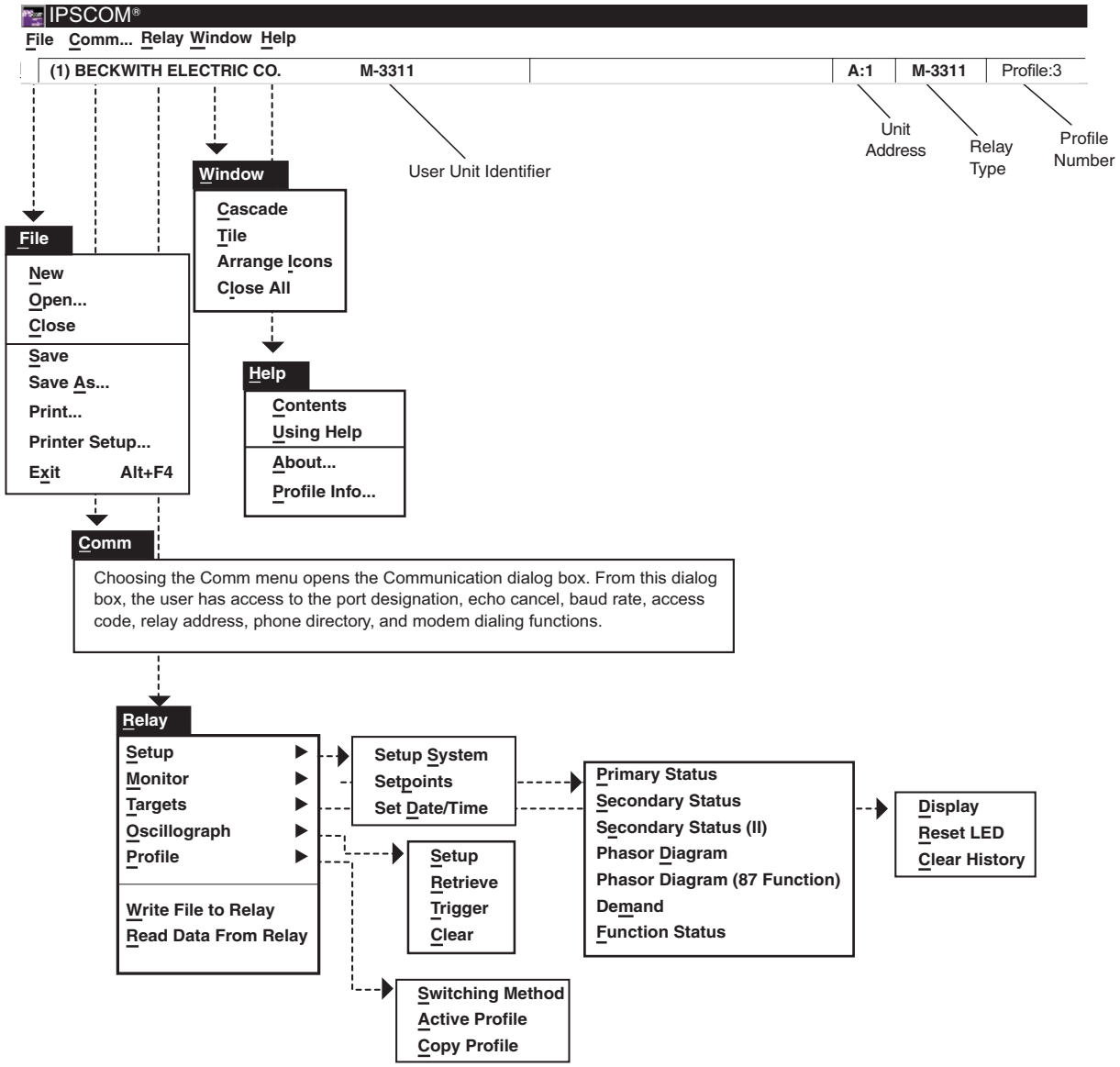
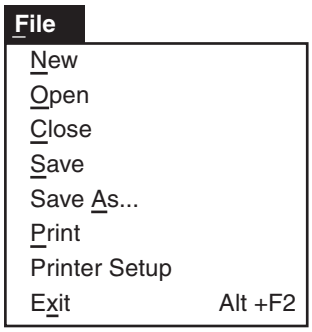


Figure 4-3 M-3820B IPScom® Menu Selections

■ **NOTE**: Greyed-out menu items are not currently available.

File Menu



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

The **File** menu enables the user to create a **New** data file, **Open** a previously created data file, **Close** the current data file, **Save** a file, and **Exit** the program.

Since IPScom® can be used with several Beckwith protection systems in addition to the M-3311 Transformer Protection Relay, the format and content of a file must be established to reflect which protective system is being addressed. When not connected to one of the protection systems, new files are established with the System Type dialog box (see Figure 4-4). Selecting **OK** allows the new data file to be named by using the **Save** or **Save As...** commands.

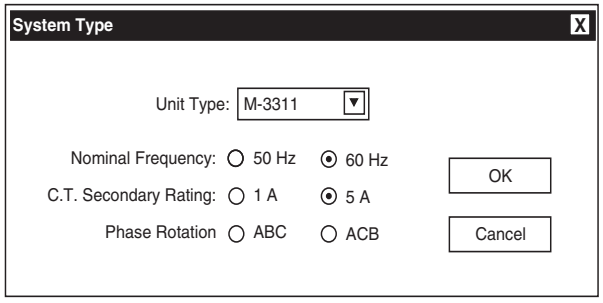


Figure 4-4 System Type Dialog Box

Path: File/New

COMMAND BUTTONS

OK Saves the currently displayed information.

Cancel Returns 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 opens previously created data files. 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 to update the PC's data image with the relay's data. This image now contains the proper system type information, eliminating the need to enter this information manually.

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

The **Exit** command quits the IPScom program.

Comm Menu

The Communication dialog box (see Figure 4-5) allows setup of IPScom communication parameters. By selecting **Modem**, the user can establish 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 **Initialize** button should be pressed. If communication cannot be established with the default string, the AT &F may be selected to initialize. Following initialization, select an entry from the modem list and press the **Dial** button to dial out.

If the modem was not used to establish communication (direct connection), press the **Open COM** button to start. If the relay has a default communication access code of 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 to establish the communication. **Close COM** discontinues communication.

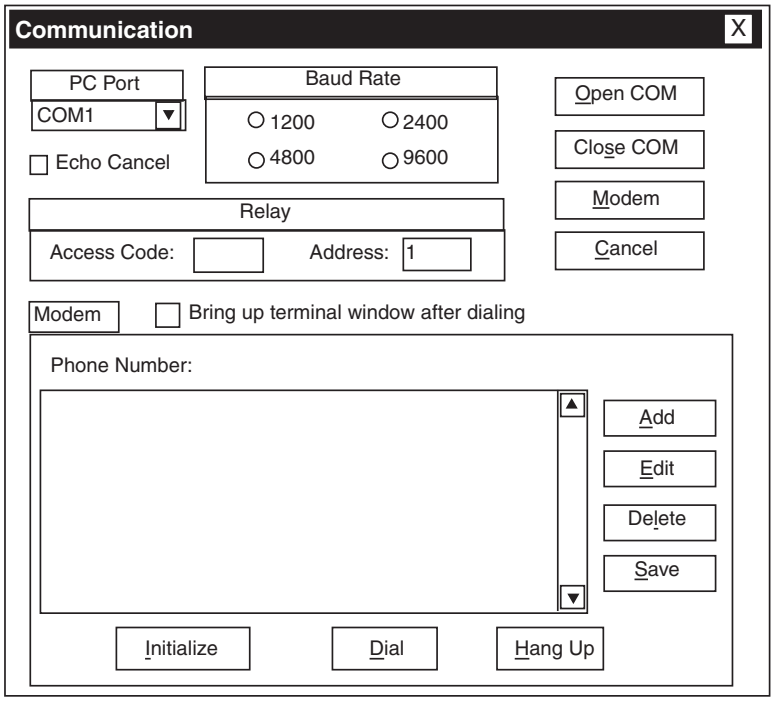


Figure 4-5 Communication Dialog Box

Path: Comm menu

COMMAND BUTTONS

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

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

Modem Displays the expanded Communication dialog box.

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

Bring Up Terminal Window Built-in terminal window allows Interactive communication between Modem and relay. (This feature is not available under Microsoft® Windows NT, XP, or 2000.)

Add Displays the Add/Edit dialog box, allowing the user to type a relay'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.

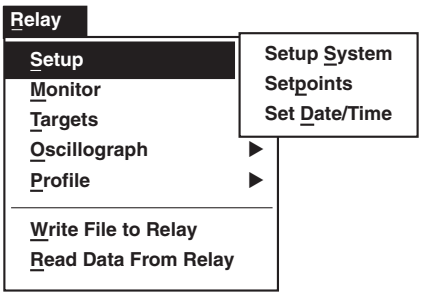
Initialize Allows the user to send special setup or other AT commands directly to the modem.

Dial Dials the entry selected from the directory.

Hang Up Ends modem communication, allowing the user to dial again.

Relay Menu

The **Relay** menu provides access to the windows used to set, monitor, and interrogate the relay.



The **Setup** submenu provides three commands: **Setup System**, **Setpoints** and **Set Date/Time**. The **Setup System** dialog box (see Figure 4-6) allows the input of pertinent information regarding the system on which the relay is applied. (See Section 2.2, **Configuration**, System Setup).

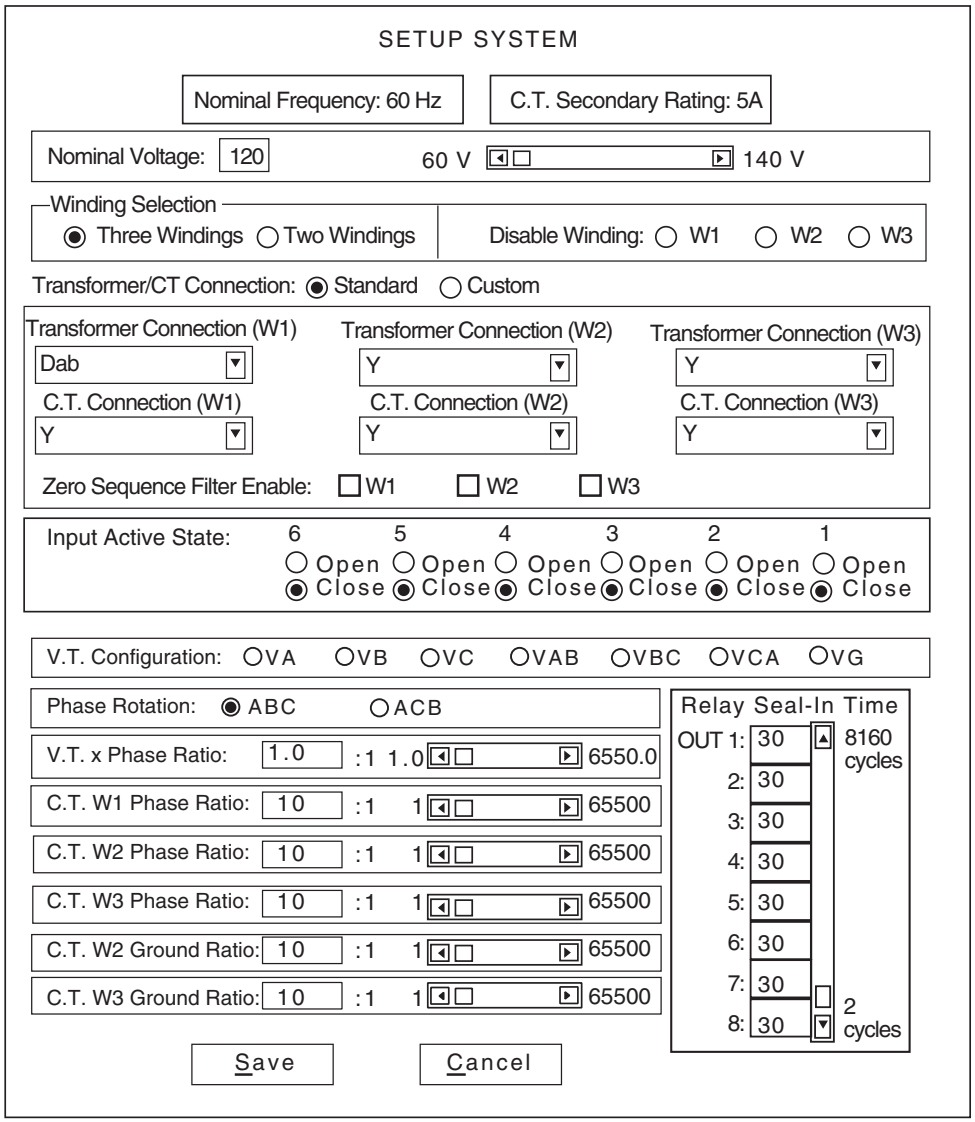


Figure 4-6 Setup System Dialog Box

The **Setpoints** command displays the **Relay Setpoints** dialog box (see Figure 4-7) from which individual relay function dialog boxes may be accessed. The configuration and settings for each function are completed through these Setpoint Configuration dialog boxes. (Function configuration is further described in Section 2.2 Configuration, and Section 2.4, Setpoints and Time Settings.)

The **Relay Setpoints** dialog box provides access to the **All Setpoints** Table and **Configure** dialog boxes (see Figures 4-8 and 4-9).

Choosing the **Display All** command button displays the **All Setpoints Table** which contains a list of settings for each relay element within a single window.

Choosing the **Configure** command button displays the Configure dialog box (see Figure 4-9) which contains a chart of programmed input and output contacts.

The **All Setpoints** Table and **Configure** dialog boxes feature hotspots which allow user to jump from a scrolling dialog box to a relay configuration dialog box and back again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog box from either scrolling dialog box.

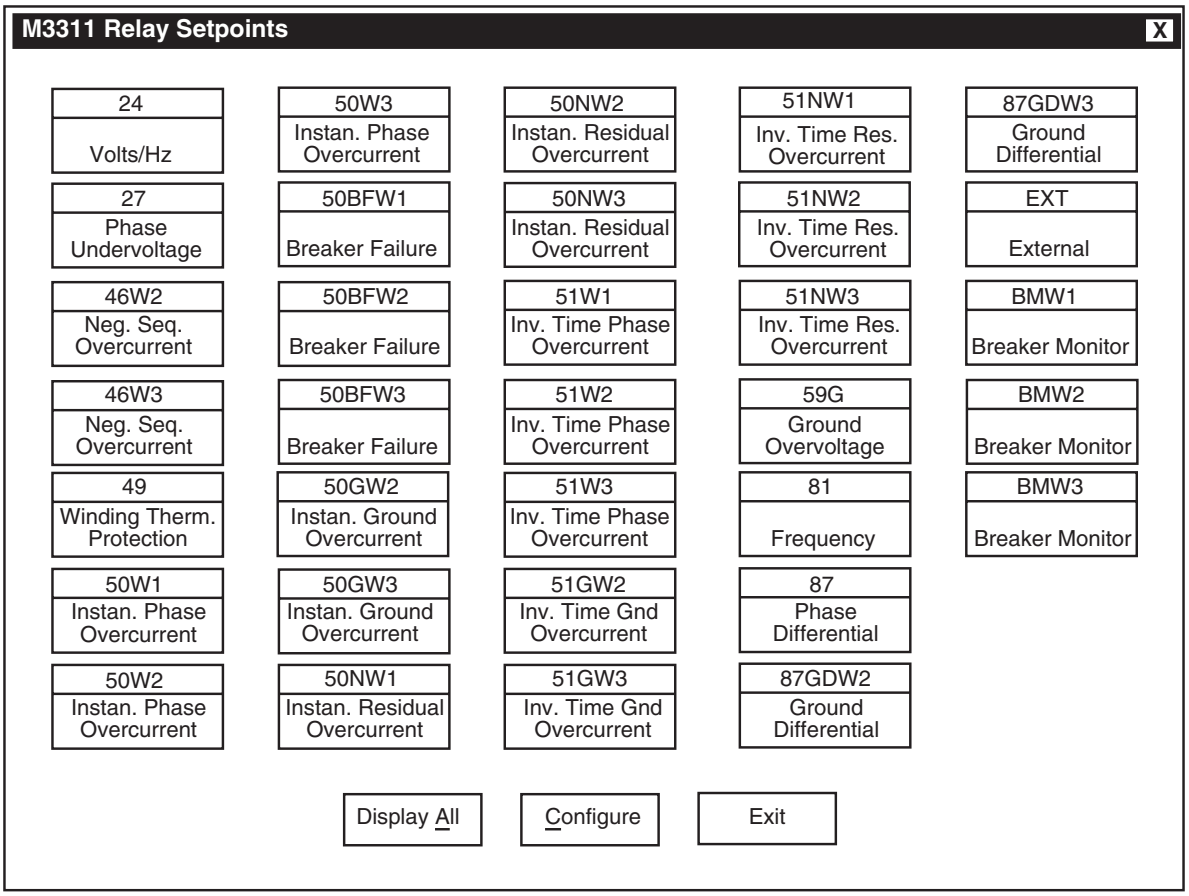


Figure 4-7 Relay Setpoints Dialog Box

Path: Relay/Setup/Setpoints

COMMAND BUTTONS

Display all Opens the All Setpoints Table dialog box.

Configure Opens the Configure dialog box.

Exit Saves the currently displayed information and returns the user to the IPScom® main window.

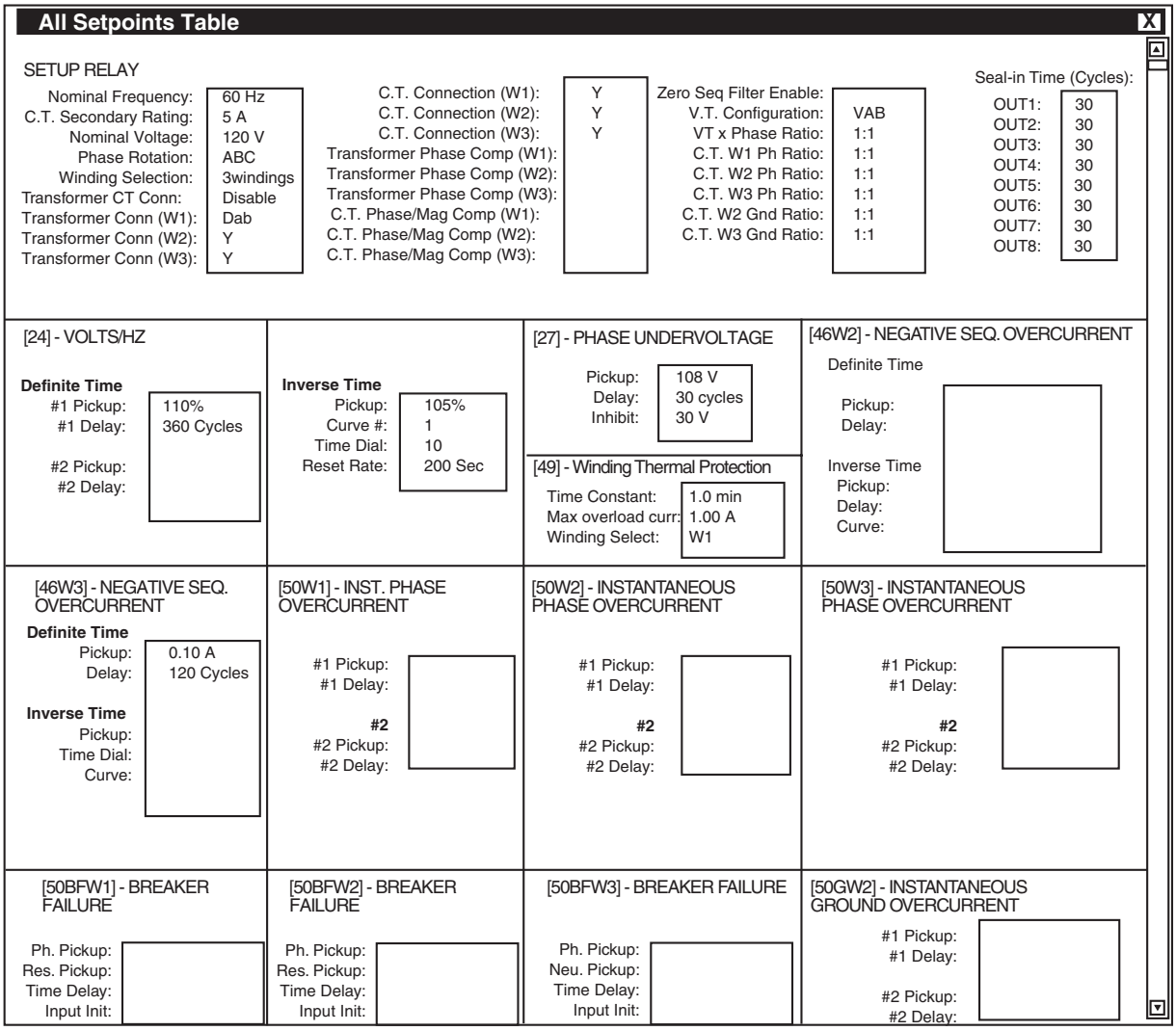


Figure 4-8 All Setpoints Dialog Box

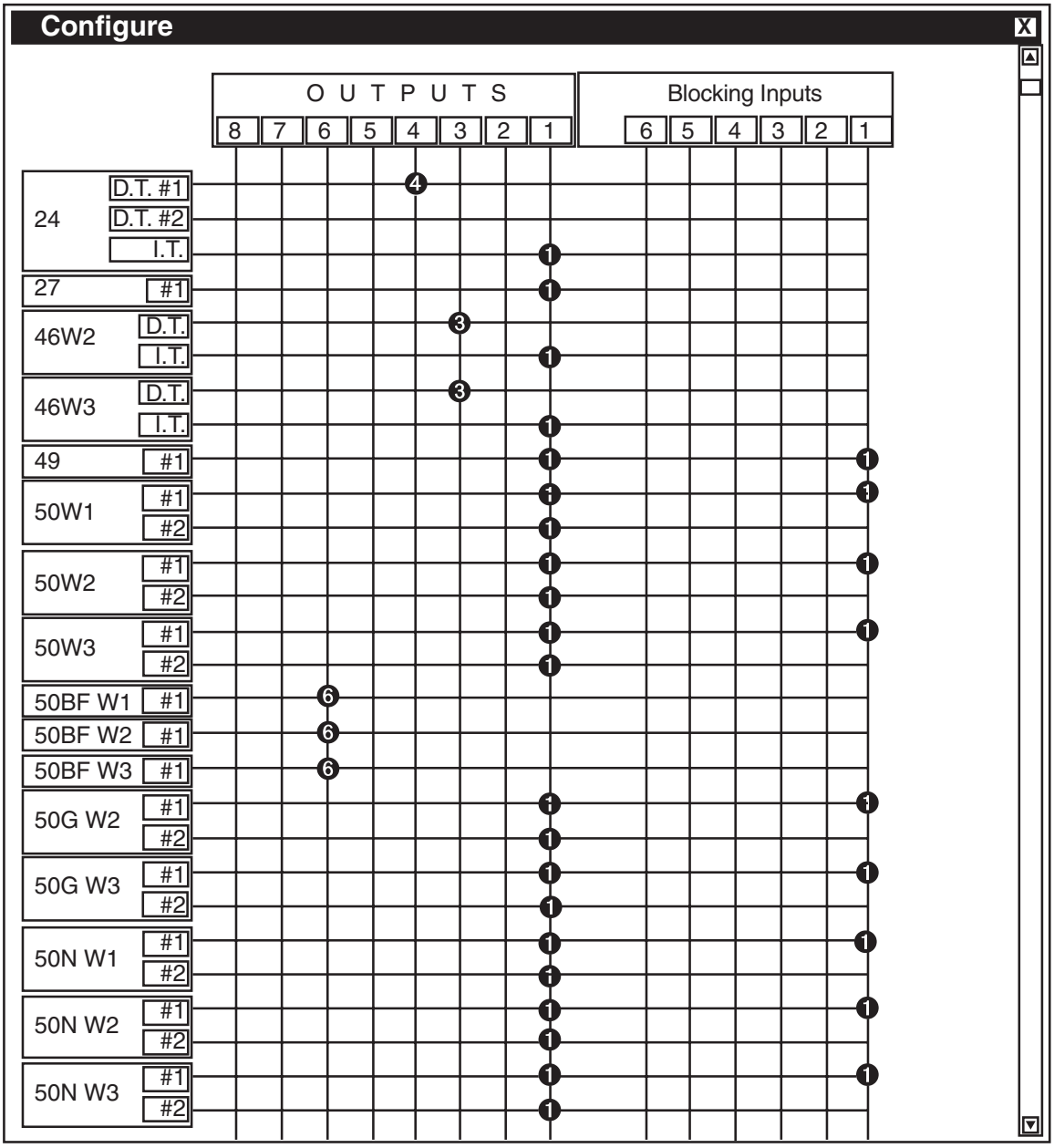


Figure 4-9 Configure Dialog Box

The **Set Date/Time** dialog (see Figure 4-10) allows setup of the relay's date and time clock. If the **Time Sync** indicator is blue, it means valid IRIG-B time information is being received. In this case, only the date fields may be edited; time fields are gray. If the **Time Sync** indicator is gray, both the **Date** and **Time** fields may be edited.

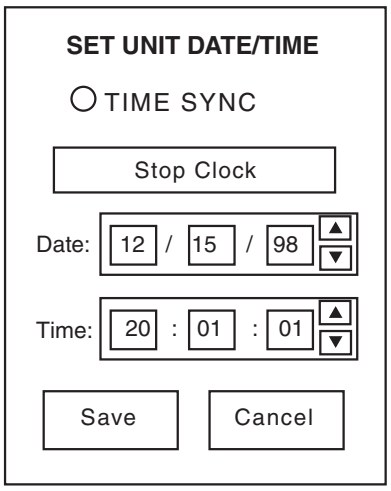
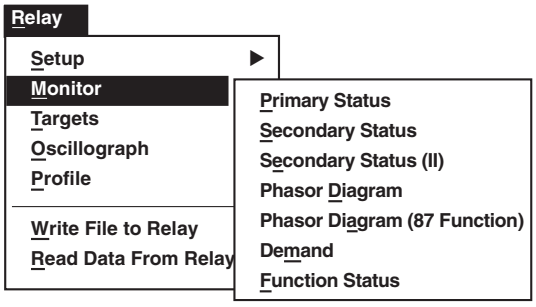
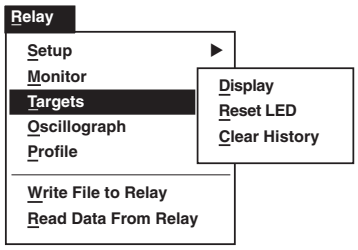


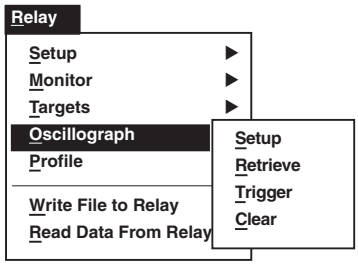
Figure 4-10 Set Unit Date/Time Dialog Box



The **Monitor** submenu provides access for reviewing the present status of the relay's measured and calculated values, other real-time parameters and conditions, as well as examining real-time and historical demand metering information (see Section 4.3, **Checkout Status/Metering)**.



The **Targets** submenu provides three command options: **Display, Reset LED**, and **Clear History**. The **Display** command displays **Target** dialog (see Figure 4-23, Target Dialog Box). This dialog box 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 itself. This command resets current target displayed on the relay. This command does not reset any target history. The **Clear** command clears all stored target history.



The **Oscillograph** submenu allows setting and control over the relay's oscillograph recorder. The **Setup** command allows user to set the number of partitions and triggering designations to be made (Figure 4-11), **Retrieves** downloads and saves collected data to a file (Figure 4-12). "**Trigger**" sends a command to the relay to capture a waveform. This is the same as issuing a manual oscillograph trigger. "**Clear**" erases all existing records. Run the optional M-3801C IPSplot® Oscillograph Analysis Software program to view the downloaded oscillograph files.

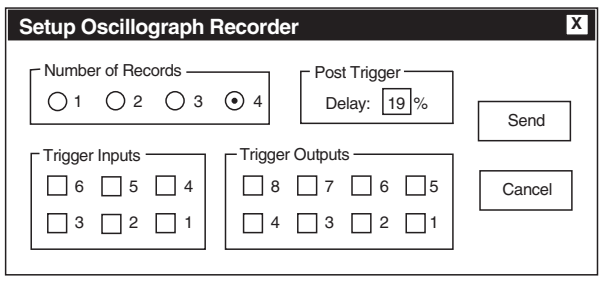


Figure 4-11 Setup Oscillograph Recorder Dialog Box

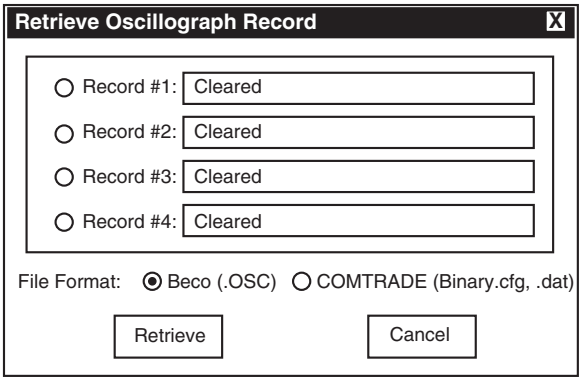
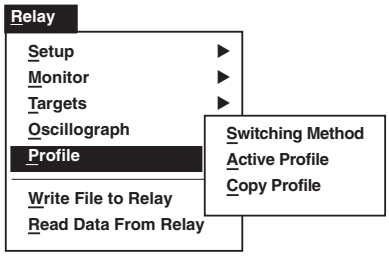


Figure 4-12 Retrieve Oscillograph Record

Profile Menu



The **Profile** submenu provides three command options: **Switching Method, Active Profile**, and **Copy Profile**.

Switching Method command allows selection of either Manual or Input contact. **Active Profile** allows user to designate active profile. **Copy Profile** copies active profile to one of four profiles (user should allow approximately 15 seconds for copying).

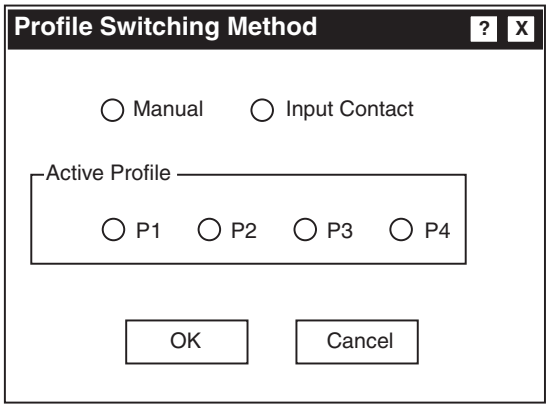


Figure 4-13 Profile Switching Method

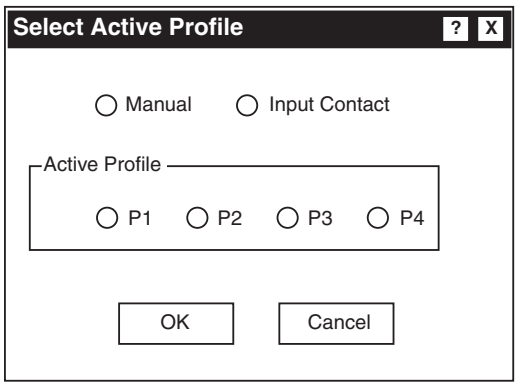


Figure 4-14 Select Active Profile

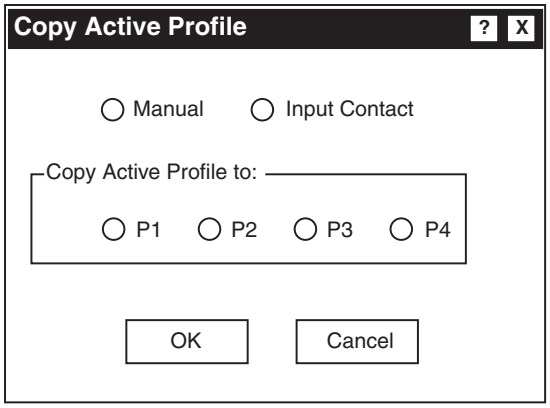


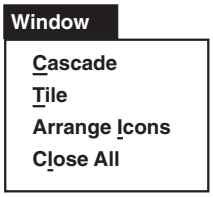
Figure 4-15 Copy Active Profile

▲ **CAUTION**: If relay is online, be sure to switch the active profile. If the wrong profile is selected, it may cause unexpected operation.

The **Write File to Relay** command sends predefined setpoint data file to the Relay.

The **Read Data from Relay** command updates PC data image with the relay's latest data.

Window Menu/Help Menu



The **Window** menu enables positioning and arrangement of 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 yet displayed window activates that window.

The **Help** menu provides four commands. The **Contents** command initiates a link to a PDF (Portable Document File) version of this instruction book for easy reference. An Adobe Acrobat® reader is required to view this document.

The M-3311 Instruction Book has been indexed to its table of contents. By selecting the 'Navigator pane' in Adobe Acrobat Reader, the user can directly access selected topics.

Using Help is currently unavailable, and will appear greyed-out in display. The **About** command displays IPScom version and development information. **Profile Info** displays user information for input and editing.

4.3 Checkout Status/Metering

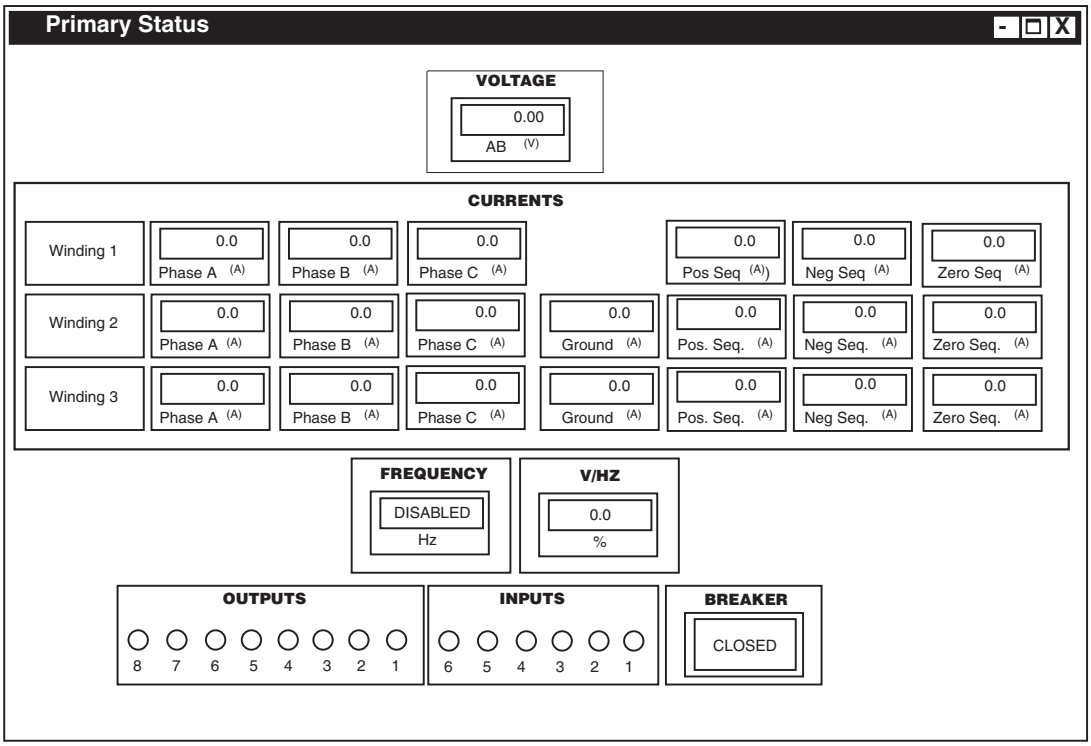


Figure 4-16 Primary Status Dialog Box

Path: Relay/Monitor/Primary Status

This metering window shows voltage status, current status (the first line is for Winding 1, second line of the current group is for Winding 2, and the third line of the current group is for Winding 3), power status, frequency status, Volts/Hz status, IN/OUT status and breaker status in primary level quantities (See Section 3.3 **Checkout/Status/Metering**).

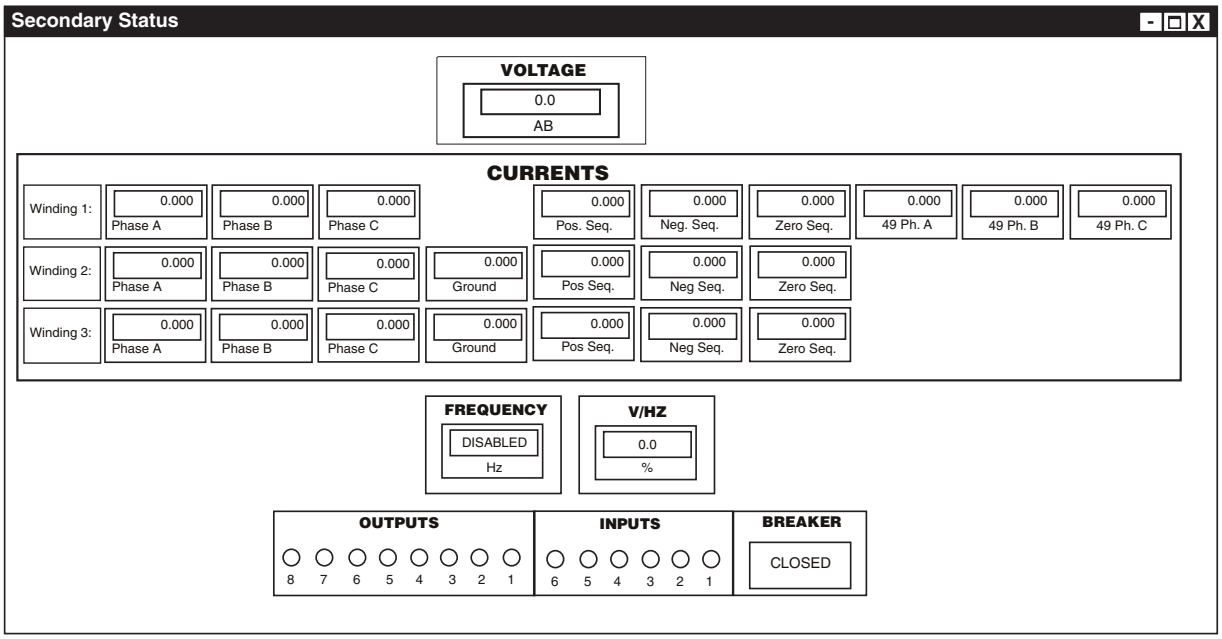


Figure 4-17 Secondary Status Dialog Box

Path: Relay/Monitor/Secondary Status

This metering window shows voltage status, current status (the first line is for Winding 1 and second line of the current group is for Winding 2), power status, frequency status, Volts/Hz status, IN/OUT status and breaker status in secondary level quantities (See Section 3.3, **Checkout/ Status/Metering**).

■ **NOTE**: When connections specifying delta-connected CTs are used, all functions (except 87T & 87H) and the Secondary Status window use and display (winding current)/(ct ratio) and not the current actually entering the relay.

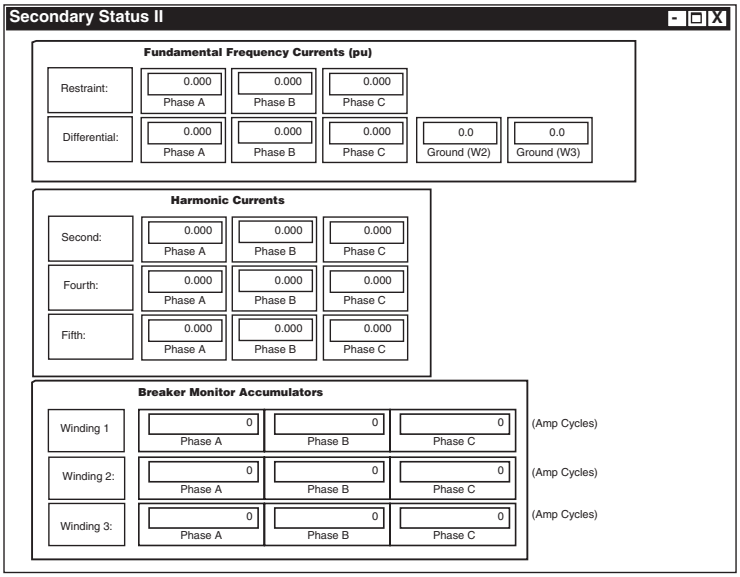


Figure 4-18 Secondary Status Dialog Box (II)

Path: Relay/Monitor/Secondary Status (II)

This metering window displays restraint currents, differential currents, and second, fourth, and fifth harmonic currents in secondary level quantities. The Secondary Status II window also displays Breaker Monitoring Accumulators for W1, W2, and W3, and currents for each phase.

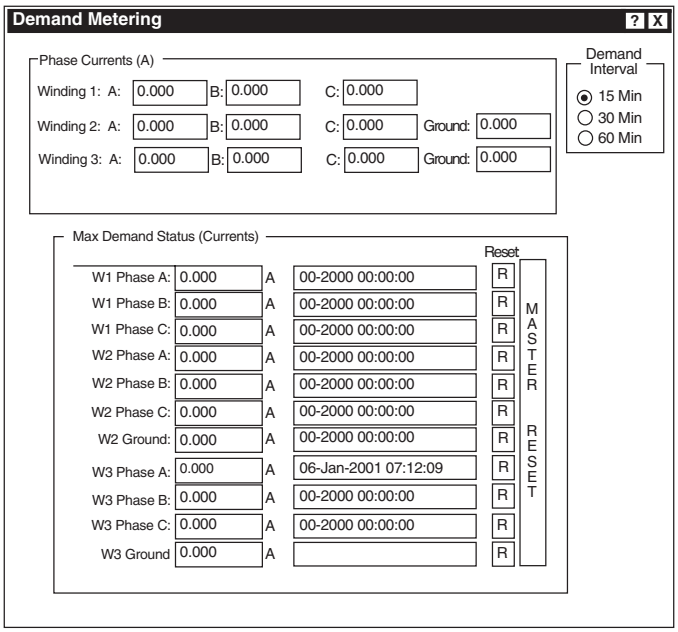


Figure 4-19 Demand Status Window

Path: Relay/Monitor/Demand

COMMAND BUTTONS

Demand Interval Allows user to interrogate over user-selected period of 15, 30, or 60 minutes

Reset (R) Reset the addressed Max Demand parameter and Date/Time at which maximum value occurred.

Master Reset Reset all listed Max Demand parameters and their Date/Time at which maximum values occurred.

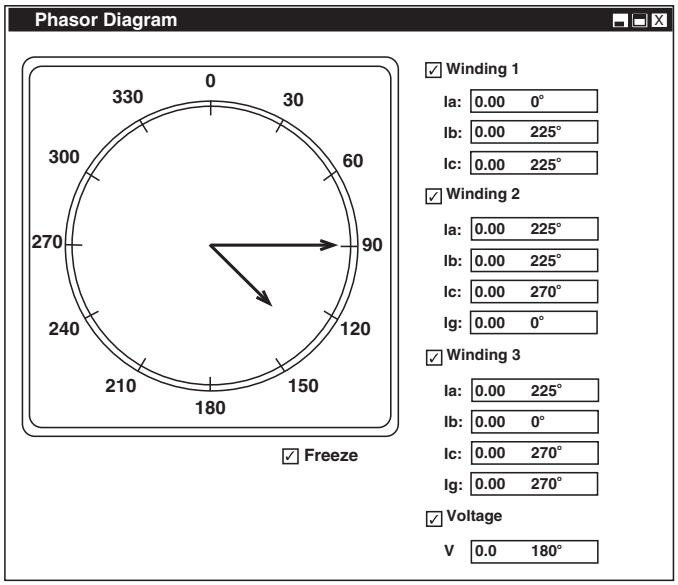


Figure 4-20 Phasor Diagram

Path: Relay/Monitor/Phasor Diagram

COMMAND BUTTONS

Freeze If checked, the Phasor Diagram will display a still picture without updated data. Unchecked, updated data will be displayed automatically.

■ **NOTE**: When connections specifying delta-connected CTs are used, functions 87T and 87H use the Phasor Diagram values (currents actually entering the relay) and not the calculated values displayed on the Secondary Monitoring Screen.

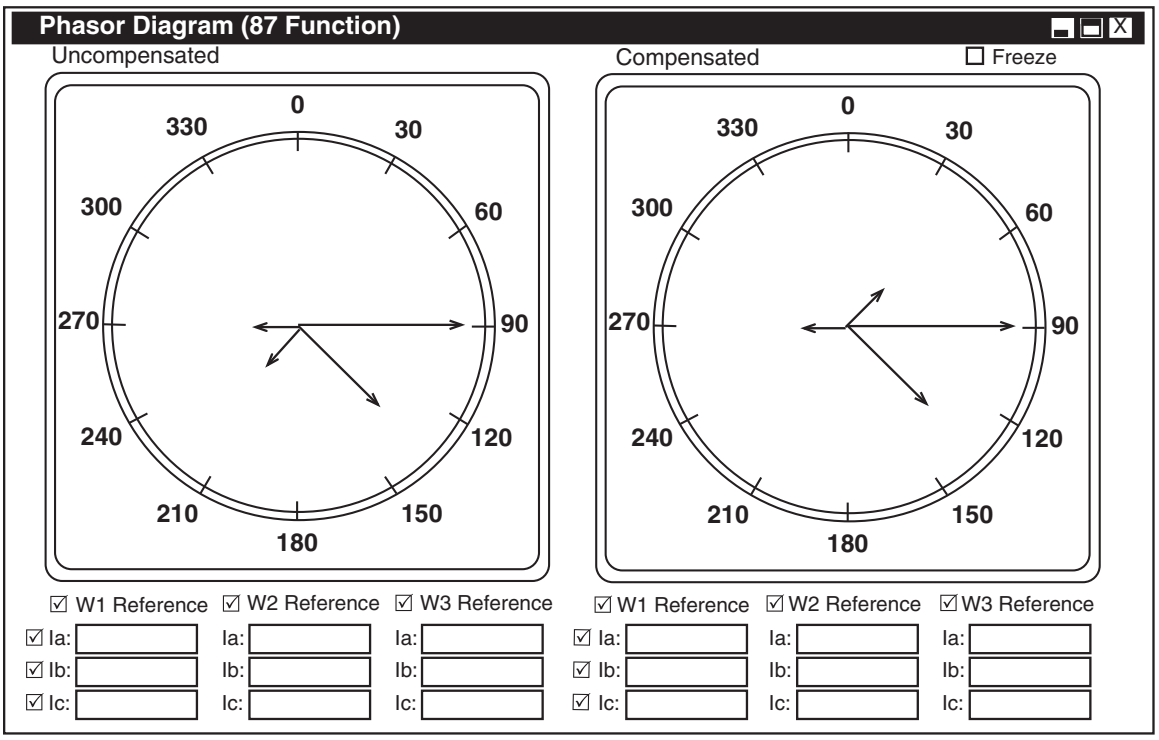


Figure 4-21 Phasor Diagram (87 Function)

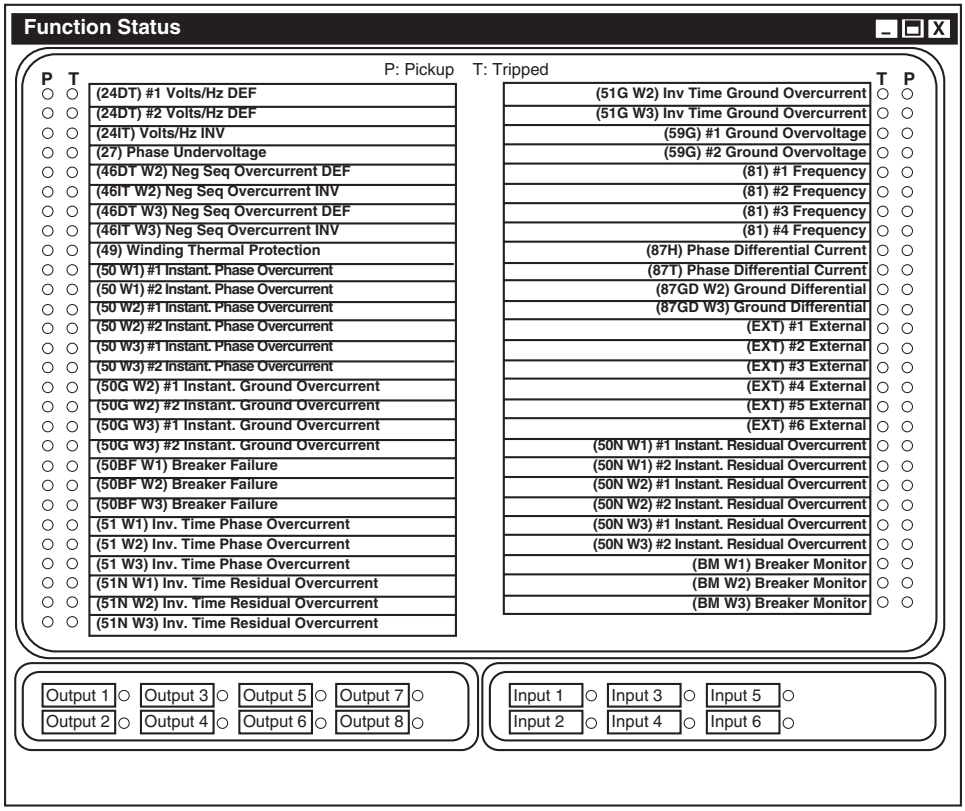


Figure 4-22 Function Status Dialog Box

Path: Relay/Monitor/Function Status

This window shows extended status information of relay functions and INPUT/OUTPUT contact information.

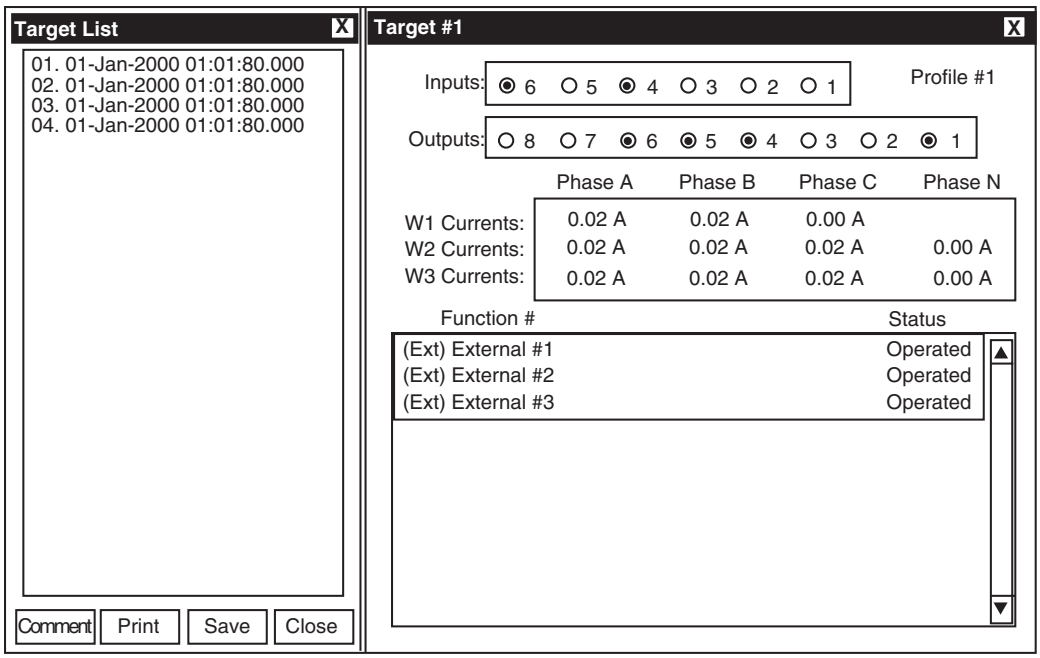


Figure 4-23 Target Dialog Box

Path: Relay menu/Target 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 current displayed dialog box.

4.4 IPSutil™ Communications Software

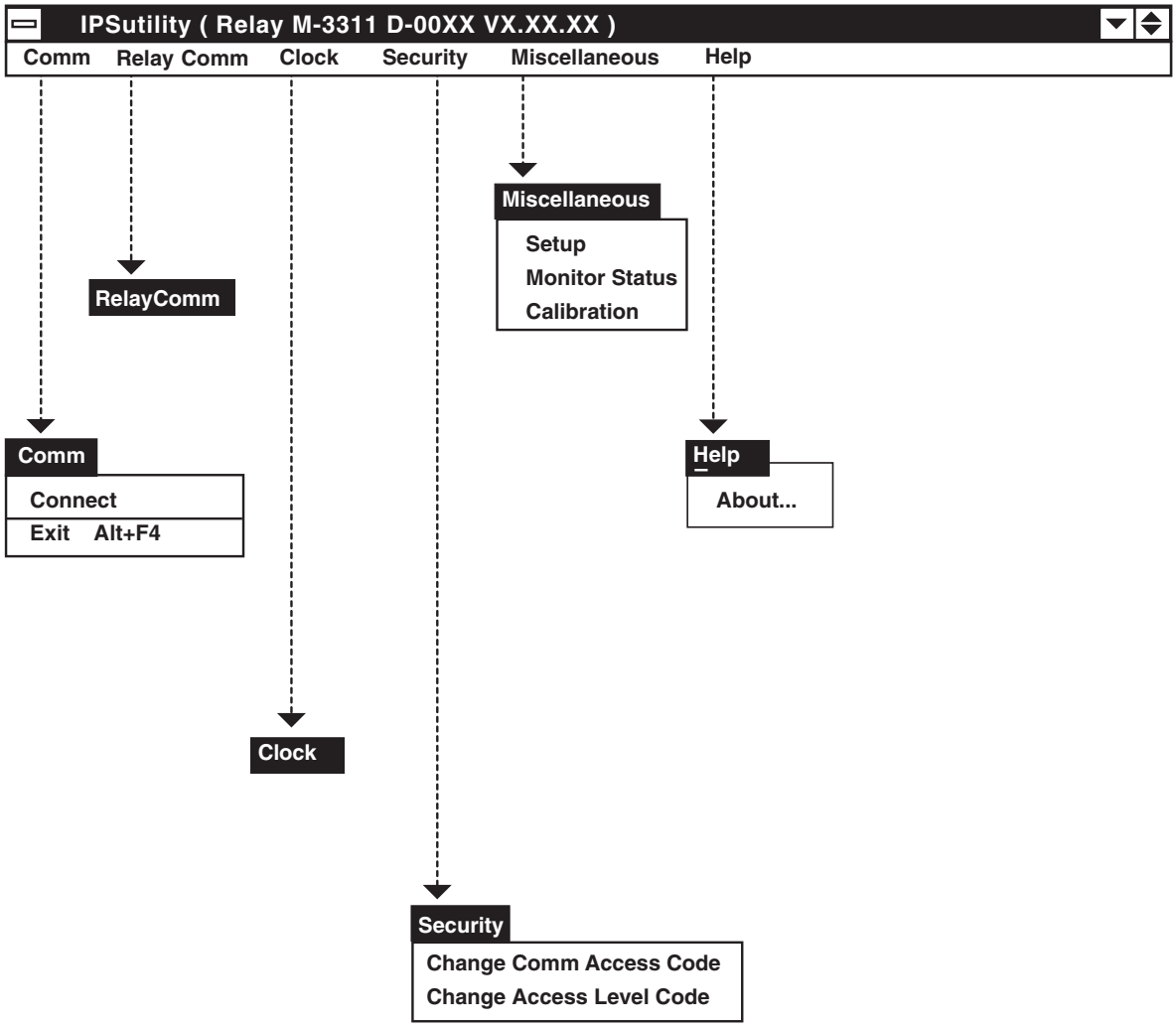


Figure 4-24 IPSutil™ Main Menu Flow

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.

Installation and Setup

IPSutil runs with the Microsoft® Windows 95 operating system or above. Hardware requirements are the same as those stated for IPScom®.

Installation

An installation utility has been provided as a part of IPScom® and IPSutil™ programs. After installation, 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 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 IPSutil is started, a warning window appears:

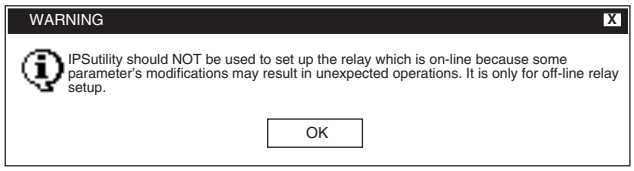
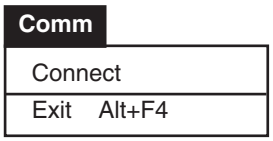


Figure 4-25 Warning Message

After you accept the warning, you can access the IPSutil main menu. The following sections describe each IPSutil menu items.

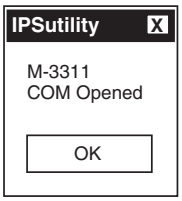
Comm Menu



The **Comm** menu allows you to make connections to the relay. This is the first command you must use to access the unit. After you click the **Connect** submenu item, the Communications dialog box appears (See Figure 4-28).

- 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.



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.

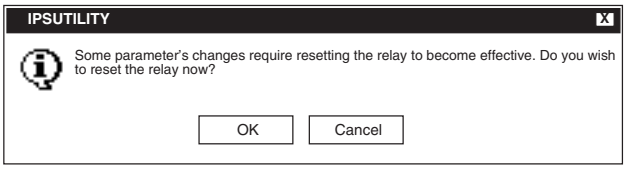


Figure 4-26 IPSutility Reset Relay Message

Relay Comm Command

When **Relay Comm** command is selected, the Relay Comm Port Settings dialog box appears (See Figure 4-29). 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.

■ **NOTE:** If COM1 baud rate is changed and the relay is reset, the new baud rate must be used to communicate with COM1

Clock Command

When the **Clock** command is selected, the "Set Unit Date/Time" dialog box appears (See Figure 4-30). Date and Time can be changed and sent to the relay. This dialog box allows you to start or stop the clock in the relay.

Security Menu

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

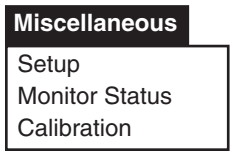
The **Change Comm Access Code** allows you to assign new communication access code to the relay. The range of the access code is 1 to 9999. Note that the access code 9999 is a factory default (See Figure 4-31).

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

The **Change User 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 4-32).

▲ **CAUTION**: This submenu allows you to change the relay level access codes.

Miscellaneous Menu



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

The **Setup** command allows you to change the users 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 (See Figure 4-33).

The **Monitor Status** command allows you to monitor and clear the error code counters, monitor the check sums, and to view inputs test status. Note that powerloss counter cannot be cleared.

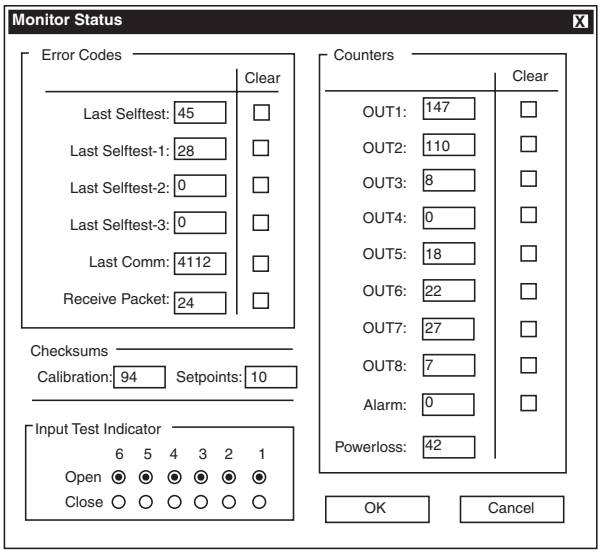


Figure 4-27 Monitor Status Screen

The **Calibration** command is reserved for factory use only.

Help Menu

Under **Help**, the **About...** submenu provides you the information on the IPSUtil™ version numbers.

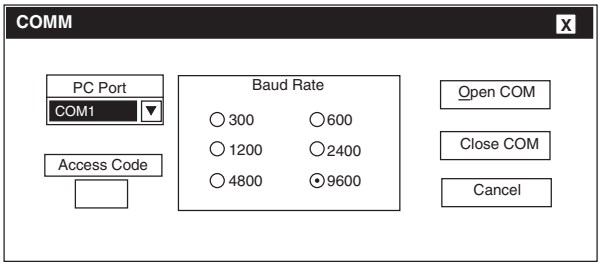


Figure 4-28 Communication Dialog

COMMAND BUTTONS

Open COM Initiates communication with the protective system by direct serial communication.

Close COM Discontinues communication with the protective system.

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

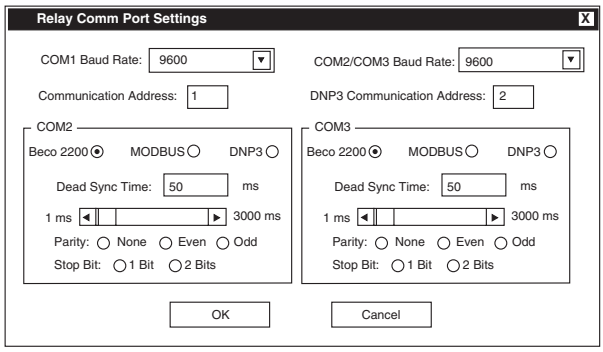


Figure 4-29 Relay Comm Port Settings

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 are lost.

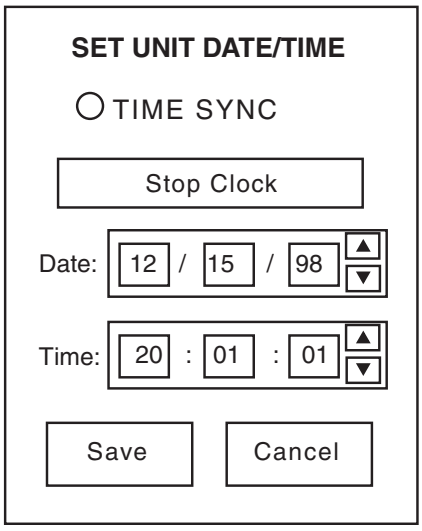


Figure 4-30 Set Unit Date/Time Dialog Box

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 are 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.

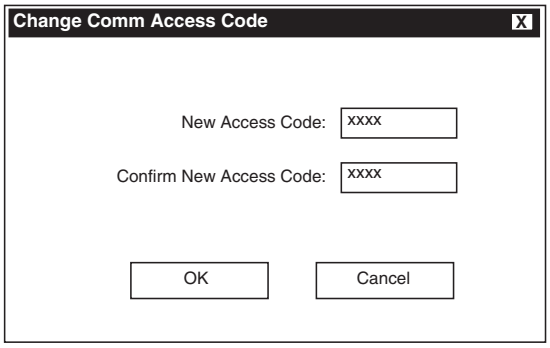


Figure 4-31 Change Communication Access Code Dialog Box

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 are lost.

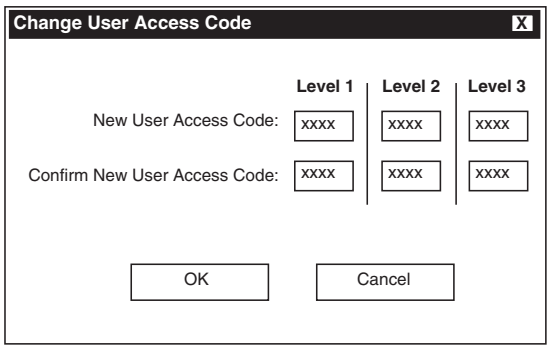


Figure 4-32 Change User Access Code Dialog Box

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 are lost.

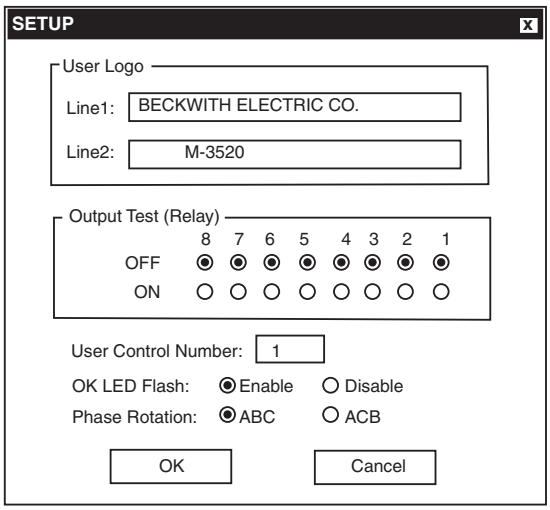


Figure 4-33 Setup Dialog Box

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 are lost.

■ **NOTE**: Output Test is not available on some versions of the M-3311 Relay.

This Page Left Intentionally Blank

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 of 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**.

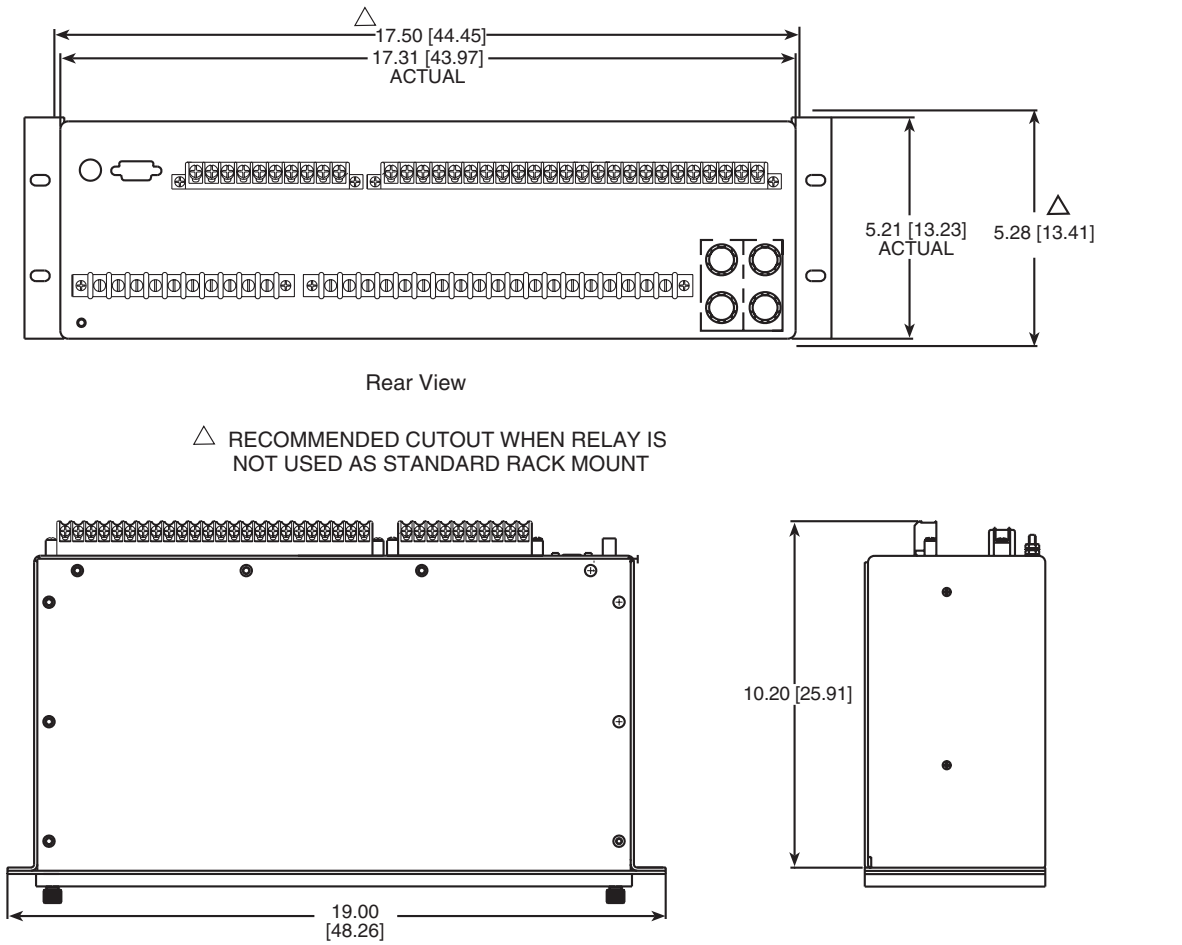
The operation of the M-3311 Transformer Protection Relay, including the initial setup procedure, is described in Chapter 3, **HMI Operation**. If the relay is provided with a Human-Machine Interface (HMI) module, refer to Chapter 4, **IPScom® Operation.**

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 relays data, individual setpoints and time settings for each function, and oscillograph recorder setup information.

Section 3.3, Checkout Status/Metering, guides the operator through the checkout status procedures including status monitoring and viewing target history.

5.2 Mechanical/Physical Dimensions

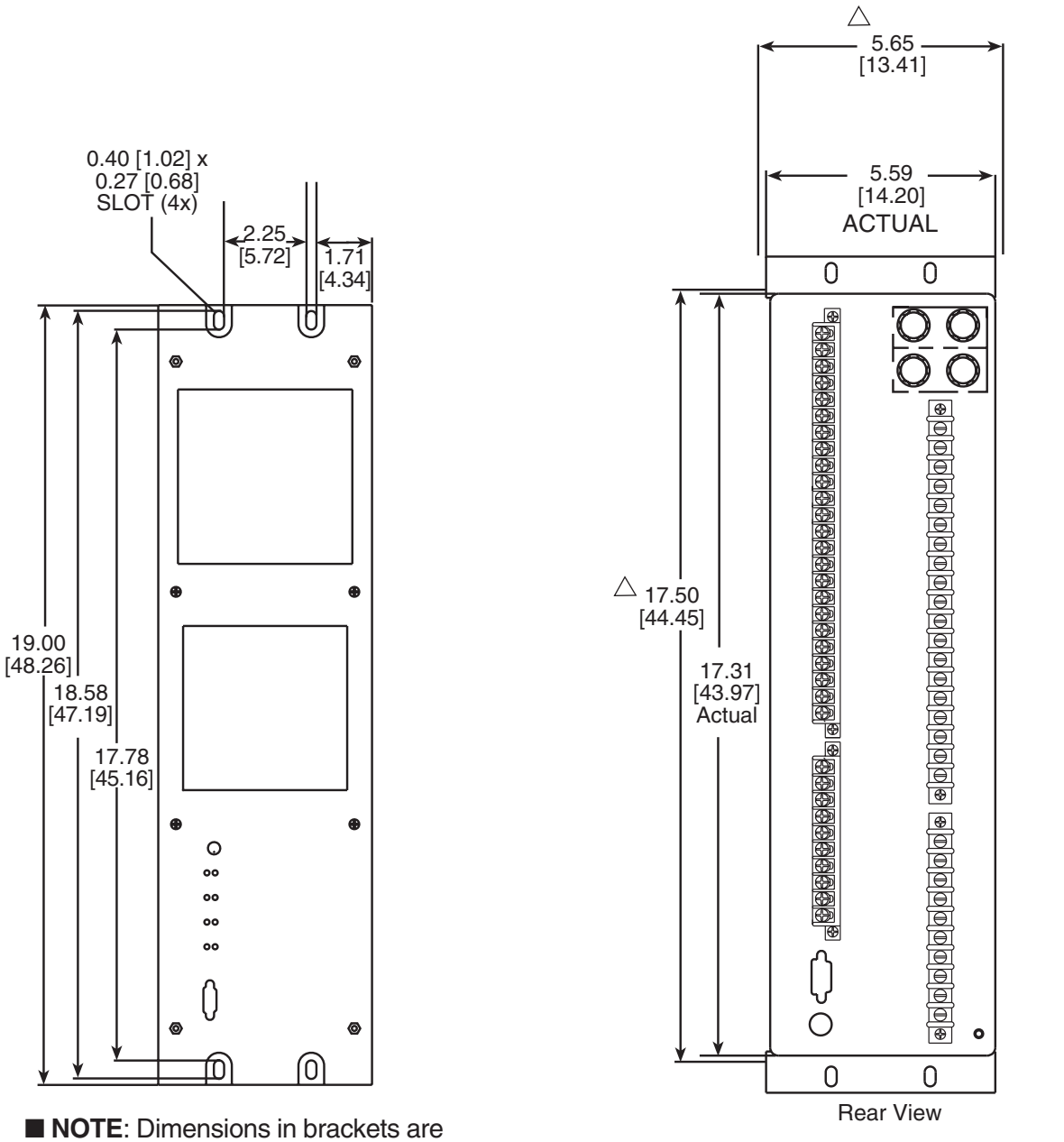
Figures 5-1 through 5-4 contain physical dimensions of the relay that may be required for mounting the unit to a rack.



Standard 19" Horizontal Mount Chassis

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

Figure 5-1 M-3311 Mounting Dimensions – Horizontal Chassis



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

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

Optional Vertical Mount Chassis

Figure 5-2 M-3311 Mounting Dimensions – Vertical Chassis

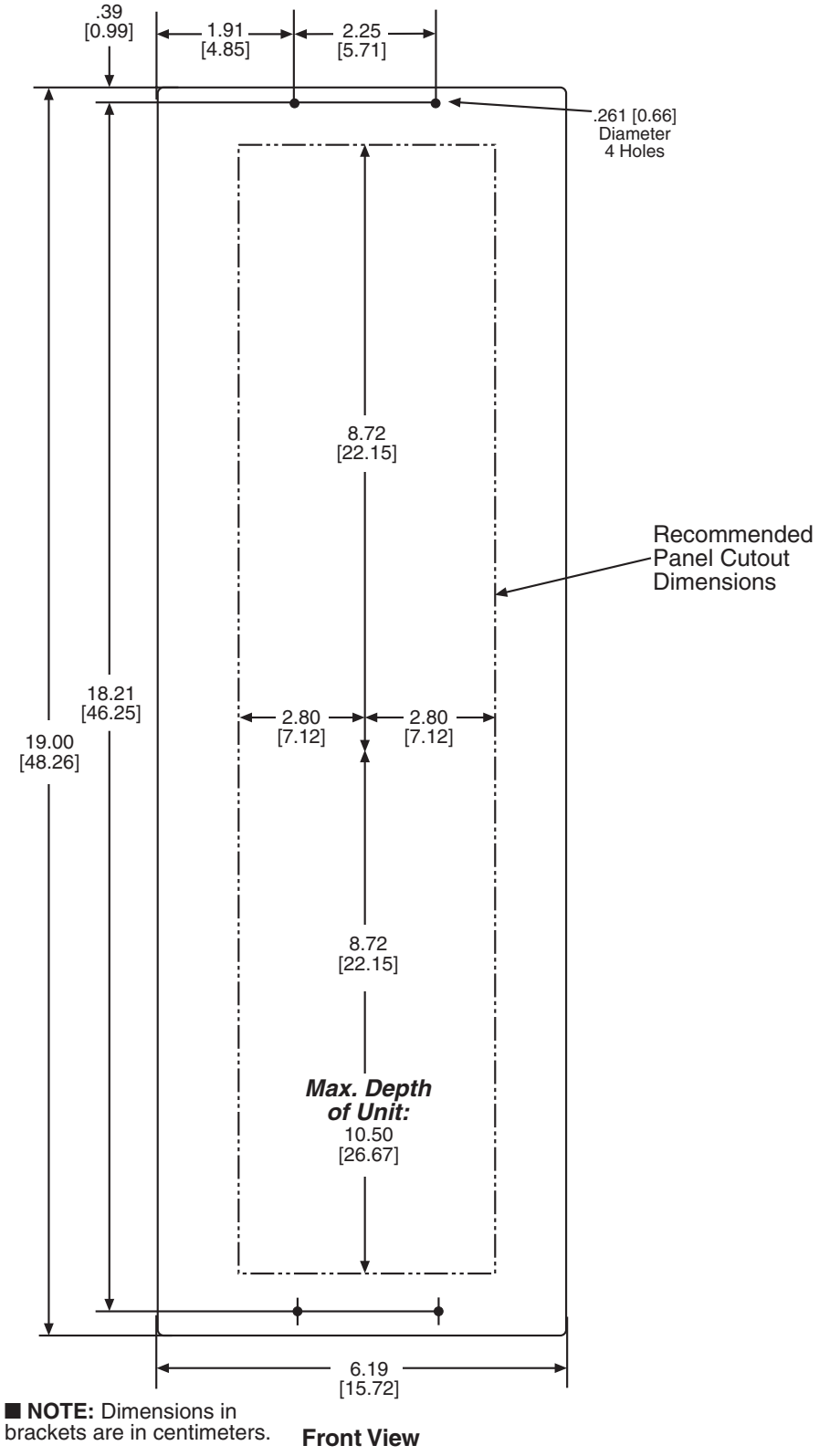


Figure 5-3 (H2) Mounting Dimensions

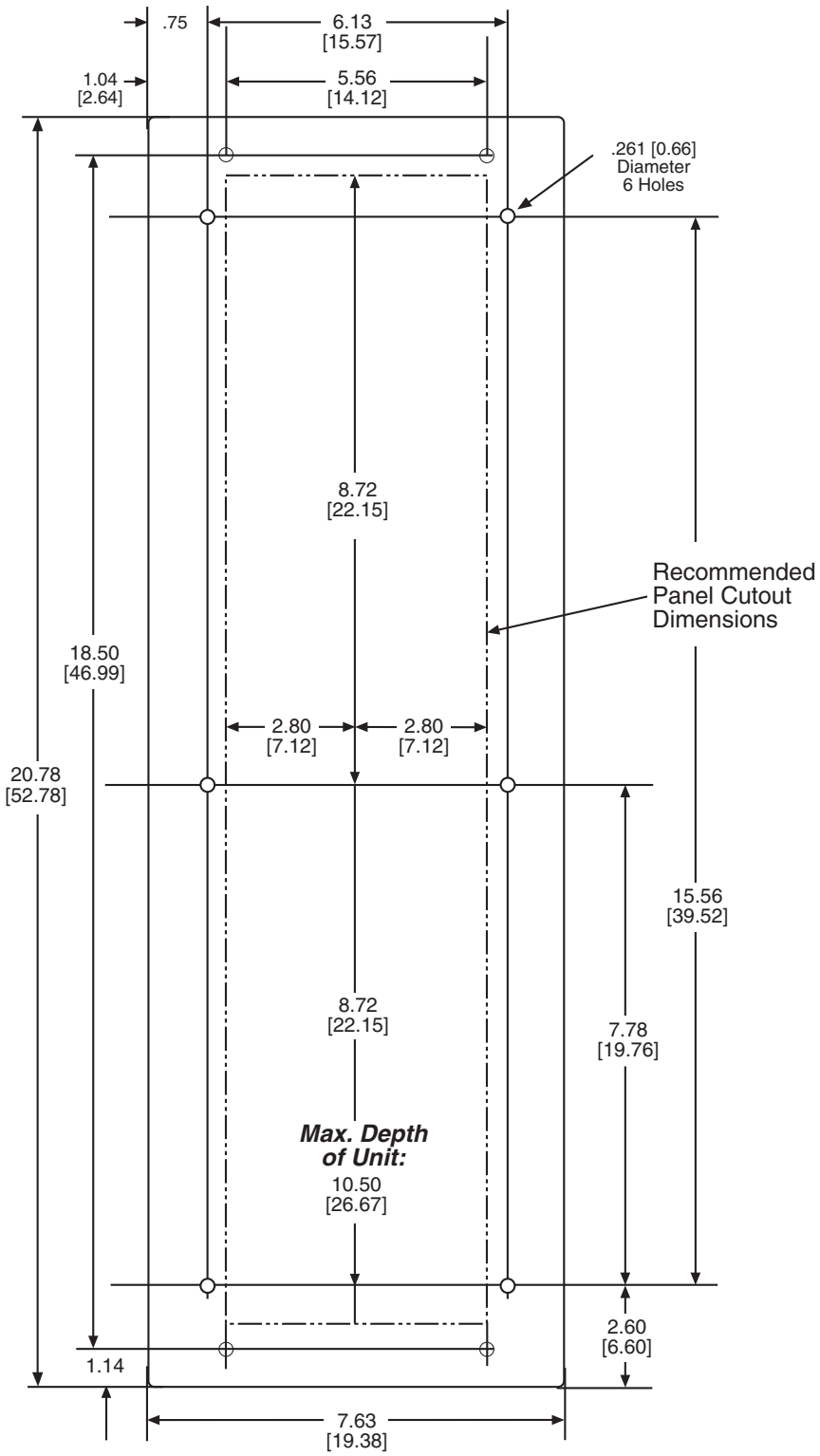


Figure 5-4 (H3) Mounting Dimensions for GE L-2 Cabinet

5.3 External Connections

▲ **CAUTION**: Application of external voltages to the INPUTS terminals may result in damage to the unit.

▲ **CAUTION**: Only dry contacts may be connected to **INPUTS** (terminals 5 through 10, with 11 common), because these contact inputs are internally wetted.

Figure 5-5 provides an explicit view of all the external contacts, communications points, and power fuses of the M-3311.

■ **NOTE**: Output contacts #1 through #4 are high-speed operation contacts. To fulfill UL and CSA listing 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.

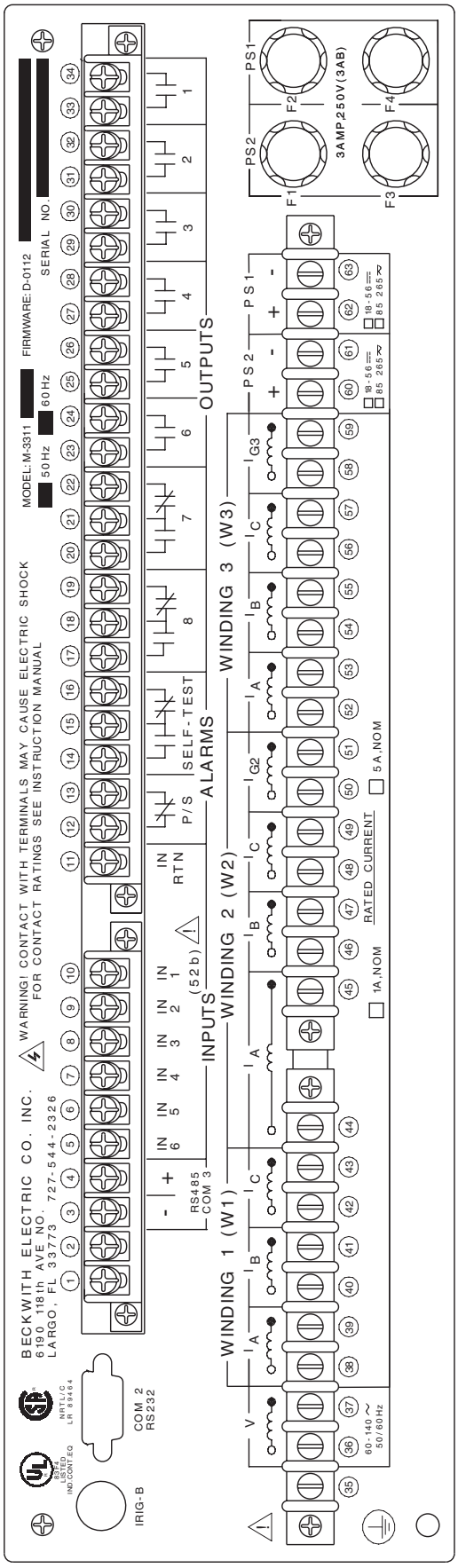


Figure 5-5 M-3311 External Connections

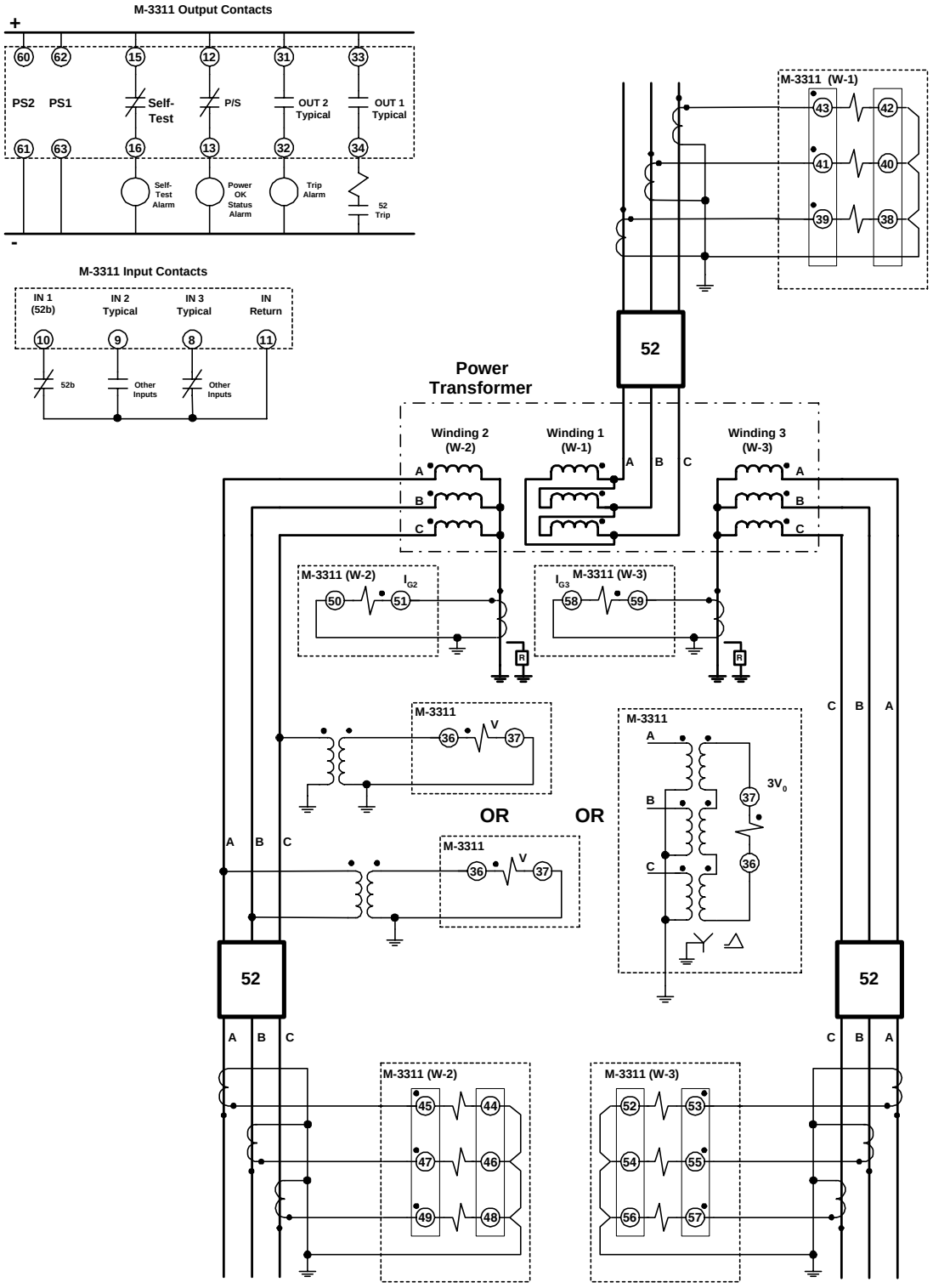


Figure 5-6 Three-Line Connection Diagram

5.4 Commissioning Checkout

During M-3311 Transformer Protection Relay field commissioning, check 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 v/hz →
```

2. Press the right arrow button until the unit displays:

```
STATUS
←STAT dmd targets→
```

3. Press **ENTER**. The unit should display:

```
VOLTAGE STATUS
VOLT curr freq v/hz →
```

4. Press **ENTER** to display the phase voltage. Use a voltmeter to compare the actual measurement. If there is a discrepancy, check for loose connections to the rear terminal block of the unit.

```
VOLTAGE
AC=
```

5. Press **EXIT**, the unit displays:

```
VOLTAGE STATUS
VOLT curr freq v/hz →
```

6. Press the right arrow once, the unit displays:

```
CURRENT STATUS
volt CURR freq v/hz →
```

7. Press **ENTER** to display line currents for Winding 1 (I_AW_1, I_BW_1, I_CW_1). 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:

```
W1 PHASE CURRENT
A= 5.00 B= 5.00 C= 5.00
```

8. Press **ENTER** to display line currents for Winding 2 (I_AW_2, I_BW_2, I_CW_2). 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:

```
W2 PHASE CURRENT
A= 5.00 B=5.00 C=5.00
```

9. Press **ENTER** to display line currents for Winding 3 (I_AW_3, I_BW_3, I_CW_3). 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:

```
W3 PHASE CURRENT
A= 5.00 B=5.00 C=5.00
```

10. Press **ENTER** for the unit to display ground current. The Ground current should be $I_GW2 \approx 0$ Amps.

```
W2 GROUND CURRENT
0.00 Amps
```

11. Press **ENTER** for the unit to display ground current. The Ground current should be $I_GW3 \approx 0$ Amps.

```
W3 GROUND CURRENT
0.00 Amps
```

12. Press **ENTER** for the unit to display restraint currents. The restraint currents should be $I_{REST} \approx$ for each phase.

```
RESTRAINT CURRENT  (PU)
A=5.000 B=5.000 C=5.000
```

13. Press **ENTER** for the unit to display the fundamental differential currents. The fundamental differential currents should be $I_{DIFF} \approx W_1 - W_2 \approx 0$ for each phase. If a significant amount of differential current is present, check the CT polarities.

```
DIFF CURRENT FUND. (PU)
A=0.000 B=0.000 C=0.000
```

14. Press **ENTER** for the unit to display the second harmonic currents. The second harmonic currents should be $I_{2ND} \approx 0$ for each phase.

```
DIFF CURRENT 2nd H (PU)
A=0.000 B=0.000 C=0.000
```

15. Press **ENTER** for the unit to display the fourth harmonic currents. The fourth harmonic currents should be $I_{4TH} \approx 0$ for each phase.

```
DIFF CURRENT 4th H (PU)
A=0.000 B=0.000 C=0.000
```

16. Press **ENTER** for the unit to display the fifth harmonic currents. The fifth harmonic currents should be $I_{5TH} \approx 0$ for each phase.

```
DIFF CURRENT 5th H (PU)
A=0.000 B=0.000 C=0.000
```

17. Press **ENTER** for the unit to display the ground differential current. The ground differential current should be $I_{GDIFF} \approx 0$.

```
GND DIFFERENTIAL CURRENT
w2=0.00 w3=0.00 Amps
```

18. Press **ENTER** for the unit to display the positive sequence current for winding 1. The positive sequence current should be $I_{POS}W_1 \approx I_AW_{1,} \approx I_BW_{1,} \approx I_CW_1$.

```
W1 POS SEQUENCE CURRENT
5.00 Amps
```

19. Press **ENTER** for the unit to display the negative sequence current for winding 1. The negative sequence current should be $I_{NEG}W_1 \approx 0$ Amps.

```
W1 NEG SEQUENCE CURRENT
0.00 Amps
```

20. Press **ENTER** for the unit to display the zero sequence current for winding 1. The zero sequence current should be $I_{ZERO}W_1 \approx 0$ Amps. If a significant amount of negative or zero sequence current is present (greater than 25% of $I_AW_{1,}$ $I_BW_{1,}$ I_CW_1), then either the phase sequence or the polarities may be incorrect. Modify connections to obtain the correct phase sequence and polarities.

```
W1 ZERO SEQUENCE CURRENT
0.00 Amps
```

21. Repeat steps 18–20 for winding 2 and winding 3 currents.

22. Press **EXIT**, the unit displays:

```
CURRENT STATUS
volt CURR freq v/hz →
```

5.5 Circuit Board Switches and Jumpers

DIP JUMPER	POSITION	DESCRIPTION
J60	AB	Connects CD signal to COM 2 pin 1 *
	AC	Connects +15V to COM 2 pin 1
J61	BC	Connects -15V to COM 2 pin 9
	AB	Disconnects COM 2 pin 9 *
J18	AB	COM3 Termination Resistor inserted
	BC	COM3 Termination Resistor not inserted*
J46	AB	COM 3 shares Baud rate with COM 1
	BC	COM 3 shares Baud rate with COM2*
J5	AB	Demodulated IRIG-B signal TTL Pin 6
	BC	Modulated IRIG-B signal BNC *

*Default setting

Table 5-1 Circuit Board Jumpers

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	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 *,**
X	D	X	X	Erasing flash memory is disabled

*Power down, set switch, then power up. After power up, the RELAY OK LED light remains off and DIAG LED will light when the operation has been satisfactorily completed.

**Power down, adjust, connect reference inputs, power up.

Table 5-2 Circuit Board Switches

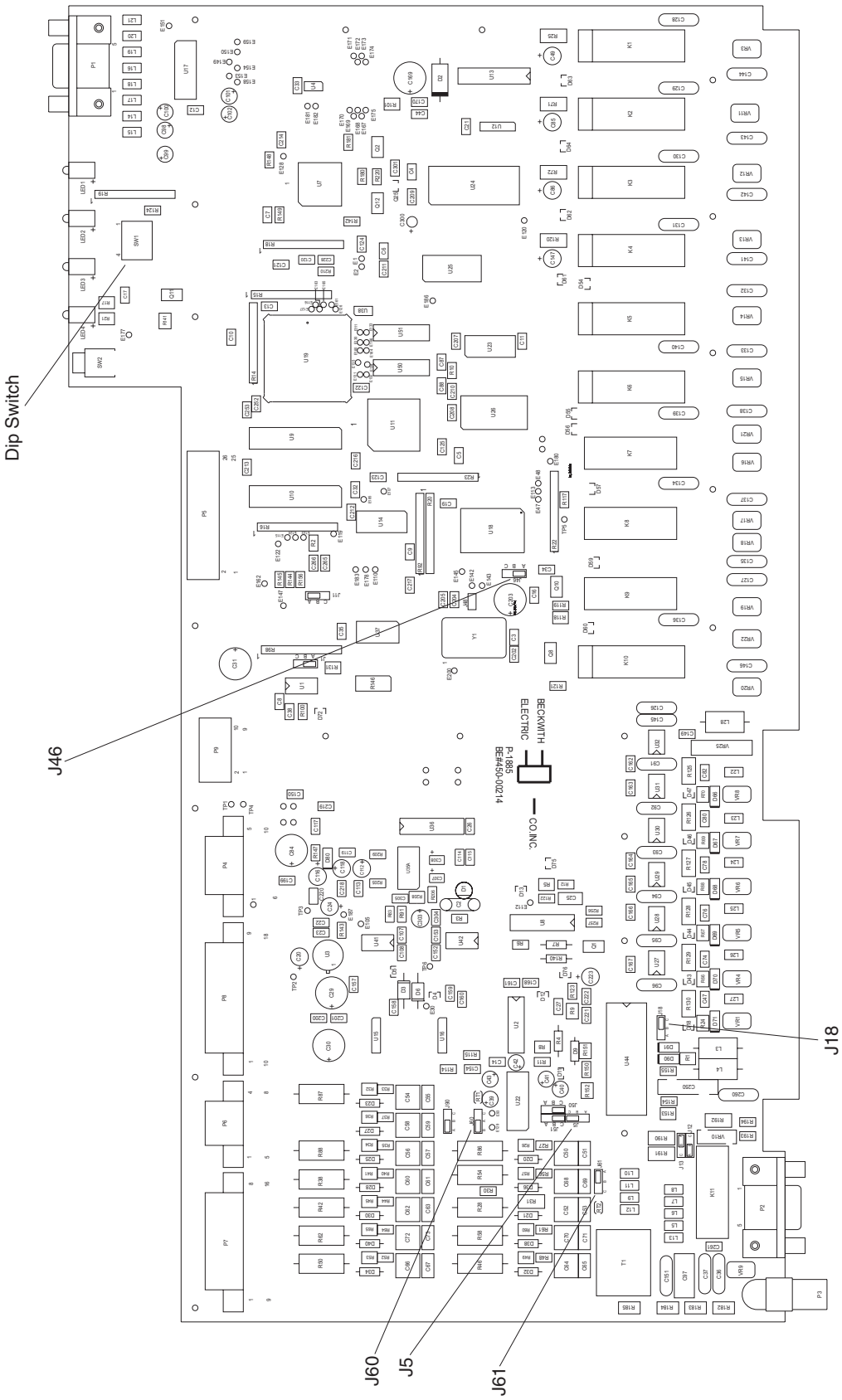


Figure 5-7 M-3311 Circuit Board

This Page Left Intentionally Blank

6 Testing

6.1 Equipment and Test Setup

No calibration is necessary, as the M-3311 Transformer Protection Relay is calibrated and fully tested at the factory. If calibration is necessary because of a component replacement, follow the Auto Calibration procedure detailed in Section 6.3.

Required Equipment

The following equipment is required to perform the test procedures outlined in this chapter:

- Two Digital Multimeters (DMM) with a 10 Amp current range. These are not required if using a Pulsar Universal Test System.
- Appropriate power supply for system power.
- Three-phase source capable of 0 to 250 V ac. (Pulsar Universal Test System or equivalent.)
- Three-phase current source capable of 0 to 25 Amps. (Pulsar Universal Test System or equivalent.)
- Electronic timer with a minimum accuracy of 8 msec. (Pulsar Universal Test System or equivalent.)

Equipment Setup

▲ **CAUTION**: The proper voltage range for the relay is clearly marked on the power supply label affixed to the rear cover.

1. Connect system power to the Relay Power Supply:
   a. PS1 Terminals 62 (hot) and 63 (neutral)
   b. PS2 Terminals 60 (hot) and 61 (neutral)
2. Connect the voltage and current sources as indicated in the configuration listed in the individual function test procedure.

	FUNCTION TO DISABLE																		
FUNCTION BEING TESTED	24DT	24IT	27	46DT	46IT	49	50W1	50W2	50W3	50GW2 50GW3	50NW1 50NW2 50NW3	50BFW1 50BFW2 50BFW3	51W1 51W2 51W3	51GW2 51GW3	51NW1 51NW2 51NW3	59G	81O/U	87H/T	87GDW2 87GDW3
24DT		X	X													X	X		
24IT	X		X													X	X		
27	X	X														X	X		
46DT					X	X		X	X				X		X			X	X
46IT				X		X		X	X				X		X			X	X
49													X		X			X	
50W1					X	X		X	X		X		X		X				X
50W2					X	X	X				X		X		X				X
50W3					X	X	X	X			X		X		X				X
50GW2 50GW3														X					X
50NW1 50NW2 50NW3				X	X	X	X	X	X				X		X			X	
50BFW1 50BFW2 50BFW3				X	X	X	X	X	X		X		X		X			X	X
51W1 51W2 51W3				X	X	X	X	X	X		X				X			X	X
51GW2 51GW3										X									X
51NW1 51NW2 51NW3				X	X	X	X	X	X		X		X					X	X
59G	X	X	X														X		
81O/U	X	X																	
87H/T					X	X	X	X	X		X	X	X		X				
87GD										X	X			X	X				

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 front panel indicators, inputs, and outputs, and the communication ports. These tests are performed in relay test mode, which is entered in the following manner:

▲ **CAUTION:** 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**, reset warning will be displayed:

```
PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE
```

▲ **CAUTION:** All relay functions and protection will be inoperative while the relay is in diagnostic mode.

6. Press **ENTER**. The unit will reset and **DIAGNOSTIC MODE** will be temporarily displayed, followed by **OUTPUT TEST (RELAY)**. This is the beginning of the diagnostic menu.

■ **NOTE**: Pressing any button other than **EXIT** will return the user to **DIAGNOSTIC MODE.**

7. When testing in **DIAGNOSTIC MODE** is complete, press **EXIT** until the following message is displayed:

```
PRESS EXIT TO
EXIT DIAGNOSTIC MODE
```

8. Press **EXIT** again to exit **DIAGNOSTIC MODE**. The relay will reset and then return to normal running 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 is accomplished by connecting a Digital Multimeter (DMM) across the appropriate contacts and confirming open or closed contact status. The de-energized or **OFF** position for each output is listed in Table 6-2, Output Contacts.

```
OUTPUT TEST (RELAY)
OUTPUT input led target
```

RELAY/OUTPUT NUMBER	NORMALLY OPEN CONTACT*		NORMALLY CLOSED CONTACTS*	
1	33	34	N/A	N/A
2	31	32	N/A	N/A
3	39	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)	13	12	N/A	N/A

**"Normal" position of the contact corresponds to the OFF or de-energized state of the relay*

Table 6-2 Output Contacts

For units equipped with an optional HMI panel:

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 arrow button to change “on” to 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 red **OUTPUT** LED illuminates.

6. Use the DMM to verify the position of the output contacts in the energized 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** LEDs 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 equipped with an optional HMI panel:

Each input can be selected by number using the up and down arrow 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). See Table 6-3, Input Contacts.

5. Alternatively, if this specific input is being used in the application, and the external wiring is complete, the actual external 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 arrow button to advance to the next input. Repeat the procedure using the contacts as shown in Table 6-3, Input Contacts.

9. When testing is complete, 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.

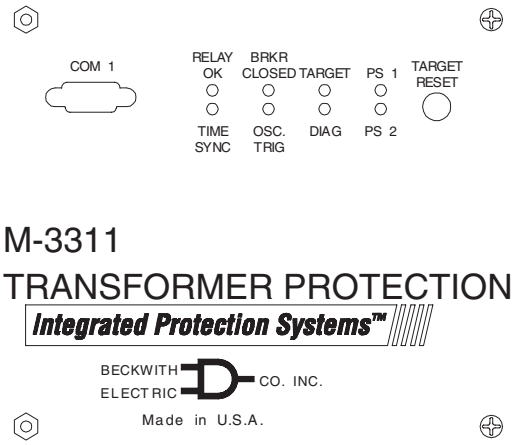


Figure 6-1 Status LED Panel

For units equipped with an 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-3910 Target Module.

The **TARGET LED TEST** menu allows the user to check the M-3911 Target Module LED's individually.

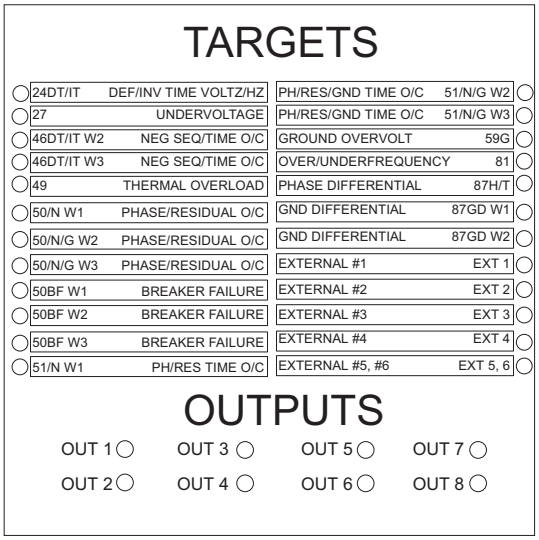


Figure 6-2 M-3911 Target Module

For units equipped with an 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, **24DT DEF TIME VOLTS/HZ**, 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**.

Pressing the **TARGET RESET** button on the front panel also provides a simultaneous test for all **TARGET** LEDs (not applicable in 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.

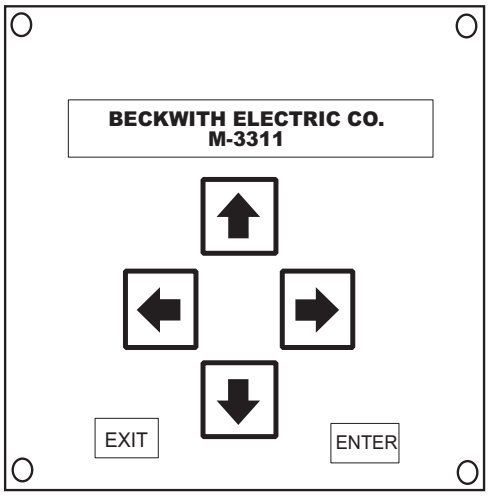


Figure 6-3 M-3931 Human-Machine Interface Module

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
```

■ **NOTE:** Pressing the **EXIT** button will terminate this test, so it should be tested last. If it is pressed before the test sequence is complete, the test may be restarted by pressing **ENTER**. Notice the word **EXIT** is displayed temporarily before the test sequence is terminated.

4. Repeat this test for each of the buttons on the keypad and the **TARGET RESET** button. As each button is presssed, the display will briefly show the name for each key (“Right Arrow”, “Up Arrow”, etc).

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 loopback plug consists of a DB9P connector (male) with pin 2 (RX) connected to pin 3 (TX) and pin 7 (RTS) connected to pin 8 (CTS). No other connections are necessary.

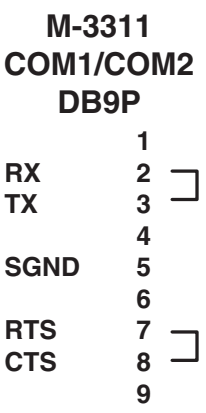


Figure 6-4 COM1/COM2 Loopback Plug

1. When **DISPLAY TEST** is displayed, press the right arrow button until the following is displayed:

```
COM1 LOOPBACK TEST
← COM1 com2 com3 →
```

2. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loopback plug to **COM1**, the front-panel RS-232 Connector.
4. Press **ENTER**. After the test, 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  →
```

7. Repeat steps 2-5 to test **COM2**.

COM3 Test (2-Wire)

■ **NOTE:** This test requires a PC with an RS-485 converter and terminal emulator software installed.

The **COM3 ECHO TEST 2 WIRE** allows the user to test the RS-485 rear terminal connections for proper operation.

1. When **COM2 LOOPBACK TEST** is displayed, press the right arrow button until the following is displayed:

```
COM3 ECHO TEST 2WIRE
← com1 com2 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.

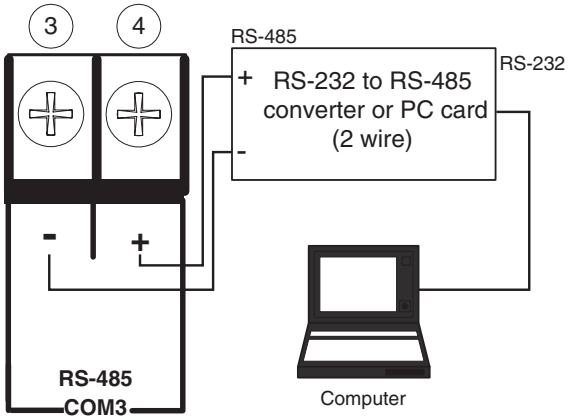


Figure 6-5 RS-485 2-Wire Testing

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.

Clock Test

1. When **COM3 ECHO TEST 2WIRE** 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
```

■ **NOTE**: 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.

5. Press **ENTER** again to stop the clock. The following is displayed:

```
CLOCK TEST
-CLOCK STOP-
```

6. A display similar to the following is shown with the seconds stopped:

■ **NOTE:** When the relay clock is stopped, the seconds will be displayed as 80.

```
CLOCK TEST
03-JAN-09:01:80.000
```

7. Repeat steps 2 and 3 to restart the clock.

Flash Relay OK LED

The **Flash Relay OK LED** function is provided to enable 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
```

▲ **CAUTION:** Programming the OK LED to remain illuminated indefinitely is not recommended. It is possible that the LED OK would remain illuminated even if the relay failed.

3. Use the right arrow key to select “on”, and press ENTER. The unit will display

```
FLASH RELAY OK LED
    –DONE–
```

4. Press **EXIT** to return to the former menu.
5. Repeat step 2 and use the left arrow key to select “off”, and press **ENTER**.
6. Press **EXIT** to return to the former menu.

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 M-3311 Transformer Protection Relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to installation. Further calibration is only necessary if a component was changed.

For units equipped with an 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 voltage inputs to terminal 36 (neutral) and terminal 37 (hot) and apply 120.00 (±0.01) VAC ∠0°.

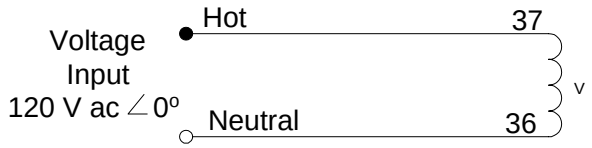


Figure 6-6 Voltage Calibration Configuration

4. Connect all current inputs in series ($I_AW_1 = I_BW_1 = I_CW_1 = I_AW_2 = I_BW_2 = I_CW_2 = I_{G2}W_2 = I_AW_3 = I_BW_3 = I_CW_3 = I_{G3}W_3$)
5. Apply 5.00 (±0.01) Amps ∠0°. For 1 Amp CT models, use 1.0 (±0.01) Amps ∠0°.

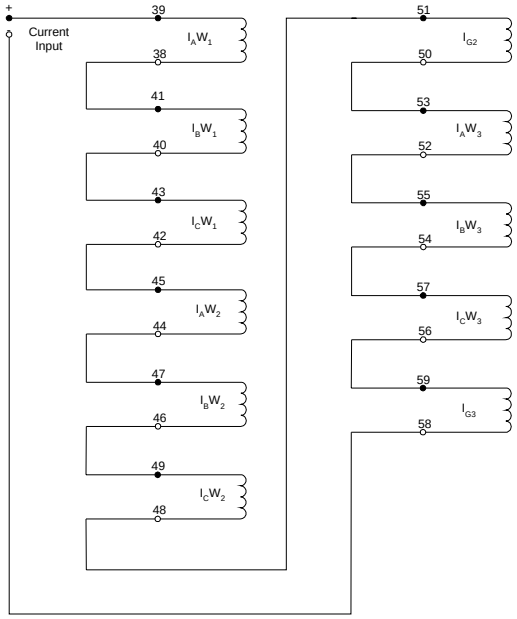


Figure 6-7 Current Calibration Configuration

6. Press **ENTER** to start calibration. While the unit is calibrating, the display will show:

```
AUTO CALIBRATION
-WAIT-
```

7. When the calibration is complete, unit will display:

```
AUTO CALIBRATION
-DONE-
```

8. The calibration can be verified by reading the Status (see the **Monitor Status** menu, and Monitor Status/Metering in Section 3.3, Checkout Status & Metering).

For units without the optional M-3931 HMI:

It is possible to autocalibrate M-3311 units that are not equipped with the optional M-3931 HMI. The procedure is similar to HMI equipped units:

1. Remove power from the unit.
2. Place unit in calibrate mode by configuring the proper dip switches (see Figure 5-2).
3. Connect voltage inputs.
4. Connect all current inputs in series.
5. Apply power to the unit. **THE DIAG** LED will illuminate when operation is complete.
6. Remove power from the unit, then return dip switches to **RUN** position.

6.4 Input Configurations

Phase angles shown here represent leading angles as positive and lagging angles as negative. Some test equipment manufacturers use lagging angles as positive, in which case $I_BW_1=\angle 120°$ and $I_CW_1=\angle 240°$. Other current phase angles should be adjusted in the same manner.

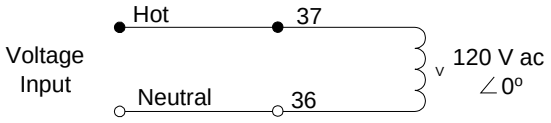


Figure 6-8 Voltage Inputs, Configuration V1

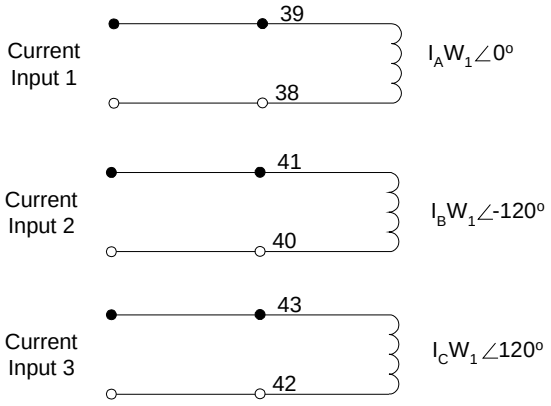


Figure 6-9 Current Inputs, Configuration C1

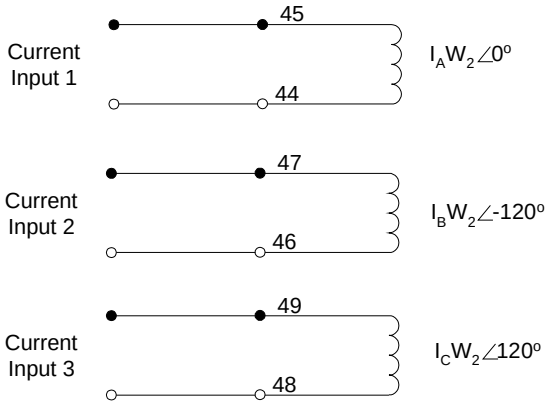


Figure 6-10 Current Inputs, Configuration C2

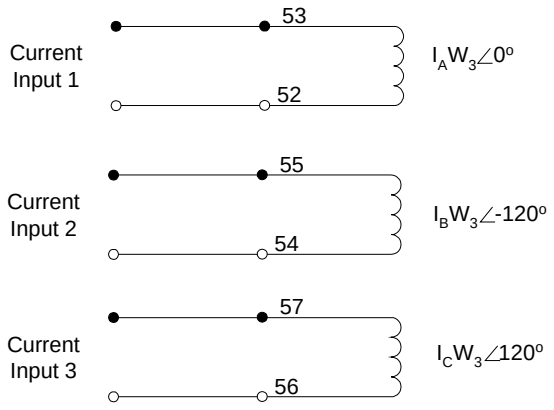


Figure 6-11 Current Inputs, Configuration C3

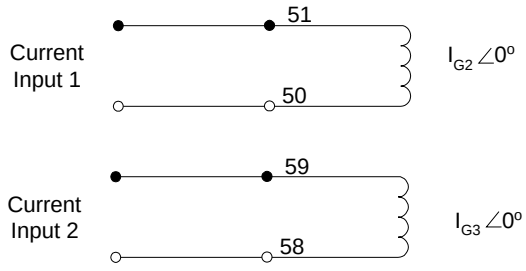


Figure 6-12 Current Inputs, Configuration C4

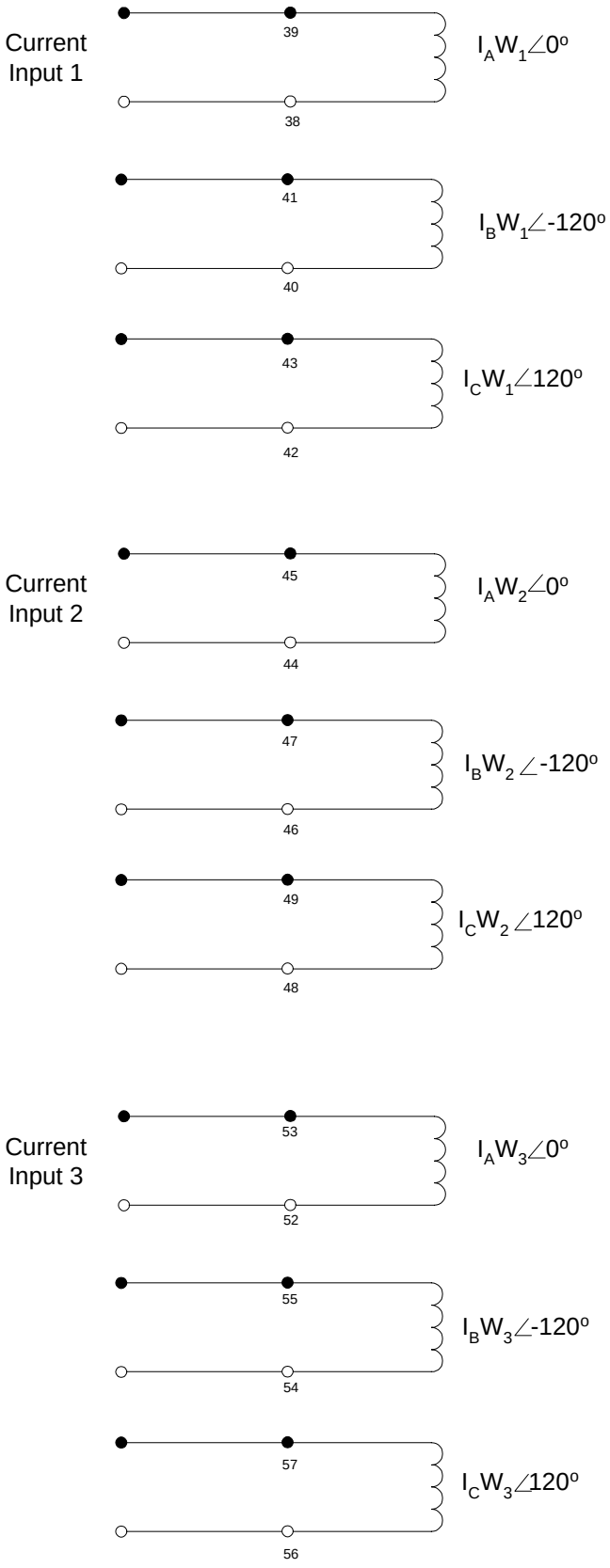


Figure 6-13 Current Configuration C5

6.5 Functional Test Procedures

This section details the test quantities, inputs and procedures for testing each function of the relay. The purpose is to confirm the function's designated output operation, the accuracy of the magnitude pickup settings, and the accuracy of time delay settings. Whereas the first test described, "Power On Self Test," does not require electrical quantity inputs, all other functional tests require inputs, and the necessary connection configurations are shown.

In all test descriptions, a process for calculating input quantities to test the actual settings of the function will be given if needed.

▲ **CAUTION***:* Care must be taken to reset or re-enable any functions that have been changed from the intended application settings when the test procedures are complete. When a function is re-enabled, both output arrangements and blocking input designations must be reestablished.

In many test cases, it will be necessary to disable other functions not being tested at the time. This action is to prevent the operation of multiple functions with one set of input quantities which could cause confusion of operation of outputs or timers.

The complete description of the method to disable/enable functions may be found in detail in Section 3.2, Configure Relay Data or Chapter 4, **Operation**. The complete description of the method to enter 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 before beginning test procedures. Use the **FUNCTIONAL CONFIGURATION RECORD FORM** and the **SETPOINT AND TIMING RECORD FORM** found in Appendix A to record 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.

It may be desirable to program all test settings in an alternate profile, or to save the relay settings in IPScom® to preserve a desired setup.

Many options for test sequences and methods are possible. As an example, the operation of the output contacts can be tested along with the operation of the LED's in the Diagnostic Test Procedures. The operation of the output contacts may also be confirmed with the LED and function operation during **Functional Test Procedures**, Section 6.5, if desired.

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Table 6-2 , Output Contacts.

It is suggested that copies of the following be made for easy referral during test procedures:

- Input Configurations - page 6–10
- Output Test (Relay)- page 6–3
- Relay Configuration Table - page A–2
- Setpoint & Time Record Form - pages A–8, 9

Power On Self Tests

VOLTAGE INPUTS: None

CURRENT INPUTS: None

1. Apply proper power to the power input terminals: 60 (hot) and 61 (neutral)
2. The unit will display:

```
POWER ON SELFTESTS
XXXXXXXXxxxxxxxxxxxxxxX
```

3. All LEDs will illuminate simultaneously for approximately 1 second. The **POWER** and **RELAY OK** LEDs will remain illuminated; the rest of the LEDs will extinguish.
4. The unit will display:

```
POWER ON SELFTESTS
PASS
```

The model number:

```
BECKWITH ELECTRIC CO.
M-3311
```

where “xx.xx.xx” signifies the software revision;

```
BECKWITH ELECTRIC CO.
D-0112Vxx.xx.xx
```

where “xxx” signifies the unit serial number:

```
BECKWITH ELECTRIC CO.
SERIAL NUMBER XXX
```

The **POWER** LED will illuminate. The **RELAY OK** LED will flash (or remain illuminated as programmed in the **Setup** menu) and the **BREAKER CLOSED** LED will remain illuminated. The Power On Self-Test ends with the system date and time and the default logo. Any recorded targets are then displayed.

24DT Volts/Hz Overexcitation Definite Time (#1 or #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:

Definite Time Pickup	P	%	(100 to 200)
Time Delay	D	Cycles	(30 to 8160)
Programmed Outputs	Z	OUT	(1 to 8)
Function 24DT #1 or 2	Disable		
Function 24IT, 27	Disable		
Function 59G, 81O/U	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the function being tested should be enabled; the other should be disabled.
3. Connect voltage input in Configuration V1 designated previously. Set the V.T. Configuration (Section 2.4) as V_A. Refer to Section 6.4, Input Configurations, for configurations.
4. The Volts/Hz pickup level at a percentage setting of nominal frequency (50 or 60Hz) is Definite Time Pickup = (**P** % ÷ 100) X (**Nominal Voltage**), see example below. The Nominal Values have been programmed in the system setup data described in Section 2.2, **Configuration,** and are recorded on the **COMMUNICATION & UNIT SETUP RECORD FORM**. Test voltage levels may be at any percentage of Nominal Voltage. Choose 4 or 5 test levels and calculate for each.

150% V/Hz	÷ 100	x 120	=180 volts
Pickup (**P**) setting	divided by 100	times **Nominal Voltage**	equals voltage level

5. ***Voltage Pickup Test*:**
   a. Apply voltage to input contacts at a level 10% lower than the pickup level calculated in Step 4.
   b. Press and hold the **TARGET RESET** button in, then slowly increase the voltage until the **24DT/IT DEF/INV TIME V/HZ** LED illuminates or the pickup indicator operates on the computer target screen. The voltage level of operation will be **P** ±1%.
   c. Release the **TARGET RESET** button, then decrease the voltage. The **OUTPUT** LED will extinguish.
   d. Press the **TARGET RESET** button to remove targets.
6. ***Frequency Pickup Test*:**
   a. Apply voltage to input contacts at the Nominal Voltage level.
   b. Press and hold the **TARGET RESET** button in, then slowly decrease the frequency until the **24DT/IT DEF/INV TIME V/HZ** LED illuminates or the pickup indicator operates on the computer target screen. The voltage level of operation will be **P** ±1%.
   c. Release the **TARGET RESET** button, then increase frequency to 1% above the pickup frequency. The **OUTPUT** LED will extinguish.
   d. Press the **TARGET RESET** button to remove targets.

60	÷150% V/Hz	X 100	=40Hz
Nominal Frequency	Pickup (**P**) setting	times 100	equals frequency level

7. ***Timer Test*:** With output contacts connected to the timer, apply the calculated voltage from Step 4 and start timing. The contacts will close after **D** cycles within +25 cycles.
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 configuration.

24IT Volts/Hz Overexcitation Inverse Time

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Inverse Time Pickup	P	%	(100 to 150)
	Inverse Time Curve	C		(1 to 4)
	Time Dial Curve #1 Curves #2 to #4	K		(1 to 100) (0.0 to 9.0)
	Reset Rate	R	Sec.	(1 to 999)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 24DT#1 & 2, 27 Functions 59G, 81O/U	Disable 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 in Configuration V1 designated previously. Set the V.T. Configuration (Section 2.4) as V_A. Refer to Section 6.4, Input Configurations**,** for configurations.
4. The Volts/Hz pickup level at a percentage setting of nominal frequency (50 or 60 Hz) is Definite Time Pickup = (**P** % ÷ 100) X (**Nominal Voltage**), see example below. The Nominal Values have been programmed in the system setup data described in Section 2.2, **Configuration,** and are recorded on the **COMMUNICATION & UNIT SETUP RECORD FORM**. Test voltage levels may be at any percentage of Nominal Voltage.

150% V/Hz	÷ 100	x 120	=180 volts
Pickup (**P**) setting	divided by100	times **Nominal Voltage**	equals voltage level

5. Test voltage levels may be at any percentage of Nominal Voltage that are a minimum of 5% higher than the selected pickup percentage, **P** %. It is suggested that 4 or 5 test levels be chosen and voltage level and operating time be calculated for each from the table below.
6. ***Timer Test***: With output contacts connected to the timer, apply the calculated voltage from Step 4 and start timing. Operating time will be as calculated in Step 5 (**±1%).** Repeat this step for all chosen test levels. The curve portion extending lower than **P**% V/Hz values is inactive and can be ignored.

$$t = \frac{.003*K}{\left[\left(\frac{V/Hz\%}{100}\right)-1\right]^2}$$ ***Curve 1***

$$t = e^{\wedge}\ \frac{115+(2.5xTD)-V/Hz\%}{4.8858}$$ ***Curve 2***

$$t = e^{\wedge}\ \frac{113.5+(2.5xTD)-V/Hz\%}{3.04}$$ ***Curve 3***

$$t = e^{\wedge}\ \frac{108.75+(2.5xTD)-V/Hz\%}{2.4429}$$ ***Curve 4***

t = time in minutes TD = Time Dial setting V/Hz in percent (%)

7. ***Reset Rate Test****:* To test the reset rate, begin timing immediately when the input voltage is reduced below pickup value. Holding the **TARGET RESET** button in, stop timing when **24DT/IT DEF/INV TIME V/HZ** LED extinguishes. The time will be the Reset Rate (**R**) within ±3 cycles or ±1%.
8. If re-testing is required, the unit should be powered down or wait for the programmed Reset time period before the next test to ensure complete resetting of the timer.
9. 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 configuration.

27 Phase Undervoltage

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Volts	(5 to 140)
	Inhibit Setting	U	Volts	(5 to 140)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 24DT, 24IT Function 59G Function 81O/U	Disable Disable 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 in Configuration V1 designated previously. Set the V.T. Configuration (Section 2.4) as V_A. Refer to Section 6.4, Input Configurations**,** for configurations.
4. Set Phase Voltage Inputs at 1.2 x **P** volts at the Nominal Frequency.
5. ***Pickup Test****:*
   a. Press and hold the **TARGET RESET** button in, then slowly decrease the input phase voltage until the **27 UNDERVOLTAGE** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** volts ±0.5 V.
   b. Release the **TARGET RESET** button, then increase the input to the Nominal Voltage. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets.
6. ***Undervoltage Inhibit Test***: Slowly decrease the input voltage until the **27 UNDERVOLTAGE** LED extinguishes. The level will be **U** volts ±0.5 volts.
7. ***Time Test***: With output contacts connected to the timer, apply approximately 50% of **P** volts and start timing. The contacts will close after **D** cycles within –1 or +3 cycles or ±1%.
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 configuration.

46DT Negative Sequence Overcurrent Definite Time

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	Configuration C2 or C3 (MODIFIED)			
TEST SETTINGS:	Definite Time Pickup 1 Amp CT Rating	P	Amps	(0.1 to 20) (0.02 to 4)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46IT, 49	Disable		
	Function 50N	Disable		
	Functions 50W2, 50W3	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87H/T	Disable		
	Function 87GD	Disable		

■ **NOTE**: Although a voltage input is not required for the testing of the 46 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they should also be disabled for the test and enabled after the tests are complete.

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 V1 and C2 (MODIFIED) as designated previously. Refer to Section 6.4, Input Configurations for configurations. The modification to C2 is to exchange Current Input 2 and 3 (B∅ current = Input 3 and C∅ current = Input 2). Set Voltages = Nominal Voltage. Configuration will be Phase B current from Source 3 and Phase C current from Source 2.

■ **NOTE**: For proper testing use I ≦ 3 X CT rating.

4. ***Pickup Test****:*
   a. Press and hold the **TARGET RESET** button in, then slowly increase the 3-phase currents until the **46DT/IT W2 NEG SEQ/TIME O/C** (46DT/IT W3 NEG SEQ TIME O/C) 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 Amp 1 A CT*) or ±3%, whichever is higher.
   b. Release the **TARGET RESET** button, then decrease the currents to a level below the Pickup Current. The **OUTPUT** LED will extinguish.
   c. Press the **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts connected to the timer, apply current of at least 1.1 X **Pickup (P)** and start timing. The contacts will close after (**D**) cycles within –1 or +3 cycles or ±1%.
6. Reduce input currents to 0 Amps
7. If further testing is desired, check the proper functions to disable for the next test and continue from this configuration.
8. Repeat steps 3, 4, 5, and 6 for Winding 3.
9. If testing is complete, enable any functions disabled for this test.

46IT Negative Sequence Overcurrent Inverse Time

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	Configuration C2 or C3 (MODIFIED)			
TEST SETTINGS:	Inverse Time Pickup 1 Amp CT Rating	P	Amps	(0.5 to 5) (0.1 to 1)
	Standard Inverse Time Curves:[1] Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11)
	IEC Inverse Time Curves: [1] IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.1)
	Programmed Outputs	Z	OUT	(1 to 8)
	Function 46DT, 49	Disable		
	Function 50W2/W3	Disable		
	Function 51, 51N	Disable		
	Function 87H/87T	Disable		
	Function 87GD	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 V1 and C2 (MODIFIED) as designated previously. Refer to Section 6.4, Input Configurations, for configurations. The modification to C2 is to exchange Current Input 2 and 3 (B∅ current = input 3 and C∅ current = input 2). Set Voltages = Nominal Voltage.

■ **NOTE**: For proper testing use I ≦ 3 X 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.

IEC Standard Inverse	**IEC Very Inverse**	**IEC Extremely Inverse**	**IEC Long Time Inverse**
$t = TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$	$t = TD \times \left[\frac{13.5}{M - 1}\right]$	$t = TD \times \left[\frac{80}{M^2 - 1}\right]$	$t = TD \times \left[\frac{120}{M - 1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

Standard Curve Testing: The operating time will be read from Appendix D, Negative Sequence 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**) and start timing. The operating time will be as calculated in Step 4, ±3 cycles or ±5%. Observe **46DT/IT W2 NEG SEQ/TIME O/C** (46 DT/IT W3 NEG SEQ/TIME O/C) LED for pickup.
6. If further testing is desired, check the proper functions to disable for the next test and continue from this configuration.
7. Repeat steps 3, 4 and 5 for Winding 3.
8. If testing is complete, enable any functions disabled for this test.

[1]Either a Standard Curve or an IEC Curve must be selected.

49 Winding Thermal Protection (#1, #2)

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	Time Constant	τ	Minutes	(1.0 to 999.9)
	Max Overload Current 1 Amp CT Rating	I_{max}	Amps	(1 to 10) (.2 to 2)
	Winding Select	WN		(W1/W2/W3)
	Programmed Outputs	Z Expanded I/O	OUT	(1 to 8) (9 to 23)

Test Setup:

1. Determine the Function 49 Thermal Overload settings to be tested. This test requires that the values for the following elements (described in detail in Chapter 2, Application) be determined:
   - τ = time constant
   - I_0 = pre-load current
   - I_{max} = maximum allowed continuous overload current
2. Enter the Function 49 Thermal Overload settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-9, Current Inputs: Configuration C1.
5. Calculate **t** (time to trip in minutes) for the desired test settings as follows:

   Where:

$$t = \tau \times \ell_n \left(\frac{I_L^2 - I_{PL}^2}{I_L^2 - I_{max}^2} \right)$$

   Where: t = time to trip in minutes
   τ = time constant
   I_L = relay current (applied)
   I_{PL} = pre-load current
   I_{max} = maximum allowed continuous overload current

Pickup Test:

1. Press and hold the **TARGET RESET** pushbutton, then slowly increase the current until the **THERMAL OVERLOAD 49** LED illuminates or the pickup indicator illuminates on the IPScom Function Status screen.

   The current level of operation will be ($\mathbf{I_{max}}$) Amps ± 0.1 A (± 0.02 Amp for 1 A CT) or ± 3%.
2. Release the **TARGET RESET** pushbutton, then decrease the current. The **OUTPUT** LED will extinguish.
3. Press **TARGET RESET** button to remove targets.

Time Test (Cold Start):

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.

■ **NOTE**: The 49 Thermal Overload 49 #1current value can be obtained utilizing either the HMI (Status/ Current Status) or IPScom® Communications Software (Relay/Monitor/Secondary Status).

2. Determine the 49 Thermal Overload 49 #1 current value. If the value is greater than 0.00 A, then remove power from the relay and then reapply power to reset the current value.
3. Apply a three phase current **(I)** to the relay greater than ($\mathbf{I_{max}}$) Amps and start timing.

   The time to trip should be **t** minutes ± 5 %.

Time Test (Preload):

1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.

■ **NOTE**: The 49 Thermal Overload 49 #1 current value can be obtained utilizing either the HMI (Status/ Current Status) or IPScom Communications Software (Relay/Monitor/Secondary Status).

2. Determine the 49 Thermal Overload 49 #1 current value. If the value is greater than 0.00 A, then remove power from the relay and then reapply power to reset the current values.
3. Apply a three phase preload current to the relay equal to ($\mathbf{I_o}$) Amps and allow current readings to stabilize.
4. Apply a three phase current **(I)** to the relay greater than ($\mathbf{I_{max}}$) Amps and start timing.

   The time to trip should be **t** minutes ± 5 %.

50 Instantaneous Phase Overcurrent Winding 1 (#1 or #2)

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C1			
TEST SETTINGS:	50W1 Pickup 1 Amp CT Rating	P	Amps	(1.0 to 100) (0.2 to 20)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Function 46IT	Disable		
	Function 49	Disable		
	Function 50W2/W3	Disable		
	Function 50N	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect inputs in Configuration C1 as designated previously. Refer to Section 6.4, Input Configurations, for configurations.

■ **NOTE:** Special attention must be taken as to which winding is being tested and which winding is disabled when changing setpoints.

4. ***Pickup Test***:
   a. Press and hold the **TARGET RESET** button in, then slowly increase current input 3 (C phase) until the **50/N W1 PHASE/RESIDUAL O/C** LED illuminates or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) Amps ±0.1 A (*±0.02 Amp 1 A CT*) or ±3%.
   b. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases.
5. ***Time Test***: With output contacts (**Z**) connected to the timer, apply current 5% above pickup (**P**) Amps and start timing. The operating time will be (**D**) cycles within ±2 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 configuration.

50 Instantaneous Phase Overcurrent Winding 2 (#1 or #2)

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C2			
TEST SETTINGS:	50W2 Pickup 1 Amp CT Rating	P	Amps	(1.0 to 100) (0.2 to 20)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Function 46IT	Disable		
	Function 49	Disable		
	Function 50W1/W3	Disable		
	Function 50N	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect inputs in Configuration C2 as designated previously. Refer to Section 6.4, Input Configurations, for configurations.

■ **NOTE:** Special attention must be taken as to which winding is being tested and which winding is disabled when changing setpoints.

4. ***Pickup Test***:
   a. Press and hold the **TARGET RESET** button in, then slowly increase current Input 3 (C phase) until the **50/N/G W2 PH/RES/GND O/C** LED illuminates or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) Amps ± 0.1 A (*± 0.02 Amp 1 A CT*) or ± 3%.
   b. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases.
5. ***Time Test***: With output contacts (**Z**) connected to the timer, apply current 5% above pickup (**P**) Amps and start timing. The operating time will be (**D**) cycles within ± 2 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.

50 Instantaneous Phase Overcurrent Winding 3 (#1 or #2)

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C3			
TEST SETTINGS:	50W3 Pickup 1 Amp CT Rating	**P**	Amps	(1.0 to 100) (0.2 to 20)
	Time Delay	**D**	Cycles	(1 to 8160)
	Programmed Outputs	**Z**	OUT	(1 to 8)
	Function 46IT	Disable		
	Function 49	Disable		
	Function 50W1/W2	Disable		
	Function 50N	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect inputs in Configuration C3 as designated previously. Refer to Section 6.4, Input Configurations, for configurations.

■ **NOTE:** Special attention must be taken as to which winding is being tested and which winding is disabled when changing setpoints.

4. ***Pickup Test***:
   a. Press and hold the **TARGET RESET** button in, then slowly increase current Input 3 (C phase) until the **50/N/G W3 PHASE/RES/GND O/C** LED illuminates or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) Amps ±0.1 A (*±0.02 Amp 1 A CT*) or ±3%.
   b. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases.
5. ***Time Test***: With output contacts (**Z**) connected to the timer, apply current 5% above pickup (**P**) Amps and start timing. The operating time will be (**D**) cycles within ±2 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.

50G Instantaneous Ground Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C4			
TEST SETTINGS:	50GW2/W3 Pickup	P	Amps	(1 to 100)
	1 Amp CT Rating			(0.2 to 20)
	Programmed Outputs	Z	OUT	(1 to 8)
	Function 51G	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested.
3. Connect the inputs in Configuration C4 as designated previously. Refer to Section 6.4, Input Configurations, for configurations. The other current phases remain disconnected.
4. ***Pickup Test****:*
   a. Press and hold the **TARGET RESET** button in, then slowly increase the I_{G2} current until the **50/N/G W2 PHASE/RES/GND 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 Amp 1 A CT) or ±3%.
   b. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets. This test may be repeated for each of the other phases.
5. ***Time Test****:* With output contacts (**Z**) connected to the timer, apply approximately 5% above pickup (**P**) amps and start timing. The operating time will be (**D**) cycles within ±2 cycles or 1%.
6. Repeat Steps 4 and 5, using I_{G3}. Observe **50/N/G W2 PHASE/RES/GND O/C** LED for pickup.
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 configuration.

50N Instantaneous Residual Overcurrent

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	As Described			
TEST SETTINGS:	Pickup 1 Amp CT Rating	P	Amps	(1.0 to 100) (0.2 to 20)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46DT, 46IT	Disable		
	Function 49	Disable		
	Function 50W1/W2/W3	Disable		
	Function 50BF	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87H/T	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 V1 and C1 (MODIFIED). Set to Nominal Voltage. See Section 6.4, Input Configurations, for configurations. Modification to C1 is to set all three currents to phase angle ∠0°.
4. ***Pickup Test***:
   a. Press and hold the **TARGET RESET** button in, then slowly increase the phase current until the **50/N W1 PHASE/RESIDUAL O/C** LED illuminates or the pickup indicator operates on the computer target screen. The current level of operation will be **(P)** Amps ± 0.1 A (± 0.02 Amp 1A CT) or ± 3%.
   b. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contact (**Z**) connected to the timer, apply approximately 5% above pickup (**P**) amps, and start timing. The operating time will be (**D**) cycles within ± 2 cycles or 1%.
6. Repeat steps 4 and 5 using current Configuration C2 (modified) and C3 (modified). Observe **50/N/G W2 PHASE/RES/GND O/C** LED and **50/N/G W3 PHASE/RES/GND O/C** LED for pickup.
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 configuration.

50BF Breaker Failure

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	As Described			
TEST SETTINGS:	50BFW1/W2/W3 Phase Pickup	P	Amps	(0.1 to 10)
	1 Amp CT Rating			(0.02 to 2)
	50BFW1/W2/W3 Residual Pickup	N	Amps	(0.1 to 10)
	1 Amp CT Rating			(0.02 to 2)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46DT, 46IT	Disable		
	Function 49	Disable		
	Function 50W1/W2/W3	Disable		
	Function 50N	Disable		
	Function 51	Disable		
	Function 51N	Disable		
	Function 87H/T	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect inputs in Configuration C1 designated previously. Refer to Section 6.4, Input Configurations, for configurations.

■ **NOTE:** For proper testing use I ≤ 3 X CT rating.

4. Select an input for 50BF Input Initiate (**IN**) and enter the number.
5. Place a jumper from Terminal **11** (RTN) to the selected input terminal (**IN**) on the rear of the unit.
6. Verify that all Output Initiates (**OUT**) are disabled.
7. ***Phase Pickup Test***:
   a. Press and hold the **TARGET RESET** button in, then slowly increase 3-phase current until the **50BF W1 BREAKER FAILURE** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be **P** Amps ±0.1 Amps (*±0.02 Amps 1 A CT*) or ±2%.
   b. Release the **TARGET RESET** button, then decrease the 3-phase current. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets.
8. ***Residual Pickup Test (Residual Current)***:
   a. Set the 50BF phase to a current higher than the residual pickup to prevent the 50BF phase from tripping.
   b. Connect the inputs in Configuration C1 (modified), designated previously. The modification to C1 is to set all three currents to phase angle ∠0°. In this configuration, the applied value of I_G is equal to the applied 3-phase currents.
   c. Press and hold the **TARGET RESET** button in, then slowly increase Winding 1 currents until the **50BF W1 BREAKER FAILURE** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be (**P**) Amps, ±0.1 Amps (*±0.02 Amps 1 A CT*) or ±2%
   d. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   e. Press **TARGET RESET** button to remove targets.

■ **NOTE:** When calculating values for residual current functions, phase levels must be added together. For example: $3I_0 = I_A + I_B + I_C$ must be used to calculate pickup time.

9. ***Timer Test :*** With output contacts (**Z**) connected to the timer, apply approximately 110% of above Pickup (**P**) Amps and start timing. The operating time will be **D** cycles within –1 or +3 cycles or ±2%.

■ **NOTE**: Both the 50BF Phase and Residual Functions use the same timer, therefore, it is only necessary to perform this test once.

10. Reduce input currents to 0 Amps.
11. Repeat Steps 4 through 10 using current Configuration C2 (modified) and C3 (modified). Observe **50BF W2 BREAKER FAILURE (50BF W3 BREAKER FAILURE)** LED for pickup.
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 configuration.

[1]Either a Standard Curve or an IEC Curve must be selected.

51 Inverse Time Phase Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C1 or C2 or C3			
TEST SETTINGS:	51W1/W2/W3 Pickup	P	Amps	(0.5 to 12)
	1 Amp CT Rating			(0.1 to 2.4)
	Standard Inverse Time Curves:[1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11)
	IEC Inverse Time Curves:[1]			
	IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.1)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46DT, 46IT	Disable		
	Function 49			
	Function 50W1/W2/W3	Disable		
	Function 50N	Disable		
	Function 51N	Disable		
	Function 87H/T	Disable		
	Function 87GD	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect current inputs in Configuration C1 as designated previously. See Section 6.4, Input Configurations, for configurations.

■ **NOTE**: Special Attention must be paid as to which winding is being tested and which winding is disabled.

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 currents used in calculations from step 4 and start timing. The operating time will be (**D**) cycles within ±3 cycles or 3% of calculated time. Repeat this step for each test level chosen. The tested points verify the operation of this function.
6. Observe **51/N/G W1 PH/RES/GND TIME O/C** LED for pickup.

IEC Standard Inverse	**IEC Very Inverse**	**IEC Extremely Inverse**	**IEC Long Time Inverse**
$t=TD \times \left[\frac{0.14}{M^{0.02}-1}\right]$	$t=TD \times \left[\frac{13.5}{M-1}\right]$	$t=TD \times \left[\frac{80}{M^{2}-1}\right]$	$t=TD \times \left[\frac{120}{M-1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

7. Repeat Steps 4 and 5 using Configurations C2 and C3. Observe **PH/RES/GND TIME O/C 51/N/G W2** LED and **PH/RES/GND TIME O/C 51/N/G W3** LED for pickup.
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 configuration.

[1]Either a Standard Curve or an IEC Curve must be selected.

51G Inverse Time Ground Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C2 or C3			
TEST SETTINGS:	51GW2/W3 Pickup	P	Amps	(0.5 to 12.00)
	1 Amp CT Rating			(0.1 to 2.4)
	Standard Inverse Time Curves:[1]			
	Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11)
	IEC Inverse Time Curves: [1]			
	IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.1)
	Programmed Outputs	Z	OUT	(1 to 8)
	Function 50G		Disable	
	Function 87GD		Disable	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect current inputs in Configuration C2 as designated previously. See 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.

IEC Standard Inverse	**IEC Very Inverse**	**IEC Extremely Inverse**	**IEC Long Time Inverse**
$t=TD \times \left[\frac{0.14}{M^{0.02}-1}\right]$	$t=TD \times \left[\frac{13.5}{M-1}\right]$	$t=TD \times \left[\frac{80}{M^{2}-1}\right]$	$t=TD \times \left[\frac{120}{M-1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

5. ***Time Test:*** With output contacts connected to the timer, apply currents used in calculations from Step 4 and start timing while observing **PH/RES/GND TIME O/C 51/N/G W2** LED for pickup. The operating time will be (**D**) cycles within ±3 cycles or ±3% of calculated time.
6. Repeat Step 5 for each test level chosen.
7. Repeat Steps 4, 5 & 6 using Configuration C3 and observing **PH/RES/GND TIME O/C 51/N/G W3** LED for pickup.
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 configuration.

[1]Either a Standard Curve or an IEC Curve must be selected.

51N Inverse Time Residual Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	As Described			
TEST SETTINGS:	51N W1/W2/W3 Pickup 1 Amp CT Rating	P	Amps (0.1 to 1.2)	(0.5 to 6)
	Standard Inverse Time Curves: [1] Curve	C		(1 to 4)
	Time Dial	TD		(0.5 to 11)
	IEC Inverse Time Curves: [1] IEC Curve	C		(5 to 8)
	IEC Time Dial	TD		(0.05 to 1.1)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46DT, 46IT, 49 Function 50W1/W2/W3 Function 50N Functions 51, 87H/T, 87GD		Disable Disable Disable Disable	

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedures.
2. Confirm settings to be tested. Only the winding being tested should be enabled; the others should be disabled.
3. Connect current inputs in Configuration C1 (modified). See Section 6.4, Input Configurations, for configurations. The modification to C1 is to set all three currents to phase angle ∠0°. In this configuration, the applied value of I_G is equal to the applied 3-phase currents.

■ **NOTE**: Special Attention must be paid to which winding is being tested and which winding is disabled.

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.

IEC Standard Inverse	**IEC Very Inverse**	**IEC Extremely Inverse**	**IEC Long Time Inverse**
$t=TD \times \left[\frac{0.14}{M^{0.02}-1}\right]$	$t=TD \times \left[\frac{13.5}{M-1}\right]$	$t=TD \times \left[\frac{80}{M^{2}-1}\right]$	$t=TD \times \left[\frac{120}{M-1}\right]$

t = time in seconds TD = Time Dial setting M = current in multiples of pickup

■ **NOTE**: When calculating values for residual current functions, phase levels must be added together. For example: $3I_0 = I_A + I_B + I_C$ must be used to calculate pickup time.

5. ***Time Test:*** With output contacts connected to the timer, apply input current used in calculations from Step 4 and start timing while observing **51/N/G W1 PH/RES/GND TIME O/C** LED for pickup. The operating time will be (**D**) cycles within ±3 cycles or 3% of calculated time.
6. Repeat Step 5 for each test level chosen. The tested points verify the operation of this function.
7. Repeat Steps 4, 5 & 6 using Configuration C2 (modified) and C3 (modified). Observe **PH/RES/GND TIME O/C 51/N/G W2** LED and **PH/RES/GND TIME O/C 51/N/G W3** LED for pickup.
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 configuration.

59G Ground Overvoltage

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	59G Pickup	P	Volts	(5 to 180)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 24DT, 24IT	Disable		
	Function 27	Disable		
	Function 81O/U	Disable		

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 as designated previously. Set the V.T. Configuration (Section 2.4) as V_G. See Section 6.4, Input Configurations, for configurations.
4. ***Pickup Test****:*
   a. Press and hold the **TARGET RESET** button, then slowly increase the input voltage until **59G GROUND OVERVOLT** LED illuminates or the pickup indicator operates on the computer target screen. The level should be equal to (**P**) volts ±0.5 V or ±0.5%.
   b. Release the **TARGET RESET** button, then decrease the input voltage. The **OUTPUT** LED will extinguish.
   c. Press **TARGET RESET** button to remove targets.
5. ***Time Test****:* With output contracts being connected to the timer, apply (P+1) Volts and start timing. The operating time will be (**D**) cycles within ±1 cycle 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 configuration.

81 Overfrequency/Underfrequency

VOLTAGE INPUTS:	Configuration V1			
CURRENT INPUTS:	None			
TEST SETTINGS:	Pickup	P	Hz	(55 to 65)
	50 Hz Relay			(45 to 55)
	Time Delay	D	Cycles	(2 to 65,500)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 24DT, 24IT	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. Set the V.T. Configuration (Section 2.4) as V_A. Refer to Section 6.4, Input Configurations for configuration.
4. ***Pickup Test:***

■ **NOTE**: When using single-phase frequency sources, connect the source to one voltage input.

   a. Set the voltages to the Nominal Frequency. Single-phase frequency sources may be used.
   b. Press and hold the **TARGET RESET** button in, then slowly decrease the frequency of the input voltage until the **OVER/UNDER FREQUENCY 81** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** Volts ±0.1 Hz.
   c. Release the **TARGET BUTTON**, then return to nominal input frequency. The **OUTPUT** LED will extinguish.
   d. Press **TARGET RESET** button to remove targets.

5. ***Time Test:*** With output contacts being connected to the timer, input (**P** – 0.5) Hz and start timing. The operating time will be (**D**) cycles within –1 to +3 cycles or ±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 configuration.

87H Phase Differential Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C5			
TEST SETTINGS:	Pickup	P	PU	(5 to 20)
	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46IT, 49	Disable		
	Function 50W1/W2/W3	Disable		
	Function 50N, 50BF	Disable		
	Function 51, 51N	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 C5 as designated previously. Refer to Section 6.4, Input Configurations for configuration. For testing purposes it is recommended that the CT Tap Corrections, **CT1**, **CT2**, and **CT3**, be set to 1.0. If it is desired to test with other CT Tap settings, the current values must be computed by using the following formulas:

   I_AW_1 (Applied) = I_AW_1 (Calculated) multiplied by CT1.

   I_AW_2 (Applied) = I_AW_2 (Calculated) multiplied by CT2.

   I_AW_3 (Applied) = I_AW_3 (Calculated) multiplied by CT3.

■ **NOTE:** All values used for this function are measured in *PU*'s, which requires calculating the actual current in Amps to be used for testing: 1 **PU** = CT Tap.

4. ***Minimum Pickup Test****:*
   a. Set the I_AW_1 (input 1) = 0 Amps.
   b. Press and hold the **TARGET RESET** button in, then slowly increase I_AW_2 (Input 2) until the **PHASE DIFFERENTIAL 87H/T** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation will be equal to (**P**) PU's ±0.1 PU or ±3%.
   c. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   d. Press **TARGET RESET** button to remove targets. This test may be repeated for testing the opposite winding or another phase.
5. ***Timer Check****:* With output contacts being connected to the timer, apply at least 10% higher I_AW_2 (Input 2) current than the minimum pickup level and start timing. The operating time will (**D**) cycles within –1 to +3 cycles or ±1%.
6. If desired, repeat Steps 4 & 5 setting I_AW_2 (input 2) and/or I_AW_3 (input 3) to 0 Amps and increasing I_AW_1 (Input 1).
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 configuration.

87T Phase Differential Overcurrent

VOLTAGE INPUTS:	None			
CURRENT INPUTS:	Configuration C5			
TEST SETTINGS:	Pickup	P	PU	(0.1 to 1)
	Percent Slope #1	S1	%	(5 to 100)
	Percent Slope #2	S2	%	(5 to 200)
	Slope Break Point	BP	PU	(1.0 to 4.0)
	Even Harmonics Restraint	E	%	(5 to 50)
	5th Harmonics Restraint	F	%	(5 to 50)
	Pickup at 5 th Harmonic Restraint	FP	PU	(0.1 to 2.0)
	CT Tap W1/W2/W3 1 Amp CT Rating	CT1/2/3		(1 to 10.00) (0.2 to 2)
	Programmed Outputs	Z	OUT	(1 to 8)
	Functions 46IT, 49 Function 50W1/W2/W3 Function 50N, 50BF Function 51, 51N	Disable Disable Disable 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 C5 as designated previously. Refer to Section 6.4, Input Configurations for configuration. For testing purposes it is recommended that the CT Tap Corrections, **CT1** and **CT2**, be set to 1.0. If it is desired to test with other CT Tap settings, the current values must be computed by using the following formulas:

   I_AW_1 (Applied) = I_AW_1 (Calculated) multiplied by CT1.

   I_AW_2 (Applied) = I_AW_2 (Calculated) multiplied by CT2.

   I_AW_3 (Applied) = I_AW_3 (Calculated) multiplied by CT3.

■ **NOTE:** All values used for this function are measured in *PU*'s, which requires calculating the actual current in Amps to be used for testing: 1 PU = CT Tap.

4. ***Minimum Pickup Test:***
   a. Set I_AW_1 (input 1) = 0 Amps.
   b. Press and hold the **TARGET RESET** button, then slowly increase I_AW_2 (Input 2) until the **PHASE DIFFERENTIAL 87H/T** LED illuminates, or the pickup indicator operates on the computer target screen. The level of operation will be equal to **P** PU'S ±0.02 PU or ±5%.
   c. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   d. Press the **TARGET RESET** button to remove targets. This test may be repeated for testing the opposite winding or another phase.
5. ***Slope 1 Test:***
   a. Define any number of testing points desirable to verify the trip I_AW_2 (Input 2) curve.
   b. Choose any values for I_AW_2 (Input 2), and calculate the expected I_A (Input 2) according to the following:

$I_AW_1 - I_AW_2$	>	$(I_AW_1 + I_AW_2)$	x	S1/100	÷ 2
Difference in Currents	is greater than	sum of the currents	times	the per unit Slope1	divided by two.

Or

$$I_AW_1 = I_AW_2 \left[\frac{(200 + S1)}{(200 - S1)}\right]$$

S1= slope in % from above.

■ **NOTE**: The differential current $I_AW_1 - I_AW_2$ must be greater than the minimum pickup current (**P**) and less than the Break Point (**BP**) value for proper operation.

c. Set I_AW_1 (Input 1) and I_AW_2 (Input 2) at the chosen value.

d. Press and hold the **TARGET RESET** button in, then slowly increase I_AW_2 (Input 2) until the **PHASE DIFFERENTIAL 87H/T** LED illuminates, or the pickup indicator operates on the computer target screen. The level of operation will equal to (**P**) ±0.02 PU or ±5%.

e. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.

f. Press the **TARGET RESET** button to remove targets. This test may be repeated for testing the opposite winding or another phase.

7. ***Slope 2 Test:***

a. Define any number of testing points desirable to verify the trip I_AW_2 (Input 2) current curve.

b. Choose any values for I_AW_2 (Input 2) and calculate the expected I_A (Input 2) according to the following:

$$I_AW_1 = \frac{\left[I_AW_2\left(1 + \frac{S2}{200}\right) + BP\left(\frac{S1-S2}{100}\right)\right]}{\left(1 - \frac{S2}{200}\right)}$$

S1 and **S2** = slope in % from above. The differential current, $I_AW_1 - I_AW_2$ must be greater than both the minimum pickup current (**P**) and the **BP** values.

c. Set I_AW_1 (Input 1) and I_AW_2 (Input 2) to the chosen value.

d. Press and hold the **TARGET RESET** button, then slowly increase I_AW_1 (Input 1) current until the **PHASE DIFFERENTIAL 87H/T** LED illuminates or the pickup indicator operates on the computer target screen. The level of operation should be equal to (**P**) PU ±0.02 PU or ±1%.

e. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.

f. Press the **TARGET RESET** button to remove targets. This test may be repeated for testing the opposite winding or another phase.

9. ***Second Harmonic Restraint Test***

a. Ensure that Even Harmonic Restraint is enabled with the amplitude of I_AW_1 (input 1) at 60 Hz (or 50 Hz) set to 10% above (**P**) PU setting and verify that the **PHASE DIFFERENTIAL 87H/T** LED illuminates.

b. Apply 0 Amps at 120 Hz (100 Hz for 50 Hz units) to I_AW_1 (Input 1).

c. Press and hold the **TARGET RESET** button in, then slowly increase the amplitude of I_AW_1 until the **PHASE DIFFERENTIAL 87H/T** LED extinguishes. This level will be (**E**) times (**P**) PU, ±1%.

11. ***Fourth Harmonic Restraint Test:***
    a. Ensure that Even Harmonic Restraint is enabled with the amplitude of I_AW_1 (Input 1) at 60 Hz (or 50 Hz) set to 10% above **P** PU setting and verify the **PHASE DIFFERENTIAL 87H/T** LED is illuminated.
    b. Apply 0 Amps at 240 Hz (200 Hz for 50 Hz units) to I_AW_1 (Input 1).
    c. Press and hold the **TARGET RESET** button in, then slowly increase the amplitude of the 4th Harmonic current I_AW_1 until the **PHASE DIFFERENTIAL 87H/T** LED extinguishes. This level will be (**E**) times (**P**) PU, ±1%.
12. ***Fifth Harmonic Restraint Test:***
    a. Ensure that 5th Harmonic Restraint is enabled with the amplitude of I_AW_1 (Input 1) at 60 Hz (or 50 Hz) set to above (**P**) PU, and below (**FP**) PU settings and verify the **PHASE DIFFERENTIAL 87H/T** LED is illuminated.
    b. Apply (**P**) times (**F**) +10% Amps at 300 Hz (250 Hz for 50 Hz units) to I_AW_1 (Input 1), and verify that the **PHASE DIFFERENTIAL 87H/T** LED extinguishes.
    c. Press and hold the **TARGET RESET** button in, then slowly decrease the amplitude of the 5th Harmonic current I_AW_1 until the **PHASE DIFFERENTIAL 87H/T** LED illuminates. This level will be (**F**) times (**P**) PU, ±1%.
13. ***Elevated Pickup at 5th Harmonic Restraint Test***
    a. Ensure that 5th Harmonic Restraint is enabled with 60 Hz (or 50 Hz) set to 10% above (**FP**) PU, and verify that the **PHASE DIFFERENTIAL 87H/T** LED illuminates.
    b. Apply (**P**) times (**F**) + 10% Amps at 300 Hz (250 Hz for 50 Hz units) to I_AW_1 (Input 1), then verify that the **PHASE DIFFERENTIAL 87H/T** LED extinguishes.
    c. Press and hold the **TARGET RESET** button, then slowly decrease the 60 Hz (or 50 Hz) amplitude of I_AW_1 until the **PHASE DIFFERENTIAL 87H/T** LED extinguishes. This level will be (**FP**) PU, ±0.1 PU or ±5%.
14. 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 configuration.

87GD Ground Differential

VOLTAGE INPUTS: None

CURRENT INPUTS: Configuration C4, C5 (As Described Below)

TEST SETTINGS:

87GD Pickup	P	Amps	(0.2 to 10)
1 Amp CT Rating			(0.04 to 2)
Time Delay	D	cycles	(1 to 8160)
CT Ratio Correction			(0.10 to 7.99)
Programmed Outputs	Z	OUT	(1 to 8)
Function 50G	Disable		
Function 50N	Disable		
Function 51G	Disable		
Function 51N	Disable		

1. Disable functions as shown. Refer to Section 3.2, **Configure Relay Data**, for procedure.
2. Confirm settings to be tested. For testing purposes, it is recommended that the CT Ratio Corrections be set to 1.0. Otherwise, current values must be computed by using the following formulas:

   $I_{G2}W_2$ = Applied Current to Winding 2 $I_{G2}W_2$ divided by CT2.

   $I_{G3}W_3$ = Applied Current to Winding 3 $I_{G3}W_3$ divided by CT3.
3. ***Non-Directional Pickup Test*:**
   a. Connect current input to I_{G2}, terminal numbers 50 and 51.
   b. Press and hold the **TARGET RESET** button in, then slowly increase I_G until the **GND DIFFERENTIAL 87GD W2** LED illuminates or the pickup indicator operates on the computer target screen. The level at operation will be equal to **(P)** Amps ±0.1 Amps or 5% (*±0.02 Amp 1 A CT*).
   c. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   d. Press **TARGET RESET** button to remove targets.
4. ***Directional Pickup Test*:**
   a. Connect current input to I_{G2}, terminal numbers 50 and 51. Connect I_AW_2, I_B, or I_C to current Input 1. Set I_{G2} to a magnitude equal to ½ (**P**) Amps.
   b. Set I_AW_2, I_B, or I_C to ∠180°, then slowly increase phase current until the **GND DIFFERENTIAL 87GD W2** LED illuminates or the pickup indicator operates on the computer screen. Operation will occur when the sum of I_{G2} and the applied phase current equal (**P**) Amps ±0.1 Amps or ±5% (*±0.02 Amp 1 A CT*).
   c. Release the **TARGET RESET** button, then decrease the current. The **OUTPUT** LED will extinguish.
   d. Reverse either current (currents now rephase) and re-test. The relay will not operate. The unit will operate regardless of the phase relationship if the phase current is reduced to 140 mAmps or less, and the difference in current between I_{G2} and phase current exceeds the pickup value.
5. ***Time Test*:** With output contacts connected to the timer, apply current at least 10% higher than (**P**) Amps and start timing while observing **GND DIFFERENTIAL 87GD W3** LED for pickup. The operating time will be (**D**) cycles within –1 to +3 cycles.
6. Repeat Step 5 for I_{G3}, connecting current to terminals 58 and 59.
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 configuration.

External Functions (#1–6)

VOLTAGE INPUTS:	As required			
CURRENT INPUTS:	As required			
TEST SETTINGS:	Time Delay	D	Cycles	(1 to 8160)
	Programmed Outputs	Z	OUT	(1 to 8)
	Blocking Inputs			(1 to 6)
	Output Initiate			(1 to 8)
	Function Initiate	(All Available Functions)		
	Initiate via Communication			
	Input Initiate			(1 to 6)
	Block via Communication			

1. Refer to Figure 2-26, External Logic Element, for logic gate configurations.
2. Select gate configuration (AND/OR) for Output Initiate, Function Initiate, Blocking Inputs and Inputs Main.
3. Select Initiating Inputs for each gate (if AND gate is selected, ensure at least two outputs are chosen). It will be necessary to enable and operate other functions to provide inputs for the Function Initiate and Output Initiate gates.
4. ***Pickup Test***: With output contact(s) **Z** connected to the timer, apply inputs to gates and start timing. The operating time will be (**D**) cycles within –1 to +3 cycles or ± 1%, and the **EXTERNAL EXT** LED and the **OUTPUT** LED will illuminate or the pickup indicator will operate on the computer target screen.
5. ***Blocking Input Test:*** To test the designated blocking inputs, press and hold the **TARGET RESET** button, then short input terminals designated as blocking inputs. The **EXTERNAL #1 EXT 1** LED will extinguish.
6. Repeat for each designated external triggering contact.
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 configuration.

This Page Left Intentionally Blank

A Appendix – Forms

This Appendix contains forms for photocopying, and recording the configuration and setting of the M-3311 Transformer Protection Relay, and to file the data for future reference. Examples of the suggested use of these forms are illustrated in Chapter 2, **Application** and Chapter 3, **Operation (Front Panel)**.

Page A-2 contains a copy of the Relay Configuration Table (which is also discussed in Section 2.2 Configuration, Functions), and is herein 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. Also 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 which is accessible via M-3820B 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 by 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:

```
81U#1 UNDERFREQUENCY
disable ENABLE
```

```
81U#1 BLOCK INPUT
    i6 i5 i4 i3 i2 i1
```

```
81U#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1
```

FUNCTION	DO/UTPU/TS 8	7	6	5	4	3	2	1	INPUTS 6	5	4	3	2	1
24 DEF TIME #1														
24 DEF TIME #2														
24 INV TIME														
27														
46 DEF TIME W2														
46 INV TIME W2														
46 DEF TIME W3														
46 INV TIME W3														
49														
50W1 #1														
50W1 #2														
50W2 #1														
50W2 #2														
50W3 #1														
50W3 #2														
50BFW1														
50BFW2														
50BFW3														
50GW2 #1														
50GW2 #2														
50GW3 #1														
50GW3 #2														
50NW1 #1														
50NW1 #2														
50NW2 #1														
50NW2 #2														
50NW3 #1														
50NW3 #2														

Table A-1 Relay Configuration (page 1 of 2)

FUNCTION	D		O	U	T	P	U	T	S		I	N	P	U	T	S
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
51W1 #1																
51W1 #2																
51W2 #1																
51W2 #2																
51W3 #1																
51W3 #2																
51GW2																
51GW3																
51NW1																
51NW2																
51NW3																
59G #1																
59G #2																
81 #1																
81 #2																
81 #3																
81 #4																
87H																
87T																
87GDW2																
87GDW3																
EXT #1																
EXT #2																
EXT #3																
EXT #4																
EXT #5																
EXT #6																
BM W1 #1																
BM W2 #1																
BM W3 #1																

Table A-1 Relay Configuration (page 2 of 2)

Key to Input Data Record Forms

A. All [ ] screens shown on forms require data inputs. Whatever is in that screen when the ENTER button is pressed will be installed in the relay.

B. All heavy bordered [ ] screens are **MENU** screens that have horizontal choices made with right or left arrows.

C. The up and down arrows are for navigating through the menus and adjusting value or letter (lower/upper case) selections.

D. 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 selections.

E. Pressing **EXIT** at any time will exit from the displayed screen to the preceding menu.

F. The arrow symbols (← →) on the edges of a display indicate additional horizontal menu choices are available in the indicated direction. As previously described, the right and left arrows will move the operator to those additional choices.

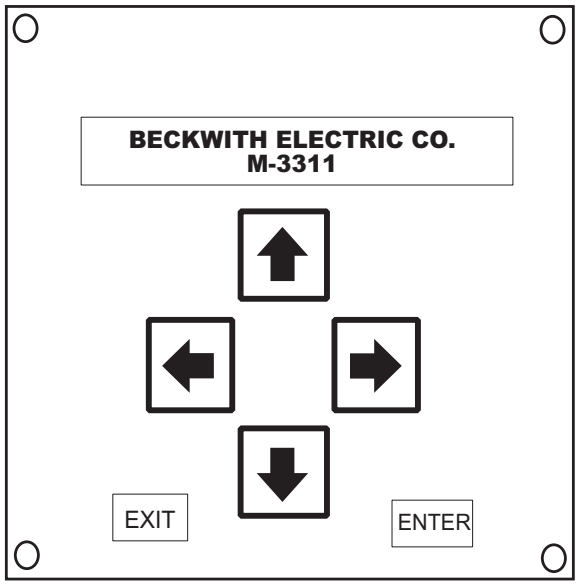


Figure A-1 M-3931 Human-Machine Interface Module

CONFIGURE RELAY
VOLTAGE_RELAY →

27 PHASE UNDERVOLTAGE
disable enable

27 BLOCK INPUT
i6 i5 i4 i3 i2 i1

27 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

59G#1 GROUND OVERVOLTAGE
disable enable

59G#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

59G#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

59G#2 GROUND OVERVOLTAGE
disable enable

59G#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

59G#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

CONFIGURE RELAY
← CURRENT_RELAY →

46DTW2 DEF TIME NSEQ O/C
disable enable

46DTW2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

46DTW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

46ITW2 INV TIME NSEQ O/C
disable enable

46ITW2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

46ITW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

CONFIGURE RELAY
← ext brkr CONFIG →

46DTW3 DEF TIME NSEQ O/C
disable enable

46DTW3 BLOCK INPUT
i6 i5 i4 i3 i2 i1

46DTW3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

46ITW3 INV TIME NSEQ O/C
disable enable

46ITW3 BLOCK INPUT
i6 i5 i4 i3 i2 i1

46ITW3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

49 THERMAL PROTECTION
disable enable

49 BLOCK INPUT
i6 i5 i4 i3 i2 i1

49 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W1#1 INST PHASE O/C
disable enable

50W1#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W1#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W1#2 INST PHASE O/C
disable enable

50W1#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W1#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W2#1 INST PHASE O/C
disable enable

50W2#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W2#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W2#2 INST PHASE O/C
disable enable

50W2#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W2#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W3#1 INST PHASE O/C
disable enable

50W3#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W3#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50W3#2 INST PHASE O/C
disable enable

50W3#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50W3#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51W1 INV TIME O/C
disable enable

51W1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51W1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51W2 INV TIME O/C
disable enable

51W2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51W2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51W3 INV TIME O/C
disable enable

51W3 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51W3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

Figure A-2 Functional Configuration Record Form (Page 1 of 4)

CONFIGURE RELAY
← ext brkr CONFIG →

50GW2#1 INST GROUND O/C
disable enable

50GW2#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50GW2#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50GW2#2 INST GROUND O/C
disable enable

50GW2#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50GW2#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50GW3#1 INST GROUND O/C
disable enable

50GW3#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50GW3#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50GW3#2 INST GROUND O/C
disable enable

50GW3#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50GW3#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51GW2 INV TIME GND O/C
disable enable

51GW2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51GW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51GW3 INV TIME GND O/C
disable enable

51GW3 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51GW3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW1#1 INST RESID O/C
disable enable

50NW1#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW1#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW1#2 INST RESID O/C
disable enable

50NW1#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW1#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW2#1 INST RESID O/C
disable enable

50NW2#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW2#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW2#2 INST RESID O/C
disable enable

50NW2#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW2#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW3#1 INST RESID O/C
disable enable

50NW3#1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW3#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

50NW3#2 INST RESID O/C
disable enable

50NW3#2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

50NW3#2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51NW1 INV TIME RESID O/C
disable enable

51NW1 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51NW1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51NW2 INV TIME RESID O/C
disable enable

51NW2 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51NW2 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

51NW3 INV TIME RESID O/C
disable enable

51NW3 BLOCK INPUT
i6 i5 i4 i3 i2 i1

51NW3 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

87H HI SET DIFFERENTIAL
disable enable

87H BLOCK INPUT
i6 i5 i4 i3 i2 i1

87H RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

87T DIFFERENTIAL CURRENT
disable enable

87T BLOCK INPUT
i6 i5 i4 i3 i2 i1

87T RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 o1

Figure A-2 Functional Configuration Record Form (Page 2 of 4)

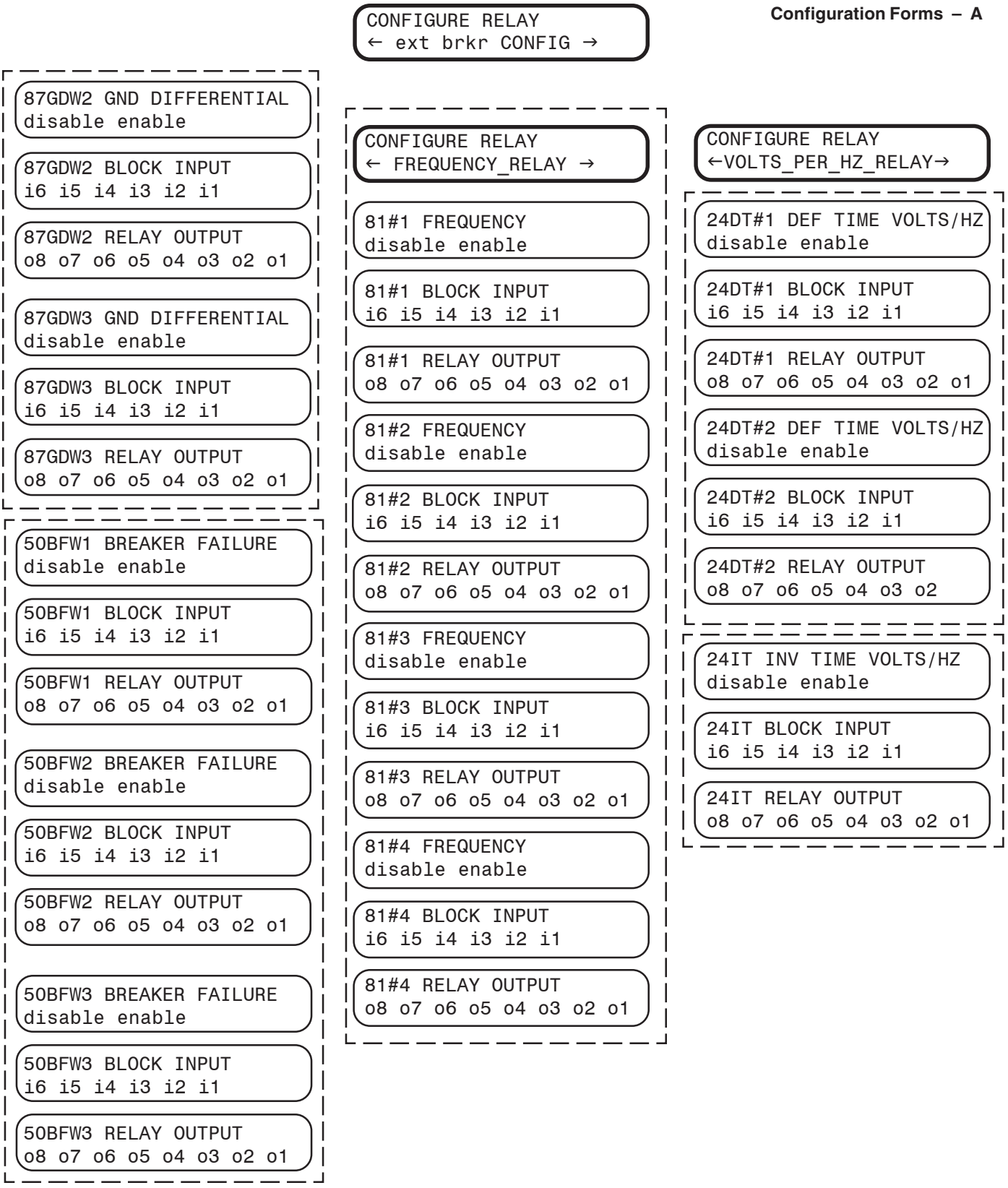


Figure A-2 Functional Configuration Record Form (Page 3 of 4)

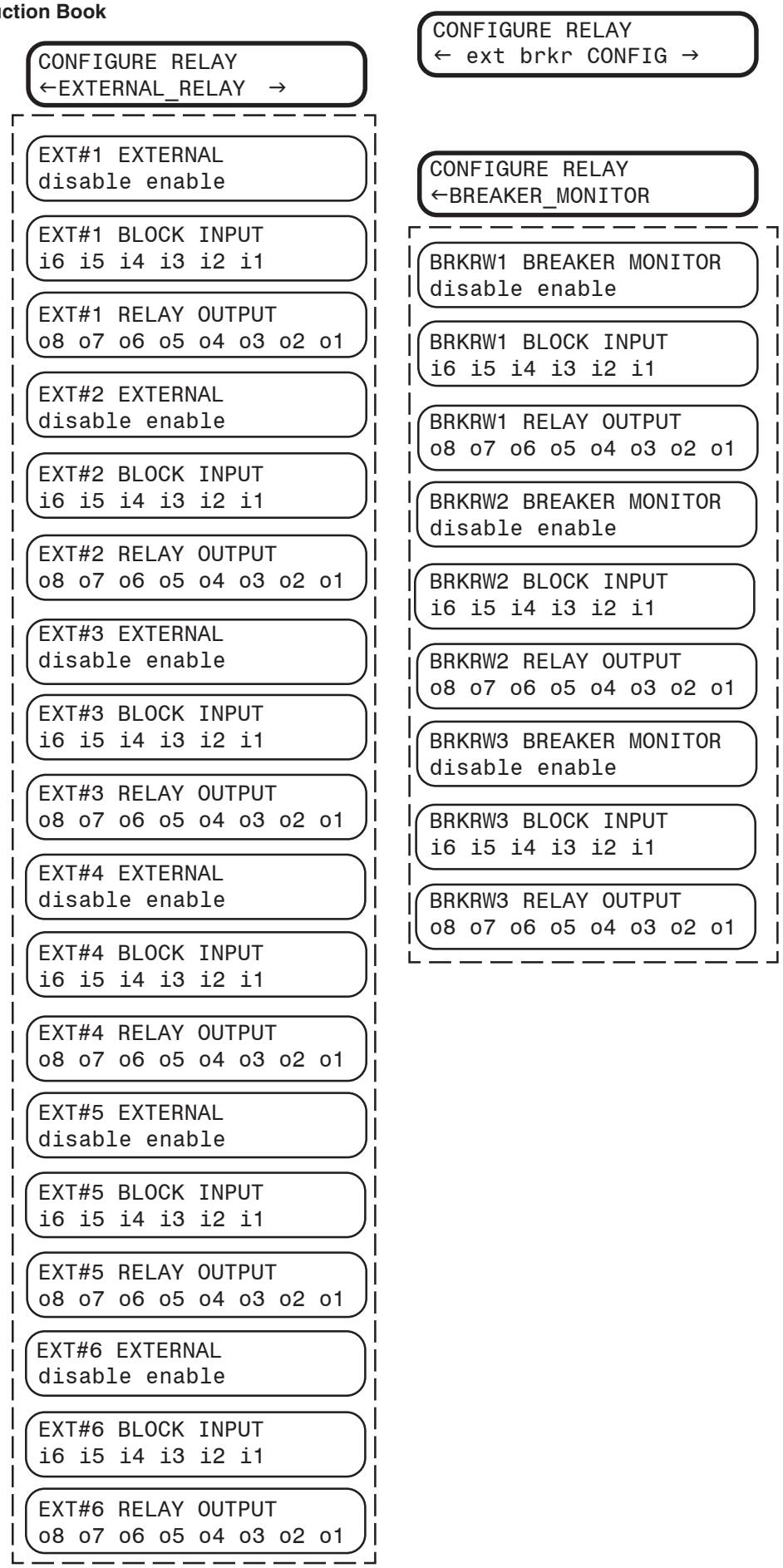


Figure A-2 Functional Configuration Record Form (Page 4 of 4)

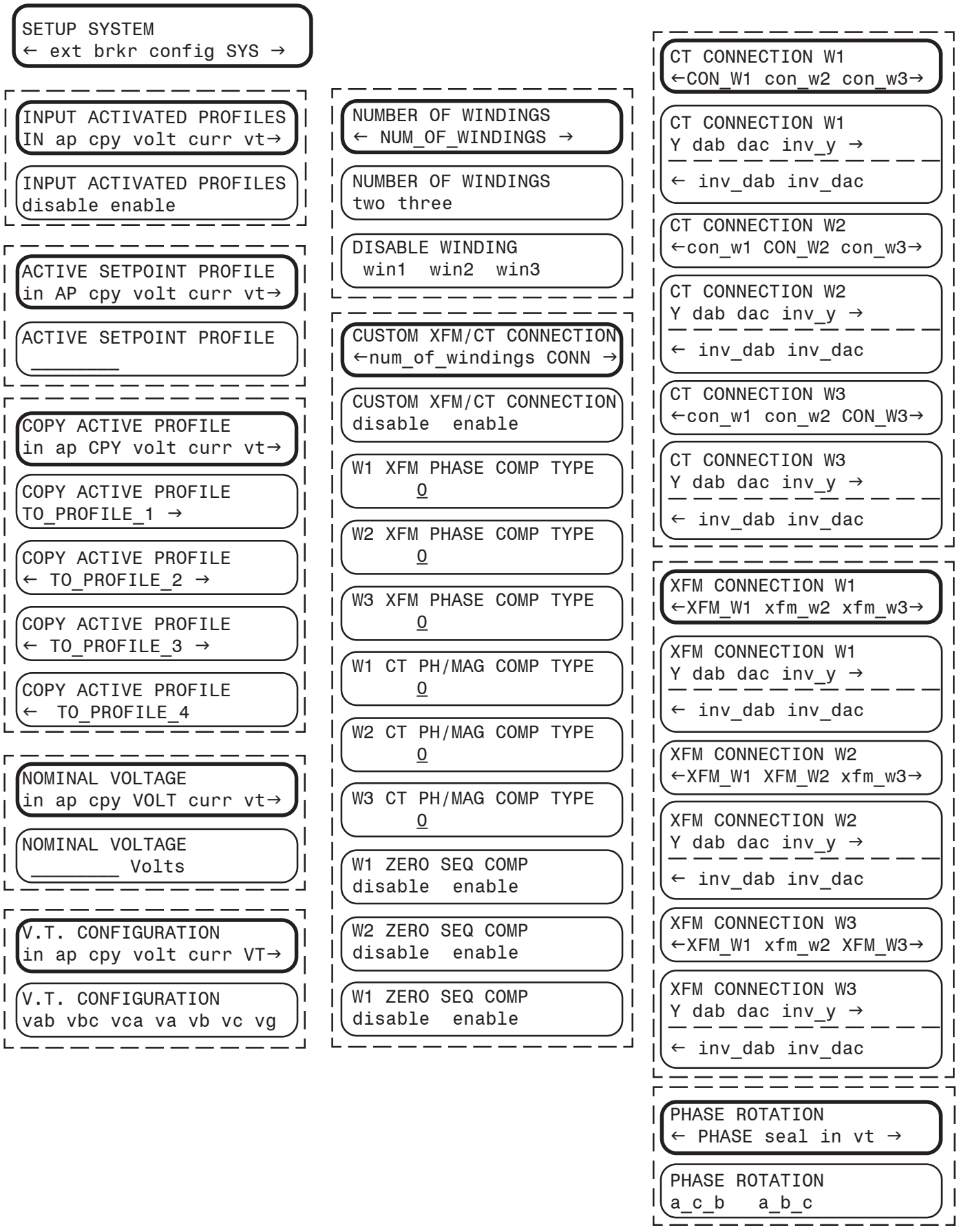


Figure A-3 Communication Data & Unit Setup Record Form (Page 1 of 3)

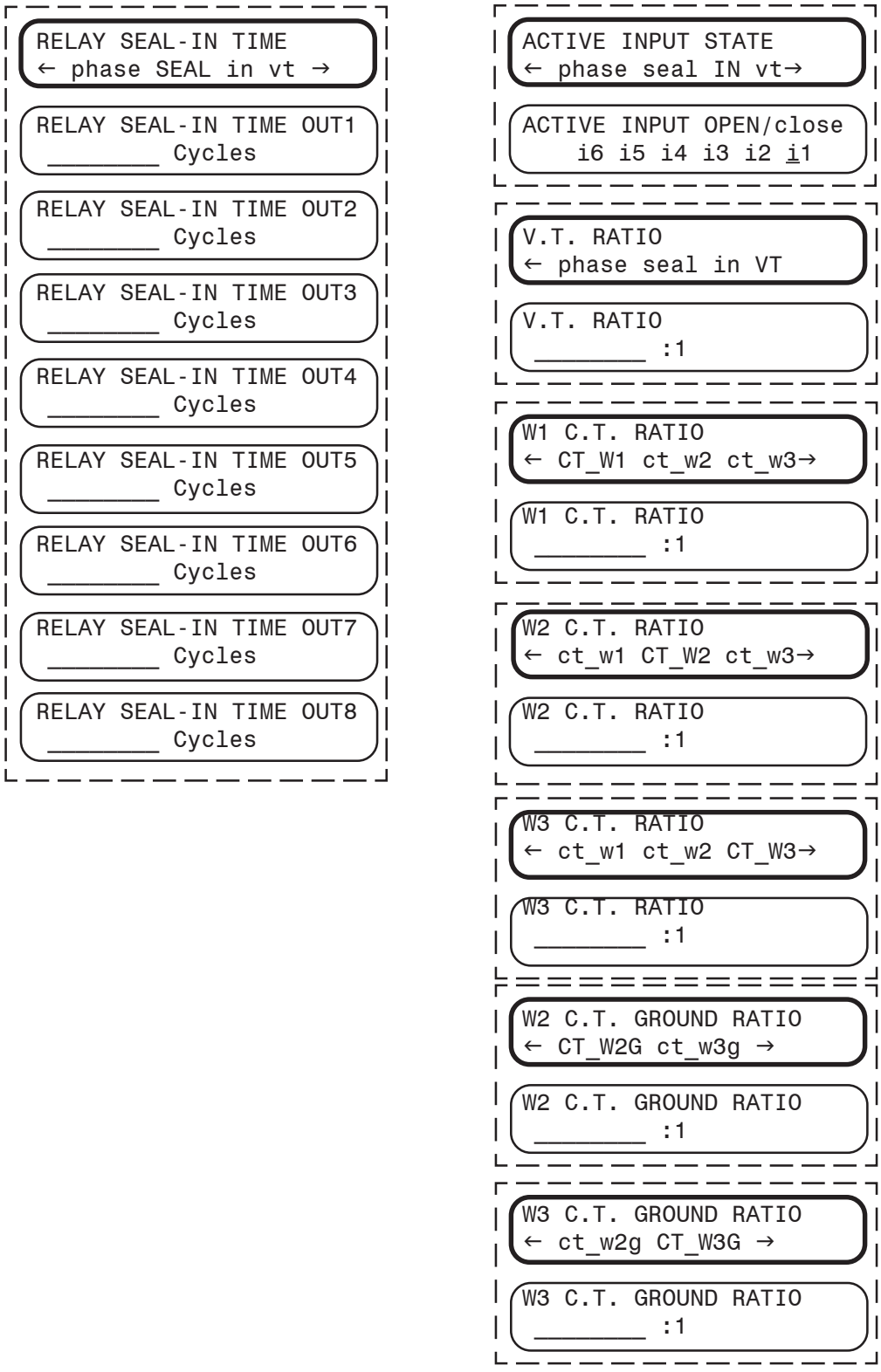


Figure A-3 Communication Data & Unit Setup Record Form (Page 2 of 3)

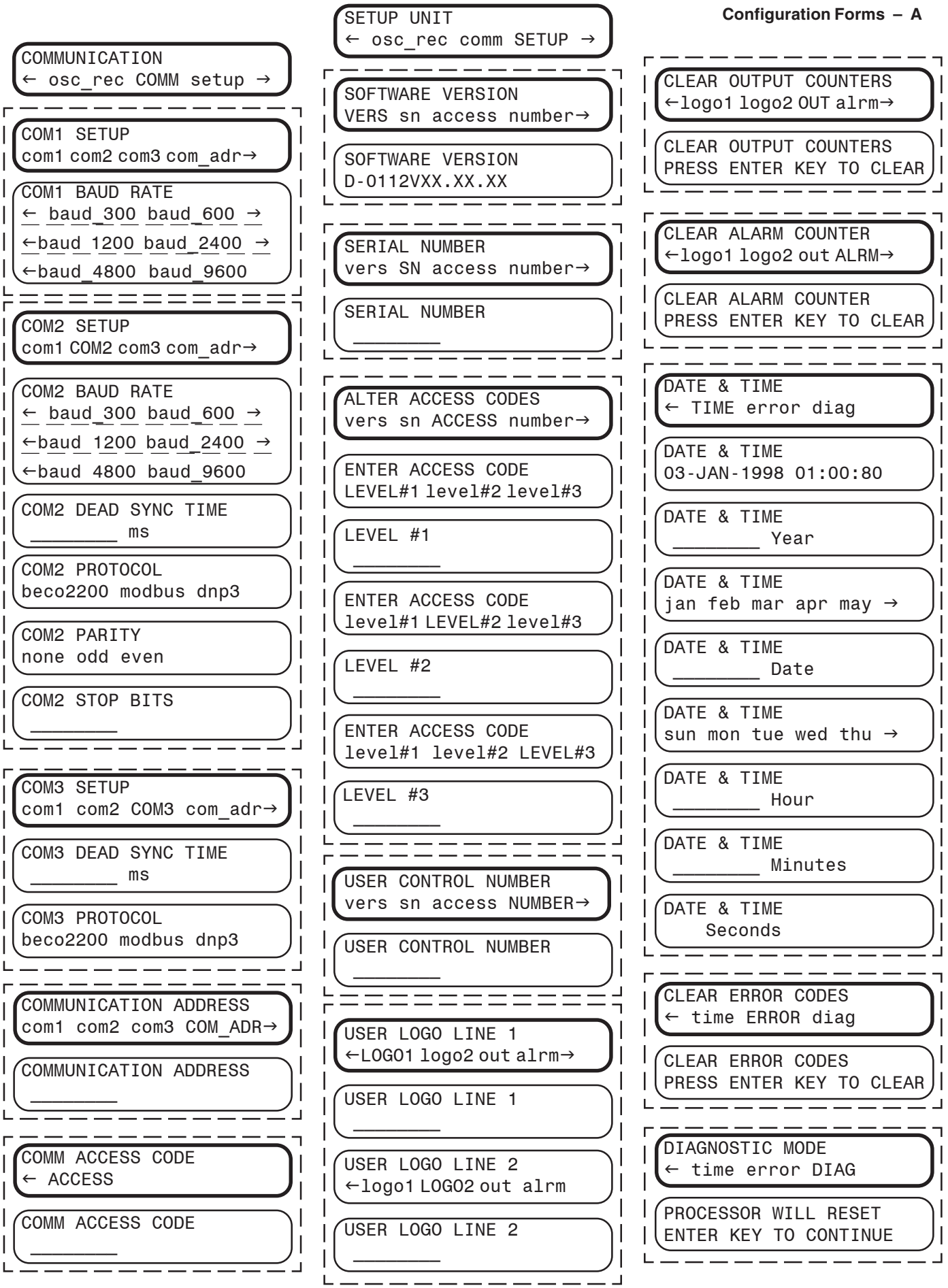


Figure A-3 Communication Data & Unit Setup Record Form (Page 3 of 3)

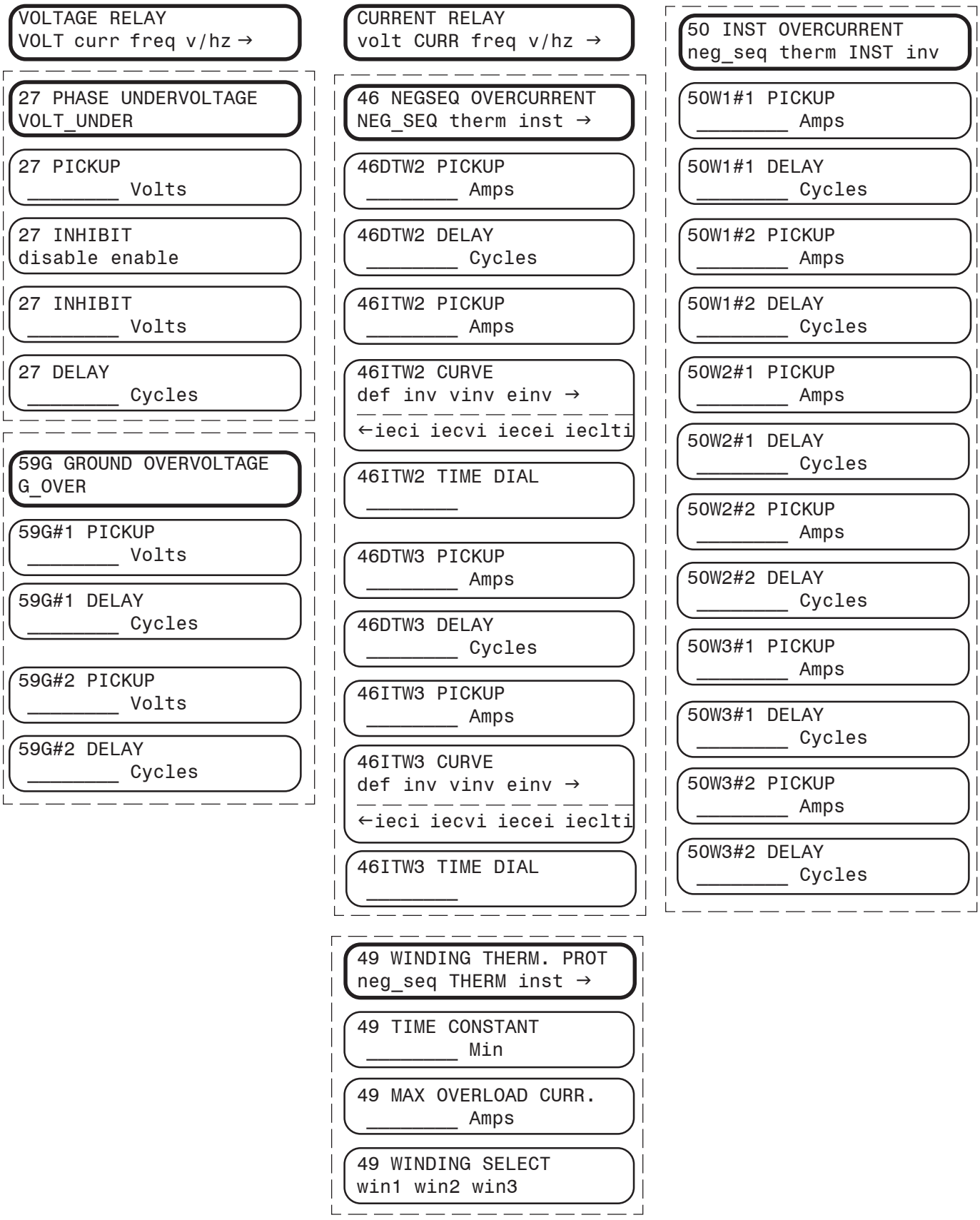


Figure A-4 Setpoint & Timing Record Form (Page 1 of 6)

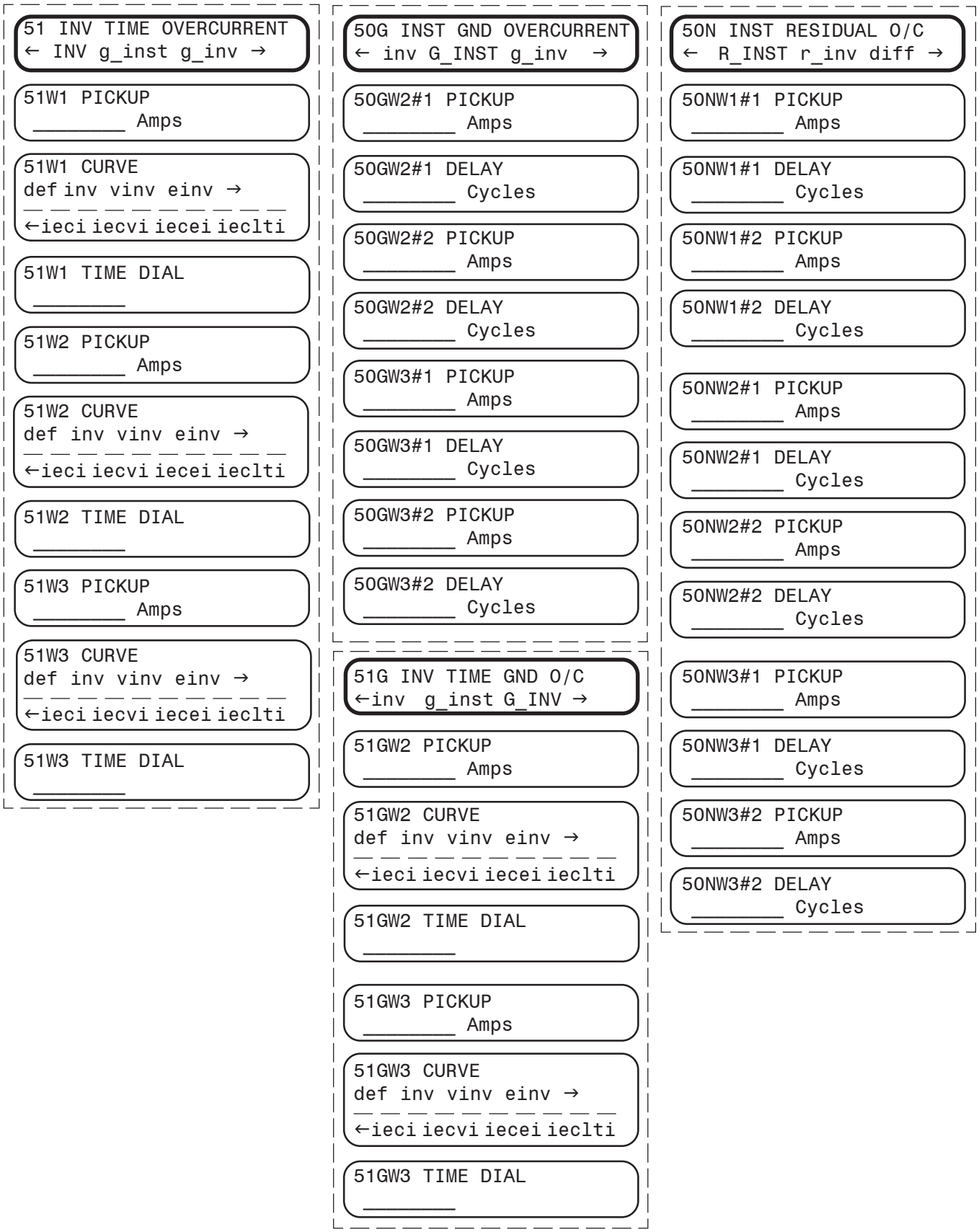


Figure A-4 Setpoint & Timing Record Form (Page 2 of 6)

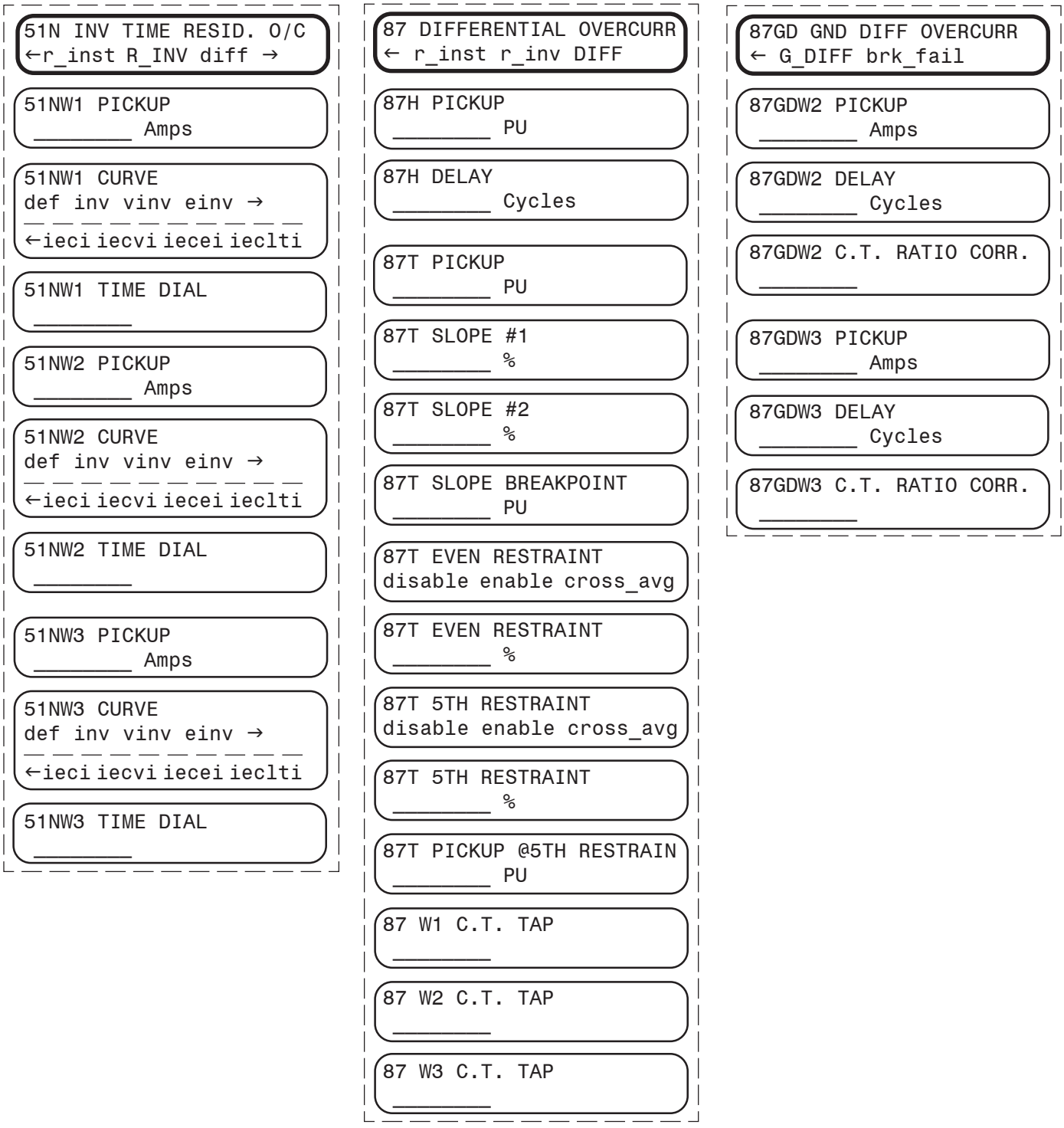


Figure A-4 Setpoint & Timing Record Form (Page 3 of 6)

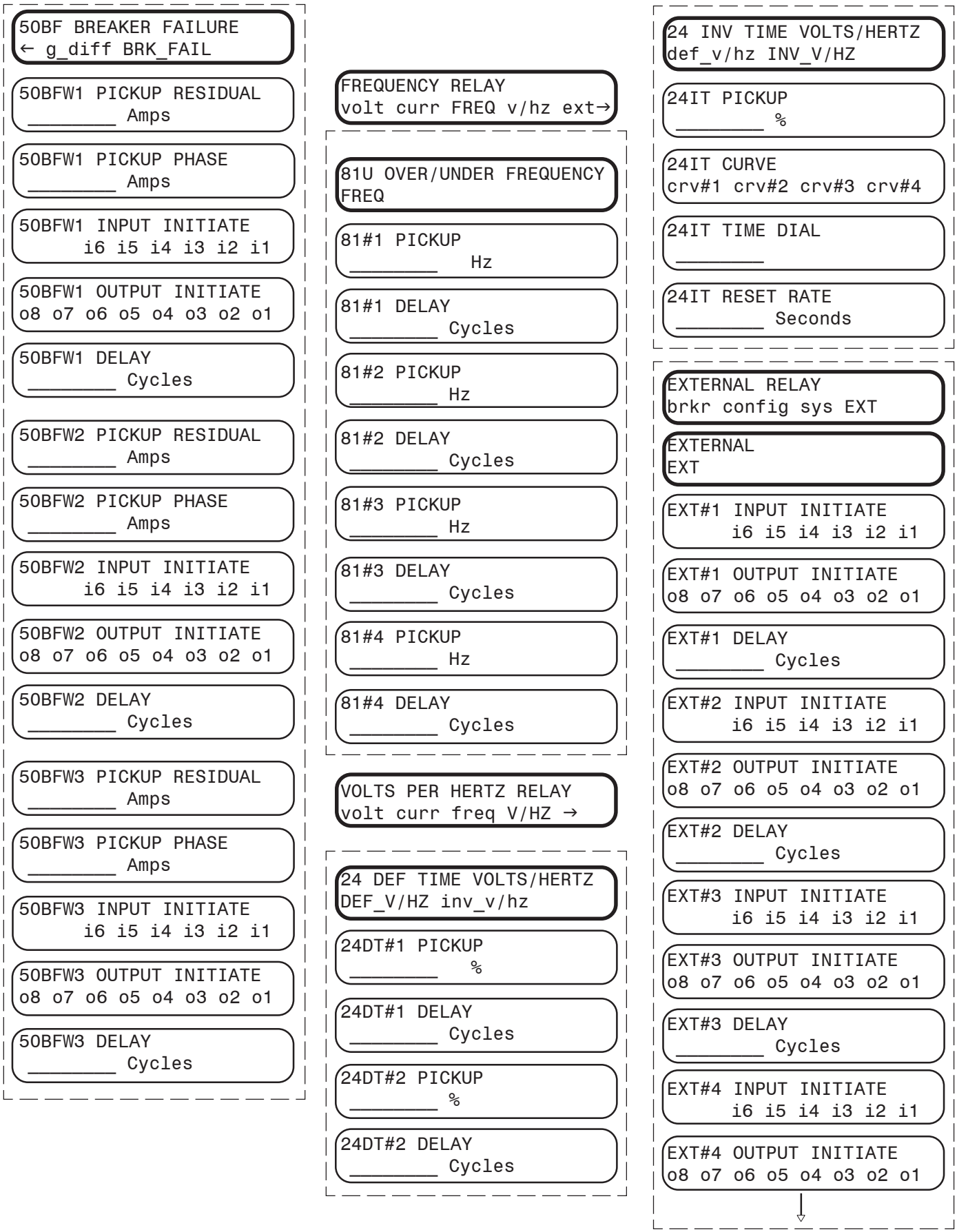


Figure A-4 Setpoint & Timing Record Form (Page 4 of 6)

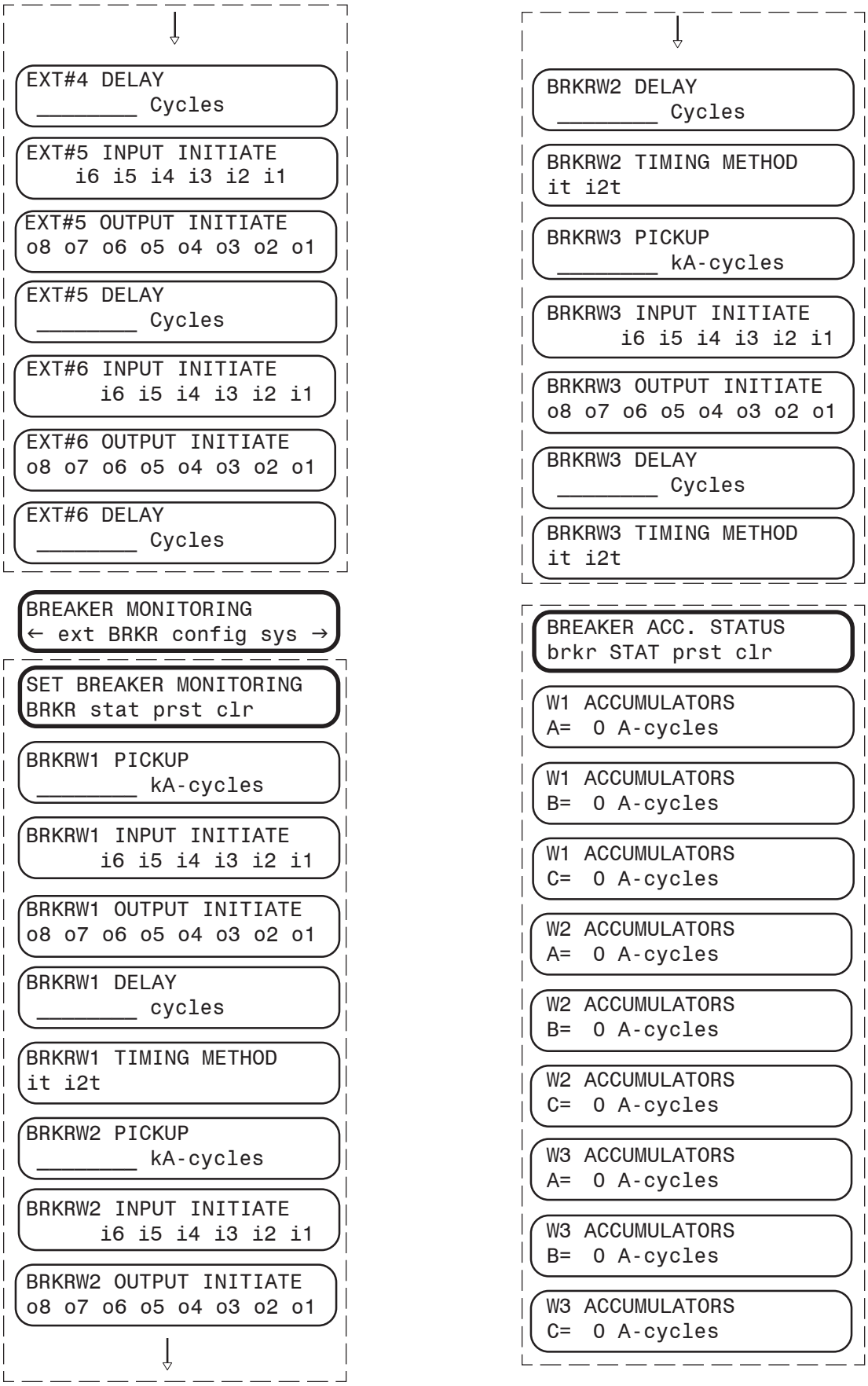


Figure A-4 Setpoint & Timing Record Form (Page 5 of 6)

PRESET ACCUMULATORS
brkr stat PRST clr

ACC. A W1 SET
A_W1 b_w1 c_w1 →

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. B W1 SET
a_w1 B_W1 c_w1 →

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. C W1 SET
a_w1 b_w1 C_W1 →

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. A W2 SET
←A_W2 b_w2 c_w2→

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. B W2 SET
←a_w2 B_W2 c_w2→

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. C W2 SET
←a_w2 b_w2 C_W2→

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. A W3 SET
←A_W3 b_w3 c_w3

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. B W3 SET
←a_w3 B_W3 c_w3

BRKR. ACCUMULATOR
_____ kA-cycles

ACC. C W3 SET
←a_w3 b_w3 C_W3

BRKR. ACCUMULATOR
_____ kA-cycles

CLEAR ACCUMULATORS
brkr stat prst CLR

ACC. A W1 CLEAR
A_W1 b_w1 c_w1 →

ACC. B W1 CLEAR
a_w1 B_W1 c_w1 →

ACC. C W1 CLEAR
a_w1 b_w1 C_W1 →

ACC. A W2 CLEAR
←A_W2 b_w2 c_w2→

ACC B W2 CLEAR
←a_w2 B_W2 c_w2→

ACC C W2 CLEAR
←a_w2 b_w2 C_W2→

ACC A W3 CLEAR
←A_W3 b_w3 c_w3

ACC B W3 CLEAR
←a_w3 B_W3 c_w3

ACC C W3 CLEAR
←a_w3 b_w3 C_W3

Figure A-4 Setpoint & Timing Record Form (Page 6 of 6)

CONFIGURE RELAY
VOLTAGE_RELAY →

27 PHASE UNDERVOLTAGE
DISABLE enable

59G#1 GROUND OVERVOLTAGE
DISABLE enable

59G#2 GROUND OVERVOLTAGE
DISABLE enable

CONFIGURE RELAY
← CURRENT_RELAY →

46DTW2 DEF TIME NSEQ O/C
DISABLE enable

46ITW2 INV TIME NSEQ O/C
DISABLE enable

46DTW3 DEF TIME NSEQ O/C
DISABLE enable

46ITW3 INV TIME NSEQ O/C
DISABLE enable

49 THERMAL PROTECTION
DISABLE enable

50W1#1 INST PHASE O/C
DISABLE enable

50W1#2 INST PHASE O/C
DISABLE enable

50W2#1 INST PHASE O/C
DISABLE enable

50W2#2 INST PHASE O/C
DISABLE enable

50W3#1 INST PHASE O/C
DISABLE enable

50W3#2 INST PHASE O/C
DISABLE enable

CONFIGURE RELAY
← ext brkr CONFIG →

51W1 INV TIME O/C
DISABLE enable

51W2 INV TIME O/C
DISABLE enable

51W3 INV TIME O/C
DISABLE enable

50GW2#1 INST GROUND O/C
DISABLE enable

50GW2#2 INST GROUND O/C
DISABLE enable

50GW3#1 INST GROUND O/C
DISABLE enable

50GW3#2 INST GROUND O/C
DISABLE enable

51GW2 INV TIME GND O/C
DISABLE enable

51GW3 INV TIME GND O/C
DISABLE enable

50NW1#1 INST RESID O/C
DISABLE enable

50NW1#2 INST RESID O/C
DISABLE enable

50NW2#1 INST RESID O/C
DISABLE enable

50NW2#2 INST RESID O/C
DISABLE enable

50NW3#1 INST RESID O/C
DISABLE enable

50NW3#2 INST RESID O/C
DISABLE enable

51NW1 INV TIME RESID O/C
DISABLE enable

51NW2 INV TIME RESID O/C
DISABLE enable

51NW3 INV TIME RESID O/C
DISABLE enable

87H HI SET DIFFERENTIAL
DISABLE enable

87T DIFFERENTIAL CURRENT
DISABLE enable

87GDW2 GND DIFFERENTIAL
DISABLE enable

87GDW3 GND DIFFERENTIAL
DISABLE enable

50BFW1 BREAKER FAILURE
DISABLE enable

50BFW2 BREAKER FAILURE
DISABLE enable

50BFW3 BREAKER FAILURE
DISABLE enable

CONFIGURE RELAY
← FREQUENCY_RELAY →

81#1 FREQUENCY
DISABLE enable

81#2 FREQUENCY
DISABLE enable

81#3 FREQUENCY
DISABLE enable

81#4 FREQUENCY
DISABLE enable

CONFIGURE RELAY
←VOLTS_PER_HZ_RELAY→

24DT#1 DEF TIME VOLTS/HZ
DISABLE enable

24DT#2 DEF TIME VOLTS/HZ
DISABLE enable

24IT INV TIME VOLTS/HZ
DISABLE enable

*Figure A-5 Functional Configuration Record Form – **As Shipped** (Page 1 of 2)*

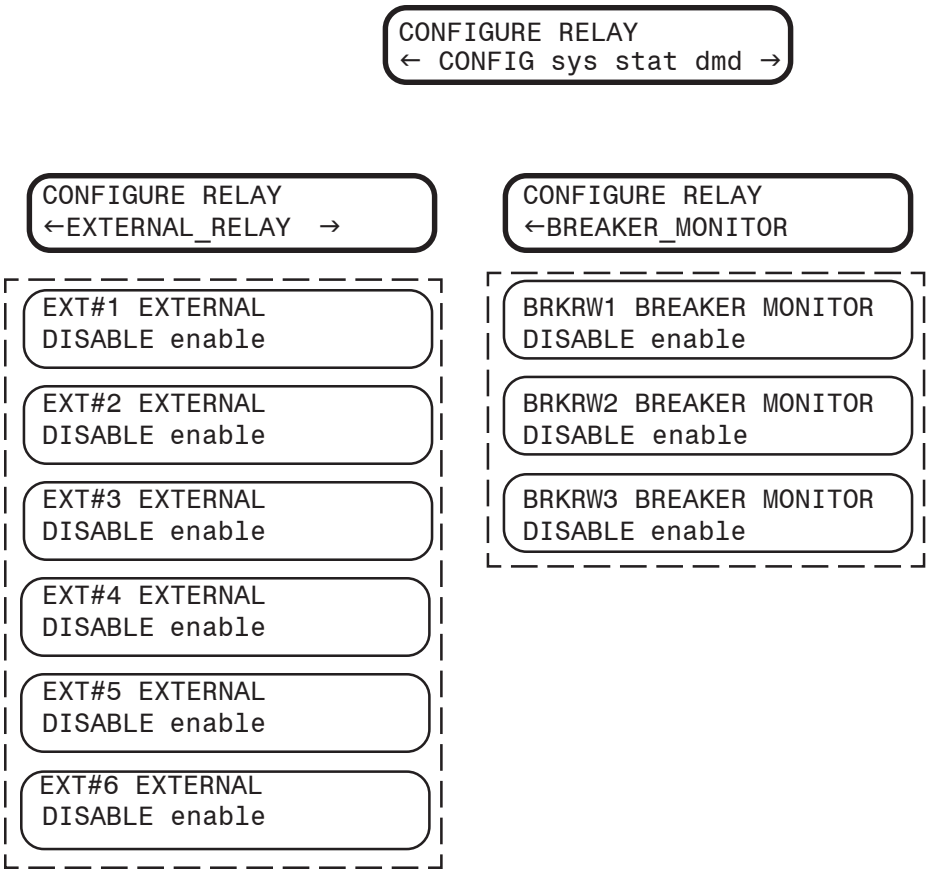


*Figure A-5 Functional Configuration Record Form – **As Shipped** (Page 2 of 2)*

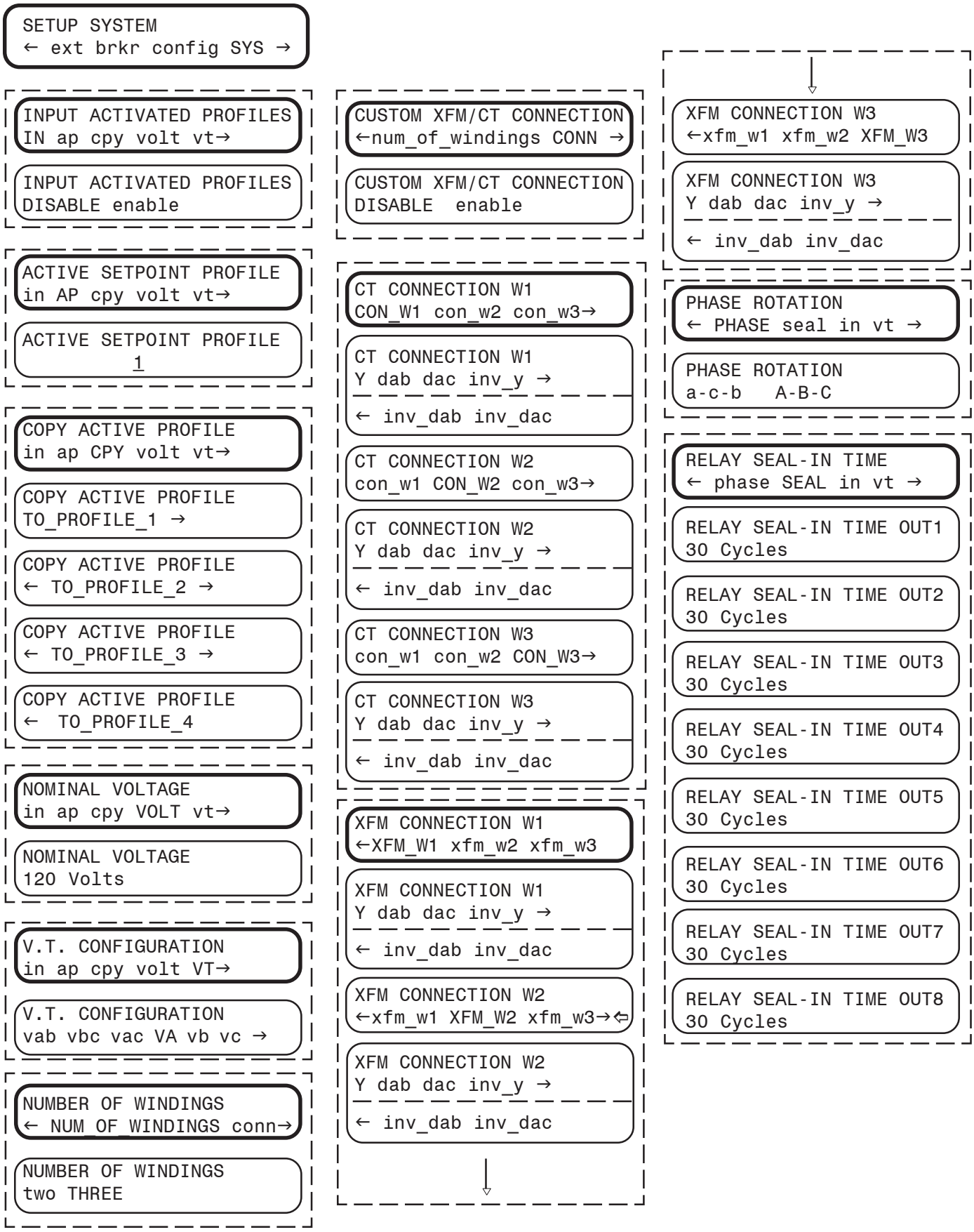


*Figure A-6 Communication Data & Unit Setup Record Form – **As Shipped** (Page 1 of 3)*

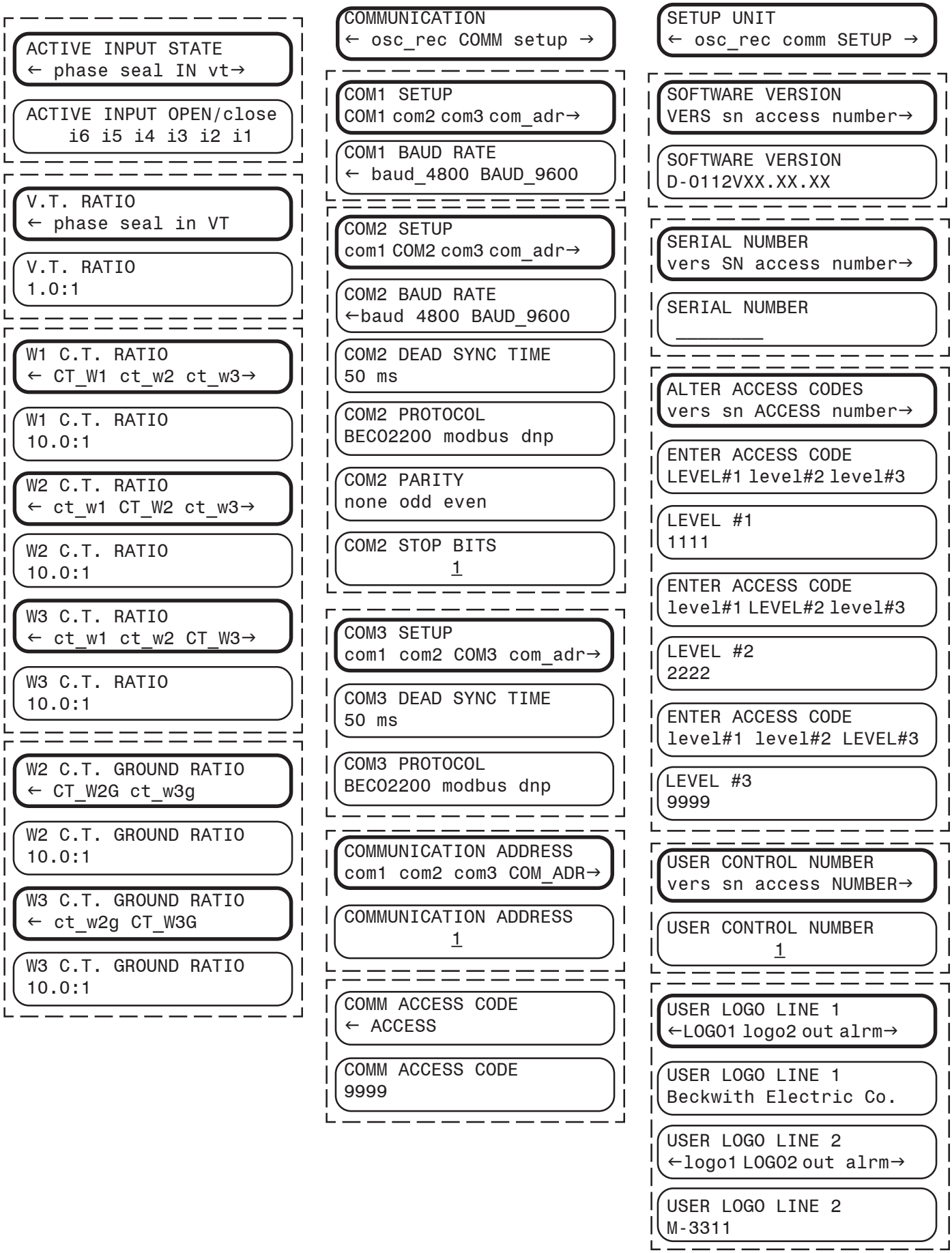


*Figure A-6 Communication Data & Unit Setup Record Form – **As Shipped** (Page 2 of 3)*

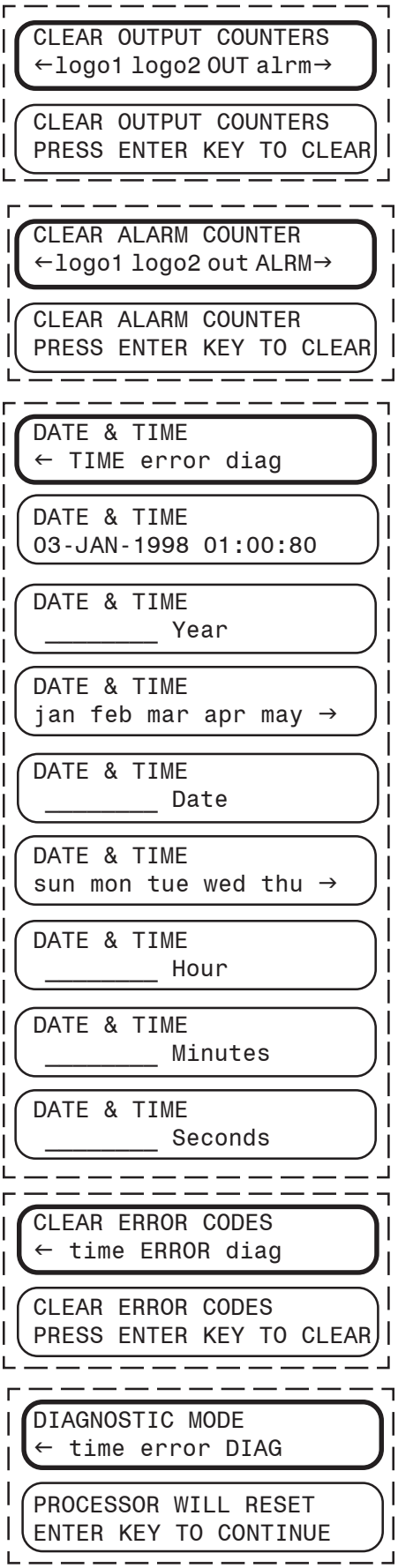


*Figure A-6 Communication Data & Unit Setup Record Form – **As Shipped** (Page 3 of 3)*

■ **NOTE**: All functions disabled; see Configuration menu to enable.

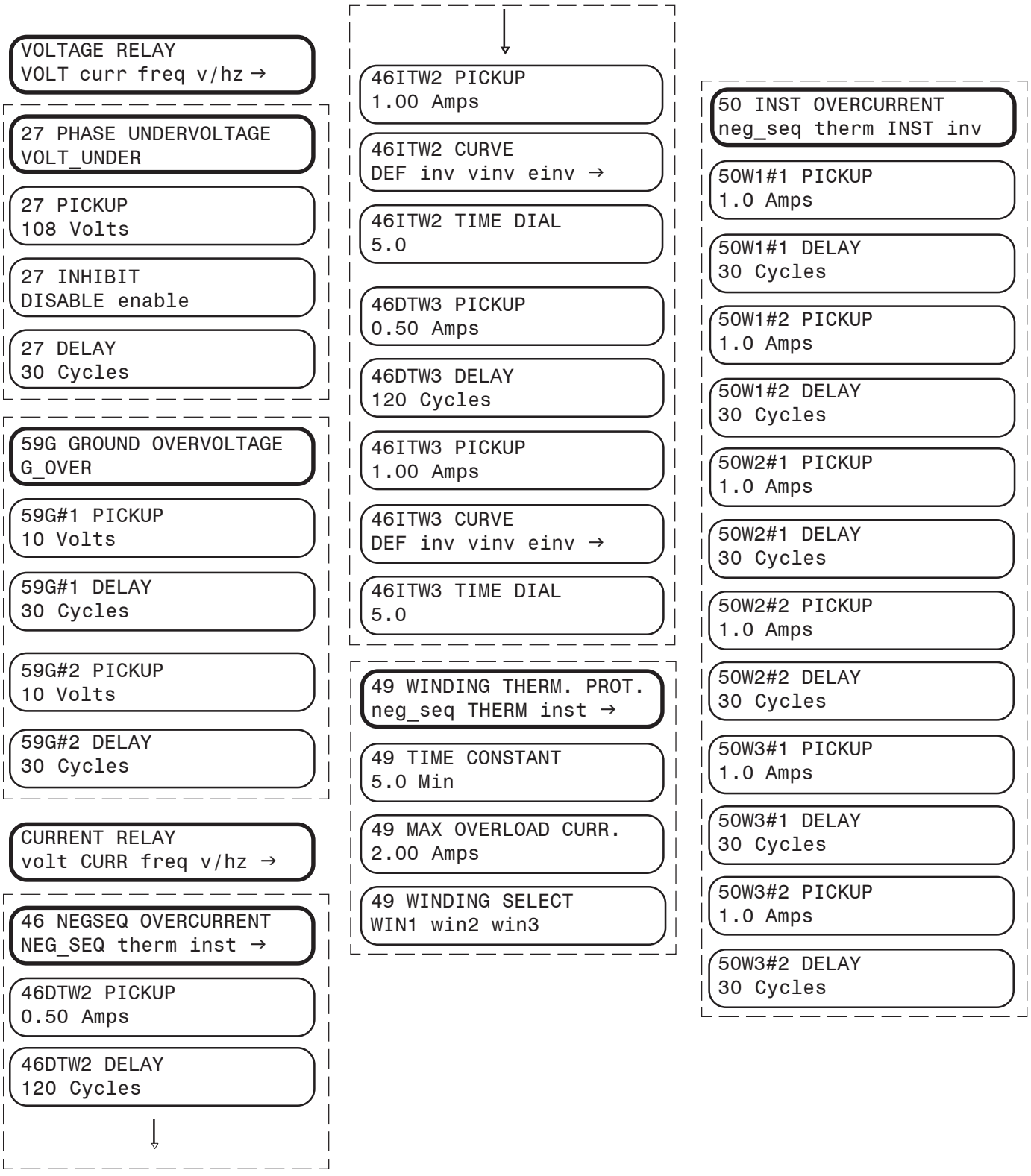


*Figure A-7 Setpoint & Timing Record Form - **As Shipped** (Page 1 of 5)*

■ **NOTE**: All functions disabled; see Configuration menu to enable.

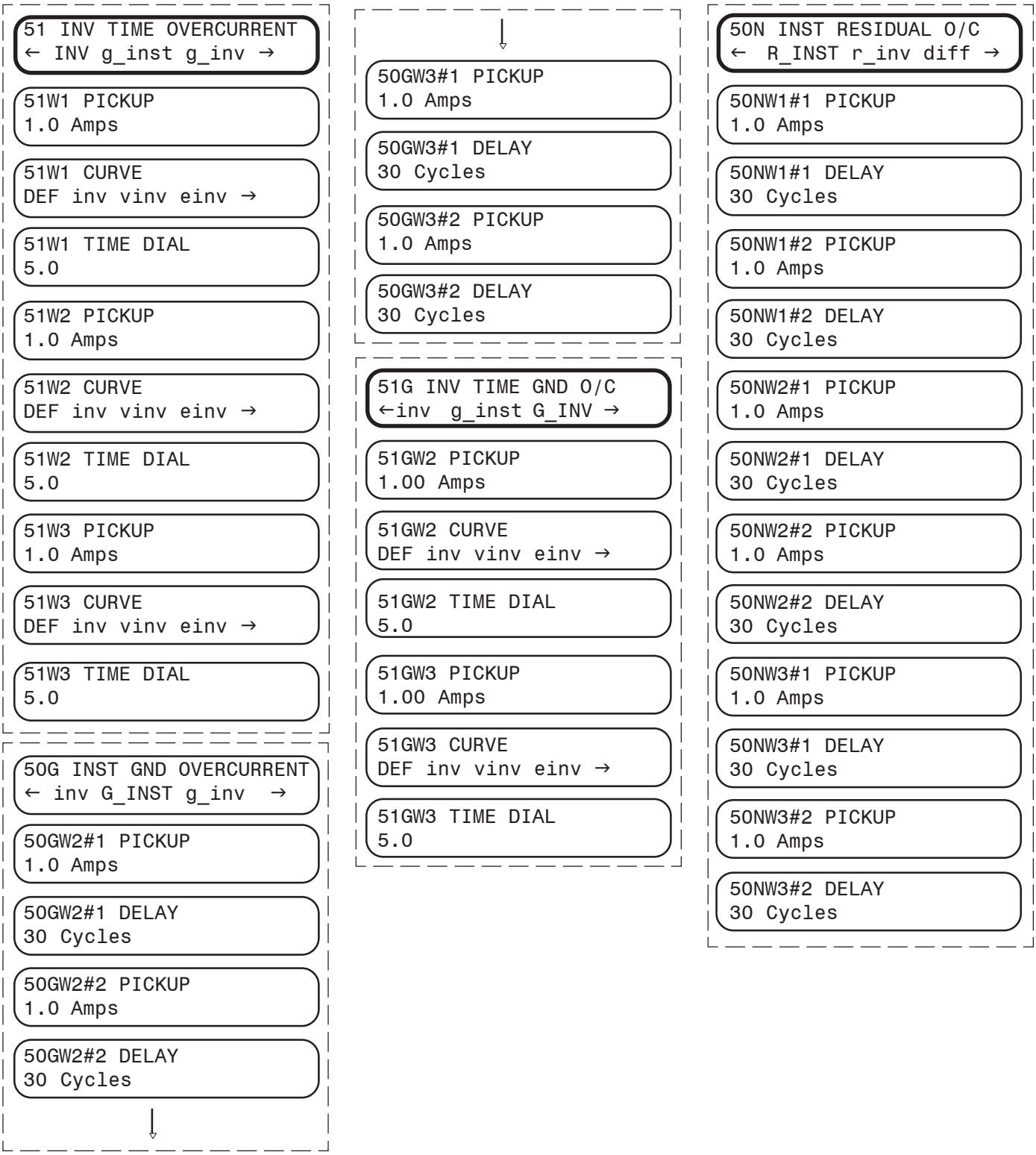


*Figure A-7 Setpoint & Timing Record Form – **As Shipped** (Page 2 of 5)*

■ **NOTE**: All functions disabled; see Configuration menu to enable.

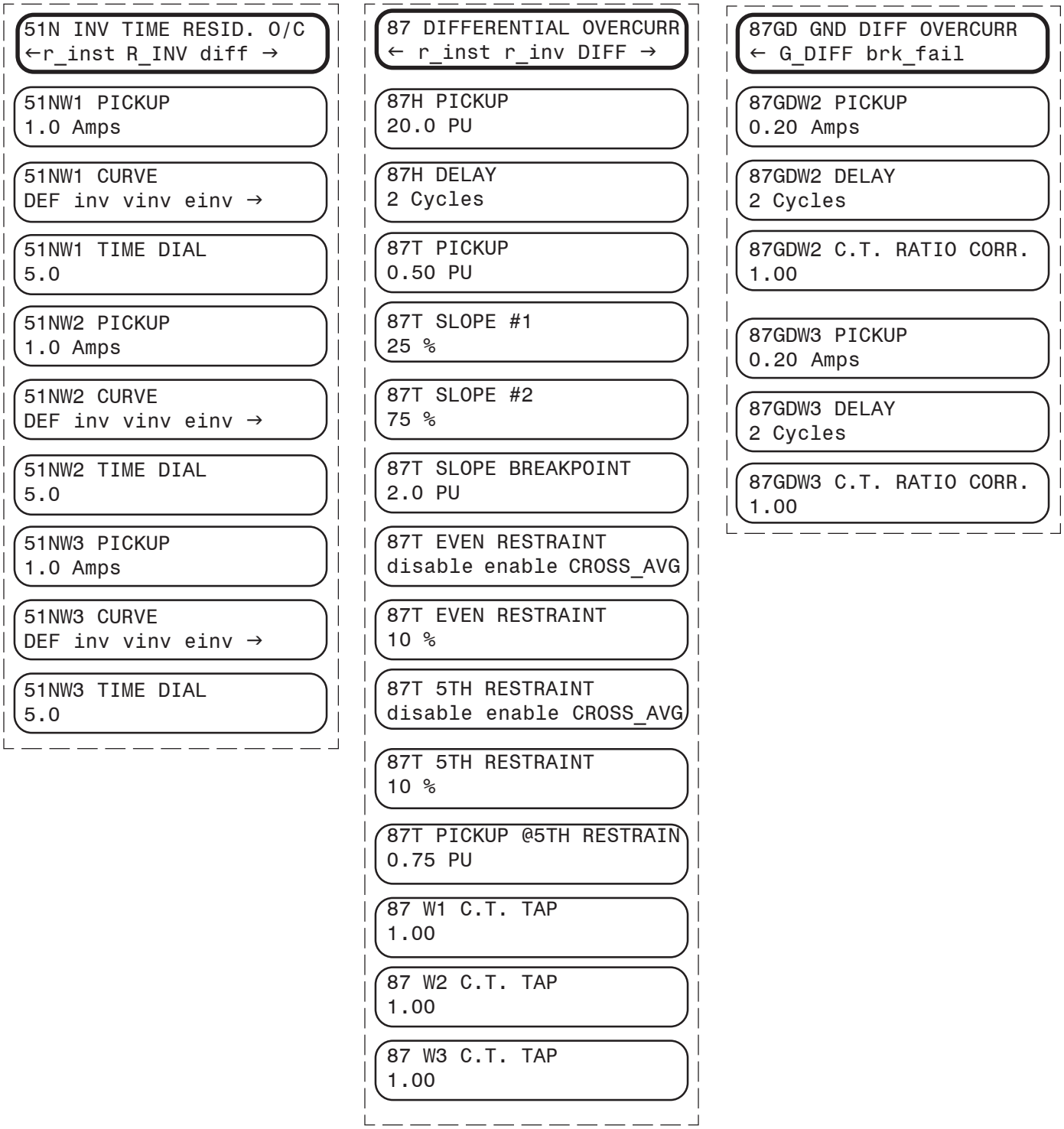


*Figure A-7 Setpoint & Timing Record Form – **As Shipped** (Page 3 of 5)*

■ **NOTE**: All functions disabled; see Configuration menu to enable.

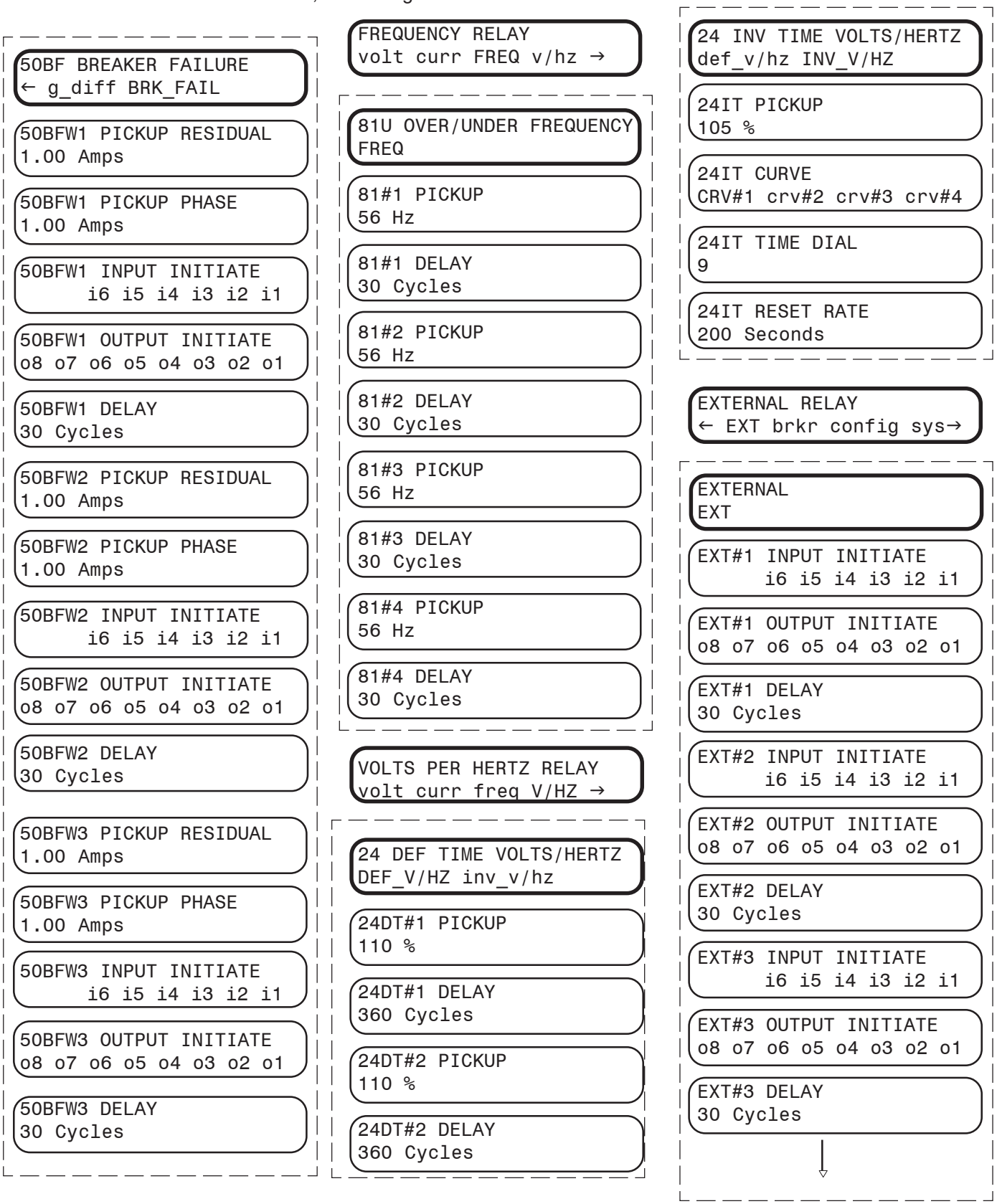


*Figure A-7 Setpoint & Timing Record Form – **As Shipped** (Page 4 of 5)*

■ **NOTE**: All functions disabled; see Configuration menu to enable.

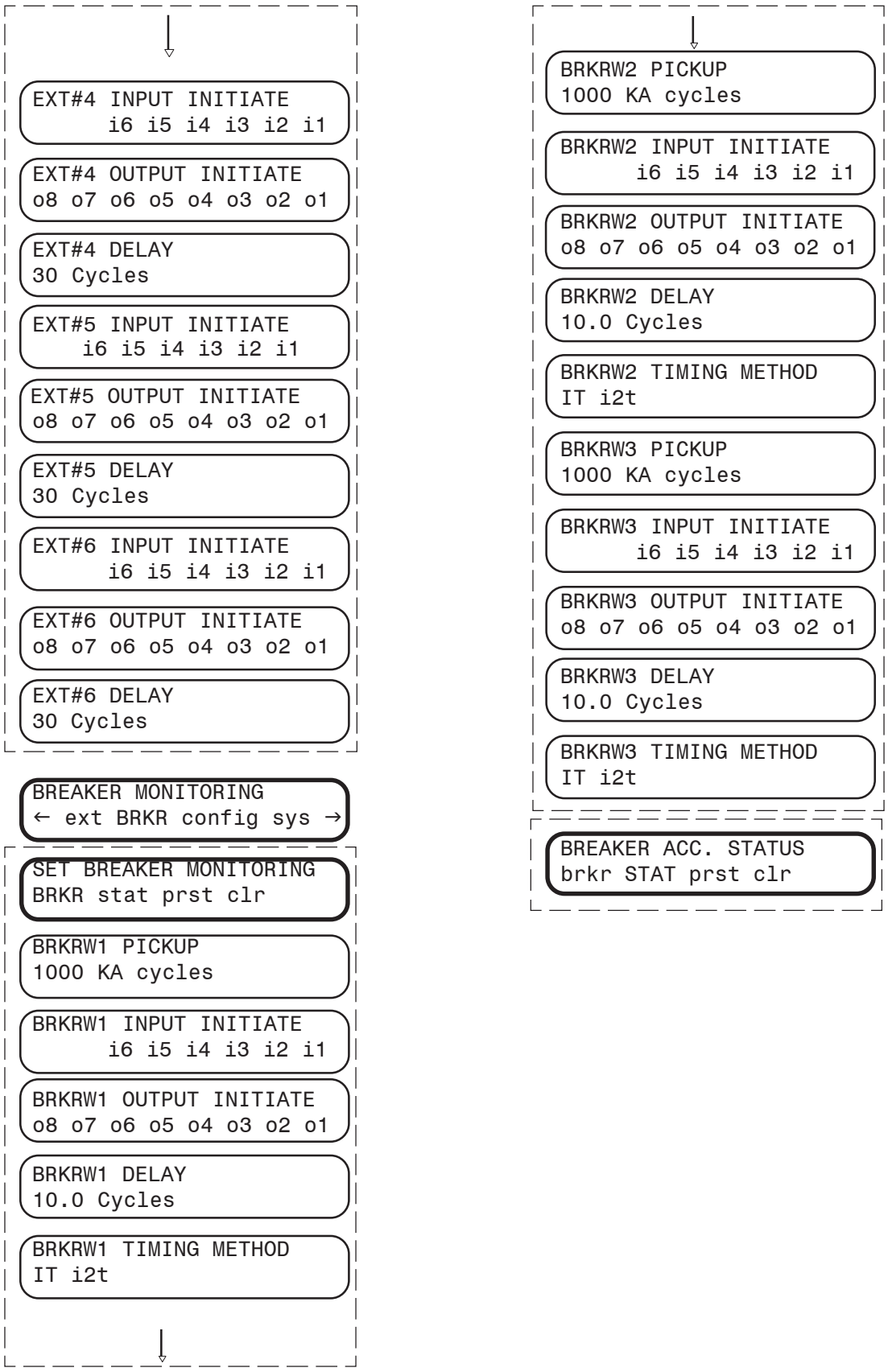


*Figure A-7 Setpoint & Timing Record Form – **As Shipped** (Page 5 of 5)*

FUNCTION	D			O	U	T	P	U	T	S		I	N	P	U	T	S
		8	7	6	5	4	3	2	1			6	5	4	3	2	1
24 DEF TIME #1	✓																
24 DEF TIME #2	✓																
24 INV TIME	✓																
27 #1	✓																
46 DEF TIME W2	✓																
46 INV TIME W2	✓																
46 DEF TIME W3	✓																
46 INV TIME W3	✓																
49 #1	✓																
50W1 #1	✓																
50W1 #2	✓																
50W2 #1	✓																
50W2 #2	✓																
50W3 #1	✓																
50W3 #2	✓																
50BFW1 #1	✓																
50BFW2 #1	✓																
50BFW3 #1	✓																
50GW2 #1	✓																
50GW2 #2	✓																
50GW3 #1	✓																
50GW3 #2	✓																
50NW1 #1	✓																
50NW1 #2	✓																
50NW2 #1	✓																
50NW2 #2	✓																
50NW3 #1	✓																
50NW3 #2	✓																

*Table A-2 Relay Configuration – **As Shipped (page 1 of 2)***

FUNCTION	D		O	U	T	P	U	T	S		I	N	P	U	T	S
		8	7	6	5	4	3	2	1		6	5	4	3	2	1
51W1 #1	✓															
51W2 #1	✓															
51W3 #1	✓															
51GW2 #1	✓															
51GW3 #1	✓															
51NW1 #1	✓															
51NW2 #1	✓															
51NW3 #1	✓															
59G #1	✓															
59G #2	✓															
81 #1	✓															
81 #2	✓															
81 #3	✓															
81 #4	✓															
87H	✓															
87T	✓															
87GDW2 #1	✓															
87GDW3 #1	✓															
EXT #1	✓															
EXT #2	✓															
EXT #3	✓															
EXT #4	✓															
EXT #5	✓															
EXT #6	✓															
BM W1 #1	✓															
BM W2 #1	✓															
BM W3 #1	✓															

*Table A-2 Relay Configuration – **As Shipped (page 2 of 2)***

This Page Left Intentionally Blank

B Appendix – Communications

The M-3311 Transformer 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 relay database specified protocol document are available from the factory or our website at www.beckwithelectric.com.

The M-3820B IPScom® Communication Software package has been supplied for communication to any IBM compatible computer running under 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,1; 8,O,1; 8,E,1; 8,N,2; 8,O,2; 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 supports oscillograph record downloading in COMTRADE file format.

For detailed information about communications, refer to Chapter 4, **IPScom Operation.**

DNP Configuration Parameters

M-3311 relays support DNP through the rear RS-232 (COM2) & RS-485 (COM3) communication ports. These ports support baud rates 1200, 2400, 4800, 9600 (default baud rate is 9600). See Figure A-3, Communication Data & Unit Setup, for sequence of DNP setup screens.

M-3311 Slave Address

DNP3 Slave IED address range is from 0 to 65519. Address 65535 (hex FFFF) is used to broadcast messages to all devices. The communication address can be set through the HMI (front panel; optional).

The DNP3 device profile document, including the point list, is available from the factory or our website, www.beckwithelectric.com.

The following restrictions apply for DNP3 protocol use:

- DNP3 is not supported on COM1.
- Parity is not supported.
- DNP3 does not support oscillograph record downloading.

The communication database profile in M-3311 using DNP3 protocol is grouped into five object types:

1. **Single Bit Binary Inputs (Status)**: (object 01, variation 01) These are considered as class 0 data.
2. **16 Bit Analog Output Block /Status (setpoints)**: (object 40, variation 01, variation 02/object 41, variation 01, variation 02) Used to write and read all setpoints and system setup.
3. **Control Relay Output Block (direct control)**: (object 12, variation 01) Used to write all configuration points.
4. **16 Bit Analog Inputs**: (object 30, variation 02) Used to represent all demand metering, target information, and control information of the relay.
5. **16 Bit Binary Counters**: (object 20, variation 02, variation 06) Used to represent all counters. Can be used to reset the counters using freeze and clear function code.
6. **Static (class 0) Data**: (object 60, variation 01) Used to represent all binary inputs, demand metering, target and control information, and counters. All points in the M-3311 relay are of static type, meaning that an integrity poll will dump all data to the querying RTU.

Communication Ports

The relay 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 EIA-232D standard. Signals are defined in Table B-1, Communication Port Signals .

The 2-wire RS-485 port is assigned to the rear panel terminal block pins 3 (–) and 4 (+).

Each communication port may be configured to operate at any of the standard baud rates (300, 600, 1200, 2400, 4800, and 9600). The RS-485 port shares the same baud rate with COM 2 (for COM1 see Section 5.4, Circuit Board Switches and Jumpers).

While the digital communication ports do include some ESD (Electrostatic Discharge) protection circuitry, they are excluded from passing ANSI/ IEEE C37.90.1-1989. Beckwith Electric recommends the use of RS-232/485 to fiber optic converters to avoid any question of surge-withstand capability or ground potential rise.

A null modem cable is also shown in Figure B-1, Null Modem Cable: M-0423, if direct connection to a PC (personal computer) is 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
		+15 V		Pin 1*
		-15 V		Pin 9*
		IRIG-B (+)		Pin 6*

**OPTIONAL - see Section 5.5, Circuit Board Switches and Jumpers*
±15V (±15%) @100 mA max.

Table B-1 Communication Port Signals

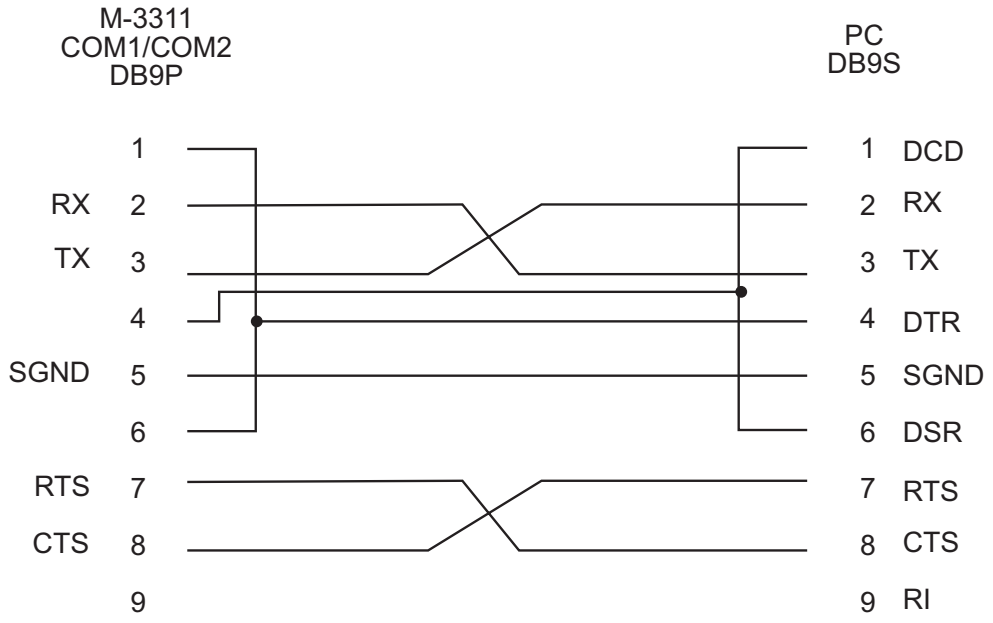


Figure B-1 Null Modem Cable for M-3311

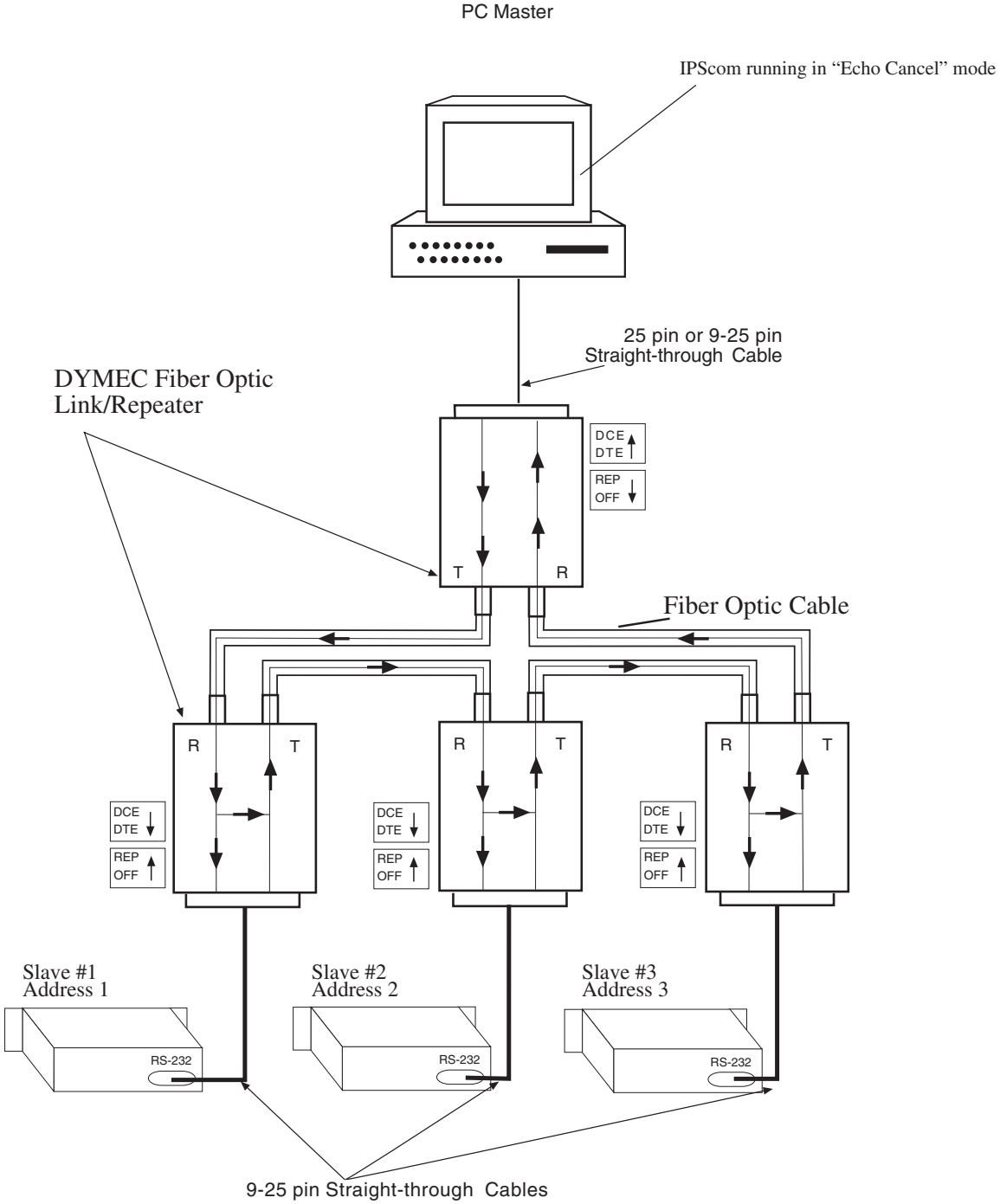
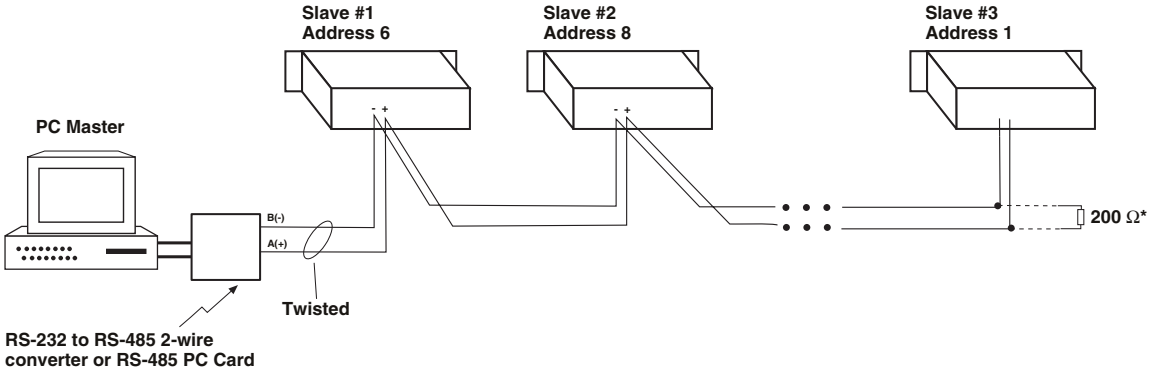


Figure B-2 RS-232 Fiber Optic Network

RS-485 2-Wire Network



▲ **CAUTION:** Due to the possibility of ground potential difference between units, all units should be mounted in the same rack. If this is not possible, fiber optics with the appropriate converters should be used for isolation.

■ **NOTE**: Each address on the network must be unique. Only the last physical slave on the network should have the termination resistor installed. This may be completed externally or using a dip jumper internal to the unit. See Section 5.5, Circuit Board Switches and Jumpers.

Figure B-3 RS-485 Network

This Page Left Intentionally Blank

C Appendix – Error Codes

Error Code	Description
1	
2	Battery backed RAM test fail
3	EEPROM write powerup fail
4	EEPROM read back powerup fail
5	Dual port RAM test fail
6	EEPROM write calibration checksum fail
7	EEPROM write setpoint checksum fail loss of power
8	EEPROM write setpoint checksum fail loss of battery backed RAM
9	DMA checksum/physical block fail
10	OSC RAM test error
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	DSP no running run mode code
21	DSP not running primary boot code
22	DSP DPRAM pattern test fail
23	EEPROM write verify error
24	BBRAM test error
25	Uninitialized EEPROM

Table C-1 Self-Test Error Codes (page 1 of 2)

Error Code	Description
26	WARNING calibration checksum mismatch warning
27	WARNING setpoint checksum mismatch warning
28	WARNING low battery (BBRAM) warning
29	Supply/Mux PGA running test fail
30	External DSP ram test fail
31	Unrecognized INT1 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	Interrupt noise int2
41	Interrupt noise int1
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
51	Setpoint write overflow
52	Field ground error

Table C-1 Self-Test Error Codes (page 2 of 2)

D Appendix – Inverse Time Curves

This Appendix contains two sets of Inverse Time Curve Families. The first set is used for Volts per Hertz functions (Figures D-1 through D-4), and the second set is for the M-3310 functions which utilize the IEC time over current curves (Figures D-5) through D-8).

■ **Note**: Figures D-1 through D-4 are Volts per Hertz curves. Figures D-5 through D-12 are inverse time curves for 51, 51N, 51G and 46 functions.

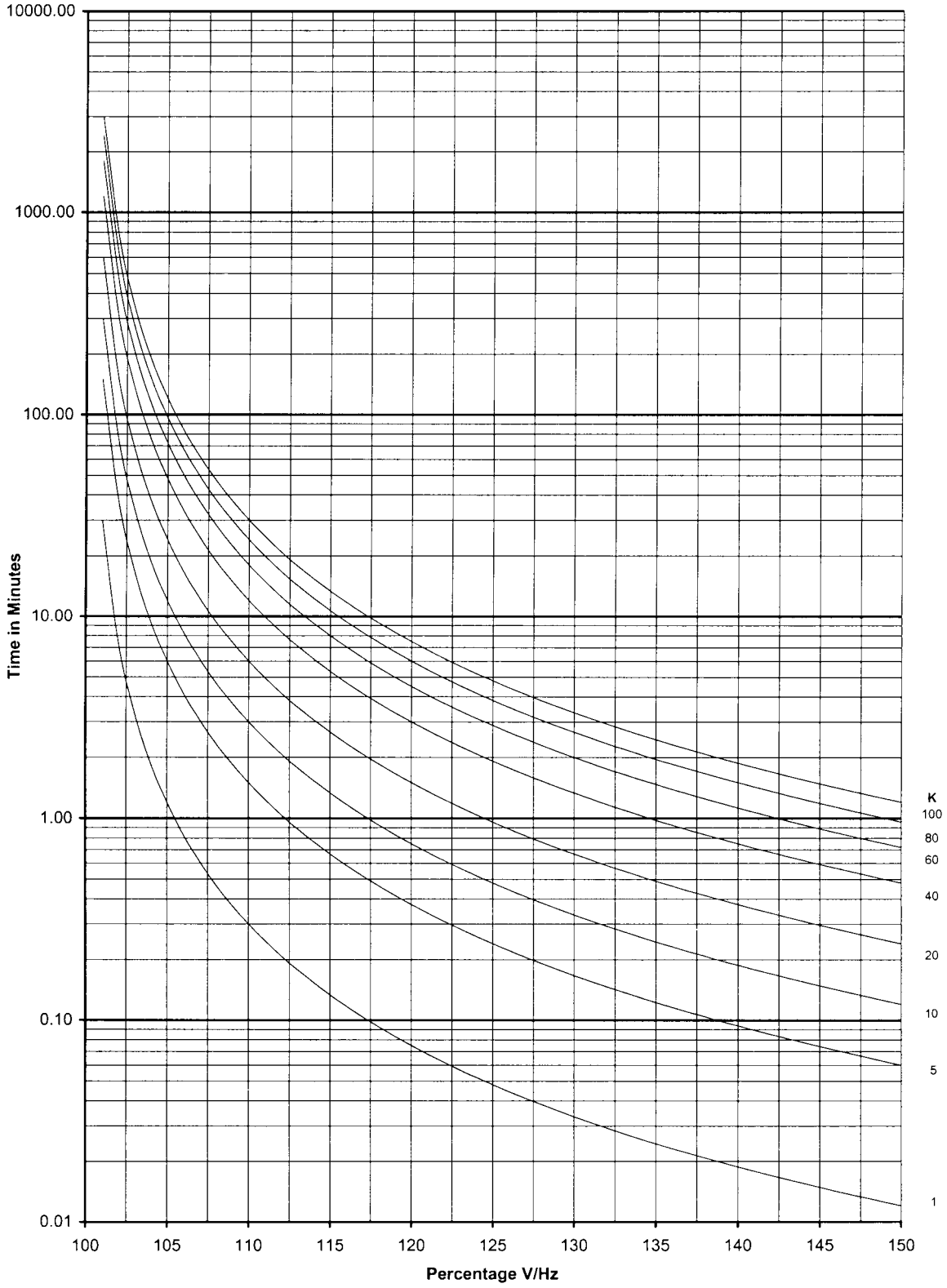


Figure D-1 Volts/Hz (24IT) Inverse Curve Family #1 (Inverse Square)

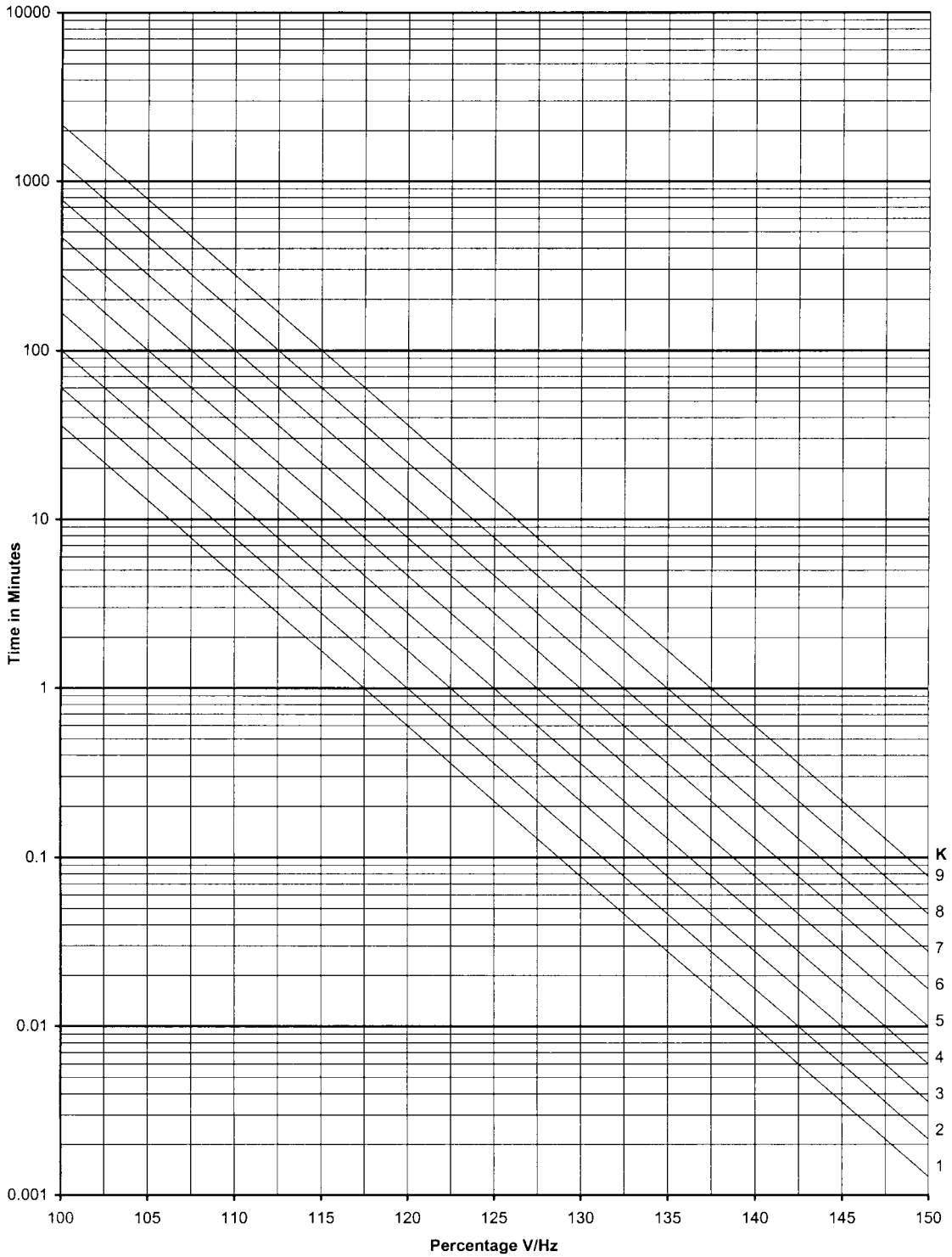


Figure D-2 Volts/Hz (24IT) Inverse Family Curve #2

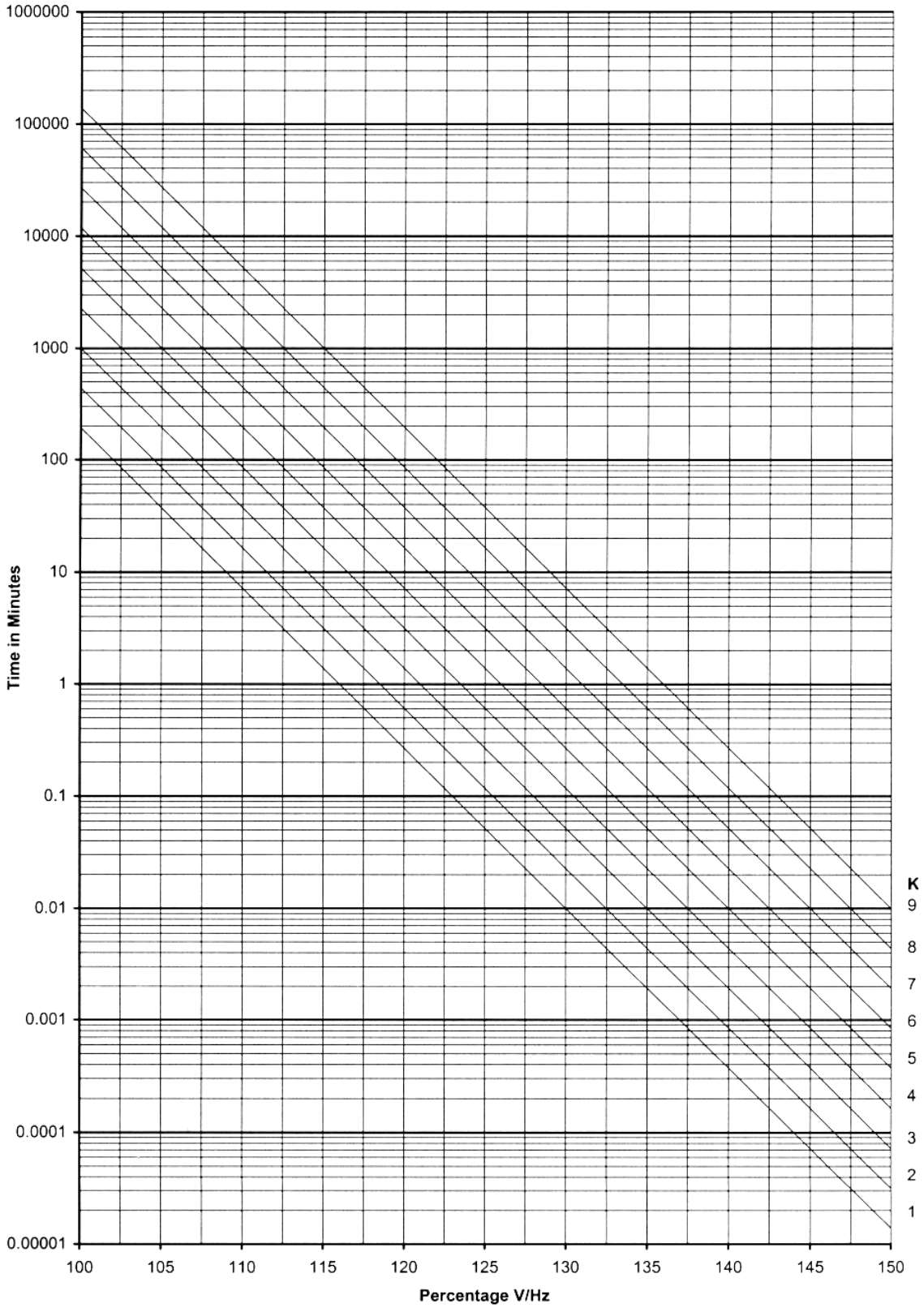


Figure D-3 Volts/Hz (24IT) Inverse Time Curve Family #3

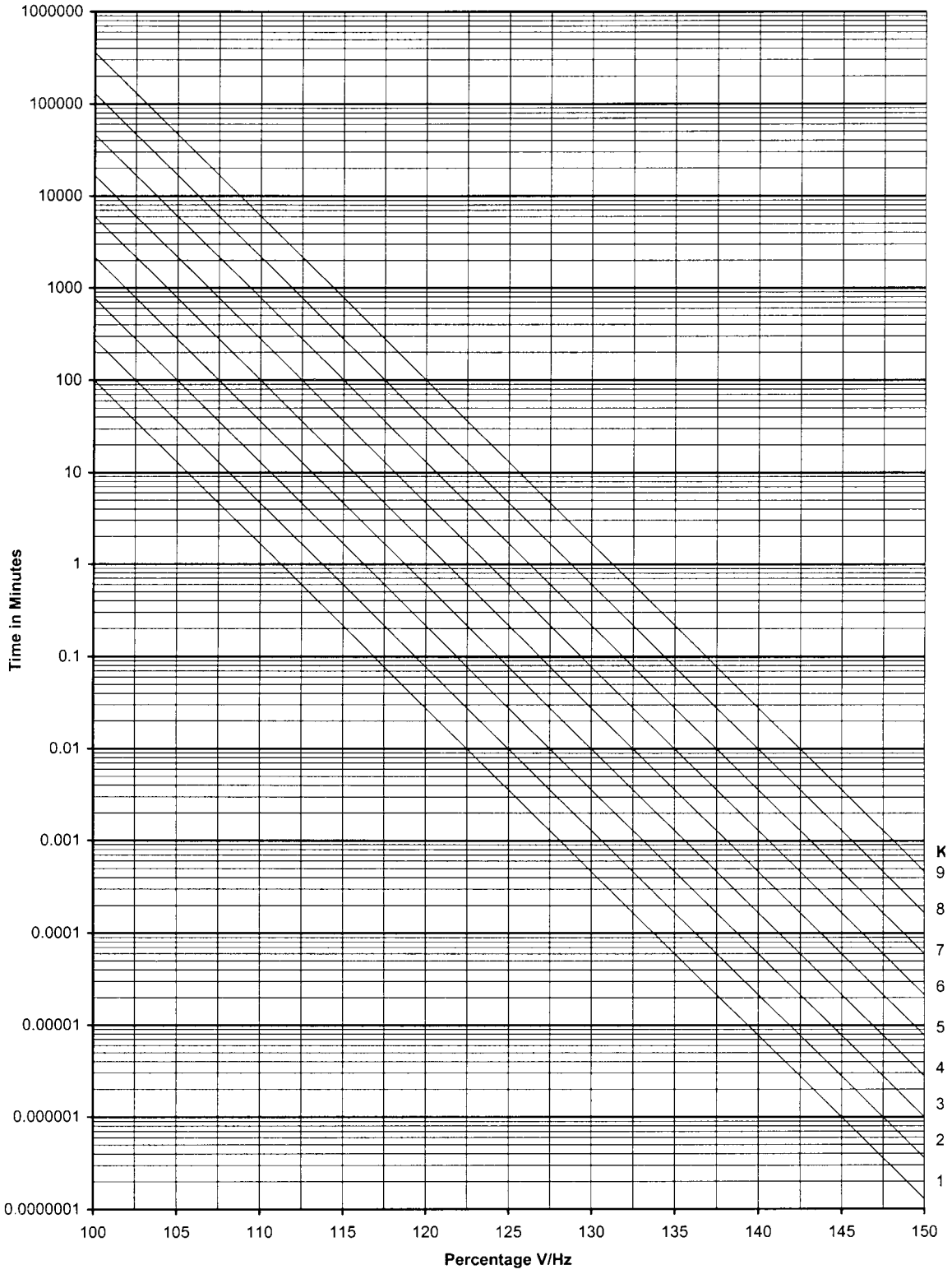


Figure D-4 Volts/Hz (24IT) Inverse Curve Family #4

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	0.39721	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-3311 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-3311 Inverse Time Overcurrent Relay Characteristic Curves

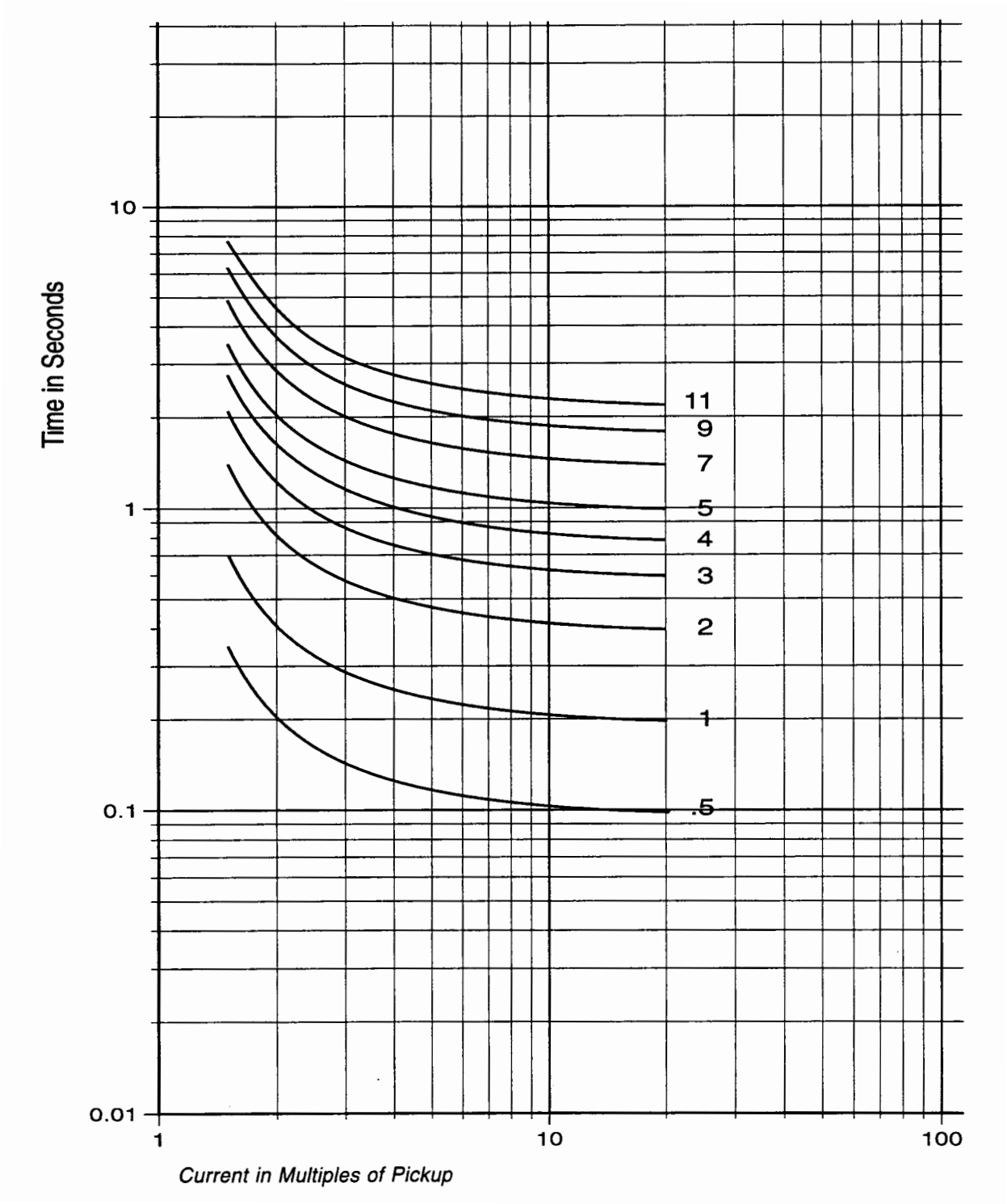


Figure D-5 Definite Time Overcurrent Curve

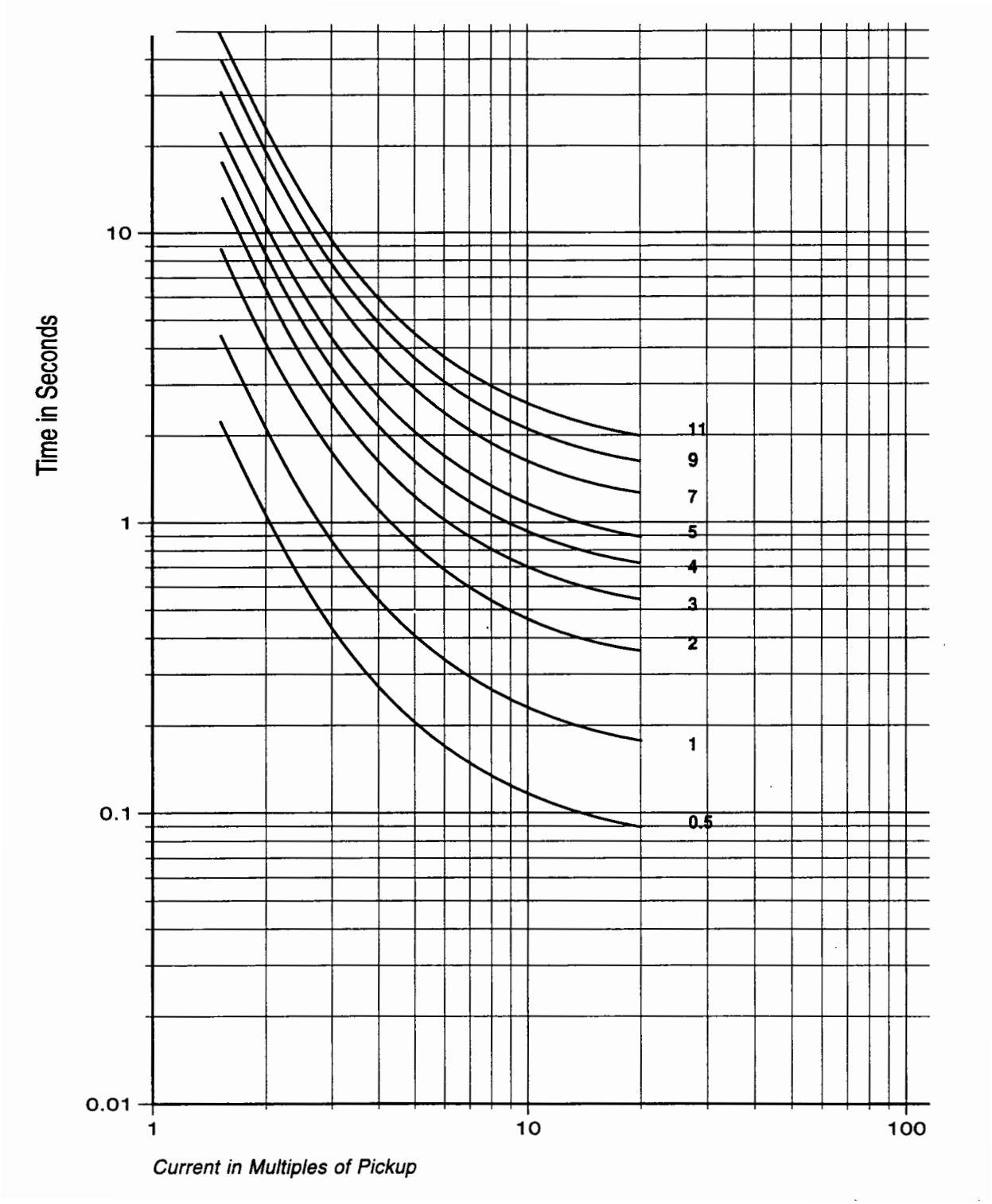


Figure D-6 Inverse Time Overcurrent Curve

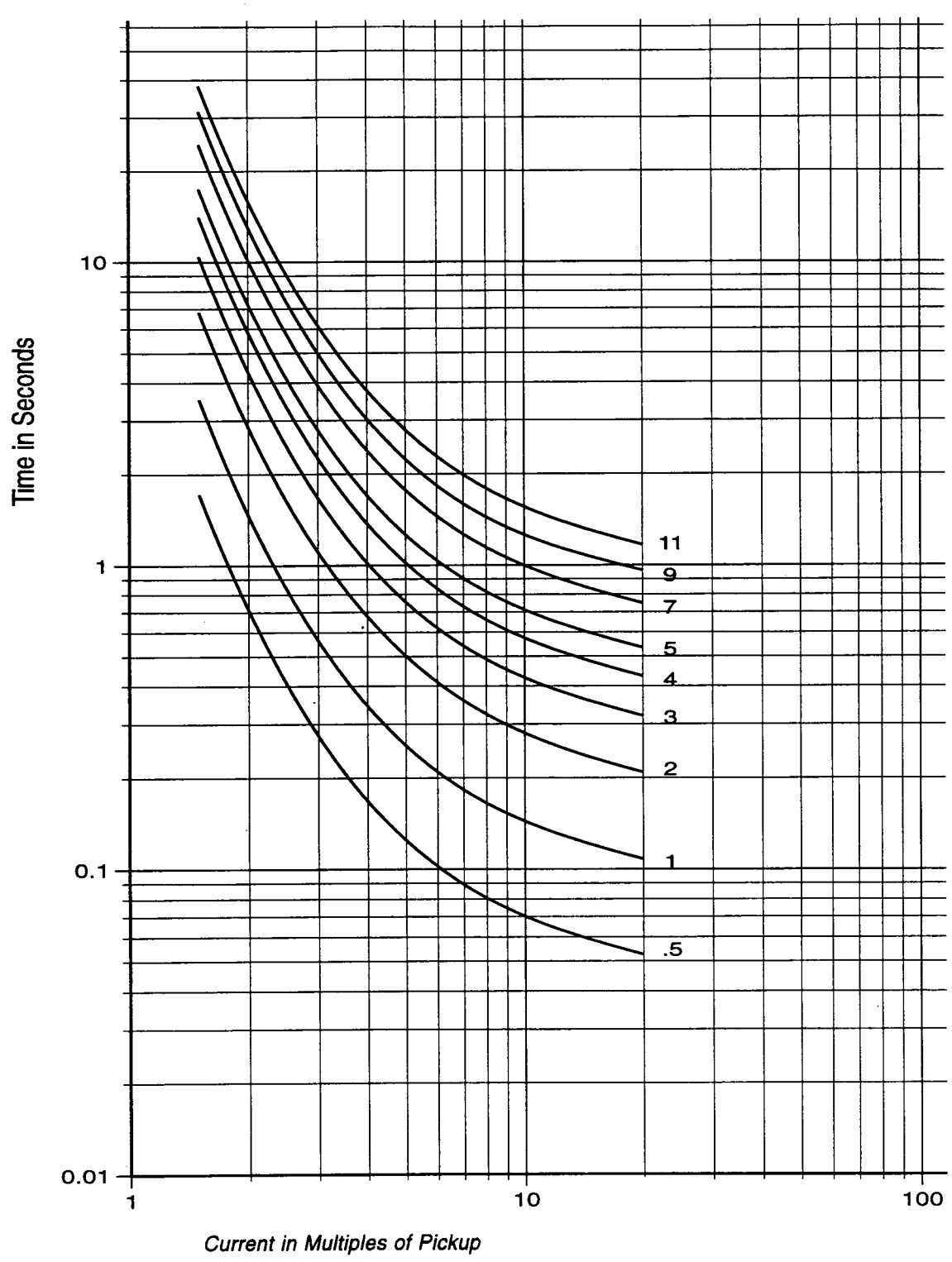


Figure D-7 Very Inverse Time Overcurrent Curve

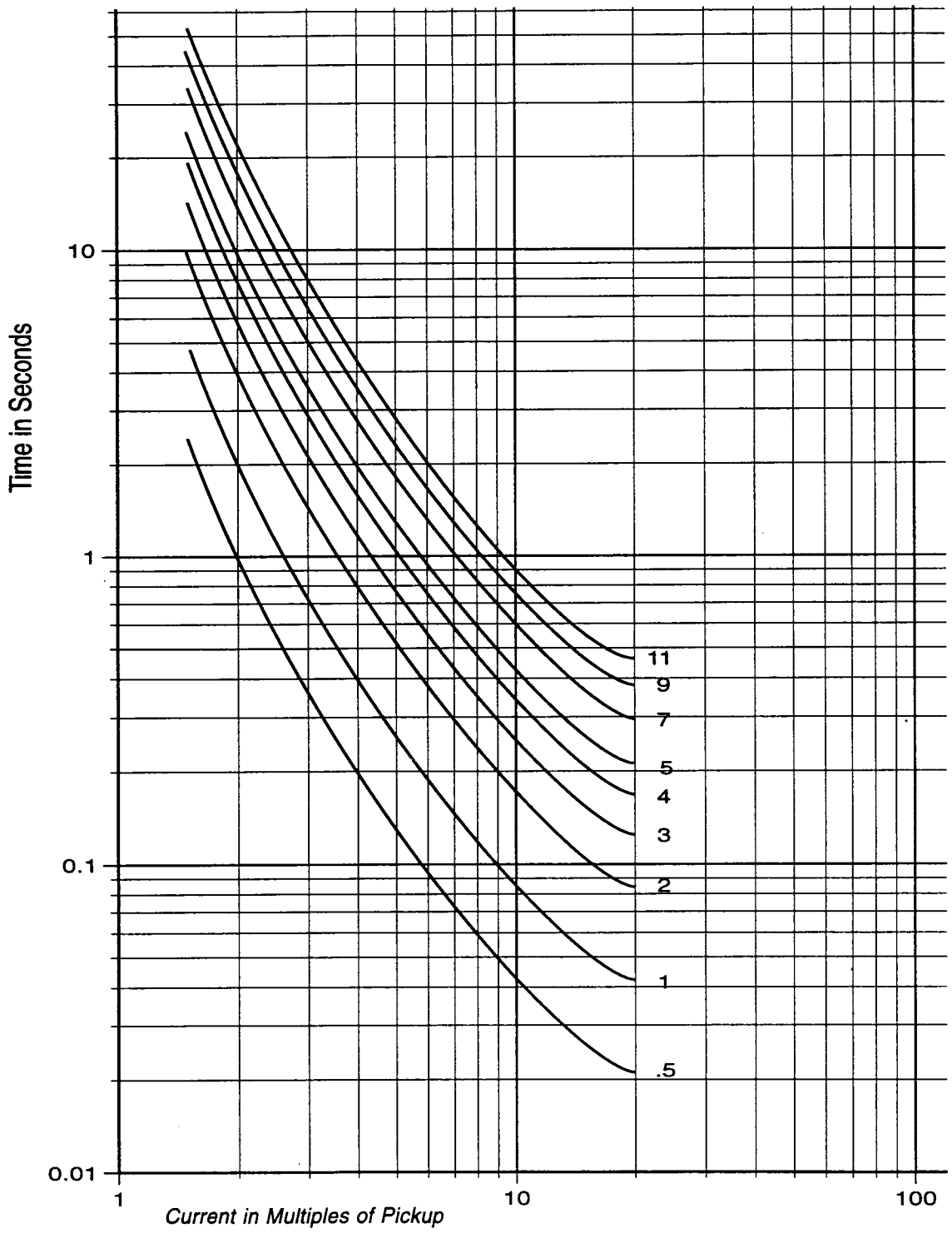
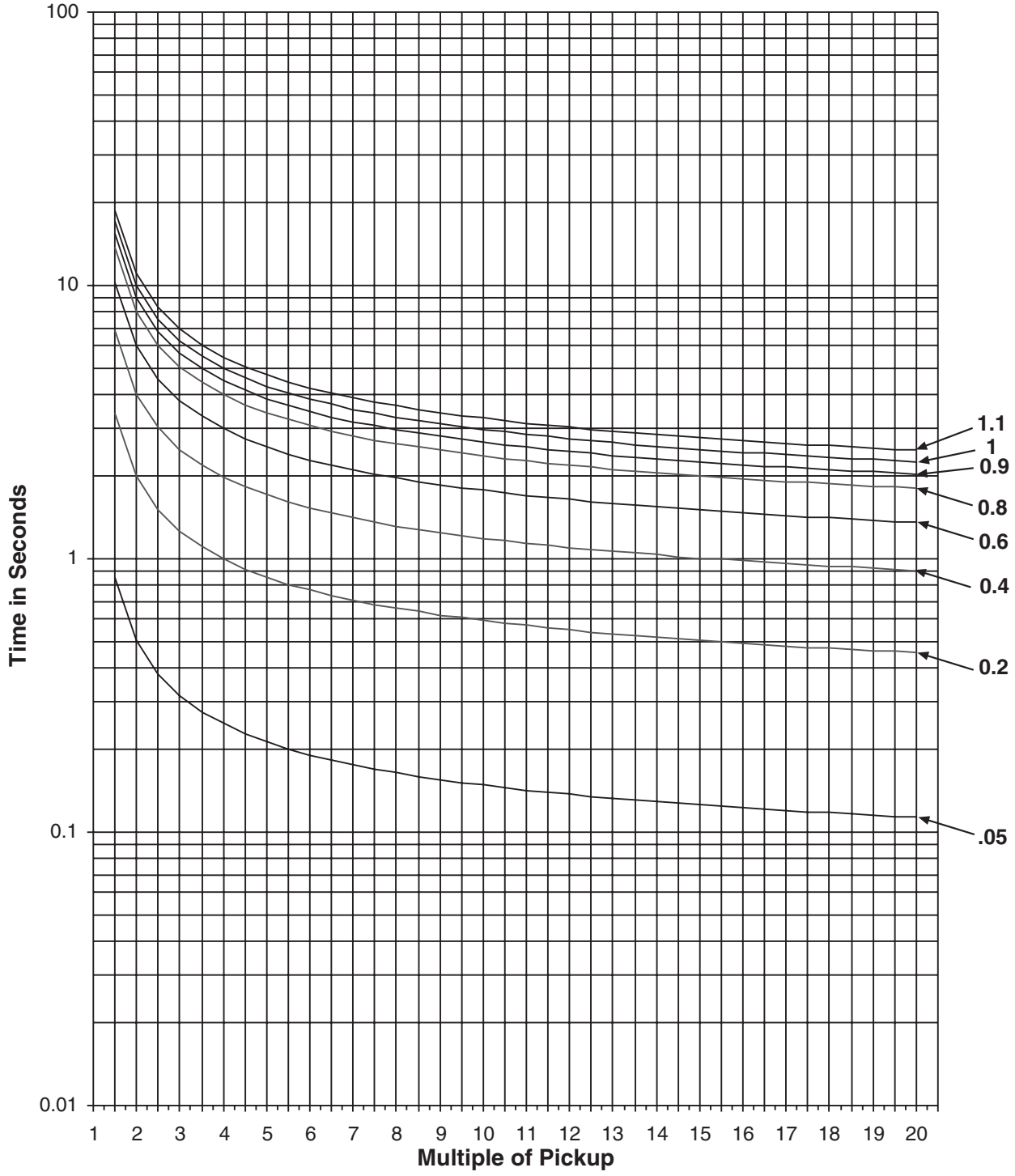
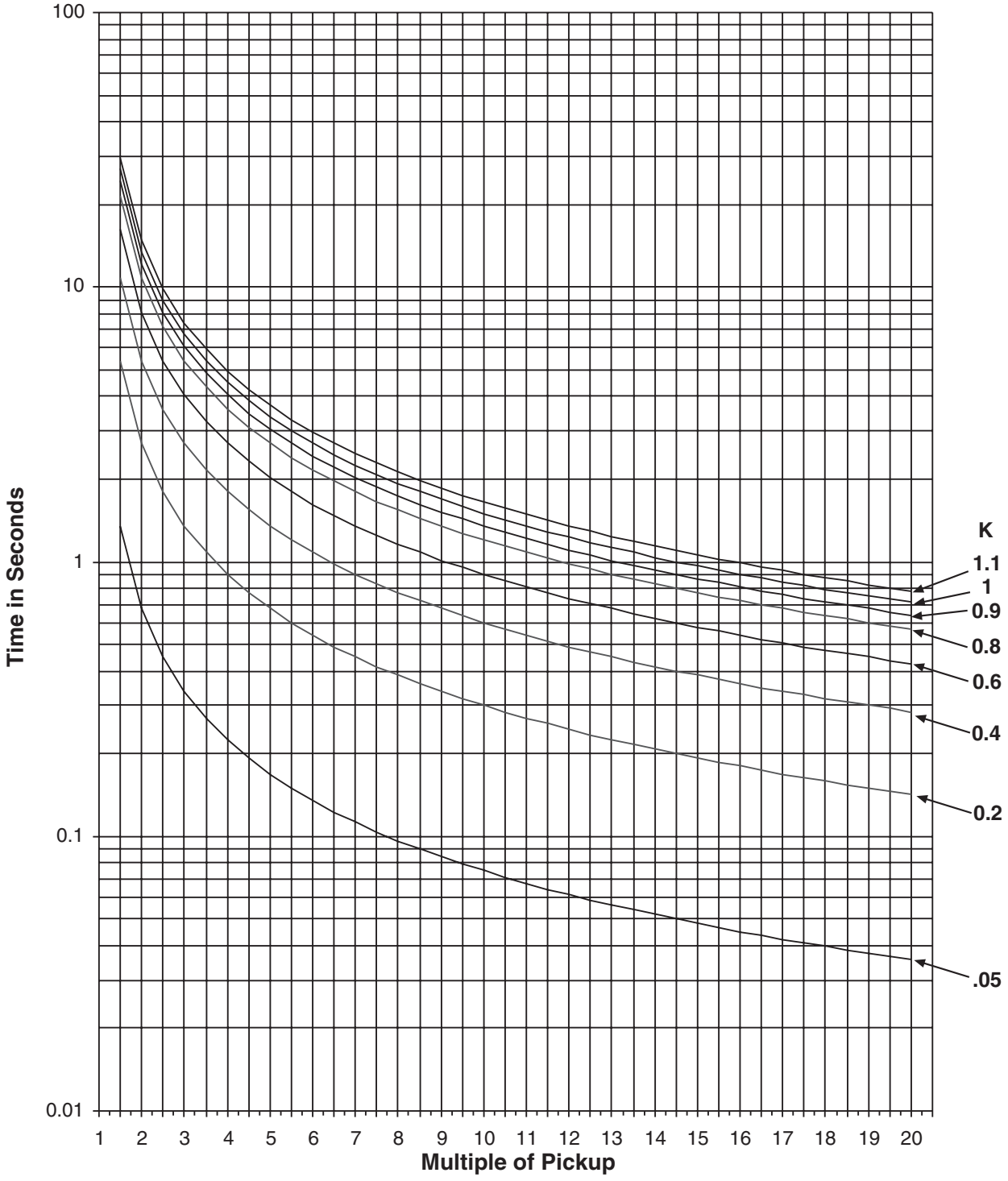


Figure D-8 Extremely Inverse Time Overcurrent Curve



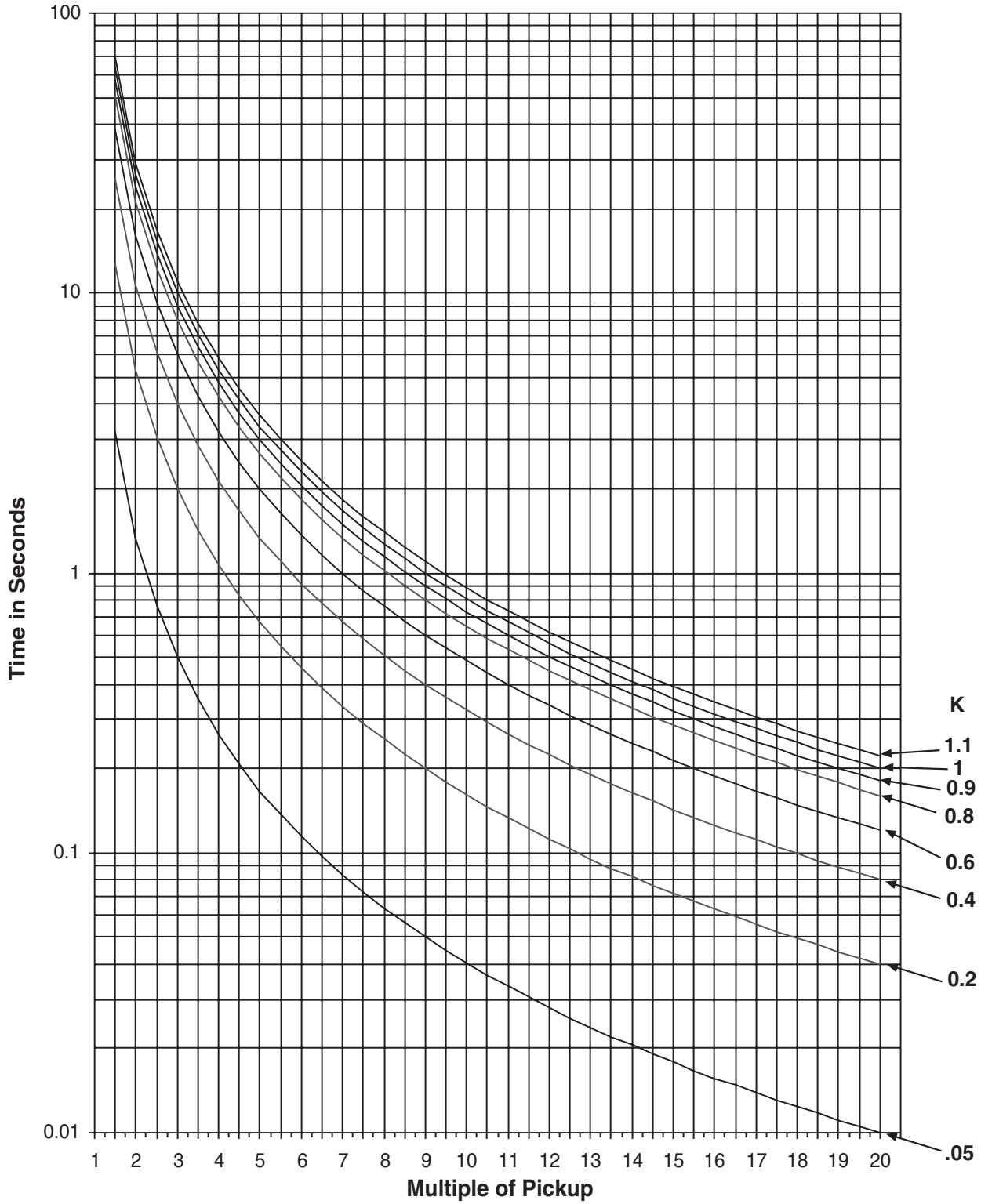
$$t = TD \times \left[\frac{0.14}{M^{0.02} - 1} \right]$$

Figure D-9 IEC Curve #1 Inverse



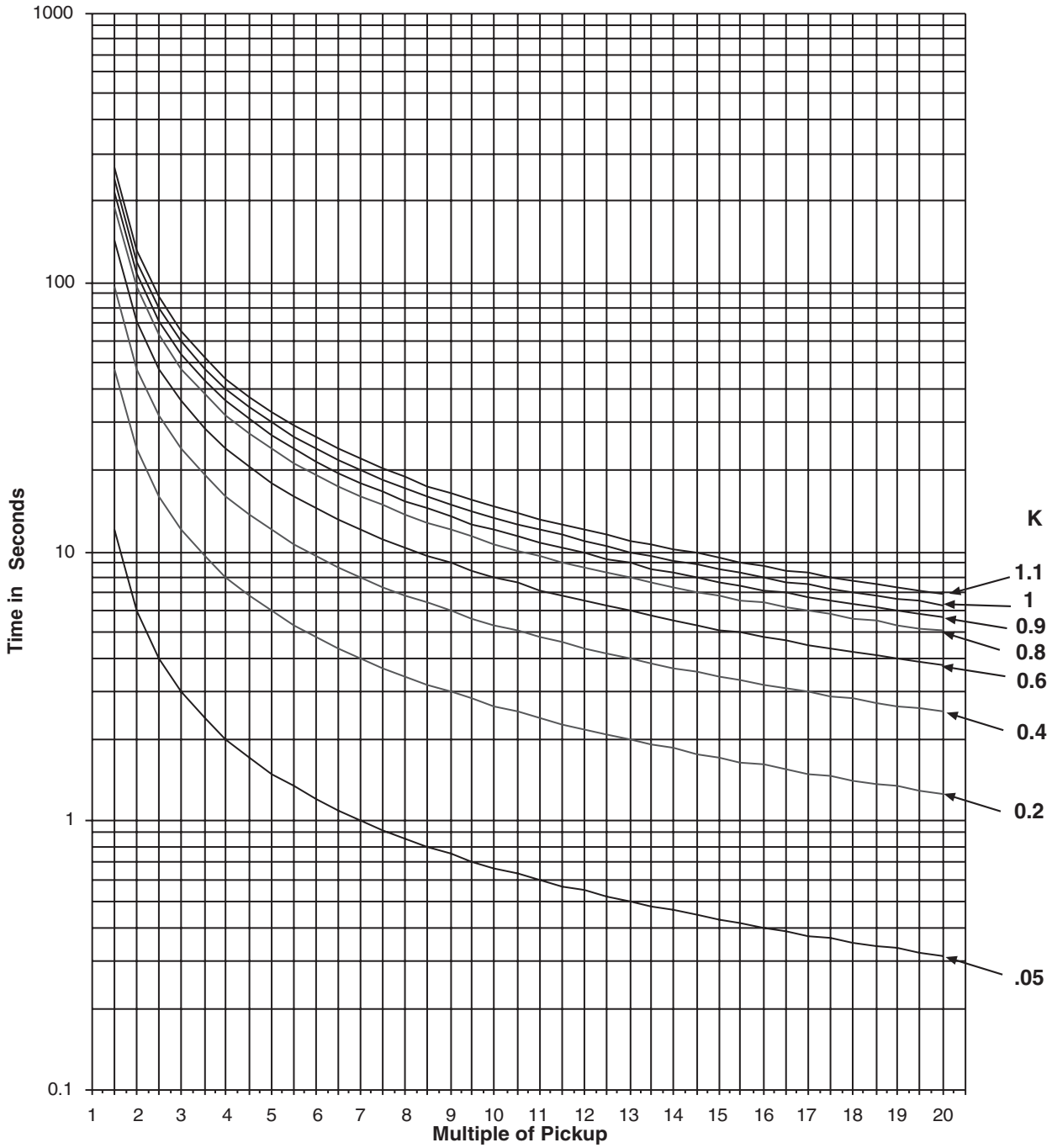
$$t = TD \times \left[\frac{13.5}{M - 1} \right]$$

Figure D-10 IEC Curve #2 Very Inverse



$$t = TD \times \left[\frac{80}{M^2 - 1} \right]$$

Figure D-11 IEC Curve #3 Extremely Inverse



$$t = TD \times \left[\frac{120}{M - 1} \right]$$

Figure D-12 IEC Curve #4 Long-Time Inverse

This Page Left Intentionally Blank

E Appendix – Layup and Storage

Appendix E includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3311 Transformer Protection Relay

Storage Requirements (Environment)

The recommended storage environment parameters for the M-3311 are:

- The ambient temperature where the M-3311 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-3311 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-3311 includes a removable lithium battery backed TIMEKEEPER® module (Beckwith Electric component U25, Figure 5-7). The TIMEKEEPER module is the M-3311 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-3311 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 4.4, 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 4-28.
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 4-30.
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-3311 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, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringementof United States Letters Patent or rights accruing thereform or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of 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.

Notice:

Any illustrations and descriptions by Beckwith Electric Co., Inc. are for the sole purpose of identification.

The drawings and/or specifications enclosed herein are the proprietary property of Beckwith Electric Co., Inc., and are issued in strict confidence; therefore, shall not be used as a basis of reproduction of the apparatus described therein without written permission of Beckwith Electric Co., Inc.

No illustration or description contained herein shall be construed as an express warranty of affirmation, promise, description, or sample, and any and all such express warranties are specifically excluded nor shall such illustration or description imply a warranty that the product is merchantable or fit for a particular purpose. There shall be no warranties which extend beyond those contained in the Beckwith Electric Co., Inc. terms of sale.

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

800-3311-IB-03MC1 10/07