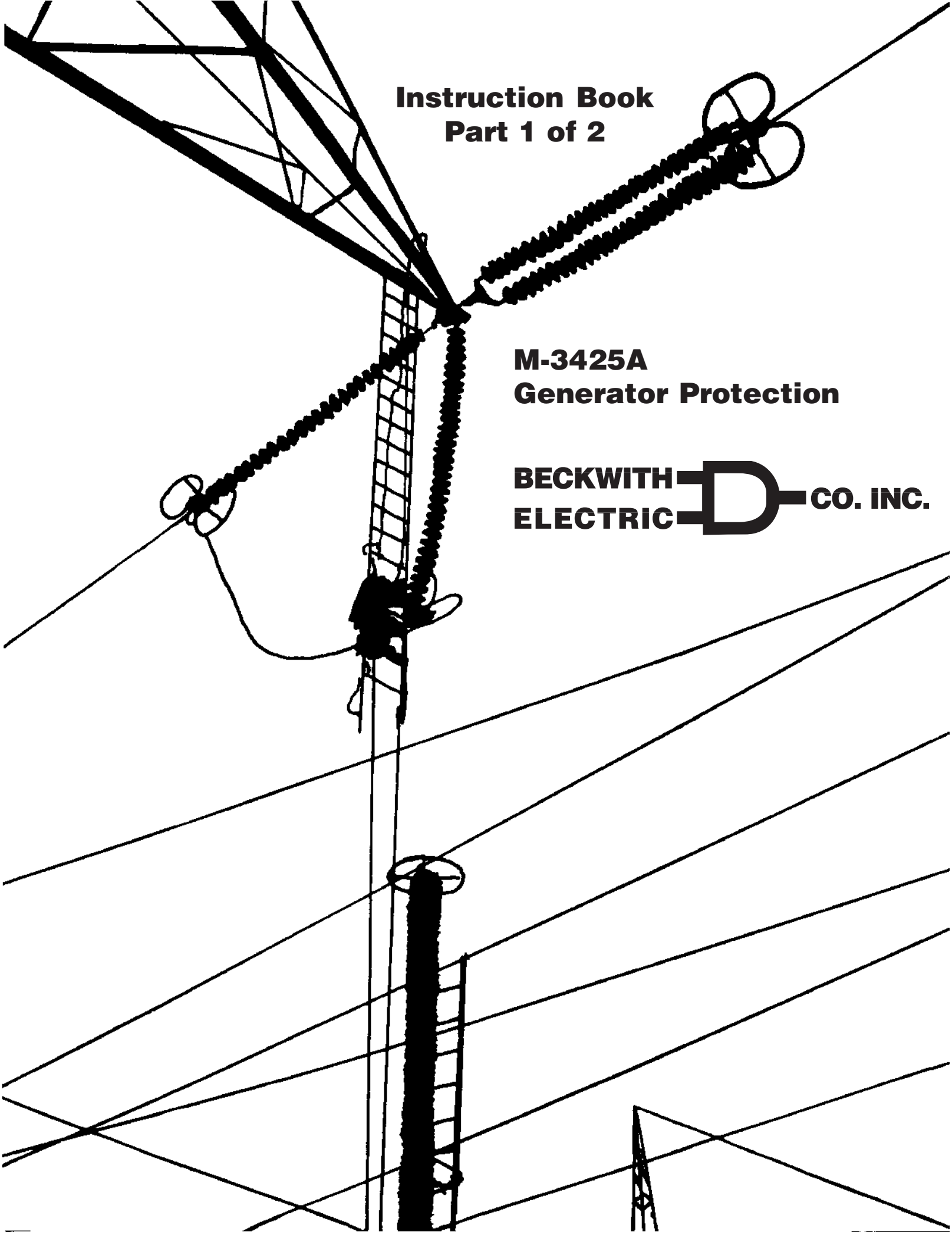
Instruction Book
Part 1 of 2

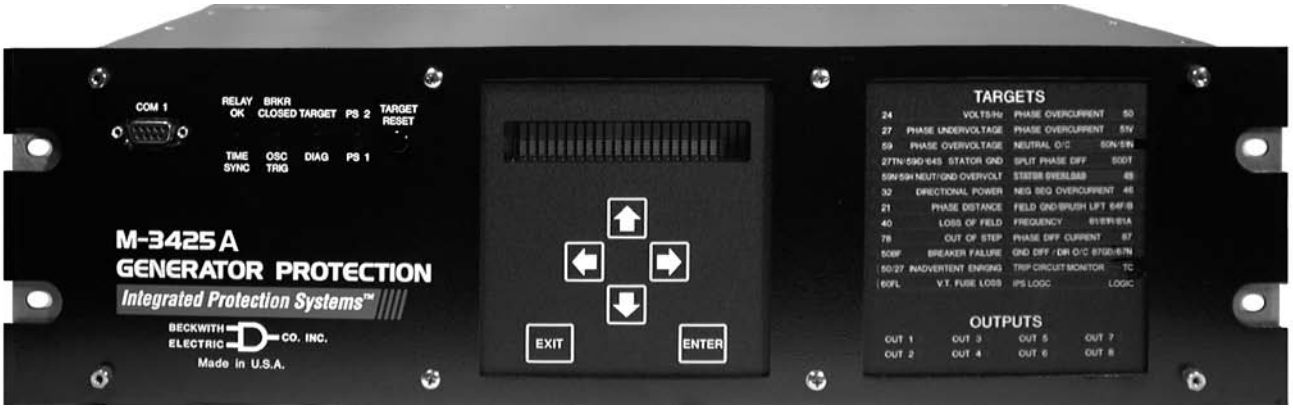


M-3425A
Generator Protection

BECKWITH ELECTRIC CO. INC.

Generator Protection M-3425A

Integrated Protection System® for Generators of All Sizes



Unit shown with optional M-3925A Target Module and M-3931 HMI (Human-Machine Interface) Module.

- **Exceeds IEEE C37.102 and Standard 242 requirements for generator protection**
- **Protects generators of any prime mover, grounding and connection type**
- **Provides all major protective functions for generator protection including Out-of-Step (78), Split-Phase Differential (50DT), Under Frequency Time Accumulation (81A), Inadvertent Energizing (50/27) and Turn-to-Turn Fault (59X)**
- **Expanded IPScom® Communications Software provides simple and logical setting and programming, including logic schemes**
- **Simple application with Base and Comprehensive protection packages**
- **Load encroachment blinders and power swing blocking for system backup protection (21) to enchance security during system abnormal conditions**
- **Options: Ethernet Connection, Field Ground/Brush Lift-Off Protection (64F/B), Sync Check (25), 100% Stator Ground Fault Protection by low frequency injection (64S) and Expanded I/O (15 additional Output Contacts and 8 additional Control/Status Inputs)**

Protective Functions

Base Package

- Overexcitation (V/Hz) (24)
- Phase Undervoltage (27)
- Directional power sensitive triple-setpoint Reverse Power, Low Forward Power or Overpower detection, one of which can be used for sequential tripping (32)
- Dual-zone, offset-mho Loss of Field (40), which may be applied with undervoltage controlled accelerated tripping
- Sensitive Negative Sequence Overcurrent protection and alarm (46)
- Instantaneous Phase Overcurrent (50)
- Inadvertent Energizing (50/27)
- Generator Breaker Failure (50BF)
- Instantaneous Neutral Overcurrent (50N)
- Inverse Time Neutral Overcurrent (51N)
- Three-phase Inverse Time Overcurrent (51V) with voltage control and voltage restraint.
- Phase Overvoltage (59)
- Neutral Overvoltage (59N)
- Multi-purpose Overvoltage (59X)
- VT Fuse-Loss Detection and blocking (60FL)
- Residual Directional Overcurrent (67N)
- Four-step Over/Underfrequency (81)
- Phase Differential Current (87)
- Ground (zero sequence) Differential Current (87GD)
- IPSlogic™ takes the contact input status and function status and generates outputs by employing (OR, AND, and NOT) boolean logic and a timer.

Protective Functions

Comprehensive Package

The Comprehensive Package includes all Base Package functions, as well as the following:

- Three-zone Phase Distance protection for phase fault backup protection (21). Zone three can be used for Out-of-Step Blocking. Load encroachment blinders can be applied.
- 100% Stator Ground Fault protection using Third Harmonic Neutral Undervoltage (27TN) or (59D) Third Harmonic Voltage Differential (ratio)
- Stator Overload (49) (Positive Sequence Overcurrent)
- Definite Time Overcurrent (50DT) can be used for split phase differential
- Out-of-Step (78)
- UnderFrequency Accumulation (81A)
- Rate of Change of Frequency (81R)

Optional Protective Functions

- Sync Check with Phase Angle, ΔV and ΔF with dead line/dead bus options (25)
- Field Ground (64F) and Brush Lift Off (64B) (Includes M-3921 Field Ground Coupler)
- 100% Stator Ground protection by low frequency injection (64S). The following equipment is supplied with the 64S option:
  - 20 Hz signal generator (430-00426)
  - Band-pass Filter (430-00429)

Standard Features

- Eight programmable outputs and six programmable inputs
- Oscillographic recording with COMTRADE or BECO format
- Time-stamped target storage for 32 events
- Metering of all measured parameters and calculated values
- Three communications ports (two RS-232 and one RS-485)
- M-3820D IPScom® Communications Software
- Includes MODBUS and BECO 2200 protocols
- Standard 19" rack-mount design (vertical mounting available)
- Removable printed circuit board and power supply
- 50 and 60 Hz models available
- Both 1A and 5 A rated CT inputs available
- Additional trip inputs for externally connected devices
- IRIG-B time synchronization
- Operating Temperature: –20° C to +70° C
- Sequence of Events Log
- Trip Circuit Monitoring
- Breaker Monitoring
- Four Setpoint Groups

Optional Features

- Redundant power supply
- M-3925A Target Module
- M-3931 Human-Machine Interface (HMI) Module
- RJ45 Ethernet port utilizing MODBUS over TCP/IP and BECO2200 over TCP/IP protocols
- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software
- Expanded I/O (15 additional outputs and 8 additional inputs)

PROTECTIVE FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Phase Distance (three-zone mho characteristic)			
21	Circle Diameter #1,#2,#3	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Offset #1,#2,#3	–100.0 to 100.0 Ω (–500.0 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Impedance Angle #1,#2,#3	0° to 90°	1°	±1°
	Load Encroachment Blinder #1,#2,#3			
	Angle	1° to 90°	1°	±1°
	R Reach	0.1 to 100 Ω		
	Time Delay #1,#2,#3	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Out-of-Step Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Overcurrent Supervision	0.1 to 20 A (0.02 to 4 A)	0.1 A 0.01 A	±0.1 A or ±2% ±0.02 A or ±2%

When out-of-step blocking on Zone 1 or Zone 2 is enabled, Zone 3 will not trip and it will be used to detect the out-of-step condition for blocking Function 21 #1 and/or 21 #2.

	Volts / Hz			
24	**Definite Time** Pickup #1, #2	100 to 200%	1%	±1%
	Time Delay #1, #2	30 to 8160 Cycles	1 Cycle	±25 Cycles
	Inverse Time			
	Pickup	100 to 200%	1%	±1%
	Characteristic Curves	Inverse Time #1–#4	—	—
	Time Dial: Curve #1 Time Dial: Curves #2–#4	1 to 100 0.0 to 9.0	1 0.1	
	Reset Rate	1 to 999 Sec. (from threshold of trip)	1 Sec.	±.02 Sec. or ±1%

The percent pickup is based on nominal VT secondary voltage and nominal system frequency settings. The pickup accuracy stated is only applicable from 10 to 80 Hz, 0 to 180 V, 100 to 150% V/Hz and a nominal voltage setting of 120 V.

	Phase Undervoltage			
27	Pickup #1, #2, #3	5 to 180 V	1 V	±0.5 V or ±0.5% ±0.8 V or ±0.75%*
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±0.5%**

** When both RMS and Line-Ground to Line-Line VT connection is selected.*

***When RMS (total waveform) is selected, timing accuracy is ≤20 cycles or ±1%.*

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Third-Harmonic Undervoltage, Neutral			
27 TN	Pickup #1, #2	0.10 to 14.00 V	0.01 V	±0.1 V or ±1%
	Positive Sequence Voltage Block	5 to 180 V	1 V	±0.5 V or ±0.5%
	Forward Under Power Block	0.01 to 1.00 PU	0.01 PU	±0.01 PU or ±2%
	Reverse Under Power Block	–1.00 to –0.01 PU	0.01 PU	±0.01 PU or ±2%
	Lead Under var Block	–1.00 to –0.01 PU	0.01 PU	±0.01 PU or ±2%
	Lag Under var Block	0.01 to 1.00 PU	0.01 PU	±0.01 PU or ±2%
	Lead Power Factor Block	0.01 to 1.00	0.01	±0.03 PU or ±3%
	Lag Power Factor Block	0.01 to 1.00	0.01	±0.03 PU or ±3%
	High Band Forward Power Block	0.01 to 1.00 PU	0.01 PU	±0.01 PU or ±2%
	Low Band Forward Power Block	0.01 to 1.00 PU	0.01 PU	±0.01 PU or ±2%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Directional Power			
32	Pickup #1, #2, #3	–3.000 to +3.000 PU	0.001 PU	±0.002 PU or ±2%
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	+16 Cycles or ±1%

The minimum Pickup limits are –.002 and +.002 respectively.

The per-unit pickup is based on nominal VT secondary voltage and nominal CT secondary current settings. This function can be selected as either overpower or underpower in the forward direction (positive setting) or reverse direction (negative setting). Element #3 can be set as real power or reactive power. This function includes a programmable target LED that may be disabled.

	Loss of Field (dual-zone offset-mho characteristic)			
40	Circle Diameter #1, #2	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω	±0.1 Ω or ±5% (±0.5 Ω or ±5%)
	Offset #1, #2	–50.0 to 50.0 Ω (–250.0 to 250.0 Ω)	0.1 Ω	±0.1 Ω or ±5% (±0.5 Ω or ±5%)
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Time Delay with Voltage Control #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Voltage Control (positive sequence)	5 to 180 V	1 V	±0.5 V or ±0.5%
	Directional Element	0° to 20°	1°	—

Time delay with voltage control for each zone can be individually enabled.

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Negative Sequence Overcurrent			
46	**Definite Time** Pickup	3 to 100%	1%	±0.5% of 5 A (±0.5% of 1 A)
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Inverse Time Pickup	3 to 100%	1%	±0.5 % of 5 A (±0.5% of 1 A)
	Time Dial Setting ($K= I_2^2t$)	1 to 95	1	±3 Cycles or ±3%
	Definite Maximum Time to Trip	600 to 65,500 Cycles	1 Cycle	±1 Cycle or ±1%
	Definite Minimum Time	12 Cycles	—	fixed
	Reset Time (Linear)	1 to 600 Seconds (from threshold of trip)	1 Second	—
	Pickup is based on the generator nominal current setting.			
	Stator Overload Protection			
49	Time Constant #1, #2	1.0 to 999.9 minutes	0.1 minutes	
	Maximum Overload Current	1.00 to 10.00 A (0.20 to 2.00 A)	0.01 A	±0.1 A or ±2%
	Instantaneous Phase Overcurrent			
50	Pickup #1, #2	0.1 to 240.0 A (0.1 to 48.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	When frequency f is < (f_{nom} –5) Hz add an additional time of (1.5/f + 0.033) sec to the time delay accuracy.			
	Breaker Failure			
50 BF	**Pickup**			
50 BF-Ph	Phase Current	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%)
50 BF-N	Neutral Current	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 Cycle or ±1%
	50BF can be initiated from designated M-3425A output contacts or programmable control/status inputs.			
	Definite Time Overcurrent			
50 DT	Pickup Phase A #1, #2	0.20 A to 240.00 A (0.04 A to 48.00 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Pickup Phase B #1, #2	(same as above)		
	Pickup Phase C #1, #2	(same as above)		
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	This function uses generator line-side currents.			
	When 50DT function is used for split-phase differential protection, 50BF, 87, and 87GD functions should not be used, and the I_A, I_B and I_C inputs must be connected to the split phase differential currents.			

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
Instantaneous Neutral Overcurrent				
50N	Pickup	0.1 to 240.0 A (0.1 to 48.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
When the frequency f is < (f_{nom} –5) Hz add an additional time of (1.5/f + 0.033) sec to the time delay accuracy.				
Inadvertent Energizing				
50/27	50 Overcurrent Pickup	0.5 to 15.00 A (0.1 to 3.00 A)	0.01 A	±0.1 A or ±2% (±0.02 A or ±2%)
	27 Undervoltage Pickup	5 to 130 V	1 V	±0.5 V
	Pick-up Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Drop-out Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
Inverse Time Neutral Overcurrent				
51N	Pickup	0.25 to 12.00 A (0.05 to 2.40 A)	0.01 A	±0.1 A or ±1% (±0.02 A or ±1%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves) 0.85 to 1.15 (IEEE curves)	0.1 0.01 0.01	±3 Cycles or ±3%*
** For IEC Curves the timing accuracy is ±5%.*				
When the frequency f is < (f_{nom} –5)Hz add an additional time of (1.5/f + 0.033) sec to the time delay accuracy.				
Inverse Time Phase Overcurrent, with Voltage Control or Voltage Restraint				
51V	Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A	±0.1 A or ±1% (±0.02 A or ±1%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC curves) 0.85 to 1.15 (IEEE curves)	0.1 0.01 0.01	±3 Cycles or ±3%*
	Voltage Control (VC) or Voltage Restraint (VR)	5 to 180 V Linear Restraint	1 V —	±0.5 V or ±0.5% —
** For IEC Curves the timing accuracy is ±5%.*				

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Phase Overvoltage			
59	Pickup #1, #2, #3	5 to 180 V	1 V	±0.5 V or ±0.5% ±0.8 V or ±0.75%*
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%**
	Input Voltage Select	Phase or Positive Sequence***		
	Third-Harmonic Voltage Differential Ratio			
59D	Ratio (V_x/V_N)	0.1 to 5.0	0.1	
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Positive Seq Voltage Block	5 to 180 V	1 V	±0.5 V or ±0.5%
	Line Side Voltage	V_X or $3V_0$ (calculated)		
	Neutral Overvoltage			
59N	Pickup #1, #2, #3	5.0 to 180.0 V	0.1 V	±0.5 V or ±0.5%
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Multi-purpose Overvoltage			
59X	Pickup #1, #2	5.0 to 180.0 V	0.1 V	±0.5 V or ±0.5%
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	VT Fuse-Loss Detection			
60 FL	**A VT fuse-loss condition is detected by using the positive and negative sequence components of the voltages and currents. VT fuse-loss output can be initiated from internally generated logic, and/or from input contacts.**			
	Alarm Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Three Phase VT Fuse Loss Detection	Enable/Disable		

** When both RMS and Line-Ground to Line-Line is selected.*

*** When RMS (total waveform) is selected, timing accuracy is +20 cycles or ±1%.*

**** When positive sequence voltage is selected, the 59 Function uses discrete Fourier transform (DFT) for magnitude calculation, irrespective of the RMS/DFT selection, and timing accuracy is ±1 Cycle or ±1%.*

The 59D function with V_X cannot be enabled if the 25 function is enabled. The line side voltage can be selected as the third harmonic of $3V_0$ (equivalent to $V_A + V_B + V_C$) or V_X.

$3V_0$ selection for line side voltage can only be used with line-ground VT configuration.

When 64S is purchased, the 59N Time Delay Accuracy is –1 to +5 cycles.

Multi-purpose input that may be used for turn-to-turn stator ground protection, bus ground protection, or as an extra Phase-Phase, or Phase-Ground voltage input.

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Residual Directional Overcurrent			
67N	**Definite Time***			
	Pickup	0.5 to 240.0 A (0.1 to 48.0 A)	0.1 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Time Delay	1 to 8160 Cycles	1 Cycle	–1 to +3 Cycles or ±1%
	Inverse Time*			
	Pickup	0.25 to 12.00 A (0.05 to 2.40 A)	0.01 A	±0.1 A or ±3% (±0.02 A or ±3%)
	Characteristic Curve	Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves		
	Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC Curves) 0.5 to 11 (IEEE curves)	0.1 0.01 0.01	±3 Cycles or ±5%
	Directional Element			
	Max Sensitivity Angle (MSA)	0 to 359°	1°	
	Polarizing Quantity	$3V_o$ (calculated), V_N or V_X		
	Out of Step (mho characteristic)			
78	Circle Diameter	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Offset	–100.0 to 100.0 Ω (–500.0 to 500.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Impedance Angle	0° to 90°	1°	±1°
	Blinder	0.1 to 50.0 Ω (0.5 to 250.0 Ω)	0.1 Ω	±0.1 Ω or 5% (±0.5 Ω or 5%)
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Trip on mho Exit	Enable/Disable		
	Pole Slip Counter	1 to 20	1	
	Pole Slip Reset	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Frequency			
81	Pickup #1,#2,#3,#4	50.00 to 67.00 Hz 40.00 to 57.00 Hz*	0.01 Hz	±0.02 Hz
	Time Delay #1–#4	3 to 65,500 Cycles	1 Cycle	±2 Cycles or ±1%

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

V_X polarization cannot be used if 25 function is enabled.

$3V_o$ polarization can only be used with line-ground VT configuration.

Operating current for 67N can be selected as $3I_o$ (calculated) or I_N (Residual CT).

If 87GD is enabled, 67N with I_N (Residual CT) operating current will not be available.

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

** This range applies to 50 Hz nominal frequency models.*

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	Frequency Accumulation			
81A	Bands #1, #2, #3, #4, #5, #6			
	High Band #1	50.00 to 67.00 Hz 40.00 to 57.00 Hz*	0.01 Hz	±0.02 Hz
	Low Band #1–#6	50.00 to 67.00 Hz 40.00 to 57.00 Hz*	0.01 Hz	±0.02 Hz
	Delay #1–#6	3 to 360,000 Cycles	1 Cycle	±2 Cycles or ±1%
	Rate of Change of Frequency			
81R	Pickup #1, #2	0.10 to 20.00 Hz/Sec.	0.01 Hz/Sec.	±0.05 Hz/Sec. or ±5%
	Time Delay #1, #2	3 to 8160 Cycles	1 Cycle	+ 20 Cycles
	Negative Sequence Voltage Inhibit	0 to 99%	1%	±0.5%
	Phase Differential Current			
87	Pickup #1, #2	0.20 A to 3.00 A (0.04 to 0.60 A)	0.01 A	±0.1 A or ±5% (±0.02 A or ±5%)
	Percent Slope #1, #2	1 to 100%	1%	±2%
	Time Delay* #1, #2	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	CT Correction**	0.50 to 2.00	0.01	
	Ground (zero sequence) Differential Current			
87 GD	Pickup	0.20 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 Cycle or ±1%
	CT Ratio Correction (R_C)	0.10 to 7.99	0.01	

When using multiple frequency bands, the lower limit of the previous band becomes the upper limit for the next band, i.e., Low Band #2 is the upper limit for Band #3, and so forth. Frequency bands must be used in sequential order, 1 to 6. Band #1 must be enabled to use Bands #2–#6. If any band is disabled, all following bands are disabled.

When frequency is within an enabled band limit, accumulation time starts (there is an internal ten cycle delay prior to accumulation) and allows the underfrequency blade resonance to be established to avoid unnecessary accumulation of time. When duration is greater than set delay, the alarm asserts and a target log entry is made.

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

** This range applies to 50 Hz nominal frequency models.*

**When a time delay of 1 cycle is selected, the response time is less than 1–1/2 cycles.*

***The CT Correction factor is multiplied by I_A,I_B,I_C.*

The 87GD function is provided primarily for low-impedance grounded generator applications. This function operates as a directional differential. If $3I_0$ or I_n is extremely small (less than 0.2 secondary Amps), the element becomes non-directional.

If 67N function with I_N (Residual) operating current is enabled, 87GD will not be available. Also, if 50DT is used for split-phase differential, 87GD function will not be available.

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

PROTECTIVE FUNCTIONS (*cont.*)

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
	IPSlogic™			
IPS	**IPSlogic uses element pickups, element trip commands, control/status input state changes, output contact close signals to develop 6 programmable logic schemes.**			
	Time Delay #1–#6	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Breaker Monitoring			
BM	Pickup	0 to 50,000 kA Cycles or kA^2 Cycles	1 kA Cycles or kA^2 Cycles	± 1 kACycles or kA^2 Cycles
	Time Delay	0.1 to 4095.9 Cycles	0.1 Cycles	±1 Cycle or ±1%
	Timing Method	IT or I^2T		
	Preset Accumulators Phase A, B, C	0 to 50,000 kA Cycles	1 kA Cycle	
	Trip Circuit Monitoring			
TC	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Nominal Settings			
	Nominal Voltage	50.0 to 140.0 V	0.1 V	—
	Nominal Current	0.50 to 6.00 A	0.01 A	—
	VT Configuration	Line-Line/Line-Ground/ Line-Ground to Line-Line*		
	Delta/Wye Unit Transformer	Disable/Delta AB/Delta AC		
	Seal-In Delay	2 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%

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

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

The accumulated value for each phase can be displayed.

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

The AUX input is provided for monitoring the integrity of the trip circuit. This input can be used for nominal trip coil voltages of 24 V dc, 48 V dc, 125 V dc and 250 V dc.

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

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

OPTIONAL PROTECTIVE FUNCTIONS

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

Various combinations of input supervised hot/dead closing schemes may be selected. The 25 function cannot be enabled if the 59D function with V_x or 67N function with V_x is enabled.

	Field Ground Protection			
64F	Pickup #1, #2	5 to 100 KΩ	1 KΩ	±10% or ±1KΩ
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	$\pm(\frac{2}{IF}+1)$ Sec.
	Injection Frequency (IF)	0.10 to 1.00 Hz	0.01 Hz	
64B	**Brush Lift-Off Detection** (measuring control circuit)			
	Pickup	0 to 5000 mV	1 mV	
	Time Delay	1 to 8160 Cycles	1 Cycle	$\pm(\frac{2}{IF}+1)$ Sec.

When 64F is purchased, an external Coupler Module (M-3921) is provided for isolation from dc field voltages.

Figure 8, Field Ground Protection Block Diagram, illustrates a typical connection utilizing the M-3921 Field Ground Coupler. Hardware dimensional and mounting information is shown in Figure 9, M-3921 Field Ground Coupler Mounting Dimensions.

	100% Stator Ground Protection by low frequency injection			
64S	Pickup	2 to 40 mA	1 mA	±1 mA
	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle* or ±1%
	Undervoltage Inhibit	5 to 30 V	1 V	±0.5 V to ±0.5%

External low frequency generator, band pass filter and current transformer are required for this function. 59D and 27TN function should be disabled when the 64S function is enabled. 59N may be applied when this function is enabled.

** Time Delay accuracy in cycles is based on 20 Hz frequency.*

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

Description

The M-3425A Generator Protection Relay is suitable for all generator ratings and prime movers. Typical connection diagrams are illustrated in Figure 4, M-3425A One-Line Functional Diagram (configured for phase differential), and Figure 5, One-Line Functional Diagram (configured for split-phase differential).

Configuration Options

The M-3425A Generator Protection Relay is available in either a Base or Comprehensive package of protective functions. This provides the user with flexibility in selecting a protective system to best suit the application. Additional Optional Protective Functions may be added at the time of purchase at per-function pricing.

The Human-Machine Interface (HMI) Module, Target Module, or redundant power supply can be selected at time of purchase.

When the Field Ground (64F) Premium Protective Function is purchased, an external coupler module (M-3921) is provided for isolation from the dc field voltages.

When 100% Stator Ground (64S) protection using low-frequency injection is purchased, an external band pass filter and frequency generator is provided.

Multiple Setpoint Profiles (Groups)

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

■ **NOTE**: During profile switching, relay operation is disabled for approximately 1 second.

Metering

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

Metering accuracies are:

Voltage:	±0.5 V or ±0.5%, whichever is greater ±0.8 V or ±0.75%, whichever is greater (when both RMS and Line-Ground to Line-Line are selected)
Current:	5 A rating, ±0.1 A or ±3%, whichever is greater 1 A rating, ±0.02 A or ±3%, whichever is greater
Power:	±0.01 PU or ±2% of VA applied, whichever is greater
Frequency:	±0.02 Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models) ±0.1 Hz beyond 63 Hz for 60 Hz models, and beyond 53 Hz for 50 Hz models
Volts/Hz:	±1%

Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, storing up to 472 cycles of data. The total record length is user-configurable from 1 to 16 partitions. The sampling rate is 16 times the power system nominal frequency (50 or 60 Hz). The recorder may be triggered using either the designated control/status inputs, trip outputs, 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 data records can be stored in either Beckwith Electric format or COMTRADE format.

Target Storage

Information associated with the last 32 trips is stored. The information includes the function(s) operated, the functions picked up, input/output status, time stamp, and phase and neutral currents at the time of trip.

Sequence of Events Log

The Sequence of Events Log records relay element status, I/O status, measured values and calculated values time stamped with 1 ms resolution at user-defined events. The Sequence of Events Log includes 512 of the most recently recorded relay events. The events and the associated data is available for viewing utilizing the M-3820D IPScom Communications Software.

Calculations

Current and Voltage RMS Values: Uses Discrete Fourier Transform algorithm on sampled voltage and current signals to extract fundamental frequency phasors for relay calculations. RMS calculation for the 50, 51N, 59 and 27 functions, and the 24 function are obtained using the time domain approach to obtain accuracy over a wide frequency band. When the RMS option is selected, the magnitude calculation for 59 and 27 functions is accurate over a wide frequency range (10 to 80 Hz). When the DFT option is selected, the magnitude calculation is accurate near nominal frequency (50 Hz/60 Hz) but will degrade outside the nominal frequency. For 50 and 51N functions the DFT is used when the frequency is 55 Hz to 65 Hz for 60 Hz (nominal) and 45 Hz to 55Hz for 50 Hz (nominal), outside of this range RMS calculation is used.

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 312.5 V dc. Withstands 300 V ac or 315 V dc for 1 second. Nominal 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.

An optional redundant power supply is available for units that are purchased without the expanded I/O.

For those units purchased with the expanded I/O, the unit includes two power supplies which are required to power the relay. Burden (nominal) 46 VA @120 V ac.

Sensing Inputs

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

Seven Current Inputs: Rated nominal current (I_R) of 5.0 A or 1.0 A at 60 Hz or 50 Hz. Will withstand $3I_R$ continuous current and $100I_R$ for 1 second. Current transformer burden is less than 0.5 VA at 5 A, or 0.3 VA at 1 A.

Control/Status Inputs

The control/status inputs, INPUT1 through INPUT6, can be programmed to block any relay protective function, to trigger the oscillograph recorder, to operate one or more outputs or can be an input into IPSlogic™. To provide breaker status LED indication on the front panel, the INPUT1 control/status input contact must be connected to the 52b breaker status contact.

The optional expanded I/O includes an additional 8 programmable control/status inputs (INPUT7 through INPUT14).

▲ **CAUTION**: The control/status inputs should be connected to dry contacts only, and are internally connected (wetted) with a 24 V dc power supply.

Output Contacts

Any of the functions can be individually programmed to activate any one or more of the eight programmable output contacts OUTPUT1 through OUTPUT8. Any output contact can also be selected as pulsed or latched. IPSlogic can also be used to activate an output contact.

The optional expanded I/O includes an additional 15 programmable output contacts (OUTPUT9 through OUTPUT23). These contacts are configurable only using IPScom software.

The eight output contacts (six form ‘a’ and two form ‘c’), the power supply alarm output contact (form ‘b’), the self-test alarm output contact (form ‘c’) and the optional 15 expanded I/O output contacts (form 'a') are all rated per ANSI/IEEE C37.90-1989 for tripping. Make 30 A for 0.2 seconds, carry 8 A, break 6 A at 120 V ac, break 0.5 A at 48 V dc; 0.3 A, 125 V dc; 0.2 A, 250 V dc with L/R=40 mSec.

IPSlogic

This feature can be programmed utilizing the IPScom® Communications Software. IPSlogic takes the contact input status and function status, and by employing (OR, AND, and NOT) boolean logic and a timer, can activate an output or change setting profiles.

Target/Status Indicators and Controls

The **RELAY OK** LED reveals proper cycling of the microcomputer. The **BRKR CLOSED** LED will turn on when the breaker is closed (when the 52b contact input is open). The **OSC TRIG** LED indicates that oscillographic data has been recorded in the unit's memory. The **TARGET** LED will turn on when any of the relay functions operate. Pressing and releasing the **TARGET RESET** button resets the target LED if the conditions causing the operation have been removed. Holding the **TARGET RESET** button displays the present pickup status of the relay functions. The **PS1** and **PS2** LEDs will remain on as long as power is applied to the unit and the power supply is operating properly. **TIME SYNC** LED illuminates when valid IRIG-B signal is applied and time synchronization has been established.

Communication

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

- Interrogation and modification of setpoints
- Time-stamped information for the 32 most recent trips
- Real-time metering of all quantities measured
- Downloading of recorded oscillographic data and Sequence of Events Recorder data.

When the optional Ethernet port is purchased it also provides MODBUS over TCP/IP and BECO2200 over TCP/IP protocols.

IRIG-B

The M-3425A Generator Protection Relay can accept either modulated or demodulated IRIG-B time clock synchronization signal. The IRIG-B time synchronization information is used to correct the hour, minutes, seconds, and milliseconds information.

HMI Module (optional)

Local access to the relay is provided through an optional M-3931 HMI (Human-Machine Interface) Module, allowing for easy-to-use, menu-driven access to all functions via six buttons and a 2-line by 24 character alphanumeric vacuum florescent display. Features of the HMI Module include :

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

Target Module (optional)

An optional M-3925A Target Module provides 24 target and 8 output LEDs. Appropriate target LEDs will light when the corresponding function operates. The targets can be reset with the **TARGET RESET** pushbutton. The **OUTPUT** LEDs indicate the status of the programmable output relays.

Temperature Controller Monitoring

Any Temperature Controller equipped with a contact output may be connected to the M-3425A and controlled by the relay's IPSlogic function. Figure 1 is an example of a typical Temperature Controller Monitoring application.

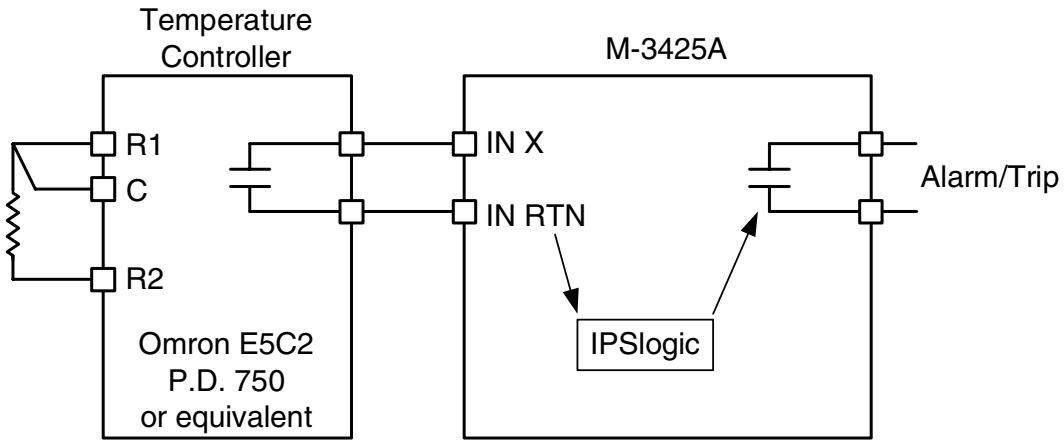


Figure 1 Typical Temperature Controller Monitoring Application

I/O Expansion (optional)

Optional I/O Expansion provides an additional 15 form 'a' output contacts and an additional 8 control/status inputs. Output LEDs indicate the status of the output relays.

Tests and Standards

The 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 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

EN 60255-22-2 Class 4 (8 kV)—point contact discharge

EN 60255-22-2 Class 4 (15kV)–air discharge

Fast Transient Disturbance Test

EN 60255-22-4 Class A (4 kV, 2.5 kHz)

Surge Withstand Capability

ANSI/IEEE C37.90.1-1989	2,500 V pk-pk oscillatory applied to each independent circuit to earth 2,500 V pk-pk oscillatory applied between each independent circuit 5,000 V pk Fast Transient applied to each independent circuit to earth 5,000 V pk Fast Transient applied between each independent circuit
ANSI/IEEE C37.90.1-2002	2,500 V pk-pk oscillatory applied to each independent circuit to earth 2,500 V pk-pk oscillatory applied between each independent circuit 4,000 V pk Fast Transient burst applied to each independent circuit to earth 4,000 V pk Fast Transient burst applied between each independent circuit

■ **NOTE**: The signal is applied to the digital data circuits (RS-232, RS-485, IRIG-B, Ethernet communication port and field ground coupling port) through capacitive coupling clamp.

Radiated Susceptibility

ANSI/IEEE C37.90.2 25-1000 Mhz @ 35 V/m

Output Contacts

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

Atmospheric Environment

Temperature

IEC 60068-2-1 Cold, –20° C
IEC 60068-2-2 Dry Heat, +70° C
IEC 60068-2-3 Damp Heat, +40° C @ 93% RH

Mechanical Environment

Vibration

IEC 60255-21-1 Vibration response Class 1, 0.5 g
Vibration endurance Class 1, 1.0 g

IEC 60255-21-2 Shock Response Class 1, 5.0 g
Shock Withstand Class 1, 15.0 g
Bump Endurance Class 1, 10.0 g

Compliance

UL-Listed per 508 – Industrial Control Equipment

UL-Listed Component per 508A Table SA1.1 Industrial Control Panels

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

CE Safety Directive – EN61010-1:2001, CAT II, Pollution Degree 2 (Pending for expanded I/O option.)

Physical

Without Optional Expanded I/O

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, three-unit high, rack-mount panel design, conforming to ANSI/EIA RS-310C and DIN 41494 Part 5 specifications. Vertical or horizontal panel-mount options are available.

Approximate Weight: 17 lbs (7.7 kg)

Approximate Shipping Weight: 25 lbs (11.3 kg)

With Optional Expanded I/O

Size: 19.00" wide x 6.96" high x 10.2" deep (48.3 cm x 17.7 cm x 25.9 cm)

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

Approximate Weight: 19 lbs (8.6 kg)

Approximate Shipping Weight: 26 lbs (11.8 kg)

Patent & Warranty

The M-3425A Generator Protection Relay is covered by U.S. Patents 5,592,393 and 5,224,011.

The M-3425A Generator Protection Relay is covered by a five year warranty from date of shipment.

Specification subject to change without notice.

External Connections

M-3425A external connection points are illustrated in Figures 2 and 3.

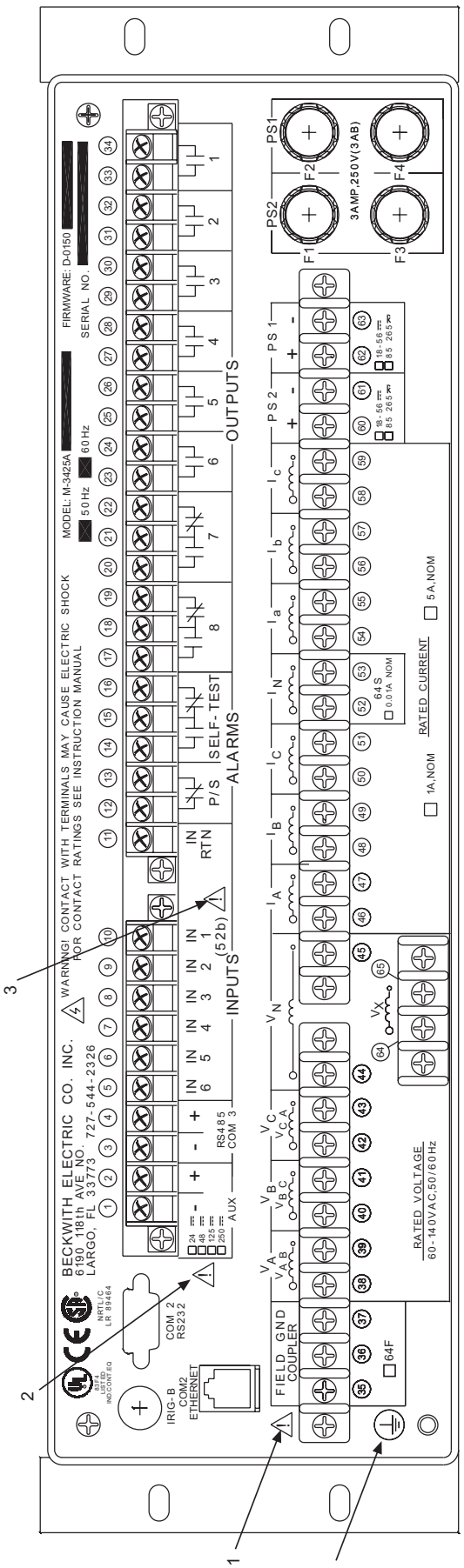


Figure 2 External Connections (Without Optional Expanded I/O)

■ **NOTES**:

1. See M-3425A Instruction Book Section 2.3, Setpoints and Time Settings, subsection for 64B/F Field Ground Protection.
2. Before making connections to the Trip Circuit Monitoring input, see M-3425A Instruction Book Section 5.5, Circuit Board Switches and Jumpers, for the information regarding setting Trip Circuit Monitoring input voltage. Connecting a voltage other than the voltage that the unit is configured to may result in mis-operation or permanent damage to the unit.
3. ● **WARNING**: **ONLY DRY CONTACTS must be connected to inputs (terminals 5 through 10 with 11 common) because these contact inputs are internally wetted. Application of external voltage on these inputs may result in damage to the units.**
4. ● **WARNING: The protective grounding terminal must be connected to an earthed ground any time external connections have been made to the unit.**

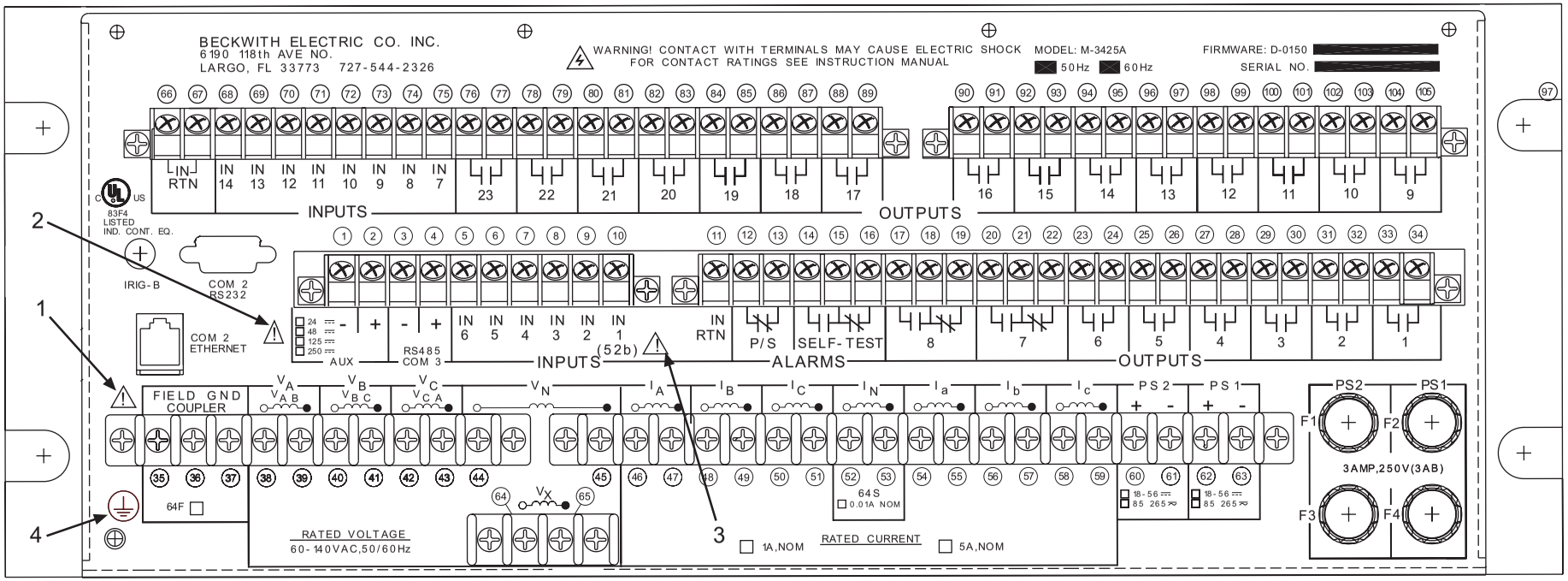
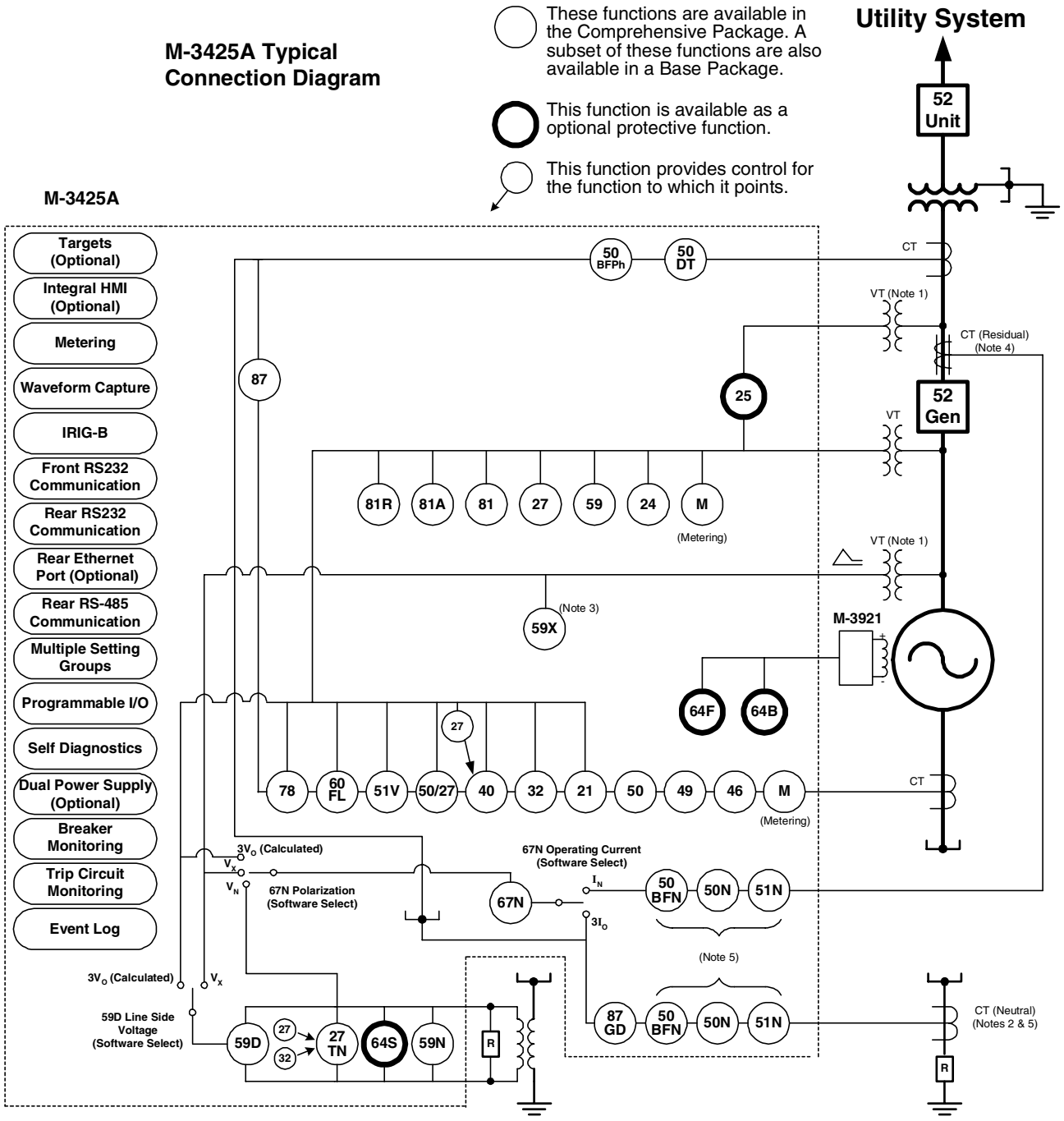


Figure 3 External Connections (With Optional Expaned I/O)

■ **NOTES**:

1. See M-3425A Instruction Book Section 2.3, Setpoints and Time Settings, subsection for 64B/F Field Ground Protection.
2. Before making connections to the Trip Circuit Monitoring input, see M-3425A Instruction Book Section 5.5, Circuit Board Switches and Jumpers, for the information regarding setting Trip Circuit Monitoring input voltage. Connecting a voltage other than the voltage that the unit is configured to may result in mis-operation or permanent damage to the unit.
3. ● **WARNING**: **ONLY DRY CONTACTS must be connected to inputs (terminals 5 through 10 with 11 common and terminals 68 through 75 with 66 and 67 common) because these contact inputs are internally wetted. Application of external voltage on these inputs may result in damage to the units.**
4. ● **WARNING: The protective grounding terminal must be connected to an earthed ground any time external connections have been made to the unit.**



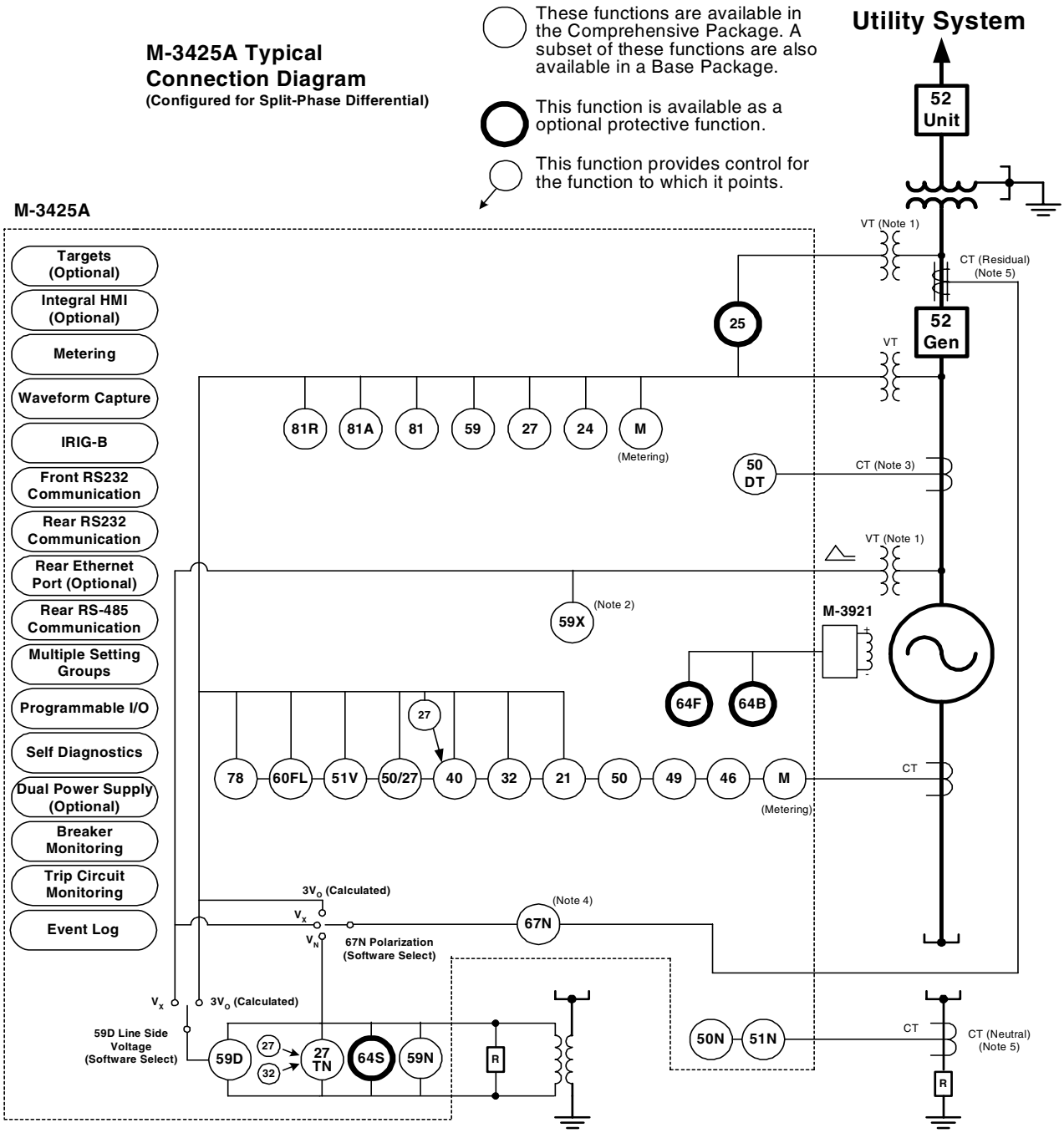
High-impedance Grounding with Third Harmonic 100% Ground Fault Protection

Low-impedance Grounding with Ground Differential and Overcurrent Stator Ground Fault Protection

■ **NOTES**:

1. When 25 function is enabled, 59X, 59D with V_X and 67N with V_X are not available, and vice versa.
2. When 67N function with I_N (Residual) operating current is enabled, 87GD is not available, and vice versa.
3. When VT source is used as a turn-to-turn fault protection device (See M-3425A Instruction Book, Chapter 2, Application, for additional 59X applications.)
4. The current input I_N can be connected either from neutral current or residual current.
5. The 50BFN, 50N, 51N, 59D, 67N (with I_N or V_N) and 87GD functions are unavailable when the 64S function has been purchased. See the M-3425A Instruction Book for connection details.

Figure 4 One-Line Functional Diagram (Configured with Phase Differential)



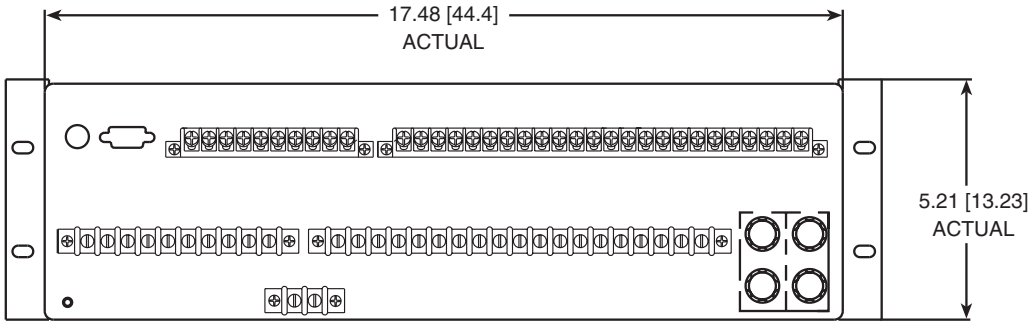
High-impedance Grounding with Third Harmonic 100% Ground Fault Protection

Low-impedance Grounding with Overcurrent Stator Ground Fault Protection

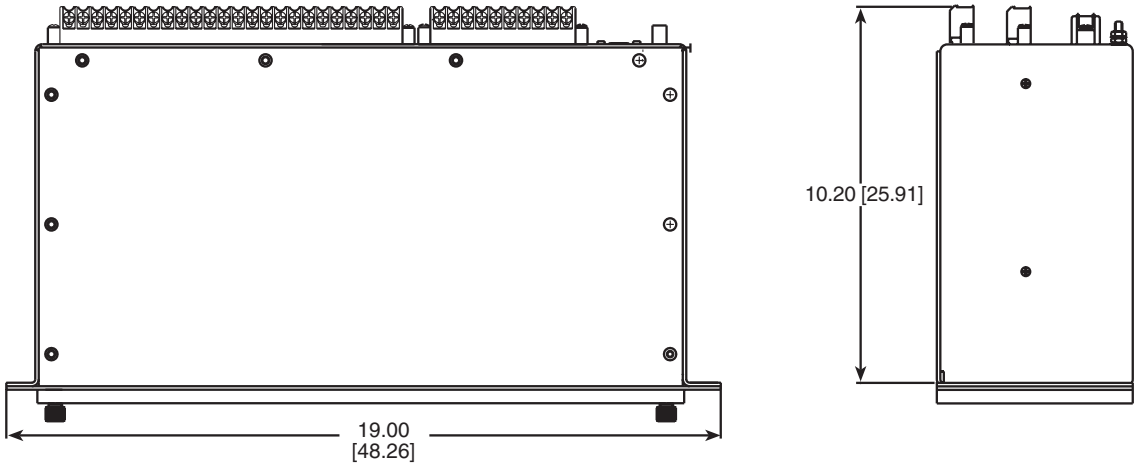
■ **NOTES**:

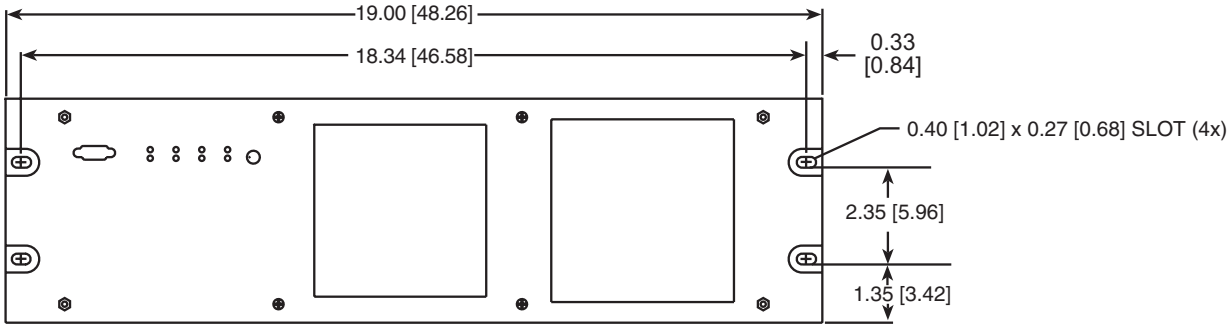
1. When 25 function is enabled, 59X, 59D with V_X and 67N with V_X are not available, and vice versa.
2. When used as a turn-turn fault protection device.
3. CTs are connected for split-phase differential current.
4. 67N operating current can only be selected to I_N (Residual) for this configuration.
5. The current input (I_N) can be connected either from neutral current or residual current.
6. The 50BFN, 50N, 51N, 59D, 67N (with I_N or V_N) and 87GD functions are unavailable when the 64S function has been purchased. See the M-3425A Instruction Book for connection details.

Figure 5 One-Line Functional Diagram (configured for split-phase diffential)



Rear View





Standard 19" Horizontal Mount Chassis

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

Figure 6 Horizontal Mounting Dimensions (Without Expanded I/O)

■ **NOTE**: Panels for vertical mounting are available (See Figure 8).

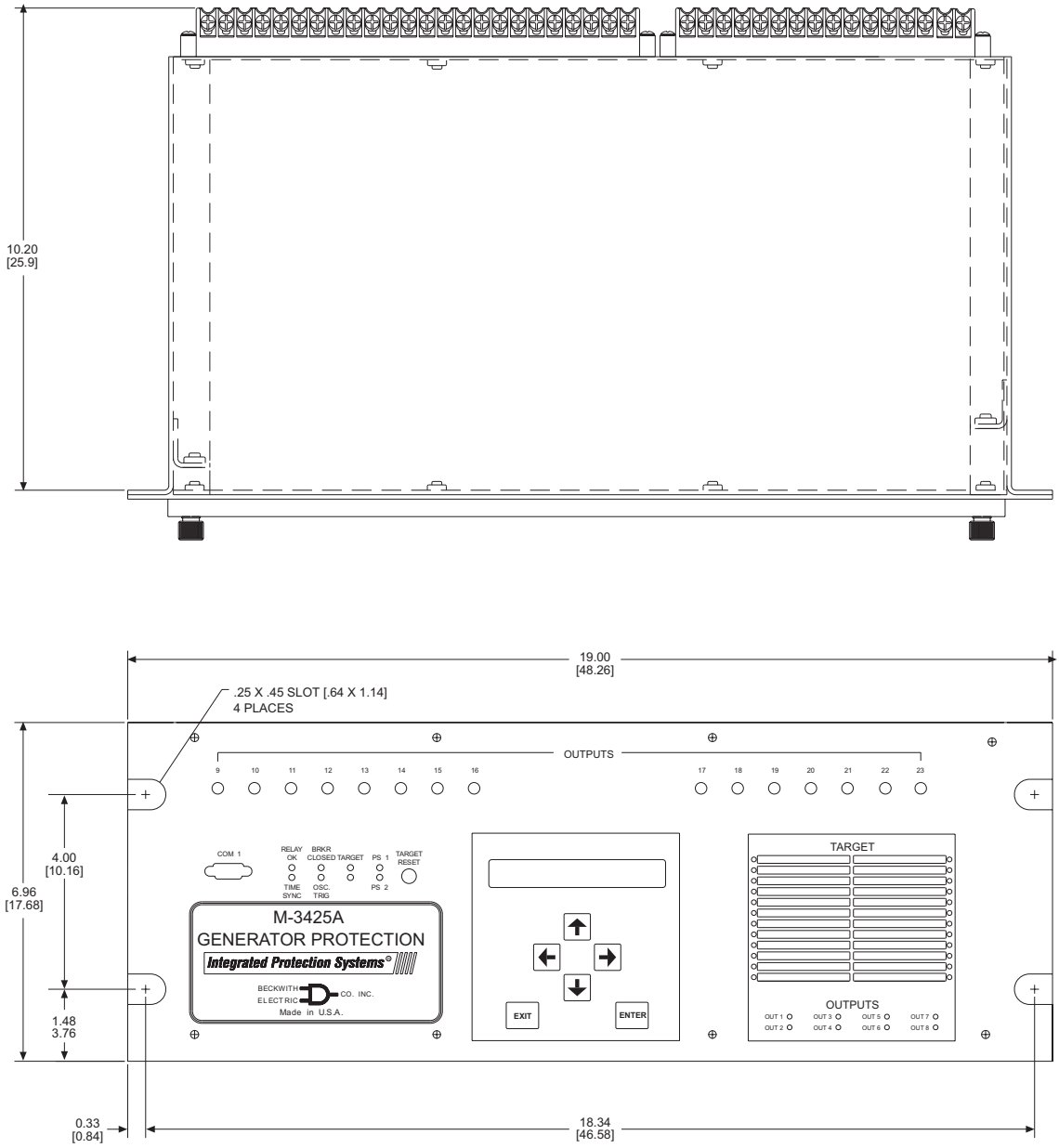
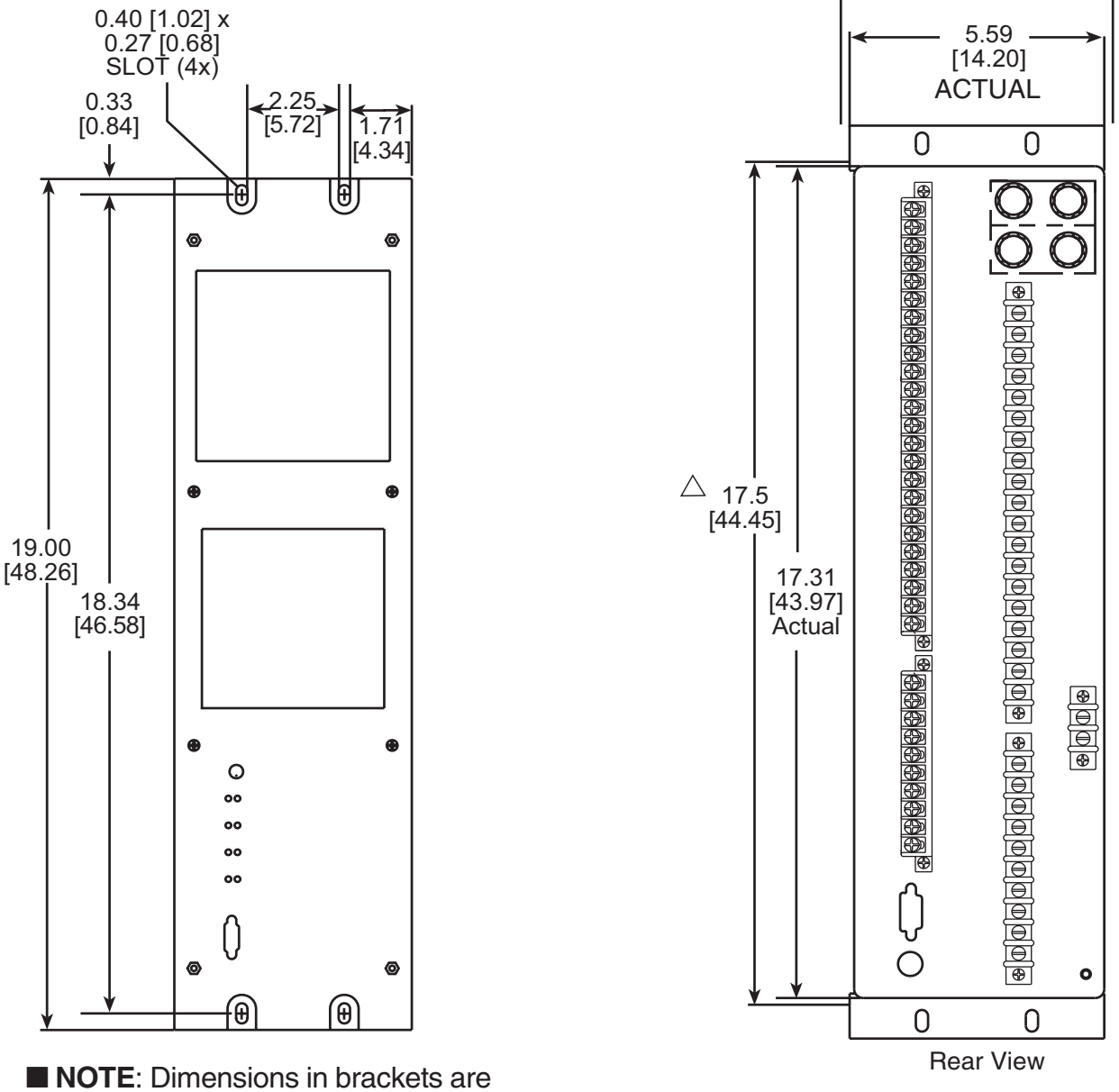


Figure 7 Horizontal Mounting Dimensions (With Expanded I/O)



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

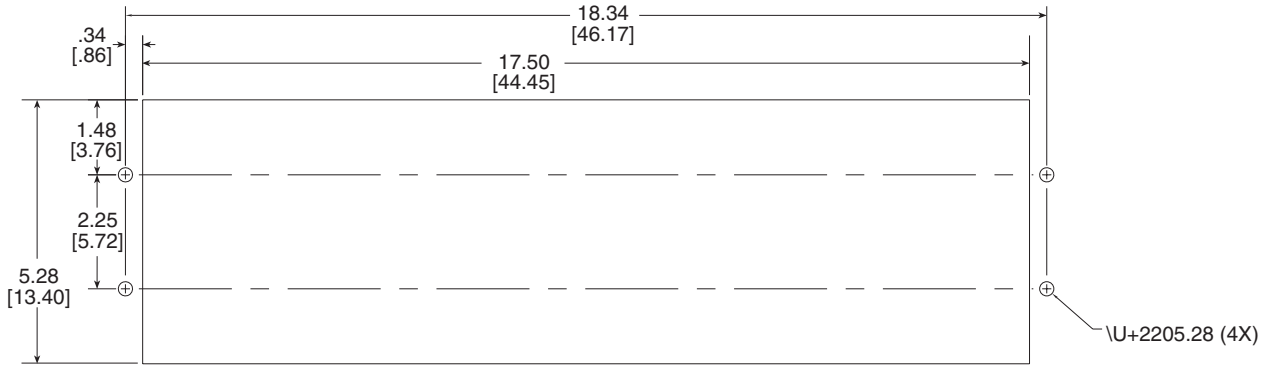
△ RECOMMENDED CUTOUT WHEN RELAY IS A PANEL MOUNT

Optional Vertical Mount Chassis

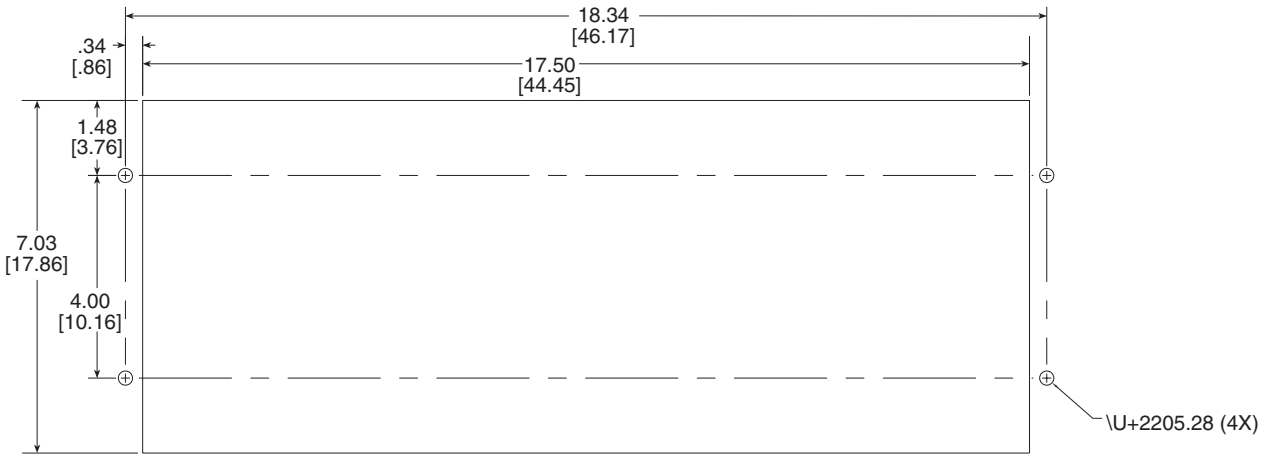
■ **NOTES**:

1. When mounted vertically, the target module will be located at the top and all front-panel text will be horizontally aligned. Consult Beckwith Electric Co. for details.
2. Expanded I/O not avilable on vertical mount chassis model.

Figure 8 Vertical Mounting Dimensions (Without Expanded I/O)



RECOMMENDED CUTOUT
STANDARD 3 UNIT PANEL M-3425A



RECOMMENDED CUTOUT
4 UNIT PANEL M-3425A (EXTENDED I/O)

TOLERANCE: .XX±.015

Figure 9 M-3425A Panel Mount Cutout Dimensions

M-3921 Field Ground Coupler

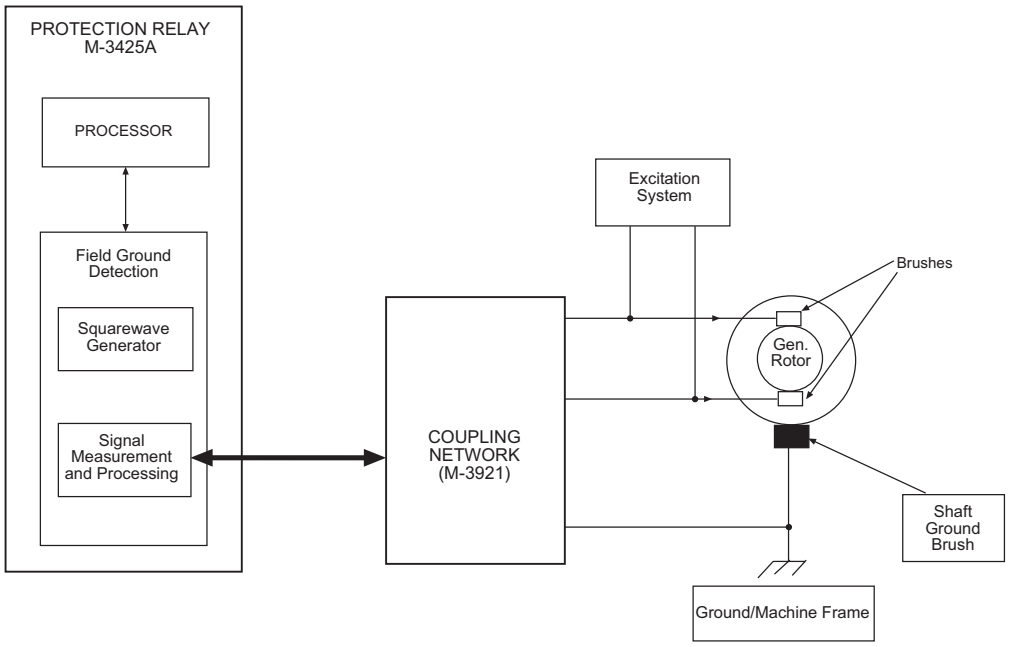


Figure 10 Field Ground Protection Block Diagram

■ **NOTES**:

1. The above circuit measures insulation resistance (R_f) between rotor field winding and ground (64F).
2. Relay injects ± 15 V squarewave (V_{out}) and measures return signal (V_f) to calculate R_f.
3. The injection frequency can be set (0.1 to 1.0 Hz) based on the rotor capacitance, in order to improve accuracy.
4. The signal rise time is analyzed to determine if shaft brushes are lifting or open (64B).
5. May also be applied on generators with brushless excitation with a grounding brush and pilot ground fault detection brush.

Function Specification

Field/Exciter Supply Voltage Rating (Terminal (3) to (2)):

- 60 to 1200 V dc, continuous
- 1500 V dc, 1 minute

Operating Temperature: –20° to +70°, Centigrade

Patent & Warranty

The M-3921 Field Ground Coupler is covered by a five-year warranty from date of shipment.

Tests and Standards

M-3921 Field Ground Coupler complies with the following tests and standards:

Voltage Withstand

Isolation

4 kV ac for 1 minute, all terminals to case

Impulse Voltage

IEC 60255–5, 5,000 V pk, 1.2 by 50 μs, 0.5 J, 3 positive and 3 negative impulses at 5 second intervals per minute

Electrical Interference

Electrostatic Discharge Test

IEC 61000-4-2 Class 4 (8 kV)—point contact discharge

Fast Transient Disturbance Tests

IEC 61000-4-4 Class 4 (4 kV, 2.5 kHz)

Surge Withstand Capability

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

■ **NOTE**: See also M-3425A Surge Withstand Capability test standards, ANSI/IEEE C37.90.2-2002.

Radiated Susceptibility

ANSI/IEEE C37.90.2 25-1000 Mhz @ 20 V/m

Atmospheric Environment

IEC 60068–2–1 Cold, –20° C
IEC 60068–2–2 Dry Heat, +70° C
IEC 60068–2–3 Damp Heat, +40° C @ 93% RH

Enclosure Protection

NEMA 1, IEC IPC-65

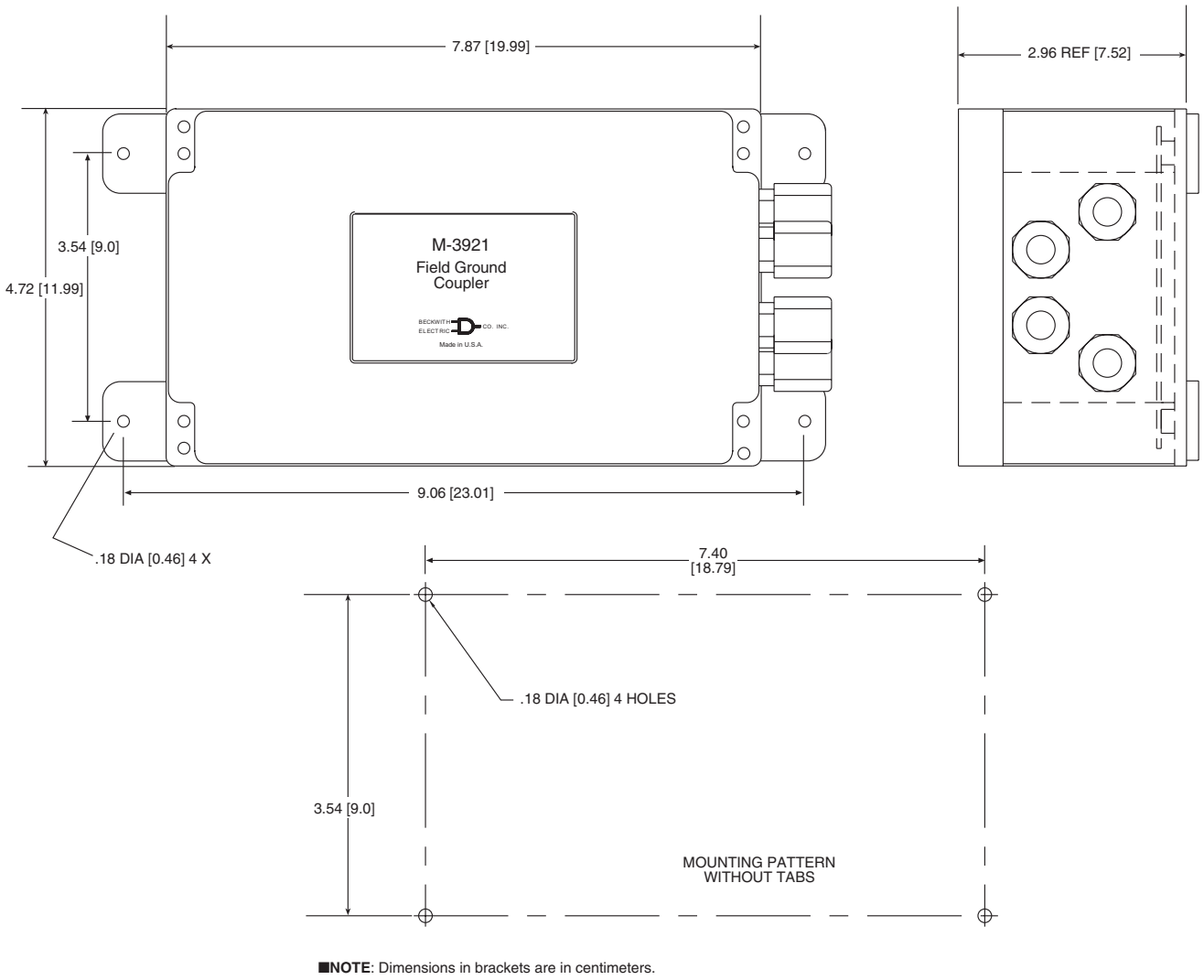


Figure 11 M-3921 Field Ground Coupler Mounting Dimensions

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

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.

NOTE

The following features, described in this Instruction Book, are only available for firmware version D-0150-V01.00.33 and later:

59N 20 Hz Injection Mode (Page 2-58)

IEEE curves for 51N, 51V, and 67N functions (Appendix D)

Sequence of Events Recorder (Page 4-18)

Dropout/Reset Time Delay added to IPSlogic (Page 2-91)

Response Time Delay for Communications (Page 4-3)

25 Function (does not produce a target) (Page 2-21)

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1 Introduction

1.1 Instruction Book Contents

This instruction book includes six chapters and five Appendices.

Chapter 1: Introduction

Chapter One summarizes relay capabilities, introduces the instruction book contents, and describes accessories.

Chapter 2: Application

Chapter Two is designed for the person or group responsible for the application of the M-3425A Generator Protection Relay. It includes functional and connection diagrams for a typical application of the relay; and describes the configuration process for the unit (choosing active functions), output contact assignment and input blocking designation. It also illustrates the definition of system quantities and equipment characteristics required by the protective relay, and describes the individual function settings.

Chapter 3: Operation

Chapter Three is designed for the person(s) responsible for the operation, direct setting, and configuration of the relay. Chapter Three provides information regarding the operation and interpretation of the unit's front panel controls and indicators, including operation of the optional M-3931, Human Machine Interface (HMI) and M-3925A Target Modules. It further describes the procedures for entering all required data to the relay. Included in this chapter is a description of the process necessary for review of setpoints and timing, monitoring function status and metering quantities, viewing the target history, and setup of the oscillograph recorder.

Chapter 4: Remote Operation

Chapter 4 is designed for the person or group responsible for the remote operation and setting of the relay using the M-3820D IPScom® Communications Software or other means.

Chapter 5: Installation

The person or group responsible for the installation of the relay will find herein all mechanical information required for physical installation, equipment ratings, and all external connections in this chapter. For reference, the Three-Line Connection Diagram is repeated from Chapter 2, **Application**. Further, a commissioning checkout procedure is outlined using the HMI option to check the external CT and VT connections. Additional tests which may be desirable at the 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 diagnostic mode and autocalibration procedures for HMI-equipped units.

Appendix A: Configuration Record Forms

This Appendix supplies a set of forms to record and document the settings required for the proper operation of the relay.

Appendix B: Communications

This Appendix describes port signals, protocols, and various topologies, and equipment required for remote communication.

Appendix C: Self-Test Error Codes

This Appendix lists all the error codes and their definitions.

Appendix D: Inverse Time Curves

This Appendix contains a graph of the four families of Inverse Time Curves for V/Hz applications, the Inverse Time Overcurrent Curves, and the IEC curves.

Appendix E: Declaration of Conformity

This Appendix contains the Beckwith Electric Co.'s Declaration of Conformity required by ISO/IEC 17050–1:2004.

1.2 M-3425A Generator Protection Relay

The M-3425A Generator Protection Relay is a microprocessor-based unit that uses digital signal processing technology to provide up to thirty-four protective relaying functions for generator protection. The relay can protect a generator from internal winding faults, system faults, and other abnormal conditions.

The available internal functions of the relay are listed in Table 1-1. The nomenclature follows the standards of ANSI/IEEE Std. C37.2, Standard Electric Power Systems Device Function Numbers.

The control/status inputs can be programmed to block any relay function and/or to trigger the oscillograph recorder. Any of the functions or the control/status inputs can be individually programmed to activate any one or more of the programmable outputs, each with a contact.

With the optional M-3931 HMI Module, all functions can be set or examined using a local, menu-driven, 2 line by 24 character alphanumeric display. OUT 9–23 and IN 7–14 for units purchased with expanded I/O can only be set utilizing M-3820D IPScom® Communications Software. The module allows local metering of various quantities, including phase, neutral, and sequence voltages and currents, real and reactive power, power factor, and positive sequence impedance measurements.

The relay stores time-tagged target information for the thirty-two most recent trips. For units equipped with the optional M-3925A Target Module, LEDs are used to provide a detailed visual indication of function operation for the most recent event.

The unit retains up to 472 cycles of oscillograph waveform data. This data can be downloaded and analyzed using the M-3801D IPSplot® *PLUS* Oscillograph Analysis Software.

The unit is powered from a wide input range switch mode power supply. An optional redundant power supply is available for units without the Expanded I/O. When expanded I/O option is selected, the unit includes the second power supply.

The relay includes self-test, auto calibration, and diagnostic capabilities, in addition to IRIG-B time-sync capability for accurate time-tagging of events.

FUNCTION	DESCRIPTION
Protective Functions	
21	Phase Distance (three-zone mho characteristic)
24	Volts/Hz (Inverse & Definite Time)
27	Phase Undervoltage
27TN	Third Harmonic Undervoltage, Neutral
32	Directional Power
40	Loss of Field (dual-zone offset-mho characteristic)
46	Negative Sequence Overcurrent
49	Stator Overload Protection (Positive Sequence Overcurrent)
50	Instantaneous Phase Overcurrent
50BF	Breaker Failure
50DT	Definite Time Overcurrent
50N	Instantaneous Neutral Overcurrent
50/27	Inadvertant Energizing
51N	Inverse Time Neutral Overcurrent
51V	Inverse Time Overcurrent, with Voltage Control or Restraint
59	Phase Overvoltage
59D	Third-Harmonic Voltage Differential
59N	Neutral Overvoltage
59X	Multi-purpose Overvoltage
60FL	VT Fuse-Loss Detection
67N	Residual Directional Overcurrent
78	Out of Step (mho characteristic)
81	Frequency
81A	Frequency Accumulation
81R	Rate of Change of Frequency
87	Phase Differential Current
87GD	Ground (zero sequence) Differential
IPS	IPSlogic
BM	Breaker Monitor
TC	Trip Circuit Monitoring
Optional Protective Functions	
25	Sync Check
64F/64B	Field Ground Protection/ Brush Lift-Off Detection
64S	100% Stator Ground Protection by Injection

Table 1-1 M-3425A Device Functions

Communication Ports

There are three physical communication ports provided on the M-3425A. If the optional RJ45 Ethernet port is purchased, then the relay includes four physical communication ports:

- COM1, located on the relay front panel, is a standard 9-pin RS-232 DTE-configured port. COM1 is used to locally set and interrogate the relay using a portable computer.
- COM2, located on the rear of the relay, is a standard 9-pin RS-232 DTE-configured port. When the optional RJ45 Ethernet Port is enabled, COM2 port is disabled.

  The RJ45 Ethernet port uses a 10Base-T type connection that accepts an RJ45 connector using CAT5 twisted pair cable. The Ethernet port supports MODBUS over TCP/IP, BECO2200 over TCP/IP. The IP address can be obtained automatically when using the DHCP protocol if enabled, or a static IP address can be manually entered, using the HMI.
- COM3, located on the rear terminal block of the relay, is an RS-485 communications port.

The relay may be remotely set and interrogated utilizing either a hard-wired RS-232 serial connection or modem (COM2 when activated as RS-232, or COM3), or when purchased, the ethernet connection (RJ45 activated).

M-3820D IPScom® Communications Software

IPScom is shipped standard with every relay. This software runs on a PC-compatible computer operating under Microsoft Windows® 95 or later. When properly connected using either a direct serial connection, modem or ethernet network connection. IPScom can provide the following functions:

- Setpoint interrogation and modification
- Line status real-time monitoring
- Recorded oscillograph data downloading

1.3 Accessories

M-3925A Target Module

The optional target module, shown below, includes 24 individually labelled **TARGET** LEDs to indicate operation of the functions on the front panel. Eight individually labelled **OUTPUT** LEDs will be lit as long as the corresponding output contact is picked up.

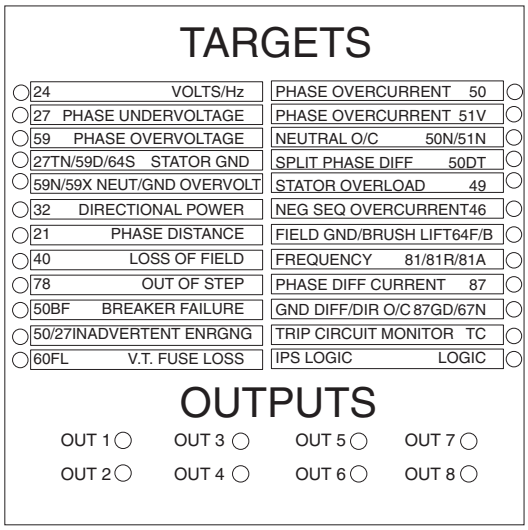


Figure 1-1 M-3925A Target Module

M-3933/M-0423 Serial Communication Cables

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

M-3931 HMI (Human-Machine Interface) Module

The optional HMI module provides the means to interrogate the relay and to input settings, access data, etc. directly from the front of the relay. Its operation is described in detail in Section 3.1, Front Panel Controls.

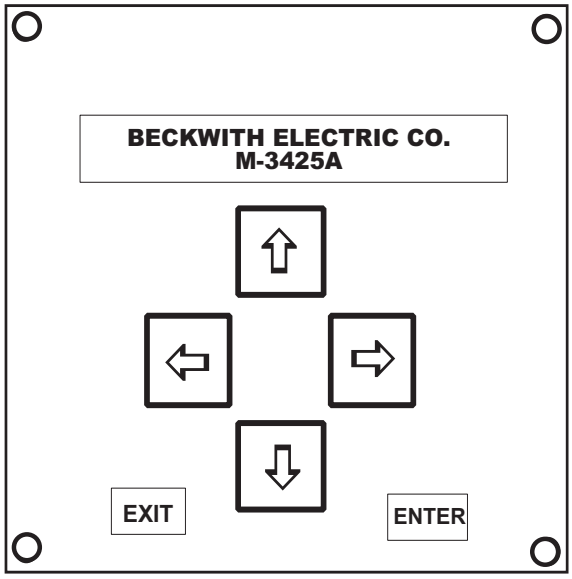


Figure 1-2 M-3931 Human-Machine Interface (HMI) Module

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

The IPSplot *PLUS* Oscillograph Analysis Software runs in conjunction with the IPScom® Communications Software on any IBM PC-compatible computer, enabling the plotting, printing, and analysis of waveform data downloaded from the M-3425A Generator Protection Relay.

2 Application

Chapter Two is designed for the person or group responsible for the application of the M-3425A Generator Protection Relay. It includes functional and connection diagrams for a typical application of the relay; and describes the configuration process for the unit (enabling functions), output contact assignment and input blocking designation. It also illustrates the definition of system quantities and equipment characteristics required by the protective relay, and describes the individual function settings.

Menu screens in the following examples are as they would appear on units equipped with the M-3931 Human Machine Interface (HMI) Module. The same setting may be entered remotely using M-3820D IPScom® Communications Software (see Chapter 4, **Remote Operation**).

2.1 Configuration

Configuration of the relay consists of enabling the functions for use in a particular application, designating the output contacts each function will operate, and which control/status inputs will block the function. The choices include eight programmable output contacts (OUT1–OUT8) and six control/status inputs (IN1–IN6), or OUT9–23 and IN7–14 for units purchased with expanded I/O, plus a block choice for fuse loss logic operation (see Section 2.3, Setpoint and Time Settings, 60FL Fuse Loss subsection for details).

The blocking control/status inputs and output contact assignments must be chosen before entering the settings for the individual functions. Both may be recorded on the Relay Configuration Table in Appendix A, **Configuration Record Forms**.

Control/status input IN1 is preassigned to be the 52b breaker status contact. If a multiple breaker scheme is used, the control/status input IN1 must be the series combination of the “52b” breaker contacts. Additional user-chosen control/status inputs may initiate actions such as breaker failure, initiate external fuse loss detection, or trigger the oscillograph recorder.

The relay allows the user to designate up to six logic functions which perform similarly to internal relay functions, using IPSlogic™. These external functions may be enabled or disabled, and output contacts and blocking control/status inputs are chosen the same as for the internal functions. The external functions are described in further detail in Section 2.3, Setpoint and Time Settings, IPSlogic subsection.

■ **NOTE**: Uppercase text indicates selection.

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

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

```
27#1 BLOCK INPUT
fl i6 i5 i4 i3 i2 I1
```

This submenu item assigns the blocking designations (up to six, plus fuse-loss logic) for the enabled function. “OR” logic is used if more than one input is selected.

```
27#1 RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1
```

This submenu item assigns the output contacts (up to eight) for the particular relay function. If no output contacts are assigned, the function will not generate any output or targets even though the function is enabled.

■ **NOTE**: Units with expanded I/O can only set OUT9–OUT23 and IN7–IN14 using IPScom®.

Profiles

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

The **Active Profile** may be chosen manually or by contact input. When the profile Switching Method is set to Manual, the HMI, remote communications or one of the IPSlogic elements will select the Active Profile. When the Switching Method is set to Input Contact, the profile is selected by the input contacts. When Input Contact is selected, only the input contacts can switch the relay’s profile, and none of the Manual methods will switch the profile.

A **Copy Profile** feature is available. This feature 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.

▲ **CAUTION**: During profile switching, relay operation is disabled for approximately 1 second.

Functions

Configuration of the relay consists of enabling the functions for use in a particular application, designating the output contacts each function will operate, and which control/status inputs will block the function. The choices include eight programmable output contacts (OUT1–OUT8) and six control/status inputs (IN1–IN6)/(OUT1–OUT23 and IN1–IN14 for expanded I/O units) plus a block choice for fuse loss logic operation (see Section 2.3, Setpoint and Time Settings, 60FL Fuse Loss subsection for details.)

Control/status inputs may also initiate actions, such as Breaker Failure Initiate, Trigger Oscillograph Recorder, Switch Setpoint Profile, or initiate an IPSlogic function. The control/status inputs and output contacts need to be chosen before configuring the individual functions. Both can be recorded on the Relay Configuration Table in Appendix A, **Forms**.

Special Considerations

Control/status input IN1 is preassigned to be the 52b breaker contact. IN5 and IN6 may be used to select setpoint profiles.

Outputs 1–6 and 9–23 are form “a” contacts (normally open), and outputs 7 and 8 are form “c” contacts (center tapped “a” and “b” normally closed) 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.

Relay System Setup

The system setup consists of defining all pertinent information regarding the system quantities. Setup screens shown here may be accessed through the **SYSTEM SETUP** menu. Regardless of the functions that are enabled or disabled, all System Setup values are required to be input. Several functions require proper setting of these values for correct operation. The Nominal Voltage and Nominal Current settings are needed for proper normalization of per unit quantities. CT and VT ratios are used only in monitoring and displaying system primary quantities.

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

```
INPUT ACTIVATED PROFILES
disable    enable
```

When Input Activated Profiles is disabled, the Active Profile can be selected using HMI or remote communication. When enabled, the Active Profile is selected by the state of Input 5 and 6 (see Table 2-1).

```
ACTIVE SETPOINT PROFILE
 ________
```

This screen sets the active setpoint profile.

```
COPY ACTIVE PROFILE
TO_PROFILE_1 →
```

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

```
NOMINAL VOLTAGE
 ________ Volts
```

The secondary VT voltage when primary voltage is equal to the rated *generator* voltage. $V_{nominal}$=(**V** gen rated ÷ VT ratio) for L-L VT connections. $V_{nominal}$=(**V**gen rated ÷ ($\sqrt{3}$ VT ratio)) for L-G VT connections.

```
NOMINAL CURRENT
 ________ Amps
```

The secondary CT current of the phase CT's with rated *generator* current. **I** nom = (VA ÷ (Vgen rated($\sqrt{3}$))(CT ratio))

```
VT CONFIGURATION
line-line line-ground→
— — — — — — — — — — —
←line-gnd_to_line-line
```

Indicates VT connection. (See Figure 2-7, Three-Line Connection Diagram.) When line-ground voltages are used, functions 24, 27, and 59 may operate for line-ground faults. If this is not desired, the line-gnd-to-line-line selection should be used to prevent operation of these functions for line-ground faults.When line-gnd-to-line-line is selected, the relay internally calculates line-line voltages from line-ground voltages for all voltage-sensitive functions. This line-gnd-to-line-line selection should be used only for a VT line-to-ground nominal secondary voltage of 69V (not for 120 V). For this selection, the nominal voltage setting entered should be line-line nominal voltage, which is $\sqrt{3}$ times line-ground nominal voltage, and voltage function pickup setpoints calculation should be made using line-to-line voltage.

```
DELTA-Y TRANSFORM
dis delta_ab delta_ac
```

When the generator is connected through a Delta-Y (delta ab or delta ac) unit transformer, the relay will internally consider the 30° phase shift for 51V and 21 functions.

```
PHASE ROTATION
a-c-b   a-b-c
```

This screen allows the user to select the phase rotation of the M-3425A to match the generator.

```
59/27 MAGNITUDE SELECT
rms dft
```

This screen allows the selection of RMS or DFT for the 59 and 27 functions. The magnitude can be selected as the RMS of the total waveform (including harmonics) or the RMS of the 60/50 Hz fundamental component of the waveform using the Discrete Fourier Transform (DFT). When the RMS option is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and the accuracy of the time delay is +20 cycles. When the DFT option is selected, the magnitude calculation is accurate near 50 or 60 Hz and the timer accuracy is ±1 cycle. When a wider frequency response is needed, select RMS. For generator protection applications, it is recommended to use the RMS selection. RMS is the default when shipped from the factory. For 59 function when positive sequence voltage is selected, the calculation uses DFT irrespective of DFT/RMS selection.

```
50DT SPLIT-PHASE DIFF
disable enable
```

If the 50DT function is to be used for split-phase differential protection, this selection should be enabled. If the 50DT function is to be used as a definite time overcurrent function, or if 50DT is not enabled, this selection should be disabled.

```
PULSE RELAY
o8 o7 o6 o5 o4 o3 o2 o1
```

If pulse relay operation is selected, output will dropout after the seal-in delay expires, even if the condition which caused the relay to pick up is still out of band. When selected, latching outputs are not available. *

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

If any of the outputs are selected as latched, then after tripping, this output will stay activated, even when the tripping condition is removed. The Latched Output can be reset using the TARGET RESET pushbutton. When selected, Pulse Relay is not available. *

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

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

```
ACTIVE INPUT OPEN/close
I6 i5 i4 i3 i2 i1
```

This designates the “active” state for the individual status input. Programming uppercase (see I6) causes the “active” or “operated” condition to be initiated by the external contact opening. Otherwise, external contact closure will activate the input.*

*■ Note: Settings for expanded I/O must be made through IPScom®.

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

Ratio of the phase VTs. Example: 13,800 V : 120 V =13,800/120=115:1

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

Ratio of the neutral VT. Example: 13,800 V : 120 V =13,800/120=115:1

```
V.T. VX RATIO
 _________ :1
```

Ratio of auxiliary VT. Example: 13,800 V : 120 V =13,800/120=115:1

```
C.T. PHASE RATIO
 _________ : 1
```

Ratio of phase CTs. Example: 3,000:5 = 3000/5=600:1

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

Ratio of neutral CT. Example: 3,000:5 = 3000/5=600:1

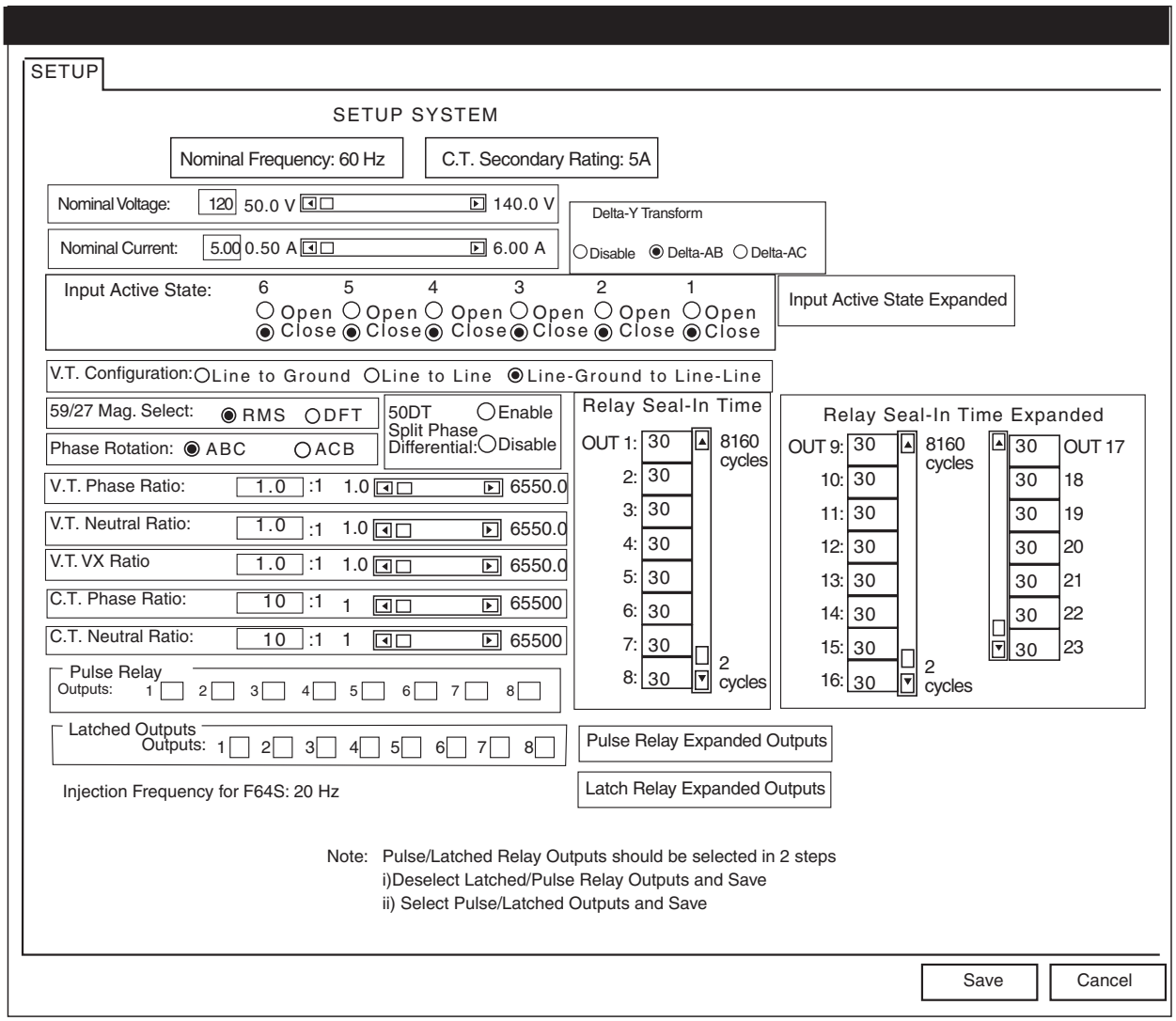


Figure 2-1 Setup System Dialog Box

Path: Relay menu / Setup submenu / Setup System command

COMMAND BUTTONS

Input Active State Expanded When the unit is equipped with expanded I/O, this command opens the Expanded Input Active State screen (Figure 2-2), to allow the selection of Expanded Inputs 7 through 14.

Pulse/Latch Relay Expanded Outputs When the unit is equipped with expanded I/O, this command opens the Pulse/Latch screen (Figures 2-3 and 2-4) to allow the selection of expanded outputs 9 through 23.

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

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

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

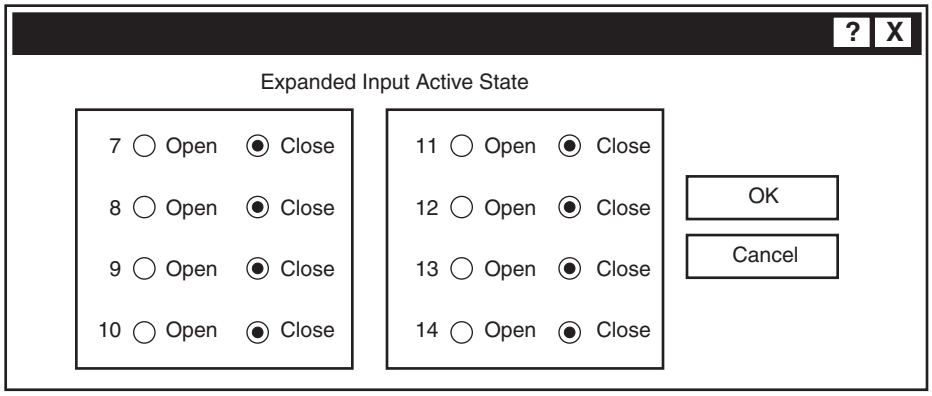


Figure 2-2 Selection Screen for Expanded Input

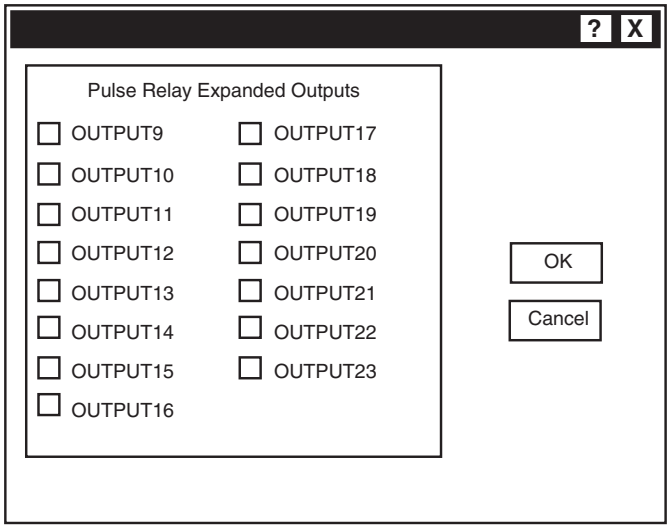


Figure 2-3 Pulse Relay Expanded Output Screen

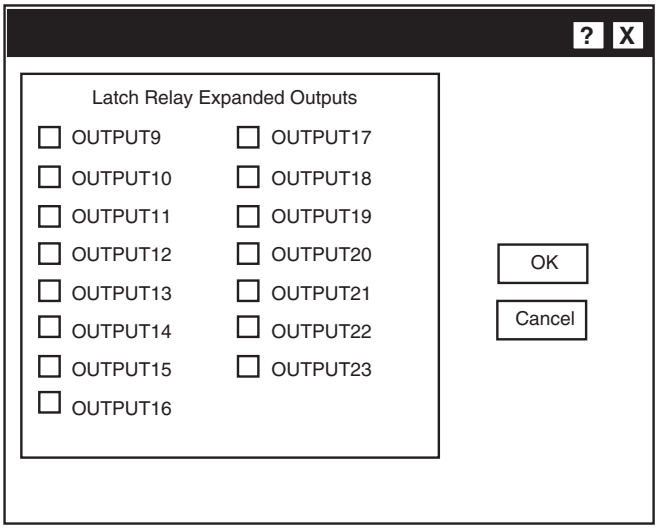
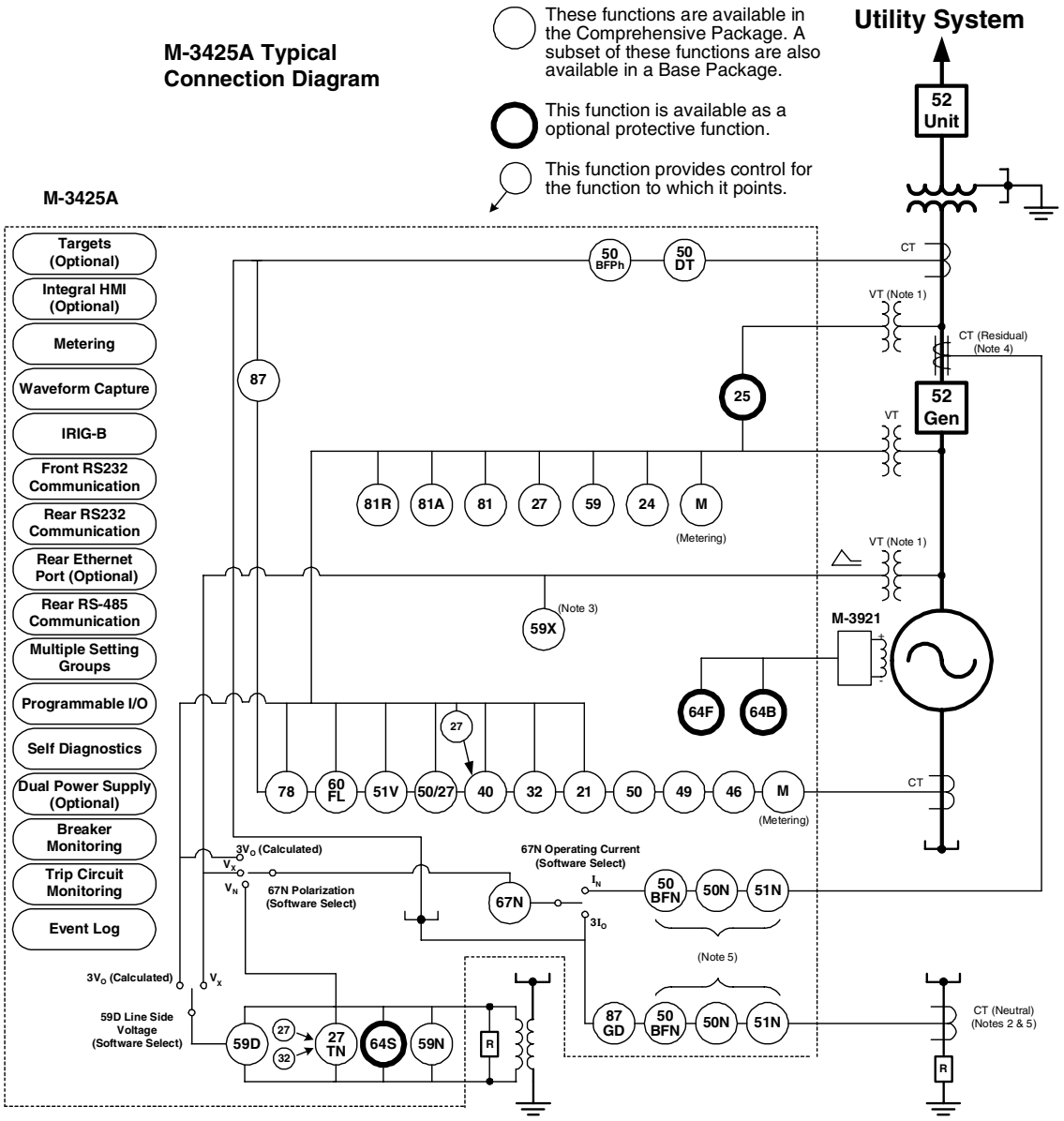


Figure 2-4 Latch Relay Expanded Output Screen

2.2 System Diagrams



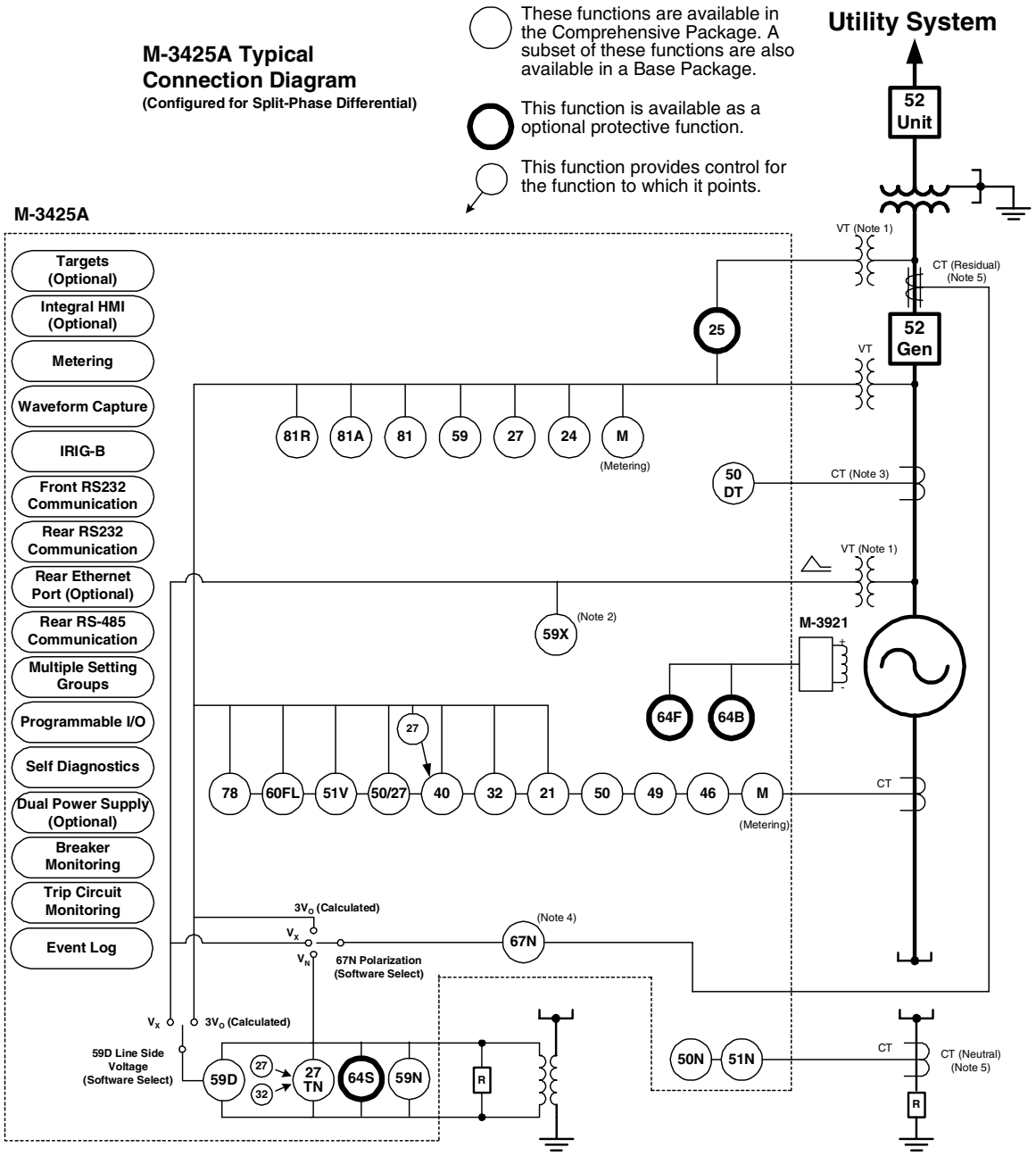
High-impedance Grounding with Third Harmonic 100% Ground Fault Protection

Low-impedance Grounding with Ground Differential and Overcurrent Stator Ground Fault Protection

■ **NOTES**:

1. When 25 function is enabled, 59X, 59D with V_X and 67N with V_X are not available, and vice versa.
2. When 67N function with I_N (Residual) operating current is enabled, 87GD is not available, and vice versa.
3. The 50BFN, 50N, and 51N may utilize either the neutral current or the residual current.
4. When used as a turn-to-turn fault protection device.
5. The current input I_N can be either from neutral current or residual current.
6. The 50BFN, 50N, 51N, 59D, 67N (with I_N or V_N) and 87GD functions are unavailable when the 64S function has been purchased. See the M-3425A Instruction Book for connection details.

Figure 2-5 One-Line Functional Diagram



High-impedance Grounding with Third Harmonic 100% Ground Fault Protection

Low-impedance Grounding with Overcurrent Stator Ground Fault Protection

■ **NOTES**:

1. When 25 function is enabled, 59, 59X, 59D with V_X and 67N with V_X are not available, and vice versa.
2. When used as a turn-to-turn fault protection device.
3. CTs are connected as split-phase differential current.
4. 67N operating current can only be selected to I_N (Residual) for this configuration.
5. The current input (I_N) can be either from neutral current or residual current.
6. The 50BFN, 50N, 51N, 59D, 67N (with I_N or V_N) and 87GD functions are unavailable when the 64S function has been purchased. See the M-3425A Instruction Book for connection details.

Figure 2-6 Alternative One-Line Functional Diagram (configured for split-phase differential)

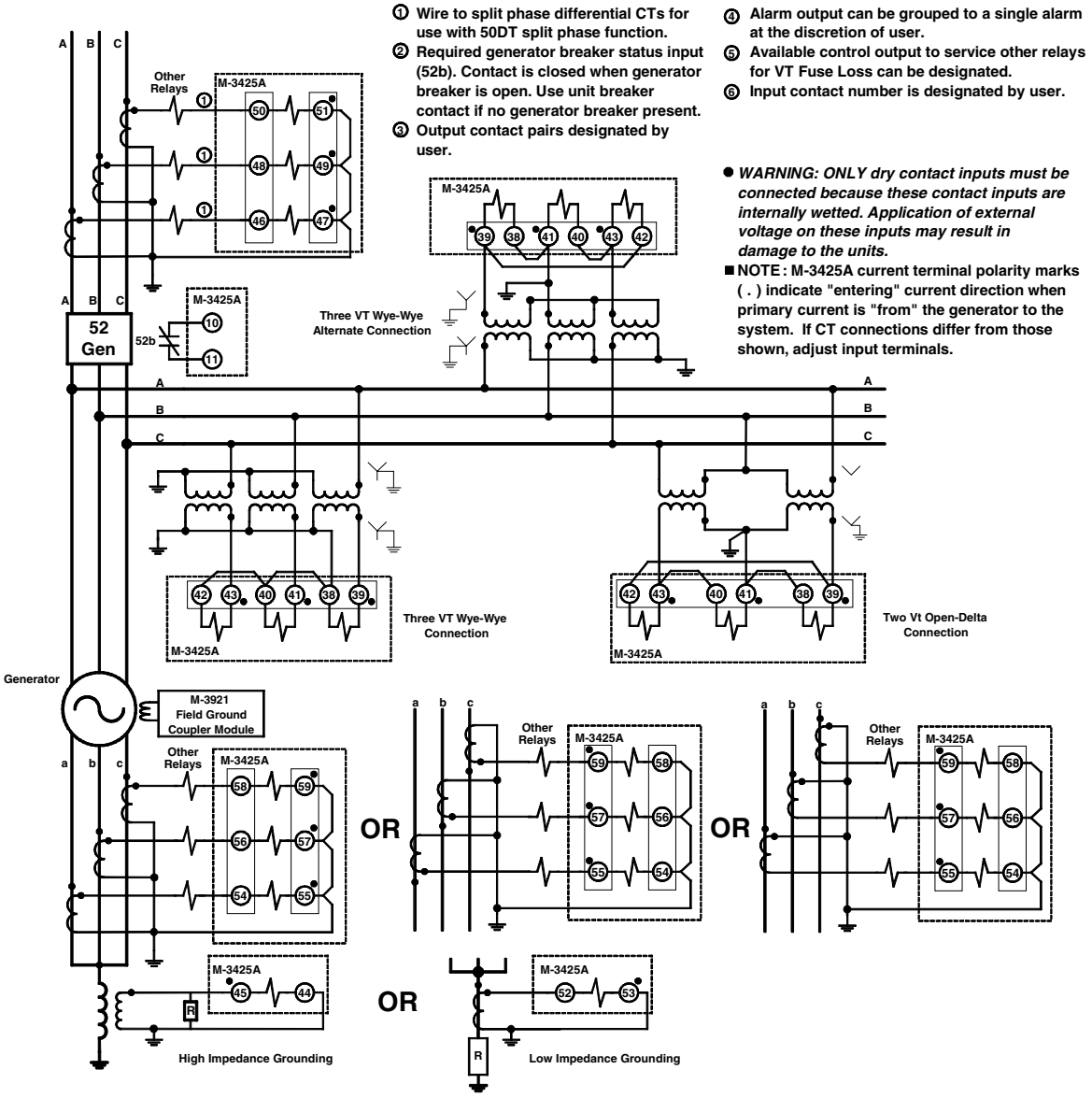
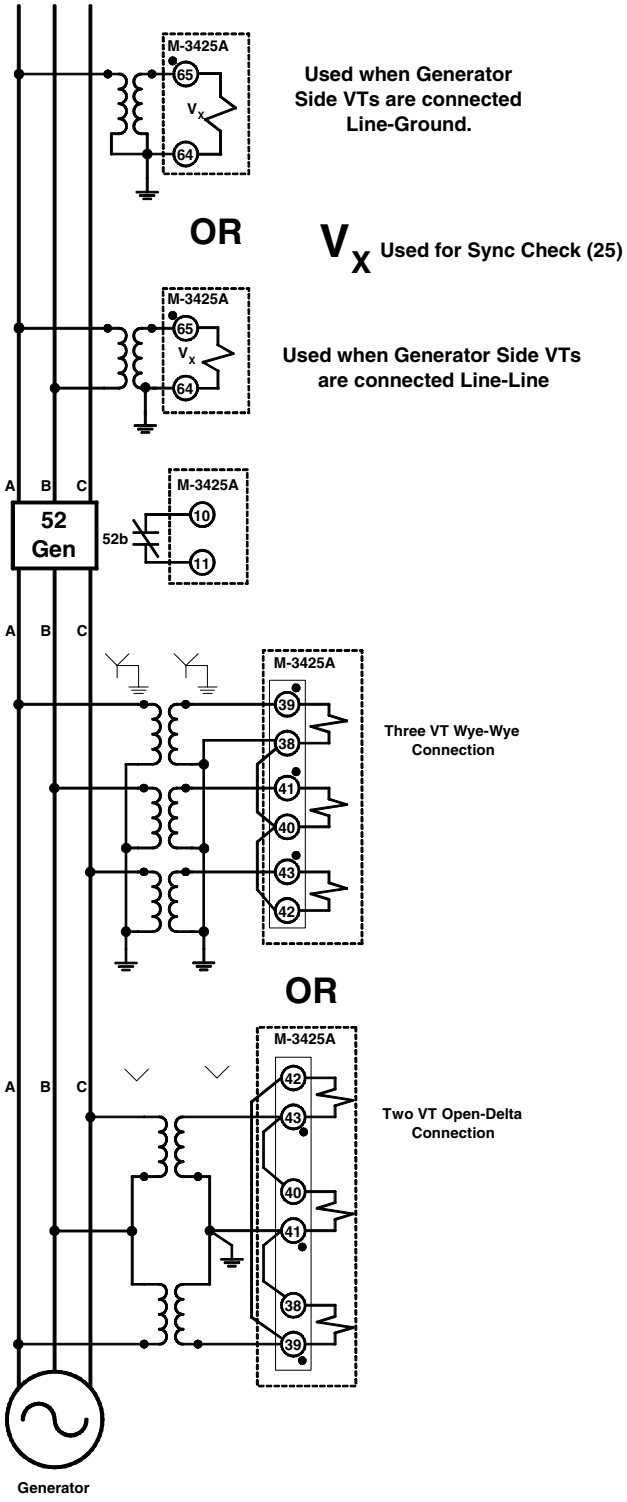
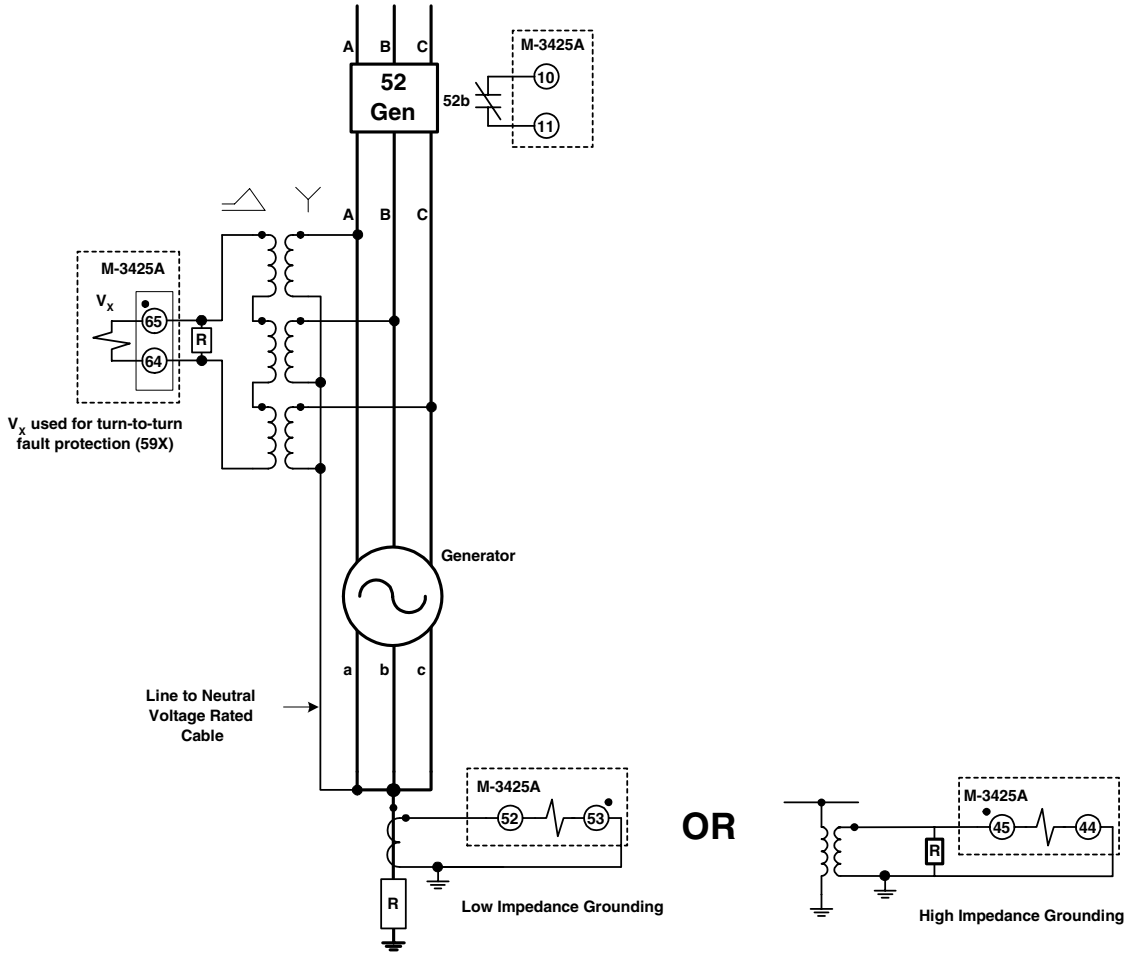


Figure 2-7 Three-Line Connection Diagram



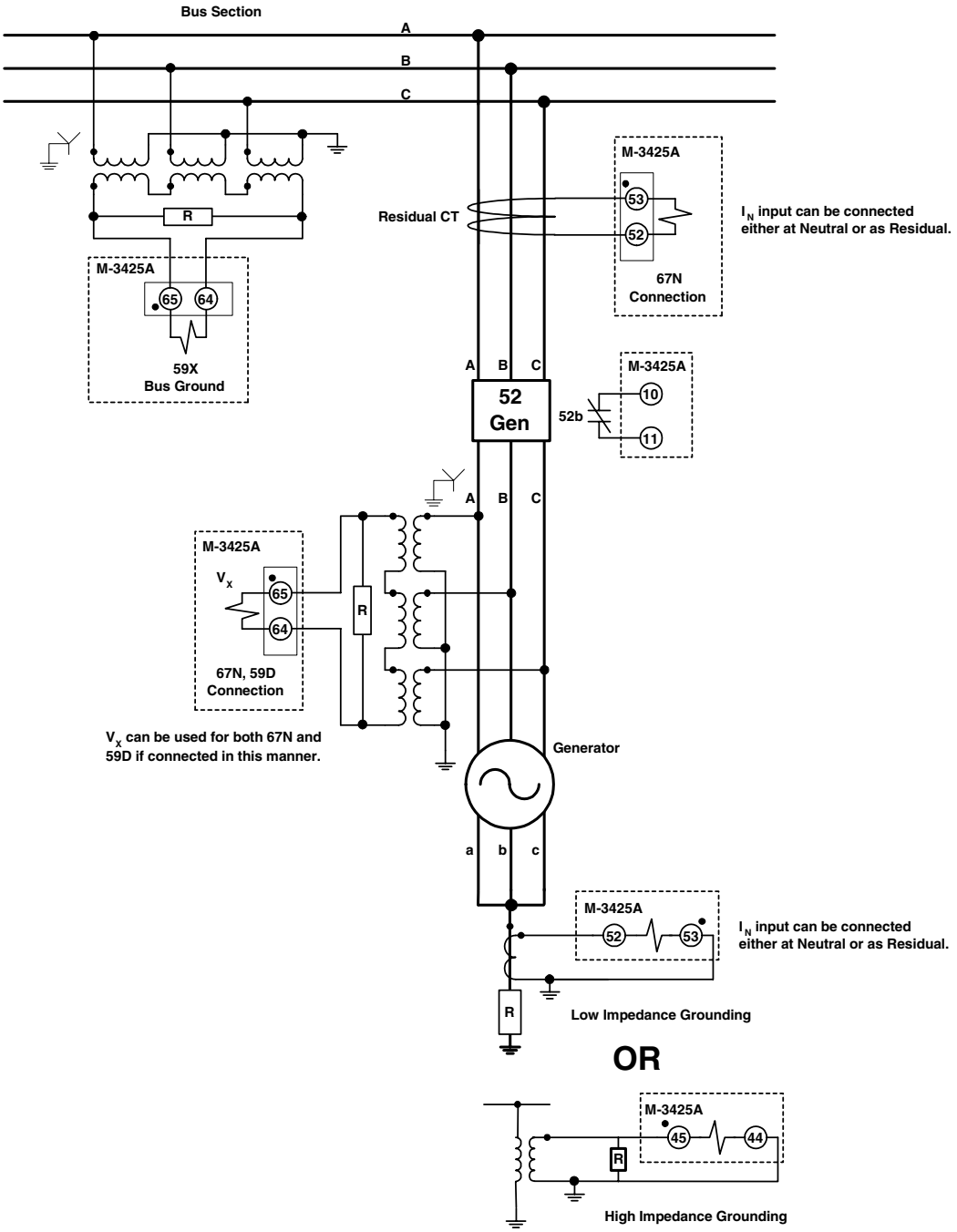
■ **NOTE**: When V_X is connected for Sync Check function (25), turn-to-turn fault protection (59X) is not available.

Figure 2-8 Function 25 Sync Check Three-Line Connection Diagram



■ **NOTE**: When V_X is connected for turn-to-turn fault protection, 59X and 25 functions are not available.

Figure 2-9 Function 59X Turn to Turn Fault Protection Three-Line Connection Diagram



■ **NOTE**: When V_X is connected for bus ground protection (59X, 67N, or 59D) , 25 function is not available.

Figure 2-10 Function 67N, 59D, 59X (Bus Ground) Three-Line Connection Diagram

2.3 Setpoints and Time Settings

The individual protective functions, along with their magnitude and timing settings are described in the following pages. Settings for disabled functions do not apply. Some menu and setting screens do not appear for functions that are disabled or not purchased. Menu screens are as they would appear on units equipped with the M-3931 HMI Module. The same setting may be entered using M-3820D IPScom Communications Software.

For those units equipped with Expanded I/O, setting of Expanded Inputs and Outputs is accomplished by selecting “Expanded I/O” from the individual function screen. IPScom® will display the Expanded I/O Initiate dialog screen (Figure 2-11).

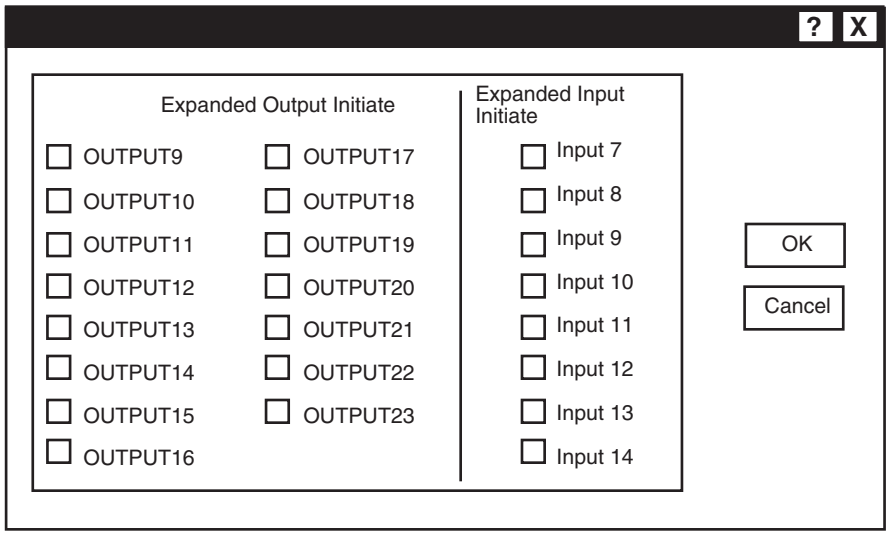


Figure 2-11 Selection Screen for Expanded I/O Initiate

21 Phase Distance

The Phase Distance function (21) is designed for system phase fault backup protection and is implemented as a three-zone mho characteristic.

Three separate distance elements are used to detect AB, BC, and CA fault types. The ranges and increments are shown in Figure 2-14. The diameter, offset, system impedance angle (relay characteristic angle), and definite time delay need to be selected for each zone for coordination with the system relaying in the specific application.

Zone 1, Zone 2 and Zone 3 may be used for backup protection for unit transformer and transmission faults. Zone 3 in conjunction with Zone 2 can be used to detect an Out of Step condition and it can be programmed to block Function 21 #1 and/or 21 #2. If Zone 3 is being used for out-of-step blocking, it does not trip.

If Zone 1 is not set to see the transmission system, out-of-step blocking is not recommended.

When Zone 3 is used for Out-of-step blocking, the out of step delay is used for the detection of the transit time of the swing between Zone 3 and Zone 2 impedances.

The load encroachment blinder function can be set with a reach and an angle as shown in Figure 2-13. When enabled, this feature will block the 21 Function from misoperating during high load conditions.

When the generator is connected to the system through a delta/wye transformer, proper voltages and currents (equivalent to the high side of the transformer) must be used in order for the relay to see correct impedances for system faults. By enabling the Delta-Y Transform feature (see Section 2.1, Configuration, Relay System Setup), the relay can internally consider the 30° phase shift (30° lead delta-ab or 30° lag delta-ac) through the delta/wye transformer, saving auxiliary VTs. Impedance calculations for various VT connections are shown in Table 2-2. All impedance settings are secondary relay quantities and can be derived from the following formula:

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

where Z_{SEC} = secondary reflected impedance, Z_{PRI} = primary impedance, R_C = current transformer ratio, and R_V = voltage transformer ratio.

The minimum current sensitivity depends on the programmed reach (diameter and offset). If the current is below the minimum sensitivity current, the impedance calculated will saturate, and not be accurate. This will not cause any relay misoperation.

An overcurrent supervision feature can be enabled, which will block the 21 function when all three phase currents are below the pickup value.

```
21 #1 DIAMETER
 _________ Ohms
```

Typically the first zone of protection is set to an impedance value enough in excess of the first external protective section (typically the unit transformer) to assure operation for faults within that protective zone. See Figure 2-12, Phase Distance (21) Coverage.

```
21 #1 OFFSET
 _________ Ohms
```

A negative or positive offset can be specified to offset the mho circle from the origin. This offset is usually set at zero. See Figure 2-13, Phase Distance (21) Function Applied For System Backup.

```
21 #1 IMPEDANCE ANGLE
 _________ Degrees
```

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

```
21#1 LOAD ENCROACHMENT
disable ENABLE
```

When enabled the 21 Function is blocked when the impedance falls within the zone but above the R Reach and below the Load Encroachment angle.

```
21 #1 LOAD ENCR ANGLE
 _________ Degrees
```

■ **NOTE**: The 21 #2 and #3 zone settings can be set for an additional external section of protection on the system (typically transmission Zone 1 distance relays) plus adequate overreach. #2 and #3 screens are identical to those in #1. Element #3 also includes out-of-step time delay when out-of-step blocking is enabled for Zone #1 and/or Zone #2.

```
21 #1 LOAD ENCR R REACH
 _________ Ohms
```

```
21 #1 OC SUPERVISION
disable    enable
```

When enabled, the overcurrent supervision blocks the 21 Function when all three phase currents are below the pickup.

```
21 #1 OC SUPERVISION
 _________ Amps
```

```
21 #1 OUT OF STEP BLOCK
disable    enable
```

When enabled the 21 Function is blocked on the detection of an out-of-step condition.

```
21 #1 DELAY
 _________ Cycles
```

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

```
21 #3 OUT OF STEP DELAY
 _________ Cycles
```

In Zone #3 when out-of-step blocking is enabled for Zone #1 or #2.

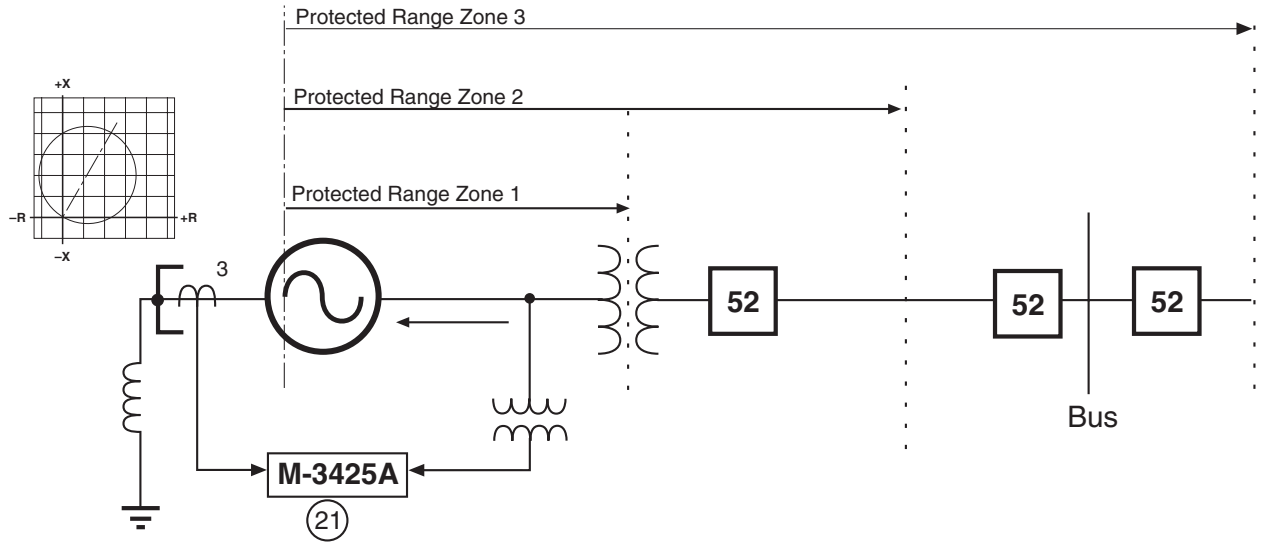
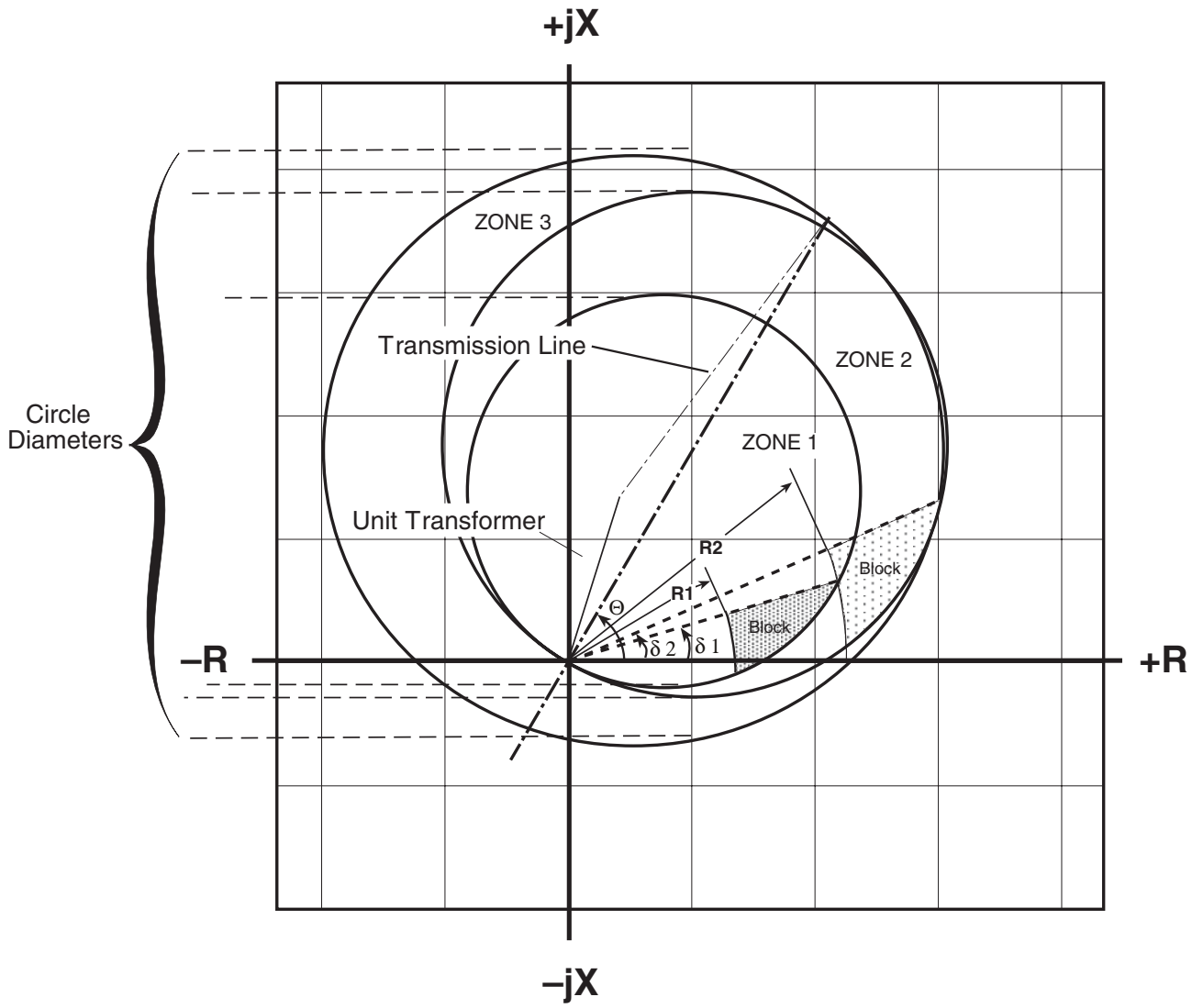


Figure 2-12 Phase Distance (21) Coverage

■ **NOTE**: The reach settings of the distance elements (21) should not include generator impedance since the distance measurement starts at the VT location. However, since the neutral side CTs are used for this function, backup protection for generator Phase-to-Phase faults is also provided



R1	Zone 1 Load Encroachment Blinder R Reach
R2	Zone 2 Load Encroachment Blinder R Reach
δ1	Zone 1 Load Encroachment Blinder Angle
δ2	Zone 2 Load Encroachment Blinder Angle
Θ	Impedance Angle Setting

■ **NOTE**: Zone #3 is used for power swing detection in this example.

Figure 2-13 Phase Distance (21) Function Applied for System Backup

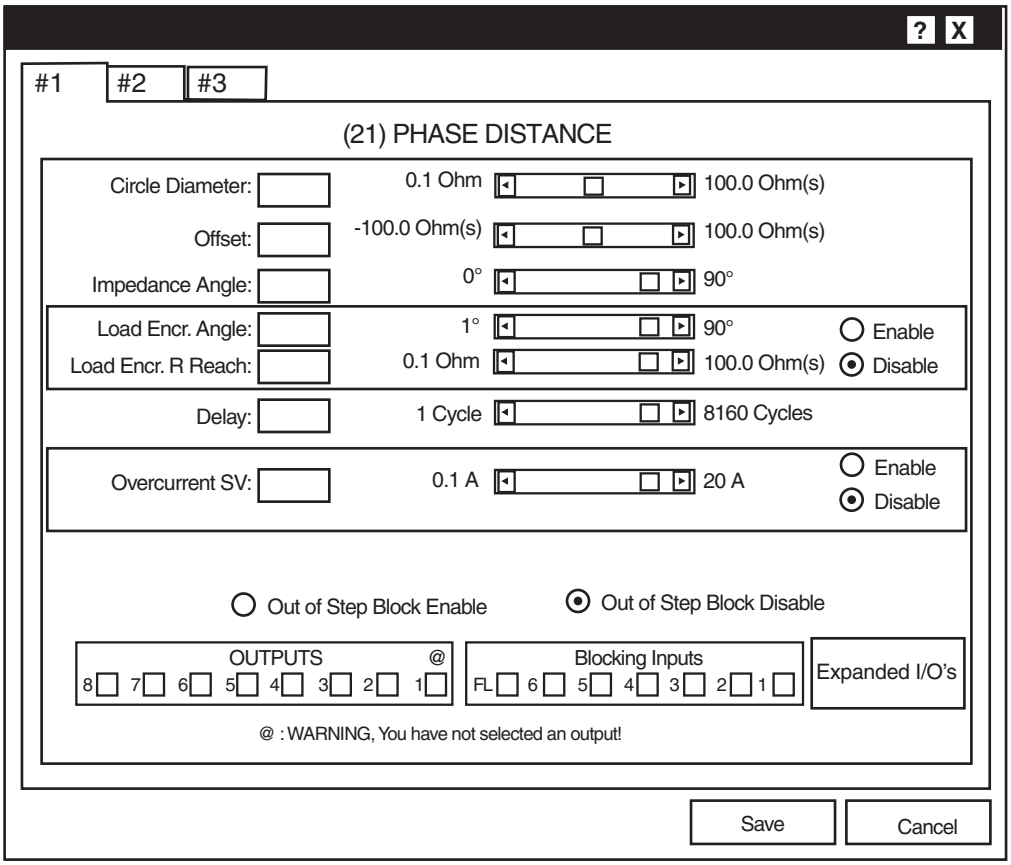


Figure 2-14 Phase Distance (21) Setpoint Ranges

	Transformer Direct Connected		Transformer Delta-AC Connected		Transformer Delta-AB Connected	
	VT Connection		VT Connection		VT Connection	
	L-L or L-G to L-L	L-G	L-L or L-G to L-L	L-G	L-L or L-G to L-L	L-G
AB Fault	$\frac{V_{AB}}{I_a - I_b}$	$\frac{V_A - V_B}{I_a - I_b}$	$\frac{V_{BC} - V_{AB}}{(3)I_b}$	$\frac{V_B - V_0}{I_b}$	$\frac{V_{AB} - V_{CA}}{(3)I_a}$	$\frac{V_a - V_0}{I_a}$
BC Fault	$\frac{V_{BC}}{I_b - I_c}$	$\frac{V_B - V_C}{I_b - I_c}$	$\frac{V_{CA} - V_{BC}}{(3)I_c}$	$\frac{V_C - V_0}{I_c}$	$\frac{V_{BC} - V_{AB}}{(3)I_b}$	$\frac{V_b - V_0}{I_b}$
CA Fault	$\frac{V_{CA}}{I_c - I_a}$	$\frac{V_C - V_A}{I_c - I_a}$	$\frac{V_{AB} - V_{CA}}{(3)I_a}$	$\frac{V_A - V_0}{I_a}$	$\frac{V_{CA} - V_{BC}}{(3)I_c}$	$\frac{V_c - V_0}{I_c}$

Table 2-2 Impedance Calculation

24 Overexcitation Volts/Hz

The Volts-Per-Hertz function (24) provides overexcitation protection for the generator and unit-connected transformers. This function incorporates two definite time elements which can be used to realize traditional two-step overexcitation protection. In addition, the relay includes an inverse time element that provides superior protection by closely approximating the combined generator/unit transformer overexcitation curve. Industry standard inverse time curves may be selected along with a linear reset rate which may be programmed to match specific machine cooling characteristics. The percent pickup is based on the Nominal Voltage setting and the nominal frequency. The V/Hz function provides reliable measurements of V/Hz up to 200% for a frequency range of 2–80 Hz. The ranges and increments are presented in Figure 2-16.

Setting this relay function involves determining the desired protection levels and operating times. The first step is to plot the combined generator and associated unit transformer overexcitation capability limits. This data is typically available from the manufacturer and should be plotted on the same voltage base. Depending on the resulting characteristic, one of the four families of inverse time curves (as shown in Appendix D, **Inverse Time Curves**) can be matched to provide the protection. The two definite time elements can be used to further shape the protection curve or provide an alarm.

Figure 2-15 illustrates a composite graph of generator and transformer limits, a chosen inverse time curve and pickup, and a definite time pickup and delay.

```
24DT #1 PICKUP
_________ %
```

Definite time setpoint #1 establishes the V/Hz level above which the protection operating time will be fixed at the definite time delay #1.

```
24DT #1 DELAY
_________ 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.

```
24DT #2 PICKUP
_________ %
```

Definite time setpoint #2 could be programmed to alarm, alerting the operator to take proper control action to possibly avoid tripping.

```
24DT #2 DELAY
_________ Cycles
```

Time to operation at any V/Hz value exceeding Definite time setting #2.

```
24IT PICKUP
_________ %
```

The pickup value is the V/Hz value at which the chosen inverse curve begins protective operation. Typical value is 105%.

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

Allows the user to designate the appropriate curve family for this protection application. These curves are shown in Appendix D**, Inverse Time Curves**.

```
24IT TIME DIAL
_________
```

The appropriate curve in the family is designated by the associated “K” value of the curve.

```
24IT RESET RATE
_________ Seconds
```

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.

M-3425A Firmware Versions D-0114VXX.XX.XX and Earlier

■ **NOTE**: ***When the inverse time element is enabled, the definite time element #1 must be enabled which will provide definite minimum time setting for the inverse time curve.***

The following steps must be followed when setting the inverse time element and definite time element #1:

1. The pickup of the inverse time element must be less than the pickup of the definite time element #1
2. The operating time of the inverse time element at the definite time element #1 pickup should be greater than the definite time element #1 time delay setting (A2>A1 in Figure 2-15).
3. When the inverse time element is enabled, definite time element #1 should not be used for alarm. Only definite time element #2 can be used for alarm.

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 Reset Rate setting entered should be time needed for the unit to cool to normal operating temperature if the V/Hz excursion time was just under the trip point.

M-3425A Firmware Version D-0150V 01.00.34

The inverse time element has a definite minimum time of 30 cycles. Definite Time Element #1 is independent, and has no effect on inverse time elements.

M-3425A Firmware Version D-0150V 01.04.00

The inverse time element has a definite minimum time of 60 cycles. Definite Time Element #1 is independent, and has no effect on inverse time elements.

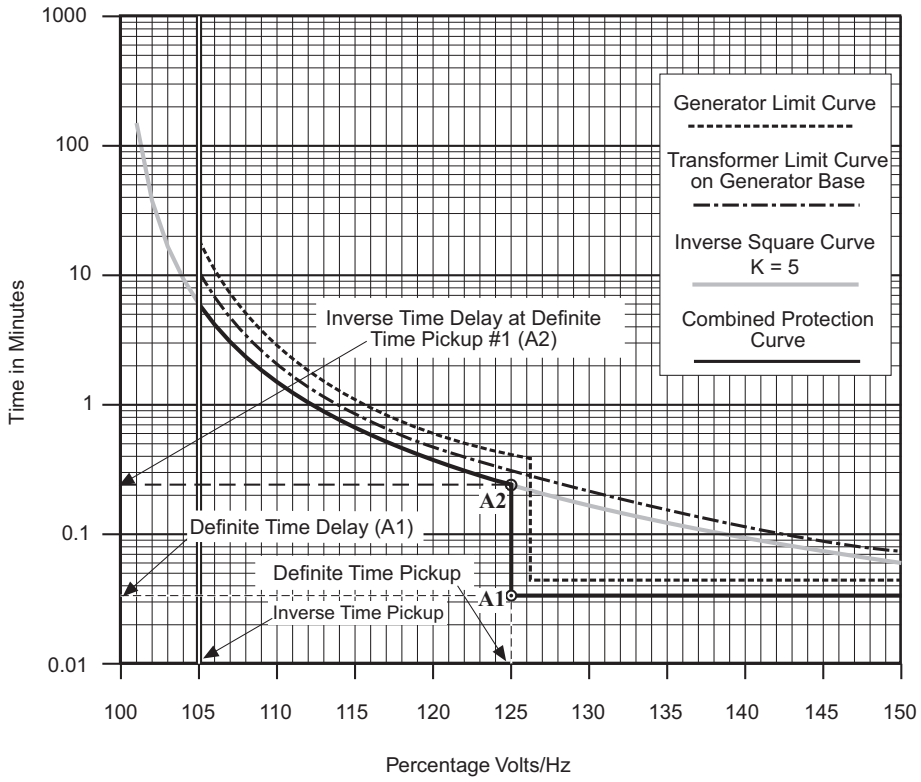


Figure 2-15 Example of Capability and Protection Curves (24)

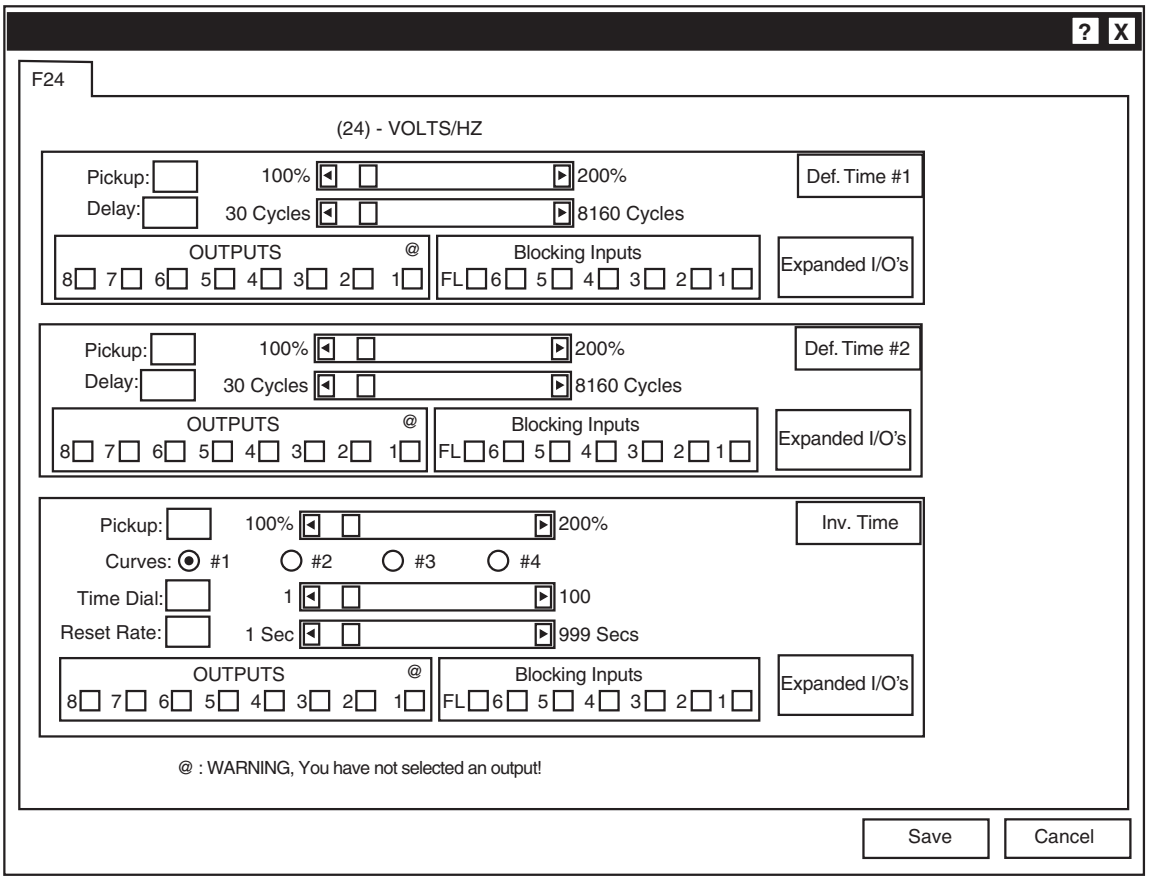


Figure 2-16 Volts-Per-Hertz (24) Setpoint Ranges

25 Sync Check

■ **NOTE**: The 25 function cannot be enabled under any one of the following conditions:

- 67N (Residual Directional Overcurrent) is enabled and the polarizing quantity has been set to V_X.
- 59D is enabled and the line side voltage is set to V_X.
- 59X is connected for turn-to-turn fault protection or bus ground protection.

The Synchronism (Sync) Check function (25) is used to ensure that the voltage magnitude, phase angle and frequency of the generator (V1) and the utility system (V_X) are within acceptable limits before the generator is synchronized with the system. Generator voltage (V1) can be selected as A, B, or C (line-to-ground and line-ground to line-line) or AB, BC, or CA (line-to-line).

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

Phase Angle Check

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

Phase angle window is defined as twice the Phase Angle Limit setting. For example, if the Phase Angle Limit is set at 10 degrees, a phase angle window of 20 degrees exists between –10 degrees and +10 degrees. The logic diagram of the phase angle check is shown in Figure 2-17.

Delta Voltage and Delta Frequency Check

Delta Voltage and Delta Frequency elements may be individually enabled or disabled, as desired. The Delta Voltage check will compare the absolute difference between the selected sync phase voltage (V1) and the measured system voltage (V_X) with the Delta Voltage Limit setting. Likewise, the Delta Frequency measures the frequency difference between V1 and V_X voltage signals. The Phase Angle Check, Delta Voltage and Delta Frequency Check all combine through an appropriate timer with the output directed to the programmed 25S output contact. A logic diagram representing this logic is presented in Figure 2-17.

Dead Line/Dead Bus Check

The Dead Volt Limit defines the Hot/Dead voltage level used in Deadline/Dead Bus closing schemes. When the measured V_X voltage is equal to or below the Dead Volt Limit, V_X is considered dead. When the measured V_X is above the Dead Volt Limit, V_X is considered hot. The opposite side of the breaker uses the positive sequence voltage measurement (V1) for 3-phase consideration in determining hot/dead detection. Different combinations of hot line/dead bus closings may be selected, depending on how the buses are referenced. A logic diagram of the Deadline/Dead Bus scheme is presented in Figure 2-17.

The Dead V1, Dead V_X, and Dead V1 & V_X enable are software switches used to enable the dead line/dead bus logic. Further conditioning can be performed on the dead detection logic by selecting one or more input contacts (Dead Input Enable) to control the enabled dead detection element. For example, if INPUT2 (I2) is selected under the Dead Input Enable screen, and both the Dead V1 and Dead V_X elements are enabled, the dead check timer will start when INPUT2 is activated, and either V1 dead/V_X hot or V1 hot/V_X dead. This allows for external control of the desired dead closing scheme. Dead Input Enable selections are common to all dead detection elements. If no inputs are selected under the Dead Input Enable screen, and any dead element is enabled, the dead check timer will start immediately when the dead condition exists.

The 25S and 25D can be programmed to be sent to two different contacts, if desired.

■ **NOTE**: The 25 function does not produce a target or LED and is accompanied by the HMI message “F25 Function Operated”.

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

```
25S PHASE LIMIT
 _________   Degrees
```
Phase angle setting.

```
25S UPPER VOLT LIMIT
 _________ Volts
```
Upper voltage limit for voltage acceptance.

```
25S LOWER VOLT LIMIT
 _________ Volts
```
Lower voltage limit for voltage acceptance.

```
25S SYNC CHECK DELAY
 _________ Cycles
```
Sync check time delay.

```
25S DELTA VOLT
disable ENABLE
```
Delta voltage element.

```
25S DELTA VOLT LIMIT
 _________ Volts
```
Delta voltage setting.

```
25S DELTA FREQUENCY
disable   ENABLE
```
Delta frequency element.

```
25S DELTA FREQ LIMIT
 _________ Hz
```
Delta frequency setting.

```
25S SYNC-CHECK PHASE
a  b  c
```
Selects the phase voltage on the generator side for Sync Check functions (A, B, or C for line-to-ground and line-ground to line-line, and AB, BC, CA for line-to-line)

```
25D DEAD VOLT LIMIT
 _________ Volts
```
Voltage less than this setting is defined as “DEAD”; above this setting as “HOT”.

```
25D DEAD V1 HOT VX
disable   ENABLE
```
Enables Dead V1/Hot V_x setting.

```
25D DEAD VX HOT V1
disable   ENABLE
```
Enables Hot V1/Dead V_x setting.

```
25D DEAD V1 & VX
DISABLE enable
```
Enables Dead V1/Dead V_x closing.

```
25D DEAD INPUT ENABLE
    i6 i5 i4 I3 i2 i1
```
Externally controlled dead closing. Inputs IN7–IN14 must be set using IPScom.

```
25D DEAD DELAY
 _________ Cycles
```
Dead delay timer setting.

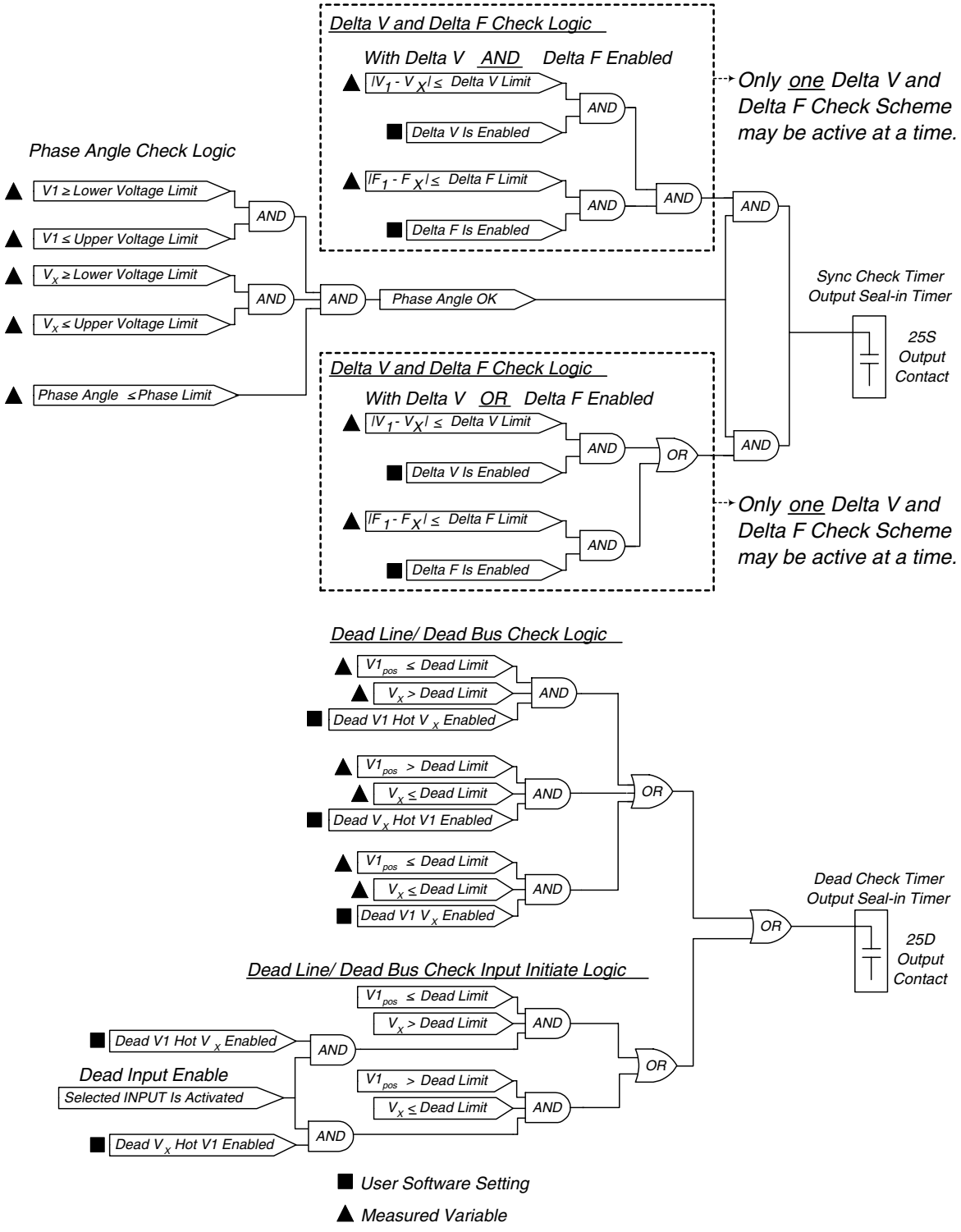


Figure 2-17 Sync Check Logic Diagrams

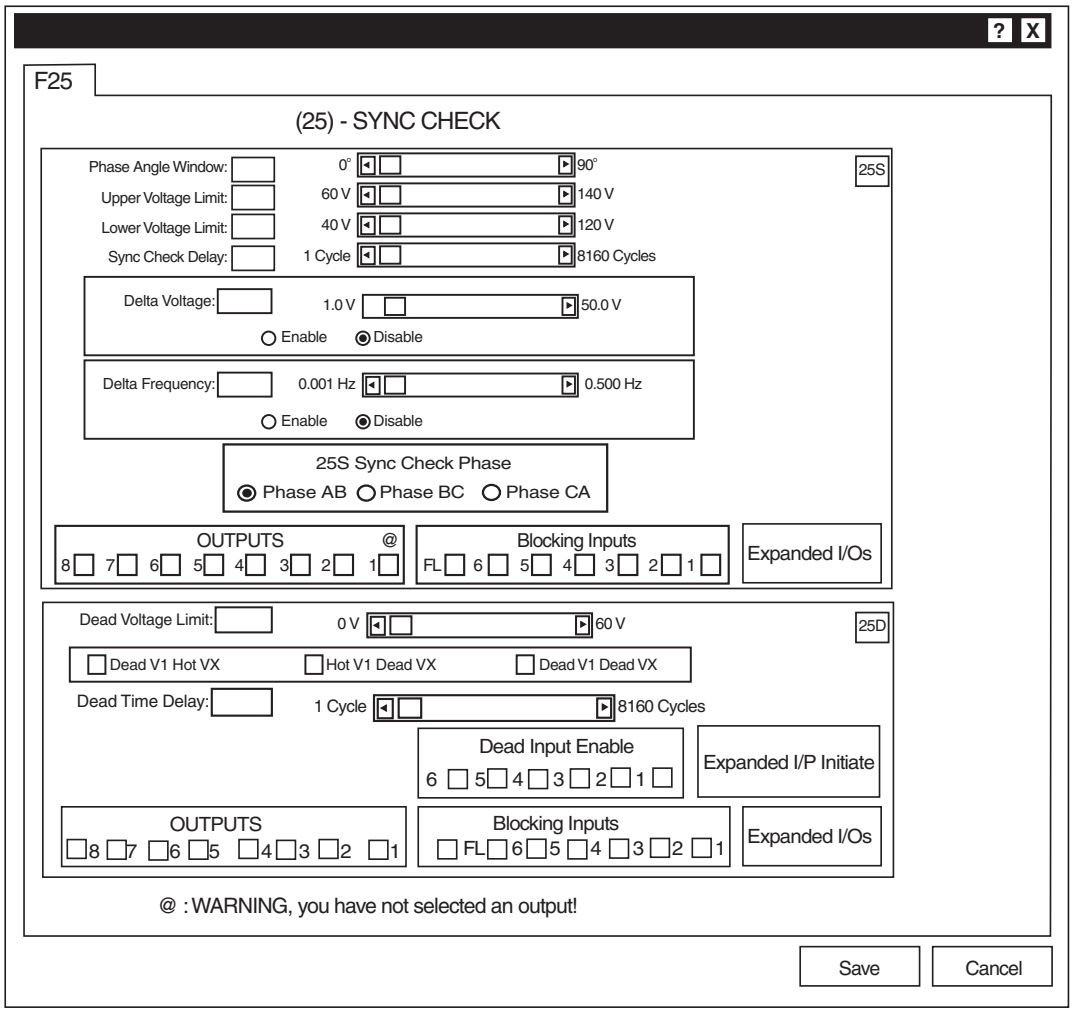


Figure 2-18 Sync Check (25) Setpoint Ranges

27 Phase Undervoltage

The Phase Undervoltage function (27) may be used to detect any condition causing long- or short-term undervoltage. This is a true three-phase function in that each phase has an independent timing element. The ranges and increments are presented in Figure 2-19.

Magnitude measurement depends on the 59/27 Magnitude Select setting. (See Section 2.1, Configuration, Relay System Setup.) When the RMS calculation is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and the accuracy of the time delay is +20 cycles. If DFT calculation is selected, the magnitude calculation is accurate near 50 or 60 Hz, and the timer accuracy is ±1 cycle.

```
27 #1 PICKUP
 ________ Volts
```

```
27 #1 DELAY
 ________ Cycles
```

27 #2 and 27 #3 Screens are identical to 27 #1.

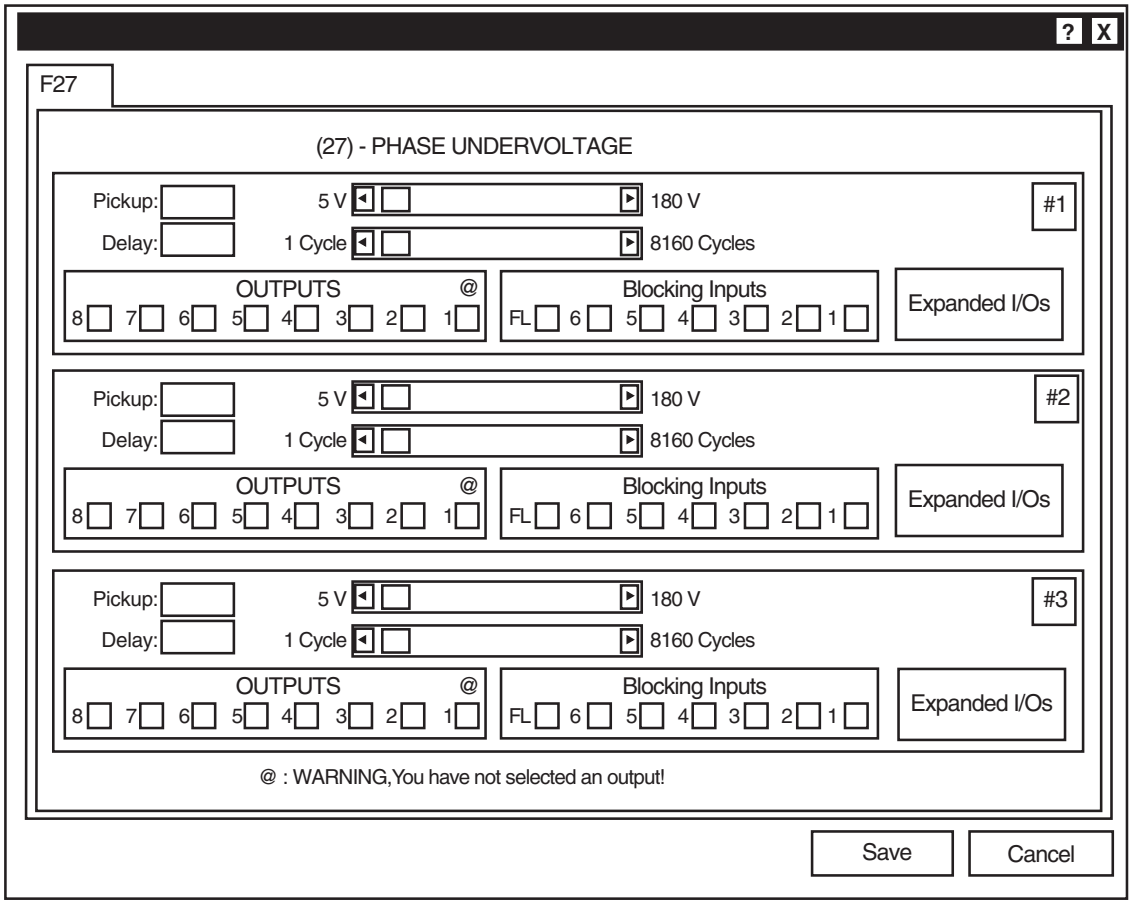


Figure 2-19 Phase Undervoltage (27) Setpoint Ranges

27TN Third Harmonic Undervoltage, Neutral

For ground faults near the stator neutral, the Third Harmonic (180/150 Hz) Neutral undervoltage function (27TN) provides stator ground-fault protection for high-impedance-grounded generator applications (See Figure 2-20). When used in conjunction with the fundamental neutral overvoltage (60/50Hz) function (59N), 100% stator ground-fault protection can be provided. This is illustrated in Figure 2-20.

The 27TN function can be supervised by the positive-sequence undervoltage element. Undervoltage supervision can prevent tripping when the generator field is not energized or the unit is not yet synchronized.

In some generators, the third harmonic voltage can be very low, especially during light load conditions. It is also observed in some generator installations that the third harmonic voltage is considerably reduced for a specific range of power output (band). To prevent mis-operation during these conditions, the 27TN function can be programmed to be supervised (blocked) by low forward power, low reverse power, low Vars (lead and lag), low power factor (lead/lag), and when the forward power is inside a band.

To properly handle pump storage operations, the M-3425A forward power blocking algorithm is enable from “zero per unit” to the forward power setpoint. During plant startup, after the field is flashed and before the unit synchronized, small current measurement errors cause the measured power to fluctuate (typically <0.2%.) This may result in a measured power value that is negative (i.e., –0.001 pu.) If the reverse power blocking is not enabled, the 27TN may be momentarily unblocked, resulting in a relay operation and nuisance generator trip. It is highly recommended that if the Forward Power Blocking is used, both the Forward Power Blocking and Reverse Power Blocking be enabled and set.

In the majority of the cases, these blocking functions will be disabled, except for those operating cases where the third harmonic neutral voltage magnitude is less than 0.5 V. The settings for the blocking functions should be set based on field measurements. Blocking regions are illustrated in Figure 2-21.

The 27TN setting depends on the actual third-harmonic neutral voltage level seen during normal operation of the generator. The setting should be about 50% of the minimum third-harmonic voltage observed during various loading conditions. This can be most conveniently measured during commissioning of the relay. Since the relay measures the third harmonic voltage levels and will display those values directly, no additional equipment is required. The undervoltage inhibit setting should be about 80% to 90% of the nominal voltage. The ranges and increments are presented in Figure 2-22.

27TN #2 Screens are identical to 27TN #1.

```
27TN #1 PICKUP
 _________ Volts
```

Relay volts are equal to the primary neutral voltage divided by the grounding transformer ratio. Generally set for approximately 50% of the minimum third harmonic voltage observed during various loading conditions.

```
27TN #1 POS SEQ VOLT BLK
disable    ENABLE
```

```
27TN #1 POS SEQ VOLT BLK
 _________ Volts
```

```
27TN #1 FWD POWER BLK
disable    ENABLE
```

```
27TN #1 FWD POWER BLK
 _________ PU
```

```
27TH #1 REV POWER BLK
disable    ENABLE
```

```
27TN #1 REV POWER BLK
 _________ PU
```

```
27TN #1 LEAD VAR BLK
disable    ENABLE
```

```
27TN #1 LEAD VAR BLK
 _________ PU
```

```
27TN #1 LAG VAR BLK
disable    ENABLE
```

```
27TN #1 LAG VAR BLK
 _________ PU
```

```
27TN #1 LEAD PF BLK
disable    enable
```

```
27TN #1 LEAD PF BLK
 _________ LEAD
```

```
27TN #1 LAG PF BLK
disable    enable
```

```
27TN #1 LAG PF BLK
 _________ LAG
```

```
27TN #1 BAND FWD PWR BLK
disable    enable
```

```
27TN#1 LO B FWD PWR BLK
 _________ PU
```

```
27TN#1 HI B FWD PWR BLK
 _________ PU
```

```
27TN #1 DELAY
 _________ Cycles
```

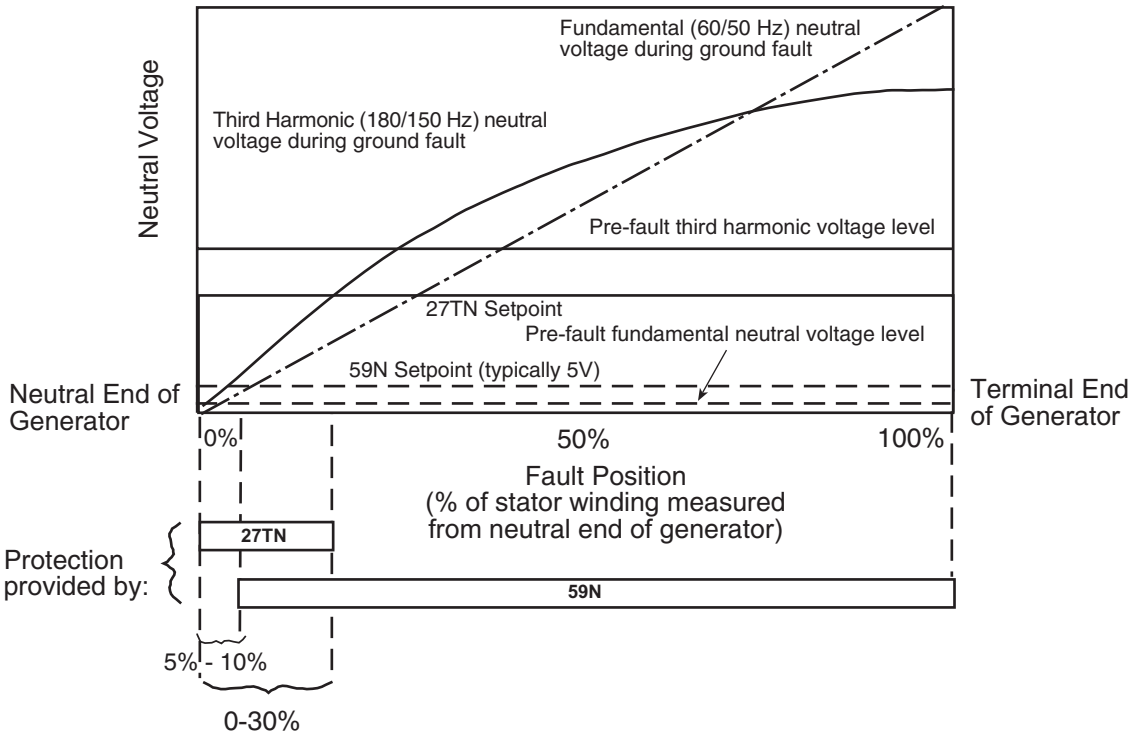


Figure 2-20 Third Harmonic Undervoltage (27TN) Protection Characteristics

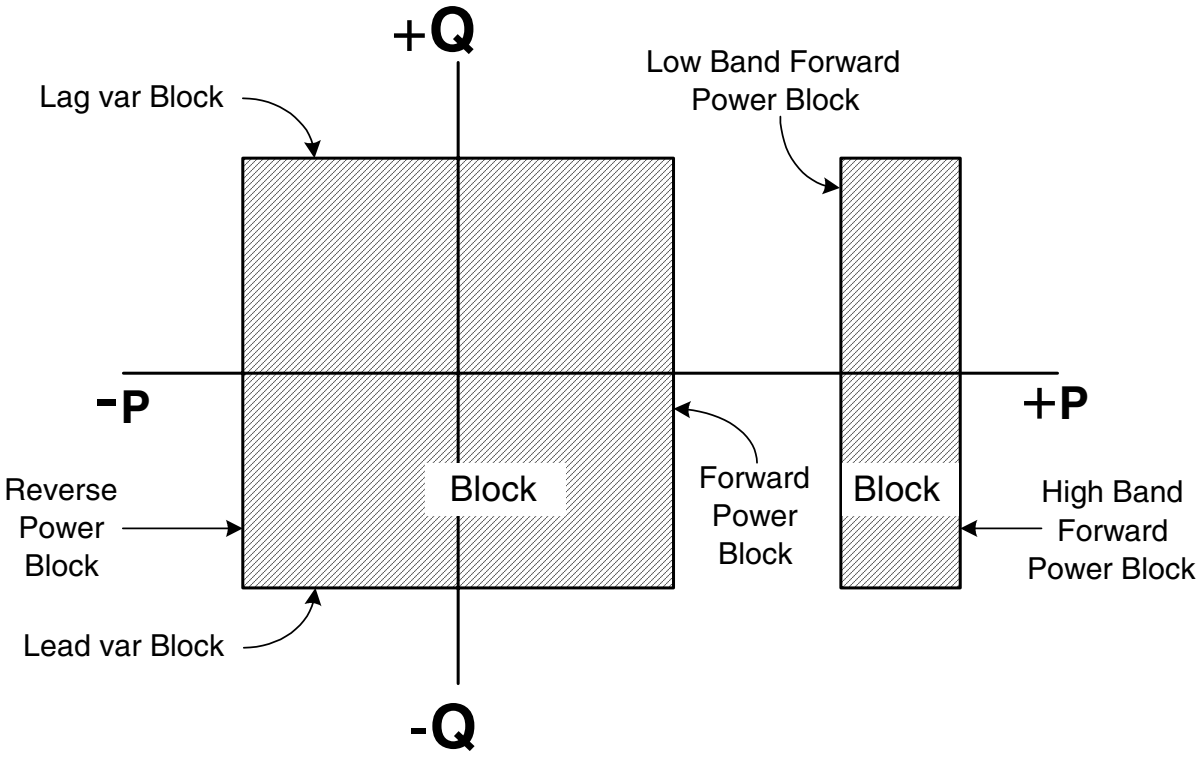


Figure 2-21 27TN Blocking Regions

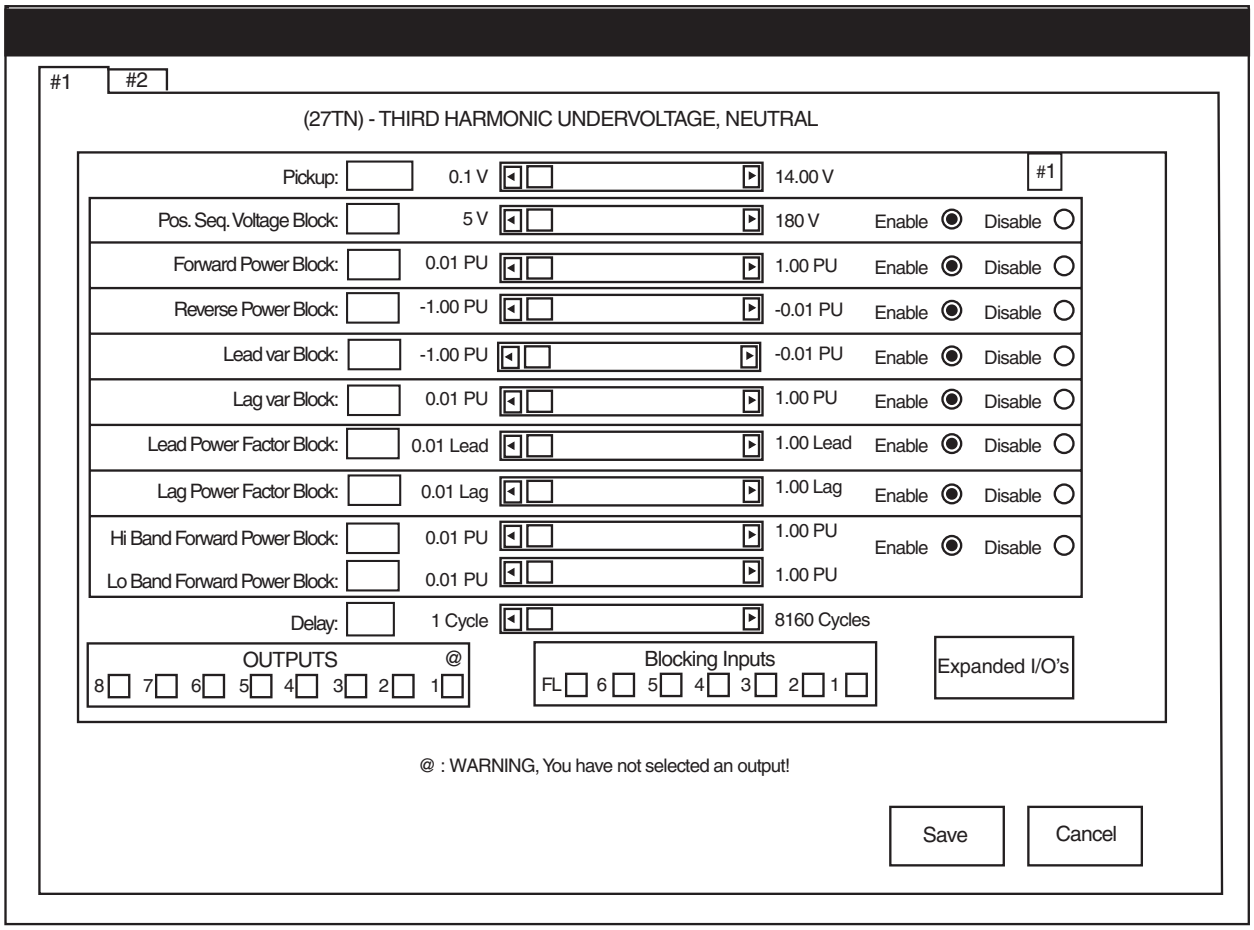


Figure 2-22 Third Harmonic Undervoltage, Neutral Circuit (27TN) Setpoint Ranges

32 Directional Power

The Directional Power function (32) can provide protection against both generator motoring and overload. It provides three power setpoints, each with a magnitude setting and a time delay. The Forward Power direction (power flow to system) is automatically chosen when the pickup setting is positive and the Reverse Power direction (power flow to generator) is automatically chosen when the pickup setting is negative. The range, as shown is from –3.000 PU to 3.000 PU where 1.0 PU is equal to the generator MVA rating. Normalized PU power flow measurements are based on Nominal Voltage and Nominal Current setting, as shown in Section 2.1, Configuration, Relay System Setup.

Protection from Generator Motoring

Protection against motoring is provided by selecting a negative pickup with Over/Under power set to Over. The relay will operate when the measured real power is greater (more negative) than the pickup setting in the reverse direction.

In some steam generator applications it is desirable to trip the generator when the forward power is less than a small value. This is due to the fact that the trapped steam will cause the generator to supply a small amount of power even though the steam valves are closed. In this case the Over/Under power setting is set to Under and a positive pickup setting is chosen. The relay will trip when the measured forward power is less than the pickup value. The function should be blocked when the generator breaker is open (using contact input blocking) otherwise the function will trip and prevent the generator from being brought online.

Protection from Generator Overload

Protection from generator overload is provided by selecting a positive pickup setting with Over/Under Power setting set to Over. The relay will operate when the measured real power is greater than the pickup setting.

Protection from Excessive Reactive Power

The directional power element #3 can be set to operate on either real power or reactive power. When protection from excessive reactive power is required the element #3 can be set to operate on reactive power. The relay will operate when the measured reactive power exceeds the pickup setting.

Figures 2-23 through 2-26 show reverse power, low forward power, over power, and over reactive power applications.

```
32 #1 PICKUP
 _________ PU
```

The reverse power pickup setting should be based on the type of prime mover and the losses when the generator is motoring.

```
32 #1 DELAY
 _________ Cycles
```

Reverse power relays should always be applied with a time delay in order to prevent mis-operation during power swing conditions. Typical time delay settings are 20 to 30 seconds.

```
32 #1 TARGET LED
disable    enable
```

Target LED for the 32 Function elements can be individually enabled or disabled.

```
32#1 UNDER/OVER POWER
over under
```

When Low Forward Power protection is desired, set this to Under with a positive pickup setting. The relay will trip when the real power measurement is *less than or equal to* the pickup setpoint.

```
32 #2 PICKUP
 _________ PU
```

If used, positive direction power settings can be used for overload protection, providing either alarm or tripping or both, when power equals or exceeds the setting. The pickup and time delay settings should be based on the capability limit of the generator.

```
32 #2 DELAY
 _________ Cycles
```

A second reverse power setting can be used for sequential tripping of the generator in which case the associated time delay will be in the range of 2 to 3 seconds.

```
32 #2 TARGET LED
disable    enable
```

```
32#2 UNDER/OVER POWER
over under
```

```
32 #3 PICKUP
 _________ PU
```

```
32 #3 DELAY
 _________ Cycles
```

```
32 #3 TARGET LED
disable    enable
```

```
32#3 UNDER/OVER POWER
over under
```

```
32 #3 DIR POWER SENSING
real    reactive
```

Directional Power Sensing for Element #3 can be selected as Real or Reactive.

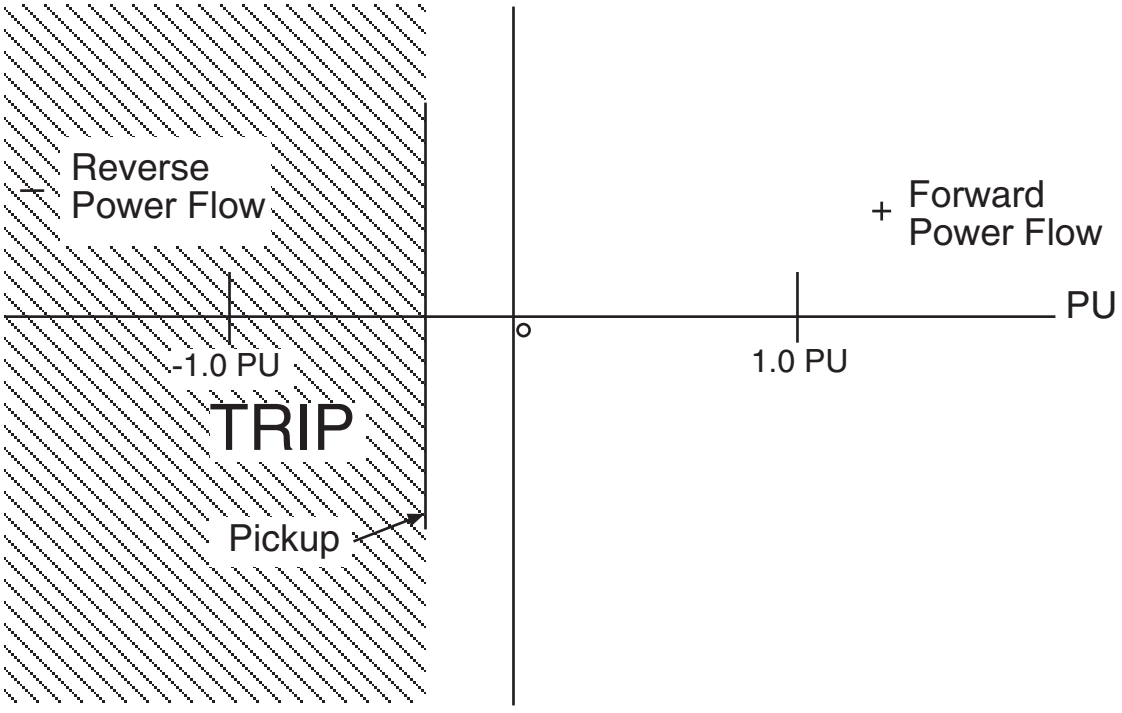


Figure 2-23 Tripping on Reverse Power Flow (Over Power with Negative Pickup)

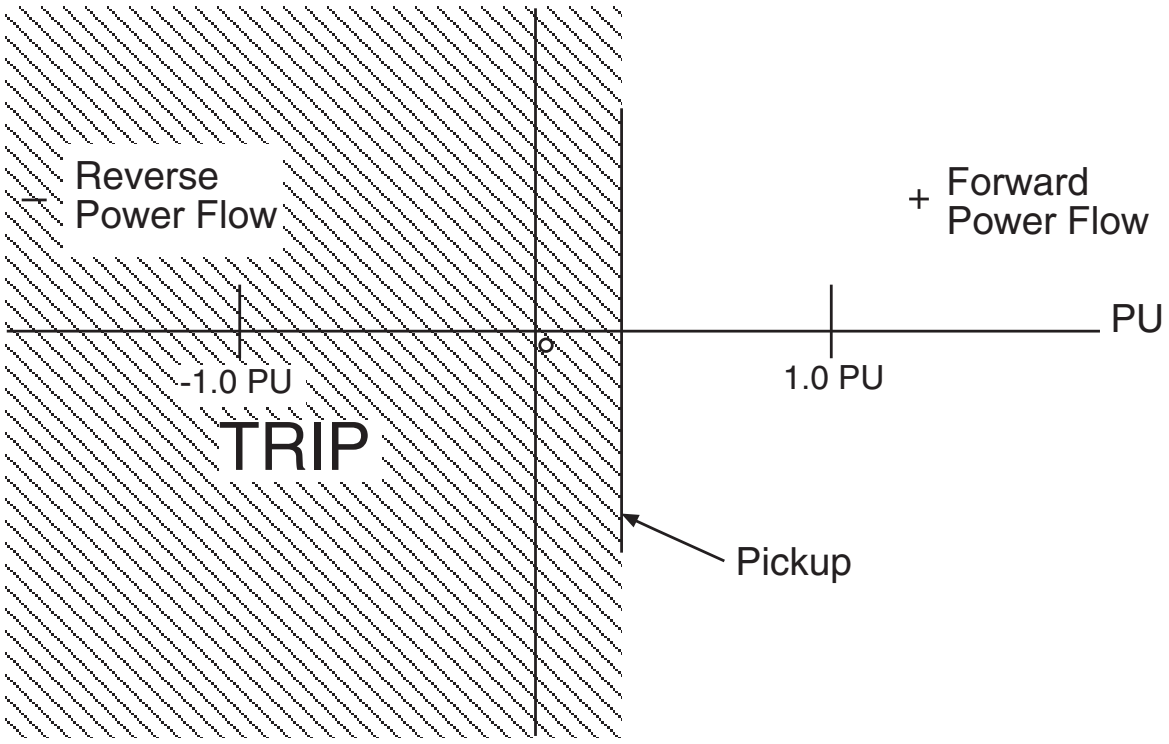


Figure 2-24 Tripping on Low Forward Power (Under Power with Positive Pickup)

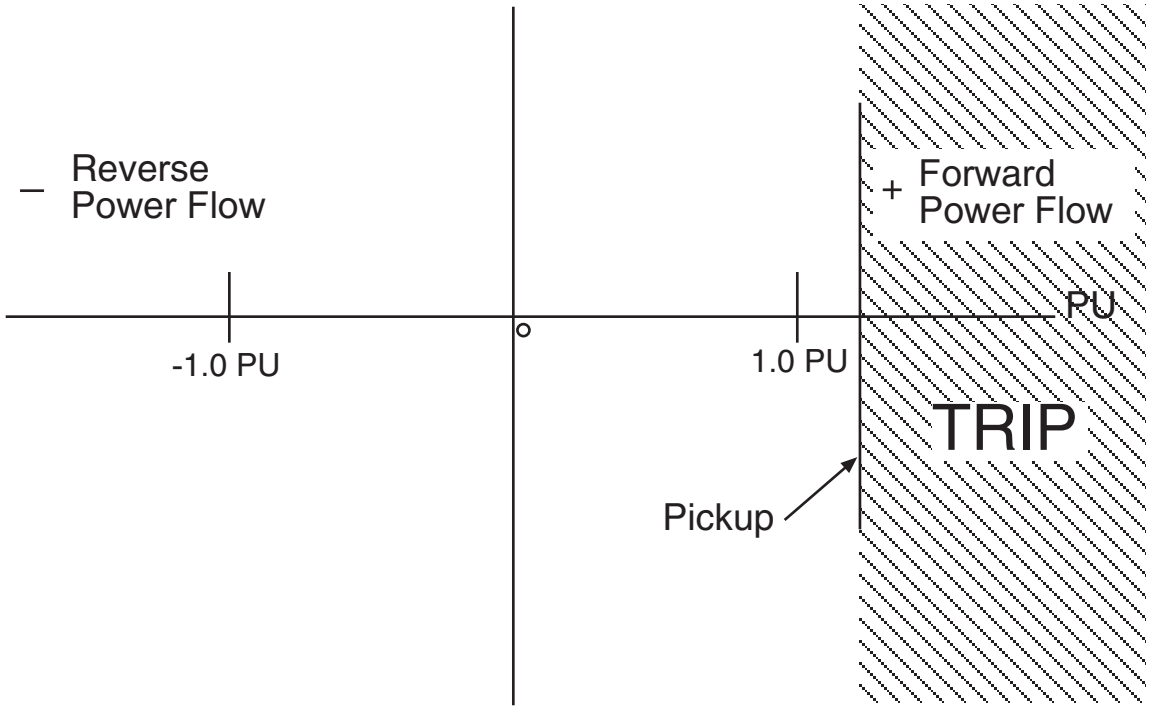


Figure 2-25 Tripping on Overpower (Over Power with Positive Pickup)

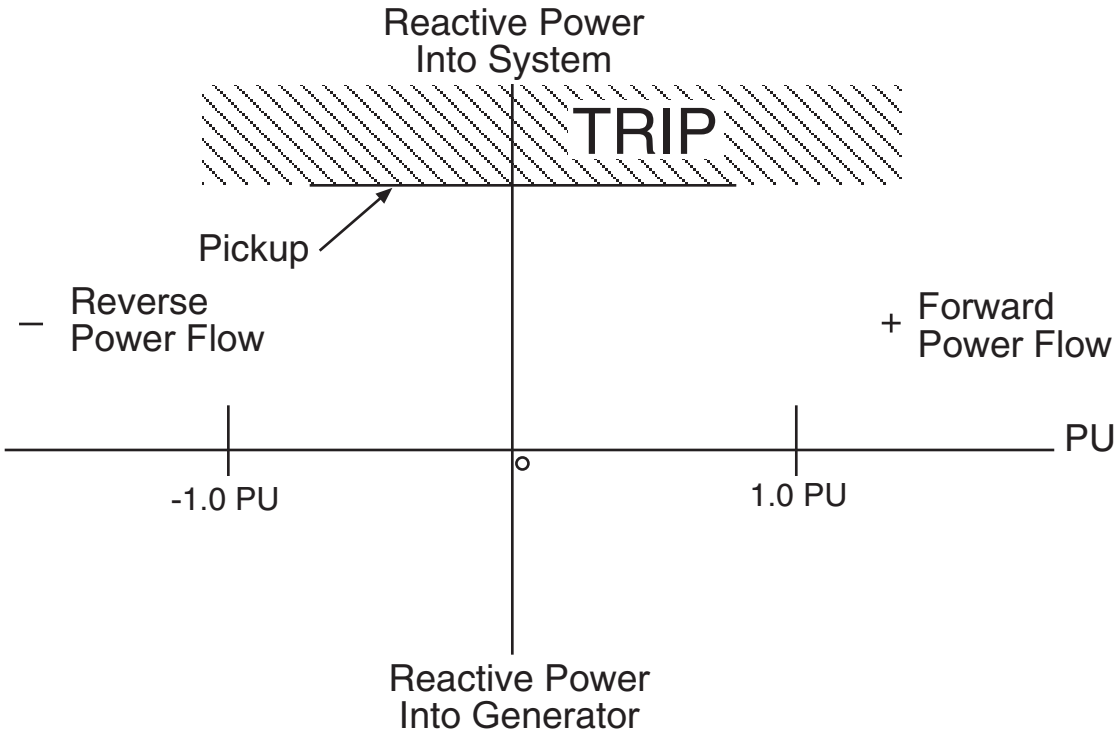


Figure 2-26 Tripping on Over Reactive Power with Element #3 (Over Power, Positive Pickup and Directional Power Sensing Set to Reactive)

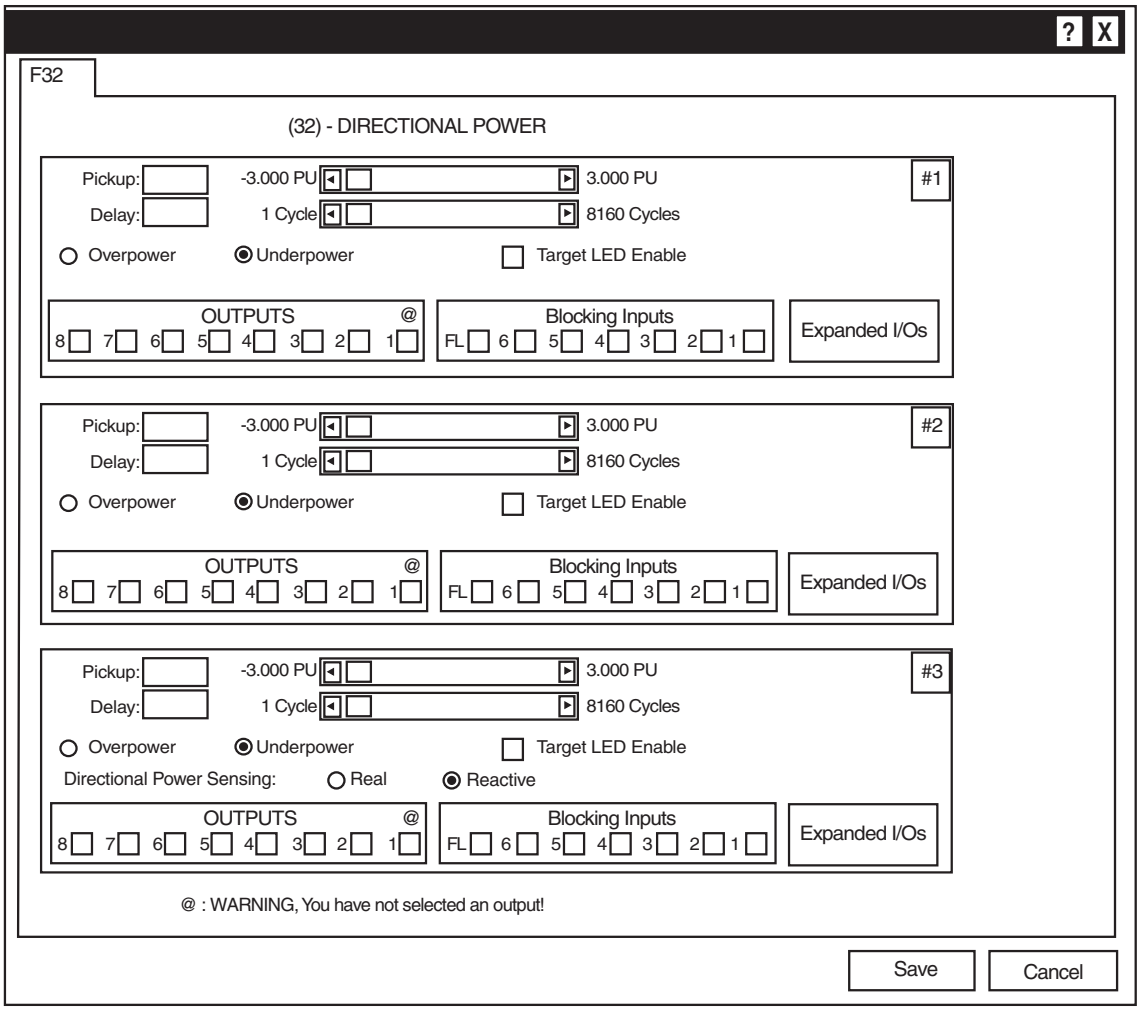


Figure 2-27 Directional Power, 3-Phase (32) Setpoint Ranges

40 Loss of Field

The Loss-of-Field function (40) provides protection for a partial or complete loss of field. A variety of possible settings make the M-3425A Generator Protection Relay very flexible when applied to loss-of-field protection. Ranges and increments are presented in Figure 2-30.

The loss-of-field function is implemented with two offset mho elements, an undervoltage element, and a directional element. The setting for each mho element, diameter, offset, and time delay, are adjusted individually. Each element has two time delay settings. The second time delay (delay with VC) is applicable with voltage control, and the timer only starts if the positive sequence voltage is below the voltage control setting. The function with voltage control and without voltage control can be programmed to send to two different output contacts, if desired. The delay with voltage control may be enabled on each element but the voltage level setting is common. The voltage control allows for faster tripping when low voltage may be caused by the VAr intake by the machine with loss of excitation. A common directional unit is provided to block the relay operation during slightly underexcited conditions (since approach #1 with negative offset is inherently directional, the directional element is not required). The directional unit's angle setting (Θ_D) can be set from 0° to 20°.

The settings of the offset mho elements should be such that the relay detects the loss-of-field condition for any loading while not mis-operating during power swings and fault conditions. Two approaches are widely used in the industry, both of which are supported by the M-3425A relay. Both approaches require knowledge of the reactances and other parameters of the generator. They are described in Figure 2-28, Loss of Field (40) — Protective Approach I and Figure 2-29, Loss of Field (40) — Protective Approach II.

Positive sequence impedance measurements are used for the loss of field functions. All impedance settings are secondary relay quantities and can be derived from the following formula:

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

where Z_{SEC} = secondary reflected impedance, Z_{PRI} = primary impedance, R_C = current transformer ratio, and R_V = voltage transformer ratio.

```
40 #1 DIAMETER
 _________ Ohms
```

```
40 #1 OFFSET
 _________ Ohms
```

```
40 #1 DELAY
 _________ Cycles
```

```
40VC #1 DELAY WITH VC
 _________ Cycles
```

The first approach is shown in Figure 2-28, Loss of Field (40) — Protective Approach I. Here, both of the offset mho elements (#1 and #2) are set with an offset of $-X'_d \div 2$, where X'_d is the (unsaturated) direct axis transient reactance of the generator. The diameter of the smaller circle (#1) is set at 1.0 pu impedance on the machine base. This mho element detects loss-of-field from full load to about 30% load. A small time delay provides fast protection.

The diameter of the larger circle (#2) is set equal to X_d, where X_d is the (unsaturated) direct axis synchronous reactance of the machine. This mho element can detect a loss-of-field condition from almost no load to full load. A time delay of 30 to 60 cycles (#2) should be used in order to prevent possible incorrect operation on stable swings.

The time delay with voltage control is typically set shorter than the other time delay.

```
40 #2 DIAMETER
 _________ Ohms
```

```
40 #2 OFFSET
 _________ Ohms
```

```
40 #2 DELAY
 _________ Cycles
```

```
40VC #2 DELAY WITH VC
 _________ Cycles
```

```
40 VOLTAGE CONTROL
 _________ Volts
```

```
40 DIRECTIONAL ELEMENT
 _________ Degrees
```

The second approach is shown in Figure 2-29, Loss of Field (40) – Protective Approach II. In this approach, one of the mho elements is set with an offset of $-X'_d \div 2$, a diameter of 1.1 X_d-($X'_d \div 2$), and a time delay of 10 to 30 cycles. The second element is set to coordinate with the generator minimum excitation limit and steady-state stability limit.

In order to obtain proper coordination, the offset of this element must be adjusted to be positive. Typically, the offset is set equal to the unit transformer reactance (X_T). The diameter is approximately equal to (1.1 X_d + X_T). A time delay of 30 to 60 cycles would prevent mis-operation on stable swings.

The following table provides suggested time settings when time delay with VC is used in addition to standard time delay.

Typical setting is 13° (0.974 power factor). This setting is common to both element #1 and #2.

Approach #1 can also be used for Zone #1, and approach #2 for Zone #2, where better coordination with AVR limiters, machine capability limits, and steady state stability limits can be obtained.

	Zone 1	Zone 2
Voltage Control Setting	N/A	80 to 90% of Nominal Voltage
Delay	15 Cycles	3,600 Cycles
Delay with VC	Disable	60 Cycles

Table 2-3 Voltage Control Time Settings

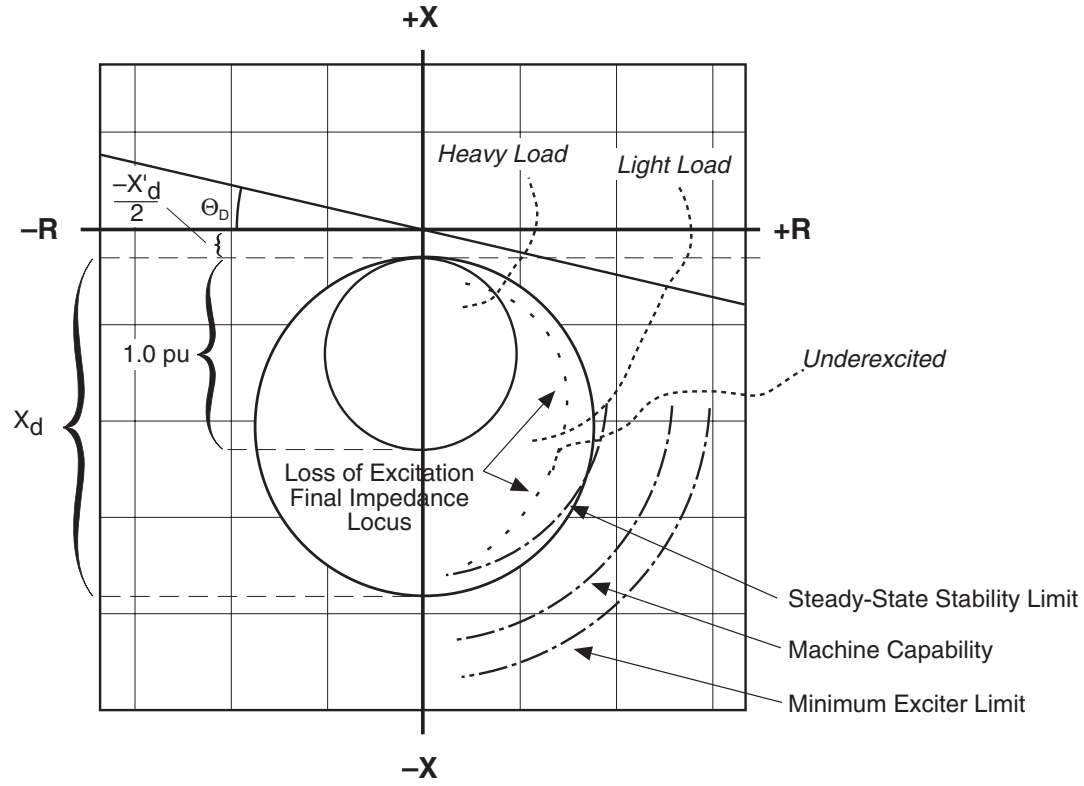


Figure 2-28 Loss of Field (40)—Protective Approach 1

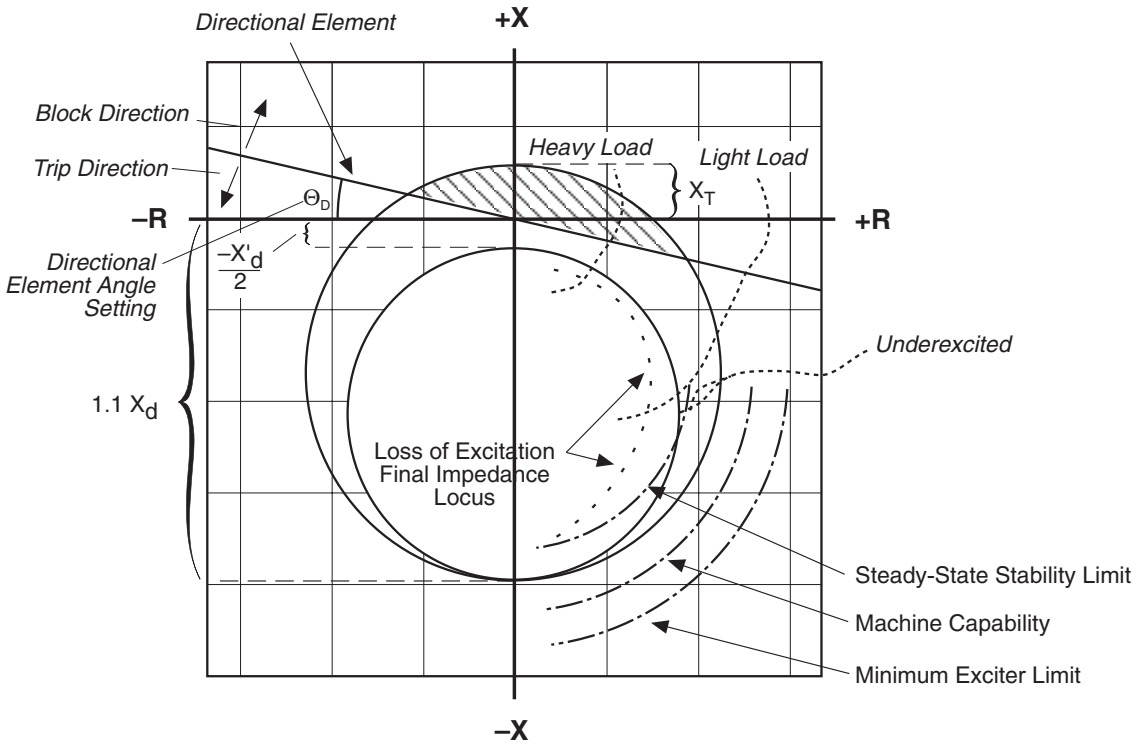


Figure 2-29 Loss of Field (40)—Protective Approach 2

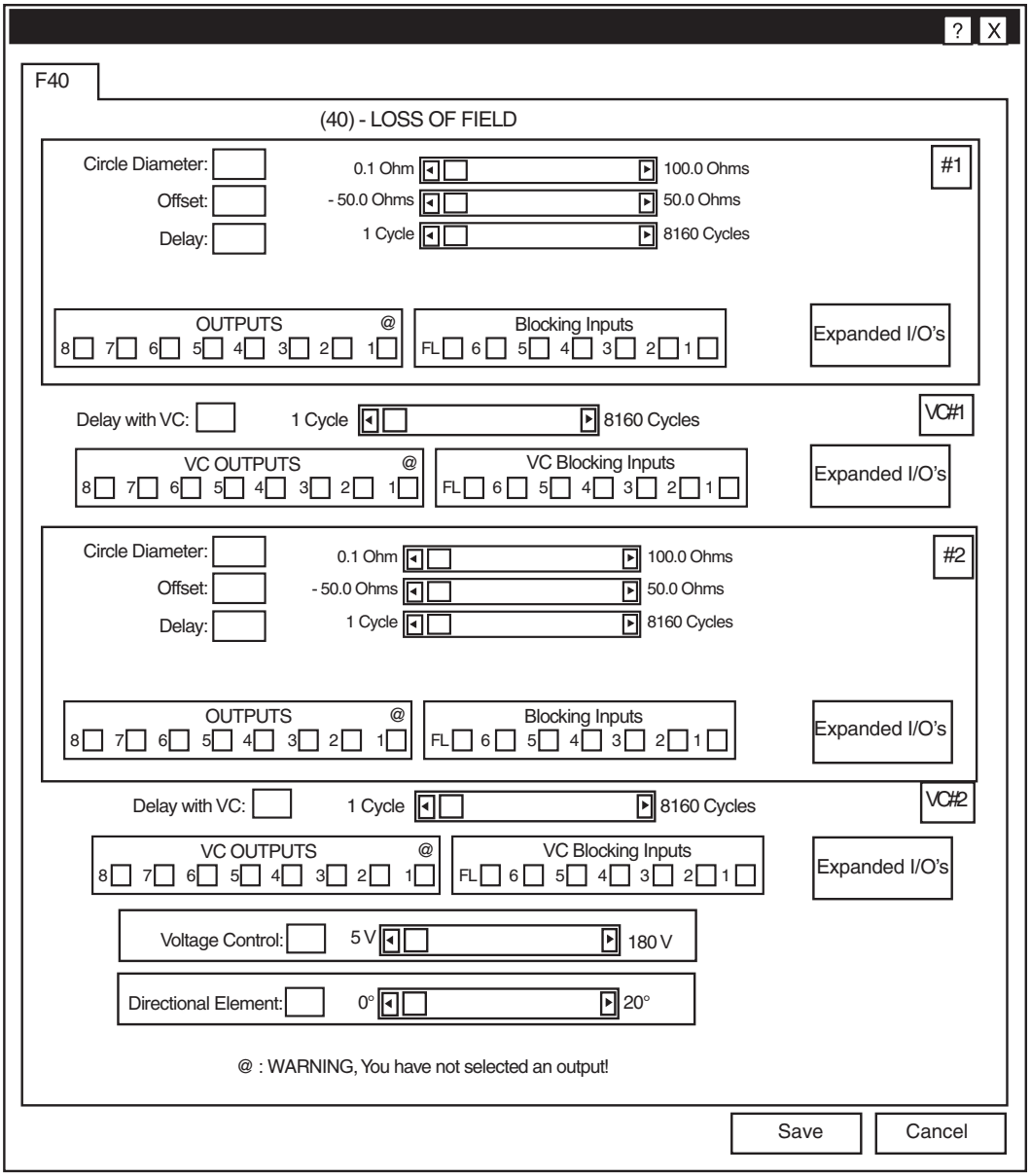


Figure 2-30 Loss-of-Field (40) Setpoint Ranges

■ **NOTE**: Out of Step Block Enable is not available for this release, and will appear greyed-out in display.

46 Negative Sequence Overcurrent

The Negative Sequence Overcurrent function (46) provides protection against possible rotor overheating and damage due to unbalanced faults or other system conditions which can cause unbalanced three phase currents in the generator. Ranges and increments are presented in Figure 2-32.

This function has a definite time element and an inverse time element. The definite time pickup value and definite operating time are normally associated with an alarm function. The inverse time element is usually associated with a trip function and has a pickup and an operating time defined by an $(I_2)^2 t = K$, where K is the Time Dial Setting and I_2 is the per unit negative sequence current.

The minimum delay for the inverse time function is factory set at 12 cycles to avoid nuisance tripping. A maximum time to trip can be set to reduce the operating times for modest imbalances. An important feature that helps protect the generator from damage due to recurring imbalances is a linear reset characteristic. When I_2 decreases below the pickup value, the trip timer takes four minutes to reset from its 100% trip level. Figure 2-31, Negative Sequence Overcurrent Inverse Time Curves, illustrates the inverse time characteristic of the negative sequence overcurrent function.

Operating times are lower than shown in Figure 2-31 when measured current values are greater than 15 A (3 A for 1 A rated circuit).

The first task of setting this function is to determine the capabilities of the associated machine. As established by ANSI standards, the machine limits are expressed as $(I_2)^2t = K$. The value of K is established by the machine design and is generally provided on test sheets of the machine. The relay can accommodate any generator size because of the wide range of K settings from 1 to 95. Typical values can be found in ANSI C50.13-1977.

The negative sequence pickup range is from 3% to 100% of the Nominal Current value input during system setup (see Section 2.1, Configuration).

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

```
46DT PICKUP
 _________ %
```

The pickup setting is usually quite low (3–5%) and the output of this function is usually connected to alarm only.

```
46DT DELAY
 _________ Cycles
```

Time delay should be set high enough to avoid alarms on transients.

```
46IT PICKUP
 _________ %
```

The 46 Inverse Time pickup setting should coincide with the continuous negative sequence current capability of the generator operating at full output.

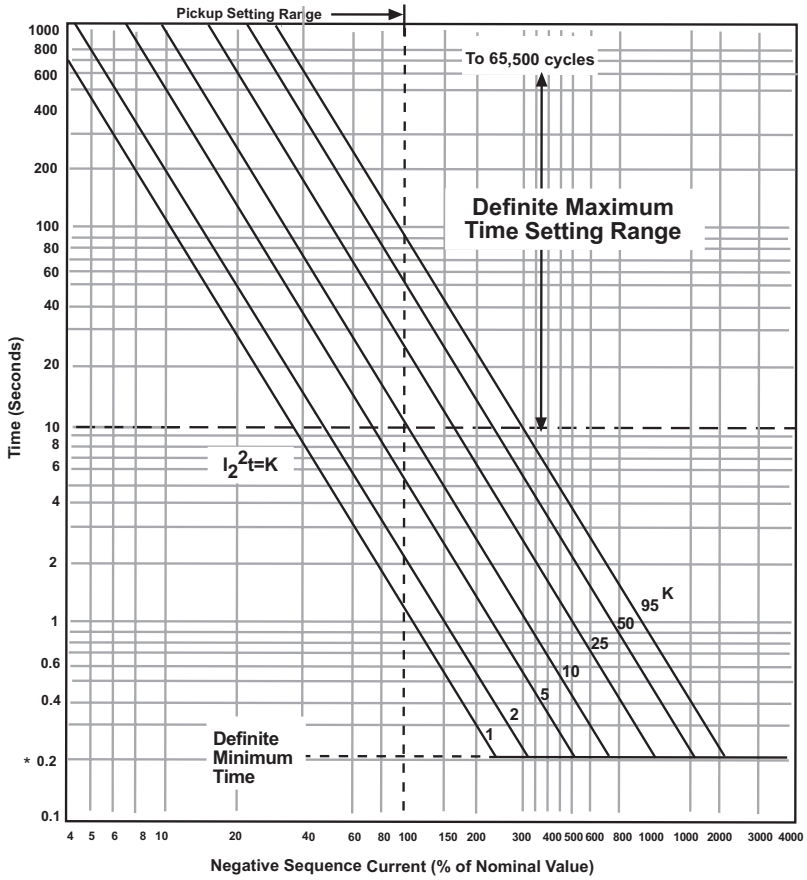
```
46IT MAX DELAY
 _________ Cycles
```

The maximum trip time is used to reduce the longer trip times associated with low to moderate imbalances to a preset time.

```
46IT RESET TIME
 _________ Seconds
```

```
46IT TIME DIAL
 _________
```

The time dial setting corresponds to the K provided by the generator manufacturer for the specific unit being protected. See Figure 2-31 for the negative sequence overcurrent inverse time curves.



■ **NOTE**: When the phase current exceeds 3X I nominal, the operating times will be greater than those shown.

* 0.24 seconds for 50 Hz units.

Figure 2-31 Negative Sequence Overcurrent Inverse Time Curves

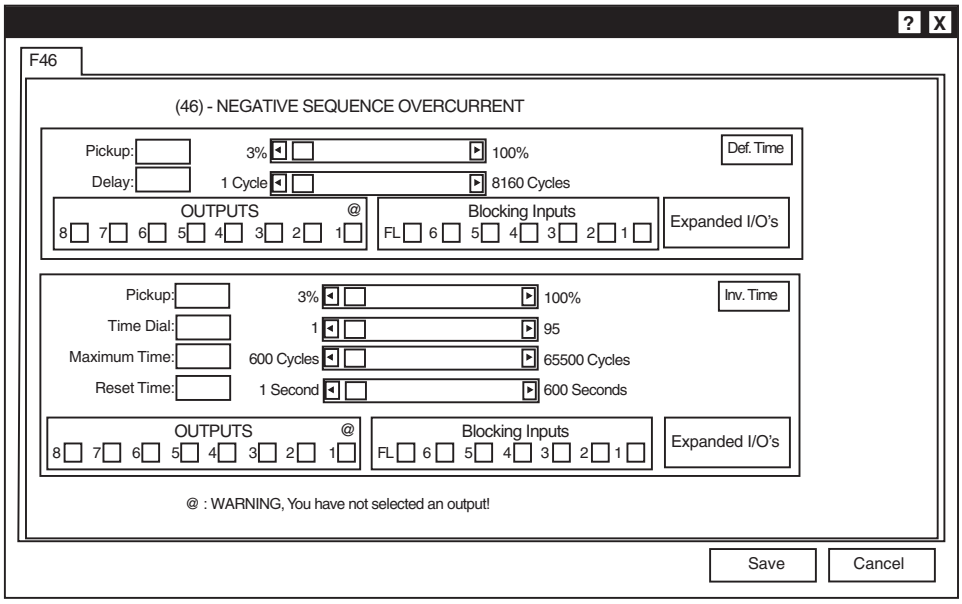


Figure 2-32 Negative Sequence Overcurrent (46) Setpoint Ranges

49 Stator Overload Protection

The Stator Thermal Overload function (49) provides protection against possible damage during overload conditions. The characteristic curves are based on IEC-255-8 standard, and represent both cold and hot curves. The function uses the thermal time constant of the generator and stator maximum allowable continuous overload current (I_{max}) in implementing the inverse time characteristic.

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

Where: t = time to trip
τ = thermal time constant
I_L = load current
I_{PL} = pre-load current
I_{max} = maximum allowed continuous overload current

Example: If we consider that the generator was loaded with 80% of its rating power prior to overload, then the current goes up to 2.0 times the maximum current ((I_L/I_{max})=2.0). Selecting the curve P=0.8 (see Figure 2-28), 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.

The 49 function has two elements, one of which can be used for trip and the other for alarm.

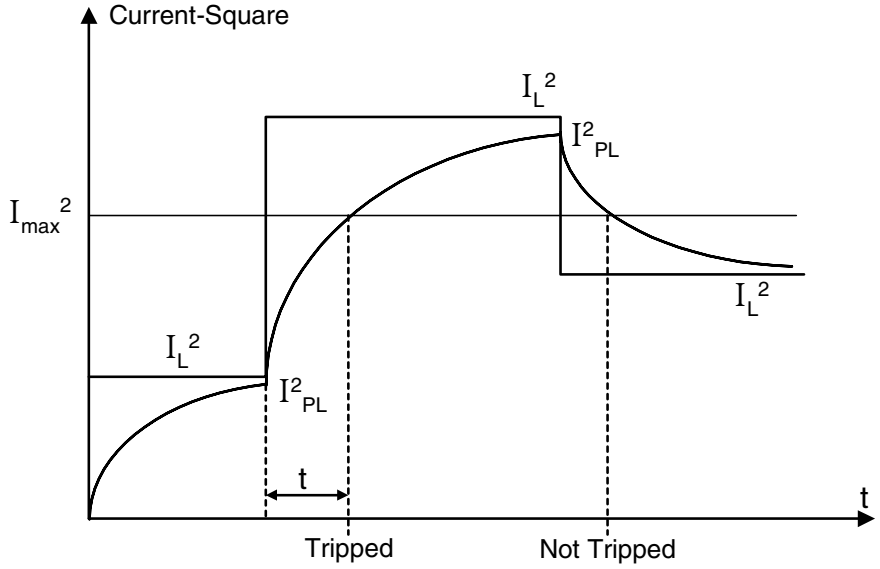


Figure 2-33 Time Constant, Function 49

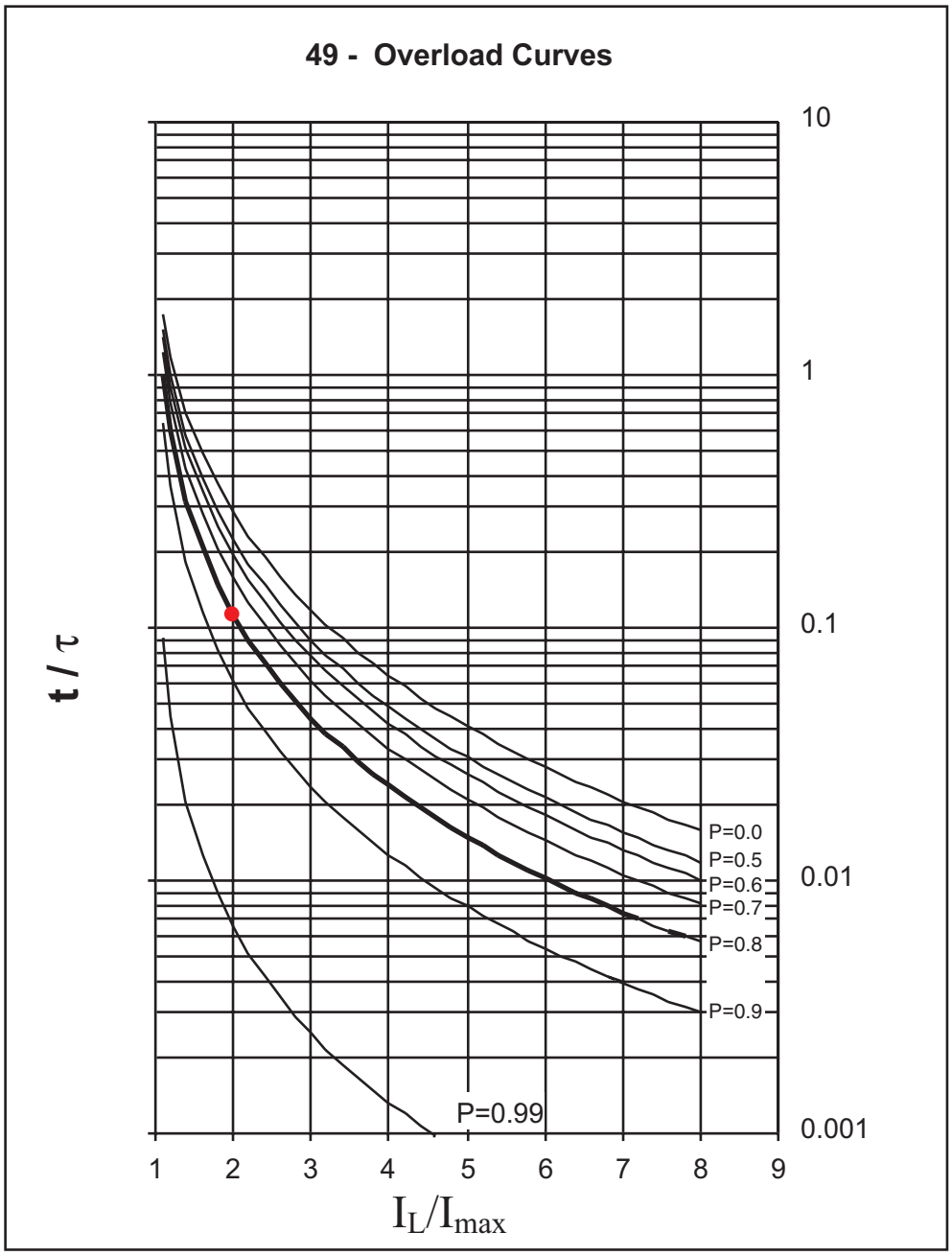
```
49 #1 TIME CONSTANT
 _________ Min
```

Selects the time constant, 'τ'

```
49#1 MAX OVERLOAD CURR
 _________ Amps
```

Selects the maximum allowed continuous overload current.

49#2 Screens are identical to those for 49#1.



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

Figure 2-34 49 Function Overload Curves

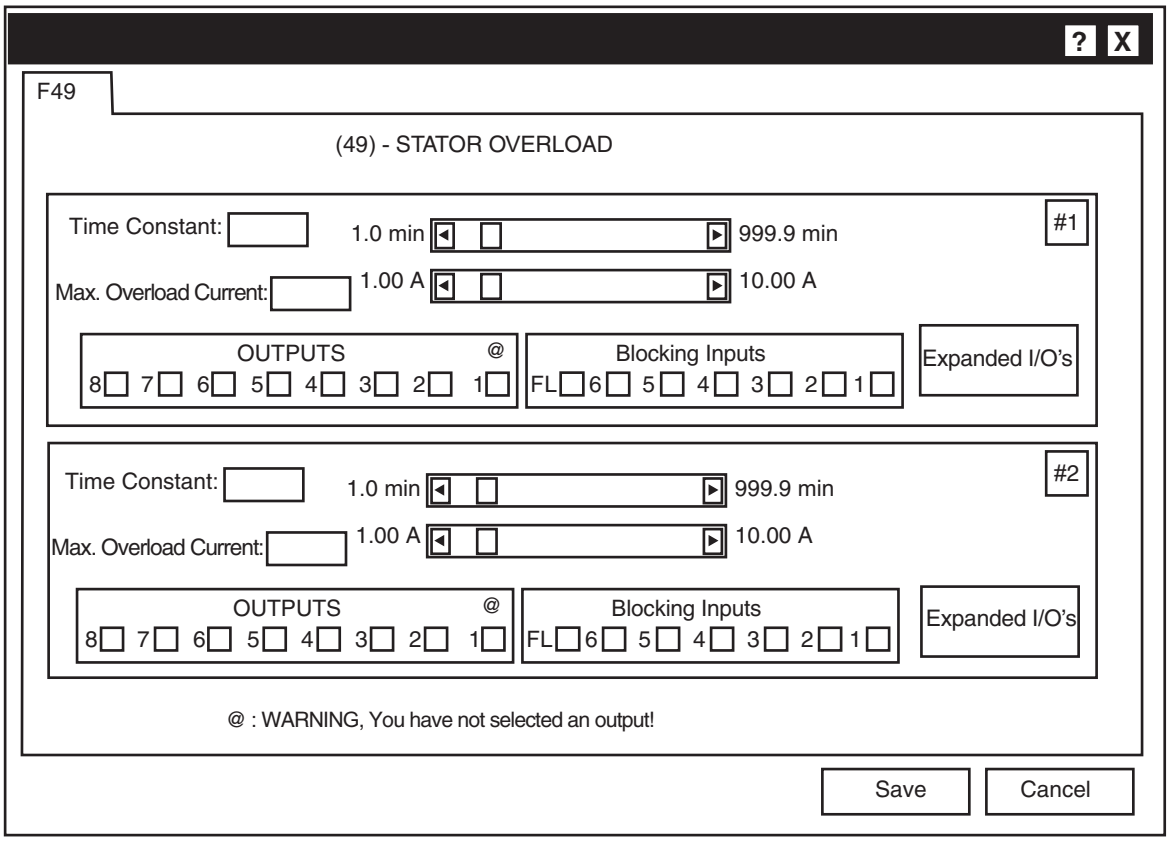


Figure 2-35 Stator Thermal Protection (49) Setpoint Ranges

50/50N Instantaneous Overcurrent, Phase and Neutral Circuits

The Instantaneous Phase (50) and Instantaneous Neutral (50N) overcurrent functions provide fast tripping for high fault currents. The settings of both functions must be set such that they will not pickup for fault or conditions outside the immediate protective zone. If the neutral current input is connected to a step-up transformer's neutral CT, the 50N function can be used as a breaker flashover protection when used in conjunction with external breaker failure protection. Ranges and Increments are presented in Figures 2-36 and 2-37. The function automatically selects fundamental RMS or total RMS calculation based on the input frequency. When the generator frequency is within ±5 Hz from the nominal frequency, it uses fundamental RMS calculation. Outside of this range, it uses total RMS calculation, which will provide protection during offline down to a frequency of 8 Hz.

For providing off-line protection, one of the elements can be supervised by a breaker 'b' contact, and the element blocked when the breaker is closed. This allows the function to be set sensitively (below full load current).

```
50#1 PICKUP
 _________ Amps
```

```
50#1 DELAY
 _________ Cycles
```

```
50N PICKUP
 _________ Amps
```

```
50N DELAY
 _________ Cycles
```

The relay current (I_R) is equal to the primary current (I_p) divided by the appropriate CT ratio. These screens are repeated for 50#2 element.

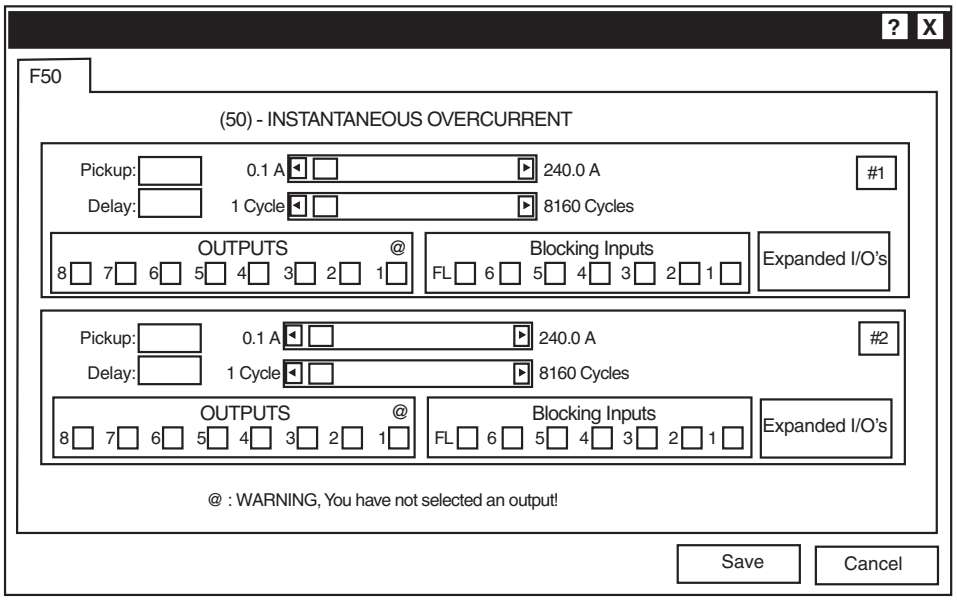


Figure 2-36 Instantaneous Overcurrent (50) Setpoint Ranges

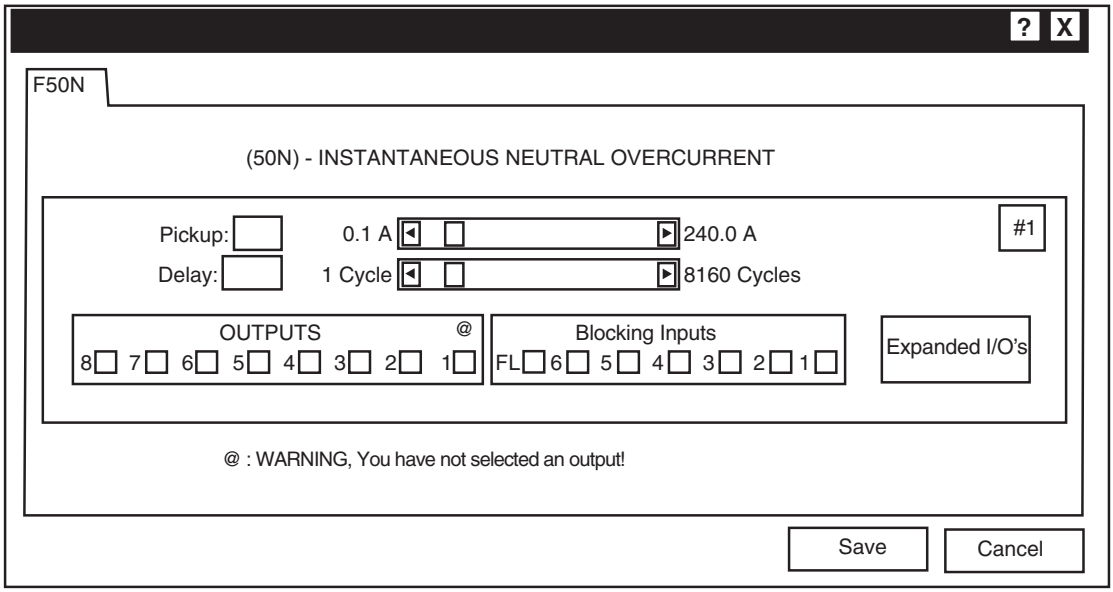


Figure 2-37 Instantaneous Neutral Overcurrent (50N) Setpoint Ranges

50BF Generator Breaker Failure/HV Breaker Flashover

The Generator Breaker Failure/HV Breaker Flashover function (50BF) is applicable when a generator breaker is present and line side generator CTs are being used. The 50BF-Ph phase detector element (if enabled) is used for breaker failure and the 50BF-N (if enabled) provides breaker flashover protection by providing an additional breaker failure initiate which is only active when the breaker is open. For high impedance grounded applications, the 50BF-N function is inapplicable and must be disabled. Ranges and increments are presented in Figure 2-39.

50BF-Ph Generator Breaker Failure: When the M-3425A Generator Protection Relay detects an internal fault or an abnormal operating condition, it closes an output contact to trip the generator breaker or the unit HV breaker. When a generator breaker is used, protection is available for the instance where it fails to clear the fault or abnormal condition. Such generator breaker failure protection output contacts must be connected to trip the additional necessary breakers to isolate the generator from the system.

The breaker-failure condition is usually detected by the continued presence of current in any one or more of the phases after a trip has been sent to the breaker. However, the current detector (50BF-Ph) may not always give the correct status of the breaker, especially for generator breakers. This is because faults and abnormal operating conditions such as ground faults, overexcitation, over/under frequency, and reverse power may not produce enough current to operate the current detectors. For this reason, the breaker status input 52b contact must be used, in addition to the 50BF-Ph, to provide adequate breaker status indication.

Implementation of the generator breaker failure function is illustrated in Figure 2-38. The breaker failure timer will be started whenever any one of the designated output contacts or the external programmed breaker failure initiate status input are operated. The timer continues to time if any one of the phase currents are above the 50BF-Ph pickup setting or if the 52b contact indicates the breaker is still closed; otherwise, the timer is reset.

Since current in the generator high side CT which energizes the 50BF protection (I_A, I_B, I_C) might not extinguish concurrently with the breaker opening for faults between the CT location and the generator breaker, a possible area of mis-operation exists. Usually the risk of faults in this limited area is small enough to be ignored but should be considered.

50BF-Neutral Element: This instantaneous overcurrent relay is energized from the generator neutral CT (See Figure 2-5, One-Line Functional Diagram). This function is internally in series with a breaker “b” contact (IN1) to provide logic for the breaker flashover protection (see Figure 2-38).

HV Breaker Failure (limited) The breaker failure function may be used for a unit breaker rather than a generator breaker. It is limited in that it has no fault detector associated with the unit breaker. Output contact operation would occur if any of the initiate contacts close and the 52b contact indicated a closed breaker after the set time delay.

This operation is chosen by disabling the neutral element, disabling the phase element, and designating initiating inputs and outputs and a time delay setting.

```
50BF PHASE ELEMENT
disable     enable
```

If generator breaker failure function is used in this application, **ENABLE** here.

```
50BF PICKUP PHASE
 _________ Amps
```

Set phase pickup amps.

```
50BF NEUTRAL ELEMENT
disable      enable
```

If the breaker flashover protection is to be used with the generator breaker failure function of the relay, set **ENABLE** (enable phase element also for this application.)

```
50BF PICKUP NEUTRAL
 _________ Amps
```

Set the neutral pickup amps.

```
50BF INPUT INITIATE
 i6 i5 i4 i3 i2 i1
```

Designate the status inputs which will initiate the breaker failure timer. Inputs IN7–IN14 must be set using IPScom®.

```
50BF OUTPUT INITIATE
o8 o7 o6 o5 o4 o3 o2 o1
```

Designate the outputs that will initiate the breaker failure timer. Outputs OUT9–OUT23 must be set using IPScom.

```
50BF DELAY
 _________ Cycles
```

For generator breaker failure protection, the time delay should be set to allow for breaker operating time plus margin.

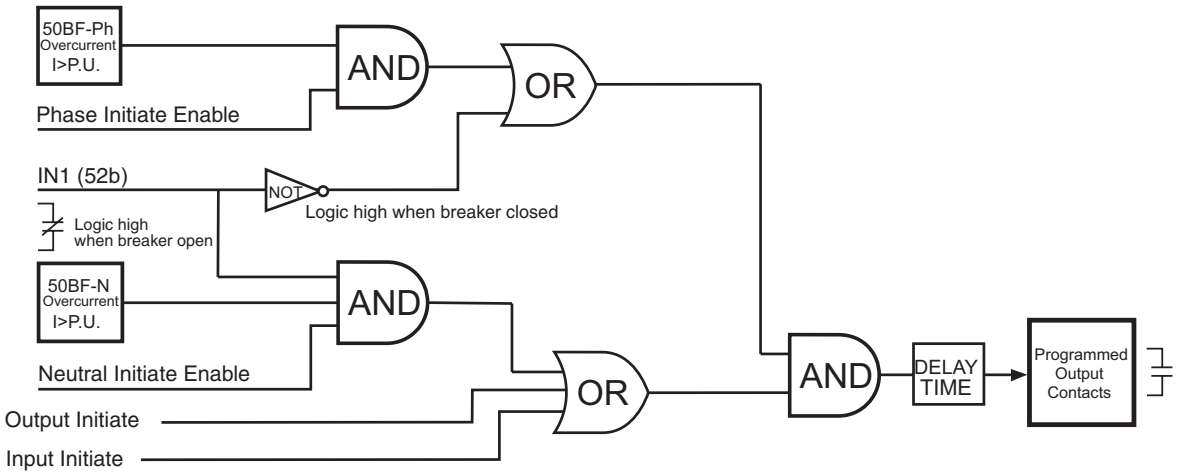


Figure 2-38 Breaker Failure Logic Diagram

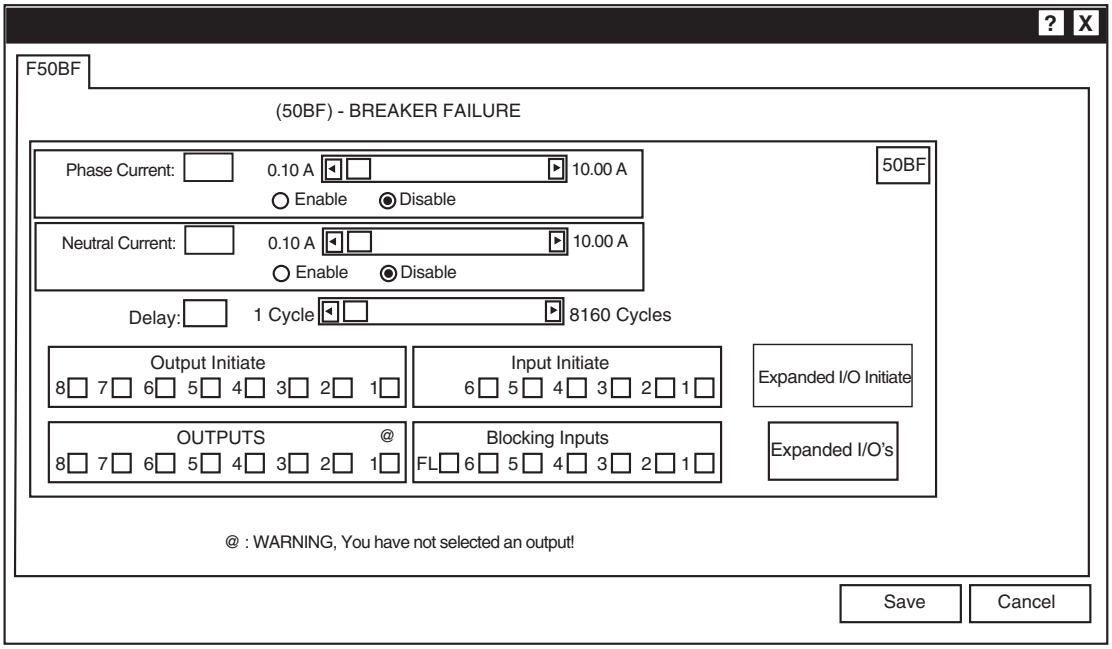


Figure 2-39 Breaker Failure (50BF) Setpoint Ranges

50DT Definite Time Overcurrent (for split-phase differential)

The Definite Time Overcurrent (50DT) function can be applied in two different configurations based on the CT connections. When CT configuration shown in Figure 2-5, One Line Functional Diagram is used, the 50DT function is used as a definite time phase overcurrent function to provide protection for external and internal faults in the generator. When the CTs are connected to measure the split phase differential current (shown in Figure 2-6, Alternative One Line Functional Diagram), the 50DT function can be used as a split-phase differential relay.

■ **NOTE**: When 50DT function is used for split-phase differential, 50BF, 87 and 87GD functions must be disabled.

Refer to Section 2.1, Configuration, Relay System Setup for a description of the 50DT Split-Phase Operate setting, and Section 2.2, System Diagrams.

In some cases, the generators may be run with a faulted turn shorted until the generator winding is repaired. To prevent mis-operation under these conditions, the pickup setting of the faulted phase should be set higher than the other phases. To accommodate this function, individual pickup settings are available for each phase. Ranges and increments are presented in Figure 2-40

```
50DT #1 PICKUP PHASE A
_________ Amps
```

```
50DT #1 PICKUP PHASE B
_________ Amps
```

```
50DT #1 PICKUP PHASE C
_________ Amps
```

```
50DT #1 DELAY
_________ Cycles
```

50DT #2 screens are identical to 50DT #1.

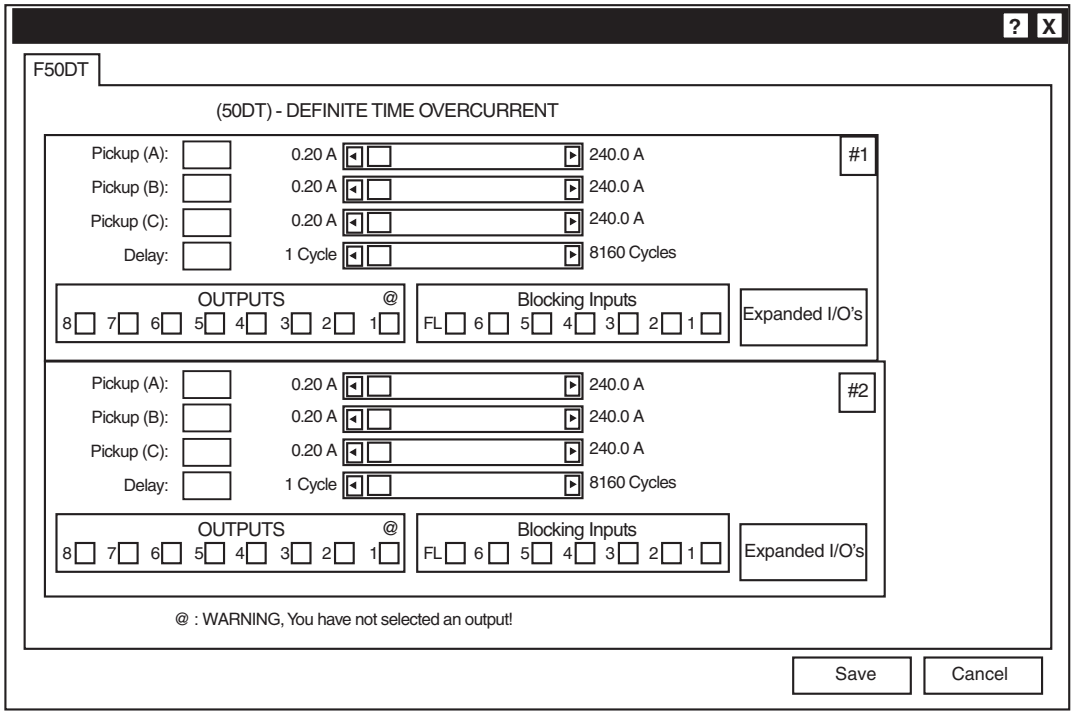


Figure 2-40 Definite Time Overcurrent (50DT) Setpoint Ranges

50/27 Inadvertent Energizing

The Inadvertent Energizing function (50/27) of the relay is an overcurrent function supervised by generator terminal bus voltage. Inadvertent or accidental energizing of off-line generators has occurred frequently enough to warrant the use of dedicated protection logic to detect this condition. Operating errors, breaker flashovers, control circuit malfunctions or a combination of these causes have resulted in generators being accidentally energized while off-line. The problem is particularly prevalent on large generators connected through a high voltage disconnect switch to either a ring bus or breaker-and-a-half bus configuration. When a generator is accidentally energized from the power system, it will accelerate like an induction motor. While the machine is accelerating, high currents induced into the rotor can cause significant damage in a matter of seconds. Voltage supervised overcurrent logic is designed to provide this protection. (See Figure 2-41, Inadvertent Energizing Function Logic Diagram)

An undervoltage element (all three phase voltages must be below pickup) with adjustable pickup and dropout time delay supervises instantaneous overcurrent tripping. The undervoltage detectors automatically arm the overcurrent tripping when the generator is taken off-line. This undervoltage detector will disable or disarm the overcurrent operation when the machine is put back in service. Ranges and increments are presented in Figure 2-42.

```
50/27 PICKUP
 _________ Amps
```

Typical pickup setting is 0.5 amps. No coordination is required with other protection since this function is only operational when the generator is off-line.

```
50/27 VOLTAGE CONTROL
 _________ Volts
```

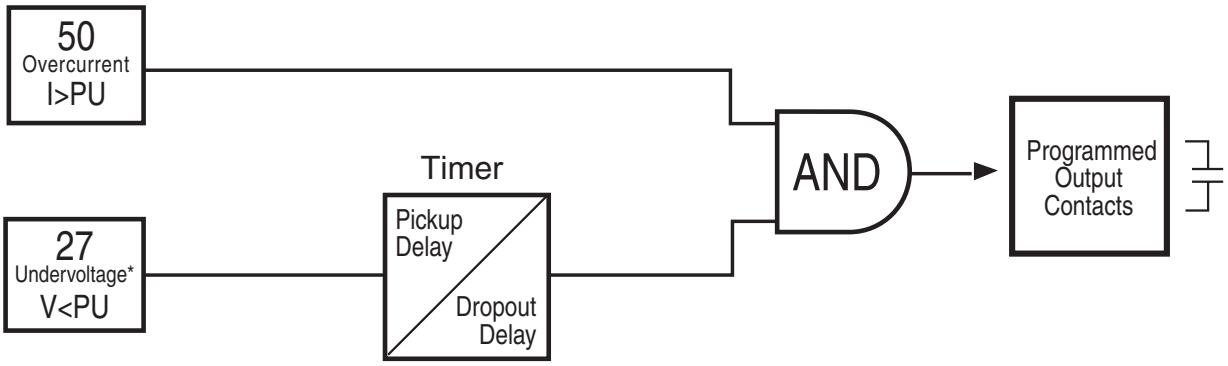
The purpose of the undervoltage detector is to determine whether the unit is connected to the system. The voltage level during this accidental energization depends on the system strength. Typical setting is 50%–70% of rated voltage (in some cases, it may be set as low as 20%.)

```
50/27 PICKUP DELAY
 _________ Cycles
```

The pickup time delay is the time for the undervoltage unit to operate to *arm* the protection. It must coordinate with other protection for conditions which cause low voltages (typically longer than 21 and 51V time delay settings.)

```
50/27 DROPOUT DELAY
 _________ Cycles
```

The dropout time delay is the time for the unit to operate to *disarm* the protection when the voltage is increased above the pickup value or the generator is brought on-line.



* On All Three Phases Simultaneously

Figure 2-41 Inadvertent Energizing Function Logic Diagram

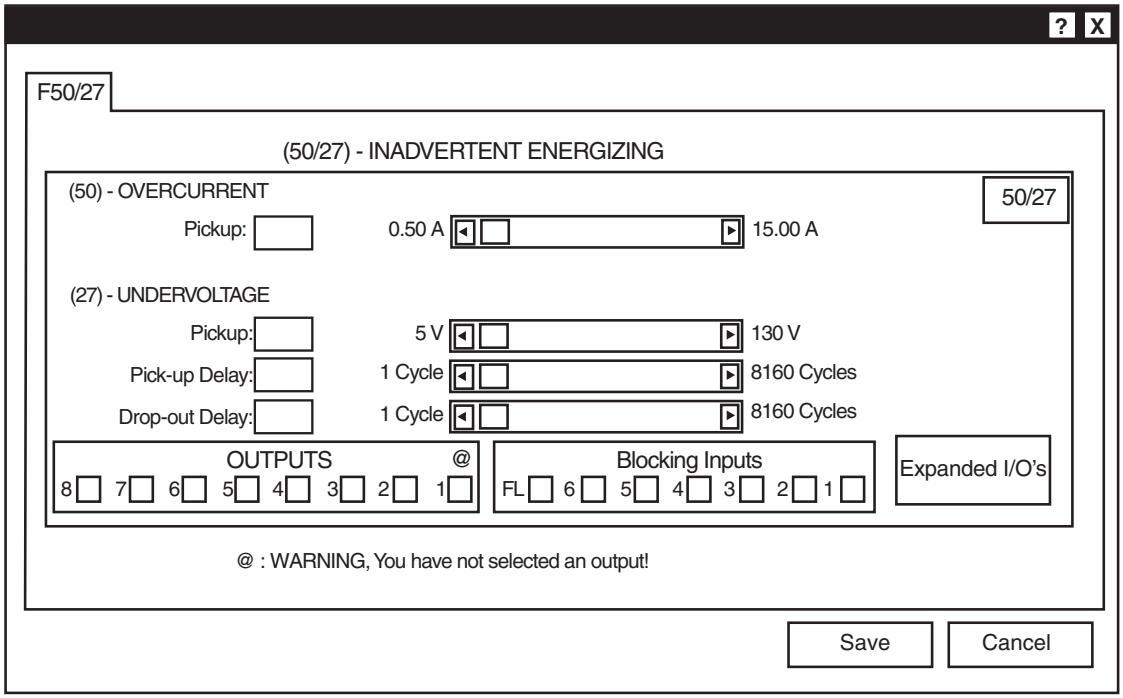


Figure 2-42 Inadvertent Energizing (50/27) Setpoint Ranges

51N Inverse Time Neutral Overcurrent

The Inverse Time Neutral Overcurrent function (51N) provides protection against ground faults. Since no zero sequence or ground current is usually present during normal operation, this function can be set for greater sensitivity than the phase overcurrent protection. If the 51N and 50N functions are not used at the generator neutral, they can be used to detect system ground faults by being energized by the step-up transformer neutral CTs. Ranges and increments are presented in Figure 2-43.

The curves available for use are shown in Appendix D, **Inverse Time Curves**. They cover a range from 1.5 to 20 times the pickup setting. An additional one cycle time delay should be added to these curves in order to obtain the relay operating time. Inverse time curves saturate beyond 20 times pickup. For currents in excess of 20 times pickup, operating times are fixed at the 20 times pickup level.

The function automatically selects fundamental RMS or total RMS calculation based on the input frequency. When the generator frequency is within ±5 Hz from the nominal frequency, it uses fundamental RMS calculation. Outside of this range, it uses total RMS calculation, which will provide protection during offline down to a frequency of 8 Hz.

```
51N PICKUP
_________ Amps
```

The relay current (I_R) is equal to the primary current (I_P) divided by the appropriate CT ratio. **$I_R = I_P \div$ CT ratio**

```
51N CURVE
bedef beinv bevinv →
```

Select one of the time curves shown in Appendix D, **Inverse Time Curves**. The appropriate curve in the selected family is designated here.

```
51N TIME DIAL
_________
```

Appropriate Time Dial for coordination with “downstream” relay protection chosen from the time curve above.

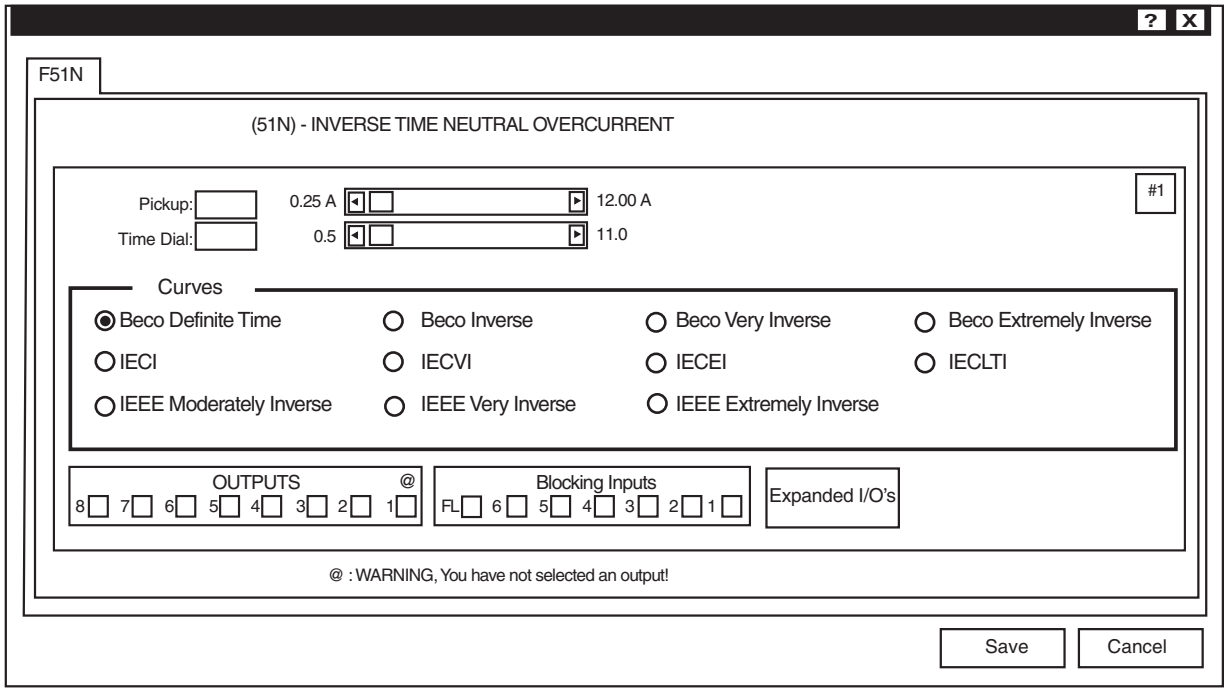


Figure 2-43 Inverse Time Neutral Overcurrent (51N) Setpoint Ranges

51V Inverse Time Phase Overcurrent with Voltage Control/Restraint

Time-overcurrent relays, one per phase, are used to trip circuits selectively and to time-coordinate with other up- or downstream relays. For this function, eight complete series of inverse time tripping characteristics are included. The same descriptions and nomenclature which are traditionally used with electromechanical relays are used in the relay. Thus, user may choose from four BECO curves (BEDEF, BEINV, BEVINV, and BEEINV), four IEC curves (IECI, IECVI, IECEI, and IECLT), and three IEEE curves (MINV, VINV, EINV.) Within each family, the operator selects time dial setting and pickup (tap) setting, just as with electromechanical relays. Ranges and increments are presented in Figure 2-45.

The curves available for use are shown in Appendix D, **Inverse Time Curves**. They cover a range from 1.5 to 20 times the pickup setting. An additional one cycle time delay should be added to these curves in order to obtain the relay operating time. Inverse time curves saturate beyond 20 times pickup. For currents in excess of 20 times pickup, operating times are fixed at the 20 time pickup level. The particular settings will be made by information from short-circuit fault studies and knowledge of the coordination requirements with other devices in the system that respond to time overcurrent.

51V is a true three-phase function, in that the relay incorporates separate integrating timers on each phase.

The inverse time overcurrent function can be voltage controlled (VC), voltage restrained (VR), or neither. For voltage-controlled operation, the function is not active unless the voltage is below the voltage control setpoint. This philosophy is used to confirm that the overcurrent is due to system fault. When applied, most users will set voltage control limits in the range of 0.7 to 0.9 per unit RMS voltage. When voltage restraint is selected (See Figure 2-44, Voltage Restraint (51VR) Characteristic), the pickup setting is continuously modified in proportion to the collapsing terminal voltage. The voltage restraint function is well-suited to small generators with relatively short time constants.

■ **NOTE**: *The 51V function should be blocked by fuse loss if in the voltage control mode only. Fuse loss blocking is not desirable for voltage restraint mode because the pickup is automatically held at 100% pickup during fuse loss conditions, and operation will continue as normal.*

The internally derived voltage used to realize the voltage control or restraint feature depends on the configured VT configuration and the Delta-Y Transform setting (see Section 2.1, Configuration, Relay System Setup). Table 2-4, Delta/Wye Transformer Voltage-Current Pairs describes the calculation for the various system VT configurations.

```
51V PICKUP
 _________ Amps
```

The pickup of the 51V is set in relay amps.
(Relay amps = primary amps ÷ CT ratio)

```
51V CURVE
bedef beinv bevinv →
```

Selects one of the time curves as shown in Appendix D, **Inverse Time Curves**. The appropriate curve in the selected family of curves is designated here.

```
51V TIME DIAL
 _________
```

```
51V VOLTAGE CONTROL
disable V_CNTL v_rstrnt
```

```
51V VOLTAGE CONTROL
 _________ Volts
```

Disable if neither voltage control nor voltage restraint is desired. If voltage restraint is designated, the tap setting is modified as shown in Figure 2-43. If voltage control is designated, the 51V will only operate when the voltage is less than the 51V voltage control setting specified below. When applied, the voltage control is usually set in the range of 70% to 90% of the nominal voltage.

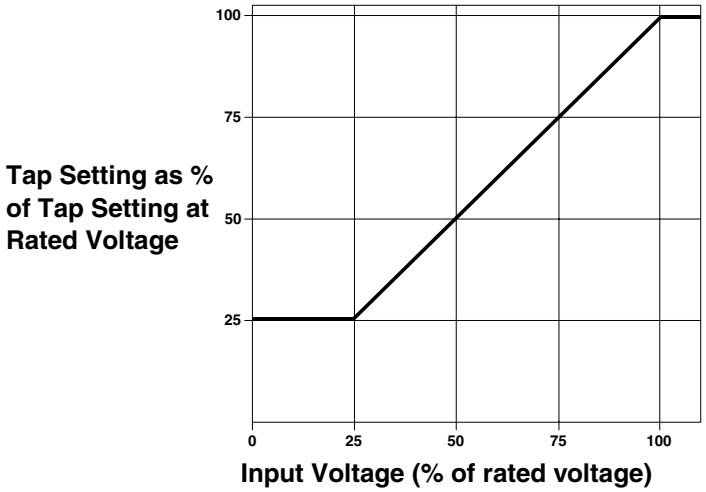


Figure 2-44 Voltage Restraint (51VR) Characteristic

Generator Directly Connected			Generator Connected Through Delta AB/Wye or Delta AC/Wye Transformer		
Current	Voltage Control or Restraint		Current	Voltage Control or Restraint	
	L-G	L-L or L-G to L-L		L-G	L-L or L-G to L-L
I_a	$(V_A - V_C)/\sqrt{3}$	V_{AB}	I_a	V_A	$(V_{AB} - V_{CA})/\sqrt{3}$
I_b	$(V_B - V_A)/\sqrt{3}$	V_{BC}	I_b	V_B	$(V_{BC} - V_{AB})/\sqrt{3}$
I_c	$(V_C - V_B)/\sqrt{3}$	V_{CA}	I_c	V_C	$(V_{CA} - V_{BC})/\sqrt{3}$

Table 2-4 Delta/Wye Transformer Voltage-Current Pairs

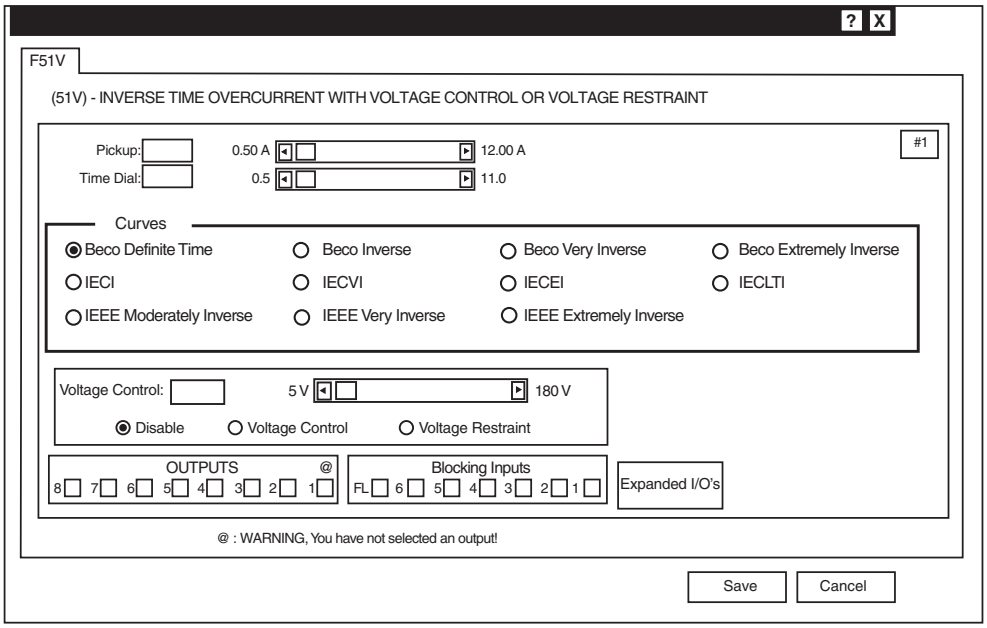


Figure 2-45 Inverse Time Overcurrent with Voltage Control/Voltage Restraint (51VC/VR) Setpoint Ranges

59 Phase Overvoltage

The Phase Overvoltage function (59) may be used to provide overvoltage protection for the generator. The relay provides overvoltage protection functions with three voltage levels and three definite-time setpoints, any one or more of which can be programmed to trip the unit or send an alarm. This is a true 3-phase function in that each phase has an independent timing element.

The 59 function can be programmed to use phase voltage (any one of the three phases) or positive sequence voltage as input.

Magnitude measurement depends on the 59/27 Magnitude Select setting (See Section 2.1, Configuration, Relay System Setup). When the RMS option is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and the accuracy of the time delay is +20 cycles. If DFT option is selected, the magnitude calculation is accurate near 50 or 60 Hz, and the timer accuracy is ± 1 cycle. When the input voltage select is set to positive sequence voltage, the 59 functions uses DFT to measure the positive sequence voltage, irrespective of DFT/RMS selection. Ranges and increments are presented in Figure 2-46.

```
59 #1 INPUT VOLTAGE SEL.
phase_volt pos_seq_volt
```

```
59 #1 PICKUP
 _______ Volts
```

```
59 #1 DELAY
 _______ Cycles
```

Generator capability is generally 105% of rated voltage.

59 #2 and 59 #3 screens are identical to 59 #1.

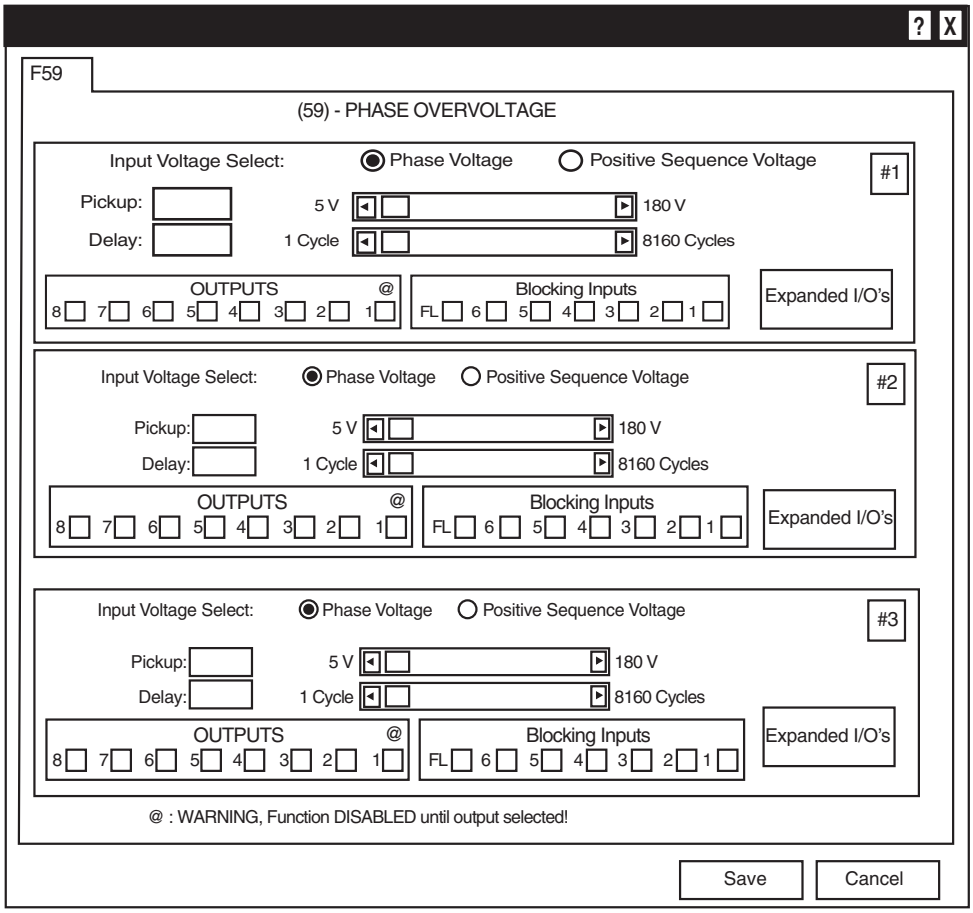


Figure 2-46 Phase Overvoltage (59) Setpoint Ranges

59D Third Harmonic Voltage Differential (Ratio)

This scheme, when used in conjunction with 59N function may provide 100% Stator Ground fault protection.

Figure 2-47 illustrates a third harmonic voltage differential scheme. This scheme compares the third harmonic voltage appearing at the neutral to that which appears at the generator terminals. The ratio of these third harmonic voltages is relatively constant for all load conditions. A stator phase-to-ground fault will disrupt this balance, causing operation of the differential relay (see Figure 2-20). The generator terminal voltage (Line Side Voltage) can be selected as $3V_0$ (Calculated by the relay from V_A, V_B and V_C) or V_X (broken delta VT input connected at the V_X input.) Positive sequence undervoltage blocking will prevent the function from misoperating when the generator is offline (the terminal voltage is below the set value).

```
59D RATIO
 ________
```

The ratio (or third harmonic) voltage measured at the generator terminals to the third harmonic voltage measured at neutral. This setting requires field measurements of third-harmonic voltage. Take measurements at various loadings and use smallest ratio:

$$\frac{V_{3N}}{V_{3X}} = \text{Ratio}$$

Ratio/2 = Setpoint (50% margin)

```
59D LINE SIDE VOLTAGE
3v0  VX
```

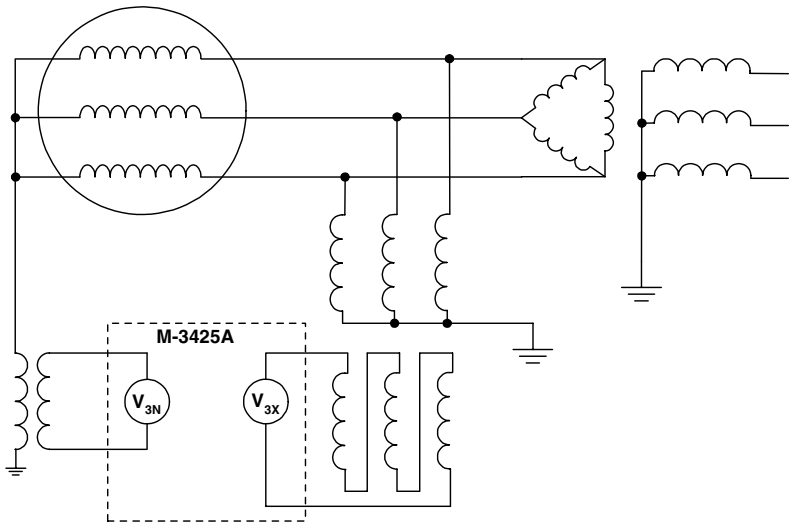
Selection of V_X will give better accuracy and sensitivity than $3V_0$. If $3V_0$ is selected, VT configuration must be set to Line-Ground. If the nominal third harmonic voltage is <1 V, $3V_0$ line side voltage selection is not recommended, because noise in the $3V_0$ and V_N can cause 59D misoperation.

```
59D POS SEQ VOLT BLK
disable  ENABLE
```

This setting is typically enabled.

```
59D POS SEQ VOLT BLK
 ________ Volts
```

```
59D DELAY
 ________ Cycles
```



The ratio $\frac{V_{3x}}{V_{3N}}$ > Pickup

Where: V_{3x} is the Third Harmonic Triple Zero Sequence voltage measured at the generator terminals.

V_{3N} is the Third Harmonic voltage measure at the neutral.

Figure 2-47 Third Harmonic Voltage Differential (Ratio) Scheme for Generator Ground Fault Protection

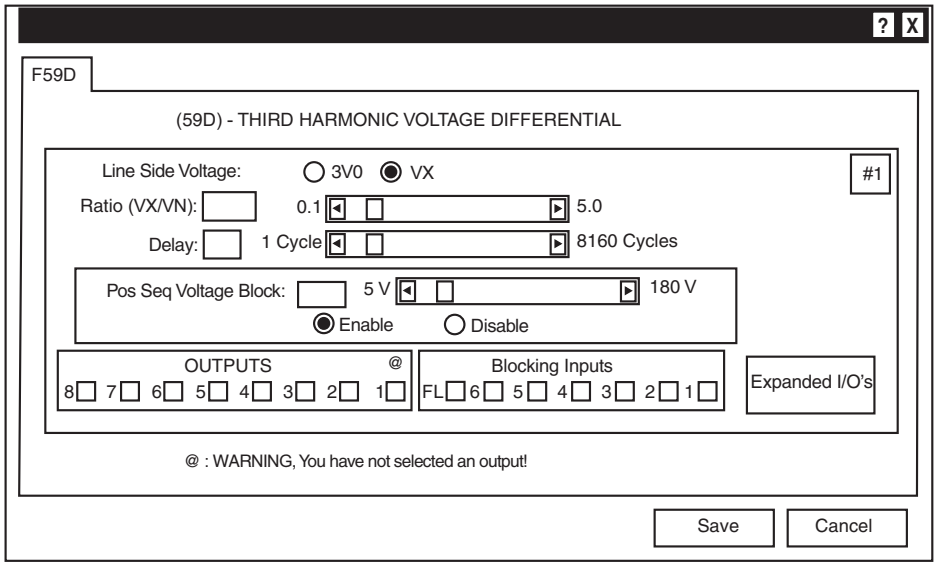


Figure 2-48 Third Harmonic Voltage Differential (59D) Setpoint Ranges

59N Overvoltage, Neutral Circuit or Zero Sequence

The Neutral Overvoltage function (59N) provides stator ground fault protection for high impedance grounded generators. The 59N function can provide ground fault protection for 90–95% of the stator winding (measured from the terminal end).

The 59N function provides three setpoints, and responds only to the fundamental frequency component, rejecting all other harmonic components. Ranges and increments are presented in Figure 2-50.

```
59N #1 PICKUP
 ________ Volts
```

With typical grounding transformer ratios and a typical minimum setting of 5 volts, this protection is capable of detecting ground faults in about 95% of the generator stator winding from the terminal end.

```
59N #1 DELAY
 ________ Cycles
```

If grounded-wye/grounded-wye VTs are connected at the machine terminals, the voltage relay must be time coordinated with VT fuses for faults on the transformer secondary winding. If relay time delay for coordination is not acceptable, the coordination problem can be alleviated by grounding one of the secondary phase conductors instead of the secondary neutral. When this technique is used, the coordination problem still exists for ground faults on the secondary neutral conductor. Thus, its usefulness is limited to those applications where the exposure to ground faults on the secondary neutral is small.

```
59N 20HZ INJECTION MODE
disable ENABLE
```

Since system ground faults can induce zero sequence voltages at the generator due to transformer capacitance coupling, this relay must coordinate with the system ground fault relaying. It is possible to set 59N#1, 59N#2, and 59N#3 to coordinate with the PT secondary fuses, and also coordinate with worst case capacitive coupling interference voltage from system ground faults (high side of the GSU).)

59N #2 and 59N #3 screens are identical to 59N #1.

For applications where the M-3425A relay (where the 64S function is purchased or not) is used with 100% Stator Ground protection with 20 Hz injection schemes, the 59N 20 Hz injection mode must be enabled in order to calculate the voltage magnitude accurately for the 59N function, due to the 20 Hz injection voltage. The time delay accuracy of the function is –1 to +5 cycles when the 20 Hz injection mode is enabled.

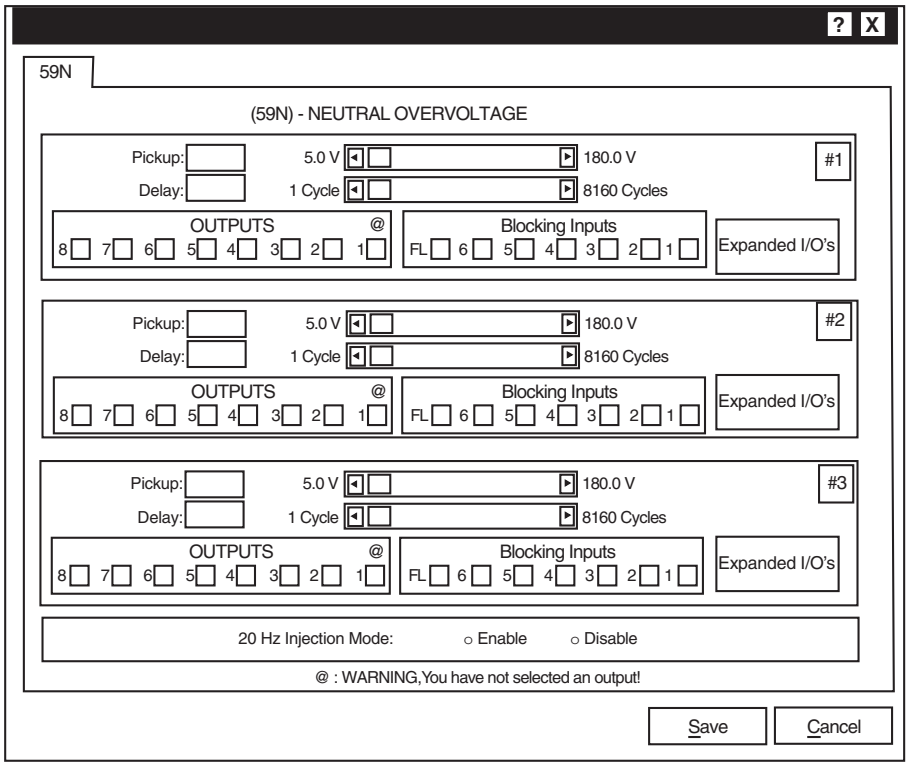


Figure 2-49 Overvoltage, Neutral Circuit or Zero Sequence (59N) Setpoint Ranges

59X Multipurpose Overvoltage (Turn-to-Turn Stator Fault Protection or Bus Ground Protection)

For generators where the stator-winding configuration does not allow the application of split-phase differential, a neutral voltage method can be used to detect turn-to-turn stator winding faults. Figure 2-50 illustrates this method. Three VTs are connected in wye and the primary ground lead is tied to the generator neutral. The secondary is connected in a "broken delta" with an overvoltage relay connected across its open delta to measure $3V_0$ voltage. In High Impedance grounded generators, connecting the primary ground lead to the generator neutral, makes this element insensitive to stator ground faults. The relay will, however, operate for turn-to-turn faults, which increase the $3V_0$ voltage above low normal levels. Installation requires the cable from the neutral of the VT to generator neutral be insulated for the system line-to-ground voltage and the relay to be tuned to fundamental (60/50 Hz) frequency components of the voltage since some third-harmonic frequency component of the voltage will be present across the broken delta VT input.

Alternatively, this function can be used to detect bus ground faults, when connected as shown in Figure 2-10.

```
59X #1 PICKUP
 ________ Volts
```

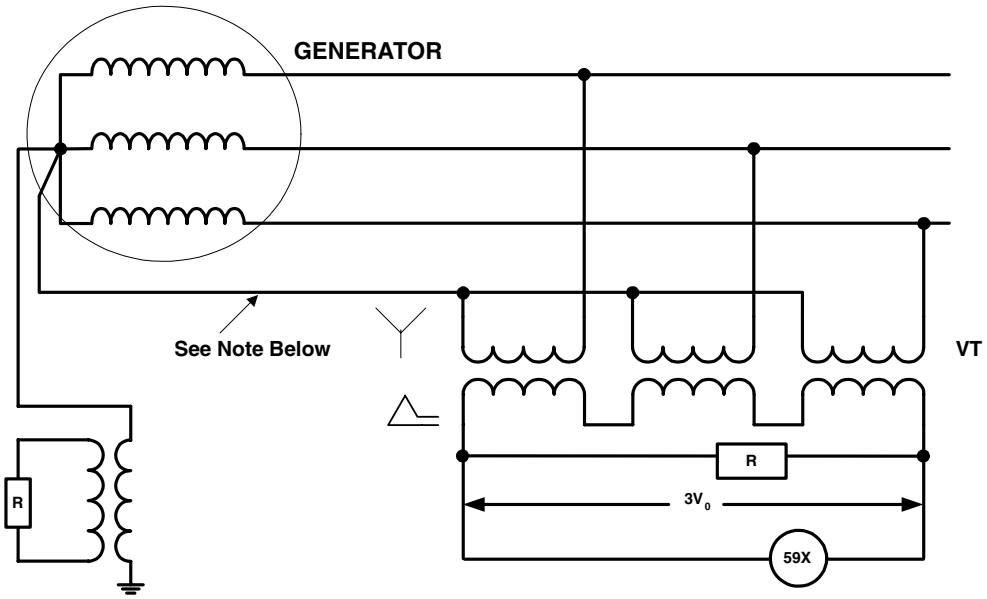
When used for Turn-to-Turn fault protection the pickup should be set above the normal zero sequence voltage level. Typically the pickup is set to 5 V.

When used for Bus Ground protection it is again set above the normal zero sequence voltage seen at the bus. Typical setting is between 10 and 20 Volts to provide sensitive protection.

```
59X #1 DELAY
 ________ Cycles
```

The Time Delay for Turn-to-Turn faults should be set to approximately 5 cycles. For bus ground fault protection application the time delay should coordinate with other ground fault relaying and VT fuses.

59X #2 screens are identical to 59X #1.



■ **NOTE**: Installation requires the cable from the neutral of the VT to generator neutral be insulated for the system line-to-ground voltage.

Figure 2-50 Turn-to-Turn Stator Winding Fault Protection

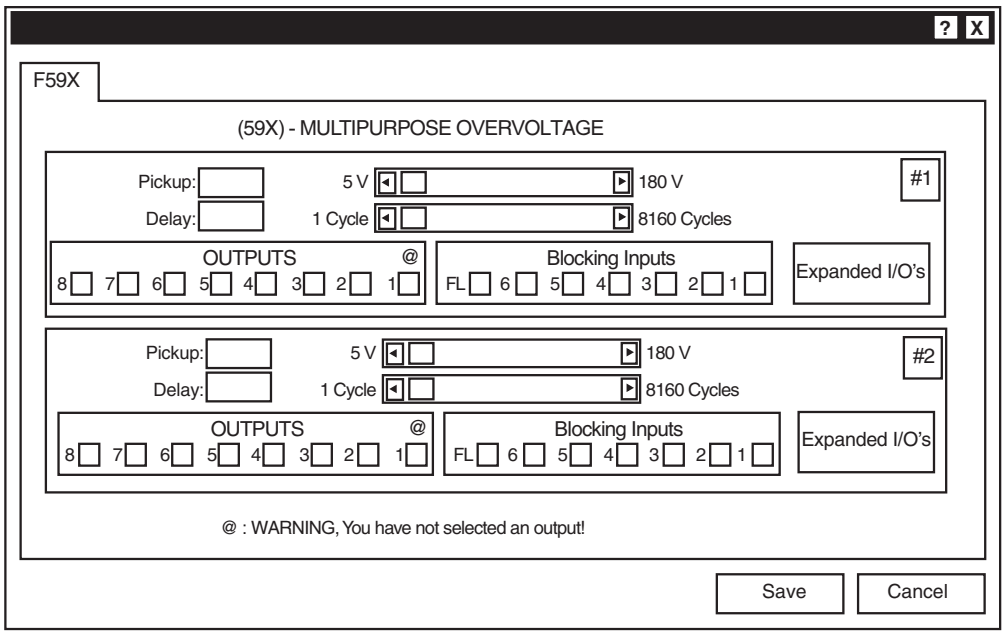


Figure 2-51 (59X) Multi-purpose Overvoltage Setpoint Ranges

60FL VT Fuse Loss

Some functions may operate inadvertently when a VT fuse is blown or an event causes a loss of one, two, or all three potentials to the relay. Provisions are incorporated for both internal and external potential loss detection and blocking of user defined functions. The logic scheme and options are illustrated in Figure 2-52.

Internal Fuse Loss Detection Logic

The internal logic scheme available will detect a loss of one, two, and all three potentials.

For the loss of one or two potentials, positive and negative sequence quantities are compared. The presence of negative sequence voltage in the absence of negative sequence current is considered to be a fuse loss condition. An additional supervising condition includes a minimum positive sequence voltage to assure voltage is being applied to the relay.

For the loss of all three phase potentials, a comparison of the three phase voltages is made to the three phase currents. If all three potentials are under 0.05 V_{nom}, and all three currents are below 1.25 I_{nom} combined with I_1 > 0.33A, a three phase potential loss is declared. A seal in circuit is provided to ensure a three phase fuse loss condition is not declared during a three phase fault if the fault current decays below the 1.25 I_{nom} pickup setting.

Protection functions in the relay may be blocked by an assertion of the fuse failure logic (FL), in each function's respective setting screen. Typical functions to block on a loss of potential event are 21, 27, 32, 40, 51V (for Voltage Control only), 67, 67N, 78 and 81.

The 60FL function does not have to be enabled in order to use the FL as a blocking input in the relay configuration menu.

External Fuse-Loss Function

For the specific application where the preceding logic cannot be considered reliable (such as when current inputs to the relay are not connected, or sustained positive sequence current during fault conditions is minimal), an external fuse failure function can be used as an input to the relay. The external 60 FL Function contact is connected across any control/status input. The relay protection functions are then blocked by an assertion of the control/status input (INx), as a blocking function in each function's respective setting screen.

60FL VT Fuse Loss Alarm Function

The 60FL alarm function is enabled by the internal logic by selecting the "FL" option in the 60 FL function setup screen. It is enable by the external logic by selecting the appropriate control/status input (INx) in the 60FL function setup screen.

A timer associated with the fuse loss alarm logic is available. This timer is to assure proper coordination for conditions that may appear as a fuse loss, such as secondary VT circuit faults that will be cleared by local low voltage circuit action (fuses or circuit breakers). Ranges and increments are presented in Figure 2-53.

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

```
60FL 3 PHASE DETECT
disable  enable
```

The initiating control/status inputs are user-designated. The closing of any of the externally connected contacts (across these inputs) will start the associated time delay to the 60FL function operation. In order to use internal fuse loss logic for 60FL function, "FL" must be checked. Externally initiated fuse loss detection may be input to other status inputs. Inputs IN7–IN14 must be set using IPScom®.

```
60FL DELAY
________ Cycles
```

The time delay is set to coordinate for conditions which may appear as a fuse loss but will be corrected by other protection (such as a secondary VT circuit fault which will be cleared by local low voltage circuit action). This delay does not affect internal FL blocking option.

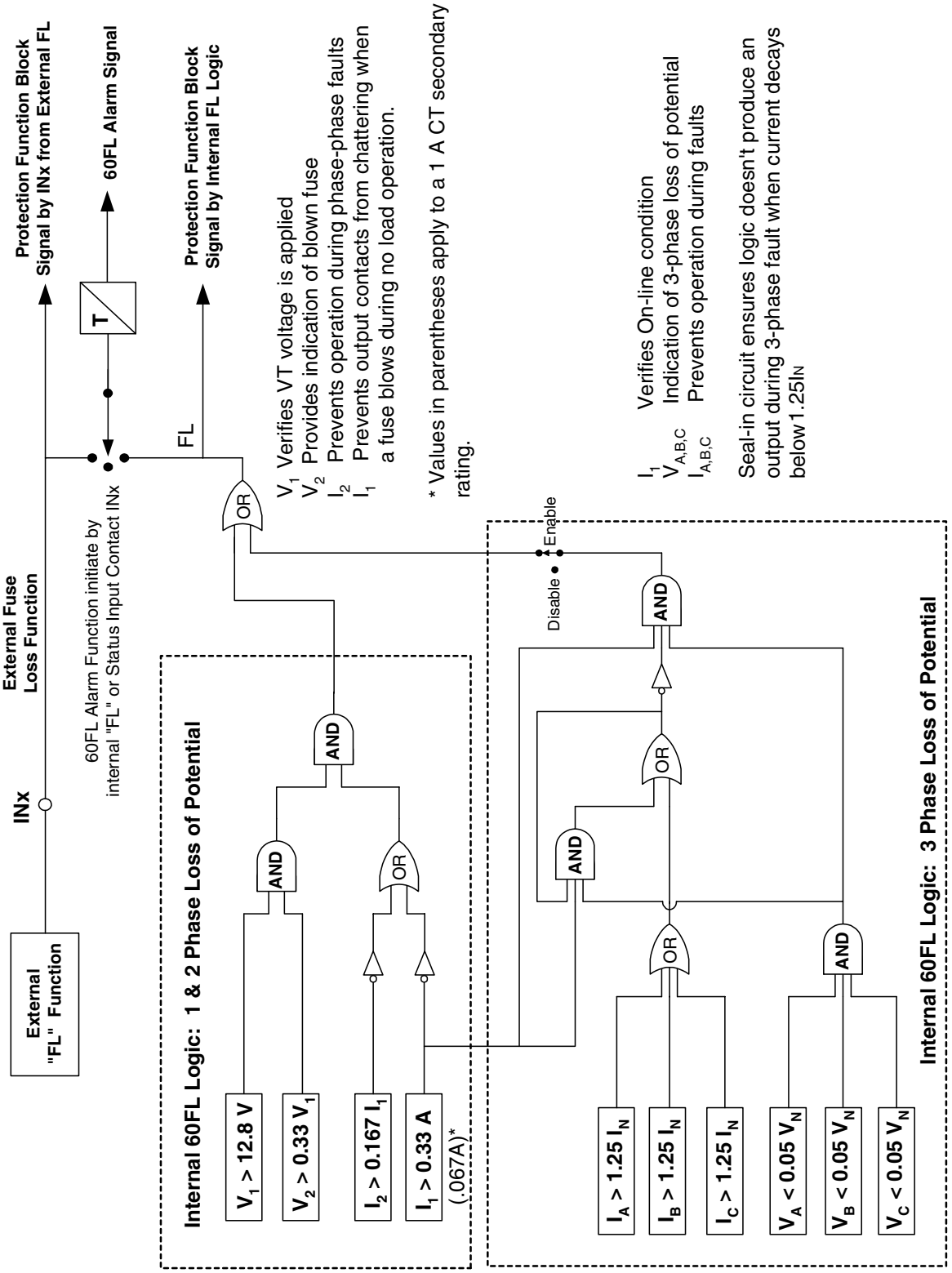


Figure 2-52 Fuse Loss (60FL) Function Logic

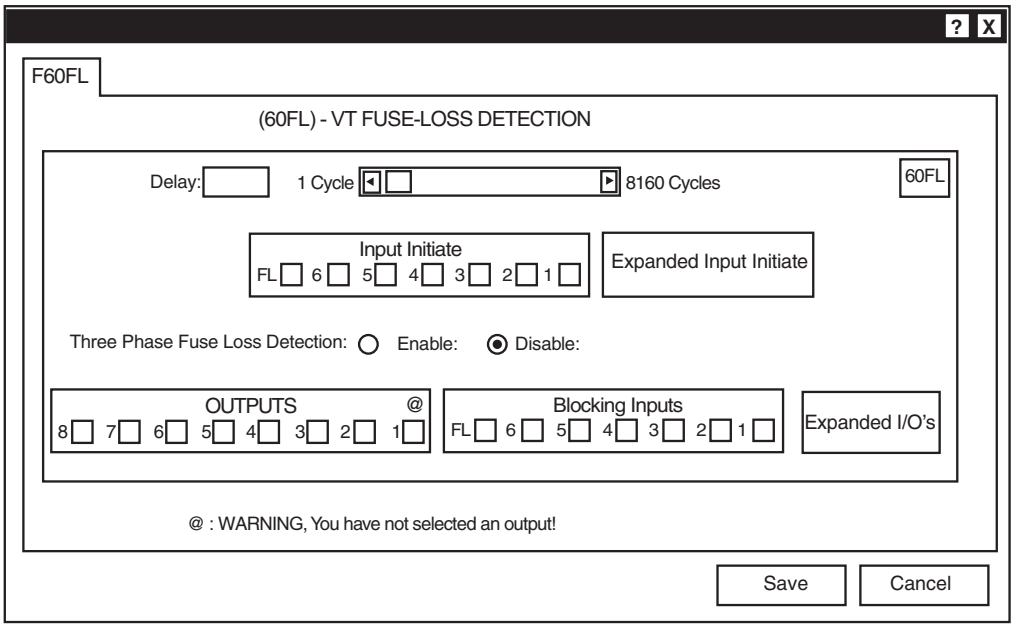


Figure 2-53 Fuse Loss (60FL) Setpoint Ranges

64B/F Field Ground Protection
64F Field Ground Detection

A typical connection diagram for Field Ground Protection is given in Figure 2-54. This function requires the connection of an external coupler (M-3921). To improve accuracy and minimize the effects of stray capacitance, the M-3921 Field Ground Coupler should be mounted close to the exciter. Connections from the coupler to the relay should use low capacitance shielded cable, and be as short as possible. Cable shield should be terminated at the relay end to the Relay Ground Stud (See Figure 5-9, External Connections). If cabling between the coupler and relay exceeds 100 feet, provisions should be made for in circuit calibration to nullify the effects of cabling capacitance. See Section 6.4, Auto Calibration, for calibration procedure.

The Field Ground function provides detection of insulation breakdown between the excitation field winding and the ground. There are two pickup and time delay settings, and one adjustable injection frequency setting for the 64F function. The adjustable frequency is provided to compensate for the amount of capacitance across the field winding and the ground so that the function accuracy is improved. Ranges and increments are presented in Figure 2-55.

```
64F #1 PICKUP
  _______ kOhm

64F #1 DELAY
  _______ Cycles

64F #2 PICKUP
  _______ kOhm

64F #2 DELAY
  _______ Cycles
```

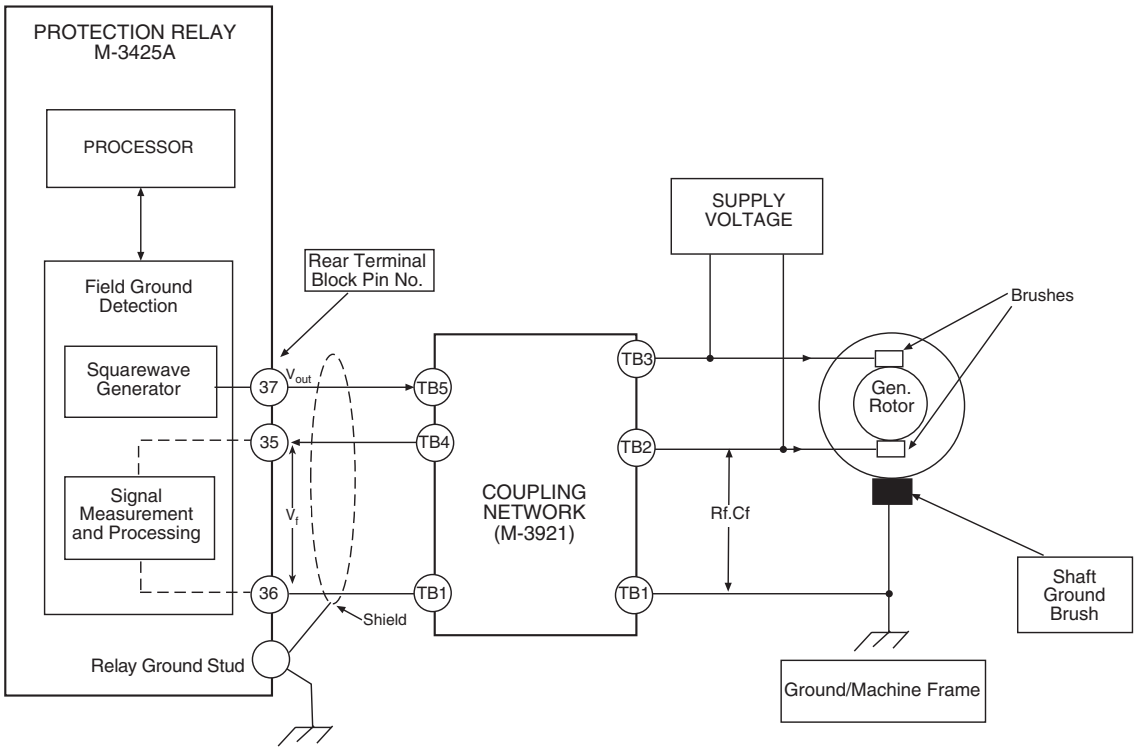


Figure 2-54 M-3921 Field Ground Coupler

The following Table gives typical frequency settings based on the rotor capacitance. The rotor capacitance can be measured with a capacitance meter by connecting the meter across the field winding to ground.

WARNING: Machine should be off-line and field excitation should be off during the capacitance measurement.

NOTE: Field breaker should be closed for the capacitance measurements.

Field Winding to Ground Capacitance	Typical Frequency Setting
1 to 2 µF	0.52 Hz
2 to 3 µF	0.49 Hz
3 to 4 µF	0.46 Hz
4 to 5 µF	0.43 Hz
5 to 6 µF	0.39 Hz
6 to 7 µF	0.35 Hz
7 to 8 µF	0.32 Hz
8 to 9 µF	0.30 Hz
9 to 10 µF	0.28 Hz
>10 µF	0.26 Hz

Table 2-5 Typical Frequency Settings

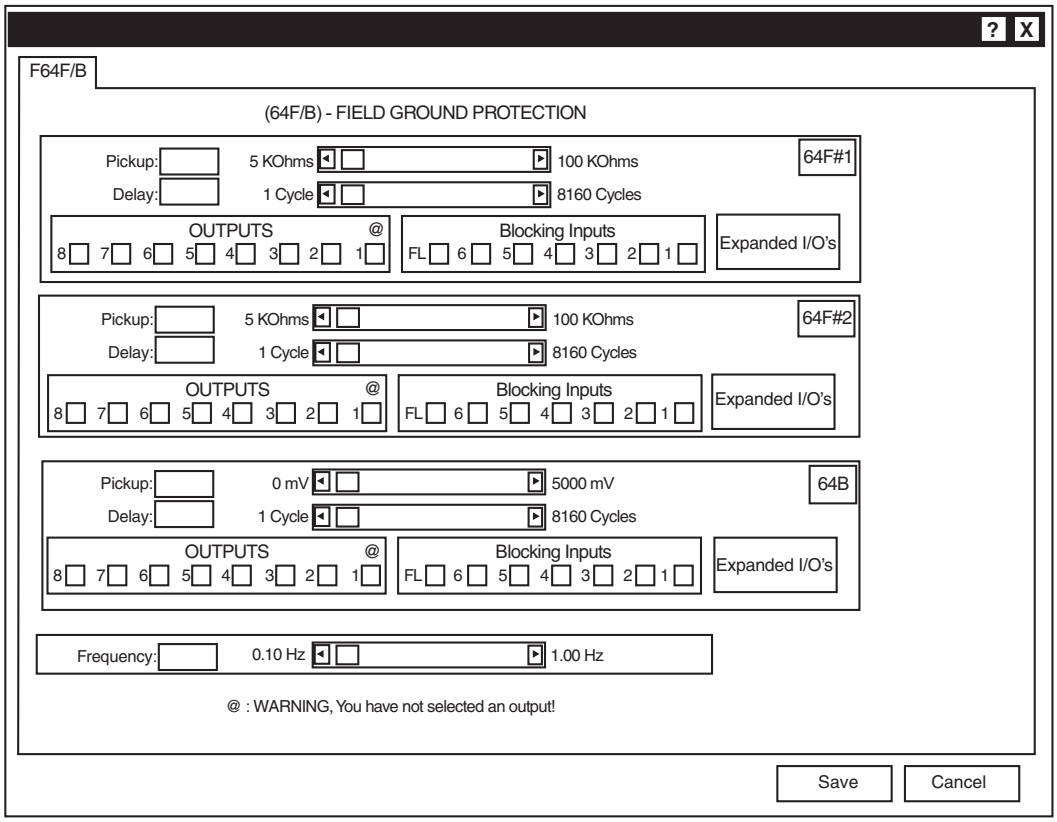


Figure 2-55 Field Ground Protection (64B/F) Setpoint Ranges

64B Brush Lift-Off Detection

Brush Lift-Off Detection (64B) provides detection of open brushes of the rotor shaft. This function works in conjunction with the 64F Field Ground Detection function, and requires the M-3921 Field Ground Coupler.

When 64B operates, indicating open brush conditions, the 64F Function cannot detect a field ground. For most generators, when the brushes of the rotor shaft are lifted, the capacitance across the field winding and the ground significantly reduces to less than 0.15 μF. The 64B Function analyzes this capacitance-related signal, and initiates an output contact when it detects an open brush condition. Typically, this output is used to alert operating personnel of an open brush condition. Ranges and increments are presented in Figure 2-58. The typical pickup setting is listed in Table 2-6, Typical Brush Lift-Off Pickup Settings.

In order to assure correct setting, it is recommended that the actual operating value be predetermined during the final stage of the relay installation. By introducing a brush-open condition, the actual value can be easily obtained from the relay. The following procedure can be used to obtain the actual operating value of the 64B during an open brush condition:

● **WARNING: Machine should be off-line and field excitation should be off during the capacitance measurement.**

■ **NOTE**: Field breaker should be closed for the capacitance measurements.

1. After installation has been completed, determine the rotor capacitance, as outlined for the 64F function.
2. With the machine still off-line, apply power to the relay and set the 64B/F operating frequency in accordance with the value listed in Table 2-5, Typical Frequency Settings.
3. Introduce a brush-open condition by disconnecting the rotor brushes or lifting the brushes from their ground. Observe the 64B voltage value displayed by IPScom or the relay. The displayed value is the actual measured operating value of the 64B function.
4. To ensure correct operation and prevent erroneous trips, the Pickup Setting for the 64B Lift-off condition should be set at 80–90% of the actual operating value.

The 64B/F Frequency is a shared setting common to both the 64B and 64F Functions. If either function is enabled, this setpoint is available, and should be set to compensate for the amount of capacitance across the field winding and ground, so that the measurement accuracy is improved.

```
64B PICKUP
 _________ mV
```

```
64B DELAY
 _________ cycles
```

```
64B/F FREQUENCY
 _________ Hz
```

To minimize measurement errors, the 64B/F frequency should be set according to the amount of capacitance across the field winding and the ground. Table 2-5 includes typical settings of the frequency for capacitance, ranging from 1 μF to 10 μF.

Equivalent Brush Lift-Off Capacitance	Typical Brush Lift-Off Pickup Setting
0.05~0.25 μF	2500 mV

Table 2-6 Typical Brush Lift-Off Pickup Setting

64S 100% Stator Ground Protection by Low Frequency Signal Injection

■ **NOTE**: The Stator Ground Protection function (64S) must be selected when the M-3425A is initially ordered.

The 100% stator ground fault protection is provided by injecting an external 20 Hz signal into the neutral of the generator. The protection is provided when the machine is on-line as well as off-line (provided that the 20 Hz generator and relay are powered on.) This scheme requires the following external components in addition to M-3425A protection system:

- 20 Hz Signal-generator (BECO Part No. 430-00426)
- Band-pass filter. (BECO Part No. 430-00427)
- 20 Hz Measuring Current Transformer, 400/5 A CT (BECO Part No. 430-00428)

The voltage signal generated by the 20 Hz signal-generator is injected into the secondary of the generator neutral grounding transformer through a band-pass filter. The band-pass filter passes the 20 Hz signal and rejects out-of-band signals. The output of the 20 Hz band-pass filter is connected to the V_N input of the M-3425A relay through a suitable voltage divider, that limits the M-3425A to ≦ 200 V ac (the voltage generator may be bypassed if the expected 50/60 Hz voltage during a phase-to-ground fault of the generator is ≦ 200 V.) The 20Hz current is also connected to the I_N input of the M-3425A, through the 20Hz current transformer.

```
64S PICKUP
      mAmps
```

```
64S VOLT INHIBIT
disable  ENABLE
```

```
64S VOLT INHIBIT
 ________ Volts
```

```
64S DELAY
 ________ Cycles
```

The expected 20 Hz current during no fault condition is given by:

$$I_{NF} = \frac{V_{20} \bullet N^2}{X_{CS}}$$

Where V20 is the 20 Hz voltage measured across the load resistor RL and X_{CS} is the capacitive reactance of the gnereator stator winding and unit transformer referred to the grounding transformer secondary. N is the turn ratio of the grounded transformer. The pickup setting should be based on the required insulation resistance setting. In order to detect a fault of 5,000 Ohms on the generator stator, the pickup current should be set at:

$$I_{PICKUP} = \frac{\left(\frac{V_{20} \bullet N^2}{\sqrt{5000^2 + X_{CS}{}^2}} \right)}{\text{20 Hz CT Ratio}}$$

When the generator is operating normally (no ground fault) only a small amount of 20 Hz current will flow as a result of the stator capacitance to ground. When a ground fault occurs anywhere on the generator stator windings the 20 Hz current will increase. The 64S function will issue a trip signal after a set time delay when the measured 20 Hz current exceeds the pickup current as illustrated in Figure 2-57.

The 64S protection can be blocked by Undervoltage Inhibit. If the 20 Hz voltage (nominal 25 V) is less than the Undervoltage Inhibit setting (and Undervoltage Inhibit is enabled), the 64S function will be blocked. For cases where the Load Resistor (RL) is small, the Undervoltage Inhibit should not be enabled, as the voltage will be small.

The 59N function (90 to 95%) should also be used in conjunction with 64S protection to provide backup.

▲ **CAUTION:** Dangerous high voltages may be present at the generator terminals if the 20 Hz injection voltage is not removed when the generator is taken out of service.

If the 20 Hz injection voltage generator receives power from the generator terminal voltage, then the 20 Hz injection voltage generator will be automatically switched off whenever the generator terminal voltage is not present.

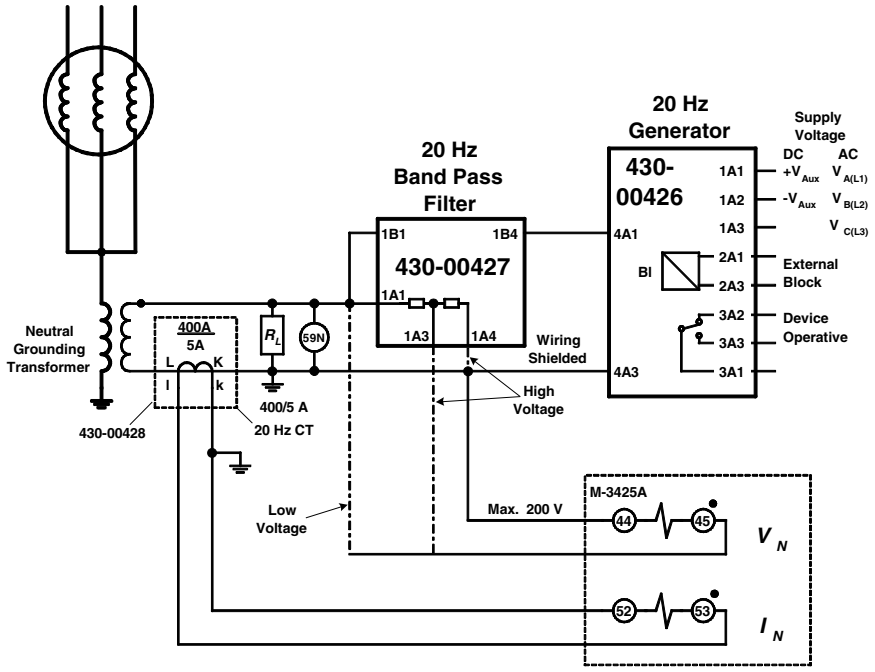


Figure 2-56 64S Function Component Connection Diagram

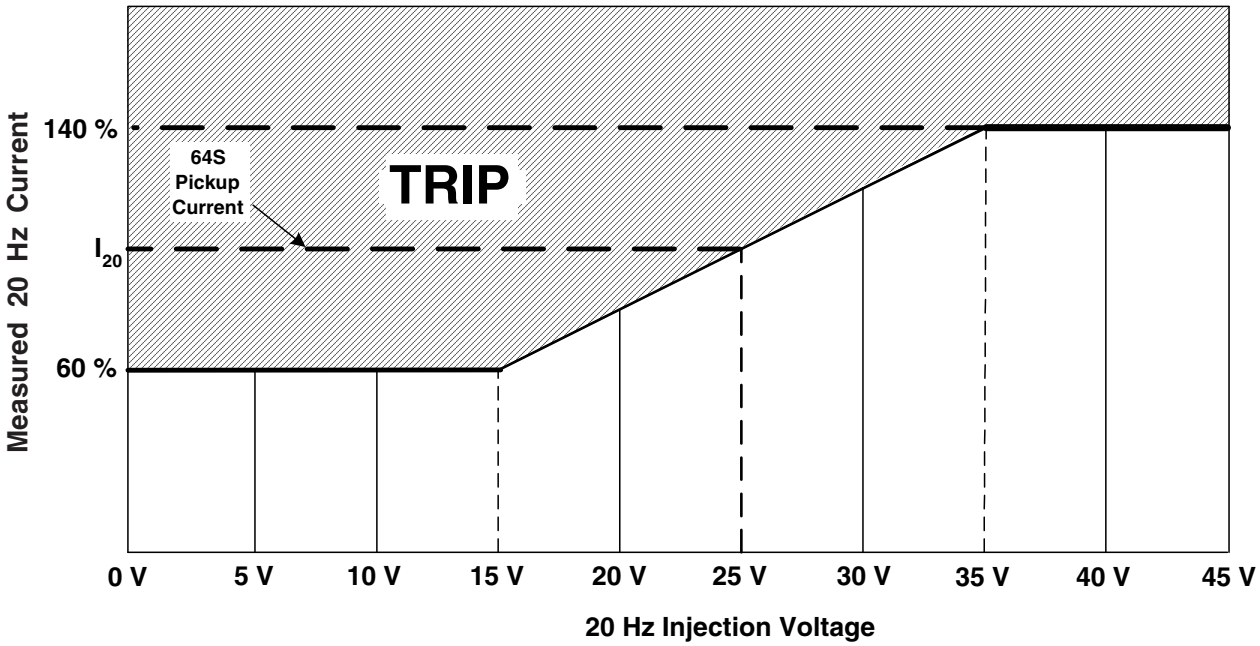


Figure 2-57 64S Function Time Delay Pickup Current Correlation

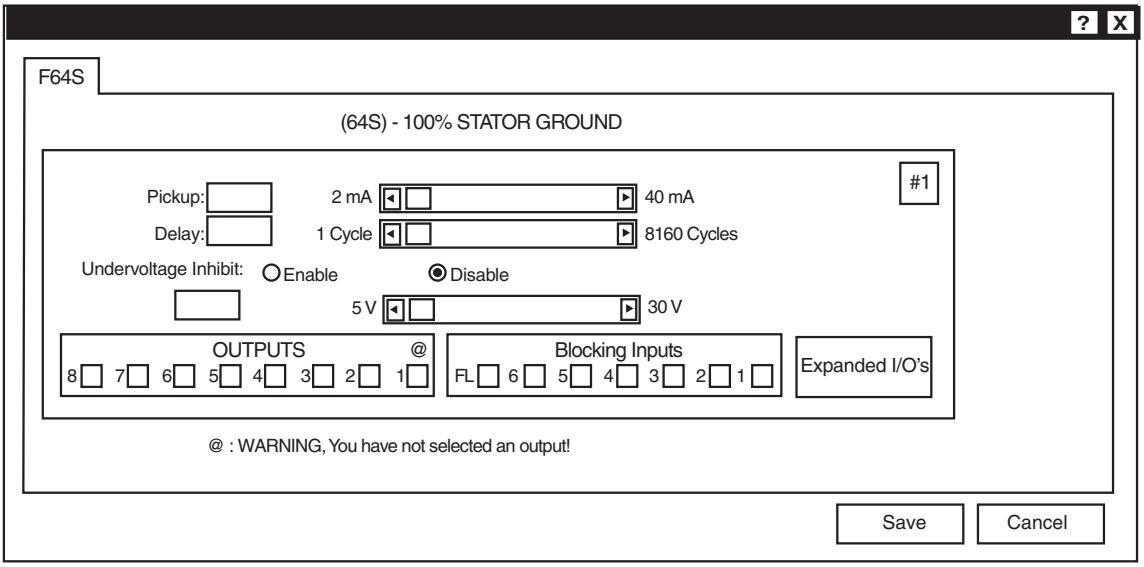


Figure 2-58 100% Stator Ground Protection (64S) Setpoint Ranges

67N Residual Directional Overcurrent

The Residual Directional Overcurrent function (67N) provides protection from ground faults. The 67N function can provide generator ground fault protection. It can also provide directional discrimination when multiple generators are bused together. The 67N Function is subject to the following configuration limitations:

- V_X polarization cannot be selected if 25 (Sync) function is enabled.
- $3V_0$ polarization can only be used with Line-Ground VT configuration.
- 67N Function is not available if 87GD is enabled.

The 67N Function operates on the residual current either from internal calculation ($3I_0$) using I_A, I_B and I_C or using a residual current input from I_N input of the relay (this is preferred compared to $3I_0$). The relay can be polarized with the neutral voltage (V_N), broken delta voltage connected at V_X input or $3V_0$ calculated using V_A, V_B and V_C inputs. The function provides both definite time and inverse time elements. The inverse time element provides several curves. The curves available for use are shown in Appendix D, **Inverse Time Curves**. They cover a range from 1.5 to 20 times the pickup setting. An additional one cycle time delay should be added to these curves in order to obtain the relay operating time. Inverse time curves saturate beyond 20 times pickup. For currents in excess of 20 times pickup, operating times are fixed at the 20 time pickup level.

To obtain maximum sensitivity for fault currents, the directional element is provided with a maximum sensitivity angle adjustment (MSA). This setting is common to both the 67NDT and 67NIT elements. The pickup sensitivity of the relay remains constant for 90° either side of the so-called Maximum Sensitivity Angle (MSA). At angles over 90° from MSA, the relay operation is blocked. Typical MSA setting for a generator internal ground fault protector is approximately 150°.

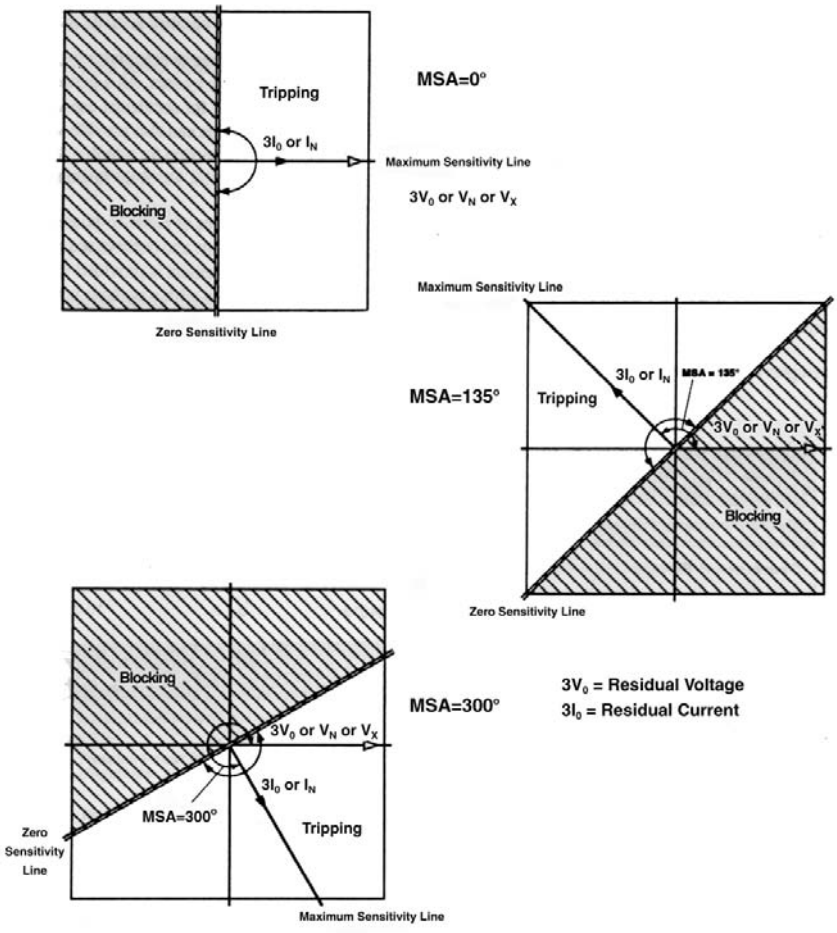


Figure 2-59 Residual Directional Overcurrent (67N) Trip Characteristics

67NDT PICKUP _____ Amps	Pickup value for the 67N element.
67NDT DIR ELEMENT disable ENABLE	Directional discrimination enable. When disabled, this function will work like a 50N.
67NDT DELAY _____ Cycles	Time Delay setting.
67NIT PICKUP _____ Amps	Inverse Time Pickup
67NIT DIR ELEMENT disable ENABLE	Directional discrimination enabled. When disabled, this function will operate like 51N.
67NIT CURVE bdef binv bvinv beinv→	Select the inverse time curve.
67NIT TIME DIAL _____	Time dial setting
67N MAX SENSITIVITY ANGLE _____ Degrees	See Figure 2-59 for Max Sensitivity Angle (MSA) settings.
67N OPERATING CURRENT 3IO in	Select the operating current.
67N POLARIZING QUANTITY 3V0 vn vx	Select the polarization voltage. If $3V_0$ is selected, VT configuration must be set to Line-Ground.

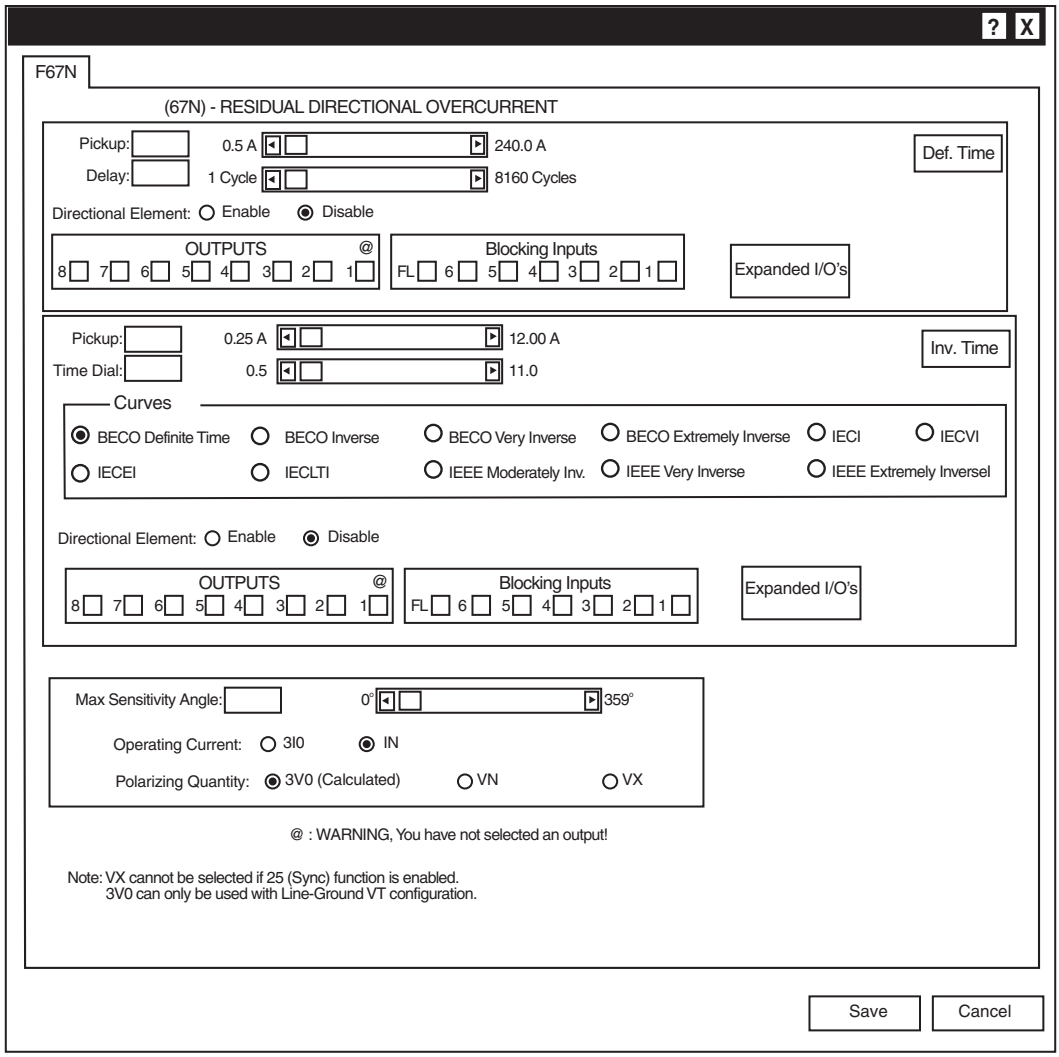


Figure 2-60 Residual Directional Overcurrent (67N) Setpoint Ranges

78 Out-of-Step

The Out-of-Step function (78) is used to protect the generator from out-of-step or pole slip conditions. This function uses one set of blinders, along with a supervisory MHO element. Ranges and increments are presented in Figure 2-63.

The pickup area is restricted to the shaded area in Figure 2-61, Out-of-Step Relay Characteristics, defined by the inner region of the MHO circle, the region to the right of the blinder A and the region to the left of blinder B. For operation of the blinder scheme, the operating point (positive sequence impedance) must originate outside either blinder A or B, and swing through the pickup area for a time greater than or equal to the time delay setting and progress to the opposite blinder from where the swing had originated. When this scenario happens, the tripping logic is complete. The contact will remain closed for the amount of time set by the seal-in timer delay.

X_T = Transformer Reactance

X_S = System Reactance

X_d' = Transient Reactance of the Generator

Consider, for example, Figure 2-62. If the Out-of-step swing progresses to impedance $Z_0(t_0)$, the MHO element and the blinder A element will both pick up. As the swing proceeds and crosses blinder B at $Z_1(t_1)$, blinder B will pick up. When the swing reaches $Z_2(t_2)$, blinder A will drop out. If TRIP ON MHO EXIT option is disabled and the timer has expired (t_2–t_1>time delay), then the trip circuit is complete. If the TRIP ON MHO EXIT option is enabled and the timer has expired, then for the trip to occur the swing must progress and cross the MHO circle at $Z_3(t_3)$ where the MHO element drops out. Note the timer is active only in the pickup region (shaded area). If the TRIP ON MHO EXIT option is enabled, a more favorable tripping angle is achieved, which reduces the breaker tripping duty. The relay can also be set with a Pole Slip Counter. The relay will operate when the number of pole slips are greater than the setting, provided the Pole Slip Reset Time was not expired. Typically, the Pole Slip Counter is set to 1, in which case the Pole Slip Reset Time is not applicable.

78 DIAMETER _____ Ohms	Typical setting is $(1.5X_T+2X_d')$
78 OFFSET _____ Ohms	Typical setting is $-2X_d'$.
78 BLINDER IMPEDANCE _____ Ohms	Typical setting is (1/2) $(X_d'+ X_T + X_S) \tan(\Theta-(\delta/2))$. Typical value for δ is 120°.
78 IMPEDANCE ANGLE _____ Degrees	Typical setting for Θ is 90°.
78 DELAY _____ Cycles	The time delay should be set based on the stability study. In the absence of such a study, it can be set between 3 and 6 cycles.
78 TRIP ON MHO EXIT disable enable	This setting is typically enabled.
78 POLE SLIP COUNT _____ slips	Typical setting is 1 pole slip.
78 POLE SLIP RESET TIME _____ Cycles	Typical setting is 120 cycles.

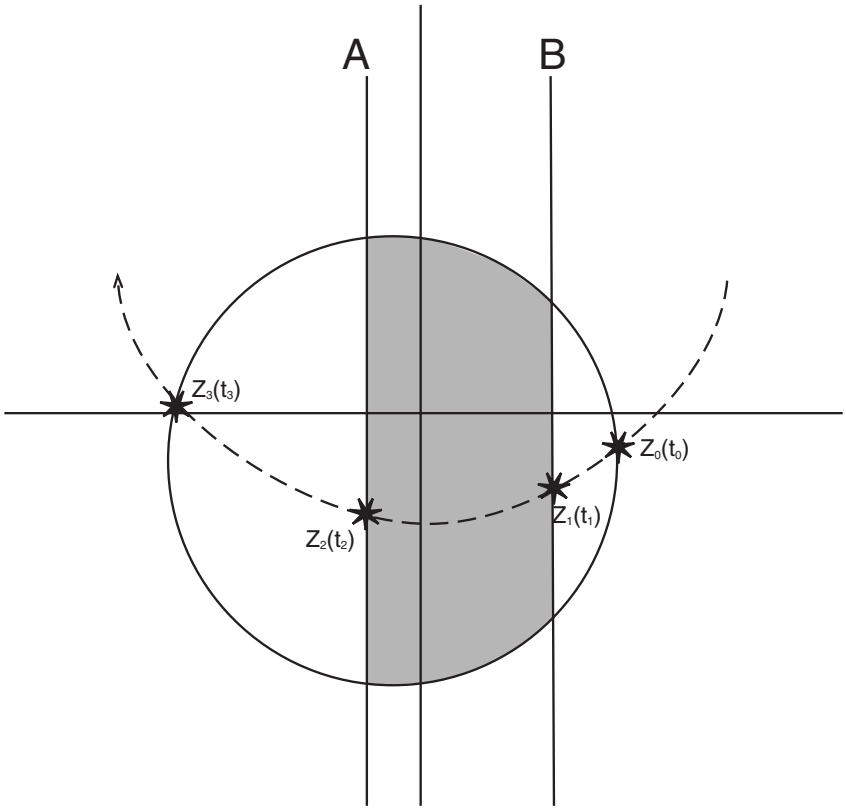


Figure 2-61 Out-of-Step Relay Characteristics

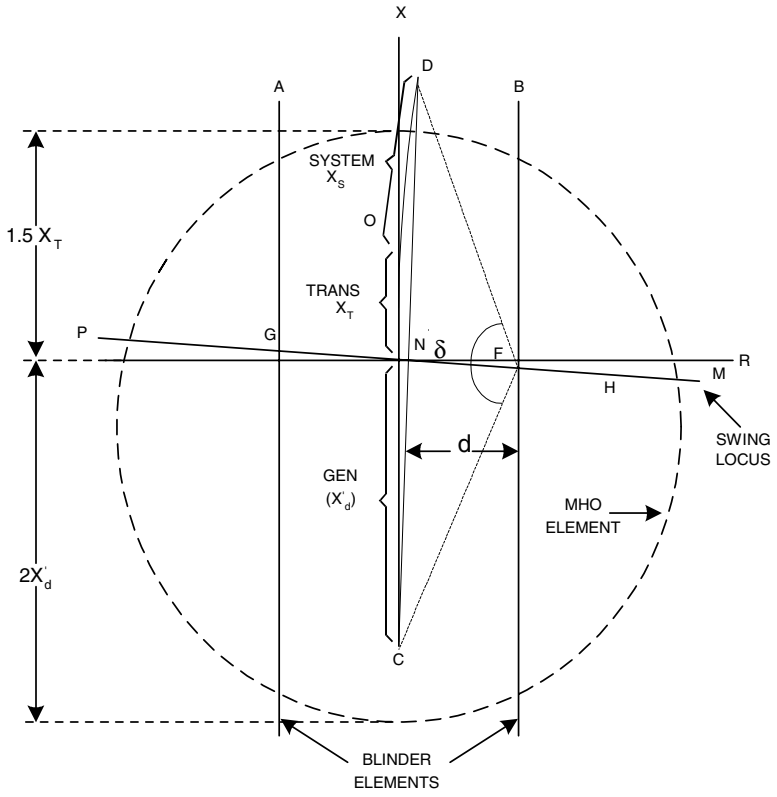


Figure 2-62 Out-of-Step Protection Settings

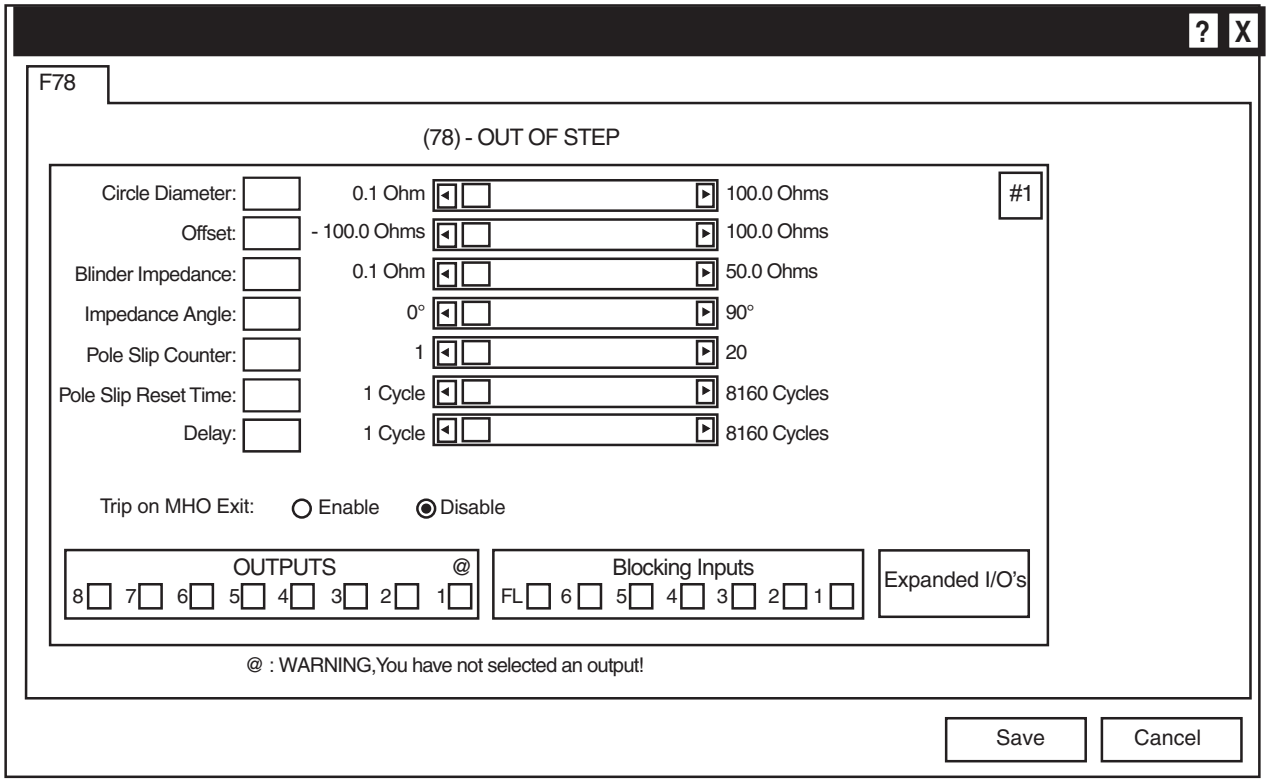


Figure 2-63 Out-of-Step (78) Setpoint Ranges

81 Frequency

The Frequency function (81) provides either overfrequency or underfrequency protection of the generator. It has four independent pickup and time delay settings. The overfrequency mode is automatically selected when the frequency setpoint is programmed higher than the base frequency (50 or 60 Hz), and the underfrequency mode selected when the setpoint is programmed below the base frequency. Ranges and increments are presented in Figure 2-65.

The steam turbine is usually considered to be more restrictive than the generator at reduced frequencies because of possible natural mechanical resonance in the many stages of the turbine blades. If the generator speed is close to the natural frequency of any of the blades, there will be an increase in vibration. Cumulative damage due to this vibration can lead to cracking of the blade structure.

Sample settings of the 81 function are shown in Figure 2-64. The frequency functions are automatically disabled when the input voltage (positive sequence) is very low (typically between 2.5 V and 15 V, based on the frequency.)

The 81 function should be disabled using breaker contact when the unit is offline.

```
81 #1 PICKUP
 _________ Hz
```

```
81 #1 DELAY
 _________ Cycles
```

```
81 #2 PICKUP
 _________ Hz
```

```
81 #2 DELAY
 _________ Cycles
```

```
81 #3 PICKUP
 _________ Hz
```

```
81 #3 DELAY
 _________ Cycles
```

```
81 #4 PICKUP
 _________ Hz
```

```
81 #4 DELAY
 _________ Cycles
```

These magnitude and time settings describe a curve (as shown in Figure 2-64, Example of Frequency (81) Trip Characteristics) which is to be coordinated with the capability curves of the turbine and generator as well as the system underfrequency load-shedding program. These capabilities are given by a description of areas of prohibited operation, restricted time operation, and continuous allowable operation.

The underfrequency function is usually connected to trip the machine whereas the overfrequency function is generally connected to an alarm.

In order to prevent mis–operation during switching transients, the time delay should be set to greater than five (5) cycles.

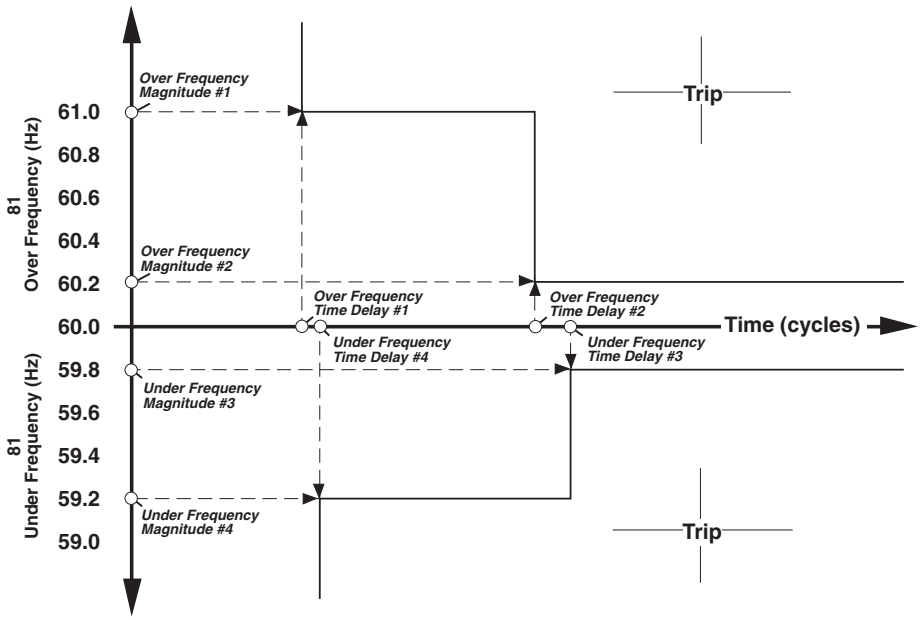


Figure 2-64 Example of Frequency (81) Trip Characteristics

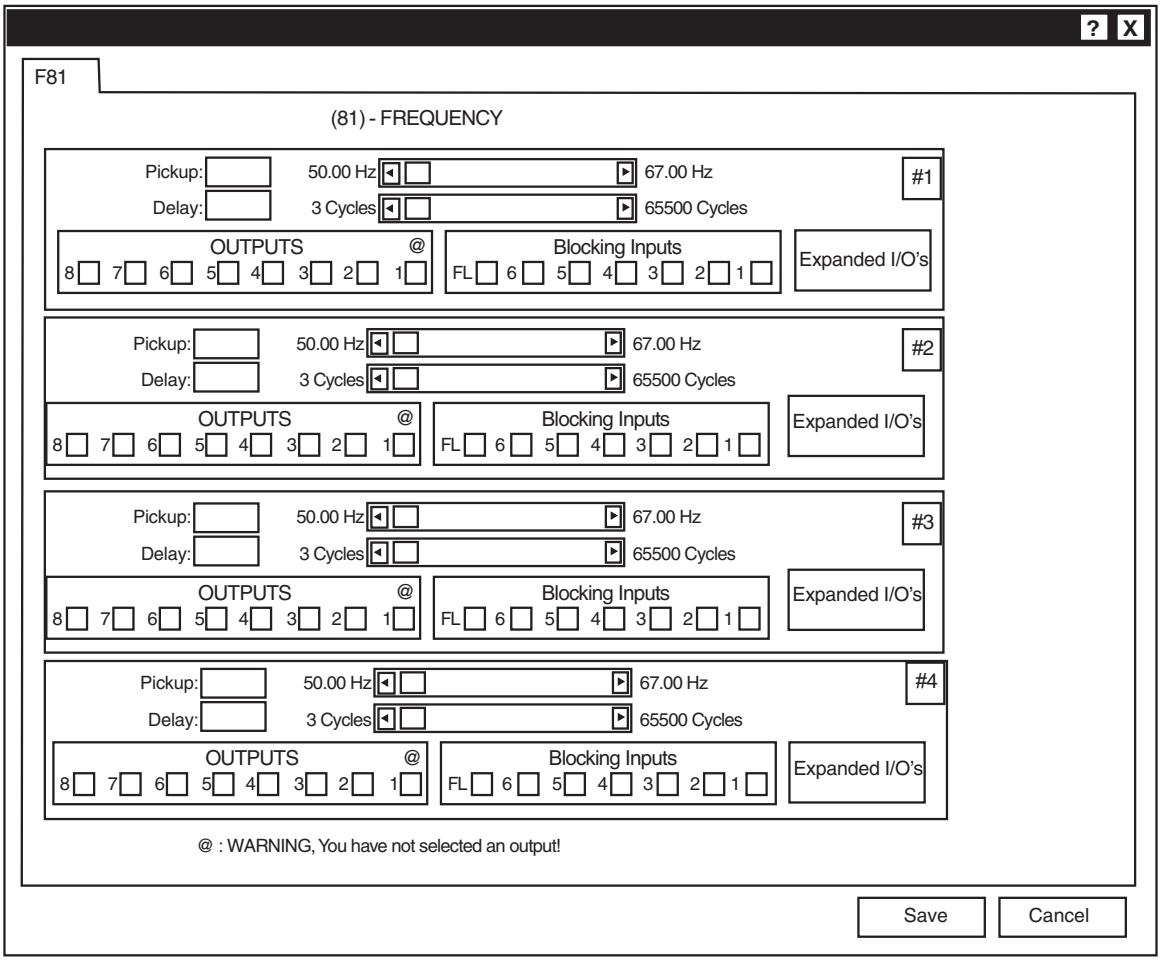


Figure 2-65 Frequency (81) Setpoint Ranges

81A Frequency Accumulator

Frequency Accumulation feature (81A) provides an indication of the amount of off frequency operation accumulated.

Turbine blades are designed and tuned to operate at rated frequencies, operating at frequencies different than rated can result in blade resonance and fatigue damage. In 60 Hz machines, the typical operating frequency range for 18 to 25 inch blades is 58.5 to 61.5 Hz and for 25 to 44 inch blades is between 59.5 and 60.5 Hz. Accumulated operation, for the life of the machine, of not more than 10 minutes for frequencies between 56 and 58.5 Hz and not more than 60 minutes for frequencies between 58.5 and 59.5 Hz is acceptable on typical machines.

The 81A function can be configured to track off nominal frequency operation by either set point or when the frequency is within a frequency band**.**

When using multiple frequency bands, the lower limit of the previous band becomes the upper limit for the next band, i.e., Low Band #2 is the upper limit for Band #3, and so forth. Frequency bands must be used in sequential order, 1 to 6. Band #1 must be enabled to use Bands #2–#6. If any band is disabled, all following bands are disabled.

When frequency is within an enabled band limit, accumulation time starts (there is an internal ten cycle delay prior to accumulation), this allows the underfrequency blade resonance to be established to avoid unnecessary accumulation of time. When accumulated duration is greater than set delay, then the 81A function operated the programmed output contact. The contact can be used to alert the operator or trip the machine.

The accumulator status can be set to preserve the accumulated information from previous devices. This allows the relay to begin accumulating information at a pre-defined value. This setpoint is only available through IPScom® Communications Software.

```
81A #1 HIGH BAND PICKUP
 _________ Hz
```

```
81A #1 LOW BAND PICKUP
 _________ Hz
```

```
81A #1 DELAY
 _________ Cycles
```

```
81A #2 LOW BAND PICKUP
 _________ Hz
```

```
81A #2 DELAY
 _________ Cycles
```

```
81A #3 LOW BAND PICKUP
 _________ Hz
```

```
81A #3 DELAY
 _________ Cycles
```

```
81A #4 LOW BAND PICKUP
 _________ Hz
```

```
81A #4 DELAY
 _________ Cycles
```

```
81A #5 LOW BAND PICKUP
 _________ Hz
```

```
81A #5 DELAY
 _________ Cycles
```

```
81A #6 LOW BAND PICKUP
 _________ Hz
```

```
81A #6 DELAY
 _________ Cycles
```

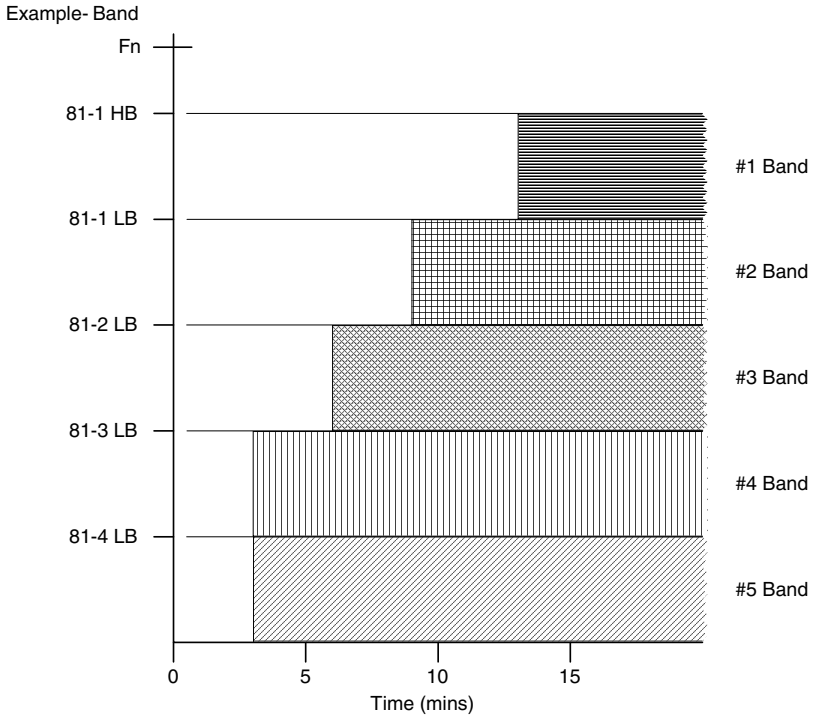


Figure 2-66 Frequency Accumulator (81A) Example Bands

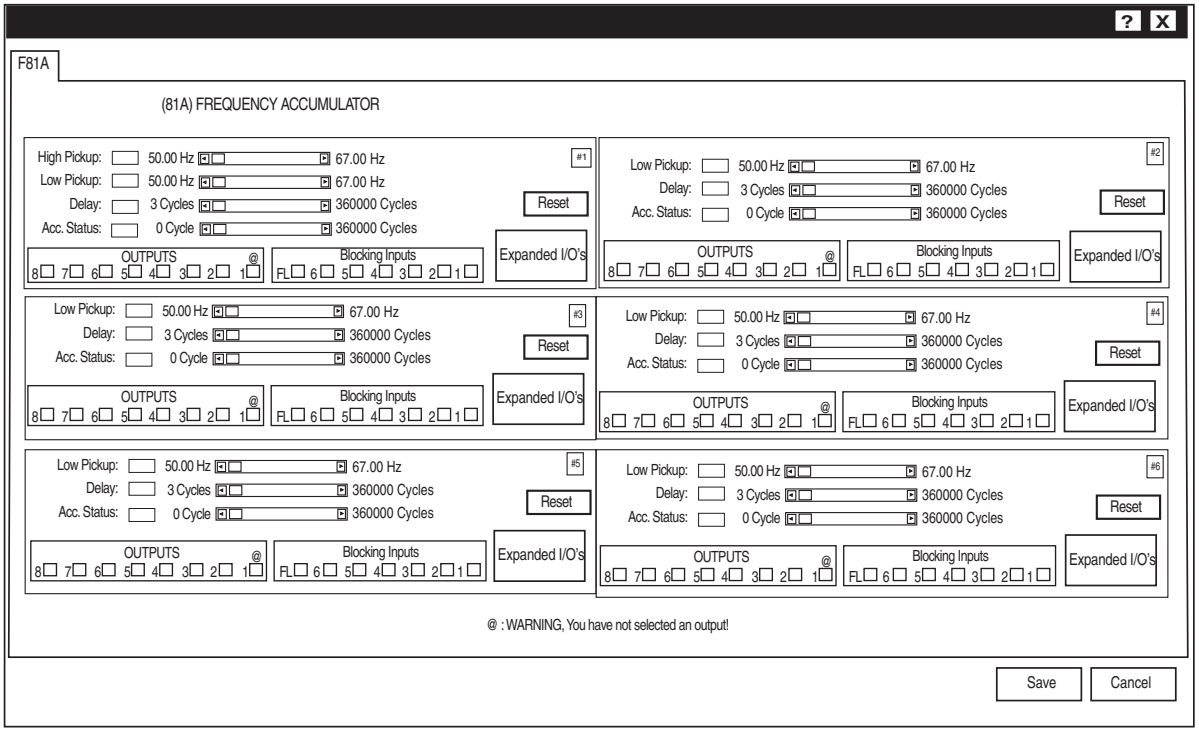


Figure 2-67 Frequency Accumulator (81A) Setpoint Ranges

81R Rate of Change of Frequency

The Rate of Change of Frequency function (81R) can be used for load shedding or tripping applications.

The function also has an automatic disable feature which disables 81R function during unbalanced faults and other system disturbances. This feature uses negative sequence voltage to block the 81R function. When the measured negative sequence voltage exceeds the inhibit setting, the function 81R and metering are blocked. The time delay and magnitude settings of 81R should be based on simulation studies. The ranges and increments are presented in Figure 2-68.

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

```
81R #1 DELAY
_________ Cycles
```

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

```
81R #2 DELAY
_________ Cycles
```

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

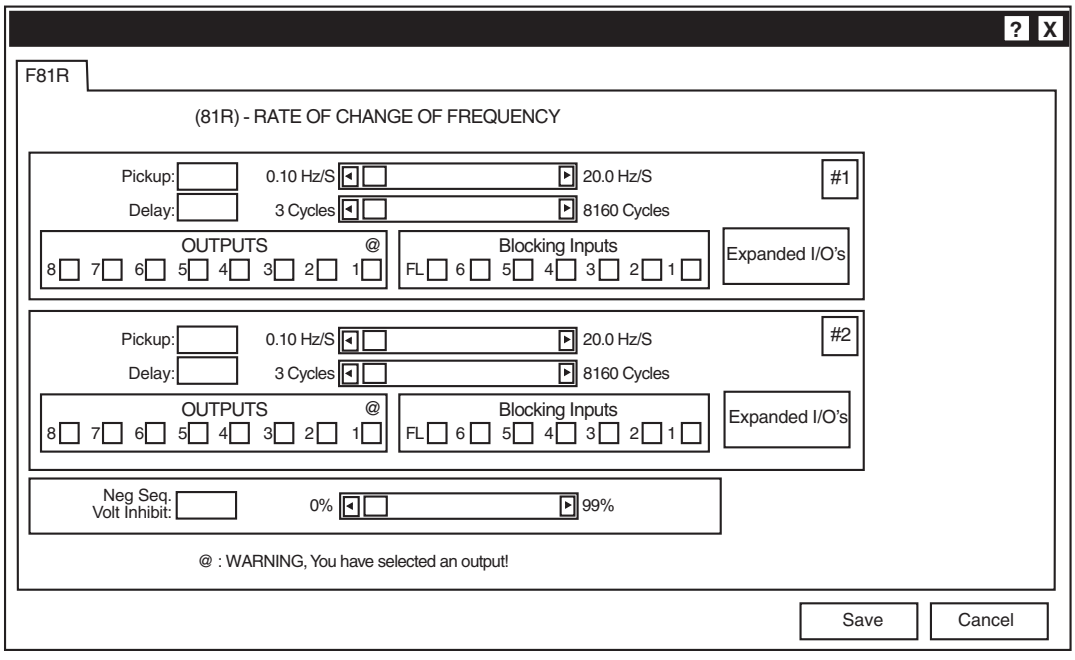


Figure 2-68 Rate of Change of Frequency (81R) Setpoint Ranges

87 Phase Differential

The Phase Differential function (87) is a percentage differential with an adjustable slope of 1–100%. Although this protection is used to protect the machine from all internal winding faults, single-phase to ground faults in machines with high impedance grounding may have currents less than the sensitivity of the differential relay (typically between 3 and 30 primary amps). Ranges and increments are presented in Figure 2-70.

Turn-to-turn faults are not detected by differential relays because the current into the generator equals the current out (see functions 50DT and 59X for turn-to-turn fault protection.) Even though the percentage differential relay is more tolerant of CT errors, all CTs should have the same characteristics and accuracies.

To provide restraint for CT saturation at high offset currents, the slope is automatically adjusted (at a restraining current equal to two times nominal current) to four times the slope setting, see Figure 2-69.

For very high currents in large generators, the proximity of CTs and leads in different phases can cause unbalanced currents to flow in the secondaries. These currents must be less than the minimum sensitivity of the relay.

There are two elements in this function. Element #2 is intended to provide phase differential protection for SFC (Static Frequency Converter) starting gas turbine generator applications. Element #1 should be disabled with a contact blocking input during a converter start operation (generator off-line), since the current is carried by only neutral side CTs and the resulting differential current may mis-operate 87#1 function. The 87#2 element, which is set with a higher current pickup, will still provide protection for this condition.

```
87 #1 PICKUP
 _________ Amps
```

A typical setting is 0.3 amps.

```
87 #1 SLOPE
 _________ %
```

A typical setting is 10%.

```
87 #1 DELAY
 _________ Cycles
```

A typical setting is one cycle. Typical settings given above assume matched current transformer performance, and that transformer inrush of the unit transformer does not cause dc saturation of the generator CTs. If there is a significant difference in current transformer ratings (C800 vs C200, for example), or if saturation of the generator CTs is expected during energizing of the step up transformer, more appropriate settings might be 0.5 A pick up, 20% slope, and a delay of 5 to 8 cycles.

```
87 #2 PICKUP
 _________ Amps
```

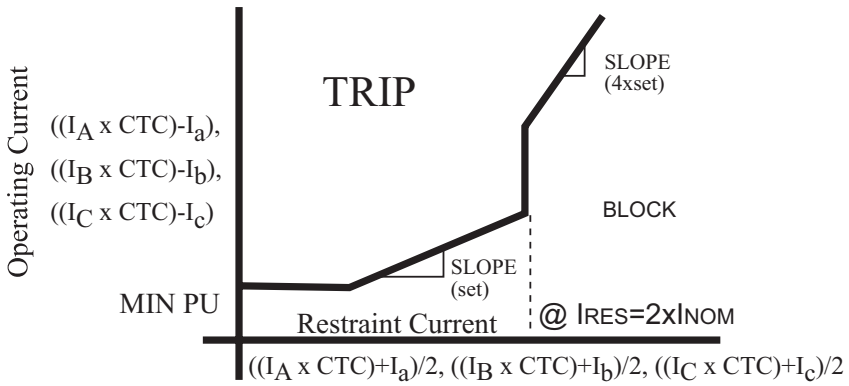
```
87 #2 SLOPE
 _________ %
```

```
87 #2 DELAY
 _________ Cycles
```

```
87 PHASE CT CORRECTION
 _________
```

If line side and neutral side CTs do not have the same ratio, the ratio error can be corrected (the line side measured current is multiplied by the phase CT correction settings.)

$$\text{Phase CT Correction} = \frac{\text{Line Side CTR}}{\text{Neutral Side CTR}}$$



Where I_A and I_a are generator high side and neutral side currents respectively, and CTC is the CT Phase correction.

Figure 2-69 Differential Relay (87) Operating Characteristics

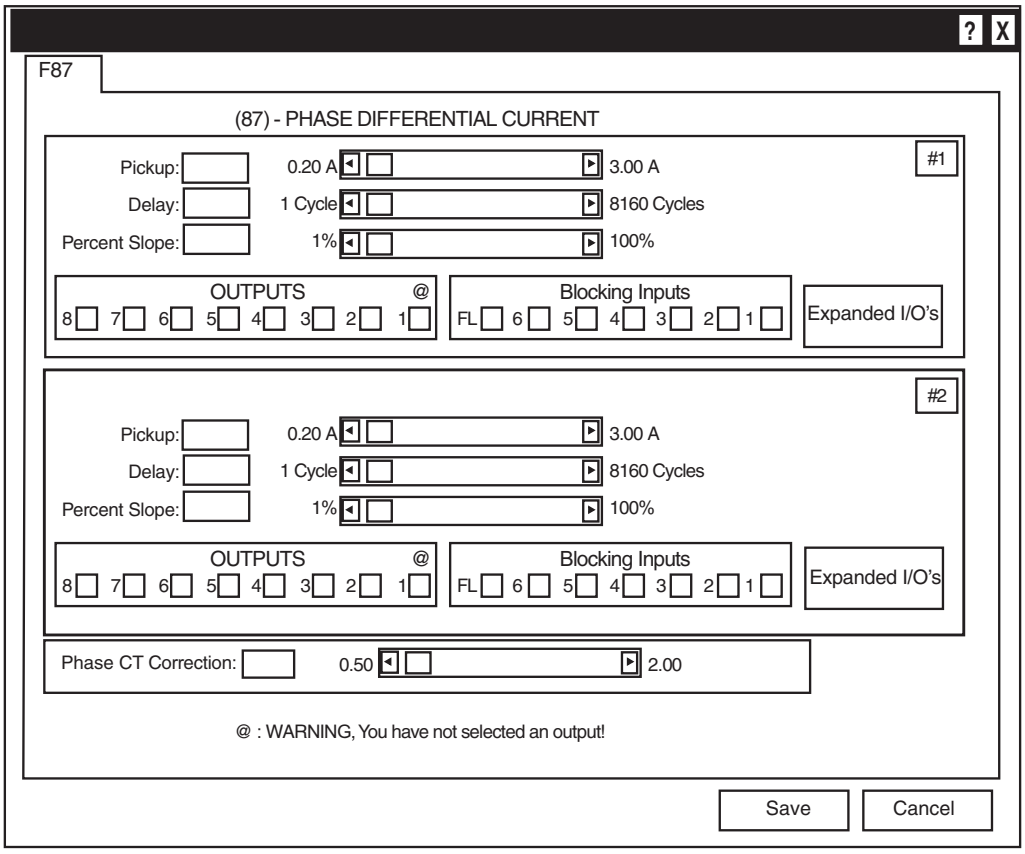


Figure 2-70 Phase Differential (87) Setpoint Ranges

87GD Ground (Zero Sequence) Differential

The Zero Sequence Differential function (87GD) provides ground fault protection for low impedance grounded generator applications. High sensitivity and fast operation can be obtained using this function. Ranges and increments are presented in Figure 2-71.

The relay provides a CT Ratio Correction Factor (R_C) which removes the need for auxiliary CTs when the phase and neutral CT ratios are different.

When the system can supply zero sequence current to the ground fault (such as when several generators are bussed together), the 87GD function operates directionally. The directional element calculates the product ($-3I_0I_N\text{Cos}\varnothing$) for directional indication. The relay will operate only if I_0 (Zero sequence current derived from phase CTs) and I_N (Neutral current from Neutral CT) have the opposite polarity, which is the case for internal generator faults.

The advantage of directional supervision is the security against ratio errors and CT saturation during faults external to the protected generator.

The directional element is inoperative if the residual current ($3I_0$) is approximately less than 0.2 A, in which case the algorithm automatically disables the directional element and the 87GD function becomes non-directional differential. The pickup quantity is then calculated as the difference between the corrected triple zero-sequence current (R_C3I_0) and the neutral current (I_N). The magnitude of the difference ($R_C3I_0–I_N$) is compared to the relay pickup.

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

■ **NOTE**: When 87GD is enabled, 67N function is not available.

```
87GD PICKUP
_________ Amps
```

A typical setting is 0.2 amps. (Relay amps = primary amps ÷ CT ratio.) For higher values of R_C, noise may create substantial differential current making higher pickup settings desirable.

```
87GD DELAY
_________ Cycles
```

In order to prevent mis-operation during external faults with CT saturation conditions, a time delay of 6 cycles or higher is recommended.

```
87GD C.T. RATIO CORRECT
_________
```

CT Ratio Correction Factor = (Phase CT Ratio)/(Neutral CT Ratio)

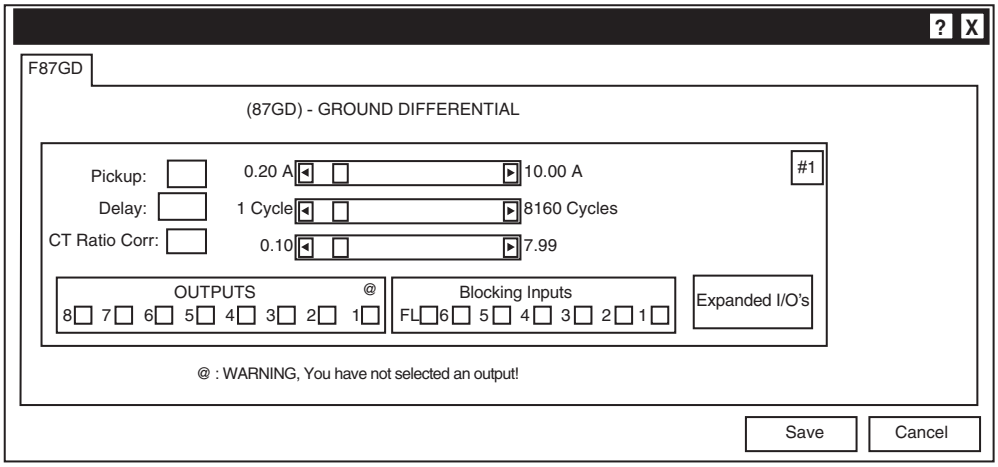


Figure 2-71 Ground Differential (87GD) Setpoint Ranges

Breaker Monitoring

The Breaker Monitoring feature calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current (IT) or current squared (I^2T) 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 operate a programmable output contact. The accumulated value for each phase can be displayed as an actual value. The accumulation starts after a set time delay from the trip initiate command to account for the time it takes for the breaker to start opening its contacts. The accumulation continues until the current drops below 10% of the nominal current setting or 10 cycles, whichever occurs first.

```
BM PICKUP
_____________ kA-cycles
```

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

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

```
BM DELAY
_________ Cycles
```

```
BM TIMING METHOD
it  i2t
```

■ **NOTE**: Preset Accumulator Setpoints are only available through IPScom®.

Expanded Inputs IN7–IN14 (if equipped) must be set using IPScom.

Expanded Outputs OUT9–OUT23 (if equipped) must be set using IPScom.

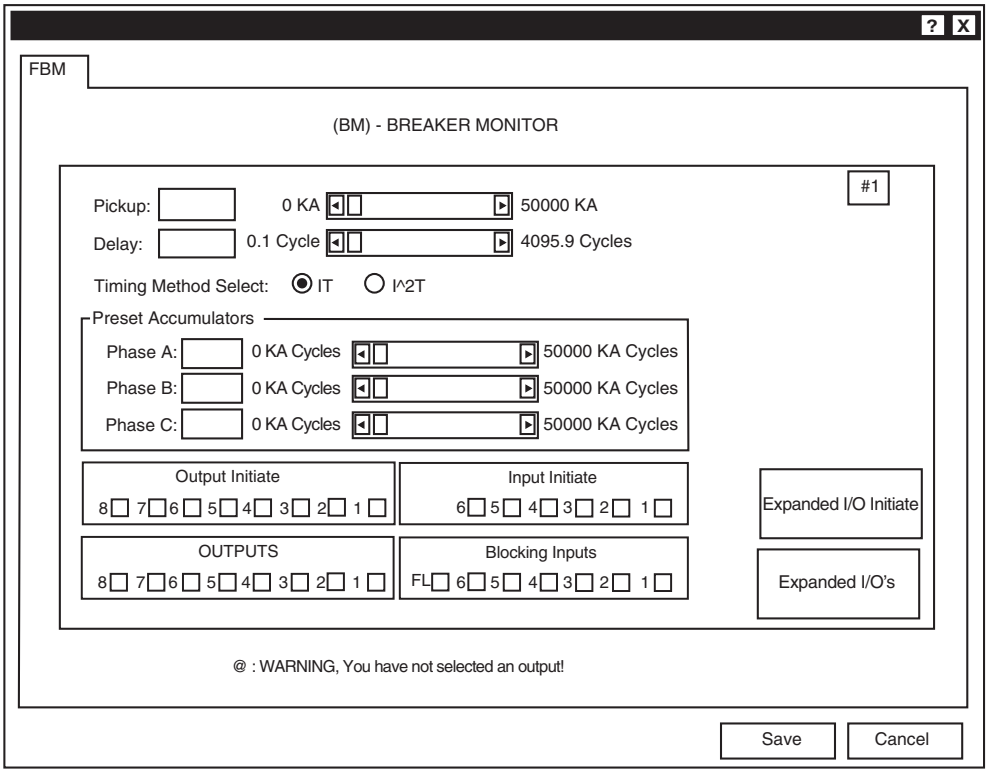


Figure 2-72 Breaker Monitor (BM) Setpoint Ranges

Trip Circuit Monitoring

External connections for the Trip Circuit Monitoring function are shown in Figure 2-73. The default Trip Circuit Monitor input voltage is 250 V dc. See Section 5.5, Circuit Board Switches and Jumpers, Table 5-3 for other available trip circuit input voltage selections.

This function should be programmed to block when the breaker is open, as indicated by 52b contact input (IN1). If the TCM is monitoring a lockout relay, a 86 contact input (INx) should be used to block when the lockout relay is tripped.

When the Output Contact is open, and continuity exists in the Trip Circuit, a small current flows that activates the Trip Circuit Monitoring Input. If the Trip Circuit is open, and the output contact is open, no current flows and the Trip Circuit Monitoring Input is deactivated. An Output Contact that is welded closed would also cause the Trip Circuit Monitoring Input to deactivate, indicating failure of the Output Contact.

When the Output Contact is closed, no current flows in the Trip Circuit Monitoring Input. If the M-3425A has issued a trip command to close the Output Contact and Trip Circuit Monitoring Input remains activated, this is an indication that the Output Contact failed to close.

The output of the Trip Circuit Monitoring function can be programmed as an alarm to alert maintenance personnel.

```
TCM DELAY
 ________ Cycles
```

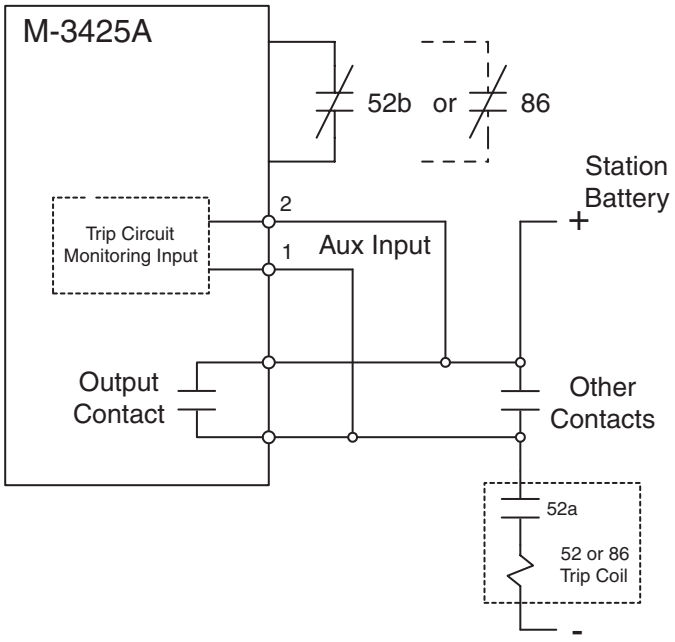


Figure 2-73 Trip Circuit Monitoring Input

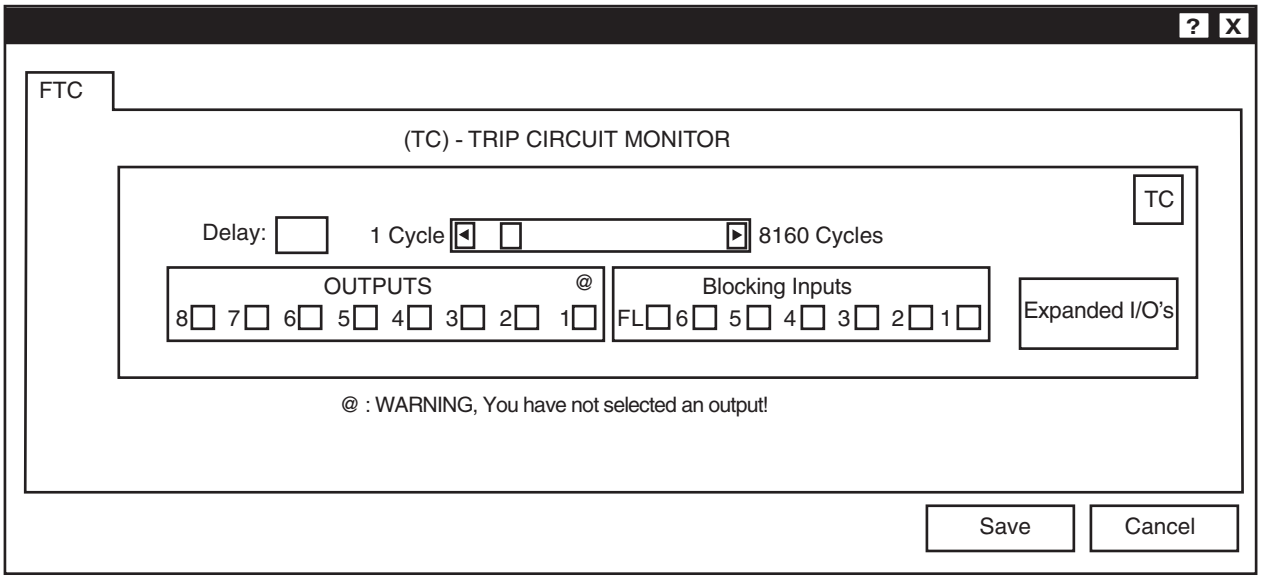


Figure 2-74 Trip Circuit Monitor (TC) Setpoint Ranges

IPSlogic™

The relay provides six logic functions and associated IPSlogic. The logic 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 IPSlogic to expand the capability of the relay by allowing the user to define customized operating logic.

Programming the IPSlogic can only be implemented through IPScom® Communications Software. The IPSlogic cannot be programmed using the Human-Machine Interface (HMI).

```
IPS LOGIC
USE IPSCOM TO CONFIGURE
```

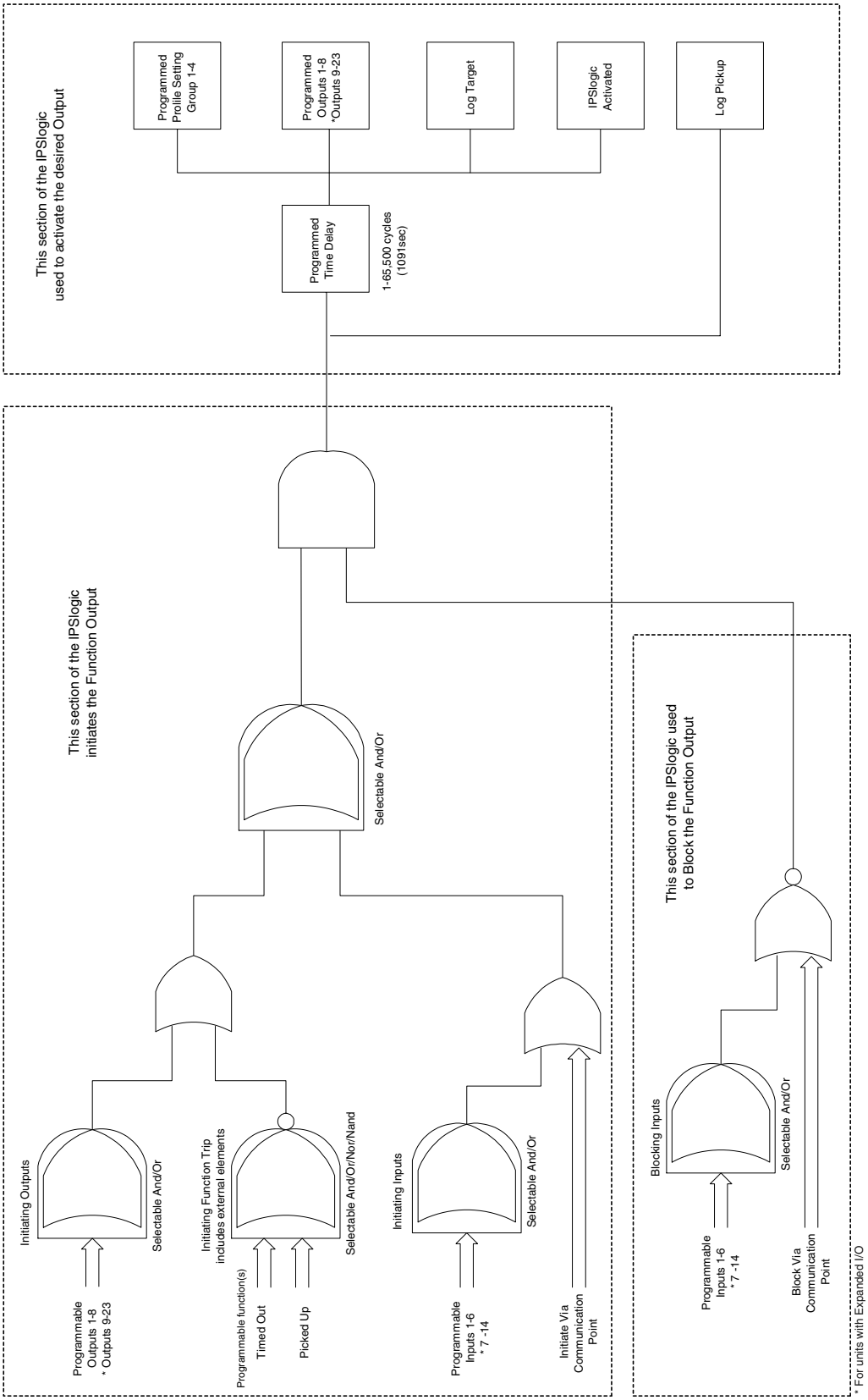


Figure 2-75 IPSlogic™ Function Setup

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

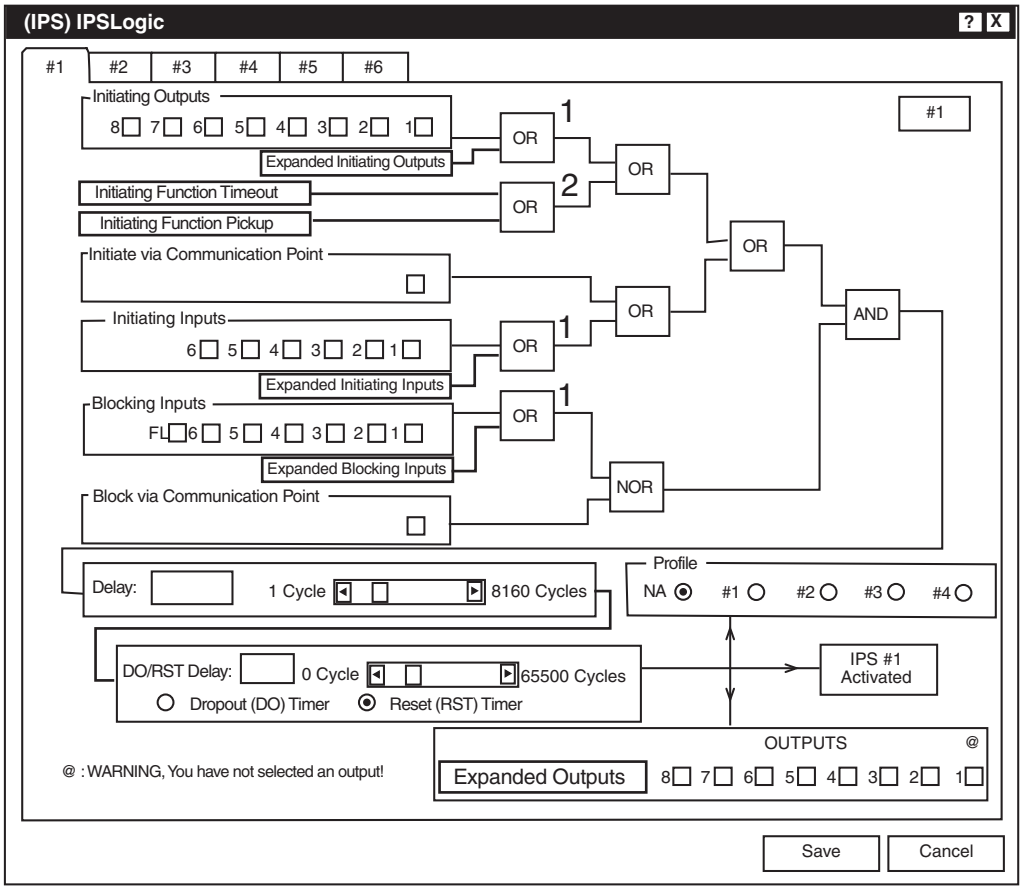
There are four initiating input sources: Initiating Outputs, Initiating Function Trips, Function Pickup (including the IPSlogic Functions themselves), Initiating Inputs, and initiation using the Communication Port. The only limitation is that an IPSlogic Function may not be used to initiate itself. There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

The activation state of the input function selected in the Initiating Function can be either timeout (Trip) or pickup. The desired time delay for security considerations can be obtained in the IPSlogic Function time delay setting.

The IPSlogic 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 IPSlogic Functions per setting profile, depending on the number of different relay settings defined, the scheme may provide up to 24 different logic schemes. The IPScom IPSlogic Function programming screen is shown in Figure 2-76.



Notes:

1. This logic gate may be selected as either AND or OR.
2. This logic gate may be selected as AND, OR, NOR, or NAND.

Figure 2-76 IPSlogic Function Programing

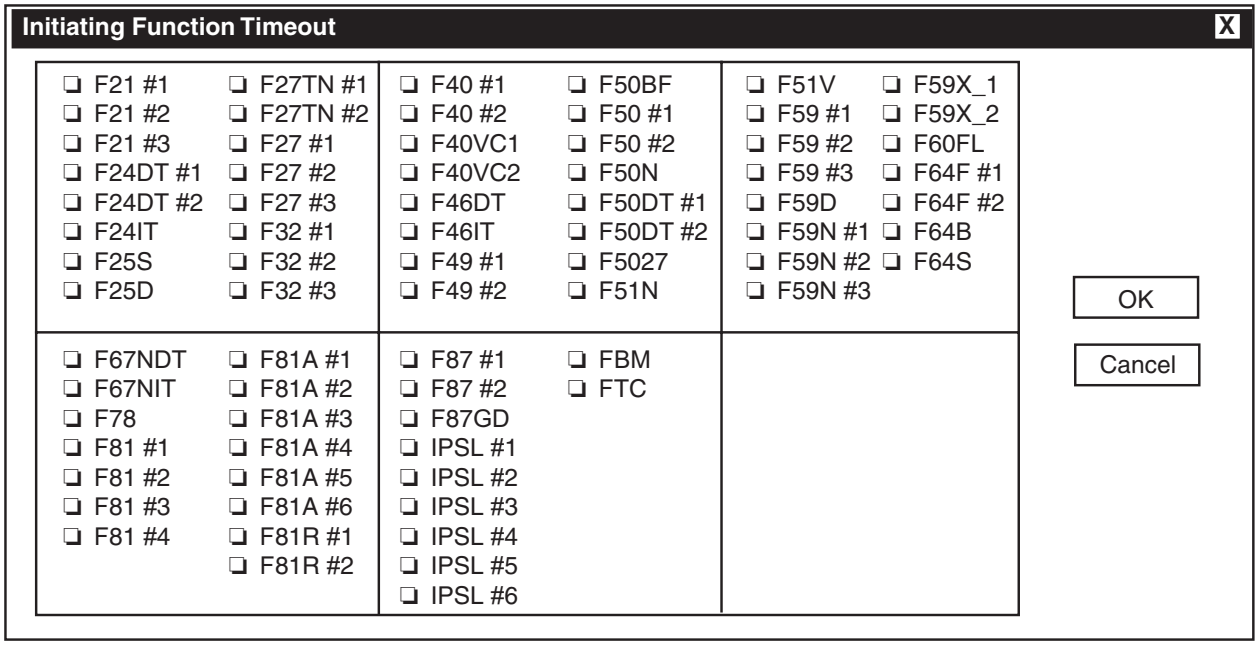


Figure 2-77 Selection Screen for Initiating Function Timeout

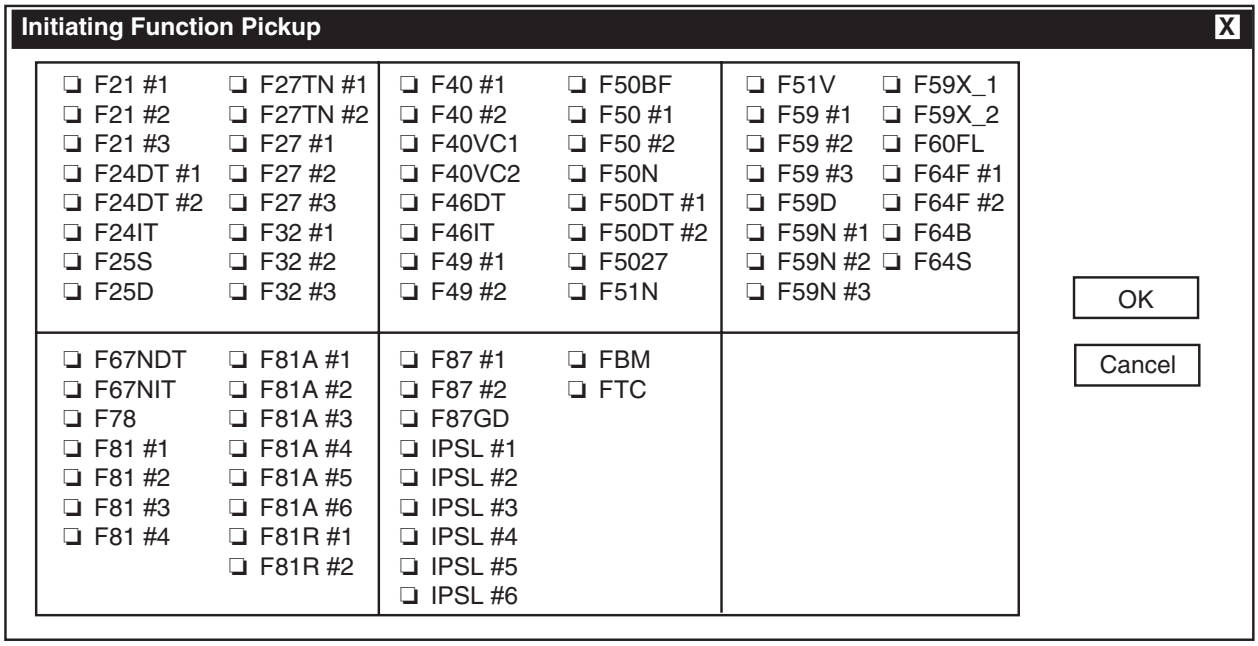


Figure 2-78 Selection Screen for Initiating Function Pickup

DO/RST (Dropout/Reset) Timer Feature

The DO/RST timer can be set as either Dropout or Reset mode. The operation of the Dropout Delay Timer and the Reset Delay Timer are described below.

Dropout Delay Timer

The Dropout Delay Timer logic is presented in Figure 2-79. The Dropout Delay Timer feature allows the user to affect an output time delay that starts when the IPSlogic PU Status drops out (A) and can hold the Output (D) status true beyound the Output Seal In Delay value (C).

However, the Seal In Delay (E) may hold the Output (B) true if the time after IPSlogic PU Status dropout (A) and Dropout Delay Timer value (D) are less than the Seal In Delay time (E).

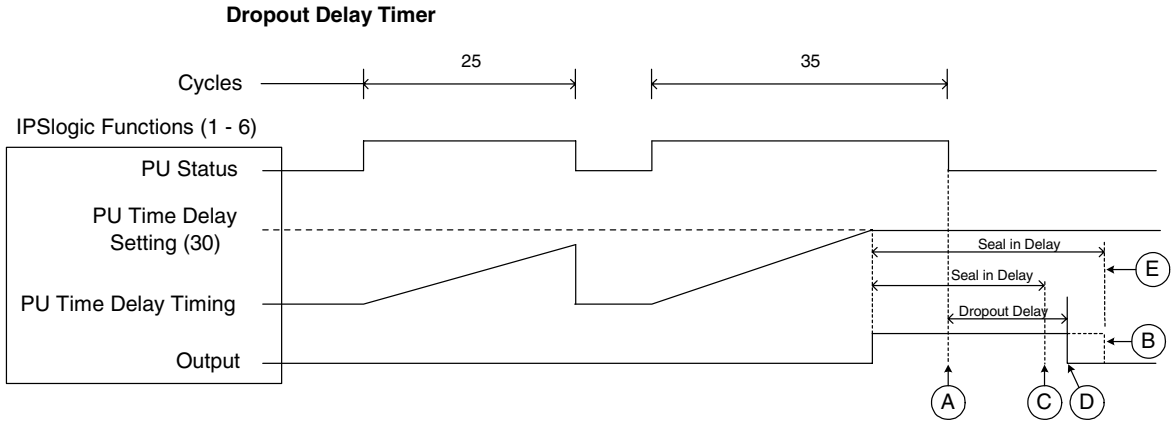


Figure 2-79 Dropout Delay Timer Logic Diagram

Reset Delay Timer

The Reset Delay Timer logic is presented in Figure 2-80. The Reset Delay Timer feature allows the user to delay the reset of the PU Time Delay Timer and hold the accumulated timer value (A) for the duration of the Reset Time Delay time period (B). The Reset Delay Timer starts when the IPSlogic PU Status drops out (C).

If the IPSlogic PU Status remains dropped out (D) after the reset delay has timed out, then the IPSlogic PU timer value will be reset to zero (E).

If the IPSlogic PU Status reasserts (F) while the Reset Delay Timer is still timing, then the PU Timer Delay begins timing from the accumulated value (G).

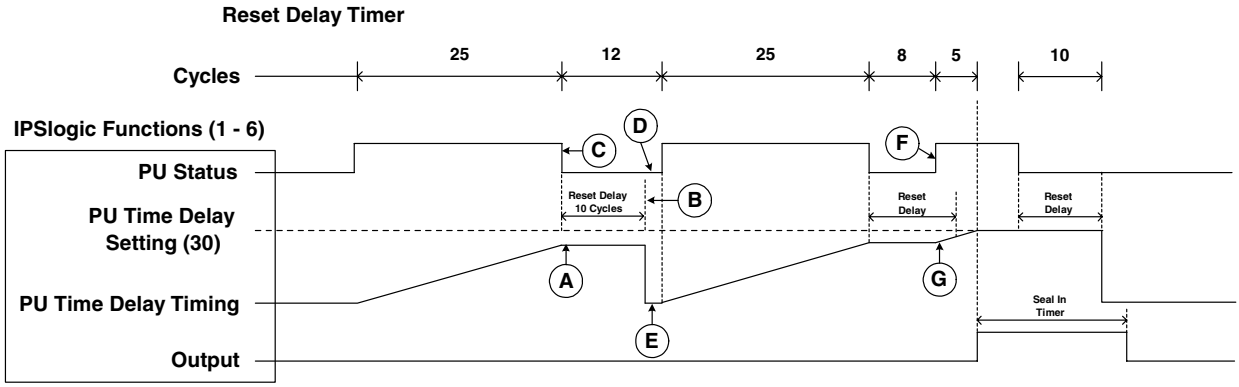


Figure 2-80 Reset Delay Timer Logic Diagram

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3 Operation

This chapter contains information that describes the operation of the M-3931 Human Machine Interface Module (HMI) and the M-3925A Target module. It further describes the direct setting and configuration procedures for entering all required data to the relay. Included in this chapter is a description of the process necessary for review of setpoints and timing, monitoring function status and metering quantities, viewing the target history, and setup of the oscillograph recorder.

3.1 Front Panel Controls

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

Alphanumeric Display

To assist the operator in setting and interrogating the relay locally, the HMI displays menus which guide the operator to the desired function or setpoint value. These menus consist of two lines. The bottom line lists lower case abbreviations of each menu selection with the chosen menu selection shown in uppercase. The top menu line provides a description of the chosen menu selection.

Screen Blanking

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

Arrow Pushbuttons

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

The up and down arrow pushbuttons increase or decrease input values or change between upper and lower case inputs. If the up or down pushbutton is pressed when adjusting numerical values, the speed of increment or decrement is increased.

EXIT Pushbutton

The **EXIT** pushbutton is used to exit from a displayed screen and move up the menu tree. Any changed setpoint in the displayed screen will *not* be saved if the selection is aborted using the **EXIT** pushbutton.

ENTER Pushbutton

The **ENTER** pushbutton is used to choose a highlighted menu selection, to replace a setpoint or other programmable value with the currently displayed value, or to move down within the menu tree.

Target & Status Indicators and Controls

The target/status indicators and controls consist of the **POWER SUPPLY** (2) LEDs, **RELAY OK** LED, the **OSCILLOGRAPH TRIG** LED, **BREAKER CLOSED** LED, **TARGET** LED, **DIAGNOSTIC** LED and **TIME SYNC** LED.

Power Supply #1 (#2) LED

The green **PS** LED indicator will remain illuminated for the appropriate power supply whenever power is applied to the unit and the power supply is operating correctly. A second power supply is available as an option, for units without expanded I/O.

Relay OK LED

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

Oscillograph Triggered LED

The red **OSC TRIG** LED will illuminate to indicate that oscillographic data has been recorded in the unit's memory and is available for download.

Breaker Closed LED

The red **BRKR CLOSED** LED will illuminate to indicate when the breaker status input IN1 (52b) is open.

Target Indicators and Target Reset

When a condition exists that causes the operation of outputs 1 through 8 (1 through 23 for units with expanded I/O), the **TARGET** LED will illuminate, indicating a relay operation. The **TARGET** LED will remain illuminated until the condition causing the trip is cleared, and the operator presses the **TARGET RESET** pushbutton. For units equipped with the optional M-3925A Target Module, additional targeting information is available. The Target module includes an additional 24 target LEDs, and 8 output status LEDs. LEDs corresponding to the particular operated function as well as the present state of the outputs are available. Pressing and holding the **TARGET RESET** pushbutton will display the present pickup status of all functions available on the target module. This is a valuable diagnostic tool which may be used during commissioning and testing.

Time Sync LED

The green **TIME SYNC** LED will illuminate to indicate that the IRIG-B time signal is received and the internal clock is synchronized with the IRIG-B time signal. IRIG-B time information is used to accurately tag target and oscillograph events.

Diagnostic LED

The diagnostic **DIAG** LED will flash when a self-test error is detected. 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 flash 2 times, followed by a long pause, then repeat LED flash sequence. For units equipped with the HMI, the Error Code number is also displayed on the screen.

Accessing Screens

To prevent unauthorized access to relay functions, the unit includes a 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.

Default Message Screens

When power is applied to the unit, the relay performs a number of self-tests to ensure that it is operating correctly. During the self-tests, the screen displays an "**x**" for each test successfully executed.

If all self-tests are executed successfully, the relay will briefly display the word PASS and then a series of status screens that include:

- Model Number
- Software Version Number
- Serial Number
- Date and time as set in the system clock
- User Logo Screen

If a test fails, 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**.

When the relay has power applied and is unattended, the user logo lines are blanked.

If a function has operated and the targets have not been reset, the screen will display the time and date of the operation and automatically cycle through screens for each applicable target (see Figure 3-2). Pressing the **ENTER** pushbutton will enter local mode operation, displaying the access code entry screen or, if access codes have been disabled, the first level menu.

Figure 3-3 presents the software menu flow map for HMI-equipped units. This map can be used as a quick reference guide to aid in navigating the relay's menus.

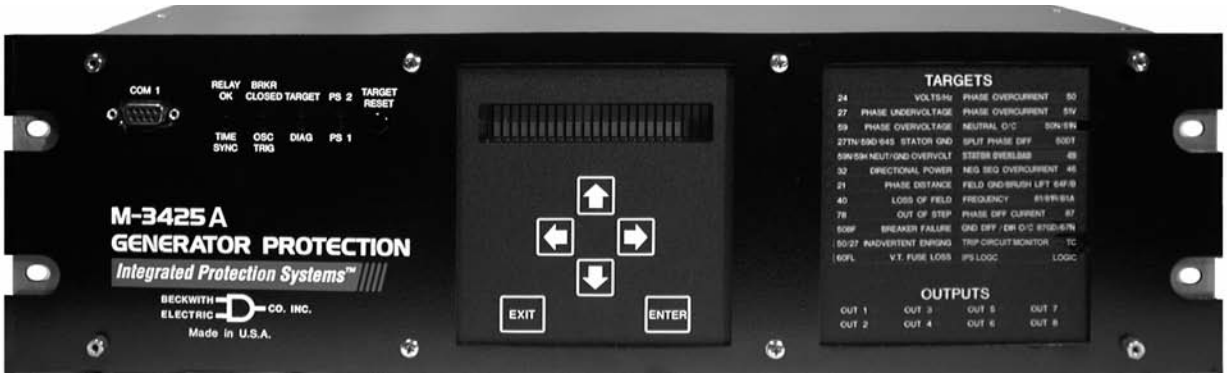

Figure 3-1 M-3425A Front Panel

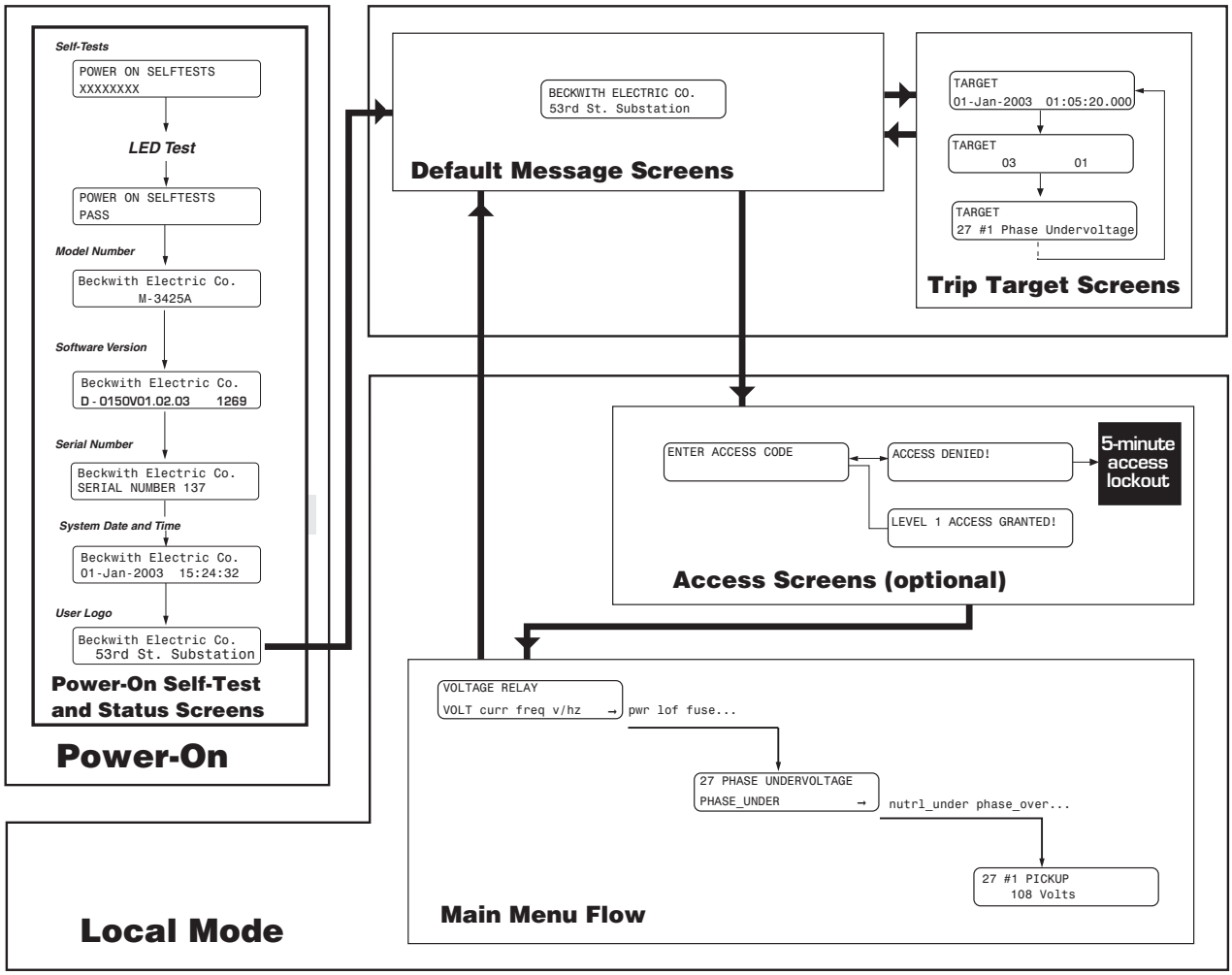

Figure 3-2 Screen Message Menu Flow

VOLTAGE RELAY
VOLT curr freq v/hz →

- 27 Phase Undervoltage
- 59 Phase Overvoltage
- 27TN Neutrl Undervolt
- 59X Overvoltage
- 59N Neutral Overvoltage
- 59D Volt. Diff. 3rd Har.

CURRENT RELAY
volt CURR freq v/Hz →

- 46 Neg Seq Overcurrent
- 50 Inst Overcurrent
- 50/27 Inadvertent Energing
- 50BF Breaker Failure
- 50DT Def. Time Overcurr
- 50N Inst Overcurrent
- 51N Inv Time Overcurrent
- 49 Stator Overload
- 51V Inv Time Overcurrent
- 87 Differential Overcurr
- 87GD Gnd Diff Overcurr
- 67N Res Dir Overcurr

FREQUENCY RELAY
volt curr FREQ v/hz →

- 81 Frequency
- 81R Rate of Change Freq
- 81A Frequency Accum.

VOLTS PER HERTZ RELAY
volt curr freq V/HZ →

- 24 Def Time Volts/Hertz
- 24 Inv Time Volts/Hertz

POWER RELAY
← PWR lof fuse dist →

- 32 Directional Power

LOSS OF FIELD RELAY
← pwr LOF fuse dist →

- 40 Loss of Field

V. T. FUSE LOSS RELAY
← pwr los FUSE dist →

- 60FL V. T. Fuse Loss

PHASE DISTANCE RELAY
← pwr lof fuse DIST →

- 21 Phase Distance
- 78 Out of Step

FIELD GROUND RELAY
←FIELD stator sync →

- 64B/F Field Ground

STATOR GROUND RELAY
← field STATOR sync →

- 64S Stator Ground

SYNC CHECK RELAY
← field stator SYNC →

- 25S Sync Check
- 25D Dead Volt

BREAKER MONITOR
←BRKR trpckt ipslog→

- Set Breaker Monitoring
- Preset Accumulators
- Clear Accumulators

TRIP CIRCUIT MONITOR
←brkr TRPCKT ipslog→

- Trip Circuit Monitor

IPS LOGIC
←brkr trpckt IPSLOG→

- IPS Logic

CONFIGURE RELAY
←CONFIG sys stat →

- Voltage Relay
- Current Relay
- Frequency Relay
- Volts per Hertz Relay
- Power Relay
- Loss of Field Relay
- V.T. Fuse Loss Relay
- Phase Distance Relay
- Field Gnd Relay
- Stator Gnd Relay
- Sync Check Relay
- Breaker Mon Relay
- Trip Ckt Mon Relay
- IPSLogic Relay

SETUP SYSTEM
←config SYS stat →

- Input Activated Profiles
- Active Setpoint Profile
- Copy Active Profile
- Nominal Voltage
- Nominal Current
- V. T. Configuration
- Delta-Y Transform
- Phase Rotation
- 59/27 Magnitude Select
- 50DT Split-phase Diff.
- Pulse Relay
- Latched Outputs
- Relay Seal-in Time
- Active Input State
- V.T. Phase Ratio
- V.T. Neutral Ratio
- V.T. VX Ratio
- C.T. Phase Ratio
- C.T. Neutral Ratio

STATUS
←config sys STAT →

- Voltage Status
- Current Status
- Frequency Status
- V/Hz Status
- Power Status
- Impedance Status
- Sync Check Status
- Breaker Mon Acc Status
- 81A Accumulators Status
- In/Out Status
- Timer Status
- Relay Temperature
- Counters
- Time of Last Power Up
- Error Codes
- Checksums

VIEW TARGET HISTORY
← TARGETS osc_rec comm →

- View Target History
- Clear Target History

OSCILLOGRAPH RECORDER
← targets OSC_REC comm →

- View Record Status
- Clear Records
- Recorder Setup

COMMUNICATION
← targets osc_rec COMM →

- COM1 Setup
- COM2 Setup
- COM3 Setup
- Communication Address
- Response Time Delay
- Comm Access Code
- Ethernet Setup
- Ethernet IP Address

SETUP UNIT
← SETUP exit

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

EXIT LOCAL MODE
← setup EXIT

■ **NOTE:** Depending on which functions are purchased, some menus may not appear.

Figure 3-3 Main Menu Flow

3.2 Initial Setup Procedure/ Settings

The M-3425A Generator Protection Relay is shipped from the factory with all functions disabled (user will only be able to enable purchased functions).

The Setup Procedure provided below is a suggested setup procedure for initially entering settings into the relay. While it is written for HMI-equipped units, the same procedure is applicable when setting the relay through remote communication utilizing M-3820D IPScom® Communications Software.

Following the Setup Procedure are several sections which provide additional detail concerning the settings required for proper commissioning.

Setup Procedure

■ **NOTE**: Configuration Record forms are available in Appendix A, **Configuration Record Forms**, to record settings for future reference.

1. Enter the Setup Unit data. This is general information required including altering access codes, setting date and time, defining user logos, and other adjustments. See Section 3.3, Setup Unit Data.
2. Configure the Setup System data. This is the general system and equipment information required for operation, including such items as CT and VT ratios, VT configuration, and Nominal values. See Section 3.4, Setup System Data subsection.
3. Enable the desired functions and elements. See Section 3.4, Configure Relay Data subsection.
4. Enter the desired setpoints for the enabled functions. See Section 3.4, Setpoints and Time Settings subsection.
5. Enter configuration information for the oscillograph recorder. See Section 3.4, Oscillograph Recorder Data subsection.
6. If remote communication is used, set the parameters as needed. See Section 3.4, Communications Settings subsection, or in Chapter 4, **Remote Operation**.

3.3 Setup Unit Data

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus associated with the **SETUP UNIT** menu.

To access the **SETUP UNIT** menu proceed as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **SETUP UNIT** is displayed on the top line of the screen.
3. Press the **ENTER** pushbutton to access the **SETUP UNIT** menu.

```
SETUP UNIT
← SETUP exit
```

4. Press the **ENTER** pushbutton to move down within the **SETUP UNIT** menu to the desired category. To exit a specific category and continue to the next menu category, press the **EXIT** pushbutton.

Setup Unit Data Entry

The general information required to complete the entry of Setup Unit Data includes:

Access Codes: The relay includes three levels of access codes. Depending on their assigned code, users have varying levels of access to the installed functions.

1. **Level 1 Access** = Read setpoints, monitor status, view target history.
2. **Level 2 Access** = All of level 1 privileges, plus read & change setpoints, target history, set time clock.
3. **Level 3 Access** = All of level 2 privileges, plus access to all configuration functions and settings.

Each access code is a user-defined one- to four-digit number. Access codes can only be altered by a level 3 user.

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, and all users have full access to all the relay menus. The relay is shipped from the factory with the access code feature disabled.

User Control Number: This is a user-defined value which can be used for inventory or identification. The relay does not use this value, but it can be accessed through the HMI or the communications interface, and can be read remotely.

User Logo: The user logo is a programmable, two-line by 24-character string, which can be used to identify the relay, and which is displayed locally when the relay is idle. This information is also available remotely.

Date and Time: This screen is used to view and set the relay's internal clock. The clock is used to time stamp system events such as trip and oscillograph operations.

The clock is disabled when shipped from the factory (indicated by "80" seconds appearing on the clock) to preserve battery life. If the relay is to be unpowered for an extended length of time, the clock should be stopped (see Diagnostic Mode). If the IRIG-B interface is used, the hours, minutes, and seconds information in the clock will be synchronized with IRIG-B time information every hour.

The relay can accept a modulated IRIG-B signal using the rear panel BNC connector, or a demodulated TTL level signal using extra pins on the rear panel COM2 RS-232 interface connector (see Figure B-4 for COM2 pinout.) If the TTL signal is to be used, then Jumper 5 will be required to be positioned (see Section 5.5, Circuit Board Switches and Jumpers).

Setup Unit Features That Do Not Require Data Entry

The Setup Unit menu categories that provide the user with read only information are **Software Version, Serial Number and Ethernet Firmware Ver.**.

The Setup Unit menu also contains features that provide the user with the ability to **Clear Output Counters, Clear Alarm Counter, Clear Error Codes** and access the **Diagnostic Mode**. The error codes are described in Appendix C**, Self Test Error Codes**. Note that while the relay is in Diagnostic Mode, all protective functions are inoperative.

3.4 Setup System Data

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus associated with the **SETUP SYSTEM** menu.

To access the **SETUP SYSTEM** menu proceed as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **SETUP SYSTEM** is displayed on the top line of the screen.
3. Press the **ENTER** pushbutton to access the **SETUP SYSTEM** menu.

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

To input the data, access the menu as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **SETUP SYSTEM** is displayed on the top line of the screen.
3. Press the **ENTER** pushbutton to access the **SETUP SYSTEM** menu and begin the data input.

System setup data is required for proper operation of the relay. Information needed to complete this section includes: Nominal Voltage, Nominal Current, VT Configuration, and other system-related information. See Section 2.1, Configuration, Relay System Setup subsection for a more detailed description of the settings required.

Configure Relay Data

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus associated with the **CONFIGURE RELAY** menu.

To input the data, access the **CONFIGURE RELAY** menu as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **CONFIGURE RELAY** is displayed on the top line of the screen.
3. Press **ENTER** to access the **CONFIGURE RELAY** menu and begin the data input.

```
CONFIGURE RELAY
←CONFIG sys stat →
```

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

- enable/disable
- output choices (OUT1–OUT8; for units with expanded I/O, OUT9–OUT23 may only be set through IPScom®)
- input blocking choices (IN1–IN6; for units with expanded I/O, IN7–IN14 may only be set through IPScom), plus fuse loss blocking

Each of the purchased functions within the relay may be individually enabled or disabled. In addition, many functions have more than one element which may also be enabled or disabled. Unused functions and elements should be disabled to avoid nuisance tripping and speed up HMI response time.

After enabling a function/element, the user is presented with two additional screens for selection of input blocking and output contact designations. Any combination of the control/status inputs or the internally generated VT fuse loss logic can be selected to dynamically block the enabled function. “OR” logic is used if more than one input is selected.

Outputs 1–6 (OUT9–OUT23 for units with expanded I/O, set through IPScom only) 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 approximately 4 ms faster than other contacts.

See Section 2.1, Configuration, for more information.

Setpoints and Time Settings

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus and specific elements associated with the **Setpoints and Time Setting** menus.

To input the data, access these menus as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **VOLTAGE RELAY**, the first of the setpoint and time setting menus, is displayed on the top line of the screen.

■ **NOTE**: Some menus are dynamic, and do not appear if the function is not purchased or is unavailable.

3. Press **ENTER** to begin the data input for this menu, or continue pressing the right arrow pushbutton until the desired setpoint and time setting menu is displayed, then press **ENTER** to begin the data input.

The general information required to complete the input data in this section includes individual relay function:

- pickup settings (converted to relay quantities)
- time delay settings
- frequency settings
- time dials
- power level settings (in percent rated)
- impedance diameter in relay ohms for distance and offset settings

Settings should be programmed based on system analysis as described in Chapter 2, **Application**. A complete description of the individual function as well as guidelines for settings are explained therein.

Oscillograph Recorder Data

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus associated with the **OSCILLOGRAPH RECORDER** menu.

To input the data, access the **OSCILLOGRAPH RECORDER** menu as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **OSCILLOGRAPH RECORDER** is displayed on the top line of the screen.
3. Press the **ENTER** pushbutton to access the **OSCILLOGRAPH RECORDER** menu and begin the data input.

```
OSCILLOGRAPH RECORDER
← targets OSC_REC comm →
```

The Oscillograph Recorder provides comprehensive data recording (voltage, current, and status input/output signals) for all monitored waveforms (at 16 samples per cycle). Oscillograph data can be downloaded using the communications ports to any IBM compatible personal computer running the M-3820D IPScom® Communications Software. Once downloaded, the waveform data can be examined and printed using the optional M-3801D IPSplot® *PLUS* Oscillograph Data Analysis Software.

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

- **Recorder Partitions**: When untriggered, the recorder continuously records waveform data, keeping the data in a buffer memory. The recorder's memory may be partitioned into 1 to 16 partitions.

  When triggered, the time stamp is recorded, and the recorder continues recording for a user-defined period. The snapshot of the waveform is stored in memory for later retrieval using IPScom Communications Software. The **OSC TRIG** LED on the front panel will indicate a recorder operation (data is available for downloading).
- **Trigger Inputs and Outputs**: The recorder can be triggered remotely through serial communications using IPScom, or automatically using programmed status inputs or outputs.
- **Post-Trigger Delay**: A post-trigger delay of 5% to 95% must be specified. After triggering, the recorder will continue to store data for the programmed portion of the total record before re-arming for the next record. For example, a setting of 80% will result in a record with 20% pretrigger data, and 80% post-trigger data.

Number of Partitions	Number of Cycles per Each Partition
1	416 Cycles
2	280 Cycles
3	208 Cycles
4	168 Cycles
5	136 Cycles
6	120 Cycles
7	104 Cycles
8	88 Cycles
9	80 Cycles
10	72 Cycles
11	64 Cycles
12	64 Cycles
13	56 Cycles
14	56 Cycles
15	48 Cycles
16	48 Cycles

Table 3-1 Recorder Partitions

Communications Settings

To enter the communications settings, access the **COMMUNICATION** menu as follows:

1. Press the **ENTER** pushbutton to access the main menu.
2. Press the right arrow pushbutton until **COMMUNICATION** is displayed on the top line of the screen.

3. Press the **ENTER** pushbutton to access the **COMMUNICATION** menu and begin the data entry.

```
COMMUNICATION
← targets osc_rec COMM →
```

The general information required to complete the communications settings entry of this section include:

- Baud rate for COM1 and COM2 communication ports. The COM3 port does not have a separate baud rate setting but uses the setting of COM2 (or COM1: see Section 5.5 Circuit Board Switches and Jumpers).
- Communications address is used to access multiple relays using a multidrop or network communication line.
- Communications access code is used for communication system security (entering an access code of 9999 disables the communication security).
- Communication protocol and dead sync time for COM2 and COM3.
- Parity for COM2 or COM3 if MODBUS or MODBUS over TCP/IP protocol is used.
- Response Time Delay
- IP Address, Net Mask and Gateway Address are required if the ethernet port is utilized and the network does not support the DHCP protocol.

Detailed information concerning setup and operation of the communication ports is described in Chapter 4, **Remote Operation**.

3.5 Status/Metering

Monitor Status/Metering

■ **NOTE**: Please see Figure 3-3, Main Menu Flow, for a list of submenus associated with the **STATUS** menu.

To access the **STATUS** menu and begin monitoring, proceed as follows:

1. Press the **ENTER** pushbutton to display the main menu.
2. Press the right arrow pushbutton until **STATUS** is displayed on the top line of the screen.
3. Press the **ENTER** pushbutton to access the **STATUS** menu.

```
STATUS
←config sys STAT →
```

■ **NOTE**: Some menus are dynamic, and do not appear if the function is not purchased or is unavailable.

4. Press the **ENTER** pushbutton to move down within the **STATUS** menu to the desired category. To exit a specific category and continue to the next menu category, press the **EXIT** pushbutton.

The menu categories for monitored values are:

- **Voltage Status**: phase voltages, neutral voltage, positive sequence voltage, negative sequence voltage, zero sequence voltage, third harmonic neutral voltage, field ground measurement circuit, stator low frequency injection voltage
- **Current Status:** phase currents (A–B–C/ a-b-c), differential current, neutral current, ground differential current, positive sequence current, negative sequence current, zero sequence current, stator low frequency injection current
- **Frequency Status**: frequency, rate of change of frequency
- **Volts/Hz Status:** volts per hertz
- **Power Status**: real power, reactive power, apparent power, power factor
- **Impedance Status**: impedance (Zab, Zbc, Zca), positive sequence impedance, field ground resistance
- **Sync Check Status**: 25S Sync Check and 25D Dead Volt
- **BRKR Monitor**
- **81A Accum. Status**
- **IN/OUT Status**: Status of input and output contacts
- **Timer:** 51V Delay Timer, 51N Delay Timer, 46IT Delay Timer, 24IT Delay Timer
- **Relay Temperature**
- **Counters**: output, alarm counter
- **Time of Last Power up**
- **Error Codes**
- **Checksums:** setpoints, calibration, ROM

3.6 Target History

The M-3425A Generator Protection Relay includes the ability to store the last 32 target conditions in a nonvolatile memory. A target is triggered whenever an output is operated. A second function attempting to operate an output (which is already operated) 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. A target includes:

- an indication which function(s) have operated, and timers expired (operated),
- status information which indicates any function that is timing (picked up),
- individual phase element information at the time of the trigger, if the operating function was a three phase function,
- phase currents at the time of operation
- neutral current at the time of operation,
- input and output status, and
- a date/time tag.

When a target is triggered, the front panel **TARGET** LED will light, indicating a recent event. If the optional M-3925A Target Module is present, the corresponding function LED will be lit. If the optional M-3931 HMI module is available, a series of screens will be presented, describing the most recent operation. This information is also available remotely by using the IPScom® Communication Software.

To access the **TARGET HISTORY** menu perform the following:

1. Press the **ENTER** pushbutton to access the main menu.
2. Press the right arrow pushbutton until **TARGET HISTORY** is displayed on the top line of the screen.

To view Target History records proceed as follows:

1. Ensure that the View Target History Menu is selected to TRGT (upper case).

```
VIEW TARGET HISTORY
TRGT clear
```

   If TRGT is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select TRGT.

2. Press **ENTER**, the following will be displayed:

```
VIEW TARGET HISTORY
1 Target number
```

   Detailed descriptions for each View Target History screen are presented on the following page.

```
VIEW TARGET HISTORY
TRGT clear
```

This screen gives access to the target history, and also allows the user to clear the target history record from memory.

```
VIEW TARGET HISTORY
 1 Target number
```

Using up and down buttons, user may select which particular target to view from the last 24 recorded triggers.

```
TARGET 1
01-JAN-2001 12:27:35.125
```

This screen gives the date and time tag of the selected target.

```
TARGET 1
08          05    01
```

This screen displays operated outputs.

```
TARGET 1
            I3    I1
```

This screen displays operated inputs at time of trip.

```
TARGET 1
-OPERATE TARGETS-
```

The following screens display the timed out or “operate” functions.

```
TARGET 1
27#1 PHASE UNDERVOLTAGE
```

This screen displays the specific function which timed out and triggered the target.

```
TARGET 1
PHASE A=X B= C=
```

This screen displays the phase information for the displayed function at time out.

```
TARGET 1
-PICKUP TARGETS-
```

The following screens display the timing on “picked up” functions when the target was recorded.

```
TARGET 1
27#1 PHASE UNDERVOLTAGE
```

```
TARGET 1
PHASE A=X B=X C=X
```

This display gives the phase pickup information for the specific function.

```
TARGET 1
-CURRENT STATUS-
```

```
TARGET 1
a=0.02 b=0.03 c=0.04
```

This screen displays the phase current at the time the target operated.

```
TARGET 1
N=0.50 AMPS
```

This screen displays the neutral current at the time the target operated.

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4 Remote Operation

This chapter is designed for the person or group responsible for the remote operation and setting of the relay using the M-3820D IPScom Communications Software or other means.

4.1 Remote Operation

The M-3425A Generator Protection Relay provides three serial communication ports and one ethernet port.

Serial Ports (RS-232)

Two serial interface ports, COM1 and COM2, are standard 9-pin, RS-232, DTE-configured ports. The front-panel port, COM1, can be used to locally set and interrogate the relay using a temporary connection to a PC or laptop computer. The second RS-232 port, COM2, is provided at the rear of the unit. COM2 is unavailable for use when the optional ethernet port is enabled.

The individual addressing capability of IPScom and the relay allows multiple systems to share a direct or modem connection when connected through COM2 using a communications-line splitter (see Figure 4-1). One such device enables 2 to 6 units to share one communications line. Appendix B, Figure B-2 illustrates a setup of RS-232 Fiber Optic network.

Serial Port (RS-485)

COM3 located on the rear terminal block of the M-3425A is an RS-485, 2-wire connection. Appendix B, Figure B-3 illustrates a 2-wire RS-485 network.

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

Optional Ethernet Port

The M-3425A when equipped with the optional Ethernet Port can be accessed from a local network. When the ethernet port is enabled the COM2 serial port (RS-232) is unavailable for use. Although the ethernet connection speed is faster than the RS-232 port (can be up to 10 Mbps), the ethernet module connects internally through the COM2 serial connection and is therefore limited to connection speeds up to 9600 bps.

Either COM2, COM3 or Ethernet port may be used to remotely set and interrogate the relay using a local area network, modem or other direct serial connection. Equipment such as RTU's, data concentrators, modems, 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, MODBUS, BECO 2200 over TCP/IP or MODBUS over TCP/IP data exchange protocols.

The communication protocols are 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 all relay functions

Protocol documents are available directly from Beckwith Electric or from our website www.beckwithelectric.com.

Direct Connection

In order for IPScom to communicate with the relay using direct serial connection, a serial "null modem" cable is required, with a 9-pin connector (DB9P) for the system, and an applicable connector for the computer (usually DB9S or DB25S). Pin-outs for a null modem adapter are provided in Appendix B, **Communications**.

An optional 10 foot null modem cable (M-0423) is available from the factory, for direct connection between a PC and the relay's front panel COM port, or the rear COM2 port.

When fabricating communication cables, every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended. The RS-232 standard specifies a maximum cable length of 50 feet for RS-232 connections. If over 50 feet of cable length is required, other technologies should be investigated.

Other communication topologies are possible using the M-3425A Generator Protection Relay. An Application Note, "*Serial Communication with Beckwith Electric's Integrated Protection System Relays*" is available from the factory or from our website at www.beckwithelectric.com.

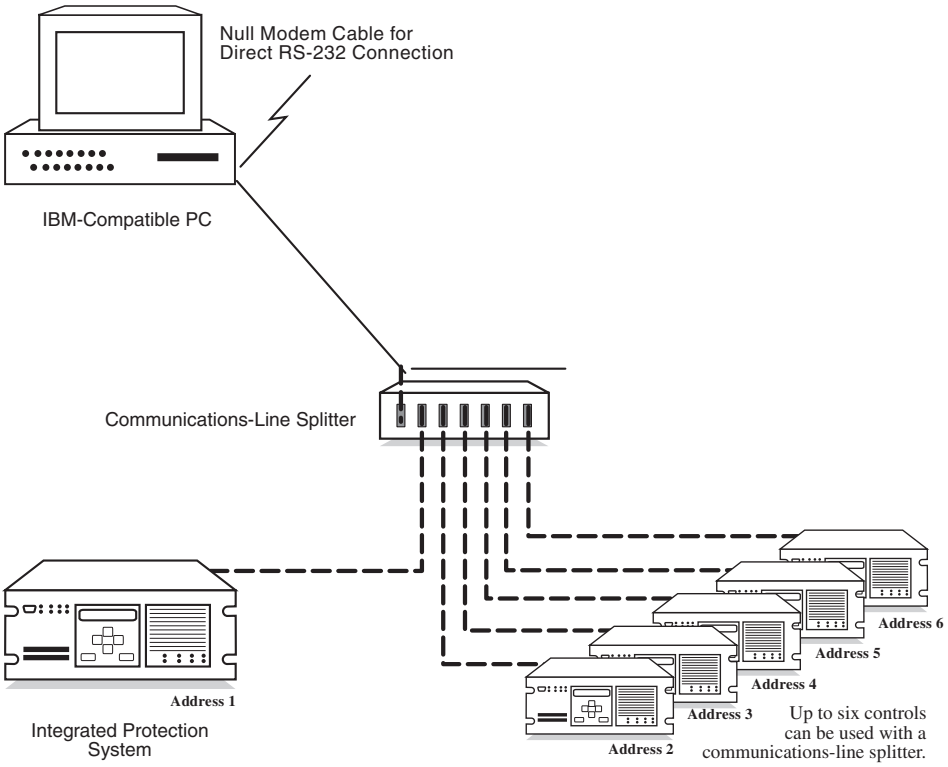


Figure 4-1 Multiple Systems Addressing Using Communications-Line Splitter

Setting Up the M-3425A Generator Protection Relay for Communication

The initial setup of the relay for communication must be completed by utilizing the optional M-3931 HMI Module or using direct serial connection.

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.

Serial Communication Settings

The following parameters must be set for proper serial communication:

COM1 Baud Rate: Standard baud rates from 300 to 9600 are available.

COM2 Baud Rate: Standard baud rates from 300 to 9600 are available. COM2 and COM3 share the same baud rate (see Section 5.5, Circuit Board Switches and Jumpers).

COM2 Dead Sync Time: This delay establishes the line idle time to re-sync packet communication. Dead sync time should be programmed based on the channel's baud rate.

COM2 Protocol: BECO 2200 or MODBUS protocol is supported on COM2.

COM2 Parity: None, odd or even parity is available if MODBUS protocol is selected.

COM2 Stop Bits: One or two stop bits available if MODBUS protocol is selected.

COM3 Dead Sync Time: This delay establishes the line idle time to re-sync packet communication. Dead sync time should be programmed based on the channel's baud rate.

COM3 Protocol: BECO 2200 or MODBUS protocol is supported on COM3.

COM3 Parity: None, odd or even parity is available if MODBUS protocol is selected.

COM3 Stop Bits: One or two stop bits available if MODBUS protocol is selected.

Communications Address: For multidrop networks, each device must have a unique address.

Response Time Delay: The extra time delay may be added while the relay is sending the response. If set to 0, the response of the relay will be equal to the time required to process the incoming packet (usually 20–80 ms.)

Communication Access Code: If additional link security is desired, a communication access code can be programmed. Like the user access codes, if the communication access code is set to 9999 (default), communication security is disabled.

Individual relay communication addresses should be between 1 and 200. The dead sync time, while not critical for most communication networks, should be programmed to match the communications channels baud rate (see Table 4-1, below).

Baud Rate	Dead-Sync Time
9600	4 ms
4800	8 ms
2400	16 ms
1200	32 ms

Table 4-1 Dead-Sync Time

Ethernet Communication Settings

The RJ45 ethernet port can be enabled utilizing either IPSutil™ from the Ethernet Settings menu or from the HMI Communication menu. When the ethernet port is enabled the COM2 Serial Port is not available for use.

The following parameters must be set for proper ethernet communication:

DHCP Protocol

ENABLE: If the network server supports the DHCP protocol the network server will assign the IP Address, Net Mask and Gateway Address.

DISABLE: If the network server does not support the DHCP protocol or the user chooses to manually input ethernet settings, then obtain the IP Address, Net Mask and Gateway address from the Network Administrator and enter the settings.

ETHERNET Protocols

SERCONV:To utilize the BECO2200 protocol over a TCP/IP connection select the SERCONV (BECO2200 TCP/IP) protocol. The IP Address of the relay must be entered in the IPScom Communication screen. Also, ensure that the COM2 protocol is selected to BECO2200 and the baud rate is set to 9600 bps.

The Standard Port Number for the BECO2200 over TCP/IP protocol is 8800. The master device may require the entry of the Standard Port Number.

MODBUS:To utilize the MODBUS protocol over a TCP/IP connection select the MODBUS (MODBUS over TCP/IP) protocol. The IP Address of the relay must be entered in the IPScom® Communication screen. Also, ensure that the COM2 protocol is selected to MODBUS, baud rate is set to 9600 bps, 1 stop bit and no parity selected.

The Standard Port Number for the MODBUS over TCP/IP protocol is 502. The master device may require the entry of the Standard Port Number.

Ethernet Port Setup

Enabling the ethernet port and selecting the required support settings can be accomplished using either the HMI or IPSutil™. Both methods are presented below.

HMI Ethernet Port Setup

1. Ensure that the Communication Menu is selected to COMM (upper case).

   ```
   COMMUNICATION
   ←  targets osc_rec COMM →
   ```

   If COMM is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select COMM.

2. Press **ENTER**, the following will be displayed:

   ```
   COM1 SETUP
   COM1 com2 com3 com_adr  →
   ```

3. Use the Right arrow pushbutton to select ETH (Upper Case).

   ```
   ETHERNET SETUP
   ←  access  ETH  eth_ip
   ```

4. Press **ENTER**, the following will be displayed:

   ```
   ETHERNET
   DISABLE enable
   ```

5. Use the Right arrow pushbutton to select ENABLE (Upper Case), then press **ENTER**, the following will be displayed:

   ```
   TCP/IP SETTINGS
   TCP prot
   ```

6. Ensure that TCP is selected (Upper Case).

   If TCP is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select TCP.

7. Press **ENTER**, the following will be displayed:

   ```
   DHCP PROTOCOL
   DISABLE enable
   ```

8. If the network does not support the DHCP protocol, then go to Manual Configuration of Ethernet Board (following page) to manually configure the ethernet board.

9. If the DHCP Protocol is to be enabled, then use the Right/Left arrow pushbutton to select ENABLE (Upper Case), then press **ENTER**, the following will be displayed:

   ```
   TCP/IP SETTINGS
   TCP prot
   ```

10. Ensure that PROT is selected (Upper Case).

    If PROT is not selected (Upper Case), then use the Right arrow pushbutton to select PROT.

11. Press **ENTER**, the following will be displayed:

    ```
    SELECT PROTOCOL
    modbus  serconv
    ```

12. Use the Right/Left arrow pushbuttons to select the desired protocol (Upper Case), then press **ENTER**, the following will be displayed:

    ```
    TCP/IP SETTINGS
    tcp PROT
    ```

13. Press **EXIT**, the ethernet board will reconfigure and the following will be displayed:

    ```
    CONFIGURING ETH...
    ```

    If the ethernet board successfully obtains an IP Address the following will be displayed for approximately 2 seconds:

    ```
    ETHERNET IP ADDRESS
    XX.XX.XX.XX
    ```

    The ethernet board is now configured for use and may be accessed through a network.

Then the display will return to the following:

```
ETHERNET SETUP
← access  ETH  eth_ip
```

If the ethernet board fails to obtain an IP Address within 15 seconds the following will be displayed (for approximately 2 seconds):

```
CONFIGURING ETH...
ETH BOARD ERROR
```

Contact the Network Administrator to determine the cause of the configuration failure.

Manual Configuration of Ethernet Board

1. Ensure that DISABLE is selected (Upper Case).

   If DISABLE is not selected (Upper Case), then use the Left arrow pushbutton to select DISABLE.

2. Press **ENTER**, the following will be displayed:

   ```
   IP ADDRESS
   XX.XX.XX.XX
   ```

3. Enter the desired IP Address, then press **ENTER**, the following will be displayed:

   ```
   NET MASK
   XX.XX.XX.XX
   ```

4. Enter the desired Net Mask, then press **ENTER**, the following will be displayed:

   ```
   GATEWAY
   XX.XX.XX.XX
   ```

5. Enter the desired Gateway, then press **ENTER**, the following will be displayed:

   ```
   TCP/IP SETTINGS
   tcp prot
   ```

6. Ensure that PROT is selected (Upper Case).

   If PROT is not selected (Upper Case), then use the Right arrow pushbutton to select PROT.

7. Press **ENTER**, the following will be displayed:

   ```
   SELECT PROTOCOL
   modbus  serconv
   ```

8. Use the Right/Left arrow pushbuttons to select the desired protocol (Upper Case), then press **ENTER**, the following will be displayed:

   ```
   TCP/IP SETTINGS
   tcp PROT
   ```

9. Press **EXIT**, the ethernet board will reconfigure and the following will be displayed:

   ```
   CONFIGURING ETH...
   ```

   If the ethernet board is successfully configured, then the entered IP Address will be displayed for approximately 2 seconds:

   ```
   ETHERNET IP ADDRESS
   XX.XX.XX.XX
   ```

   The ethernet board is now configured for use and may be accessed through a network.

IPSutil™ Ethernet Port Setup with DHCP

1. Connect the appropriate RS232 cable from the PC hosting IPSutil to the target relay.
2. Launch IPSutil, then select **Ethernet** from the menu bar. IPSutil will display the Ethernet Settings screen Figure 4-43.
3. From the Ethernet Settings screen select Ethernet **Enable**.
4. Select DHCP Protocol **Enable**.
5. Select the desired protocol.
6. Select **Save**, IPSutil will respond with the Advance Setup dialog box stating "*It will take about 15 seconds to reset Ethernet board to allow the menu of the unit to reflect the change*."
7. Select **OK**, IPSutil will configure the ethernet board, then close the Ethernet Settings screen. The ethernet board is now configured for use and may be accessed through a network.

IPSutil™ Ethernet Port Setup without DHCP

1. Connect the appropriate RS232 cable from the PC hosting IPSutil to the target relay.
2. Launch IPSutil, then select **Ethernet** from the menu bar. IPSutil will display the Ethernet Settings screen Figure 4-43.

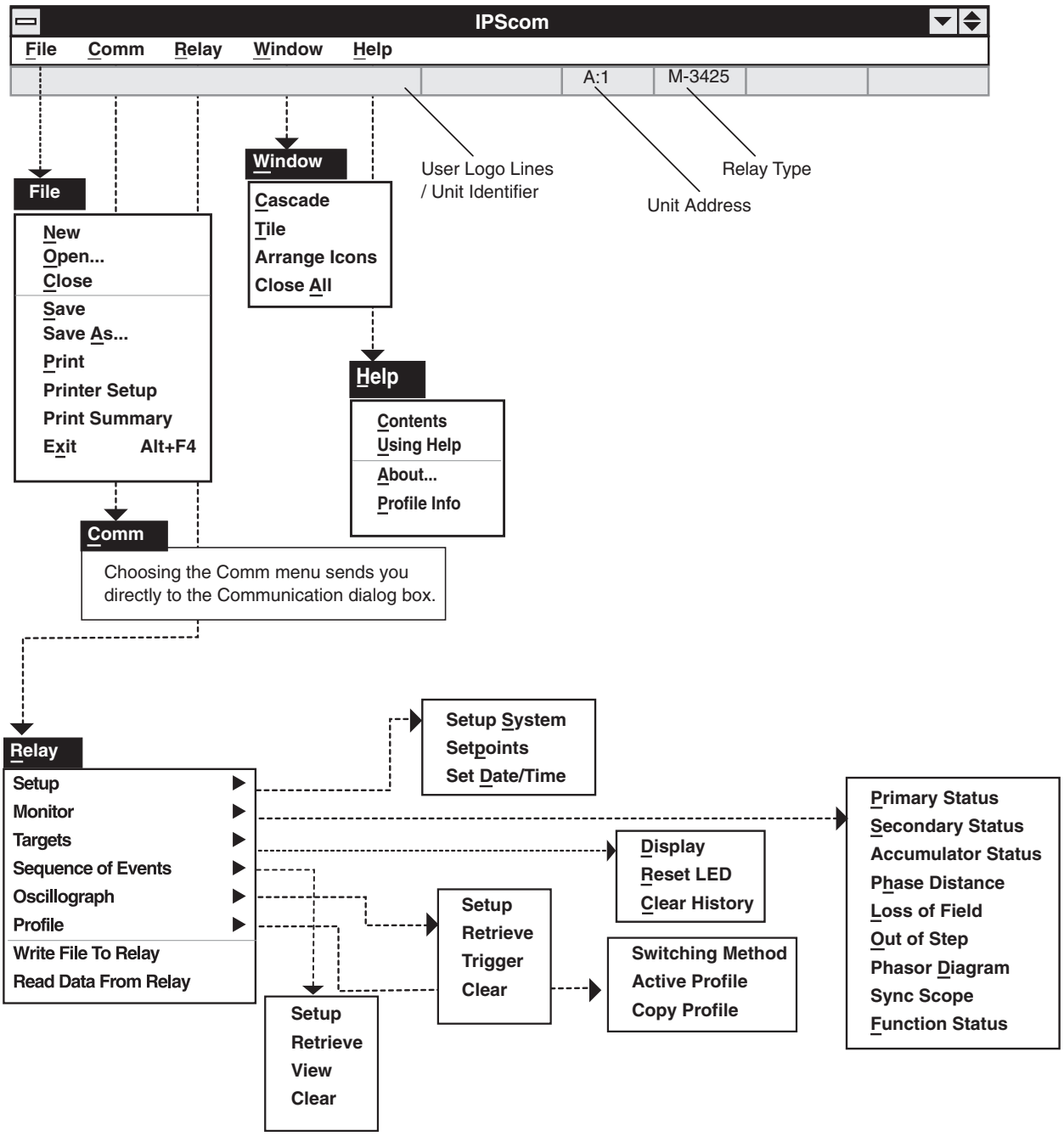


Figure 4-2 IPScom® Menu Selections

■ **NOTE**: Greyed-out menu items are for future release, and are not currently available.

3. From the Ethernet Settings screen select Ethernet **Enable**.
4. Select DHCP Protocol **Disable**.
5. Enter values for IP Address, Net Mask and Gateway.
6. Select the desired protocol.
7. Select **Save**, IPSutil will respond with the Advance Setup dialog box stating "*It will take about 15 seconds to reset Ethernet board to allow the menu of the unit to reflect the change*."
8. Select **OK**, IPSutil will configure the ethernet board, then close the Ethernet Settings screen. The ethernet board is now configured for use and may be accessed through a network.

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.

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

- An external modem (1200 baud or higher), capable of understanding standard AT commands.
- Serial modem cable with 9-pin connector for the unit and the applicable connector for the modem.

■ **NOTE**: Any compatible modem may be used; however, the unit only communicates at 1200 to 9600 baud.

Similarly, the computer running IPScom must also have access to an internal or external compatible modem.

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

1. Connecting the modem to the computer:
   a. If the computer has an external modem, use a standard straight-through RS-232 modem cable to connect the computer and modem (M-3933). If the computer has an internal modem, refer to the modem's instruction book to determine which communications port should be selected.
   b. The modem must be attached to (if external) or assigned to (if internal) the same serial port as assigned in IPScom. While IPScom can use any of the four serial ports (COM1 through COM4), most computers support only COM1 and COM2.
   c. Connect the modem to the telephone line and power up.
2. Connecting the Modem to the Relay:

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

   After programming, the modem will power up in the proper state for communicating with 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.

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

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

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

The following commands may also be required at the modem:

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

There are some variations in the AT commands supported by modem manufacturers. Refer to the hardware user documentation for a list of supported AT commands and direction on issuing these commands.

4.2 Installation and Setup (IPScom)

IPScom runs with the Microsoft Windows® 95 operating system or later. IPScom® only supports communication using the BECO 2200 protocol.

IPScom is available on CD-ROM, or it my be downloaded from our website at www.beckwithelectric.com

The M-3820D IPScom Communications Software package is not copy-protected and can be copied to a hard disk. For more information on your specific rights and responsibilities, see the licensing agreement enclosed with your software or contact Beckwith Electric.

Hardware Requirements

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

- 8 MB of RAM
- Microsoft Windows 95 or later
- CD-ROM drive
- one serial (RS-232) communication port
- pointing device (mouse)

Installing IPScom

1. Insert software CD-ROM into your drive.

   An Auto-Install program will establish a program folder (Becoware) and subdirectory (IPScom). After installation, the IPScom program item icon (see Figure 4-3) is located in Becoware. The default location for the application files is on drive C:, in the new subdirectory "IPScom" (C:\Becoware\Ipscom).

2. If the Auto-Install program does not launch when the CD-ROM is inserted into the drive then proceed as follows:

   a. Select Run from the Start Menu.

   b. In the Run dialog box, locate the installation file contained on the installation disk (sfi_m3425Acom_V_____.exe).

   c. Select Run to start the installation process.

Figure 4-3 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 automatically installed in the Becoware folder, along with the IPScom files, and does not require separate installation.

4.3 Operation

Activating Communications

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

1. Choose the IPScom icon from the Becoware folder.

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

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

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

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

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

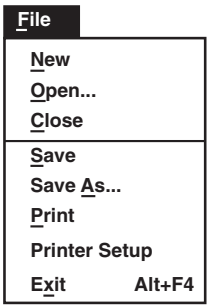
5. To end communication when communicating by modem, choose the **Hang Up** command button from the expanded Communication dialog box. To close the communication channel when connected locally, choose the **Close COM** command button.

Overview

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

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

File Menu



The **File** menu enables the user to create a new data file, open a previously created data file, close, print, and save the file. The IPScom program can also be exited through the **File** menu.

Since IPScom can be used with several Beckwith protection systems in addition to the M-3425A Generator Protection Relay, the format and contents of a file must be established depending on which protective system is being addressed. When not connected to one of the protection systems, using the **New** command, a new file is established with the New Device Profile dialog box (see Figure 4-4). Choosing the **OK** command button allows the new data file to be named by using the **Save** or **Save As**... commands.

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

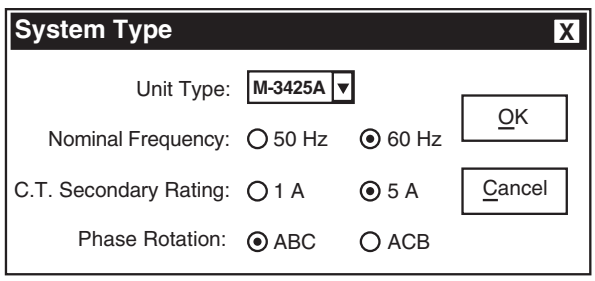


Figure 4-4 New Device Profile Dialog Box

Path: File menu / New command

COMMAND BUTTONS

OK Saves the currently displayed information.

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

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

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

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

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

Comm Menu

The Communication dialog box (see Figure 4-5) allows setup of the IPScom communication data to coordinate with the relay and by choosing the **Modem** button, to 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 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 be displayed showing Access Level #3 was granted. Otherwise, another dialog box will appear to prompt the user to enter the access code in order to establish the communication. **Close COM** discontinues communication.

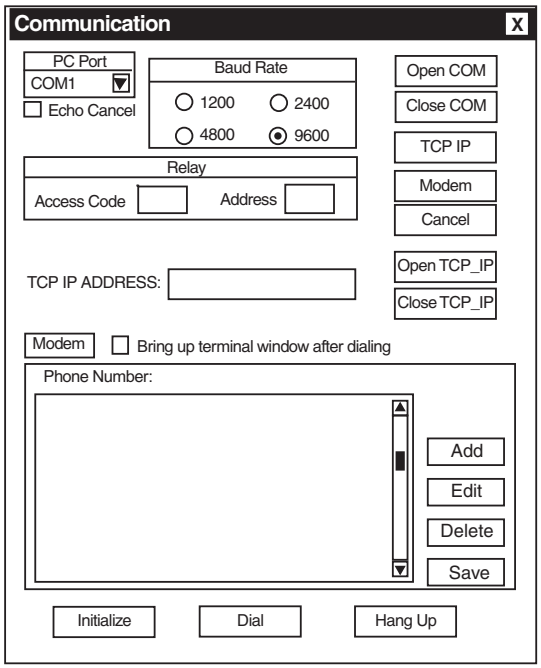


Figure 4-5 Communication Dialog Box

Path: Comm menu

COMMAND BUTTONS

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

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

TCP_IP Opens the ethernet applicable communication screen selections to allow user to enter a TCP_IP address (if necessary), and opening and closing communication with the target relay.

Modem Displays the expanded Communication dialog box.

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

Open TCP_IP Initiates contact with the protective system by ethernet connection.

Close TCP_IP Closes Ethernet connection.

Bring Up Terminal Window After Dialing When selected, following connection to the target modem, allows the user to send commands to the modem.

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

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

Delete Deletes a selected entry.

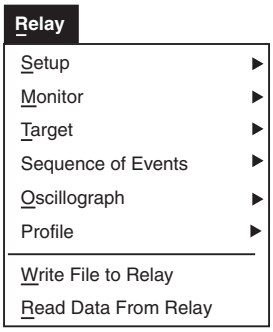
Save Saves any changes to the displayed information

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

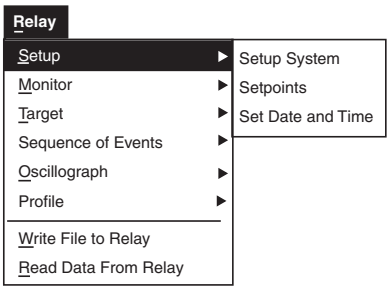
Dial Dials the entry selected from the directory.

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, or interrogate the relay. Six submenus are provided: **Setup, Monitor, Target** , **Sequence of Events**, **Oscillograph** and **Profile** as well as two commands, **Write File to Relay,** and **Read Data From Relay**.



The **Setup** submenu provides three commands: **Setup System**, **Setpoints**, and **Set Date/Time**. The **Setup System** command displays the Setup System dialog box (Figure 4-6) allowing the input of the pertinent information regarding the system on which the protective relay is applied (see Section 2.1, **Configuration**, Relay System Setup).

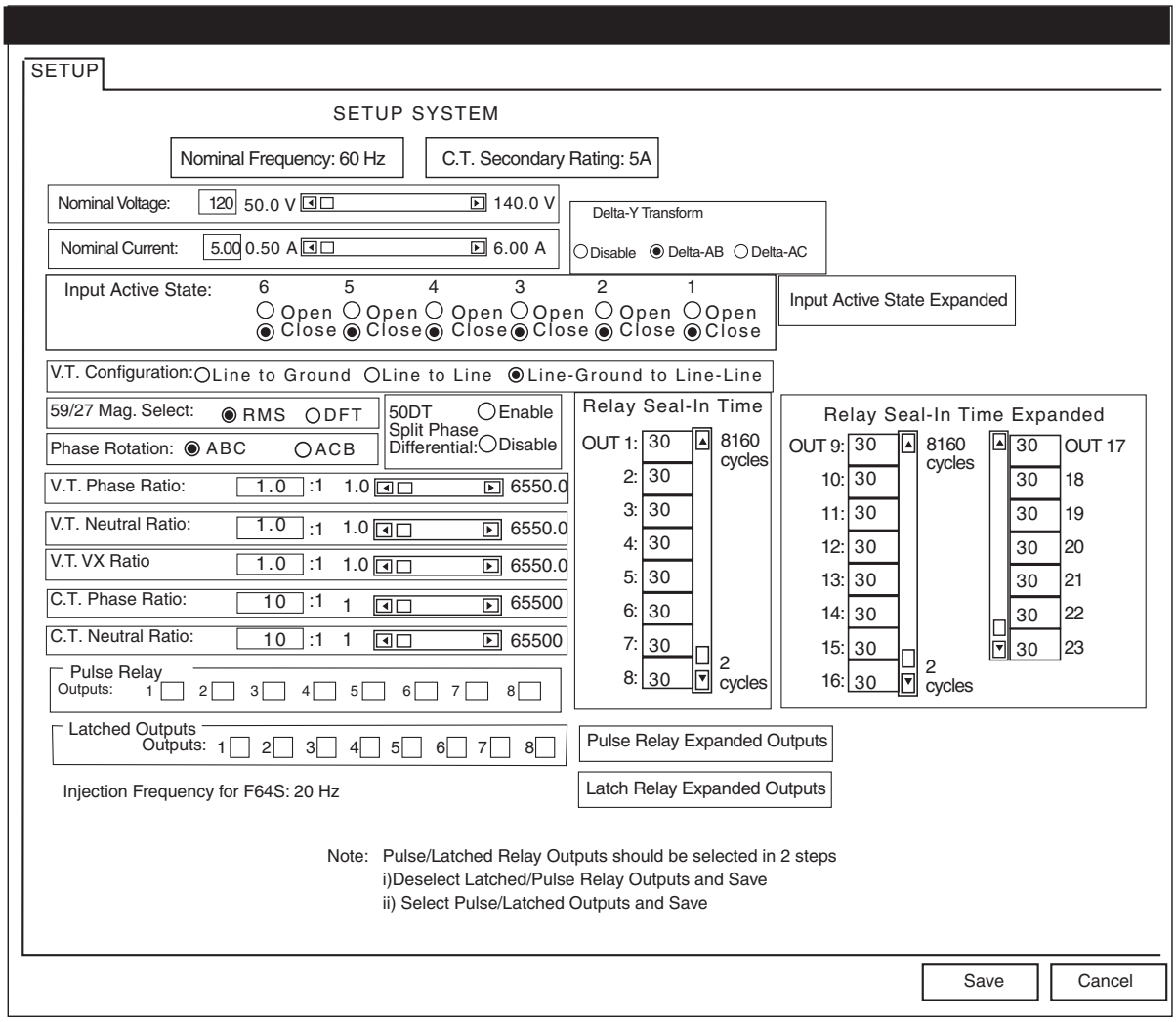


Figure 4-6 Setup System Dialog Box

Path: Relay menu / Setup submenu / Setup System command

COMMAND BUTTONS

Input Active State Expanded When the unit is equipped with expanded I/O, this command opens the Expanded Input Active State screen (Figure 4-7), to allow the selection of Expanded Inputs 7 through 14.

Pulse/Latch Relay Expanded Outputs When the unit is equipped with expanded I/O, this command opens the Pulse/Latch screen (Figures 4-8 and 4-9) to allow the selection of expanded outputs 9 through 23.

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

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

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

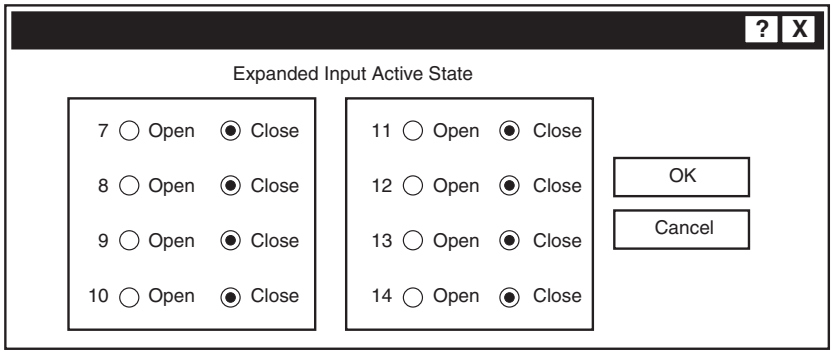


Figure 4-7 Expanded Input Active State

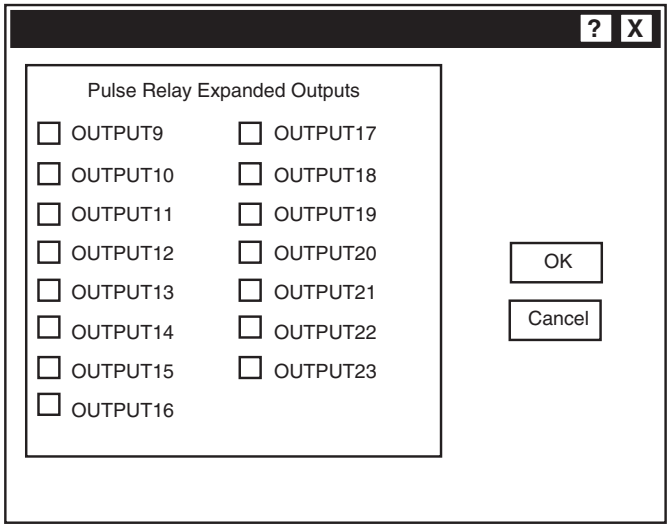


Figure 4-8 Pulse Relay Expanded Output Screen

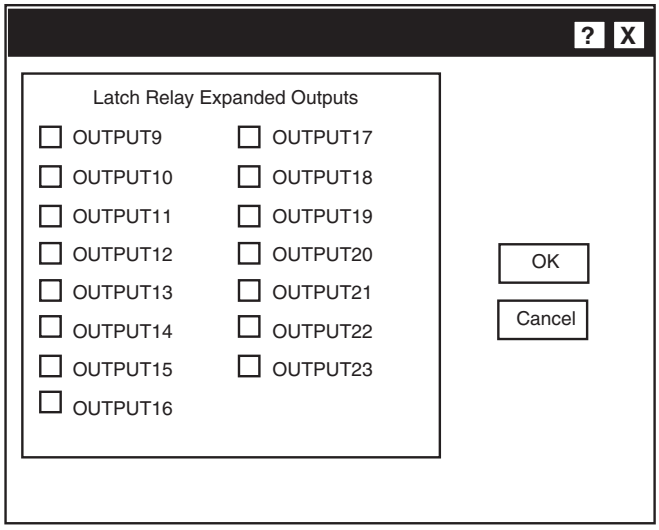


Figure 4-9 Latch Relay Expanded Output Screen

The **Setpoints** command displays the Relay Setpoints dialog box (see Figure 4-10) from which the individual relay function dialog boxes can be accessed. Choosing a Relay function button will display the corresponding function dialog box (see Figure 4-11 for example).

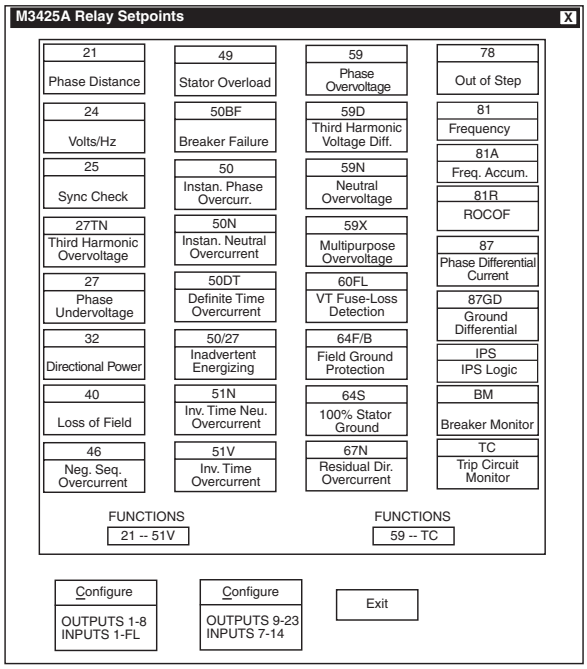


Figure 4-10 Relay Setpoints Dialog Box

Path: Relay menu / Setup submenu / Setpoints window

COMMAND BUTTONS

Functions Opens the All Setpoints Table dialog box for the specified range of functions.

Configure Opens the Configure dialog box.

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

The Relay Setpoints dialog box gives access to two additional dialog boxes: All Setpoints Table and Configure.

Choosing either of the **Functions** command buttons (either **21–51V** or **59–TC**) displays an All Setpoints Table dialog box for the specified range of setpoints (see Fig. 4-13). This dialog box contains a list of settings for each relay within a single window to allow scrolling through all relay setpoint configuration values. Choosing the **Configure** command button displays the Configure dialog box (see Fig. 4-14), which contains a chart of programmed input and output contacts, in order to allow scrolling through all relay output and blocking input configurations. Both dialog boxes (All Setpoint Table and Configure), feature hotspots which allows the user to jump from a scrolling dialog box to an individual relay function dialog box and return to the scrolling dialog box again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog box from either scrolling dialog box.

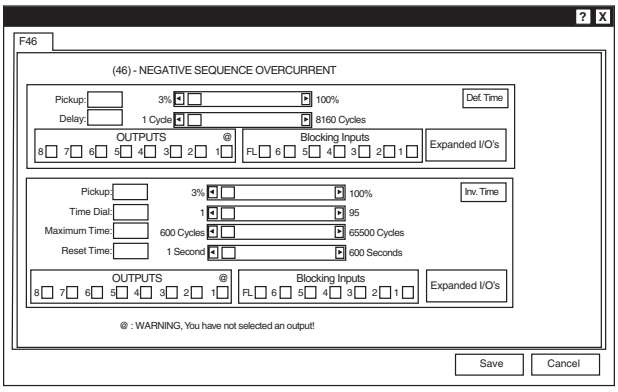


Figure 4-11 Typical Setpoint Dialog Box

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

COMMAND BUTTONS

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

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

Expanded I/O's When the unit is equipped with expanded I/O, this selection allows the user to select expanded outputs 9–23 and expanded inputs 7–14.

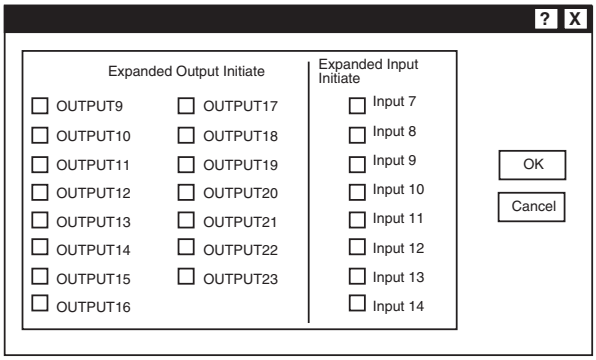


Figure 4-12 Expanded I/O Initiate

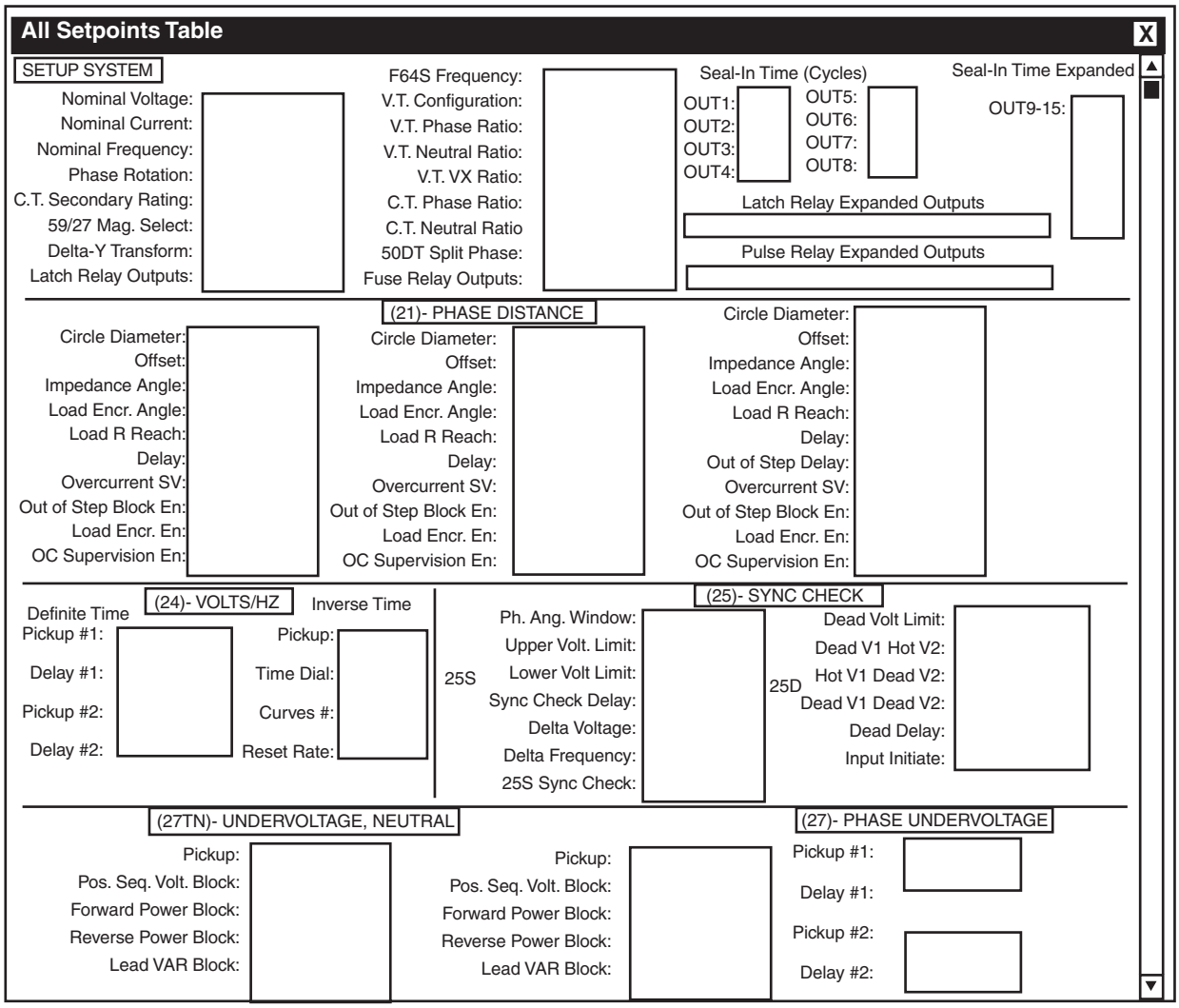


Figure 4-13 All Setpoints Table Dialog Box (partial)

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

JUMP HOTSPOTS

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

CONTROL MENU

Close Returns you to the Relay Setpoints dialog box.

Move Allows you to reposition the dialog box.

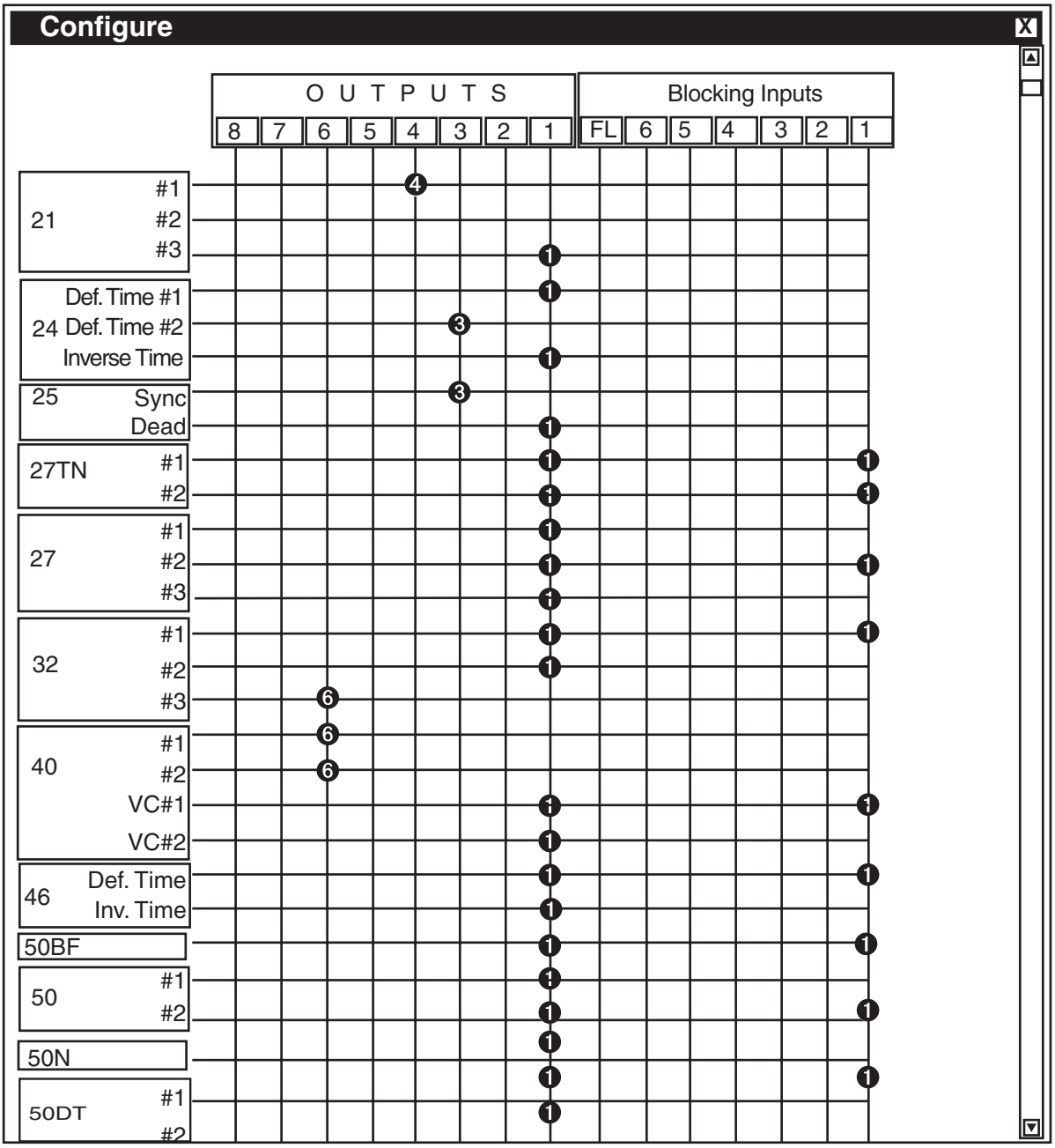


Figure 4-14 Configure Dialog Box (partial)

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

JUMP HOTSPOTS

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

CONTROL MENU

Close Returns you to the Relay Setpoints dialog box.

Move Allows you to reposition the dialog box.

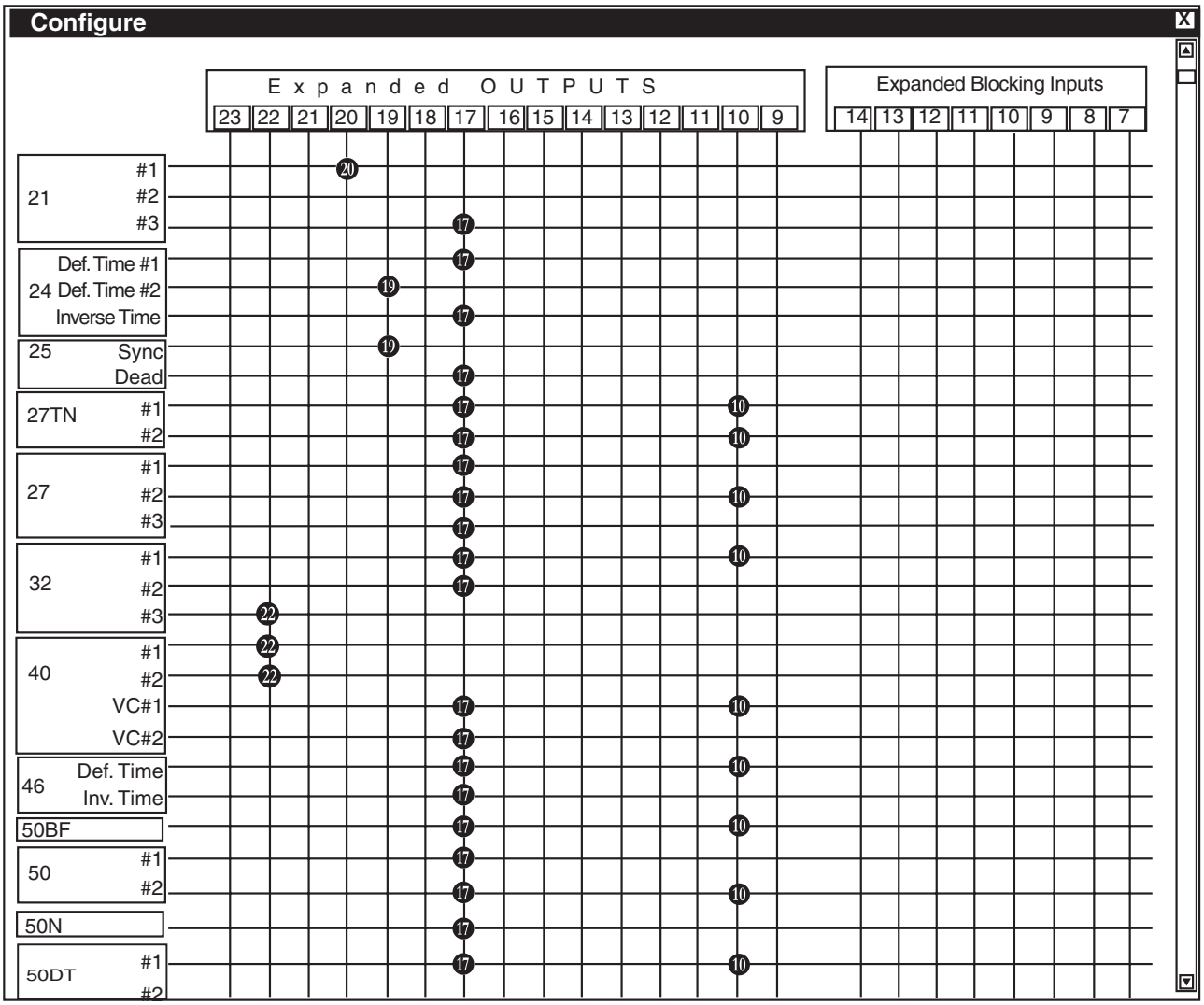


Figure 4-15 Configure Dialog Partial (Shown with Expanded Input/Outputs)

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

JUMP HOTSPOTS

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

CONTROL MENU

Close Returns you to the Relay Setpoints dialog box.

Move Allows you to reposition the dialog box.

The **Set Date/Time** command (see Figure 4-16) allows the system date and time to be set, or system clock to be stopped. This dialog box also displays an LED mimic to identify when the Time Sync is in use (preventing date/time from being changed by user).

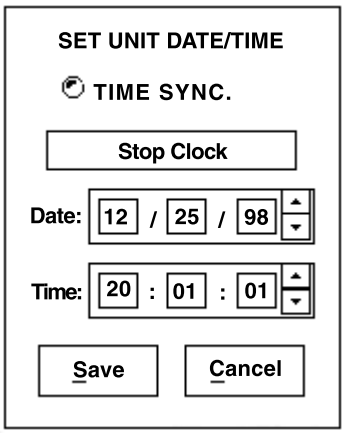


Figure 4-16 Unit Date/Time Dialog Box

Path: Relay menu/ Setup submenu/ Set Date/Time Command

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

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

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

COMMAND BUTTONS

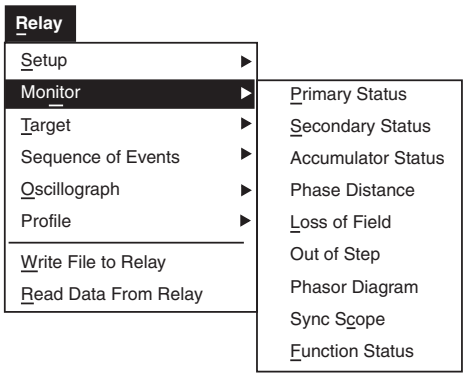
Stop Clock This toggles between start/stop, the relay clock. 'Stop' pauses, 'Start' resumes.

Save Saves Time and Date settings to the relay when applicable.

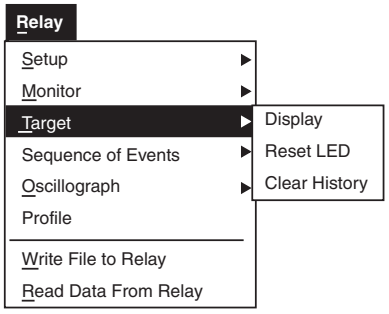
Cancel Returns you to the IPScom® main window. Any changes to the displayed information is lost.

The **Monitor** submenu provides access for reviewing the present status of the 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 4.4, Checkout Status/Metering). A cascading menu appears, providing several command options as shown below.

■ **NOTE**: Displayed parameters in status screens will vary depending on unit configuration.



The **Targets** submenu provides three command options: **Display**, **Reset LED**, and **Clear History**. The **Display** command displays the **Target** Dialog. This dialog box (see Figure 4-17) provides detailed data on target events, including time, date, function status, phase current values, and IN/OUT contact status at the time of trip. Individually recorded events may be selected within the dialog box and saved into a text file, or be printed out with optional added comments. The **Reset LED** is similar to pushing the **Target Reset** button on the relay's front panel, resetting current target(s) displayed on the relay. This command does not reset any target history.



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

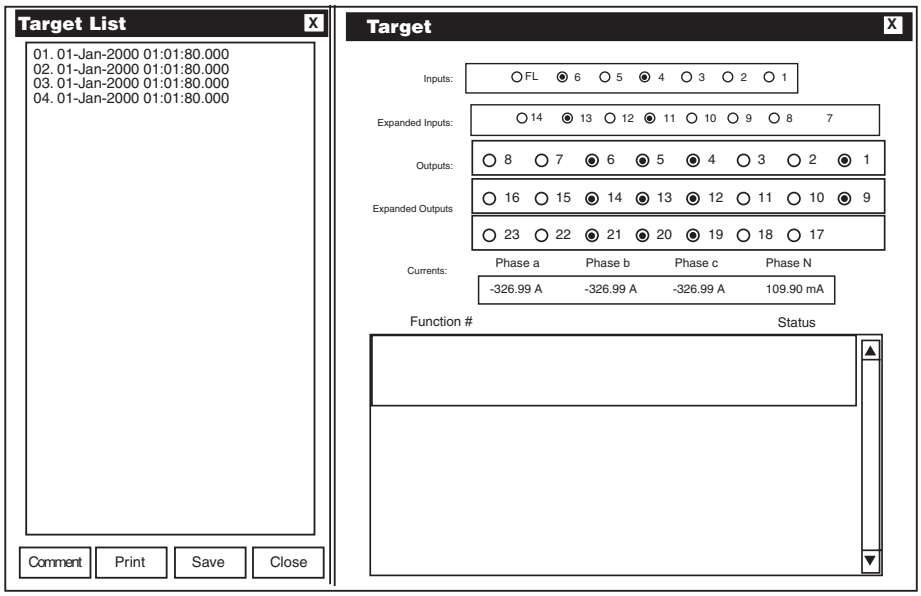


Figure 4-17 Target Dialog Box

Path: Relay menu / Targets submenu / Display window

Time is displayed in milliseconds.

COMMAND BUTTONS

Comment Opens comment dialog box for annotation.

Print Prints out selected target information, with comment.

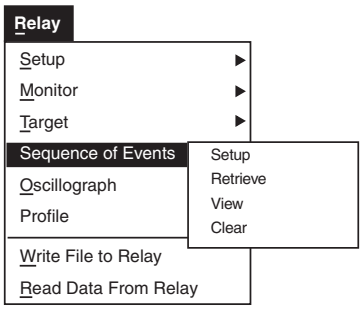
Save Saves selected target information, with comment, as a text file.

Close Exits the currently displayed dialog box.

Sequence of Events

The Sequence of Events function provides a time stamped history of the Pickup (PU), Trip (TR) or Dropout (DR) for each element, input or output selected in the Event Trigger Setup screen.

During each event the voltage, current, impedance, frequency, input and output status and Volts/Hz are recorded. Up to 512 events are logged before the buffer begins to write over the oldest event. If multiple events occur, then the log entries are recorded with one millisecond resolution within each event.



The **Sequence of Events** submenu allows the user to **Setup** the events that trigger the Sequence of Events recorder, **Retrieve** events from the relay, **View** the pararmeters captured at the time of the event and **Clear** the event recorder.

The **Setup** menu item displays the Event Trigger Setup screen Figure 4-18. Protective function Pickup, Trip, Dropout and/or Output/Input Pickup or Dropout are selected to trigger the Sequence of Events Recorder.

The **Retrieve** command downloads the events from the currently connected relay (events must be retrieved from the relay and stored in a file in order to view them.)

View permits the user to see a detailed list of past events and their corresponding captured parameters (real power, reactive power, differential current, delta voltage, delta frequency, phase angle, 59D ratio, V brush (64B), field insulation resistance (64F), Vstator (20 Hz), and Istator (20 Hz) which are displayed in the Event Log Viewer screen Figure 4-19.

The event log viewer screen includes the commands **Open**, **Close**, **Print Summary**, and **Print Detail**. **Open** opens a saved sequence of events file. **Close** closes the print file. **Print Summary** prints an event summary, and **Print Detail** prints the detailed event report. **Clear** deletes event history from the control.

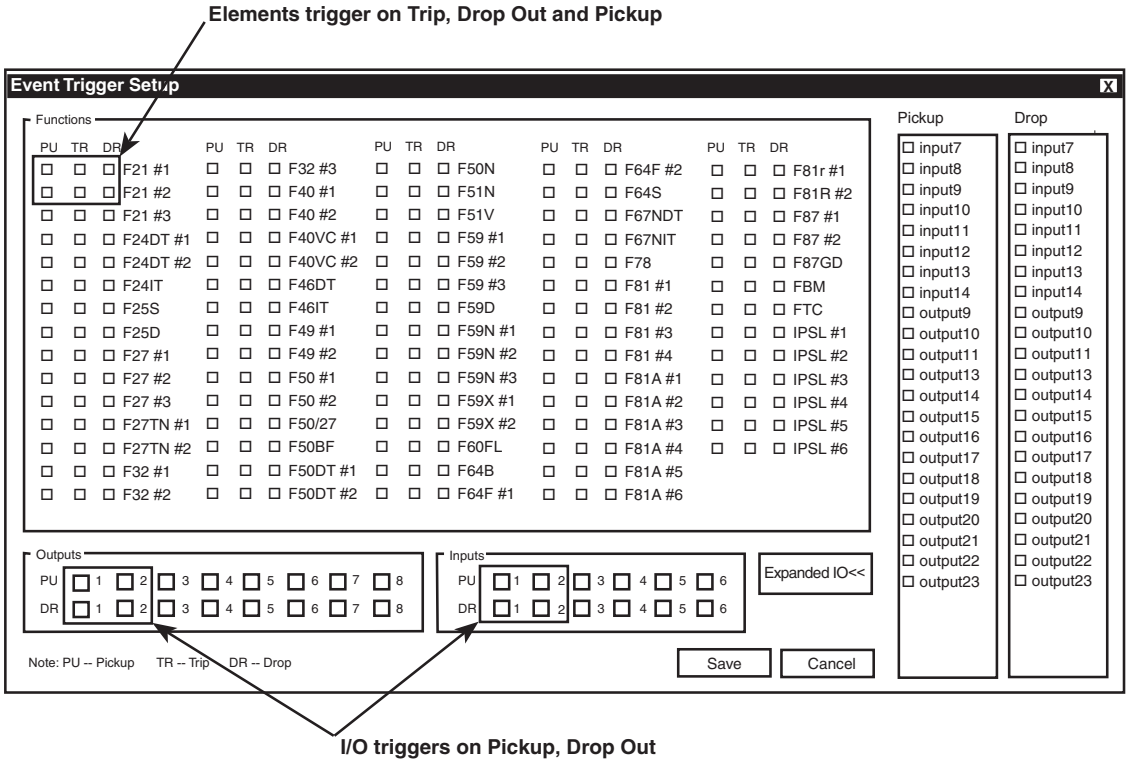


Figure 4-18 Trigger Events Screen with Expanded I/O

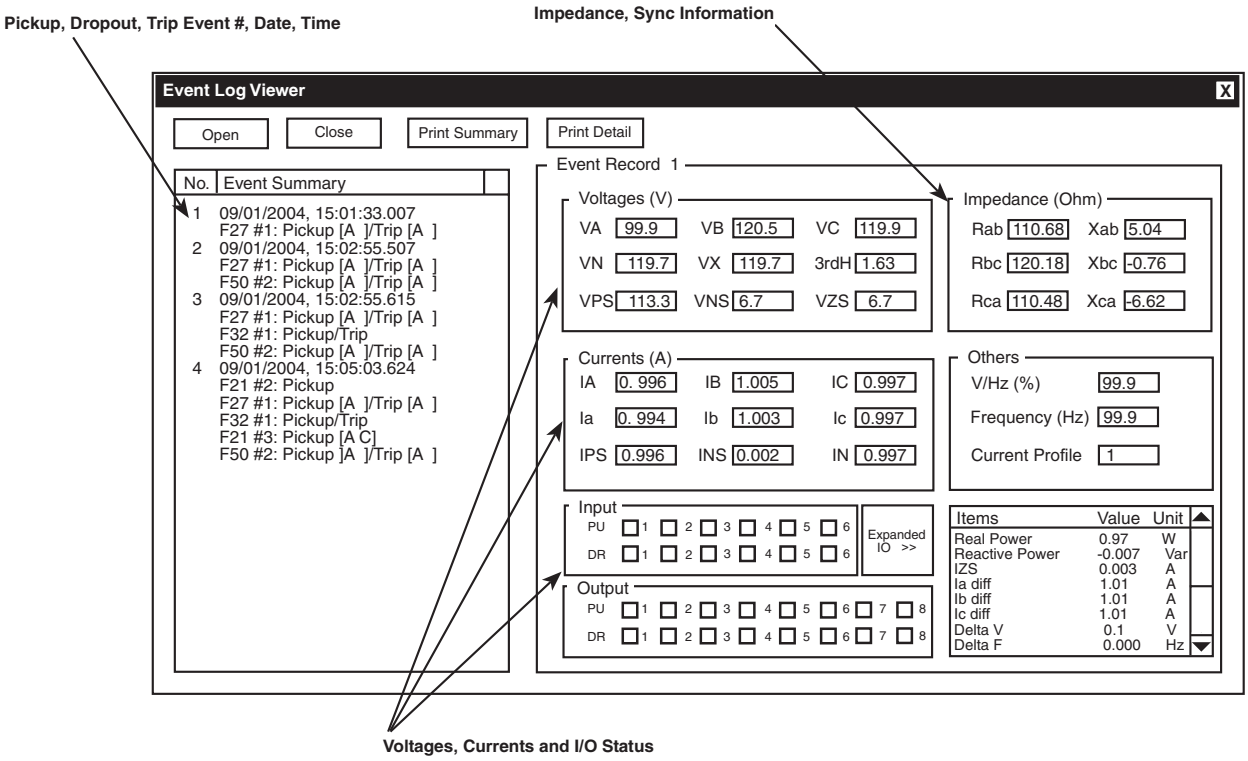


Figure 4-19 Event Log Viewer

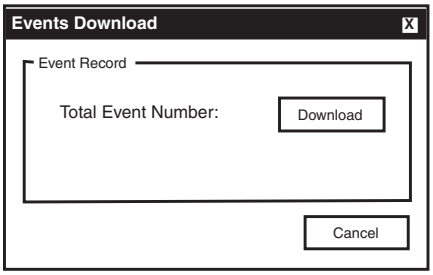
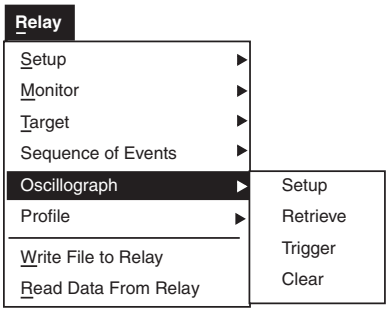


Figure 4-20 Event Download Screen



The **Oscillograph** submenu allows storing data on selected parameters for review and plotting at a later time. The **Setup** command allows the user to set the number of partitions and triggering designations to be made (see Table 3-1, Recorder Particitions). The **Retrieve** command downloads and stores collected data to a file; **Trigger** allows the manual triggering of the recorder; **Clear** erases the existing records. Run the optional M-3801D IPSplot® *PLUS* Oscillograph Analysis Software program to view the downloaded oscillograph files.

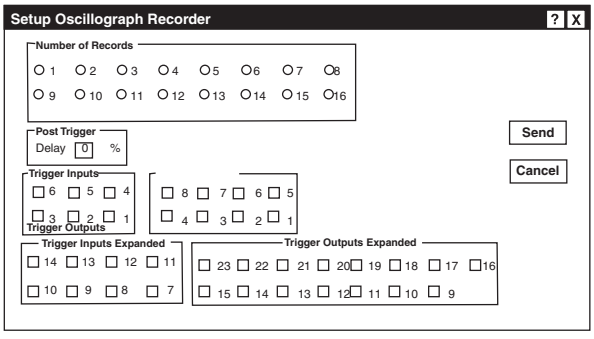


Figure 4-21 Setup Oscillograph Recorder

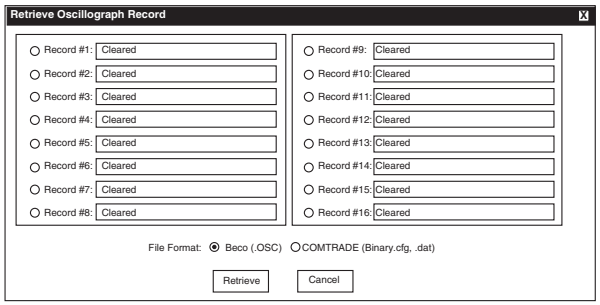
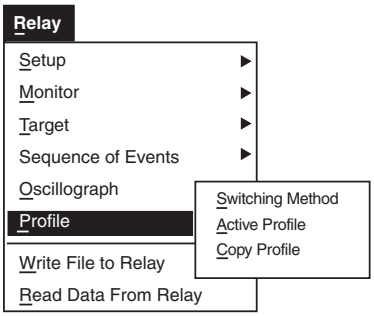


Figure 4-22 Retrieve Oscillograph Record Dialog



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 2 minutes for copying.)

▲ **CAUTION**: Switching the active profile when the relay is on-line may cause unexpected operation if the wrong profile is selected.

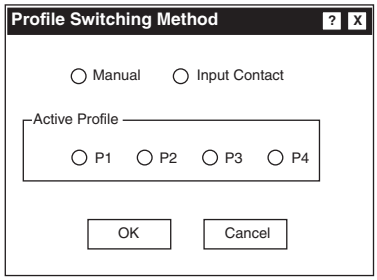


Figure 4-23 Profile Switching Method Dialog

■ **NOTE**: During Profile Switching, relay operation is disabled for approximately 1 second.

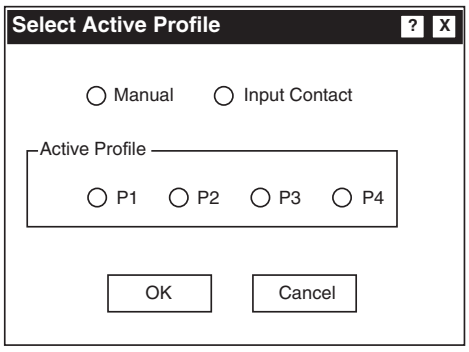


Figure 4-24 Select Active Profile

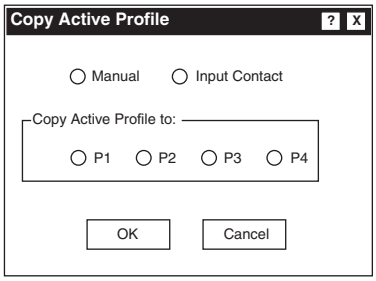
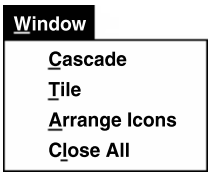


Figure 4-25 Copy Active Profile

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

Window Menu/Help Menu



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

Currently in revision, the **Help** menu will enable the user to look up information about any IPScom menus or commands. Though displaying (greyed-out) **Help** commands, this menu item is currently unavailable.

The **Help** menu provides three 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-3425A 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. The **About** command displays IPScom version and development information. **Profile Info** displays user infromation for input and editing.

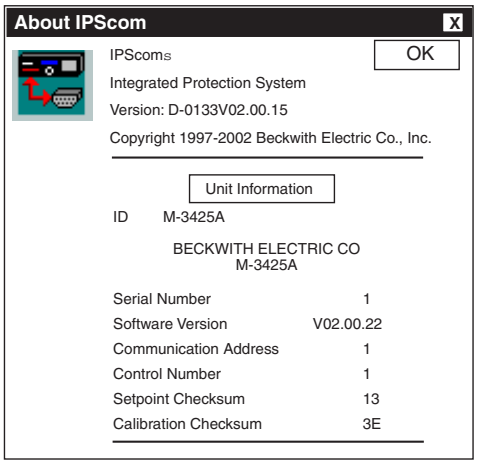


Figure 4-26 About IPScom Dialog Box

4.4 Checkout Status/Metering

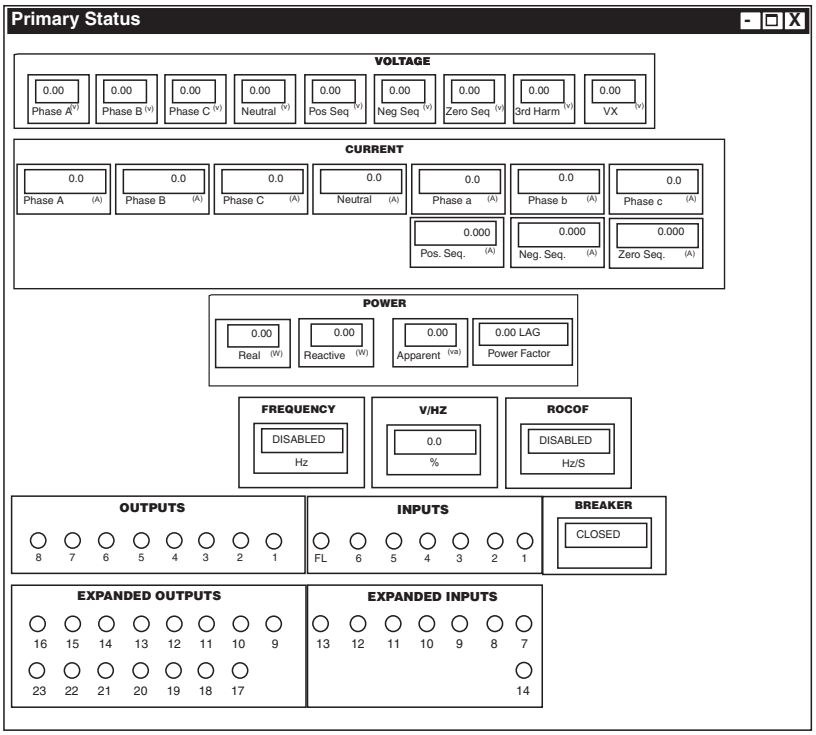


Figure 4-27 Primary Status Dialog Box

Path: Relay menu/ Monitor submenu/ Primary Status window

These are calculated values based on the VT and CT inputs.

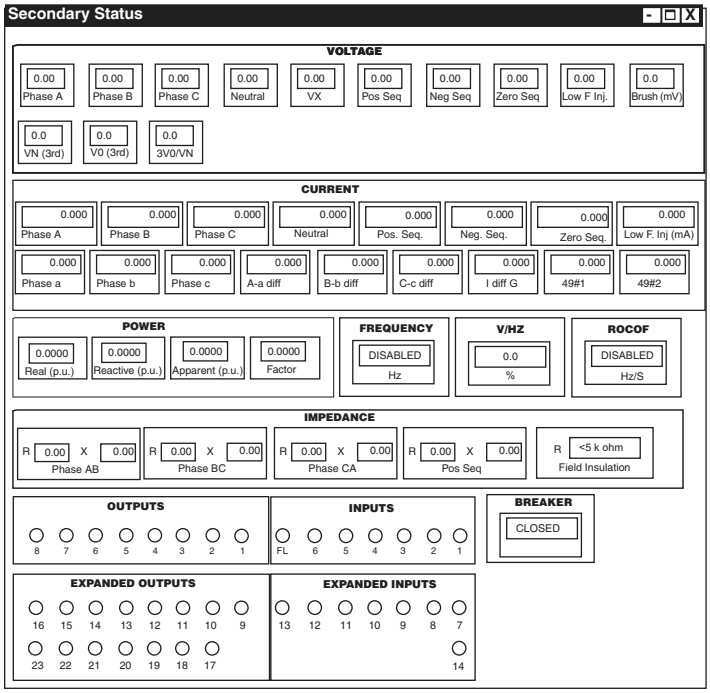


Figure 4-28 Secondary Status Dialog Box

Path: Relay menu/ Monitor submenu/ Secondary Status window

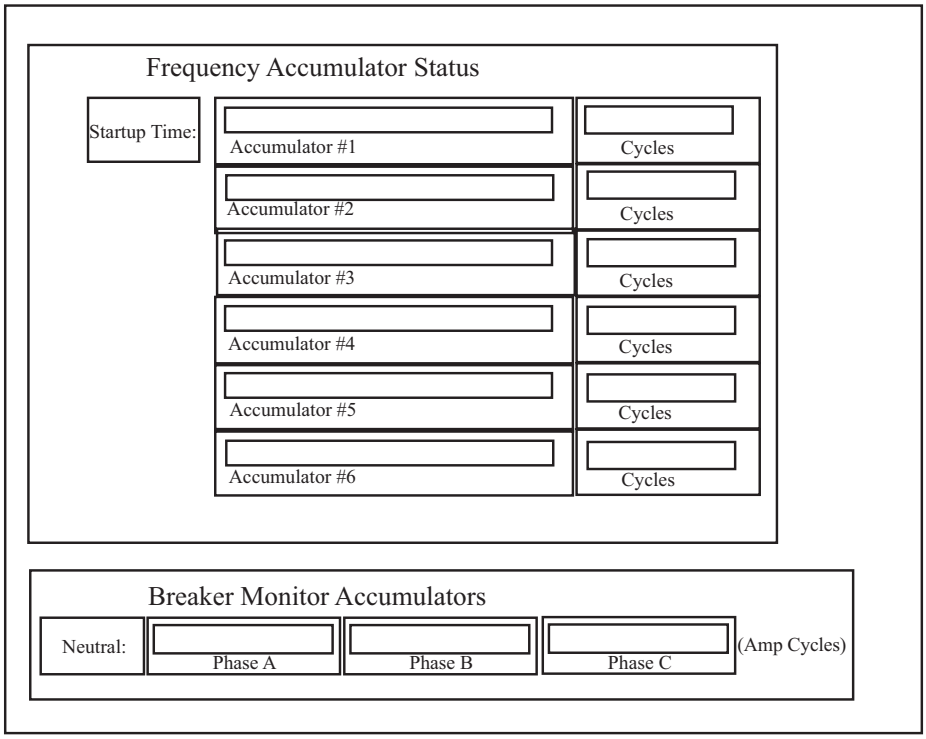


Figure 4-29 Accumulator Status Screen

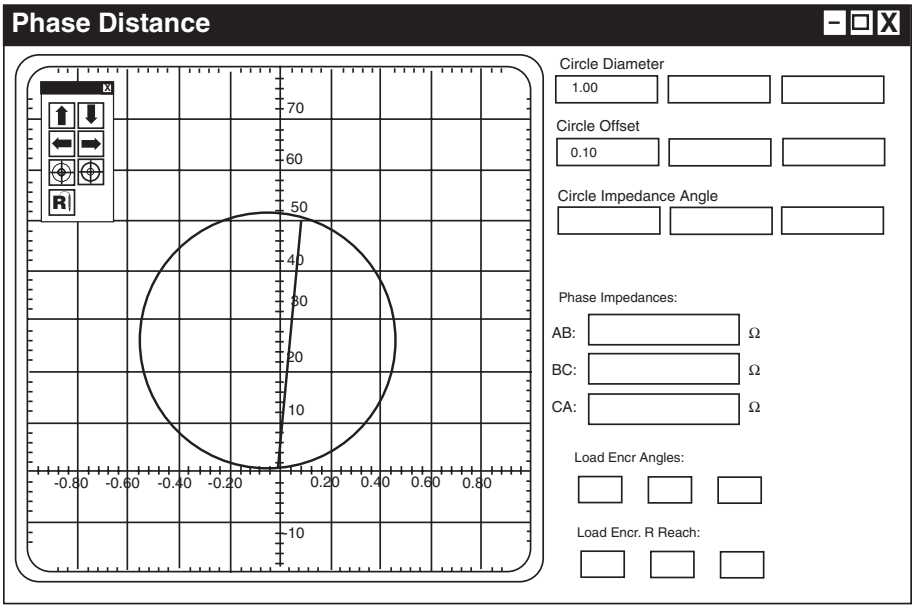


Figure 4-30 Phase Distance Dialog Box

Path: Relay menu / Monitor submenu / Phase Distance window

Phase Distance window shows a graphic representation of phase distance settings.

CONTROL BUTTONS

- Move up the scope window
- Move down the scope window
- Move the scope window to the left
- Move the scope window to the right
- Zoom In
- Zoom Out
- Refresh Scope

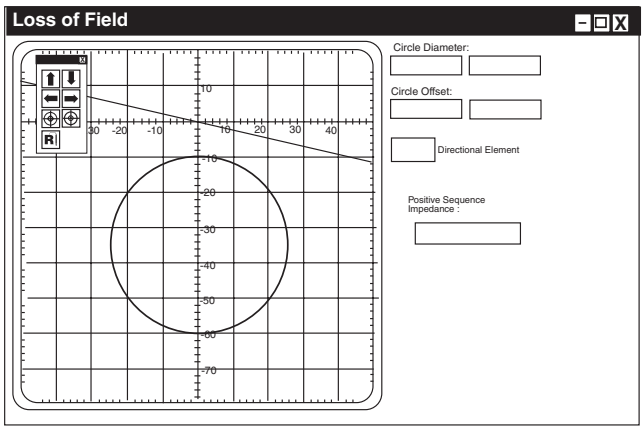


Figure 4-31 Loss of Field Dialog Box

Path: Relay menu / Monitor submenu / Loss of Field window

Loss-of-Field window shows a graphic representation of loss-of-field settings, and also displays the positive sequence impedance.

CONTROL BUTTONS

- Move up the scope window
- Move down the scope window
- Move the scope window to the left
- Move the scope window to the right
- Zoom In
- Zoom Out
- Refresh Scope

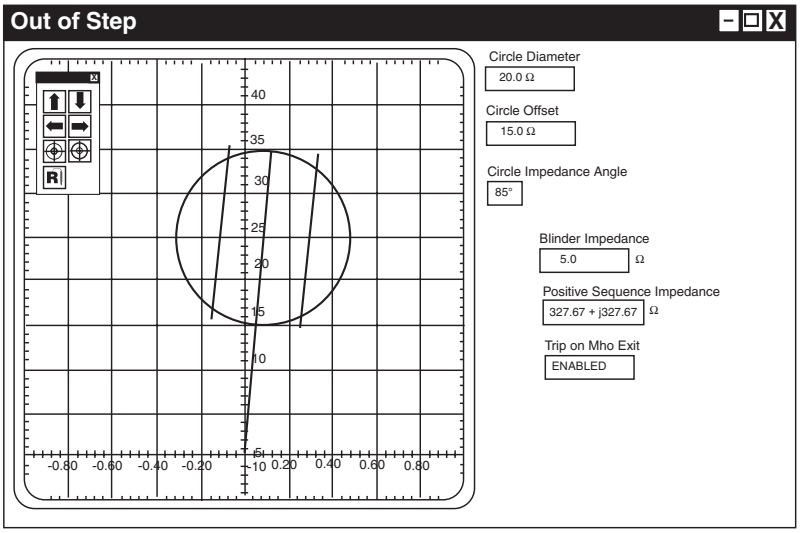


Figure 4-32 Out-of-Step Dialog

Path: Relay menu / Monitor submenu / Out-of-Step window

CONTROL BUTTONS

- Move up the scope window
- Move down the scope window
- Move the scope window to the left
- Move the scope window to the right
- Zoom In
- Zoom Out
- Refresh Scope

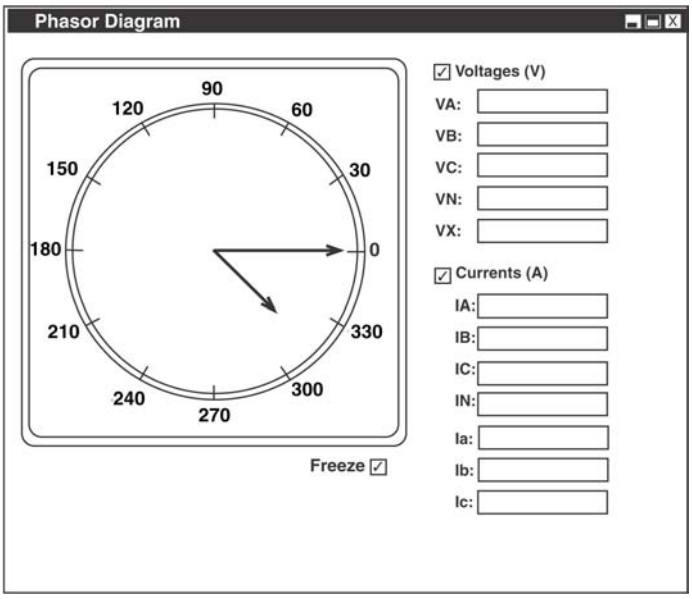


Figure 4-33 Phasor Dialog Box

Path: Relay menu / Monitor submenu / Phasor Diagram window

CONTROL BUTTONS

- ❒ Voltage Toggle & display voltage channel information
- ❒ Currents (A) Toggle & display current channel information.
- ❒ Freeze Toggle & update information

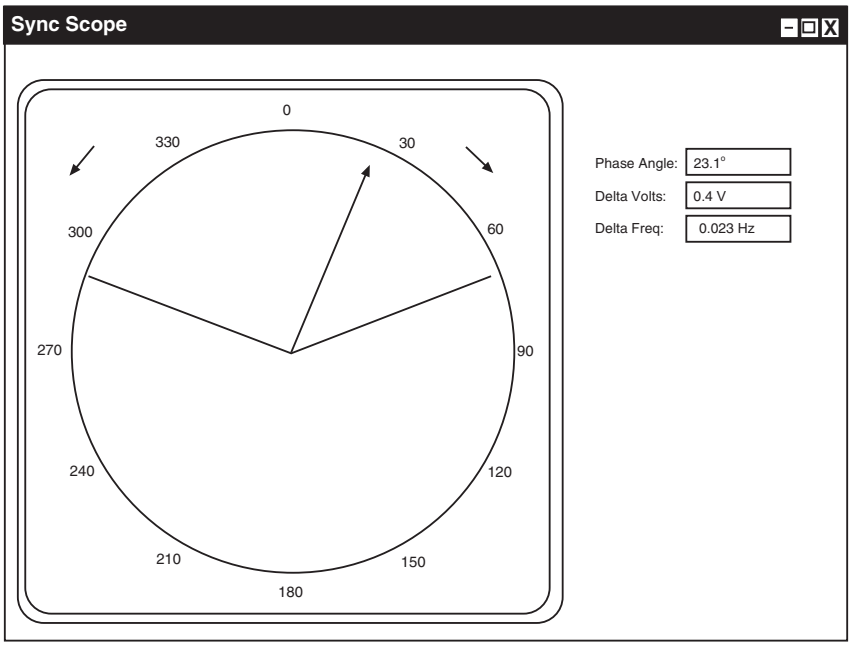


Figure 4-34 Sync Scope Screen

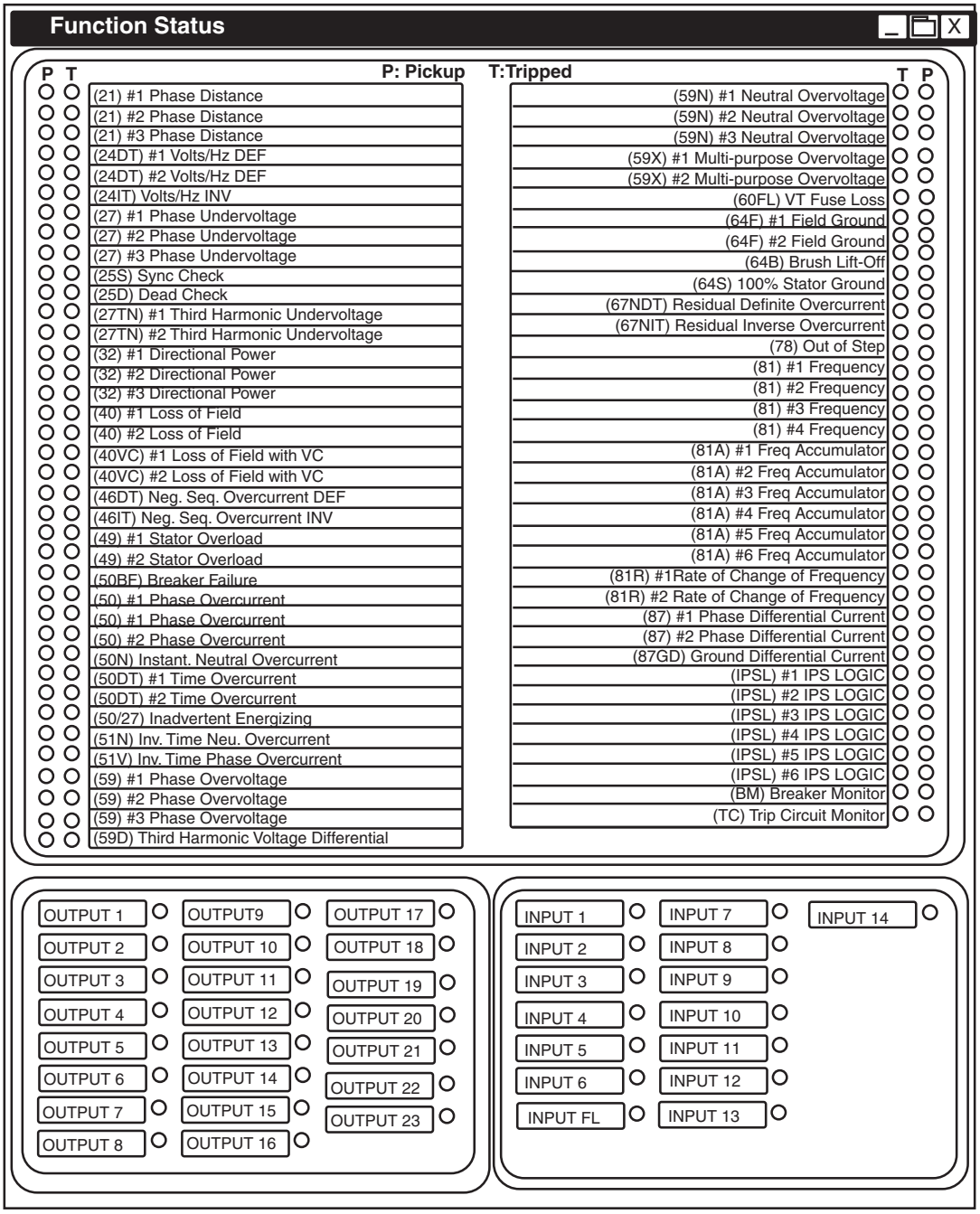


Figure 4-35 Function Status Screen

Path: Relay menu / Monitor submenu / Function Status window

Function Status window shows the status of various functions, with “T” representing the function which has tripped, and “P” representing the function which has picked up and is timing.
Path: Help menu / About... command

COMMAND BUTTONS

OK Exits the currently displayed dialog box.

The **Profile Info** command will allow the user to view or make notations for the relay setpoint data files.

4.5 Cautions

System and IPScom® Compatibility

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

System Priority

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

Time and Date Stamping

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

Echo Cancel

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

Serial Port Connections

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

4.6 Keyboard Shortcuts

Keyboard Shortcuts

SYSTEM KEYS

These keys can be used within Microsoft Windows® and IPScom®.

Alt-Tab	To switch between applications.
Ctrl-Esc	To open Task List dialog box. Opens Start Menu (Win 95/98).
Ctrl-Tab	To switch between windows within an application.
Arrow Keys	To select an application or group icon.
First Character of Name	To select application or group icon.
Enter	To open selected group or run selected application.

MENU KEYS

These keys enable you to select menus and choose commands.

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

DIALOG BOX KEYS

These keys are useful when working in a dialog box.

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

Table 4-2 Microsoft Windows Keyboard Shortcuts

4.7 IPSutil™ Communications Software

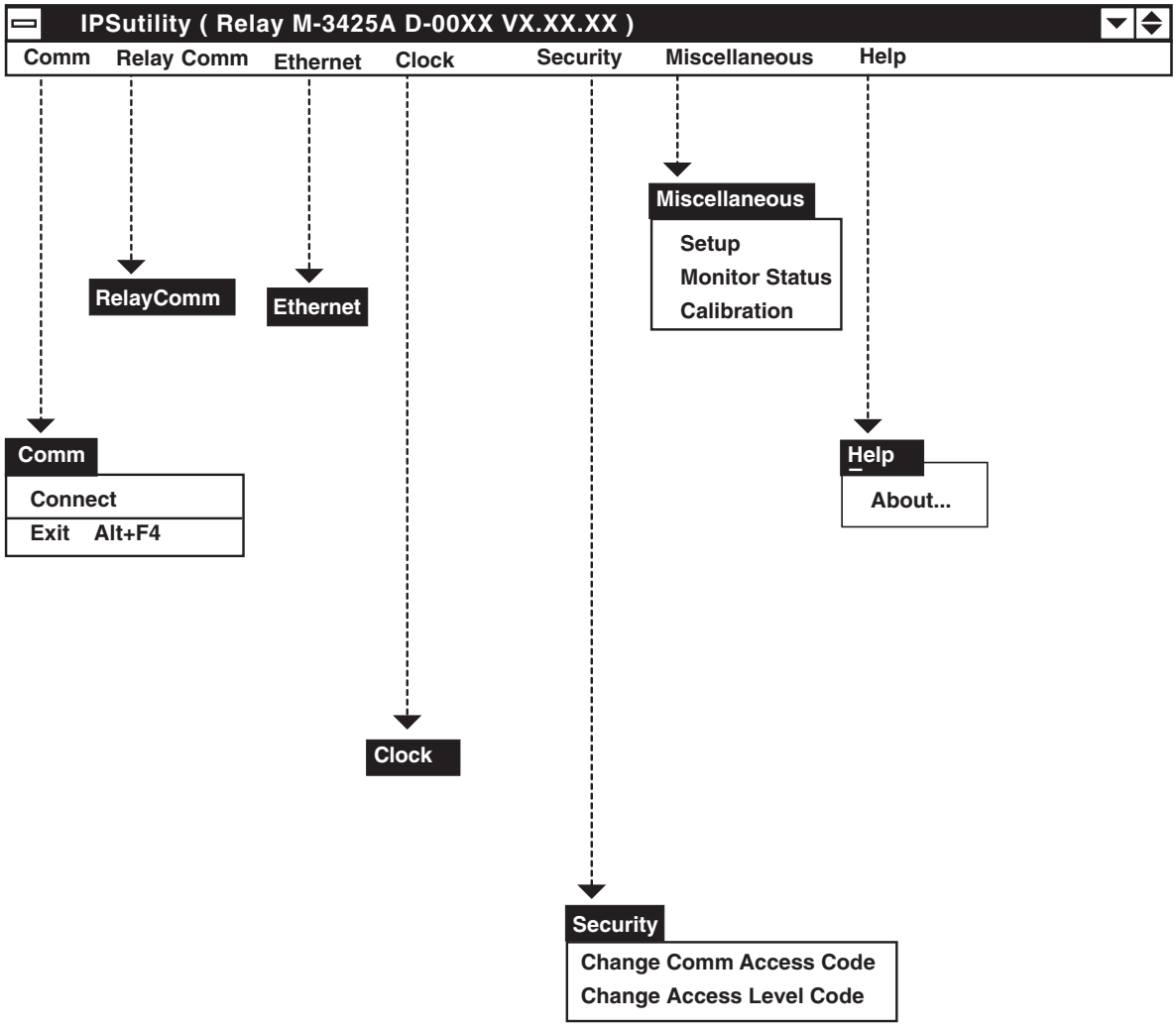


Figure 4-36 IPSutil Main Menu Flow

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:

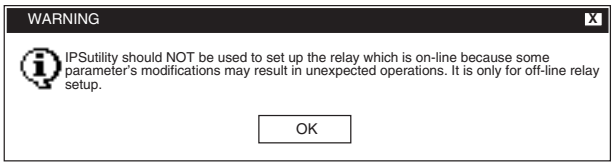
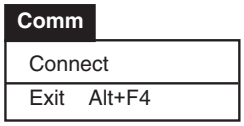


Figure 4-37 Warning Message

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

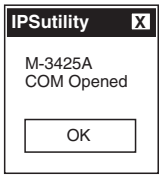
Comm Menu



The **Comm** menu allows the user to make connections to the relay. This is the first command the user must use to access the unit. After the user selects the **Connect** submenu item, the Communications dialog box appears (See Figure 4-41).

- 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.
- Select "Open com".

The following message window will be displayed 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.

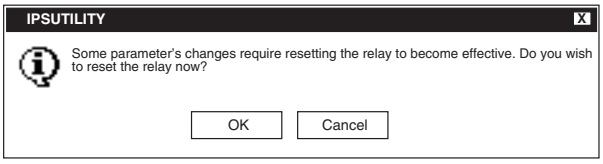


Figure 4-38 IPSutility Reset Relay Message

Relay Comm Command

When **Relay Comm** command is selected, the Relay Comm Port Settings dialog box appears (See Figure 4-42). 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

Ethernet Command

When the Ethernet command is selected, the Ethernet Settings dialog box appears (see Figure 4-43.) This command allows the user to enable or disable the ethernet connection and enable/set protocols.

Clock Command

When the **Clock** command is selected, the "Set Unit Date/Time" dialog box appears (See Figure 4-44). 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

Security

Change Comm Access Code
Change Level Access Code

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

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 4-45).

■ **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 4-46).

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

Miscellaneous Menu

Miscellaneous

Setup
Monitor Status
Calibration

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 4-47).

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.

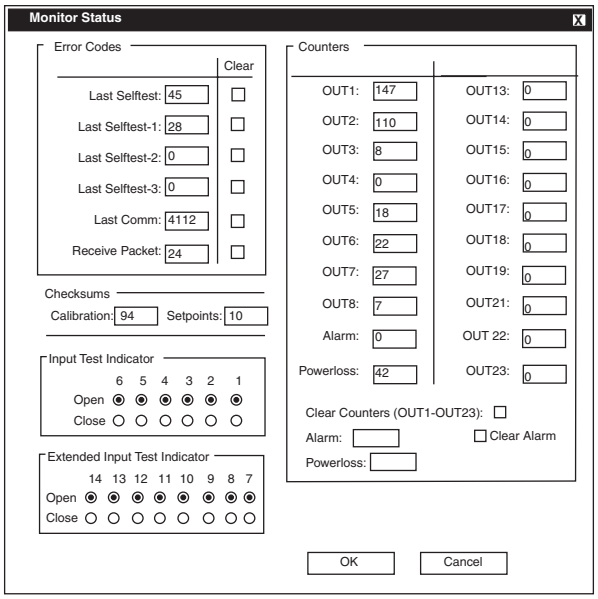


Figure 4-39 Monitor Status Screen

The **Calibration** command provides the user with instructions to recalibrate Nominal Frequency, Third Harmonic, (64F) Field Ground, and (64S) Stator Protection.

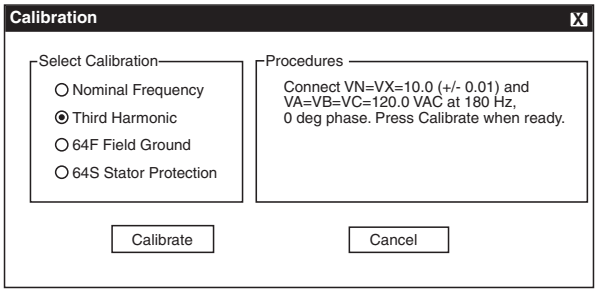


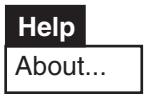
Figure 4-40 Calibration Dialog

COMMAND BUTTONS

Calibrate Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window.

Help Menu



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

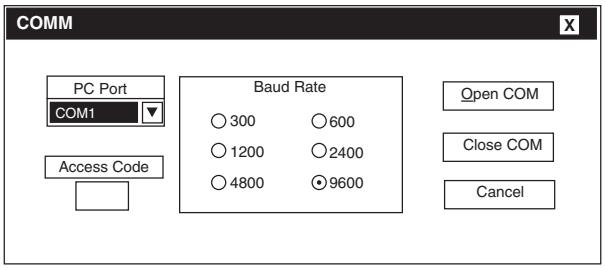


Figure 4-41 Communication Dialog

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.

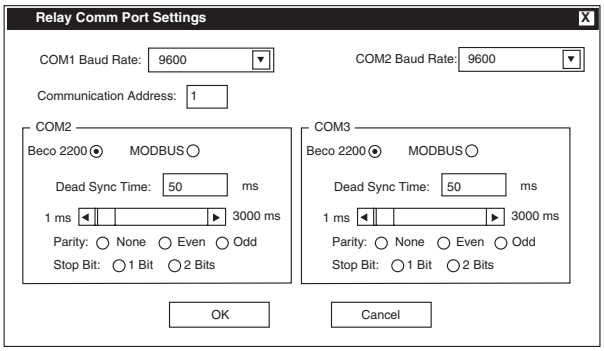


Figure 4-42 Relay Comm Port Settings

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.

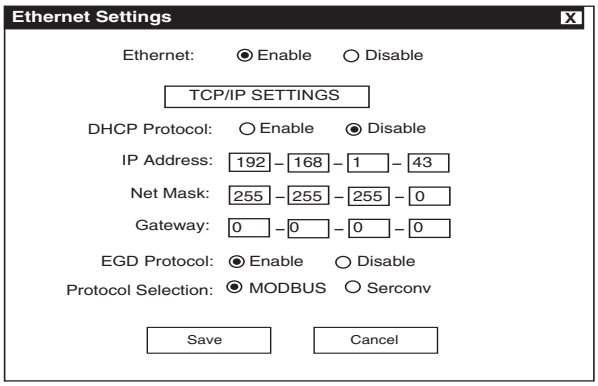


Figure 4-43 Ethernet Settings

COMMAND BUTTONS

Ethernet Enable/Disable: Allows user to enable and disable the Ehternet Port.

DHCP Protocol Enable/Disable: Allows the user to enable or disable the DHCP protocol. When DHCP protocol is enabled the the IP Address portion of the screen is grayed out. When DHCP protocol is disabled the IP Address can be manually entered.

EGD Protocol Enable/Disable: Not available.

Protocol Selection MODBUS/Serconv: Provides the user with the ability to select either MODBUS over TCP/IP or Serconv (BECO2200 over TCP\IP) protocol.

Save Saves values to the relay.

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

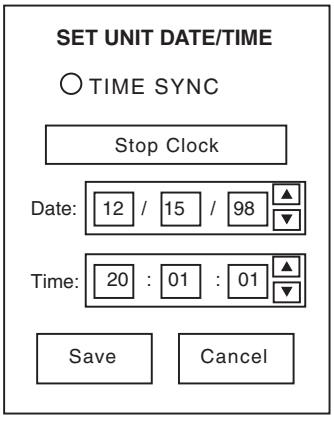


Figure 4-44 Set Unit Date/Time Dialog Box

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 the Set Date/ Time 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.

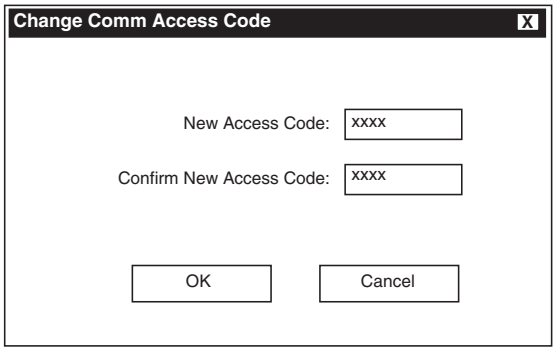


Figure 4-45 Change Communication Access Code Dialog Box

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.

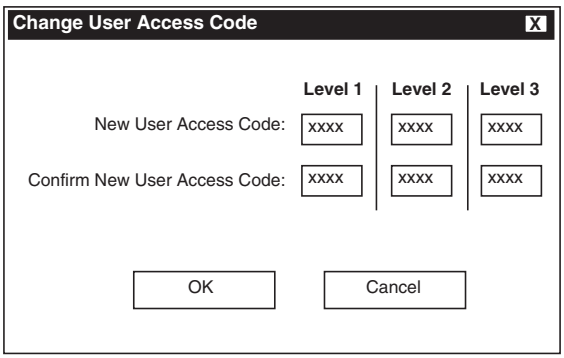


Figure 4-46 Change User Access Code Dialog Box

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.

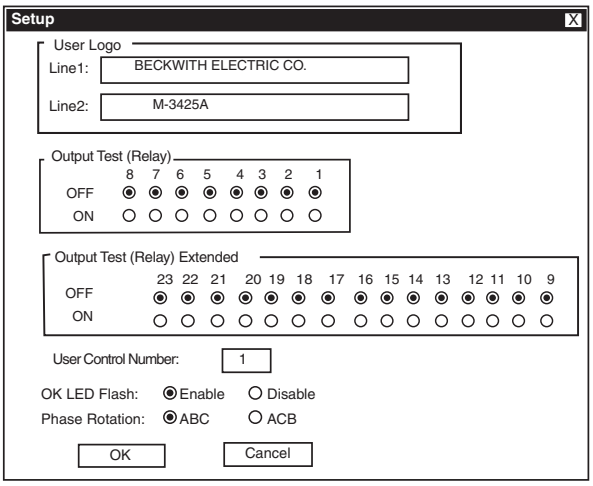


Figure 4-47 Setup Dialog Box

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-3425A Relay.

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Legal Information

Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

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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.

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

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