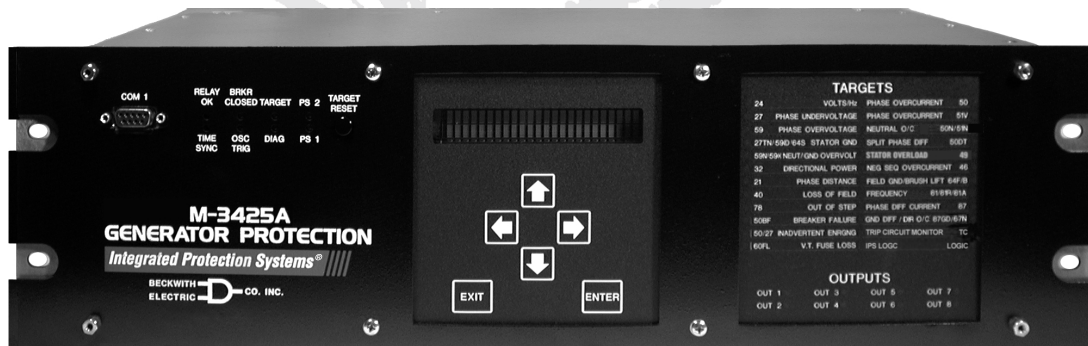


# Generator Protection M-3425A

**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 enhance security during system abnormal conditions**
- **Options: Ethernet Connection, Field Ground/Brush Lift-Off Protection (64F/B), 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.
- Sync Check with Phase Angle,  $\Delta V$  and  $\Delta F$  with dead line/dead bus options (25)
- 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

- 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 required with the 64S option:
  - 20 Hz signal generator (430-00426)
  - Band Pass Filter (430-00427)
  - 400/5 A 20 Hz CT (430-00428)

## 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: Dual Serial Ports TIA-232 and Serial Port TIA-485 (includes MODBUS and BECO2200 protocols)
- S-3400 IPScom® Communications Software
- 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 Profiles (Groups)
- IPScom Profile File Manager

## Comprehensive Package

- M-3925A Target Module
- M-3931 Human-Machine Interface (HMI) Module

## Optional Features

- Redundant power supply
- Ethernet Port RJ-45 10/100 Base-T (MODBUS over TCP/IP)
- Ethernet Port RJ-45 10/100 Base-T (DNP over TCP/IP)
- Serial Port TIA-232 with RJ-45 Connector (DNP)
- Serial Port TIA-485 with RJ-45 Connector (DNP)
- Ethernet Port RJ-45 10/100 Base-T (IEC 61850 Protocol)
- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software
- Expanded I/O (15 additional outputs and 8 additional inputs)
- Standard and Expanded I/O Models available in vertical panel mount

**PROTECTIVE FUNCTIONS**

Device Number	Function	Setpoint Ranges	Increment	Accuracy†	
<b>Phase Distance (three-zone mho characteristic)</b>					
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°	
	<b>Load Encroachment Blinder #1,#2,#3</b>				
	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.

<b>Volts / Hz</b>				
24	<b>Definite Time</b>			
	Pickup #1, #2	100 to 200%	1%	±1%
	Time Delay #1, #2	30 to 8160 Cycles	1 Cycle	±25 Cycles
	<b>Inverse Time</b>			
	Pickup	100 to 200%	1%	±1%
	Characteristic Curves	Inverse Time #1–#4	–	–
	Time Dial: Curve #1	1 to 100	1	±1%
	Time Dial: Curves #2–#4	0.0 to 9.0	0.1	±1%
	Reset Rate	1 to 999 Sec. (from threshold of trip)	1 Sec.	±1 Second 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 80Hz, 0 to 180V, 100 to 150% V/Hz and a nominal voltage setting of 120V.

<b>Sync Check</b>				
25S	<b>Sync Check</b>			
	Phase Angle Limit	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%
	Sync Check Delay	1 to 8160 Cycles	1 Cycle	-1 to +3 Cycles or ±1%
	Delta Voltage	1.0 to 50.0 V	0.1 V	±0.5 V or ±0.5%
	Delta Frequency	0.001 to 0.500 Hz	0.001 Hz	±0.0007 Hz or ±5%
	Vx Nominal Voltage	50.0 to 140.0 V	0.1 V	–
	Vx Phase Angle Compensation	-180° to 180°	1°	±1°
	<b>Dead Check</b>			
25D	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%

Various combinations of input supervised hot/dead closing schemes may be selected. The 25 function cannot be enabled if the 59D function with VX or 67N function with VX is 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 <sup>†</sup>
<b>Phase Undervoltage</b>				
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%.

<b>Third-Harmonic Undervoltage, Neutral</b>				
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 to +5 Cycles or ±1%

<b>Directional Power</b>				
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 -0.002 and +0.002 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.

<b>Loss of Field (dual-zone offset-mho characteristic)</b>				
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.

<sup>†</sup>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†
<b>Negative Sequence Overcurrent</b>				
46	<b>Definite Time Pickup</b>	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%
	<b>Inverse Time Pickup</b>	3 to 100%	1%	±0.5 % of 5 A (±0.5% of 1 A)
	Time Dial Setting (K= I <sub>2</sub> <sup>2</sup> t)	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	±1 Second or ±1%

Pickup is based on the generator nominal current setting.

<b>Stator Overload Protection</b>				
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%

<b>Instantaneous Phase Overcurrent</b>				
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.

<b>Breaker Failure</b>				
50 BF	<b>Pickup</b>			
	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%)
	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.

<b>Definite Time Overcurrent</b>				
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<sub>A</sub>, I<sub>B</sub> and I<sub>C</sub> 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†
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**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	30 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%
	Drop-out Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%

When RMS (total Waveform) is selected, timing accuracy is  $\leq 20$  cycles or  $\pm 1\%$ .

**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) 0.5 to 15.0 (IEEE curves)	0.1 0.01 0.01	±3 Cycles or ±3%*

\* For IEC Curves the timing accuracy is  $\pm 5\%$ .

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) 0.5 to 15.0 (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  $\pm 5\%$ .

†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†
<b>Phase Overvoltage</b>				
59	Pickup #1, #2, #3	5 to 180 V	1 V	$\pm 0.5$ V or $\pm 0.5\%$ $\pm 0.8$ V or $\pm 0.75\%^*$
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	$\pm 1$ Cycle or $\pm 1\%^{**}$
	Input Voltage Select	Phase, Positive or Negative Sequence***		

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

\*\* When RMS (total waveform) is selected, timing accuracy is  $\leq 20$  cycles or  $\pm 1\%$ .

\*\*\* When positive or negative sequence voltage is selected, the 59 Function uses the discrete Fourier transform (DFT) for magnitude calculation, irrespective of the RMS/DFT selection, and timing accuracy is  $\pm 1$  Cycle or  $\pm 1\%$ . Positive and negative sequence voltages are calculated in terms of line-to-line voltage when Line to Line is selected for V.T. Configuration.

<b>Third-Harmonic Voltage Differential Ratio</b>				
59D	Ratio ( $V_X/V_N$ )	0.1 to 5.0	0.1	
	Time Delay	1 to 8160 Cycles	1 Cycle	$\pm 1$ Cycle or $\pm 1\%$
	Positive Seq Voltage Block	5 to 180 V	1 V	$\pm 0.5$ V or $\pm 0.5\%$
	Line Side Voltage	$V_X$ or $3V_0$ (calculated)		

The 59D function has a cutoff voltage of 0.5 V for 3<sup>rd</sup> harmonic  $V_X$  voltage. If the 180 Hz component of  $V_N$  is expected to be less than 0.5 V the 59D function can not be used.

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.

<b>Neutral Overvoltage</b>				
59N	Pickup #1, #2, #3	5.0 to 180.0 V	0.1 V	$\pm 0.5$ V or $\pm 0.5\%$
	Time Delay #1, #2, #3	1 to 8160 Cycles	1 Cycle	$\pm 1$ Cycle or $\pm 1\%$
	Neg. Seq. Voltage Inhibit (>)	1.0 to 100.0 %	0.1 %	$\pm 0.5$ V or $\pm 0.5\%$
	Zero Seq. Voltage Inhibit (<)	1.0 to 100.0 %	0.1 %	$\pm 0.5$ V or $\pm 0.5\%$
	Zero Seq. Voltage Selection	$3V_0$ or $V_X$		
	20 Hz Injection Mode	Enable/Disable		

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

<b>Multi-purpose Overvoltage</b>				
59X	Pickup #1, #2	5 to 180 V	1 V	$\pm 0.5$ V or $\pm 0.5\%$
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	$\pm 1$ Cycle or $\pm 1\%$

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.

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

†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†
<b>VT Fuse-Loss Detection</b>				
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		
<b>Residual Directional Overcurrent</b>				
67N	<b>Definite Time*</b>			
	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%
	<b>Inverse Time*</b>			
	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 15.0 (IEEE curves)	0.1 0.01 0.01	±3 Cycles or ±5%
	<b>Directional Element</b>			
	Max Sensitivity Angle (MSA)	0 to 359°	1°	
	Polarizing Quantity	3V <sub>0</sub> (calculated), V <sub>N</sub> or V <sub>X</sub>		
*Directional control for 67NDT or 67NIT may be disabled.				
V <sub>X</sub> polarization cannot be used if 25 function is enabled.				
3V <sub>0</sub> polarization can only be used with line-ground VT configuration.				
Operating current for 67N can be selected as 3I <sub>0</sub> (calculated) or I <sub>N</sub> (Residual CT).				
If 87GD is enabled, 67N with I <sub>N</sub> (Residual CT) operating current will not be available.				
<b>Out of Step (mho characteristic)</b>				
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%

†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†
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<b>Frequency</b>				
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%

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.

<b>Frequency Accumulation</b>				
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%

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.

<b>Rate of Change of Frequency</b>				
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%

<b>Phase Differential Current</b>				
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	

\*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  $I_A$ ,  $I_B$ ,  $I_C$ .

†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 <sup>†</sup>
<b>Ground (zero sequence) Differential Current</b>				
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 to -2 Cycles or ±1%
	CT Ratio Correction (R <sub>C</sub> )	0.10 to 7.99	0.01	

\*The Time Delay Setting should not be less than 2 Cycles.

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.

<b>IPSlogic™</b>				
IPS	<b>IPSlogic uses element pickups, element trip commands, control/status input state changes, output contact close signals to develop 6 programmable logic schemes.</b>			
	Time Delay #1–#6	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%

<b>Breaker Monitoring</b>				
BM	Pickup	0 to 50,000 kA Cycles or kA <sup>2</sup> Cycles	1 kA Cycles or kA <sup>2</sup> Cycles	± 1 kA Cycles or kA <sup>2</sup> Cycles
	Time Delay	0.1 to 4095.9 Cycles	0.1 Cycles	±1 Cycle or ±1%
	Timing Method	IT or I <sup>2</sup> T		
	Preset Accumulators Phase A, B, C	0 to 50,000 kA Cycles	1 kA Cycle	

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 threshold value. When the threshold is exceeded in any phase, the relay can set a programmable output contact.

The accumulated value for each phase can be displayed.

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

<sup>†</sup>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†
<b>Trip Circuit Monitoring</b>				
TC	Time Delay	1 to 8160 Cycles	1 Cycle	±1 Cycle or ±1%

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 Vdc, 48 Vdc, 125 Vdc and 250 Vdc.

<b>Nominal Settings</b>				
	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%

\*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.

**PROTECTIVE FUNCTIONS (cont.)**

Device Number	Function	Setpoint Ranges	Increment	Accuracy <sup>†</sup>
<b>Field Ground Protection</b>				
64F	Pickup #1, #2	5 to 100 K $\Omega$	1 K $\Omega$	$\pm 10\%$ or $\pm 1$ K $\Omega$
	Time Delay #1, #2	1 to 8160 Cycles	1 Cycle	$\pm(\frac{2}{f_F} + 1)$ Sec.
64B	Injection Frequency (IF)	0.10 to 1.00 Hz	0.01 Hz	
<b>Brush Lift-Off Detection</b> (measuring control circuit)				
	Pickup	0 to 5000 mV	1 mV	
	Time Delay	1 to 8160 Cycles	1 Cycle	$\pm(\frac{2}{f_F} + 1)$ Sec.

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

[Figure 11](#), 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 12](#), M-3921 Field Ground Coupler Mounting Dimensions.

<b>100% Stator Ground Protection by low frequency injection</b>				
64S	Total Current Pickup	2.0 to 75.0 mA	0.1 mA	$\pm 2$ mA or $\pm 10\%$
	Real Component Current**	2.0 to 75.0 mA	0.1 mA	$\pm 2$ mA or $\pm 10\%$
	Time Delay	1 to 8160 Cycles	1 Cycle	$\pm 1$ Cycle* or $\pm 1\%$
<b>20 Hz Gen Output Fuse Failure</b>				
	VN20min	0.1 to 15.0 V	0.1 V	$\pm 0.5$ V or $\pm 0.5\%$
	IN20min	1.0 to 25.0 mA	0.1 mA	$\pm 2$ mA or $\pm 10\%$

An external Low Frequency Generator, Band Pass Filter and Current Transformer are required for this function. 64S Function Connection Diagrams ([Figure 13](#) and [Figure 14](#)), illustrate a typical 100% Stator Ground Protection by Low Frequency Injection application. Hardware dimensional and mounting information is illustrated in [Figure 15](#), [Figure 16](#) and [Figure 17](#).

59D is automatically disabled and cannot be enabled, when the 64S function is purchased. 59N should typically also be applied when the 64S function is enabled.

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

\*\* Operation of the real component requires voltage applied to  $V_N$  input to be  $> 0.5$  Volts at 20 Hz.

<sup>†</sup>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. The IPScom Profile File Manager utility simplifies editing and managing setpoint profile groups.

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

## Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, storing up to 416 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. Oscillograph records are not retained if power to the relay is interrupted.

## 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 S-3400 IPScom Communications Software. Sequence of Events records are not retained if power to the relay is interrupted.

## 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 55 Hz for 50 Hz (nominal), outside of this range RMS calculation is used.

## Power Input Options

Nominal 110/120/230/240 Vac, 50/60 Hz, or nominal 110/125/220/250 Vdc. UL rating 85 Vac to 265 Vac and from 80 Vdc to 288 Vdc. Nominal burden 20 VA at 120 Vac/125 Vdc. Withstands 300 Vac or 300 Vdc for 1 second.

Nominal 24/48 Vdc, operating range from 18 Vdc to 56 Vdc, withstands 65 Vdc for 1 second. Burden 20 VA at 24 Vdc and 20 VA at 48 Vdc.

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.

## Sensing Inputs

*Five Voltage Inputs:* Rated for a nominal voltage of 60 Vac to 140 Vac 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 Vac.

*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 minimum current value to initiate/pickup an Input is  $\geq 25$  mA. 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 Vdc 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 IEEE C37.90 (See Tests and Standards section for details).

OUTPUT CONTACTS – TYPICAL OPERATING TIME		
Outputs 1-4: 4 ms	Outputs 5-8: 8 ms	Outputs 9-23 (Extended I/O): 8 ms

## 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 illuminate 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 illuminate 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 push button displays the present pickup status of the relay functions. The PS1 and PS2 LEDs will remain illuminated 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 TIA-232 and TIA-485 ports, a front panel TIA-232 port, a rear-panel IRIG-B port, an Ethernet port (optional) and an RJ-45 port with TIA-485 (optional). The optional RJ-45 port with TIA-485 includes the DNP3.0 protocol. The communications protocol implements serial, byte-oriented, asynchronous communication, providing the following functions when used with S-3400 IPScom Communications Software. MODBUS, BECO 2200 and DNP3.0 protocols provide:

- 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.

### *Optional Ethernet Port*

The RJ-45 Ethernet port supports 10/100 Base-T fast Ethernet standard with auto negotiable speed. Additionally, MDI-X capability is provided to eliminate the need of a crossover cable when two similar devices are connected.

The optional RJ-45 Ethernet port may be purchased with the following communication protocols:

- MODBUS/BECO2200 over TCP/IP
- DNP over TCP/IP
- IEC 61850: up to 4 concurrent sessions, to monitor all metering values, change settings and generate unsolicited reports. Refer to M-3425A Instruction Book, Section 4.1 Unit Setup for detailed information.

## IRIG-B

The M-3425A Generator Protection Relay can accept either modulated (B-122) using the BNC Port or demodulated (B-002) using the TIA-232 Port 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\* (Comprehensive Package)

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 utilizing six pushbuttons and a 2-line by 24 character alphanumeric LCD display. Features of the HMI Module include :

- User-definable access codes that 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

\* Not available on Base Package



## Target Module\* (Comprehensive Package)

An optional M-3925A Target Module provides 24 programmable target and 8 output LEDs. Target LEDs may be individually Enabled/Disabled for each function element associated with a target LED. Target LEDs will illuminate when any of the enabled corresponding function elements operates. The targets can be reset with the **TARGET RESET** pushbutton. The **OUTPUT** LEDs indicate the status of the programmable output relays.

\* Not available on Base Package

## Temperature Controller Monitoring

Any Temperature Controller equipped with a contact output may be connected to the M-3425A and controlled by the relay's programmable IPSlogic function. [Figure 1](#) is an example of a typical Temperature Controller Monitoring application. The Omron E5C2 Temperature Controller is a DIN rail mounted RTD interface to the M-3425A Generator Protection relay. The E5C2 accepts type J or K thermocouples, platinum RTDs or thermistors as its input. Supply voltage for the E5C2 accepts 110/120 Vac 50/60 Hz, or 220/240 Vac 50/60 Hz or 24 Vdc.

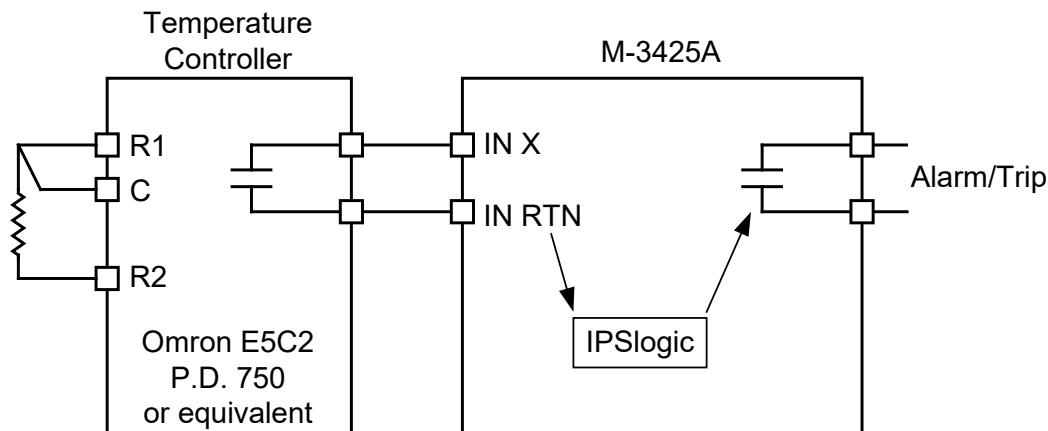


Figure 1 Typical Temperature Controller Monitoring Application

## 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.

## External Connections

M-3425A external connection points are illustrated in [Figure 2](#) and [Figure 3](#).

## Tests and Standards

The relay complies with the following type tests and standards:

### Voltage Withstand

#### Dielectric Withstand

IEC 60255-5	3,500 Vdc for 1 minute applied to each independent circuit to earth
	3,500 Vdc for 1 minute applied between each independent circuit
	1,500 Vdc for 1 minute applied to IRIG-B circuit to earth
	1,500 Vdc for 1 minute applied between IRIG-B to each independent circuit
	1,500 Vdc for 1 minute applied between TIA-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 $\mu$ s, 500 ohms impedance, three surges at 1 every 5 seconds

#### Insulation Resistance

IEC 60255-5	> 100 Megaohms
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## 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)  
Ethernet Port (2 kV, 2.5 kHz)

### *Surge Withstand Capability*

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

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 (TIA-232, TIA-485, IRIG-B, Ethernet communication port and field ground coupling port) through capacitive coupling clamp.

### *Radiated Susceptibility*

IEEE C37.90.2 80 – 1000 Mhz @ 35 V/m  
IEC 61000-4-3 1000 – 6000 MHz @ 10 V/m

### *Output Contacts*

IEEE C37.90 30 A make for 0.2 seconds at 250 Vdc Resistive  
UL 508 8 A carry at 120 Vac, 50/60 Hz  
6 A break at 120 Vac, 50/60 Hz  
0.5 A break at 48 Vdc, 24 VA  
0.3 A break at 125 Vdc, 37.5 VA  
0.2 A break at 250 Vdc, 50 VA

## Atmospheric Environment

### *Temperature*

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  
IEC 60068-2-30 Damp Heat Cycle, +55° C @ 95%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

- cULus-Listed per 508 – NRGU.E128716 Industrial Control Equipment
- NRGU7.E128716 Industrial Control Equipment Certified for Canada  
CAN/USA C22.2 No. 14-M91
- cULus-Listed per 508A – Table SA1.1 Industrial Control Panels

## 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.

**Environmental:** For flat surface mounting on a Type 1 enclosure, rated to 70° C surrounding air ambient.

**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.

**Environmental:** For flat surface mounting on a Type 1 enclosure, rated to 70° C surrounding air ambient.

**Approximate Weight:** 19 lbs (8.6 kg)

**Approximate Shipping Weight:** 26 lbs (11.8 kg)

## Recommended Storage Parameters

**Temperature:** 5° C to 40° C

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

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

**See M-3425A Instruction Book, Appendix E, Layup and Storage for additional information.**

## Disposal and Recycling

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

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

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

## 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 ten year warranty from date of shipment.

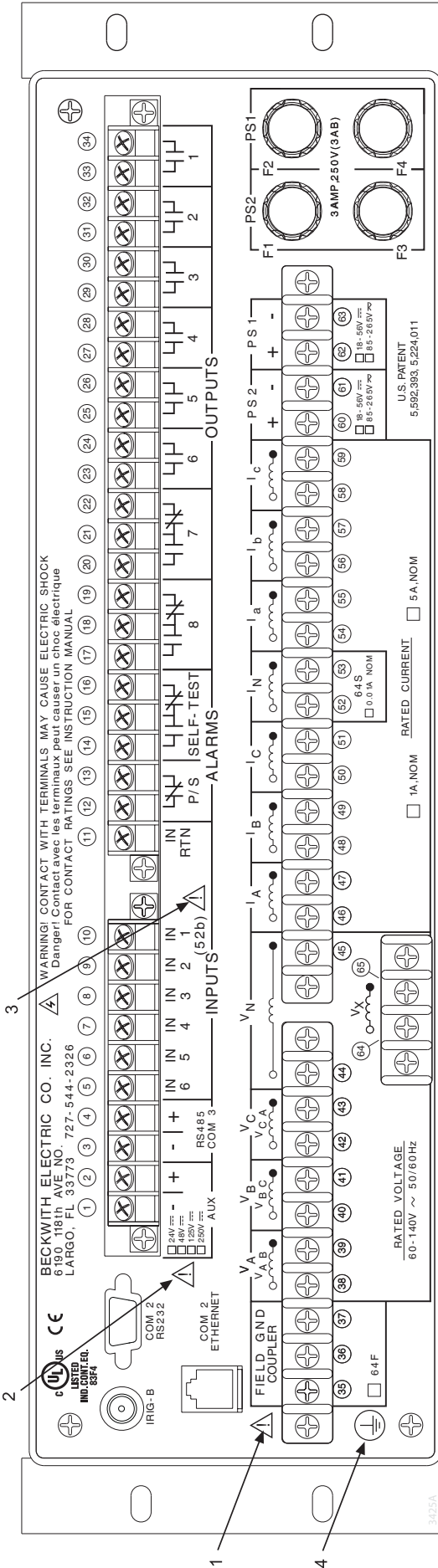


Figure 2 External Connections (Without Optional Expanded I/O)

■ NOTES:

1. See M-3425A Instruction Book Section 4.4, System Setpoints, 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. ▲ CAUTION: 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.

To fulfill requirements for UL listing, terminal block connections must be made with No. 22–12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector and wire insulation used must be rated at 75° C minimum.

Torque Requirements:

- Terminals 1–34: 12.0 in-lbs
- Terminals 35–63: 8.0 in-lbs, minimum, and 9.0 in-lbs, maximum.

▲ CAUTION: Over torquing may result in terminal damage

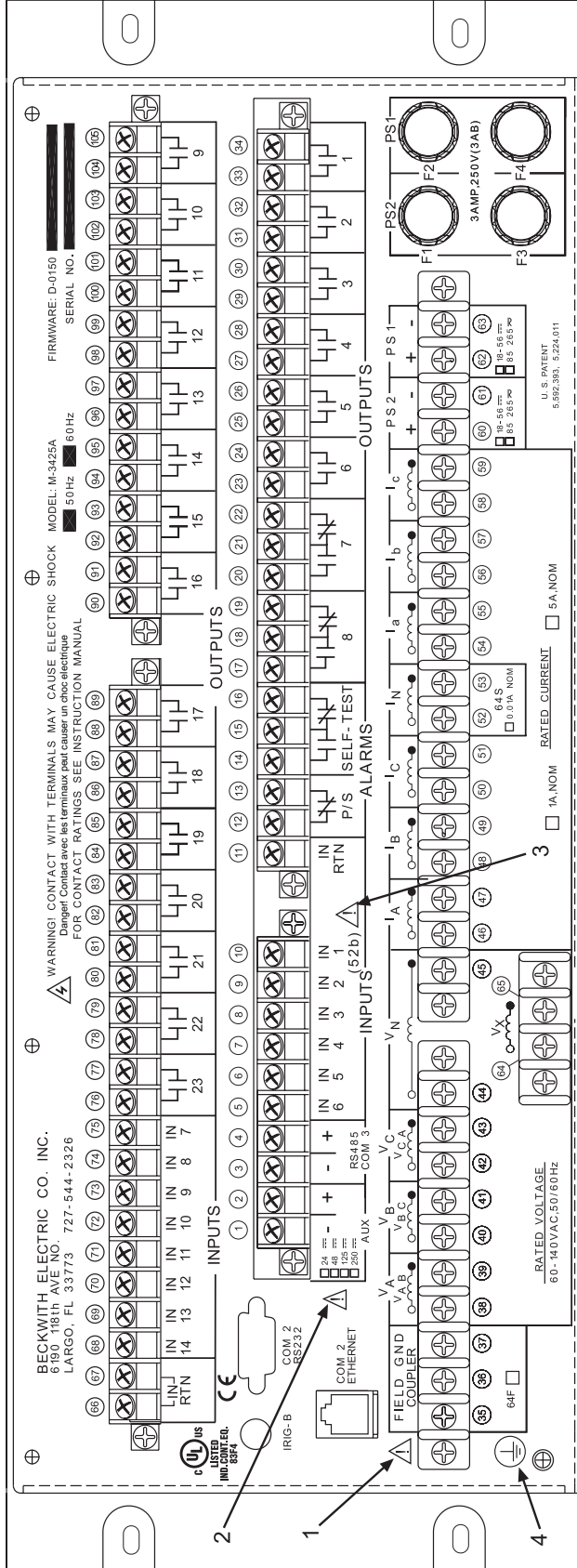


Figure 3 External Connections (With Optional Expanded I/O)

■ NOTES:

1. See M-3425A Instruction Book Section 4.4, System Setpoints, 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. ▲ CAUTION: 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.

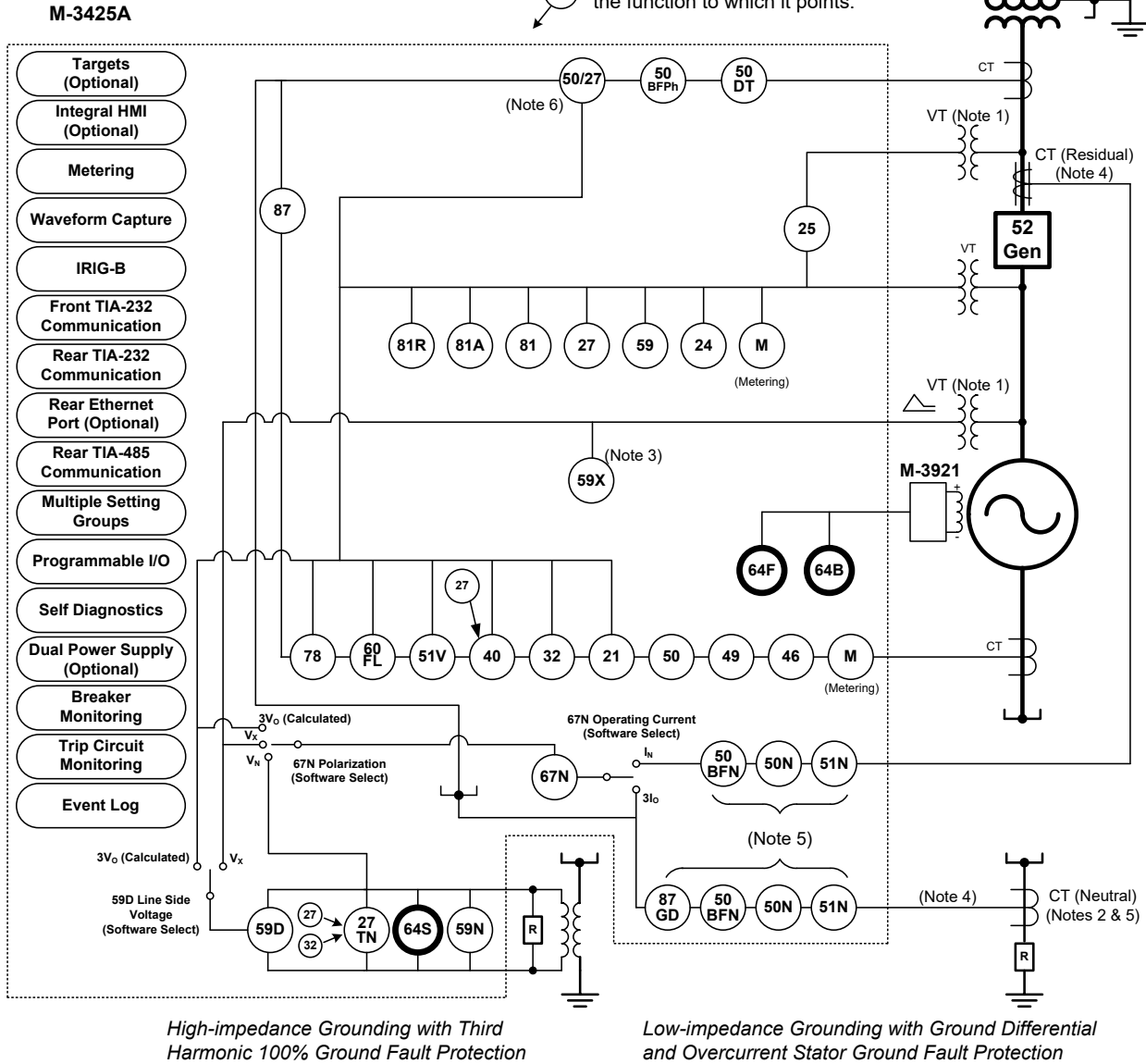
To fulfill requirements for UL listing, terminal block connections must be made with No. 22–12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector and wire insulation used must be rated at 75° C minimum.

Torque Requirements:

- Terminals 1–34, 66 –105: 12.0 in-lbs
  - Terminals 35–63: 8.0 in-lbs, minimum, and 9.0 in-lbs, maximum.
- ▲ CAUTION: Over torquing may result in terminal damage.

**M-3425A Typical Connection Diagram**

- These functions are available in the Comprehensive Package. A subset of these functions are also available in a Base Package.
- ◉ This function is available as an optional protective function.
- ◐ This function provides control for the function to which it points.






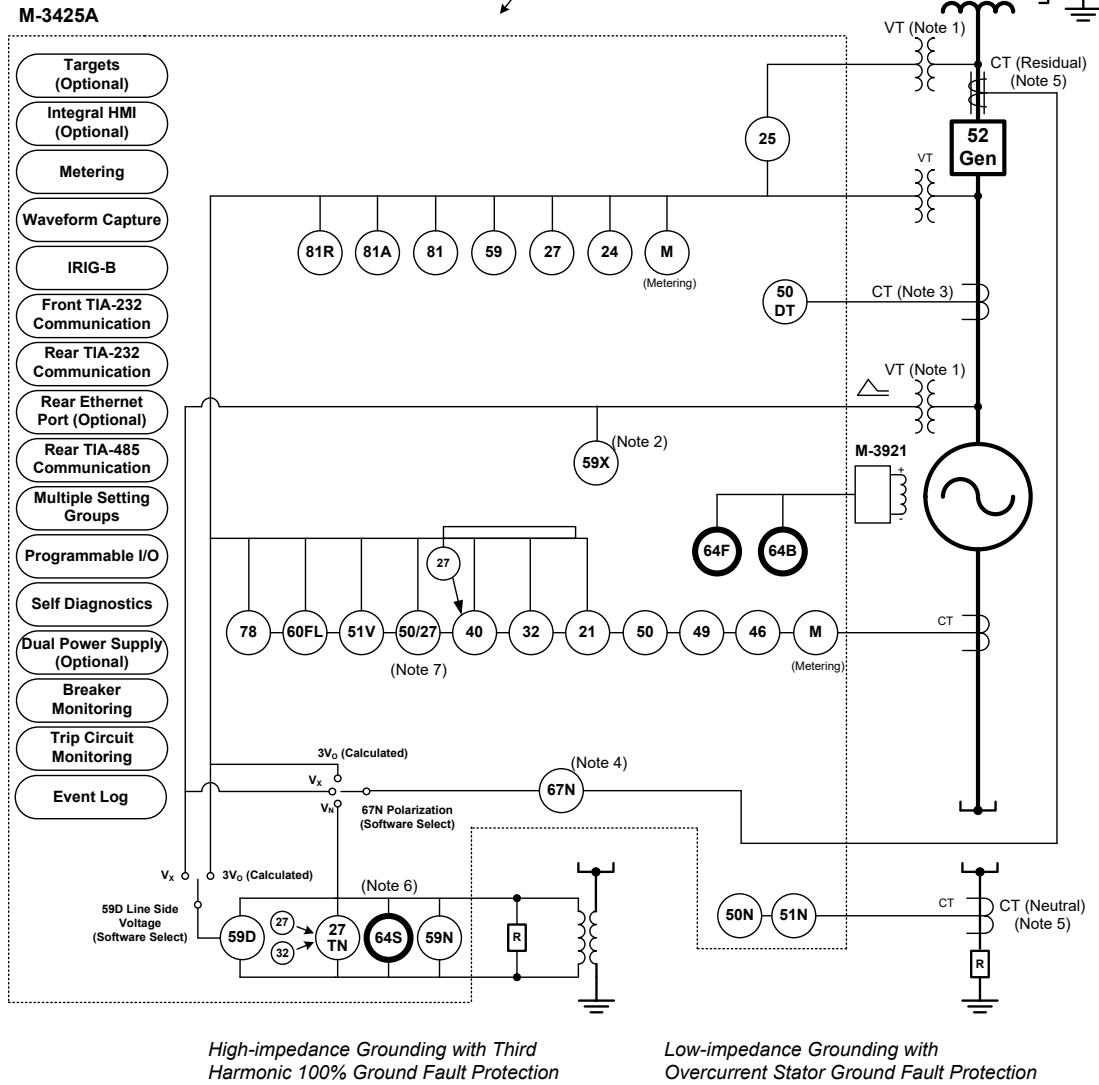
**NOTES:**

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 4, System Setup and Setpoints, 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.
6. The 50/27 current is sourced from the terminal-side CTs, when 50DT Split-Phase Differential is disabled, for relays with Firmware version D-0150V07.07.00 and higher. For relays with Firmware versions less than D-0150V07.07.00, 50/27 current is always sourced from the neutral-side CTs regardless of the 50DT Split-Phase Differential setting.

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

**M-3425A Typical Connection Diagram**  
(Configured for Split-Phase Differential)

-  These functions are available in the Comprehensive Package. A subset of these functions are also available in a Base Package.
-  This function is available as an optional protective function.
-  This function provides control for the function to which it points.

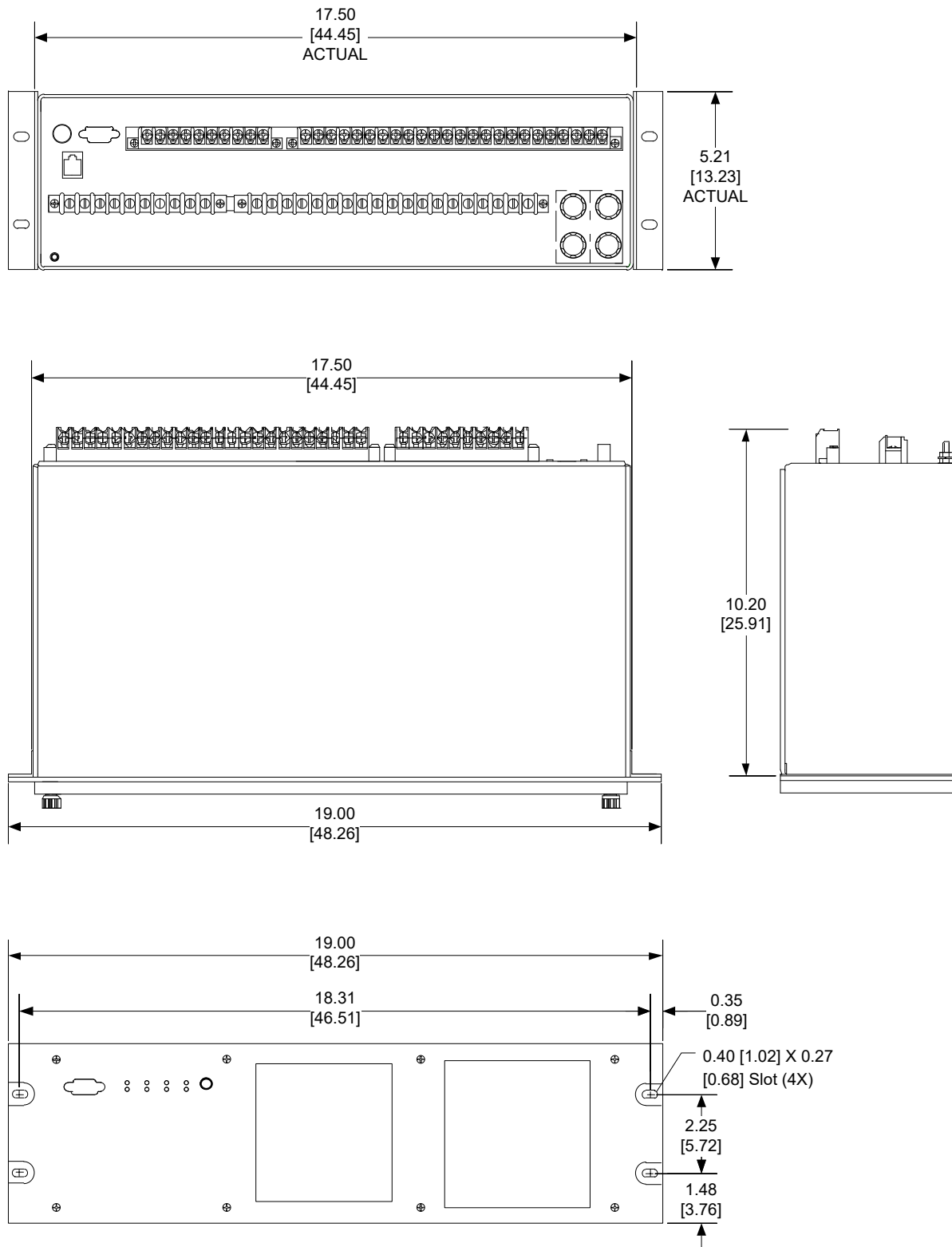


■ **NOTES:**

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.
7. The 50/27 current is sourced from the neutral-side CTs, when 50DT Split-Phase Differential is enabled, for relays with Firmware version D-0150V07.07.00 and higher. For relays with Firmware versions less than D-0150V07.07.00, 50/27 current is always sourced from the neutral-side CTs regardless of the 50DT Split-Phase Differential setting. When 50DT Split-Phase Differential is enabled, then 87, 87GD, 50BF, and 50BFN are not available.

Figure 5 One-Line Functional Diagram (configured for Split-Phase Differential)

M-3425A Generator Protection Relay – Specification



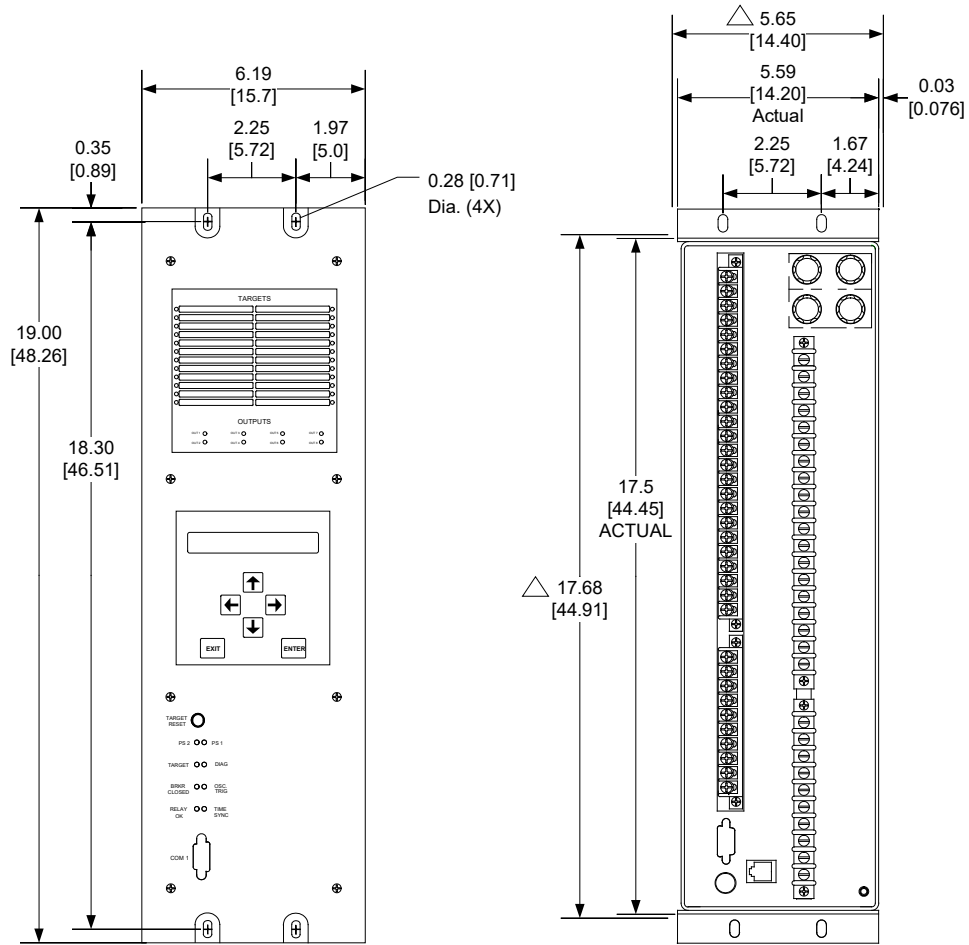
Standard 19" Horizontal Mount Chassis

■ NOTES:

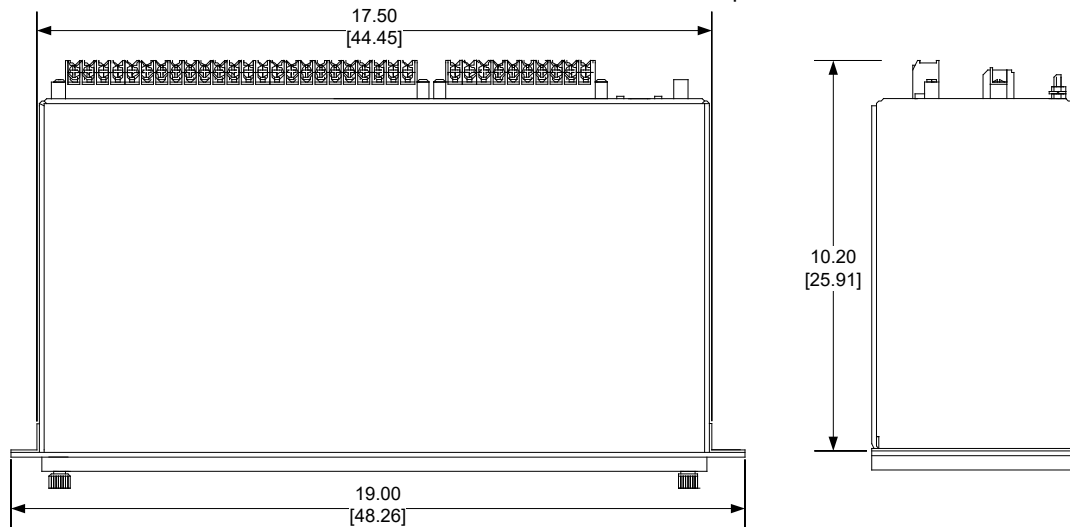
1. Dimensions in brackets are in centimeters.
2. See Instruction Book Chapter 5 for Mounting and Cutout information.

Figure 6 Horizontal Unit Dimensions Without Expanded I/O (H1)





△ Recommended cutout when relay is not used as standard rack mount and is panel cut out mounted.



■ NOTES:

1. Dimensions in brackets are in centimeters.
2. See Instruction Book Chapter 5 for Mounting and Cutout information.

Figure 7 Vertical Unit Dimensions Without Expanded I/O (H2)

M-3425A Generator Protection Relay – Specification

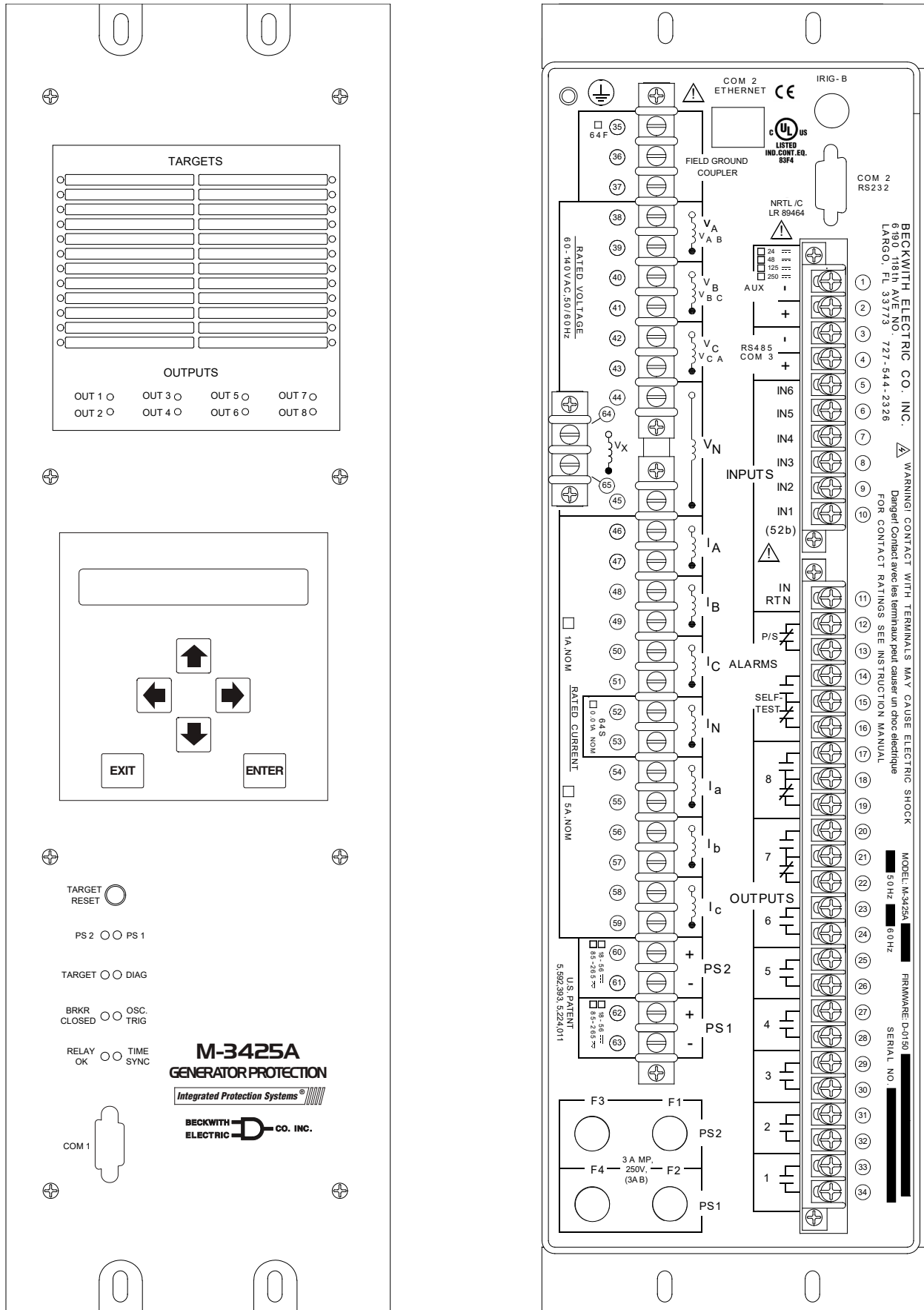
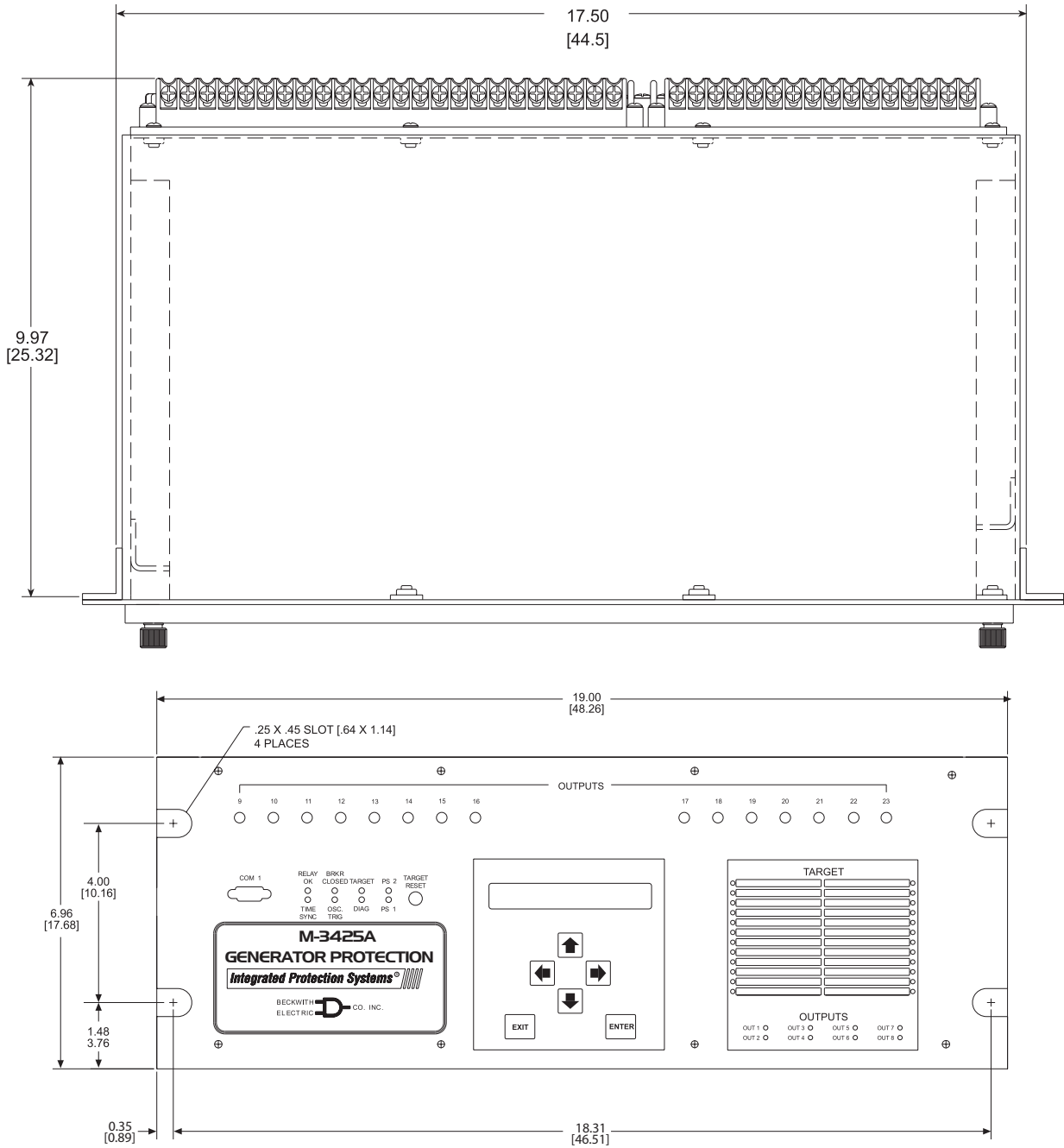


Figure 8 M-3425A Vertical Unit Layout

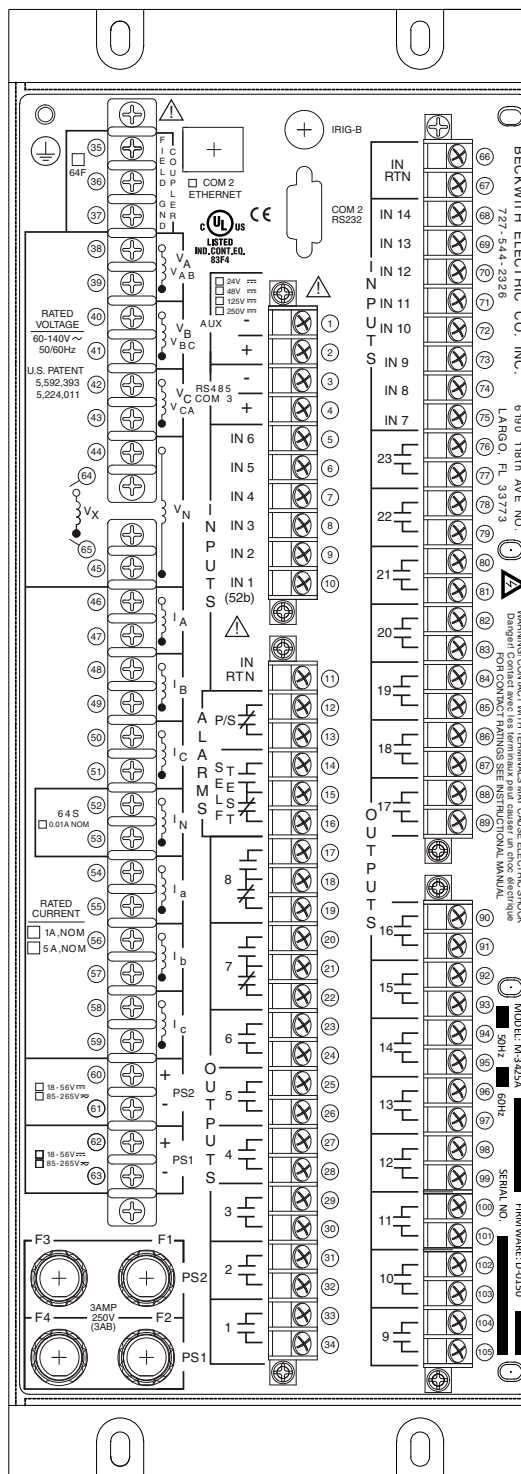
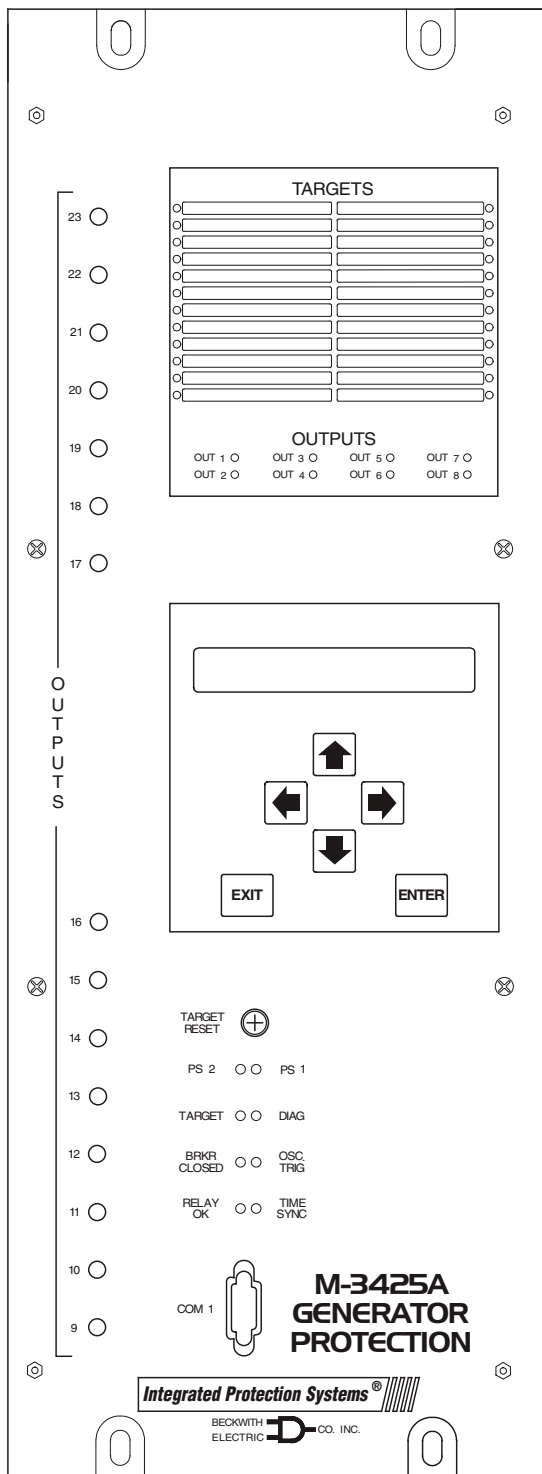
# M-3425A Generator Protection Relay – Specification



## NOTES:

1. Dimensions in brackets are in centimeters.
2. See Instruction Book Chapter 5 for Mounting and Cutout information.

Figure 9 Horizontal and Vertical Unit Dimensions With Expanded I/O



NOTES:

1. The M-3425A Expanded I/O vertical panel is the same physical size as the M-3425A Expanded I/O horizontal panel. See [Figure 9](#) for dimensions.
2. See Instruction Book Section 5 for Mounting and Cutout information.

Figure 10 M-3425A Expanded I/O Vertical Unit Layout

## M-3921 Field Ground Coupler

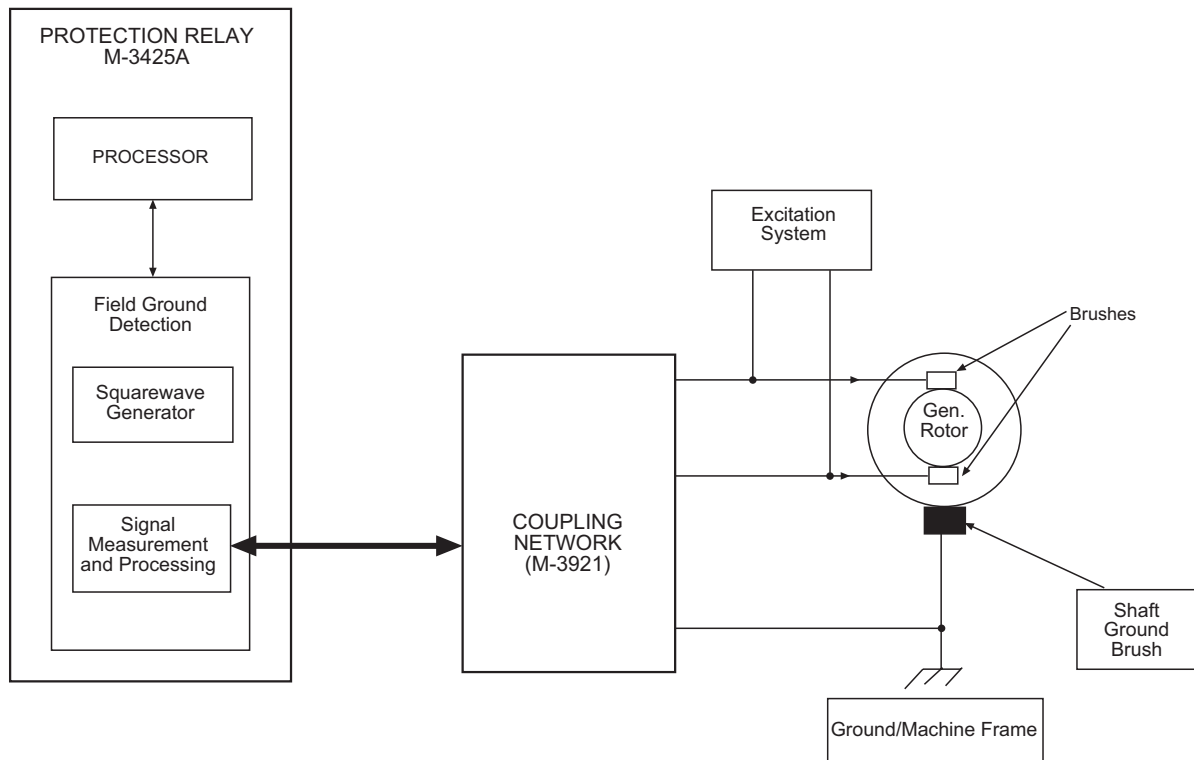


Figure 11 Field Ground Protection Block Diagram

### ■ NOTES:

1. The above circuit measures insulation resistance ( $R_f$ ) between rotor field winding and ground (64F).
2. Relay injects  $\pm 15$  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 Vdc, continuous
- 1500 Vdc, 1 minute

Operating Temperature:  $-20^\circ$  to  $+70^\circ$ , 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*

5 kV ac for 1 minute, all terminals to case

#### *Impulse Voltage*

IEC 60255-5      5,000 V pk, 1.2 by 50  $\mu$ s, 0.5 J, 3 positive and 3 negative impulses at 5 second intervals per minute

### Electrical Interference

#### *Electrostatic Discharge Test*

EN 60255-22-2    Class 4 (8 kV) – point contact discharge  
Class 4 (15 kV) – air discharge

#### *Fast Transient Disturbance Tests*

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

#### *Surge Withstand Capability*

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

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

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

#### *Radiated Susceptibility*

IEEE C37.90.2    25-1000 Mhz @ 35 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 I3, IP65C

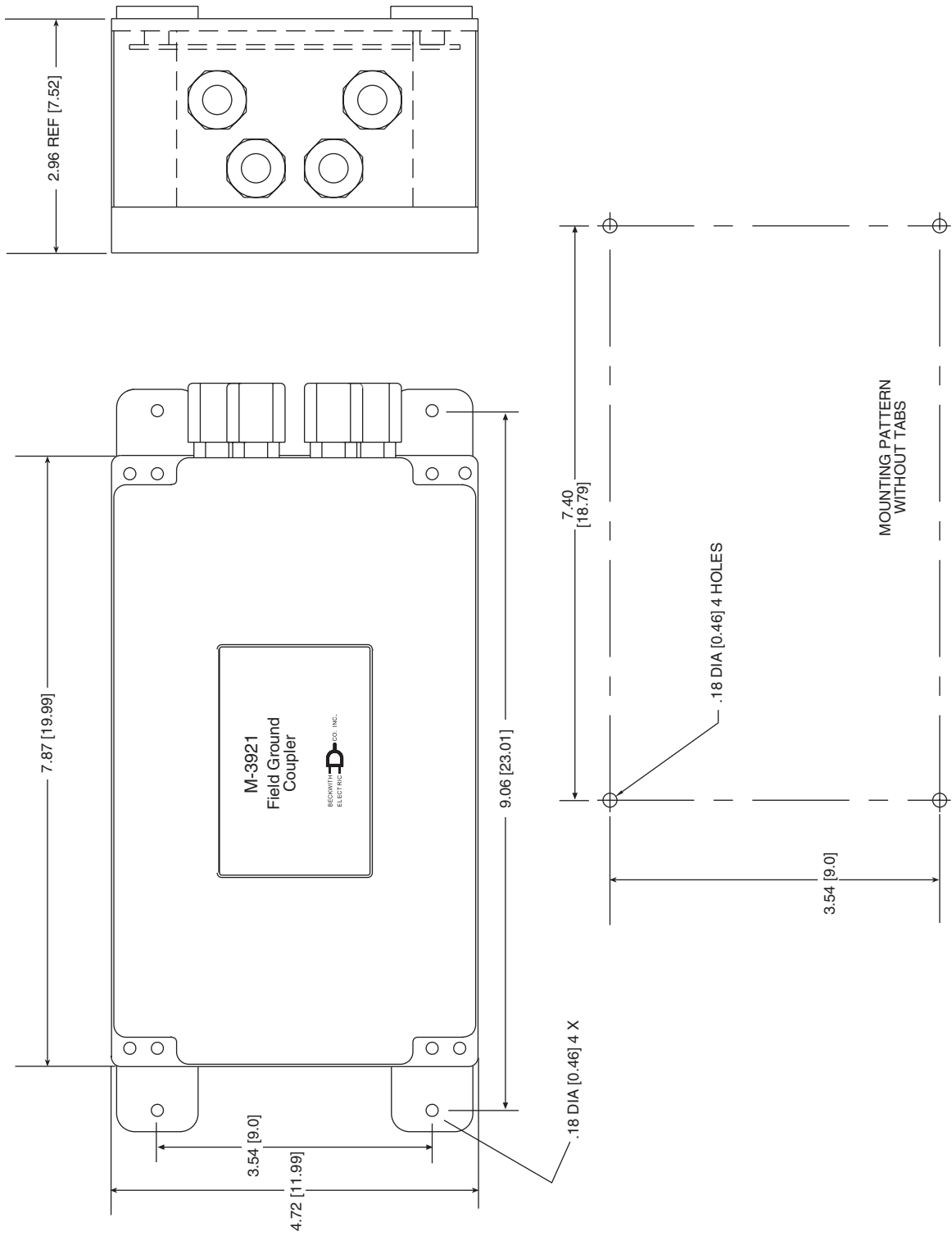


Figure 12 M-3921 Field Ground Coupler Mounting Dimensions

## **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 and the Firmware version is D-0150V08.03.xx and higher.) For relays with Firmware versions prior to this, off-line protection will not be provided if Underfrequency Inhibit is enabled. This setting name was changed to "Frequency Inhibit" in Firmware versions D-0150V08.03.xx and higher.

This scheme requires the following external components in addition to M-3425A protection system:

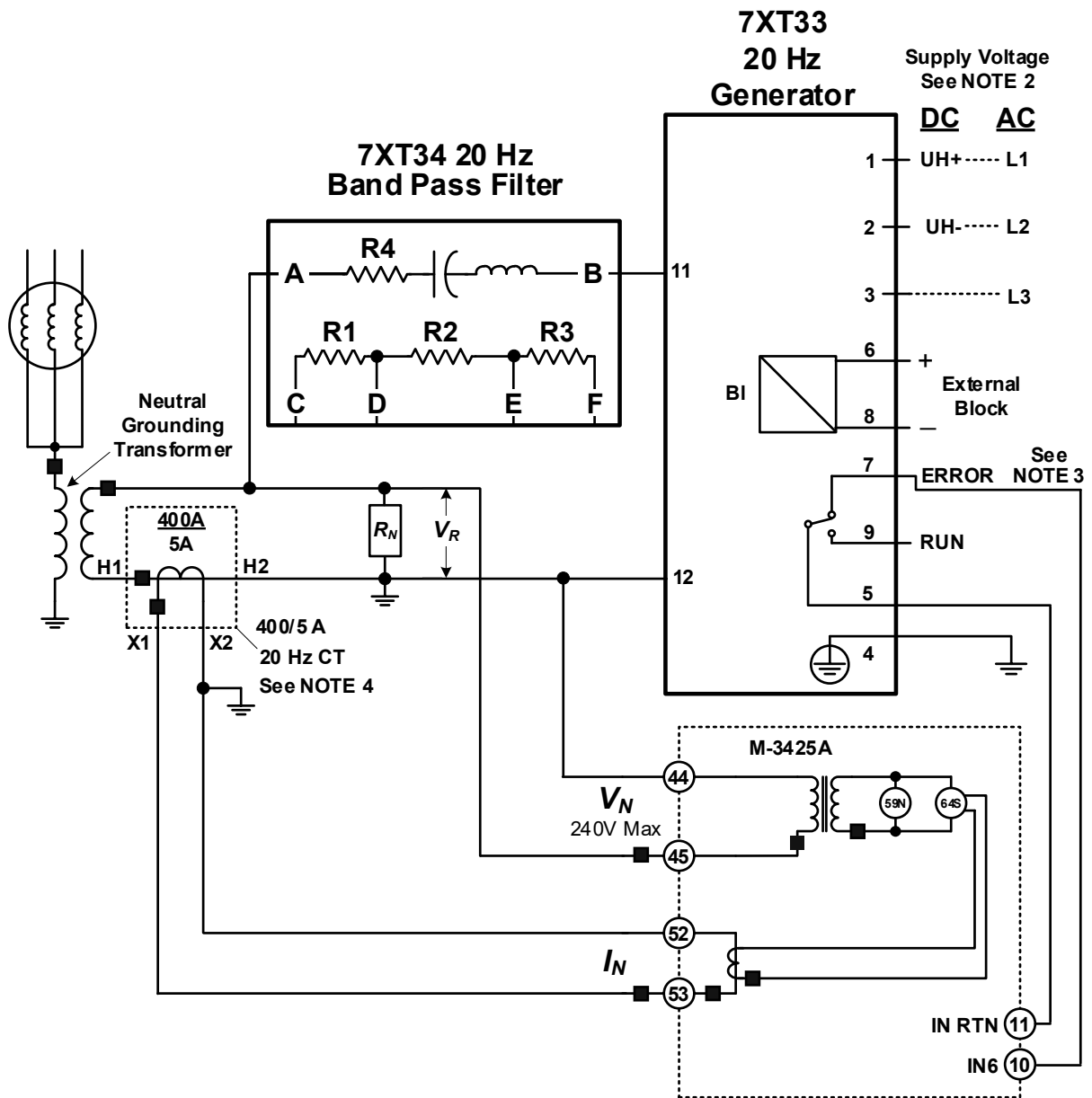
- 20 Hz Signal-generator (BECO Surface Mount/Flush Part No. 430-00426)(Siemens 7XT33)
- Band-pass filter (BECO Surface Mount/Flush Part No. 430-00427)(Siemens 7XT34)
- 20 Hz Measuring Current Transformer, 400/5 A CT (BECO Part No. 430-00428) (ITI-CTW3-60-T50-401)

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, if required, that limits the voltage at  $V_N$  to  $\leq 240$  Vac. Use a Straight Through Connection if the maximum 50/60 Hz ground fault voltage measured by  $V_N$  is less than or equal to 240 Vac. The 20 Hz current is also connected to the  $I_N$  input of the M-3425A through the 20 Hz current transformer.

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. The 20 Hz current increases when a ground fault occurs anywhere on the generator stator windings. The 64S function issues a trip signal after a set time delay when the measured 20 Hz current exceeds the pickup current setting.

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

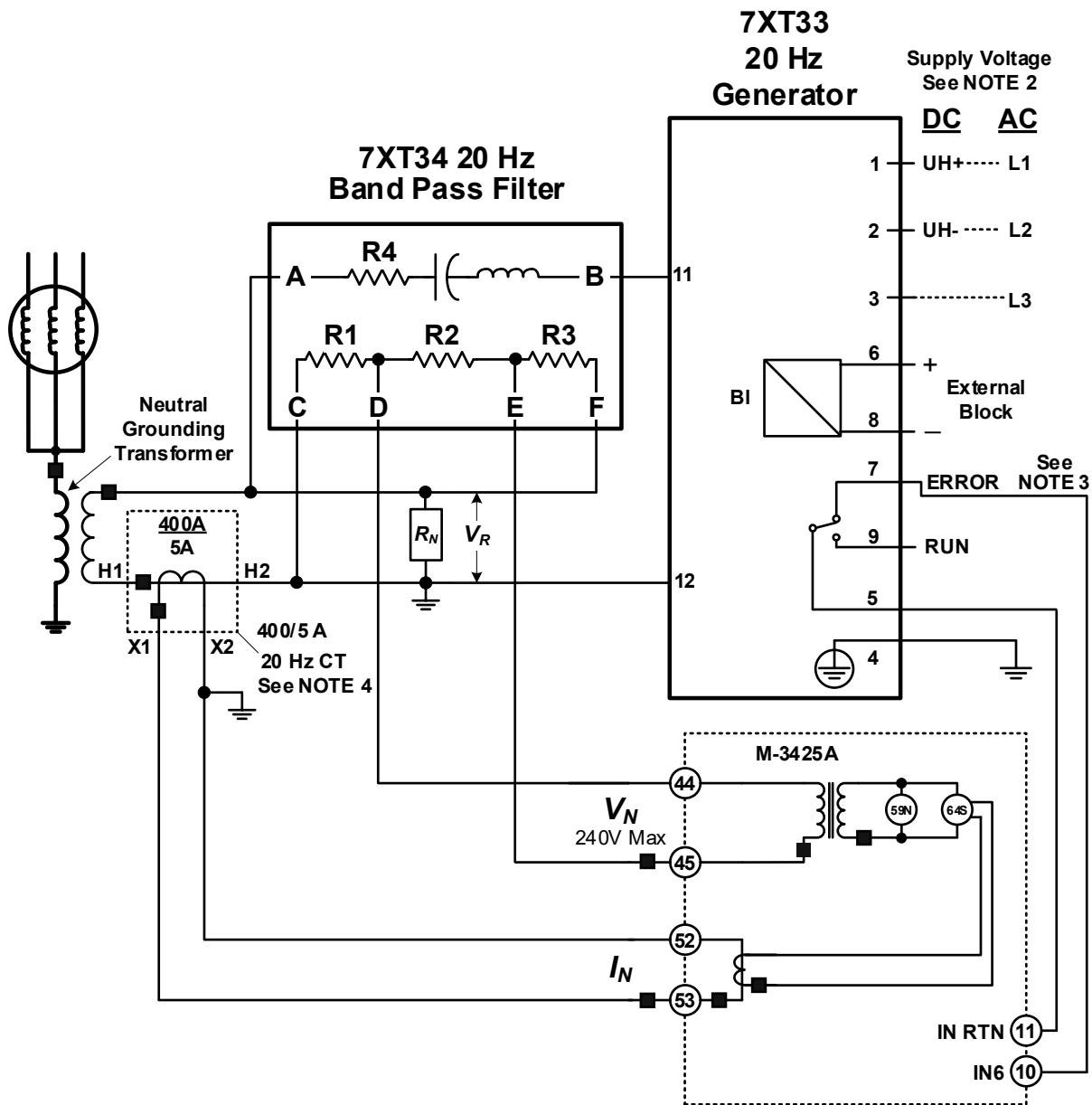




■NOTES:

1. Use the Straight Through Connection for applications that have a worst-case 50/60 Hz ground fault voltage < 240 Vac at the  $V_N$  voltage input.
2. See Chapter 4 of the Instruction Book for detailed information.
3. Connections from 20 Hz Generator terminals 5 and 7 to M-3425A terminals 10 and 11 are used to provide operational status of the 20 Hz generator to the M-3425A. Input 6 (IN6) is shown in the figure, but any other unused input can be used. This input should be programmed to initiate an alarm via the M-3425A for local/remote communications when the 20 Hz generator is out-of-service. This input can also be used to enable the 27TN function to provide 100% stator ground protection when the 20 Hz generator is out-of-service.
4. The current transformer provided by Beckwith Electric Co. is T50 Class and begins to saturate at 50V. Both the primary and secondary of the current transformer are connected to ground. These two factors reduce the concern regarding insulation of the current transformer.

Figure 13 64S Function Straight Through Connection Diagram



■ NOTES:

1. Use the Voltage Divider Connection for applications that have a worst-case 50/60 Hz ground fault voltage > 240 Vac at the  $V_N$  voltage input.
2. See Chapter 4 of the Instruction Book for detailed information.
3. Connections from 20 Hz Generator terminals 5 and 7 to M-3425A terminals 10 and 11 are used to provide operational status of the 20 Hz generator to the M-3425A. Input 6 (IN6) is shown in the figure, but any other unused input can be used. This input should be programmed to initiate an alarm via the M-3425A for local/remote communications when the 20 Hz generator is out-of-service. This input can also be used to enable the 27TN function to provide 100% stator ground protection when the 20 Hz generator is out-of-service.
4. The current transformer provided by Beckwith Electric Co. is T50 Class and begins to saturate at 50V. Both the primary and secondary of the current transformer are connected to ground. These two factors reduce the concern regarding insulation of the current transformer.

Figure 14 64S Function Voltage Divider Connection Diagram

## 20 Hz Signal Generator Function Specifications

### Auxiliary Voltage

Rated auxiliary voltage $U_H$ ac	3x (100/120 Vac), 50/60 Hz	1x (100 to 120 Vac), 50/60 Hz
Permissible variations ac	88 to 230 Vac	
<i>OR</i>		
Rated auxiliary voltage $U_H$ dc	110 to 220 Vdc	
Permissible Variations dc	88 to 250 Vdc	

Permissible consumption at 8 Ohm impedance  $\leq 100$  VA

■NOTE: 230 Vac is permissible for commissioning only, which is limited in time.

### 20 Hz Output Voltage

Connections (11 and 12)

Output Voltage	approx. 26 V $\pm 10$ %, rectangular; 20 Hz $\pm 0.1$ Hz
Power Output, permanently	100 VA over all ranges

■NOTE: Output is not resistant to short-circuits.

### Binary Input for Blocking

Connections (6 and 8)

Switching Threshold	Adjustable voltage range with jumper	
– For control voltages	24 V	
	48 V	
	60 V	DC 19 V: $U_{high} \geq DC 19 V$ , $U_{low} \leq DC 10 V$
– For control voltages	110 V	
	125 V	
	220 V	
	250 V	DC 88 V: $U_{high} \geq DC 88 V$ , $U_{low} \leq DC 44 V$
Permissible voltage, continuous	300 Vdc	

### Life Contact

Connections (5, 7 and 9)

Switching capacity	MAKE	30W/VA
	BREAK	20 VA
		30 W resistance load
		25 W @ L/R $\leq 50$ ms
Switching voltage	DC 24 V to DC 250 V	
	AC 24 to AC 230 V	
Permissible current	1 A permanent	

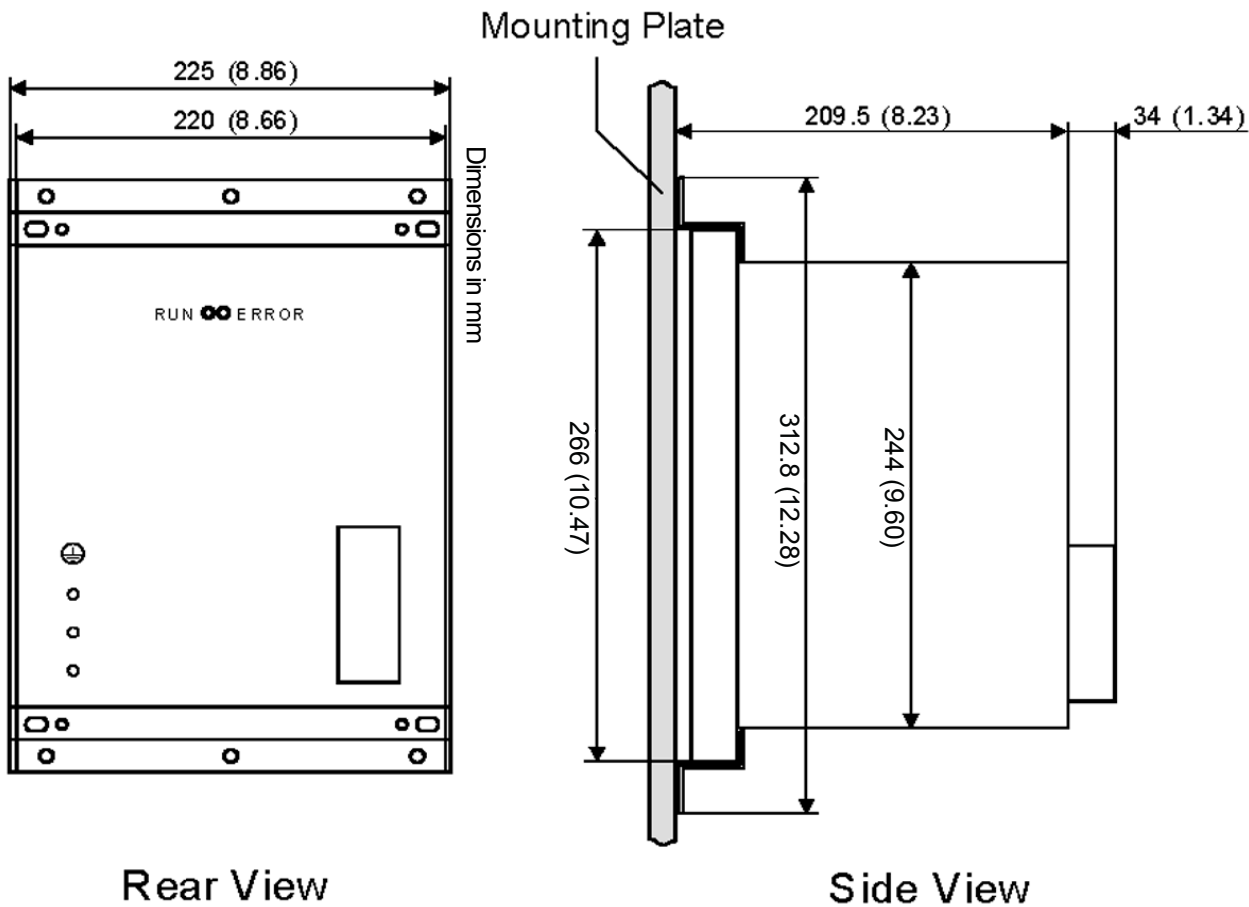
### Permissible Ambient Temperatures

$R_L$  describes the load resistance at the Band Pass output.

with  $R_L < 5$  Ohm  $\leq 55^\circ C$  or  $\leq 131^\circ F$

with  $R_L > 5$  Ohm  $\leq 70^\circ C$  or  $\leq 158^\circ F$

■NOTE: With maximum power output, the device has a power loss of approximately 24 W. To ensure unhindered heat dissipation through the vent holes, the distance to other devices located at the top and bottom must be at least 100 mm. This device must therefore always be mounted in the bottom part of the cabinet.



■ **NOTE:** Detailed Mounting information is contained in the M-3425A Instruction Book Chapter 5, Installation Section 5.6.

*Figure 15 20 Hz Signal Generator Dimensions*

## **Band-pass Filter Specifications**

### ***Load Capacity of the 20 Hz Band-pass Filter***

Connections (1B1-1B4)	
Permissible voltage, continuous	55 Vac
Permissible voltage for $\leq 30$ s	550 Vac
Frequency of superimposed ac voltage	$\geq 45$ Hz
Overload capability, continuous	3.25 A ac
Test Voltage	2.8 kV dc

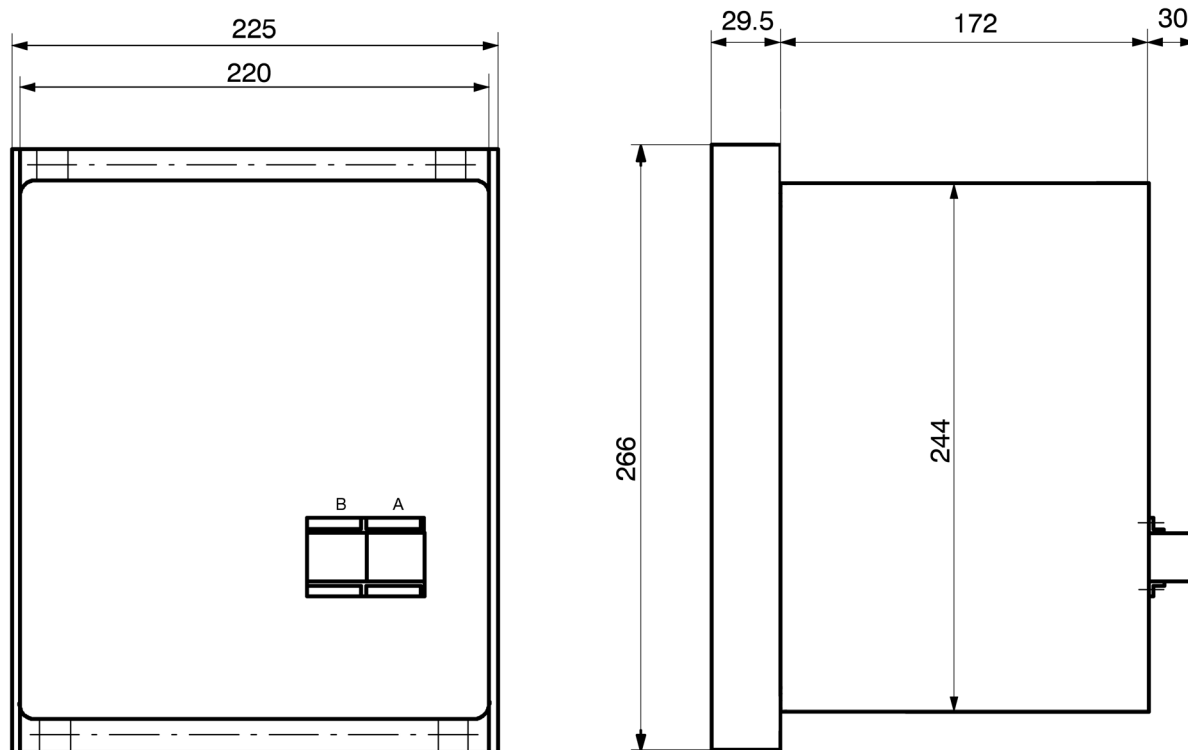
### ***Load Capability of the Voltage Divider Circuit***

Connections (1A1-1A4):	
Permissible voltage, continuous	55 Vac
Permissible voltage for $\leq 30$ s	50 Vac
Test Voltage	2.8 kV dc

### ***Permissible Ambient Temperatures***

with $R_L < 5 \Omega$ burden	$\leq 40^\circ \text{C}$ or $\leq 104^\circ \text{F}$
with $R_L > 5 \Omega$ burden	$\leq 55^\circ \text{C}$ or $\leq 131^\circ \text{F}$

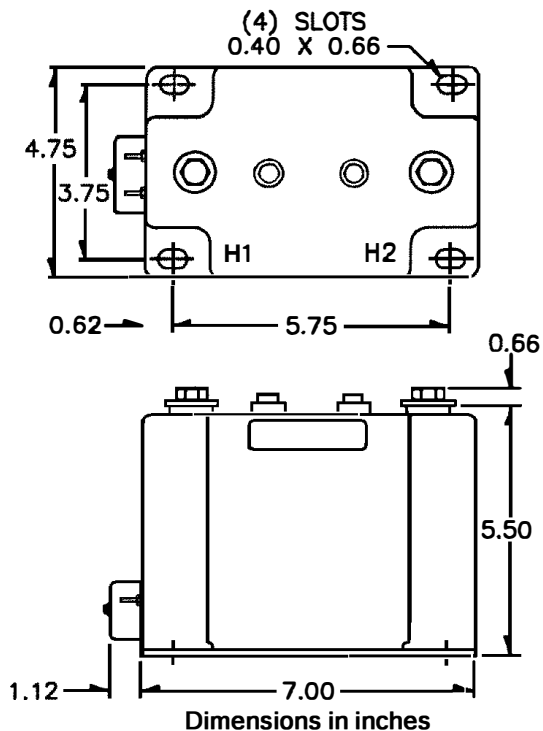
- **NOTE:** The device may produce up to 75 W power losses during service. In order to prevent heat pockets, the dissipation of the losses must not be restricted. The minimum clearance above and below the device to other units or walls is 100 mm or 4 inches. In cubicles, the device shall be installed in the bottom area.



Dimensions in mm

■ **NOTE:** Detailed Mounting information is contained in the M-3425A Instruction Book Chapter 5, Installation Section 5.

Figure 16 Band-pass Filter Dimensions



Dimensions in inches

Figure 17 20 Hz Measuring Current Transformer 400-5 A CT

## **TRADEMARKS**

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



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