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), 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, ∆V and ∆F 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 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 (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
- RJ45 Ethernet port utilizing 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

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase Distance (three-zone mho characteristic)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Circle Diameter #1,#2,#3</td>
<td>0.1 to 100.0 Ω (0.5 to 500.0 Ω)</td>
<td>0.1 Ω</td>
<td>± 0.1 Ω or 5% or 0.5 Ω or 5%</td>
</tr>
<tr>
<td></td>
<td>Offset #1,#2,#3</td>
<td>-100.0 to 100.0 Ω (-500.0 to 500.0 Ω)</td>
<td>0.1 Ω</td>
<td>± 0.1 Ω or 5% or 0.5 Ω or 5%</td>
</tr>
<tr>
<td></td>
<td>Impedance Angle #1,#2,#3</td>
<td>0° to 90°</td>
<td>1°</td>
<td>± 1°</td>
</tr>
<tr>
<td></td>
<td>Load Encroachment Blinder #1,#2,#3</td>
<td>Angle</td>
<td>1° to 90°</td>
<td>1°</td>
</tr>
<tr>
<td></td>
<td>Time Delay #1,#2,#3</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>± 1 Cycle or ± 1%</td>
</tr>
<tr>
<td></td>
<td>Out-of-Step Delay</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>± 1 Cycle or ± 1%</td>
</tr>
<tr>
<td></td>
<td>Overcurrent Supervision</td>
<td>0.1 to 20 A (0.02 to 4 A)</td>
<td>0.1 A</td>
<td>± 0.1 A or ± 2%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Function</th>
<th>Pickup #1, #2</th>
<th>100 to 200%</th>
<th>1%</th>
<th>± 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Delay #1, #2</td>
<td>30 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>± 25 Cycles</td>
<td></td>
</tr>
</tbody>
</table>

### Inverse Time

<table>
<thead>
<tr>
<th>Characteristic Curves</th>
<th>Time Dial: Curve #1</th>
<th>1 to 100</th>
<th>1</th>
<th>± 1%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Dial: Curves #2–#4</td>
<td>0.0 to 9.0</td>
<td>0.1</td>
<td>± 1%</td>
<td></td>
</tr>
</tbody>
</table>

| 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 80 Hz, 0 to 180 V, 100 to 150% V/Hz and a nominal voltage setting of 120V.

### Phase Undervoltage

| Pickup #1, #2, #3 | 5 to 180 V | 1 V | ± 0.5 V or ± 0.5% or ± 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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Third-Harmonic Undervoltage, Neutral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup #1, #2</td>
<td>0.10 to 14.00 V</td>
<td>0.01 V</td>
<td>±0.1 V or ±1%</td>
</tr>
<tr>
<td></td>
<td>Positive Sequence Voltage Block</td>
<td>5 to 180 V</td>
<td>1 V</td>
<td>±0.5 V or ±0.5%</td>
</tr>
<tr>
<td></td>
<td>Forward Under Power Block</td>
<td>0.01 to 1.00 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Reverse Under Power Block</td>
<td>–1.00 to –0.01 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Lead Under VAr Block</td>
<td>–1.00 to –0.01 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Lag Under VAr Block</td>
<td>0.01 to 1.00 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Lead Power Factor Block</td>
<td>0.01 to 1.00</td>
<td>0.01</td>
<td>±0.03 PU or ±3%</td>
</tr>
<tr>
<td></td>
<td>Lag Power Factor Block</td>
<td>0.01 to 1.00</td>
<td>0.01</td>
<td>±0.03 PU or ±3%</td>
</tr>
<tr>
<td></td>
<td>High Band Forward Power Block</td>
<td>0.01 to 1.00 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Low Band Forward Power Block</td>
<td>0.01 to 1.00 PU</td>
<td>0.01 PU</td>
<td>±0.01 PU or ±2%</td>
</tr>
<tr>
<td></td>
<td>Time Delay #1, #2</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>–1 to +5 Cycles or ±1%</td>
</tr>
</tbody>
</table>

#### Directional Power

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Pickup #1, #2, #3</td>
<td>–3.000 to +3.000 PU</td>
<td>0.001 PU</td>
<td>±0.002 PU or ±2%</td>
</tr>
<tr>
<td>32</td>
<td>Time Delay #1, #2, #3</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>+16 Cycles or ±1%</td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Circle Diameter #1, #2</td>
<td>0.1 to 100.0 Ω (0.5 to 500.0 Ω)</td>
<td>0.1 Ω</td>
<td>±0.1 Ω or ±5% (±0.5 Ω or ±5%)</td>
</tr>
<tr>
<td>40</td>
<td>Offset #1, #2</td>
<td>–50.0 to 50.0 Ω (-250.0 to 250.0 Ω)</td>
<td>0.1 Ω</td>
<td>±0.1 Ω or ±5% (±0.5 Ω or ±5%)</td>
</tr>
<tr>
<td>40</td>
<td>Time Delay #1, #2</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>±1 Cycle or ±1%</td>
</tr>
<tr>
<td>40</td>
<td>Time Delay with Voltage Control #1, #2</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>±1 Cycle or ±1%</td>
</tr>
<tr>
<td>40</td>
<td>Voltage Control (positive sequence)</td>
<td>5 to 180 V</td>
<td>1 V</td>
<td>±0.5 V or ±0.5%</td>
</tr>
<tr>
<td>40</td>
<td>Directional Element</td>
<td>0° to 20°</td>
<td>1°</td>
<td>—</td>
</tr>
</tbody>
</table>

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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Negative Sequence Overcurrent</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Definite Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup</td>
<td>3 to 100%</td>
<td>1%</td>
<td>±0.5% of 5 A (±0.5% of 1 A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Inverse Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup</td>
<td>3 to 100%</td>
<td>1%</td>
<td>±0.5% of 5 A (±0.5% of 1 A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Time Delay</strong></td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>±1 Cycle or ±1%</td>
</tr>
<tr>
<td></td>
<td><strong>Inverse Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup</td>
<td>3 to 100%</td>
<td>1%</td>
<td>±0.5% of 5 A (±0.5% of 1 A)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Time Dial Setting</strong></td>
<td>1 to 95</td>
<td>1</td>
<td>±3 Cycles or ±3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Definite Maximum</strong></td>
<td>600 to 65,500 Cycles</td>
<td>1 Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Definite Minimum Time</strong></td>
<td>12 Cycles</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td><strong>Reset Time (Linear)</strong></td>
<td>1 to 600 Seconds</td>
<td>1 Second</td>
<td>±1 Second or ±1%</td>
</tr>
</tbody>
</table>

Pickup is based on the generator nominal current setting.

|               | **Stator Overload Protection**   |                                  |           |           |
|               | **Time Constant #1, #2**         | 1.0 to 999.9 minutes             | 0.1 minutes | ±0.1 A or ±2% |
|               | **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** |                                  |           |           |
|               | **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**              |                                  |           |           |
|               | **Pickup**                       | 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.

|               | **Definite Time Overcurrent**    |                                  |           |           |
|               | **50DT**                         | **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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>50N</strong></td>
<td>Instantaneous Neutral Overcurrent</td>
<td>Pickup 0.1 to 240.0 A (0.1 to 48.0 A)</td>
<td>0.1 A</td>
<td>±0.1 A or ±3% (±0.02 A or ±3%)</td>
</tr>
<tr>
<td></td>
<td>Time Delay</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>±1 Cycle or ±1%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Overcurrent</th>
<th>Pickup 0.5 to 15.00 A (0.1 to 3.00 A)</th>
<th>0.01 A</th>
<th>±0.1 A or ±2% (±0.02 A or ±2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>50/27</strong></td>
<td>Undervoltage</td>
<td>Pickup 5 to 130 V</td>
<td>1 V</td>
<td>±0.5 V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pick-up Time Delay</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drop-out Time Delay</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
</tr>
</tbody>
</table>

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

### Inverse Time Neutral Overcurrent

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Pickup 0.25 to 12.00 A (0.05 to 2.40 A)</th>
<th>0.01 A</th>
<th>±0.1 A or ±1% (±0.02 A or ±1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>51N</strong></td>
<td>Characteristic Curve</td>
<td>Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Dial</td>
<td>0.5 to 11.0</td>
<td>0.05 to 1.10 (IEC curves) 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 to 15.0 (IEEE curves) 0.01</td>
<td></td>
</tr>
</tbody>
</table>

* 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

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Pickup 0.50 to 12.00 A (0.10 to 2.40 A)</th>
<th>0.01 A</th>
<th>±0.1 A or ±1% (±0.02 A or ±1%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>51V</strong></td>
<td>Characteristic Curve</td>
<td>Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Dial</td>
<td>0.5 to 11.0</td>
<td>0.05 to 1.10 (IEC curves) 0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 to 15.0 (IEEE curves) 0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage Control (VC)</td>
<td>5 to 180 V</td>
<td>1 V</td>
</tr>
<tr>
<td></td>
<td>Voltage Restraint (VR)</td>
<td>Linear Restraint</td>
<td>—</td>
</tr>
</tbody>
</table>

* 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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>59</strong></td>
<td><strong>Phase Overvoltage</strong></td>
<td>5 to 180 V</td>
<td>1 V</td>
<td>±0.5 V or ±0.5%</td>
</tr>
<tr>
<td></td>
<td>Time Delay #1, #2, #3</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>±1 Cycle or ±1%**</td>
</tr>
<tr>
<td></td>
<td>Input Voltage Select</td>
<td>Phase, Positive or Negative Sequence***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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 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 ±1 Cycle or ±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.

### Third-Harmonic Voltage Differential Ratio

| 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$_o$ (calculated) |

The 59D function has a cutoff voltage of 0.5 V for 3rd harmonic V$_x$ voltage. If the 180 Hz component of V$_n$ is expected to be less than 0.5 V the 59D function cannot 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$_o$ (equivalent to V$_A$ + V$_B$ + V$_C$) or V$_x$.

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

### Neutral Overvoltage

| 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% |

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

### Multi-purpose Overvoltage

| 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% |

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.

### VT Fuse-Loss Detection

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 |

†Select the greater of these accuracy values. Values in parentheses apply to 1 A CT secondary rating.
<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function Description</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>67N</td>
<td>Residual Directional Overcurrent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Definite Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup</td>
<td>0.5 to 240.0 A</td>
<td>0.1 A</td>
<td>±0.1 A or ±3% (±0.02 A or ±3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1 to 48.0 A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Delay</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>−1 to +3 Cycles or ±1%</td>
</tr>
<tr>
<td></td>
<td><strong>Inverse Time</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup</td>
<td>0.25 to 12.00 A</td>
<td>0.01 A</td>
<td>±0.1 A or ±3% (±0.02 A or ±3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.05 to 2.40 A)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Characteristic Curve</td>
<td>Definite Time/Inverse/Very Inverse/Extremely Inverse/IEC Curves</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderately Inverse/Very Inverse/Extremely Inverse/IEEE Curves</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Dial</td>
<td>0.5 to 11.0</td>
<td>0.1</td>
<td>±3 Cycles or ±5%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05 to 1.10 (IEC Curves)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 to 15.0 (IEEE curves)</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>78</td>
<td>Directional Element</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max Sensitivity Angle (MSA)</td>
<td>0 to 359°</td>
<td>1°</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polarizing Quantity</td>
<td>$3V_o$ (calculated), $V_n$ or $V_x$</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>*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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>81</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pickup #1,#2,#3,#4</td>
<td>50.00 to 67.00 Hz</td>
<td>0.01 Hz</td>
<td>±0.02 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40.00 to 57.00 Hz*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Time Delay #1–#4</td>
<td>3 to 65,500 Cycles</td>
<td>1 Cycle</td>
<td>±2 Cycles or ±1%</td>
</tr>
</tbody>
</table>

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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency Accumulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bands #1, #2, #3, #4, #5, #6</td>
<td>High Band #1</td>
<td>50.00 to 67.00 Hz</td>
<td>0.01 Hz</td>
</tr>
<tr>
<td>81A</td>
<td></td>
<td>40.00 to 57.00 Hz*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low Band #1–#6</td>
<td>50.00 to 67.00 Hz</td>
<td>0.01 Hz</td>
<td>± 0.02 Hz</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40.00 to 57.00 Hz*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay #1–#6</td>
<td>3 to 360,000 Cycles</td>
<td>1 Cycle</td>
<td>± 2 Cycles or ± 1%</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Rate of Change of Frequency</th>
<th>Pickup #1, #2</th>
<th>0.10 to 20.00 Hz/Sec.</th>
<th>0.01 Hz/Sec.</th>
<th>± 0.05 Hz/Sec. or ± 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>81R</td>
<td>Time Delay #1, #2</td>
<td>3 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>+ 20 Cycles</td>
</tr>
<tr>
<td>Negative Sequence Voltage Inhibit</td>
<td>0 to 99%</td>
<td>1%</td>
<td>± 0.5%</td>
<td></td>
</tr>
</tbody>
</table>

| Phase Differential Current | Pickup #1, #2 | 0.20 A to 3.00 A | 0.01 A | ± 0.1 A or ± 5% (± 0.02 A or ± 5%) |
|                           | (0.04 to 0.60 A) |           |       |           |
| 87                        | 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|.

<table>
<thead>
<tr>
<th>Ground (zero sequence) Differential Current</th>
<th>Pickup</th>
<th>0.20 to 10.00 A</th>
<th>0.01 A</th>
<th>± 0.1 A or ± 5% (± 0.02 A or ± 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>87 GD</td>
<td>(0.04 to 2.00 A)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time Delay*</td>
<td>1 to 8160 Cycles</td>
<td>1 Cycle</td>
<td>+1 to -2 Cycles or ± 1%</td>
<td></td>
</tr>
<tr>
<td>CT Ratio Correction (R_c)</td>
<td>0.10 to 7.99</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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 3|I_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.)

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSlogic™</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPS</td>
<td>Breaker Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td>Pickup</td>
<td>0 to 50,000 kA Cycles</td>
<td>1 kA Cycles</td>
<td>± 1 kACycles</td>
</tr>
<tr>
<td></td>
<td>Time Delay</td>
<td>0.1 to 4095.9 Cycles</td>
<td>0.1 Cycles</td>
<td>± 1 Cycle or ±1%</td>
</tr>
<tr>
<td></td>
<td>Timing Method</td>
<td>IT or I²T</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preset Accumulators</td>
<td>0 to 50,000 kA Cycles</td>
<td>1 kA Cycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phase A, B, C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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%

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.

### Trip Circuit Monitoring

<table>
<thead>
<tr>
<th>TC</th>
<th>Time Delay</th>
<th>1 to 8160 Cycles</th>
<th>1 Cycle</th>
<th>± 1 Cycle or ±1%</th>
</tr>
</thead>
</table>

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.

### 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% |

*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

<table>
<thead>
<tr>
<th>Device Number</th>
<th>Function</th>
<th>Setpoint Ranges</th>
<th>Increment</th>
<th>Accuracy†</th>
</tr>
</thead>
</table>

**Sync Check**

**Dead Check**
- Dead Voltage Limit: 0 to 60 V
- Dead Time Delay: 1 to 8160 Cycles

**Sync Check**
- Phase Angle Limit: 0° to 90°
- Upper Voltage Limit: 60 to 140 V
- Lower Voltage Limit: 40 to 120 V
- Delta Voltage Limit: 1.0 to 50.0 V
- Delta Frequency Limit: 0.001 to 0.500 Hz
- Sync Check Time Delay: 1 to 8160 Cycles

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

**Field Ground Protection**

- Pickup #1, #2: 5 to 100 KΩ
- Time Delay #1, #2: 1 to 8160 Cycles
- Injection Frequency (IF): 0.10 to 1.00 Hz
- Brush Lift-Off Detection (measuring control circuit):
  - Pickup: 0 to 5000 mV
  - Time Delay: 1 to 8160 Cycles

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

**100% Stator Ground Protection by low frequency injection**

- Total Current Pickup: 2 to 75 mA
- Real Component of Total Current Pickup: 2 to 75 mA
- Time Delay: 1 to 8160 Cycles

An 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 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.

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.
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 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 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 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 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.

The optional Ethernet port can be purchased with MODBUS over TCP/IP and BECO2200 over TCP/IP protocols or with the IEC 61850 protocol.

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 utilizing six pushbuttons and a 2-line by 24 character alphanumeric vacuum florescent 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

Target Module (optional)
An optional M-3925A Target Module provides 24 target and 8 output LEDs. Appropriate target LEDs will illuminate 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 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 V ac, 50/60 Hz, or 220/240 V ac 50/60 Hz or 24 V dc.

![Figure 1 Typical Temperature Controller Monitoring Application](image)

**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

- > 100 Megohms
**Electrical Environment**

*Electrostatic Discharge Test*
EN 60255-22-2 Class 4 (8 kV)—point contact discharge
EN 60255-22-2 Class 4 (15 kV)—air discharge

*Fast Transient Disturbance Test*
EN 60255-22-4 Class A (4 kV, 2.5 kHz)

**Surge Withstand Capability**

<table>
<thead>
<tr>
<th>ANSI/IEEE</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C37.90.1-</td>
<td>2,500 V pk-pk oscillatory applied to each independent circuit to earth</td>
</tr>
<tr>
<td>1989</td>
<td>5,000 V pk Fast Transient applied to each independent circuit to earth</td>
</tr>
<tr>
<td></td>
<td>5,000 V pk Fast Transient applied between each independent circuit</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ANSI/IEEE</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C37.90.1-</td>
<td>2,500 V pk-pk oscillatory applied to each independent circuit to earth</td>
</tr>
<tr>
<td>2002</td>
<td>4,000 V pk Fast Transient burst applied to each independent circuit to earth</td>
</tr>
<tr>
<td></td>
<td>4,000 V pk Fast Transient burst applied between each independent circuit</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>ANSI/IEEE</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C37.90.2</td>
<td>25-1000 Mhz @ 35 V/m</td>
</tr>
</tbody>
</table>

**Output Contacts**

<table>
<thead>
<tr>
<th>ANSI/IEEE</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>C37.90.0</td>
<td>Make 30 A for 0.2 seconds, off for 15 seconds for 2,000 operations, per Section 6.7.1, Tripping Output Performance Requirements</td>
</tr>
</tbody>
</table>

**Atmospheric Environment**

*Temperature*

<table>
<thead>
<tr>
<th>IEC60068-2-1</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold, -20° C</td>
<td></td>
</tr>
<tr>
<td>IEC60068-2-2</td>
<td>Dry Heat, +70° C</td>
</tr>
<tr>
<td>IEC60068-2-3</td>
<td>Damp Heat, +40° C @ 93% RH</td>
</tr>
</tbody>
</table>

**Mechanical Environment**

*Vibration*

<table>
<thead>
<tr>
<th>IEC60255-21-1</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration response Class 1, 0.5 g</td>
<td></td>
</tr>
<tr>
<td>Vibration endurance Class 1, 1.0 g</td>
<td></td>
</tr>
<tr>
<td>IEC60255-21-2</td>
<td>Requirement</td>
</tr>
<tr>
<td>Shock Response Class 1, 5.0 g</td>
<td></td>
</tr>
<tr>
<td>Shock Withstand Class 1, 15.0 g</td>
<td></td>
</tr>
<tr>
<td>Bump Endurance Class 1, 10.0 g</td>
<td></td>
</tr>
</tbody>
</table>

**Compliance**

UL-Listed per 508 – Industrial Control Equipment
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)

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.

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.
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 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 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 \( I_v \) 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)
M-3425A Generator Protection Relay

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

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 differential)
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)
**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)*
Figure 8  M-3425A Vertical Unit Layout
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 (H5 and H6)
M-3425A Generator Protection Relay

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 7 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

**NOTES:**
1. The above circuit measures insulation resistance \( R_f \) between rotor field winding and ground (64F).
2. Relay injects \( \pm 15 \text{ V squarewave} \) \( V_{\text{out}} \) 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:** \(-20^\circ\) to \(+70^\circ\), Centigrade

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

---

**Figure 11 Field Ground Protection Block Diagram**
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 µs, 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
ANSI/IEEE 2,500 V pk-pk oscillatory applied to each independent circuit to earth
C37.90.1-1989 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
ANSI/IEEE 2,500 V pk-pk oscillatory applied to each independent circuit to earth
C37.90.1-2002 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 (RS-232, RS-485, IRIG-B, Ethernet communication port and field ground coupling port) through capacitive coupling clamp.

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

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
M-3921 Field Ground Coupler Mounting Dimensions

Figure 12  M-3921 Field Ground Coupler Mounting Dimensions
**M-3425A Generator Protection Relay**

---

**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 the 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, that limits the M-3425A to 0 200 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 0 200 V.) The 20Hz current is also connected to the $I_N$ input of the M-3425A, through the 20Hz 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. 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.

For cases where the Load Resistor ($R_L$) 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.
**Figure 13**  
64S Function Component Connection Diagram (Model A00/EE 20 Hz Signal Generator)

* For applications with a transformer secondary rating that will result in 50/60 Hz phase ground fault voltages >200 V ac, use the "High Voltage" connection for the 59N Function.

** If 20 Hz Signal Generator is prior to Model EE a step down transformer is necessary for voltages >120 VAC.
20 Hz Signal Generator Function Specifications

**Auxiliary Voltage**

<table>
<thead>
<tr>
<th>Rated auxiliary voltage $U_{\text{H, ac}}$</th>
<th>3x (100/120 V ac), 50/60 Hz</th>
<th>1x (100 to 120 V ac), 50/60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permissible variations ac</td>
<td>88 to 230 V ac</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rated auxiliary voltage $U_{\text{H, dc}}$</td>
<td>110 to 220 V dc</td>
<td></td>
</tr>
<tr>
<td>Permissible Variations dc</td>
<td>88 to 250 V dc</td>
<td></td>
</tr>
</tbody>
</table>

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)

<table>
<thead>
<tr>
<th>Output Voltage</th>
<th>approx. 26 V ±10 %, rectangular; 20 Hz ± 0.1 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Output, permanently</td>
<td>100 VA over all ranges</td>
</tr>
</tbody>
</table>

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

**Binary Input for Blocking**

Connections (6 and 8)

<table>
<thead>
<tr>
<th>Switching Threshold</th>
<th>Adjustable voltage range with jumper</th>
</tr>
</thead>
<tbody>
<tr>
<td>– For control voltages</td>
<td>24 V</td>
</tr>
<tr>
<td></td>
<td>48 V</td>
</tr>
<tr>
<td></td>
<td>60 V</td>
</tr>
<tr>
<td>DC 19 V: $U_{\text{high}} \geq$</td>
<td>DC 19 V, $U_{\text{low}} \leq$ DC 10 V</td>
</tr>
<tr>
<td>– For control voltages</td>
<td>110 V</td>
</tr>
<tr>
<td></td>
<td>125 V</td>
</tr>
<tr>
<td></td>
<td>220 V</td>
</tr>
<tr>
<td>DC 88 V: $U_{\text{high}} \geq$</td>
<td>DC 88 V, $U_{\text{low}} \leq$ DC 44 V</td>
</tr>
</tbody>
</table>

Permissible voltage, continuous 300 V dc

**Life Contact**

Connections (5, 7 and 9)

<table>
<thead>
<tr>
<th>Switching capacity</th>
<th>MAKE 30W/VA</th>
</tr>
</thead>
<tbody>
<tr>
<td>BREAK</td>
<td>20 VA</td>
</tr>
<tr>
<td>30 W resistance load</td>
<td>50 ms</td>
</tr>
<tr>
<td>25 W @ L/R</td>
<td>50 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switching voltage</th>
<th>DC 24 V to DC 250 V</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AC 24 to AC 230 V</td>
</tr>
</tbody>
</table>

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 14 20Hz Signal Generator Dimensions
**Band-pass Filter Specifications**

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

Connections (1B1-1B4):
- Permissible voltage, continuous: 55 V ac
- Permissible voltage for ≤30 s: 550 V ac
- Frequency of superimposed ac voltage: ≥ 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 V ac
- Permissible voltage for ≤30 s: 50 V ac

Test Voltage: 2.8 kV dc

*Permissible Ambient Temperatures*

with \( R_L < 5 \) Ω burden: ≤40°C or ≤104°F
with \( R_L > 5 \) Ω burden: ≤55°C or ≤131°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.
**NOTE:** Detailed Mounting information is contained in the M-3425A Instruction Book Chapter 5, Installation Section 5.

*Figure 15  Band-pass Filter Dimensions*

*Figure 16  20 Hz Measuring Current Transformer 400-5 A CT*
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 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-V01.00.34 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)
# TABLE OF CONTENTS

M-3425A Generator Protection
Instruction Book

## Chapter 1 Introduction

1.1 Instruction Book Contents .................................................................1-1
1.2 M-3425A Generator Protection Relay .................................................1-2
1.3 Accessories ..................................................................................1-4

## Chapter 2 Application

2.1 Configuration .....................................................................................2-2
Profiles ......................................................................................................2-3
Functions ..................................................................................................2-3
Special Considerations ...........................................................................2-3
Relay System Setup ................................................................................2-3
2.2 System Diagrams ................................................................................2-8
2.3 Setpoints and Time Settings .................................................................2-14
21 Phase Distance ..................................................................................2-14
24 Overexcitation Volts/Hz .....................................................................2-18
M-3425A Firmware Versions D-0114VXX.XX.XX and Earlier ..................2-19
M-3425A Firmware Version D-0150V 01.00.34 ......................................2-19
M-3425A Firmware Version D-0150V 01.04.00 ......................................2-19
25 Sync Check ..........................................................................................2-21
Phase Angle Check ..................................................................................2-21
Delta Voltage and Delta Frequency Check .............................................2-21
27 Phase Undervoltage ..........................................................................2-25
27TN #2 Screens are identical to 27TN #1 ..............................................2-28
32 Directional Power .............................................................................2-29
Protection from Generator Motoring ......................................................2-29
Protection from Generator Overload .......................................................2-29
Protection from Excessive Reactive Power ............................................2-29
40 Loss of Field .....................................................................................2-33
46 Negative Sequence Overcurrent .......................................................2-37
49 Stator Overload Protection .................................................................2-39
50/50N Instantaneous Overcurrent, Phase and Neutral Circuits ..........2-42
50BF Generator Breaker Failure/HV Breaker Flashover .........................2-44
50DT Definite Time Overcurrent (for split-phase differential) ...............2-46
50/27 Inadvertent Energizing .................................................................2-47
51N Inverse Time Neutral Overcurrent ...............................................2-49
51V Inverse Time Phase Overcurrent with Voltage Control/Restraint ....2-50
59 Phase Overvoltage .............................................................................2-52
59D Third Harmonic Voltage Differential (Ratio) ..................................2-53
59N Overvoltage, Neutral Circuit or Zero Sequence ..............................2-55
59X Multipurpose Overvoltage (Turn-to-Turn Stator Fault Protection or Bus Ground Protection) ..........................................................2-56
Chapter 2 Application (Cont.'d)

60FL VT Fuse Loss ................................................................. 2–58
Internal Fuse Loss Detection Logic ......................................... 2–58
External Fuse-Loss Function ................................................... 2–58
60FL VT Fuse Loss Alarm Function ......................................... 2–58
64B/F Field Ground Protection ............................................... 2–61
64F Field Ground Detection ................................................... 2–61
Factors Affecting 64F Performance .......................................... 2–61
64B Brush Lift-Off Detection ................................................... 2–63
64S 100% Stator Ground Protection by Low Frequency Signal Injection .... 2–65
67N Residual Directional Overcurrent ........................................ 2–71
78 Out-of-Step ...................................................................... 2–74
81 Frequency ........................................................................ 2–77
81A Frequency Accumulator ................................................... 2–79
81R Rate of Change of Frequency ............................................ 2–81
87 Phase Differential ............................................................ 2–82
87GD Ground (Zero Sequence) Differential ............................... 2–84
Breaker Monitoring ............................................................... 2–85
Trip Circuit Monitoring .......................................................... 2–86
IPSlogic™ ............................................................................ 2–87
Settings and Logic Applicable when IPSlogic™ Function(s) programmed using IPScom® .............................................. 2–89
DO/RST (Dropout/Reset) Timer Feature ...................................... 2–91
Reset Delay Timer ................................................................. 2–91
Dropout Delay Timer ............................................................. 2–91

Chapter 3 Operation

3.1 Front Panel Controls .......................................................... 3–1
Alphanumeric Display ............................................................ 3–1
Screen Blanking ..................................................................... 3–1
Arrow Pushbuttons .................................................................. 3–1
Exit Pushbutton ...................................................................... 3–1
Enter Pushbutton ..................................................................... 3–1
Target & Status Indicators and Controls ................................. 3–1
Power Supply #1 (#2) LED ...................................................... 3–2
Relay OK LED ....................................................................... 3–2
Oscillograph Recorded LED .................................................... 3–2
Breaker Closed LED ............................................................... 3–2
Target Indicators and Target Reset .......................................... 3–2
Time Sync LED ...................................................................... 3–2
Diagnostic LED ..................................................................... 3–2
Accessing Screens .................................................................. 3–2
Default Message Screens ....................................................... 3–2

3.2 Initial Setup Procedure/Settings .......................................... 3–5

3.3 Setup Unit Data .................................................................. 3–5
Setup Unit Data Entry ............................................................ 3–5
Setup Unit Features That Do Not Require Data Entry .................. 3–6
## Chapter 3 Operation (Cont.’d)

3.4 Setup System Data ................................................................. 3–6  
Configure Relay Data ................................................................. 3–7  
Setpoints and Time Settings ...................................................... 3–7  
Oscillograph Recorder Data ..................................................... 3–8  
Communications Settings ......................................................... 3–8  
3.5 Status/Metering ................................................................. 3–9  
3.6 Target History ................................................................. 3–10

## Chapter 4 Remote Operation

4.1 Remote Operation ................................................................. 4–1  
Serial Ports (RS-232) ................................................................. 4–1  
Serial Port (RS-485) ................................................................. 4–1  
Optional Ethernet Port ............................................................... 4–1  
Direct Connection ................................................................. 4–2  
Setting up the M-3425A Generator Protection Relay for Communication ................................................................. 4–3  
Serial Communication Settings ................................................ 4–3  
Com Port Security ................................................................. 4–3  
Disabling Com Port ................................................................. 4–3  
Ethernet Communication Settings ........................................... 4–4  
DHCP Protocol ................................................................. 4–4  
Ethernet Protocols ................................................................. 4–4  
Ethernet Port Setup ................................................................. 4–4  
HMI Ethernet Port Setup ............................................................. 4–4  
Manual Configuration of Ethernet Board ................................... 4–5  
IPSutil™ Ethernet Port Setup with DHCP ................................. 4–6  
IPSutil Ethernet Port Setup without DHCP ............................... 4–6  
Installing the Modems ............................................................. 4–6  
4.2 Installation and Setup (IPScom®) ........................................... 4–9  
4.3 Operation ................................................................. 4–9  
Activating Communications .................................................... 4–9  
Overview ................................................................. 4–9  
File Menu ................................................................. 4–10  
Comm Menu ................................................................. 4–10  
Relay Menu ................................................................. 4–11  
Sequence of Events ................................................................. 4–19  
Oscillograph ................................................................. 4–21  
Profile ................................................................. 4–21  
Window Menu/Help Menu ...................................................... 4–22  
4.4 Checkout Status/Metering ..................................................... 4–23  
4.5 Cautions ................................................................. 4–28  
4.6 Keyboard Shortcuts ............................................................. 4–29
Chapter 4 Remote Operation (Cont.’d)

4.7 IPSutil Communications Software .......................................................... 4–30
M-3890 IPSutil ......................................................................................... 4–30
Installation and Setup ............................................................................. 4–30
Installation ............................................................................................... 4–31
System Setup ........................................................................................... 4–31
Overview .................................................................................................. 4–31
Comm Menu ............................................................................................. 4–31
Relay Comm Command ........................................................................... 4–31
Ethernet Command .................................................................................. 4–31
Clock Command ....................................................................................... 4–31
Security Menu .......................................................................................... 4–32
Miscellaneous Menu ............................................................................... 4–32
Help Menu ............................................................................................... 4–32

Chapter 5 Installation

5.1 General Information ............................................................................. 5–1
5.2 Mechanical/Physical Dimensions ......................................................... 5–2
5.3 External Connections ........................................................................... 5–8
5.4 Commissioning Checkout ..................................................................... 5–14
5.5 Circuit Board Switches and Jumper ....................................................... 5–19
5.6 Low Frequency Signal Injection Equipment ........................................ 5–23

Chapter 6 Testing

6.1 Equipment/Test Setup ........................................................................... 6–2
   Equipment Required ............................................................................... 6–2
   Setup ...................................................................................................... 6–2
6.2 Functional Test Procedures .................................................................. 6–6
   Power On Self Tests ............................................................................ 6–7
   21 Phase Distance (#1, #2 or #3) .......................................................... 6–8
   24 Volts/Hz Definite Time (#1 or #2) .................................................... 6–9
   24 Volts/Hz Inverse Time .................................................................... 6–10
   25D Dead Check ................................................................................. 6–12
   25S Sync Check ................................................................................... 6–14
   27 Phase Undervoltage, 3 Phase (#1, #2, #3) ...................................... 6–16
   27TN Third-Harmonic Undervoltage, Neutral (#1 or #2) ..................... 6–17
   32 Directional Power, 3 Phase (#1, #2, #3) .......................................... 6–21
   40 Loss of Field (#1 or #2, VC #1 or #2) .............................................. 6–24
   46 Negative Sequence Overcurrent Definite Time ............................... 6–26
   46 Negative Sequence Overcurrent Inverse Time ............................... 6–27
   49 Stator Overload Protection (#1, #2) ................................................ 6–28
   50 Instantaneous Phase Overcurrent (#1, #2) ........................................ 6–30
   50BF/50BF-N Breaker Failure ............................................................... 6–31
   50/27 Inadvertent Energizing ............................................................... 6–33
   50DT Definite Time Overcurrent (for split-phase differential), #1 or #2 .... 6–34
   50N Instantaneous Neutral Overcurrent ............................................. 6–35
   51N Inverse Time Neutral Overcurrent .............................................. 6–36
Chapter 6 Testing (Cont.'d)

51V Inverse Time Phase Overcurrent with Voltage Control/Restraint........6-37
59 Phase Overvoltage, 3-Phase (#1, #2, #3).................................6-39
59D Third-Harmonic Voltage Differential........................................6-40
59N Overvoltage, Neutral Circuit or Zero Sequence (#1, #2, #3)........6-41
59X Multi-purpose Overvoltage (#1 or #2)......................................6-42
60FL VT Fuse Loss Detection.........................................................6-43
64F Field Ground Protection (#1 or #2)..........................................6-44
64B Brush Lift-Off Detection.........................................................6-46
64S 100% Stator Ground Protection by low frequency injection........6-47
67N Residual Directional Overcurrent, Definite Time.....................6-50
67N Residual Directional Overcurrent, Inverse Time.......................6-52
78 Out of Step .............................................................................6-54
81 Frequency (#1, #2, #3, #4) .....................................................6-56
81A Frequency Accumulator (Band #1, #2, #3, #4, #5, #6).............6-57
81R Rate of Change of Frequency (#1, #2)....................................6-58
87 Phase Differential (#1 or #2)...................................................6-60
87GD Ground Differential.............................................................6-62
BM Breaker Monitoring..................................................................6-64
Trip Circuit Monitoring..................................................................6-66
IPSlogicTM (#1, #2, #3, #4, #5, #6).............................................6-67

6.3 Diagnostic Test Procedures........................................................6-68
Overview.........................................................................................6-68
Entering Relay Diagnostic Mode .....................................................6-68
Output Relay Test (Output Relays 1–23 and 25)...............................6-69
Output Relay Test (Power Supply Relay 24).....................................6-70
Input Test (Control/Status)..............................................................6-70
Status LED Test............................................................................6-71
Target LED Test............................................................................6-72
Button Test....................................................................................6-72
Display Test...................................................................................6-73
COM1/COM2 Loopback Test............................................................6-73
COM3 Test (2-Wire).......................................................................6-74
Clock ON/OFF ............................................................................6-75
Relay OK LED Flash/Illuminated....................................................6-76
Auto Calibration............................................................................6-76
Factory Use Only...........................................................................6-76

6.4 Auto Calibration ........................................................................6-77
Phase and Neutral Fundamental Calibration.................................6-77
Third Harmonic Calibration.............................................................6-78
64S 100% Stator Ground by Low Frequency Injection Calibration.....6-78
Field Ground Calibration.................................................................6-79

Appendices

Appendix A: Configuration Record Forms.......................................A-1
Appendix B: Communications.........................................................B-1
Appendix C: Self-Test Error Codes..................................................C-1
Appendix D: Inverse Time Curves...................................................D-1
Appendix E: Declaration of Conformity...........................................E-1
<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chapter 1</strong></td>
<td></td>
</tr>
<tr>
<td>1-1 M-3925A Target Module</td>
<td>1-4</td>
</tr>
<tr>
<td>1-2 M-3931 Human-Machine Interface (HMI) Module</td>
<td>1-4</td>
</tr>
<tr>
<td><strong>Chapter 2</strong></td>
<td></td>
</tr>
<tr>
<td>2-1 Setup System Dialog Box</td>
<td>2-6</td>
</tr>
<tr>
<td>2-2 Selection Screen for Expanded Input</td>
<td>2-7</td>
</tr>
<tr>
<td>2-3 Pulse Relay Expanded Output Screen</td>
<td>2-7</td>
</tr>
<tr>
<td>2-4 Latch Relay Expanded Output Screen</td>
<td>2-7</td>
</tr>
<tr>
<td>2-5 One-Line Functional Diagram</td>
<td>2-8</td>
</tr>
<tr>
<td>2-6 Alternative One-Line Functional Diagram (configured for split-phase differential)</td>
<td>2-9</td>
</tr>
<tr>
<td>2-7 Three-Line Connection Diagram</td>
<td>2-10</td>
</tr>
<tr>
<td>2-8 Function 25 Sync Check Three-Line Connection Diagram</td>
<td>2-11</td>
</tr>
<tr>
<td>2-9 Function 59X Turn to Turn Fault Protection Three-Line Connection Diagram</td>
<td>2-12</td>
</tr>
<tr>
<td>2-10 Function 67N, 59D, 59X (Bus Ground) Three-Line Connection Diagram</td>
<td>2-13</td>
</tr>
<tr>
<td>2-11 Selection Screen for Expanded I/O Initiate</td>
<td>2-14</td>
</tr>
<tr>
<td>2-12 Phase Distance (21) Coverage</td>
<td>2-16</td>
</tr>
<tr>
<td>2-13 Phase Distance (21) Function Applied for System Backup</td>
<td>2-16</td>
</tr>
<tr>
<td>2-14 Phase Distance (21) Setpoint Ranges</td>
<td>2-17</td>
</tr>
<tr>
<td>2-15 Example of Capability and Protection Curves (24)</td>
<td>2-19</td>
</tr>
<tr>
<td>2-16 Volts-Per-Hertz (24) Setpoint Ranges</td>
<td>2-20</td>
</tr>
<tr>
<td>2-17 Sync Check Logic Diagrams</td>
<td>2-23</td>
</tr>
<tr>
<td>2-18 Sync Check (25) Setpoint Ranges</td>
<td>2-24</td>
</tr>
<tr>
<td>2-19 Phase Undervoltage (27) Setpoint Ranges</td>
<td>2-25</td>
</tr>
<tr>
<td>2-20 Third Harmonic Undervoltage (27TN) Protection Characteristics</td>
<td>2-26</td>
</tr>
<tr>
<td>2-21 27TN Blocking Regions</td>
<td>2-27</td>
</tr>
<tr>
<td>2-22 Third Harmonic Undervoltage, Neutral Circuit (27TN) Setpoint Ranges</td>
<td>2-27</td>
</tr>
<tr>
<td>2-23 Tripping on Reverse Power Flow (Over Power with Negative Pickup)</td>
<td>2-29</td>
</tr>
<tr>
<td>2-24 Tripping on Low Forward Power (Under Power with Positive Pickup)</td>
<td>2-31</td>
</tr>
<tr>
<td>2-25 Tripping on Overpower (Over Power with Positive Pickup)</td>
<td>2-31</td>
</tr>
<tr>
<td>2-26 Tripping on Over Reactive Power with Element #3 (Over Power, Positive Pickup and Directional Power Sensing Set to Reactive)</td>
<td>2-32</td>
</tr>
<tr>
<td>2-27 Directional Power, 3-Phase (32) Setpoint Ranges</td>
<td>2-32</td>
</tr>
<tr>
<td>2-28 Loss of Field (40)—Protective Approach 1</td>
<td>2-35</td>
</tr>
<tr>
<td>2-29 Loss of Field (40)—Protective Approach 2</td>
<td>2-35</td>
</tr>
<tr>
<td>2-30 Loss-of-Field (40) Setpoint Ranges</td>
<td>2-36</td>
</tr>
<tr>
<td>2-31 Negative Sequence Overcurrent Inverse Time Curves</td>
<td>2-38</td>
</tr>
<tr>
<td>2-32 Negative Sequence Overcurrent (46) Setpoint Ranges</td>
<td>2-38</td>
</tr>
<tr>
<td>2-33 Time Constant, Function 49</td>
<td>2-39</td>
</tr>
<tr>
<td>2-34 49 Function Overload Curves</td>
<td>2-40</td>
</tr>
<tr>
<td>2-35 Stator Thermal Protection (49) Setpoint Ranges</td>
<td>2-41</td>
</tr>
<tr>
<td>2-36 Instantaneous Overcurrent (50) Setpoint Ranges</td>
<td>2-43</td>
</tr>
<tr>
<td>2-37 Instantaneous Neutral Overcurrent (50N) Setpoint Ranges</td>
<td>2-43</td>
</tr>
<tr>
<td>2-38 Breaker Failure Logic Diagram</td>
<td>2-44</td>
</tr>
<tr>
<td>2-39 Breaker Failure (50BF) Setpoint Ranges</td>
<td>2-45</td>
</tr>
<tr>
<td>2-40 Definite Time Overcurrent (50DT) Setpoint Ranges</td>
<td>2-46</td>
</tr>
<tr>
<td>2-41 Inadvertent Energizing Function Logic Diagram</td>
<td>2-48</td>
</tr>
</tbody>
</table>
## Figures (Cont.’d)

### Chapter 2 (Cont.’d)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-42</td>
<td>Inadvertent Energizing (50/27) Setpoint Ranges</td>
<td>2-48</td>
</tr>
<tr>
<td>2-43</td>
<td>Inverse Time Neutral Overcurrent (51N) Setpoint Ranges</td>
<td>2-49</td>
</tr>
<tr>
<td>2-44</td>
<td>Voltage Restraint (51VR) Characteristic</td>
<td>2-51</td>
</tr>
<tr>
<td>2-45</td>
<td>Inverse Time Overcurrent with Voltage</td>
<td>2-51</td>
</tr>
<tr>
<td>2-46</td>
<td>Phase Overvoltage (59) Setpoint Ranges</td>
<td>2-52</td>
</tr>
<tr>
<td>2-47</td>
<td>Third Harmonic Voltage Differential (Ratio) Scheme</td>
<td>2-54</td>
</tr>
<tr>
<td>2-48</td>
<td>Third Harmonic Voltage Differential (59D) Setpoint Ranges</td>
<td>2-54</td>
</tr>
<tr>
<td>2-49</td>
<td>Overvoltage, Neutral Circuit or Zero Sequence (59N) Setpoint Ranges</td>
<td>2-55</td>
</tr>
<tr>
<td>2-50</td>
<td>Turn-to-Turn Stator Winding Fault Protection</td>
<td>2-57</td>
</tr>
<tr>
<td>2-51</td>
<td>(59X) Multi-purpose Overvoltage Setpoint Ranges</td>
<td>2-57</td>
</tr>
<tr>
<td>2-52</td>
<td>Fuse Loss (60FL) Function Logic</td>
<td>2-59</td>
</tr>
<tr>
<td>2-53</td>
<td>Fuse Loss (60FL) Setpoint Ranges</td>
<td>2-60</td>
</tr>
<tr>
<td>2-54</td>
<td>M-3921 Field Ground Coupler</td>
<td>2-62</td>
</tr>
<tr>
<td>2-55</td>
<td>Field Ground Protection (64B/F) Setpoint Ranges</td>
<td>2-63</td>
</tr>
<tr>
<td>2-56</td>
<td>64S Function Component Connection Diagram (Model A00/CC 20 Hz Signal Generator)</td>
<td>2-66</td>
</tr>
<tr>
<td>2-57</td>
<td>64S Function Component Connection Diagram (Model A00DE 20 Hz Signal Generator)</td>
<td>2-67</td>
</tr>
<tr>
<td>2-58</td>
<td>64S Network</td>
<td>2-68</td>
</tr>
<tr>
<td>2-59</td>
<td>Primary Transferred To Transformer Secondary</td>
<td>2-68</td>
</tr>
<tr>
<td>2-60</td>
<td>64S Function Time Delay Pickup Current Correlation</td>
<td>2-70</td>
</tr>
<tr>
<td>2-61</td>
<td>100% Stator Ground Protection (64S) Setpoint Ranges</td>
<td>2-70</td>
</tr>
<tr>
<td>2-62</td>
<td>Residual Directional Overcurrent (67N) Trip Characteristics</td>
<td>2-71</td>
</tr>
<tr>
<td>2-63</td>
<td>Residual Directional Overcurrent (67N) Setpoint Ranges</td>
<td>2-73</td>
</tr>
<tr>
<td>2-64</td>
<td>Out-of-Step Relay Characteristics</td>
<td>2-75</td>
</tr>
<tr>
<td>2-65</td>
<td>Out-of-Step Protection Settings</td>
<td>2-75</td>
</tr>
<tr>
<td>2-66</td>
<td>Out-of-Step (78) Setpoint Ranges</td>
<td>2-76</td>
</tr>
<tr>
<td>2-67</td>
<td>Example of Frequency (81) Trip Characteristics</td>
<td>2-78</td>
</tr>
<tr>
<td>2-68</td>
<td>Frequency (81) Setpoint Ranges</td>
<td>2-78</td>
</tr>
<tr>
<td>2-69</td>
<td>Frequency Accumulator (81A) Example Bands</td>
<td>2-80</td>
</tr>
<tr>
<td>2-70</td>
<td>Frequency Accumulator (81A) Setpoint Ranges</td>
<td>2-80</td>
</tr>
<tr>
<td>2-71</td>
<td>Rate of Change of Frequency (81R) Setpoint Ranges</td>
<td>2-81</td>
</tr>
<tr>
<td>2-72</td>
<td>Differential Relay (87) Operating Characteristics</td>
<td>2-83</td>
</tr>
<tr>
<td>2-73</td>
<td>Phase Differential (87) Setpoint Ranges</td>
<td>2-83</td>
</tr>
<tr>
<td>2-74</td>
<td>Ground Differential (87GD) Setpoint Ranges</td>
<td>2-84</td>
</tr>
<tr>
<td>2-75</td>
<td>Breaker Monitor (BM) Setpoint Ranges</td>
<td>2-85</td>
</tr>
<tr>
<td>2-76</td>
<td>Trip Circuit Monitoring Input</td>
<td>2-86</td>
</tr>
<tr>
<td>2-77</td>
<td>Trip Circuit Monitor (TC) Setpoint Ranges</td>
<td>2-86</td>
</tr>
<tr>
<td>2-78</td>
<td>IPSlogic™ Function Setup</td>
<td>2-88</td>
</tr>
<tr>
<td>2-79</td>
<td>IPSlogic Function Programming</td>
<td>2-89</td>
</tr>
<tr>
<td>2-80</td>
<td>Selection Screen for Initiating Function Timeout</td>
<td>2-90</td>
</tr>
<tr>
<td>2-81</td>
<td>Selection Screen for Initiating Function Pickup</td>
<td>2-90</td>
</tr>
<tr>
<td>2-82</td>
<td>Dropout Delay Timer Logic Diagram</td>
<td>2-91</td>
</tr>
<tr>
<td>2-83</td>
<td>Reset Delay Timer Logic Diagram</td>
<td>2-91</td>
</tr>
</tbody>
</table>

## Chapter 3

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-1</td>
<td>M-3425A Front Panel</td>
<td>3-3</td>
</tr>
<tr>
<td>3-2</td>
<td>Screen Message Menu Flow</td>
<td>3-3</td>
</tr>
<tr>
<td>3-3</td>
<td>Main Menu Flow</td>
<td>3-4</td>
</tr>
</tbody>
</table>
## Figures (Cont.'d)

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-1</td>
<td>Multiple System Addressing Using Communications Line Splitter</td>
<td>4-2</td>
</tr>
<tr>
<td>4-2</td>
<td>IPScom® Menu Selections</td>
<td>4-8</td>
</tr>
<tr>
<td>4-3</td>
<td>IPScom Program Icon</td>
<td>4-9</td>
</tr>
<tr>
<td>4-4</td>
<td>System Type Dialog Box</td>
<td>4-10</td>
</tr>
<tr>
<td>4-5</td>
<td>Communication Dialog Box</td>
<td>4-11</td>
</tr>
<tr>
<td>4-6</td>
<td>Setup System Dialog Box</td>
<td>4-12</td>
</tr>
<tr>
<td>4-7</td>
<td>Expanded Input Active State</td>
<td>4-13</td>
</tr>
<tr>
<td>4-8</td>
<td>Pulse Relay Expanded Output Screen</td>
<td>4-13</td>
</tr>
<tr>
<td>4-9</td>
<td>Latch Relay Expanded Output Screen</td>
<td>4-13</td>
</tr>
<tr>
<td>4-10</td>
<td>Relay Setpoints Dialog Box</td>
<td>4-14</td>
</tr>
<tr>
<td>4-11</td>
<td>Typical Setpoint Dialog Box</td>
<td>4-14</td>
</tr>
<tr>
<td>4-12</td>
<td>Expanded I/O Initiate</td>
<td>4-14</td>
</tr>
<tr>
<td>4-13</td>
<td>All Setpoints Table Dialog Box (Partial)</td>
<td>4-15</td>
</tr>
<tr>
<td>4-14</td>
<td>Configure Dialog Box (Partial)</td>
<td>4-16</td>
</tr>
<tr>
<td>4-15</td>
<td>Configure Dialog Box Partial (shown with Expanded Input/Outputs)</td>
<td>4-17</td>
</tr>
<tr>
<td>4-16</td>
<td>Unit Date/Time Dialog Box</td>
<td>4-18</td>
</tr>
<tr>
<td>4-17</td>
<td>Target Dialog Box</td>
<td>4-19</td>
</tr>
<tr>
<td>4-18</td>
<td>Trigger Events Screen with Expanded I/O</td>
<td>4-20</td>
</tr>
<tr>
<td>4-19</td>
<td>Event Log Viewer</td>
<td>4-20</td>
</tr>
<tr>
<td>4-20</td>
<td>Event Download Screen</td>
<td>4-21</td>
</tr>
<tr>
<td>4-21</td>
<td>Setup Oscillograph Recorder</td>
<td>4-21</td>
</tr>
<tr>
<td>4-22</td>
<td>Retrieve Oscillograph Record Dialog</td>
<td>4-21</td>
</tr>
<tr>
<td>4-23</td>
<td>Profile Switching Method Dialog</td>
<td>4-21</td>
</tr>
<tr>
<td>4-24</td>
<td>Select Active Profile</td>
<td>4-22</td>
</tr>
<tr>
<td>4-25</td>
<td>Copy Active Profile</td>
<td>4-22</td>
</tr>
<tr>
<td>4-26</td>
<td>About IPScom® Dialog Box</td>
<td>4-22</td>
</tr>
<tr>
<td>4-27</td>
<td>Primary Status Dialog Box</td>
<td>4-23</td>
</tr>
<tr>
<td>4-28</td>
<td>Secondary Status Dialog Box</td>
<td>4-23</td>
</tr>
<tr>
<td>4-29</td>
<td>Accumulator Status Screen</td>
<td>4-24</td>
</tr>
<tr>
<td>4-30</td>
<td>Phase Distance Dialog Box</td>
<td>4-24</td>
</tr>
<tr>
<td>4-31</td>
<td>Loss of Field Dialog Box</td>
<td>4-25</td>
</tr>
<tr>
<td>4-32</td>
<td>Out of Step Dialog Box</td>
<td>4-25</td>
</tr>
<tr>
<td>4-33</td>
<td>Phasor Dialog Box</td>
<td>4-26</td>
</tr>
<tr>
<td>4-34</td>
<td>Sync Scope Screen</td>
<td>4-26</td>
</tr>
<tr>
<td>4-35</td>
<td>Function Status Screen</td>
<td>4-27</td>
</tr>
<tr>
<td>4-36</td>
<td>IPSutil™ Main Menu Flow</td>
<td>4-30</td>
</tr>
<tr>
<td>4-37</td>
<td>Warning Message</td>
<td>4-31</td>
</tr>
<tr>
<td>4-38</td>
<td>IPSutility Reset Relay Message</td>
<td>4-31</td>
</tr>
<tr>
<td>4-39</td>
<td>Monitor Status Screen</td>
<td>4-32</td>
</tr>
<tr>
<td>4-40</td>
<td>Calibration Dialog Box</td>
<td>4-32</td>
</tr>
<tr>
<td>4-41</td>
<td>Communication Dialog Box</td>
<td>4-33</td>
</tr>
<tr>
<td>4-42</td>
<td>Relay Comm Port Settings</td>
<td>4-33</td>
</tr>
<tr>
<td>4-43</td>
<td>Ethernet Settings</td>
<td>4-33</td>
</tr>
<tr>
<td>4-44</td>
<td>Set Unit Date/Time Dialog Box</td>
<td>4-33</td>
</tr>
<tr>
<td>4-45</td>
<td>Change Communication Access Code Dialog Box</td>
<td>4-34</td>
</tr>
<tr>
<td>4-46</td>
<td>Change User Access Code Dialog Box</td>
<td>4-34</td>
</tr>
<tr>
<td>4-47</td>
<td>Setup Dialog Box</td>
<td>4-34</td>
</tr>
</tbody>
</table>
Appendix A

A-1 Human-Machine Interface (HMI) Module................................. A-6
A-2 Communication Data & Unit Setup Record Form...................... A-7
A-3 Functional Configuration Record Form................................ A-10
A-4 Setpoint & Timing Record Form........................................... A-28
Appendix B

B-1 Null Modem Cable: M-0423
B-2 RS-232 Fiber Optic Network
B-3 RS-485 Network
B-4 COM2 Pinout for Demodulated TTL Level Signal

Appendix D

D-1 Volts/Hz (24) Inverse Time Curve Family #1 (Inverse Square)
D-2 Volts/Hz (24) Inverse Time Family Curve #2
D-3 Volts/Hz (24IT) Inverse Time Curve Family #3
D-4 Volts/Hz (24IT) Inverse Time Curve Family #4
D-5 BECO Definite Time Overcurrent Curve
D-6 BECO Inverse Time Overcurrent Curve
D-7 BECO Very Inverse Time Overcurrent Curve
D-8 BECO Extremely Inverse Time Overcurrent Curve
D-9 IEC Curve #1 - Inverse
D-10 IEC Curve #2 - Very Inverse
D-11 IEC Curve #3 - Extremely Inverse
D-12 IEC Curve #4 - Long Time Inverse
D-13 IEEE Inverse Time Overcurrent Curves
D-14 IEEE Very Inverse Time Overcurrent Curves
D-15 IEEE Extremely Inverse Time Overcurrent Curves

Chapter 1

1-1 M-3425A Device Functions

Chapter 2

2-1 Input Activated Profile
2-2 Impedance Calculation
2-3 Voltage Control Time Settings
2-4 Delta/Wye Transformer Voltage-Current Pairs
2-5 Typical Frequency Settings
2-6 Typical Brush Lift-Off Pickup Setting
2-7 Low Frequency Signal Injection Equipment Part Number Cross Reference

Chapter 3

3-1 Recorder Partitions
## Table of Contents

<table>
<thead>
<tr>
<th>Table of Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tables (Cont.'d)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Chapter 4</strong></td>
<td></td>
</tr>
<tr>
<td>4-1 Dead-Sync Time</td>
<td>4–3</td>
</tr>
<tr>
<td>4-2 Protective System Firmware Association</td>
<td>4–10</td>
</tr>
<tr>
<td>4-3 Microsoft Windows Keyboard Shortcuts</td>
<td>4–29</td>
</tr>
<tr>
<td><strong>Chapter 5</strong></td>
<td></td>
</tr>
<tr>
<td>5-1 Jumpers</td>
<td>5–19</td>
</tr>
<tr>
<td>5-2 Dip Switch SW-1</td>
<td>5–20</td>
</tr>
<tr>
<td>5-3 Trip Circuit Monitor Input Voltage Select Jumper Configuration</td>
<td>5–20</td>
</tr>
<tr>
<td><strong>Chapter 6</strong></td>
<td></td>
</tr>
<tr>
<td>6-1 Output Contacts</td>
<td>6–69</td>
</tr>
<tr>
<td>6-2 Input Contacts</td>
<td>6–70</td>
</tr>
<tr>
<td><strong>Appendix A</strong></td>
<td></td>
</tr>
<tr>
<td>A-1 Relay Configuration Table</td>
<td>A–2</td>
</tr>
<tr>
<td><strong>Appendix B</strong></td>
<td></td>
</tr>
<tr>
<td>B-1 Communication Port Signals</td>
<td>B–2</td>
</tr>
<tr>
<td><strong>Appendix C</strong></td>
<td></td>
</tr>
<tr>
<td>C-1 Self-Test Error Codes</td>
<td>C–1</td>
</tr>
<tr>
<td>C-2 IPScom® Error Messages</td>
<td>C–2</td>
</tr>
<tr>
<td><strong>Appendix D</strong></td>
<td></td>
</tr>
<tr>
<td>D-1A M-3425A Inverse Time Overcurrent Relay Characteristic Curves</td>
<td>D–6</td>
</tr>
<tr>
<td><strong>Appendix E</strong></td>
<td></td>
</tr>
<tr>
<td>E-1 Declaration of Conformity</td>
<td>E–2</td>
</tr>
</tbody>
</table>
1 Introduction

1.1 Instruction Book Contents .............................................................. 1–1
1.2 M-3425A Generator Protection Relay ........................................... 1–2
1.3 Accessories .................................................................................. 1–4

1.1 Instruction Book Contents

This instruction book includes six chapters and seven 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 Four 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 Diagrams are 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: Layup and Storage
This Appendix includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3425A Generator Protection Relay.

Appendix F: Index
This Appendix includes the index for the M-3425A Instruction Book.

Appendix G: Declaration of Conformity

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.
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 for communications. The demodulated IRIG-B may still be used via the COM2 Port when ethernet is enabled.

The RJ45 Ethernet port uses a 10Base-T type connection that accepts an RJ45 connector using CAT5 twisted pair cable. The Ethernet port can support MODBUS over TCP/IP and BECO2200 over TCP/IP or IEC 61850. 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 a RS-485 communications port.

**NOTE:** COM1, COM2 and COM3 can be disabled for security purposes from the Communications HMI menu. A Level 2 Access Code is required.

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® 98 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

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

Table 1-1  M-3425A Device Functions
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.
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.

**NOTE:** Uppercase text indicates selection.

<table>
<thead>
<tr>
<th>27#1 PHASE UNDERVOLTAGE</th>
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<tr>
<td>disable ENABLE</td>
</tr>
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</table>

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

<table>
<thead>
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<th>27#1 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 I1</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>27#1 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Input 5</th>
<th>Input 6</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open</td>
<td>Open</td>
<td>Profile 1</td>
</tr>
<tr>
<td>Closed</td>
<td>Open</td>
<td>Profile 2</td>
</tr>
<tr>
<td>Open</td>
<td>Closed</td>
<td>Profile 3</td>
</tr>
<tr>
<td>Closed</td>
<td>Closed</td>
<td>Profile 4</td>
</tr>
</tbody>
</table>

Table 2-1 Input Activated Profile
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).

This screen sets the active setpoint profile.

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

The secondary VT voltage when primary voltage is equal to the rated generator voltage. \( V_{\text{nominal}} = \frac{V_{\text{gen}} \times I_{\text{VT ratio}}}{\sqrt{3}} \) for L-L VT connections. \( V_{\text{nominal}} = \frac{V_{\text{gen}} \times I_{\text{VT ratio}}}{S_3} \) for L-G VT connections.

The secondary CT current of the phase CT’s with rated generator current. \( I_{\text{nom}} = \frac{VA 	imes I_{\text{VT ratio}}}{V_{\text{gen}} \times S_3} \)

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 120V). For this selection, the nominal voltage setting entered should be line-line nominal voltage, which is \( S_3 \) times line-ground nominal voltage, and voltage function pickup setpoints calculation should be made using line-to-line voltage.

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. It defines the connection of the Delta windings of the Delta /Y transformer. If the polarity of the A winding is connected to the non-polarity of the C winding, it is defined as Delta-AC and if the polarity of the A winding is connected to the non-polarity of the B winding, then it is defined as Delta-AB. In the ABC phase rotation, delta lags Y by 30 degrees in Delta-AC and delta leads Y by 30 degrees in Delta-AB.

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

**NOTE:** If neither pulsed or latched output is enabled, then the output contact will default to the Normal Mode. Normal Mode maintains the output contact energized as long as the condition that caused it to operate exists. After the actuating condition is cleared, the contact will reset after the programmed seal-in time has elapsed.

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.

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.*

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.*

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.*

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 IPS.com®.

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

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

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

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

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**  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.

**Expanded**  When the unit is equipped with expanded I/O, this command opens the Pulse/Latch Relay Expanded Outputs 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.
**NOTE:** If neither pulsed or latched output is enabled, then the output contact will default to the Normal Mode. Normal Mode maintains the output contact energized as long as the condition that caused it to operate exists. After the actuating condition is cleared, the contact will reset after the programmed seal-in time has elapsed.
2.2 System Diagrams

M-3425A Typical Connection Diagram

**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 $V_x$) 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
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)
WARNING: ONLY dry contact inputs must be connected because these contact inputs are internally wetted. Application of external voltage on these inputs may result in damage to the units.

NOTE: M-3425A current terminal polarity marks ( . ) indicate "entering" current direction when primary current is "from" the generator to the system. If CT connections differ from those shown, adjust input terminals.

Example of Control/Output Connections

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.
■ NOTE: When $V_x$ is connected for turn-to-turn faults 59X must use 3$V_o$ for the line side voltage (i.e., setting selection) and the V.T. configuration must be Line to Ground. The 25 function is 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).

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:

\[ Z_{sec} = Z_{pri} \times (R_C + R_V) \]

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.

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

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.

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

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.

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.

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

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

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.

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

**NOTE:** Zone #3 is used for power swing detection in this example.
Figure 2-14  Phase Distance (21) Setpoint Ranges

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.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24DT #1 PICKUP</td>
<td>Definite time setpoint #1 establishes the V/Hz level above which the protection operating time will be fixed at the definite time delay #1.</td>
</tr>
<tr>
<td>24DT #1 DELAY</td>
<td>Delay time #1 establishes the operation time of the protection for all V/Hz values above the level set by definite time setpoint #1.</td>
</tr>
<tr>
<td>24DT #2 PICKUP</td>
<td>Definite time setpoint #2 could be programmed to alarm, alerting the operator to take proper control action to possibly avoid tripping.</td>
</tr>
<tr>
<td>24DT #2 DELAY</td>
<td>Time to operation at any V/Hz value exceeding Definite time setting #2.</td>
</tr>
<tr>
<td>24IT PICKUP</td>
<td>The pickup value is the V/Hz value at which the chosen inverse curve begins protective operation. Typical value is 105%.</td>
</tr>
<tr>
<td>24IT CURVE</td>
<td>Allows the user to designate the appropriate curve family for this protection application. These curves are shown in Appendix D, Inverse Time Curves.</td>
</tr>
<tr>
<td>crv#1 crv#2 crv#3 crv#4</td>
<td>The appropriate curve in the family is designated by the associated “K” value of the curve.</td>
</tr>
<tr>
<td>24IT TIME DIAL</td>
<td>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.</td>
</tr>
<tr>
<td>24IT RESET RATE</td>
<td></td>
</tr>
<tr>
<td>Seconds</td>
<td></td>
</tr>
</tbody>
</table>
**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 ($A_2 > A_1$ 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.

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**Figure 2-15  Example of Capability and Protection Curves (24)**
**Figure 2-16 Volts-Per-Hertz (24) SetpointRanges**
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 (VX) 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-to-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 (VX) 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 (VX) with the Delta Voltage Limit setting. Likewise, the Delta Frequency measures the frequency difference between V1 and VX 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 VX voltage is equal to or below the Dead Volt Limit, VX is considered dead. When the measured VX is above the Dead Volt Limit, V1 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 VX, and Dead V1 & VX 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 VX elements are enabled, the dead check timer will start when INPUT2 is activated, and either V1 dead/VX hot or V1 hot/VX 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:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>25S PHASE LIMIT</td>
<td>Phase angle setting.</td>
</tr>
<tr>
<td>25S UPPER VOLT LIMIT</td>
<td>Upper voltage limit for voltage acceptance.</td>
</tr>
<tr>
<td>25S LOWER VOLT LIMIT</td>
<td>Lower voltage limit for voltage acceptance.</td>
</tr>
<tr>
<td>25S SYNC CHECK DELAY</td>
<td>Sync check time delay.</td>
</tr>
<tr>
<td>25S DELTA VOLT</td>
<td>Delta voltage element.</td>
</tr>
<tr>
<td>25S DELTA VOLT LIMIT</td>
<td>Delta voltage setting.</td>
</tr>
<tr>
<td>25S DELTA FREQUENCY</td>
<td>Delta frequency element.</td>
</tr>
<tr>
<td>25S DELTA FREQ LIMIT</td>
<td>Delta frequency setting.</td>
</tr>
<tr>
<td>25S SYNC-CHECK PHASE</td>
<td>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)</td>
</tr>
<tr>
<td>25D DEAD VOLT LIMIT</td>
<td>Voltage less than this setting is defined as “DEAD”; above this setting as “HOT”.</td>
</tr>
<tr>
<td>25D DEAD V1 HOT VX</td>
<td>Enables Dead V1/Hot Vx setting.</td>
</tr>
<tr>
<td>25D DEAD VX HOT V1</td>
<td>Enables Hot V1/Dead Vx setting.</td>
</tr>
<tr>
<td>25D DEAD V1 &amp; VX</td>
<td>Enables Dead V1/Dead Vx closing.</td>
</tr>
<tr>
<td>25D DEAD INPUT ENABLE</td>
<td>Externally controlled dead closing. Inputs IN7–IN14 must be set using IPScom.</td>
</tr>
<tr>
<td>25D DEAD DELAY</td>
<td>Dead delay timer setting.</td>
</tr>
</tbody>
</table>
Phase Angle Check Logic

- \( V_1 \geq \text{Lower Voltage Limit} \) 
- \( V_1 \leq \text{Upper Voltage Limit} \) 
- \( V_X \geq \text{Lower Voltage Limit} \) 
- \( V_X \leq \text{Upper Voltage Limit} \) 
- \( \text{Phase Angle} \leq \text{Phase Limit} \)

Delta V and Delta F Check Logic

**With Delta V AND Delta F Enabled**

- \(|V_1 - V_X| \leq \text{Delta V Limit} \)
- \( \text{Delta V Is Enabled} \)
- \( \text{Delta F Is Enabled} \)

**With Delta V OR Delta F Enabled**

- \(|V_1 - V_X| \leq \text{Delta V Limit} \)
- \( \text{Delta V Is Enabled} \)
- \(|F_1 - F_X| \leq \text{Delta F Limit} \)
- \( \text{Delta F Is Enabled} \)

Dead Line/ Dead Bus Check Logic

- \( V_{1pos} \leq \text{Dead Limit} \)
- \( V_1 > \text{Dead Limit} \)
- \( \text{Dead V1 Hot Vx Enabled} \)
- \( V_{1pos} > \text{Dead Limit} \)
- \( V_1 < \text{Dead Limit} \)
- \( \text{Dead V1 Hot Vx Enabled} \)
- \( V_{1pos} < \text{Dead Limit} \)
- \( V_1 < \text{Dead Limit} \)
- \( \text{Dead V1 Vx Enabled} \)

Dead Line/ Dead Bus Check Input Initiate Logic

- \( V_{1pos} \leq \text{Dead Limit} \)
- \( V_1 > \text{Dead Limit} \)
- \( \text{Dead V1 Hot Vx Enabled} \)
- \( V_{1pos} > \text{Dead Limit} \)
- \( V_1 < \text{Dead Limit} \)
- \( \text{Dead V1 Vx Enabled} \)

- User Software Setting
- Measured Variable

Only one Delta V and Delta F Check Scheme may be active at a time.

Sync Check Timer

Output Seal-in Timer

25S Output Contact

Dead Check Timer

Output Seal-in Timer

25D Output Contact

Dead Time Relay

25D Output Contact

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.

27TN Third Harmonic Undervoltage, Neutral
For ground faults near the stator neutral, the Third

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
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 (60/50 Hz) 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.

![Figure 2-20 Third Harmonic Undervoltage (27TN) Protection Characteristics](image-url)
Figure 2-21  27TN Blocking Regions

Figure 2-22  Third Harmonic Undervoltage, Neutral Circuit (27TN) Setpoint Ranges
27TN #2 Screens are identical to 27TN #1.
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.
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.

Figure 2-23  Tripping on Reverse Power Flow (Over Power with Negative Pickup)
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>32 #1 PICKUP</td>
<td>PU</td>
</tr>
<tr>
<td>32 #1 DELAY</td>
<td>Cycles</td>
</tr>
<tr>
<td>32 #1 TARGET LED</td>
<td>disable, enable</td>
</tr>
<tr>
<td>32 #1 UNDER/OVER POWER</td>
<td>over, under</td>
</tr>
<tr>
<td>32 #2 PICKUP</td>
<td>PU</td>
</tr>
<tr>
<td>32 #2 DELAY</td>
<td>Cycles</td>
</tr>
<tr>
<td>32 #2 TARGET LED</td>
<td>disable, enable</td>
</tr>
<tr>
<td>32 #2 UNDER/OVER POWER</td>
<td>over, under</td>
</tr>
<tr>
<td>32 #3 PICKUP</td>
<td>PU</td>
</tr>
<tr>
<td>32 #3 DELAY</td>
<td>Cycles</td>
</tr>
<tr>
<td>32 #3 TARGET LED</td>
<td>disable, enable</td>
</tr>
<tr>
<td>32 #3 UNDER/OVER POWER</td>
<td>over, under</td>
</tr>
<tr>
<td>32 #3 DIR POWER SENSING</td>
<td>real, reactive</td>
</tr>
</tbody>
</table>

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

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.

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

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.

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.

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.

Directional Power Sensing for Element #3 can be selected as Real or Reactive.
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 \( Q_{d} \) 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:

\[
Z_{\text{SEC}} = Z_{\text{PRI}} \times (R_{c} + R_{v})
\]

where \( Z_{\text{SEC}} \) = secondary reflected impedance, \( Z_{\text{PRI}} \) = primary impedance, \( R_{c} \) = current transformer ratio, and \( R_{v} \) = voltage transformer ratio.

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 \(-X_{d}+2\), where \( X_{d} \) is the (saturated) 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 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 \(-X_{d} \), 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.

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 \((I_2)^2t = K\), 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 the reset time setting 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 slower 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
________________ %

46DT DELAY
___________ Cycles

46IT PICKUP
________________ %

46IT MAX DELAY
___________ Cycles

46IT RESET TIME
_____________ Seconds

46IT TIME DIAL

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

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

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

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

Emulates generator cool down time.

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 ($I_{\text{max}}$) in implementing the inverse time characteristic.

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

Where: $t$ = time to trip
$\tau$ = thermal time constant
$I_L$ = load current
$I_{\text{PL}}$ = pre-load current
$I_{\text{max}}$ = 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 ($I_L/I_{\text{max}}=2.0$). Selecting the curve $P=0.8$ (see Figure 2-34), we have $t/\tau=0.1133$. If $\tau=30$ minutes, then the time delay for this condition would be: $t=0.1133 \times 30=3.3999$ 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](image-url)

<table>
<thead>
<tr>
<th>49 #1 TIME CONSTANT</th>
<th>Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>49#1 MAX OVERLOAD CURR</td>
<td>Amps</td>
</tr>
</tbody>
</table>

Selects the time constant, ‘$\tau$’

Selects the maximum allowed continuous overload current.

49#2 Screens are identical to those for 49#1.
Figure 2-34  49 Function Overload Curves

where: \[ P = \frac{I_{pl}}{I_{max}} \]
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).

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.

Figure 2-38 Breaker Failure Logic Diagram
If generator breaker failure function is used in this application, **Enable** here.

Set phase pickup amps.

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.)

Set the neutral pickup amps.

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

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

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

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 Settings](Image)

**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.

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.

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%).

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.)

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.
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.

![Figure 2-43 Inverse Time Neutral Overcurrent (51N) Setpoint Ranges](Image)

The relay current \( I_n \) is equal to the primary current \( I_p \) divided by the appropriate CT ratio. \( I_n = I_p ÷ \text{CT ratio} \)

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

Appropriate Time Dial for coordination with "downstream" relay protection chosen from the time curve above.
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, BEVIN, 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 beinv →

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

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.

51V VOLTAGE CONTROL
Volts
Figure 2-44  Voltage Restraint (51VR) Characteristic

<table>
<thead>
<tr>
<th>Generator Directly Connected</th>
<th>Generator Connected Through Delta AB/Wye or Delta AC/Wye Transformer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>Voltage Control or Restraint</td>
</tr>
<tr>
<td></td>
<td>L-G</td>
</tr>
<tr>
<td>I_a</td>
<td>(V_a - V_c)/\sqrt{3}</td>
</tr>
<tr>
<td>I_b</td>
<td>(V_b - V_c)/\sqrt{3}</td>
</tr>
<tr>
<td>I_c</td>
<td>(V_c - V_b)/\sqrt{3}</td>
</tr>
</tbody>
</table>

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.

Positive and negative sequence voltages are calculated in terms of line-to-line voltage when Line to Line is selected for V.T. Configuration.

\[ V_1 = \frac{1}{3}(V_{ab} + aV_{bc} + a^2V_{ca}) \]
\[ V_2 = \frac{1}{3}(V_{ab} + a^2V_{bc} + aV_{ca}) \]

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.

Figure 2-46  Phase Overvoltage (59) Setpoint Ranges

Generator capability is generally 105% of rated voltage. 59 #2 and 59 #3 screens are identical to 59 #1.
**59D Third Harmonic Voltage Differential (Ratio)**

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

- **NOTE:** The 59D function has a cutoff voltage of 0.5 V for 3rd harmonic Vx voltage. If the 180 Hz component of Vx is expected to be less than 0.5 V the 59D function can not be used.

The ratio (or third harmonic) voltage measured at the generator terminals to the third harmonic voltage measured at neutral.

The 59D Ratio Pickup Setting can be calculated using field measurement of Third Harmonic Voltages as follows:

\[
59D \text{ Ratio Pickup} = 1.5 \times \left( \frac{V_{3XM}}{V_{3NM}} \right) \text{ OR } \left( \frac{3V_{OM}}{V_{3NM}} \right)
\]

Where: \( \frac{V_{3XM}}{V_{3NM}} \text{ OR } \left( \frac{3V_{OM}}{V_{3NM}} \right) \)

is the maximum measured Ratio of the Third Harmonic Voltages at various loading conditions of the generator.

Selection of Vx will give better accuracy and sensitivity than 3V0. If 3Vx is selected, VT configuration must be set to Line-Ground. If the nominal third harmonic voltage is <1 V, 3V0 line side voltage selection is not recommended, because noise in the 3V0 and Vx can cause 59D misoperation.

This setting is typically enabled.

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 3Vx (Calculated by the relay from Vx, Vy, and Vz) or Vx (broken delta VT input connected at the Vx input.) Positive sequence undervoltage blocking will prevent the function from misoperating when the generator is offline (the terminal voltage is below the set value).
The ratio \( \frac{V_{3X}}{V_{3N}} \) OR \( \frac{\frac{3V_0}{V_{3N}}}{V_{3N}} \) > 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).

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.

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.

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).

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.

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.
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 3V₀ 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 3V₀ 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.

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.

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.

A frequency check element is included in the fuse loss detection logic to avoid erroneous alarms when the generator is in a start up condition. For a 50Hz system, the 60FL alarm will be inhibited if the measured frequency is greater than 55.12 Hz F_{0} or less than 44.88 Hz F_{1}. For a 60 Hz system, the 60FL alarm will be inhibited if the measured frequency is greater than 65.12 Hz F_{0} or less than 54.88 Hz F_{1}. The Frequency Band Detector does not inhibit the 60FL three-phase loss of potential logic.

**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.

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®.

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.
Frequency Checking

\[
F < F_U \quad \text{AND} \quad F > F_I
\]

Internal 60FL Logic: 1 & 2 Phase Loss of Potential

\[
V_1 > 12.8 \text{ V} \\
V_2 > 0.33 V_1 \\
I_2 > 0.167 I_1 \\
I_1 > 0.33 A
\quad \quad \quad \quad .067 A^*
\]

Internal 60FL Logic: 3 Phase Loss of Potential

\[
I_A > 1.25 I_N \\
I_B > 1.25 I_N \\
I_C > 1.25 I_N \\
V_A < 0.05 V_N \\
V_B < 0.05 V_N \\
V_C < 0.05 V_N
\]

Software Select Enable/Disable 3 Phase Fuse Loss Detection

60FL Alarm Function initiate by internal "FL" or Status Input Contact INx

60FL Alarm Signal

Protection Function Block Signal by INx from External FL

Protection Function Block Signal by Internal FL Logic

**Values in parentheses apply to a 1 A CT secondary rating.**

\[
I_1 \quad \text{Verifies On-Line condition} \\
V_{A,B,C} \quad \text{Indication of 3-phase loss of potential} \\
I_{A,B,C} \quad \text{Prevents operation during faults} \\
\text{Seal-in circuit ensures logic doesn't produce an output during 3-phase fault when current decays below 1.25 } I_N
\]
Figure 2-53  Fuse Loss (60FL) Setpoint Ranges
64B/F Field Ground Protection

64F Field Ground Detection

Typical connections for Field Ground Protection applications (including hydro turbine-generator and brushless generators) 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. The minimum time delay should be set greater than \((2/\text{IF} + 1)\) seconds. Where \(\text{IF} = \) Injection frequency. Ranges and increments are presented in Figure 2-55.

Factors Affecting 64F Performance

Some excitation systems include shaft voltage suppressors which include capacitors that are installed between the +/- field and ground. The effect of these capacitors is given by the following equation:

\[
R = \frac{1}{(2\pi \text{IF} C)}
\]

where:
- \(R\) = Parallel winding-ground resistance
- \(\text{IF}\) = Injection frequency setting
- \(C\) = Capacitance value

To minimize this effect the following may be implemented:

- The injection frequency setting can be reduced, however accuracy decreases as a result.
- With the concurrence of the exciter manufacturer, surge capacitors rated at a lower value may be installed.

Table 2-5 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.

<table>
<thead>
<tr>
<th>64F #1 PICKUP</th>
<th>kOhm</th>
</tr>
</thead>
<tbody>
<tr>
<td>64F #1 DELAY</td>
<td>Cycles</td>
</tr>
<tr>
<td>64F #2 PICKUP</td>
<td>kOhm</td>
</tr>
<tr>
<td>64F #2 DELAY</td>
<td>Cycles</td>
</tr>
</tbody>
</table>

This setting should not exceed 80% of the ungrounded resistance value to prevent nuisance tripping. Typical setting for the 64F #1 pickup element for alarming is 20 Kohms.

Typical delay setting for tripping is 800 cycles.

Typical setting for 64F #2 pickup element for tripping is 5 Kohms.

Typical delay setting for alarming is 180 cycles.
**64F Application for Hydro Turbine-Generators**

The application of the 64F Function requires a ground return path, either through a shaft ground brush (Figure 2-54 Detail A) or though an alternate ground path (i.e., water for some hydro machines.)

Hydro Turbine-Generator unit shafts that extend into the water with no electrical isolation between the turbine shaft and the generator shaft can use the water as the alternate ground path (see Figure 2-54 Detail B). In this application, the water provides the alternate ground path and a shaft grounding brush is not required. Francis and Kaplan Turbine Generators usually meet this application requirement. If the unit can experience a low water condition, the low water may not provide a reliable ground return. For this condition, a shaft ground brush may be required.

A shaft ground brush must be utilized for the 64F Function on Pelton Hydro Turbine-Generator applications.

**64F Application for Brushless Generators**

The 64F Function can be implemented on brushless generators that employ a "measurement" brush (see Figure 2-54 Detail C) to verify the integrity of field. In this configuration generally only one field polarity is available. Therefore, a suitably sized jumper must be installed from TB2 to TB3 (Coupling Network box M-2931) and then to the positive or negative field lead.

In some configurations the measurement brush is continuously applied. In others the measurement brush is applied periodically. In configurations that automatically lift the measurement brush, the 64B Function must be blocked by an input to the relay to prevent an alarm when the measurement brush is lifted. If the 64B Function is not desired, then the 64B Function should be disabled.

The 64F Function can not be used on brushless generators utilizing LED coupling.

---

Figure 2-54  M-3921 Field Ground Coupler
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.

**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.

<table>
<thead>
<tr>
<th>Field Winding to Ground Capacitance</th>
<th>Typical Frequency Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 2 µF</td>
<td>0.52 Hz</td>
</tr>
<tr>
<td>2 to 3 µF</td>
<td>0.49 Hz</td>
</tr>
<tr>
<td>3 to 4 µF</td>
<td>0.46 Hz</td>
</tr>
<tr>
<td>4 to 5 µF</td>
<td>0.43 Hz</td>
</tr>
<tr>
<td>5 to 6 µF</td>
<td>0.39 Hz</td>
</tr>
<tr>
<td>6 to 7 µF</td>
<td>0.35 Hz</td>
</tr>
<tr>
<td>7 to 8 µF</td>
<td>0.32 Hz</td>
</tr>
<tr>
<td>8 to 9 µF</td>
<td>0.30 Hz</td>
</tr>
<tr>
<td>9 to 10 µF</td>
<td>0.28 Hz</td>
</tr>
<tr>
<td>&gt;10 µF</td>
<td>0.26 Hz</td>
</tr>
</tbody>
</table>

*Table 2-5  Typical Frequency Settings*

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

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

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

3. After installation has been completed, determine the rotor capacitance, as outlined for the 64F function.

4. 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.

5. 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.

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.

<table>
<thead>
<tr>
<th>Equivalent Brush Lift-Off Capacitance</th>
<th>0.05~0.25 μF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Brush Lift-Off Pickup Setting</td>
<td>2500 mV</td>
</tr>
</tbody>
</table>

Table 2-6  Typical Brush Lift-Off Pickup Setting
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 Vol input of the M-3425A relay through a suitable voltage divider, that limits the M-3425A to 0-200 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 In input of the M-3425A, through the 20Hz current transformer.

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

\[ I_{NF} = \frac{V_{20}}{X_{CS} N^2} \]

Where \( V_{20} \) is the 20 Hz voltage measured across the neutral resistor \( R_N \) and \( X_{CS} \) is the capacitive reactance of the generator stator winding and unit transformer referred to the grounding transformer secondary. \( N \) is the turn ratio of the grounding transformer. There are two overcurrent pickup settings. One operates on the magnitude of total 20 Hz neu-

### 64S TOTAL CURRENT

| 64S TOTAL CURRENT ENABLE
| 64S TOTAL CURR PU mAmps
|

### 64S REAL COMP CURRENT

| 64S REAL COMP CURRENT ENABLE
| 64S REAL COMP CURR PU mAmps
|

### 64S DELAY

| 64S DELAY Cycles
|

### 64S VOLT RESTRAINT

| 64S VOLT RESTRAINT ENABLE
|

### 64S UNDERFREQ INHIBIT

| 64S UNDERFREQ INHIBIT ENABLE
|

Pickup setting for the overcurrent element that operates on the 20 Hz neutral current measured by the relay (\( I_{NF} \)). This setting ranges from 2 to 75 mA and is for the total current, which includes both the real and imaginary components.

This is the pickup setting for the overcurrent element that operates on the real component of the 20 Hz neutral current measured by the relay (\( Re(I_{NF}) \)). The 20 Hz neutral voltage measured by the relay is the reference used to calculate the real component. This setting is in milli-amps and ranges from 2 to 75 mA.

This is the time delay on pickup for both overcurrent elements described above.

If voltage restraint is enabled the overcurrent pickup settings described above are varied depending on the magnitude of 20 Hz neutral voltage measured by the relay. The pickup settings are more sensitive for neutral voltage less than or equal to 25 volts. The pickup settings are desensitized for neutral voltage greater than 25 volts. Refer to Figure 2-60. Voltage restraint is typically disabled.

Enable this setting to block F64S when the system voltage measured by the relay is 40 Hz or less such as during startup. This can prevent nuisance tripping during startup and shutdown when the generator is transitioning through the lower frequencies.
tral current measured by the relay. The other pickup setting operates on the real component of the 20 Hz neutral current where $V_{20}$ is the reference. $V_{20}$ is the 20 Hz voltage measured across the neutral resistor $R_N$. **The real component** of the 20 Hz current increases in magnitude during a ground fault on the generator stator since the insulation resistance decreases. **The real component of current pickup is disabled when $V_N$ is less than 0.1 V @ 20 Hz.** Set the two pickups utilizing the equations illustrated in Figure 2-58.

The 20 Hz signal generator has an output of 25 volts and the band pass filter is eight ohms purely resistive.

Only a small amount of 20 Hz current flows when the generator is operating normally (that is, no ground fault) as a result of the stator capacitance to ground. The magnitude of 20 Hz current increases when there is a ground fault anywhere along the stator windings. The 64S function issues a trip signal after a set time delay when the measured 20 Hz current exceeds a pickup as illustrated in Figure 2-60.

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.
* For applications with a transformer secondary rating that will result in 50/60 Hz phase ground fault voltages >200 V ac, use the "High Voltage" connection for the 59N Function.

** If 20 Hz Signal Generator is prior to Model EE a step down transformer is necessary for voltages >120 VAC.
$X_{CS} = \frac{X_{CP}}{N^2}$ Capacitive reactance of stator windings and unit transformer (secondary)

$R_S = \frac{R_{Stator}}{N^2}$ Insulation resistance (secondary)

Where:

$X_{CP} =$ Capacitive reactance of stator windings and unit transformer (primary)

$R_{Stator} =$ Insulation resistance (primary)

$N =$ Turns ratio of grounding transformer

$R_N =$ Neutral grounding resistance (secondary)

Figure 2-57 64S Network

Figure 2-58 Primary Transferred To Transformer Secondary
Calculate the total current measured by the current input \( I_N \) as follows:

\[
I_T = \frac{25}{8 + \left(1 + \frac{8}{R_N}\right) \cdot Z_S}
\]

\[
Z_S = \left(\frac{R_S \cdot X_{CS}}{\sqrt{R_S^2 + X_{CS}^2}}\right) \angle \theta
\]

\[
\theta = -90^0 - \tan^{-1}\left(\frac{-X_{CS}}{R}\right)
\]

\[
I_N = \frac{I_T}{80}
\]

Calculate the real component of the current measured by the current input \( I_N \) with respect to the neutral voltage input as follows:

\[
\text{Re}(I_T) = I_T \cdot \cos(\phi)
\]

\[
\text{Re}(I_N) = \frac{I_T}{80} \cdot \cos(\phi)
\]

Where:

\[
\phi = \text{ArcTAN} \left[ \frac{1 + \frac{8}{R_N} \cdot (Z_S) \sin \theta}{8 + \left(1 + \frac{8}{R_N}\right) \cdot (Z_S) \cos \theta} \right]
\]

\( \text{Re}(Z_S) \) is the real component of \( Z_S \) and \( \text{Im}(Z_S) \) is the imaginary component.

Calculate the total current when the system is faulted and unfaulted to determine if there is adequate sensitivity for this pickup setting. Use the following two assumptions for the insulation resistance to calculate the current during normal operating conditions and a ground fault:

\[ R_{\text{Stator}} = 100 \ \text{kilo-Ohms (normal operating conditions)} \]

\[ R_{\text{Stator}} = 5 \ \text{kilo-Ohms (ground fault)} \]

There may be only 2 to 3 milli-amps or less in difference for the total current when the system is faulted and unfaulted for applications that have a large value of capacitive coupling to ground (\( C_0 \) greater than 1.5 micro-Farads) when combined with a low value for the grounding resistor (\( R_N \) less than 0.3 Ohms). Use the real component of the total current for these applications as there will be a larger margin in difference when the system is faulted and unfaulted.
Table 2-7  Low Frequency Signal Injection Equipment Part Number Cross Reference

<table>
<thead>
<tr>
<th>Equipment Description</th>
<th>Surface/Flush Mount Beco. Part No.</th>
<th>OEM Part No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 Hz Signal-Generator</td>
<td>430-00426</td>
<td>Siemens 7XT33</td>
</tr>
<tr>
<td>20 Hz Band-pass Filter</td>
<td>430-00427</td>
<td>Siemens 7XT34</td>
</tr>
<tr>
<td>20 Hz Measuring Current Transformer 400-5 A CT</td>
<td>430-00428</td>
<td>ITI CTWS-60-T50-401</td>
</tr>
</tbody>
</table>

Figure 2-59  64S Function Time Delay Pickup Current Correlation

Figure 2-60  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 $V_x$, $V_y$, and $V_z$ 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 2-61 Residual Directional Overcurrent (67N) Trip Characteristics](image-url)
Pickup value for the 67N element.

Directional discrimination enable. When disabled, this function will work like a 50N.

Time Delay setting.

Inverse Time Pickup

Directional discrimination enabled. When disabled, this function will operate like 51N.

Select the inverse time curve.

Time dial setting

See Figure 2-60 for Max Sensitivity Angle (MSA) settings.

Select the operating current.

Select the polarization voltage. If $3V_0$ is selected, VT configuration must be set to Line-Ground.
Figure 2-62  Residual Directional Overcurrent (67N) Setpoint Ranges
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 2-65.

The pickup area is restricted to the shaded area in Figure 2-63, 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.

\[ X_t = \text{Transformer Reactance} \]
\[ X_s = \text{System Reactance} \]
\[ X_{d'} = \text{Transient Reactance of the Generator} \]

Consider, for example, Figure 2-64. If the Out-of-step swing progresses to impedance \( Z_2(t_0) \), 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 \( (t_2-t_1 > \text{time delay}) \), 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 \( Z_2(t_2) \) 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 equal to 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.

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>78 DIAMETER</td>
<td>( X_t + 2X_{d'} )</td>
</tr>
<tr>
<td>78 OFFSET</td>
<td>( -2X_{d'} )</td>
</tr>
<tr>
<td>78 BLINDER IMPEDANCE</td>
<td>( (1/2)(X_{d'} + X_t + X_s) \tan(\theta - \delta/2) )</td>
</tr>
<tr>
<td>78 IMPEDANCE ANGLE</td>
<td>( 90^\circ )</td>
</tr>
<tr>
<td>78 DELAY</td>
<td>( \text{cycles} )</td>
</tr>
<tr>
<td>78 TRIP ON MHO EXIT</td>
<td>disable enable</td>
</tr>
<tr>
<td>78 POLE SLIP COUNT</td>
<td>slips</td>
</tr>
<tr>
<td>78 POLE SLIP RESET TIME</td>
<td>( \text{cycles} )</td>
</tr>
</tbody>
</table>

Typical setting is \( (1.5X_t + 2X_{d'}) \).
Typical setting is \( -2X_{d'} \).
Typical setting is \( (1/2)(X_{d'} + X_t + X_s) \tan(\theta - \delta/2)) \). Typical value for \( \delta \) is \( 120^\circ \).
Typical setting for \( \theta \) is \( 90^\circ \).

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.
This setting is typically enabled.
Typical setting is 1 pole slip.
Typical setting is 120 cycles.
Figure 2-63  Out-of-Step Relay Characteristics

Figure 2-64  Out-of-Step Protection Settings
Figure 2-65  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 2-68.

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 2-66. 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.

These magnitude and time settings describe a curve (as shown in Figure 2-66, 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 2-66  Example of Frequency (81) Trip Characteristics

Figure 2-67  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.
Figure 2-68  Frequency Accumulator (81A) Example Bands

Figure 2-69  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 shown in Figure 2-70.

Figure 2-70  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 2-72.

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 2-71.

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.

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>87 #1 PICKUP</td>
<td>0.3 Amps</td>
</tr>
<tr>
<td>87 #1 SLOPE</td>
<td>10%</td>
</tr>
<tr>
<td>87 #1 DELAY</td>
<td>1 Cycle</td>
</tr>
<tr>
<td>87 #2 PICKUP</td>
<td>0.5 Amps</td>
</tr>
<tr>
<td>87 #2 SLOPE</td>
<td>20%</td>
</tr>
<tr>
<td>87 #2 DELAY</td>
<td>5 to 8 Cycles</td>
</tr>
</tbody>
</table>

A typical setting is 0.3 amps.

A typical setting is 10%.

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.

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 $I_N$ are generator high side and neutral side currents respectively, and CTC is the CT Phase correction.

**Figure 2-71  Differential Relay (87) Operating Characteristics**

**Figure 2-72  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 2-73.

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 \(-3I_0 \cos \theta\) 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.

\[ \text{CT Ratio Correction Factor} = \left( \frac{\text{Phase CT Ratio}}{\text{Neutral CT Ratio}} \right) \]

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. The pickup quantity is then calculated as the difference between the corrected triple zero-sequence current \( (R_c 3I_0) \) and the neutral current \( I_n \). The magnitude of the difference \( (R_c 3I_0 - I_n) \) 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.

\[ \text{\textbf{NOTE:}} \] When 87GD is enabled, 67N function is not available.

- **87GD PICKUP**
  
  \[ \text{\textbf{Amps}} \]

- **87GD DELAY**
  
  \[ \text{\textbf{Cycles}} \]

- **87GD C.T. RATIO CORRECT**
  
  \[ \text{A typical setting is 0.2 amps. (Relay amps = primary amps ÷ CT ratio.) For higher values of } R_c, \text{ noise may create substantial differential current making higher pickup settings desirable.} \]

  \[ \text{\textbf{CAUTION:}} \text{ Do NOT set the Delay to less than 2 Cycles.} \]

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

  \[ \text{CT Ratio Correction Factor} = \left( \frac{\text{Phase CT Ratio}}{\text{Neutral CT Ratio}} \right) \]

\[ \text{\textbf{NOTE:}} \text{ When 87GD is enabled, 67N function is not available.} \]
Breaker Monitoring
The Breaker Monitoring feature calculates an estimate of the per-phase wear on the breaker contacts by measuring and integrating the current (I) 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.

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

![Breaker Monitor (BM) Setpoint Ranges](image)

**Figure 2-74 Breaker Monitor (BM) Setpoint Ranges**
Trip Circuit Monitoring

External connections for the Trip Circuit Monitoring function are shown in Figure 2-75. 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.

![Figure 2-75 Trip Circuit Monitoring Input](image)

![Figure 2-76 Trip Circuit Monitor (TC) Setpoint Ranges](image)
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 2-77  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 2-78.

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 2-78 IPSlogic Function Programing
Figure 2-79  Selection Screen for Initiating Function Timeout

Figure 2-80  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 2-81. 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 beyond 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 2-81 Dropout Delay Timer Logic Diagram**

**Reset Delay Timer**

The Reset Delay Timer logic is presented in Figure 2-82. 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 2-82 Reset Delay Timer Logic Diagram**
3 Operation

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.

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 3-3  Main Menu Flow

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

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.

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.

▲ CAUTION: Oscillograph records are not retained if power to the relay is interrupted.

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).

<table>
<thead>
<tr>
<th>Number of Partitions</th>
<th>Number of Cycles per Each Partition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>416 Cycles</td>
</tr>
<tr>
<td>2</td>
<td>280 Cycles</td>
</tr>
<tr>
<td>3</td>
<td>208 Cycles</td>
</tr>
<tr>
<td>4</td>
<td>168 Cycles</td>
</tr>
<tr>
<td>5</td>
<td>136 Cycles</td>
</tr>
<tr>
<td>6</td>
<td>120 Cycles</td>
</tr>
<tr>
<td>7</td>
<td>104 Cycles</td>
</tr>
<tr>
<td>8</td>
<td>88 Cycles</td>
</tr>
<tr>
<td>9</td>
<td>80 Cycles</td>
</tr>
<tr>
<td>10</td>
<td>72 Cycles</td>
</tr>
<tr>
<td>11</td>
<td>64 Cycles</td>
</tr>
<tr>
<td>12</td>
<td>64 Cycles</td>
</tr>
<tr>
<td>13</td>
<td>56 Cycles</td>
</tr>
<tr>
<td>14</td>
<td>56 Cycles</td>
</tr>
<tr>
<td>15</td>
<td>48 Cycles</td>
</tr>
<tr>
<td>16</td>
<td>48 Cycles</td>
</tr>
</tbody>
</table>

Table 3-1 Recorder Partitions

- **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.

Communications Settings

To enter the communications settings, access the COMMUNICATION menu as follows:

■ NOTE: COM1, COM2 and COM3 can be disabled for security purposes from the Communications HMI menu. A Level 2 Access Code is required.

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.

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 of which function(s) have operated, and timers expired (operated)
- Status information which identifies 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 IPS.com 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).

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 | TRGT clear |

   Detailed descriptions for each View Target History screen are presented on the following page.
This screen gives access to the target history, and also allows the user to clear the target history record from memory.

Using up and down buttons, user may select which particular target to view from the last 24 recorded triggers.

This screen gives the date and time tag of the selected target.

This screen displays operated outputs.

This screen displays operated inputs at time of trip.

The following screens display the timed out or “operate” functions.

This screen displays the specific function which timed out and triggered the target.

This screen displays the phase information for the displayed function at time out.

The following screens display the timing on “picked up” functions when the target was recorded.

This display gives the phase pickup information for the specific function.

This screen displays the phase current at the time the target operated.

This screen displays the neutral current at the time the target operated.
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.

**NOTE:** COM1, COM2 and COM3 can be disabled for security purposes from the Communications HMI menu. A Level 2 Access Code is required.

**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 communications when the optional ethernet port is enabled. The demodulated IRIG-B may still be used via the COM2 Port when ethernet 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 communications. 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, MODBUS over TCP/IP or IEC 61850 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.

![Diagram](image)
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).

<table>
<thead>
<tr>
<th>Baud Rate</th>
<th>Dead-Sync Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>9600</td>
<td>4 ms</td>
</tr>
<tr>
<td>4800</td>
<td>8 ms</td>
</tr>
<tr>
<td>2400</td>
<td>16 ms</td>
</tr>
<tr>
<td>1200</td>
<td>32 ms</td>
</tr>
</tbody>
</table>

| Table 4-1 Dead-Sync Time |

**COM Port Security**

COM1, COM2 and COM3 may be disabled for security purposes from the unit HMI. A Level 2 Access Code is required.

**Disabling COM Ports**

1. Press the ENTER pushbutton.
2. If Level Access is active, the following is displayed:

   ENTER ACCESS CODE

   0

   a. Input the required Access Code, then press ENTER.
   b. If the proper Access Code has been entered, the HMI will return:

   LEVEL #(1,2 or 3)
   Access Granted!

   INIT TRANSFER
   INIT rmte_lcal

   c. Go to step 4.
3. If Level Access is not active, then the following is displayed:

   INIT TRANSFER
   INIT rmte_lcal
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.

IEC61850: When the Ethernet option is purchased with the IEC61850 protocol, no other protocol may be selected.

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).

   \[
   \text{COMMUNICATION} \\
   \leftarrow \text{targets osc_rec COMM} \\
   \rightarrow
   \]

   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:

   \[
   \text{COM1 SETUP} \\
   \text{COM1 com2 com3 com_adr}
   \]

3. Use the Right arrow pushbutton to select ETH (Upper Case).

   \[
   \text{ETHERNET SETUP} \\
   \leftarrow \text{access ETH eth_ip}
   \]
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**, depending on the Ethernet board that is installed one of the following screens will be displayed:

    - **SELECT PROTOCOL**
      ```
      modbus  serconv
      ```
    - **SELECT PROTOCOL**
      ```
      IEC 61850
      ```

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) for DHCP Protocol.
   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 PRO T is not selected (Upper Case), then use the Right arrow pushbutton to select PROT.

7. Press ENTER, depending on the Ethernet board that is installed one of the following screens will be displayed:

SELECT PROTOCOL
modbus serconv

SELECT PROTOCOL
IEC 61850

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.
5. Enter values for IP Address, Net Mask and Gateway.
6. Select the desired protocol.
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.
3. From the Ethernet Settings screen select Ethernet Enable.
5. Enter values for IP Address, Net Mask and Gateway.
6. Select the desired protocol.
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.

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
- &D0 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.
Figure 4-2 IPScom® Menu Selections

**NOTE**: Greyed-out menu items are for future release, and are not currently available.
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 may 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.

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.

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 System Type dialog box (see Figure 4-4). Choices for Unit Type in the System Type Screen include M-3425, M-3425A, M-3425A(SOE) and M-3425A Expanded I/O. The selected Unit Type ensures that the “New” file is consistent with the protective system firmware version (Table 4-2). Choosing the **OK** command button allows the new data file to be opened. Selecting **Save** or **Save As** commands allows the file to be named and saved.

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

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.

<table>
<thead>
<tr>
<th>Protective System Unit Type</th>
<th>Firmware Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-3425</td>
<td>D-0070XXXXXXX.XX</td>
</tr>
<tr>
<td>M-3425A</td>
<td>D-0114XXXXXXX.XX</td>
</tr>
<tr>
<td>M-3425A(SOE)</td>
<td>D-0150XXXXXXX.XX</td>
</tr>
<tr>
<td>M-3425A Expanded I/O</td>
<td>D-0150XXXXXXX.XX</td>
</tr>
</tbody>
</table>

**Table 4-2 Protective System Firmware Association**
Path:  Comm menu

COMMAND BUTTONS

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

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

TCP_IP  Opens the ethernet applicable communication screen selections to allow the 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).
**NOTE:** Pulse/Latched Relay Outputs should be selected in 2 steps.

1. Deselect Latched/Pulsed Relay Outputs and Save.
2. Select Pulse/Latched Outputs and Save

*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 Relay Expanded Outputs 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).

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 Setpoints 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 4-10  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.

**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 Dialog Box**
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](Image)

**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.

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

**View** the parameters 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.

**View** 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.
NOTE: When in “File Mode,” selecting “Send” will result in a warning message stating, “To send settings, IPScom needs to be connected to relay.”

Figure 4-18 Trigger Events Screen with Expanded I/O

Figure 4-19 Event Log Viewer
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 Partitions). 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.

▲ CAUTION: Oscillograph records are not retained if power to the relay is interrupted.

■ NOTE: Oscillograph Post Trigger Delay is set to 5% in “File Mode”.

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.

■ NOTE: When in “File Mode,” selecting “Send” will result in a warning message stating, “To send settings, IPScom needs to be connected to relay.”

■ NOTE: When in “File Mode” selecting OK to change Profile Switching Method will result in a warning message, “To change Profile Switching Method, IPScom needs to be connected to relay”.

■ NOTE: During Profile Switching, relay operation is disabled for approximately 1 second.
NOTE: When in “File Mode” selecting OK to select the Active Profile will result in a warning message, “To select the Active Profile, IPScom needs to be connected to Relay”.

Figure 4-24 Select Active Profile

NOTE: When in “File Mode” selecting OK to copy the Active Profile will result in a warning message, “To copy the Active Profile, IPScom needs to be connected to Relay”.

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. The **Profile Info** displays user information for input and editing.

The **About IPScom** dialog box displays version, serial number, communication protocol, and other related information.
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 Screen

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.
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.

▲ CAUTION: Oscillograph records are not retained if power to the relay is interrupted.
## 4.6 Keyboard Shortcuts

### Keyboard Shortcuts

<table>
<thead>
<tr>
<th>SYSTEM KEYS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>These keys can be used within Microsoft Windows® and IPScom®.</strong></td>
<td></td>
</tr>
<tr>
<td>Alt-Tab</td>
<td>To switch between applications.</td>
</tr>
<tr>
<td>Ctrl-Esc</td>
<td>To open Task List dialog box. Opens Start Menu (Win 95/98).</td>
</tr>
<tr>
<td>Ctrl-Tab</td>
<td>To switch between windows within an application.</td>
</tr>
<tr>
<td><strong>Arrow Keys</strong></td>
<td>To select an application or group icon.</td>
</tr>
<tr>
<td>First Character of Name</td>
<td>To select application or group icon.</td>
</tr>
<tr>
<td>Enter</td>
<td>To open selected group or run selected application.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MENU KEYS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>These keys enable you to select menus and choose commands.</strong></td>
<td></td>
</tr>
<tr>
<td>Alt or F10</td>
<td>To select or cancel selection of the Setup menu on the menu bar.</td>
</tr>
<tr>
<td>Left Arrow, Right Arrow</td>
<td>To move between menus.</td>
</tr>
<tr>
<td>Up Arrow, Down Arrow</td>
<td>To move between commands.</td>
</tr>
<tr>
<td>A character key</td>
<td>To choose the menu or command. The underlined character matches the one you type.</td>
</tr>
<tr>
<td>Enter</td>
<td>To choose the selected menu name or command.</td>
</tr>
<tr>
<td>Esc</td>
<td>To cancel the selected menu name, or to close the open menu.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DIALOG BOX KEYS</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>These keys are useful when working in a dialog box.</strong></td>
<td></td>
</tr>
<tr>
<td>Alt-a character key</td>
<td>To move to the option or group whose underlined letter or number matches the one you type.</td>
</tr>
<tr>
<td><strong>Arrow Keys</strong></td>
<td>To move highlighted selections within list boxes.</td>
</tr>
<tr>
<td>Alt-Down Arrow</td>
<td>To open a list.</td>
</tr>
<tr>
<td>Spacebar</td>
<td>To select an item or cancel a selection in a list. Also to select or clear a check box.</td>
</tr>
<tr>
<td>Enter</td>
<td>To carry out a command.</td>
</tr>
<tr>
<td>Esc or Alt-F4</td>
<td>To close a dialog box without completing the command.</td>
</tr>
</tbody>
</table>

*Table 4-3 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:

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.

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

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

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.
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 Ethernet 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.

**Figure 4-44 Set Unit Date/Time Dialog Box**

- **Save**: Saves values to the relay.
- **Cancel**: Returns you to the IPSUtil main window. Any changes to the displayed information are lost.
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.
5.1 General Information

NOTE: Prior to installation of the equipment, it is essential to review the contents of this manual to locate data which may be of importance during installation procedures. The following is a quick review of the contents in the chapters of this manual.

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 Diagrams are 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.

Service Conditions and Conformity to CE Standard

Stating conformance to CE Standard EN 61010-1 2001, operation of this equipment within the following service conditions does not present any known personnel hazards outside of those stated herein:

- 5° to 40° Centigrade
- Maximum relative humidity 80% for temperatures up to 31°C, decreasing in a linear manner to 50% relative humidity at 40°C.

This equipment will function properly, and at stated accuracies beyond the limits of this CE Standard, as per the equipment’s specifications, stated in this Instruction Book.

It is suggested the terminal connections illustrated here be transferred to station one-line wiring and three-line connection diagrams, station panel drawings and station DC wiring schematics.

If during the commissioning of the M-3425A Generator Protection Relay, additional tests are desired, Chapter 6, Testing, may be consulted.

The operation of the relay, including the initial setup procedure, is described in Chapter 3, Operation, for HMI front panel users and in Chapter 4, Remote Operation, when using a personal computer. Section 3.1, Front Panel Controls, details the front panel controls.

Section 3.2, Initial Setup Procedure/Settings, details the HMI setup procedure. This includes details necessary for input of the communications data, unit setup data, configure relays data, the individual setpoints and time settings for each function, and oscillograph recorder setup information. Section 3.5, Status/Metering, guides the operator through the status and metering screens, including monitoring the status. Section 3.6 includes information on viewing the target history.
5.2 Mechanical/Physical Dimensions

Figures 5-1 through 5-6 contain physical dimensions of the relay that may be required for mounting the unit on a rack.

NOTE: Dimensions in brackets are in centimeters.

Figure 5-1  M-3425A Horizontal Chassis Mounting Dimensions Without Expanded I/O (H1)
Recommended cutout when relay is not used as standard rack mount and is panel cut out mounted.

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

*Figure 5-2  M-3425A Vertical Chassis Mounting Dimensions Without Expanded I/O (H2)*
Figure 5-3  M-3425A Mounting Dimensions Horizontal and Vertical Chassis With Expanded I/O
Figure 5-4  M-3425A Panel Mount Cutout Dimensions
Figure 5-5  Mounting Dimensions for GE L-2 Cabinet H3 and H4
5.3 External Connections

**WARNING:** The protective grounding terminal must be connected to an earthed ground anytime external connections have been made to the unit.

**WARNING:** 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.

**WARNING:** Do not open live CT circuits. Live CT circuits should be shorted prior to disconnecting CT wiring to the M-3425A. Death or severe electrical shock may result.

▲ **CAUTION:** Mis-operation or permanent damage may result to the unit if a voltage is applied to Terminals 1 and 2 (aux) that does not match the configured Trip Circuit Monitoring input voltage.

To fulfill requirements for UL and CSA listings, terminal block connections must be made with No. 12 AWG solid or stranded copper wire inserted in an AMP #324915 (or equivalent) connector, and wire insulation used must be rated at 60° C minimum.

**Power Supply**

When the M-3425A without expanded I/O is equipped with the optional second power supply (Figure 5-6), the power source may be the same or two different sources.

![Figure 5-6 Optional Dual Power Supply](image)

When the M-3425A with expanded I/O is equipped with two (not redundant) power supplies, the power supplies must be powered from the same source.

**Grounding Requirements**

The M-3425A is designed to be mounted in an adequately grounded metal panel, using grounding techniques (metal-to-metal mounting) and hardware that assures a low impedance ground.

**Unit Isolation**

Sensing inputs should be equipped with test switches and shorting devices where necessary to isolate the unit from external potential or current sources.

A switch or circuit breaker for the M-3425A's power shall be included in the building installation, and shall be in close proximity to the relay and within easy reach of the operator, and shall be plainly marked as being the power disconnect device for the relay.

**Insulation Coordination**

Sensing Inputs: 60 V to 140 V, Installation Category IV, Transient Voltages not to exceed 5,000 V.

**Torque Requirements**

- **Terminals 1–34 & 66–105:** 7.5 in-lbs, minimum, and 8.0 in-lbs, maximum
- **Terminals 35–65:** 8.5 in-lbs, minimum, and 9.0 in-lbs, maximum

**Relay Outputs**

All outputs are shown in the de-energized state for standard reference. Relay standard reference is defined as protective elements in the non-trip, reconnection and sync logic in the non-asserted state, or power to the relay is removed. Output contacts #1 through #4 are high speed operation contacts. The power supply relay (P/S) is energized when the power supply is OK. The self-test relay is energized when the relay has performed all self-tests successfully.

**Replacement Fuses**

F1–F4 replacement fuses must be fast-acting 3 Amp, 250 V (3AB) Beckwith Electric Part Number 420-00885.
1. **NOTES:**

   See Section 2.3, Setpoints and Time Settings, subsection for 64B/F Field Ground Protection.

2. **NOTES:**

   Before making connections to the Trip Circuit Monitoring input, see 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. **NOTES:**

   **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. **NOTES:**

   **WARNING:** The protective grounding terminal must be connected to an earthed ground any time external connections have been made to the unit.
WARNING: ONLY dry contact inputs must be connected because these contact inputs are internally wetted. Application of external voltage on these inputs may result in damage to the units.

NOTE: M-3425A current terminal polarity marks (\( \cdot \) ) indicate "entering" current direction when primary current is "from" the generator to the system. If CT connections differ from those shown, adjust input terminals.
Figure 5-10  Function 25 Sync Check Three-Line Connection Diagram
Figure 5-11  Function 59X Turn to Turn Fault Protection Three-Line Connection Diagram
Figure 5-12  Function 67N, 59D, 59X (Bus Ground) Three-Line Connection Diagram
5.4 Commissioning Checkout

During field commissioning, check the following to ensure that the CT and VT connections are correct.

1. Press ENTER. After a short delay, the unit should display:

   **VOLTAGE RELAY**
   **VOLT curr freq v/hz pwr →**

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

   **STATUS**
   left config sys STAT →

3. Press ENTER. The unit should display:

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

4. Press ENTER. The unit should display either $V_A$, $V_B$, $V_C$ (line-to-ground connections) or $V_{AB}$, $V_{BC}$, $V_{CA}$ (line-to-line or line-ground to line-line connections).

   **PHASE VOLTAGE**
   A=  B=  C=

   Compare these voltages with actual measurements using a voltmeter. If there is a discrepancy, check for loose connections to the rear terminal block of the unit. If line-ground to line-line voltage selection is used, the voltages displayed are \(\sqrt{3}\) times of the line-ground voltages applied.

5. Press ENTER to display the Neutral Voltage:

   **NEUTRAL VOLTAGE**
   ____ Volts

   The neutral voltage should be near zero volts.

6. Press ENTER to display $V_X$ Voltage:

   **$V_X$ VOLTAGE**
   ____ Volts

7. Press ENTER to display Third Harmonic Differential Ratio:

   **3RD HARMONIC DIFF RATIO**
   ________

   Press ENTER once more to display the line side Third Harmonic Voltage:

   **3RD HARMONIC 3V0 VOLT**
   ________

8. Press ENTER to display Stator Low Frequency Injection (20 Hz) Voltage:

   **STATOR LOW FREQUENCY INJECT.**
   ____ Volts

9. Display positive, negative and zero sequence voltages. Press ENTER until the unit displays:

   **POS SEQUENCE VOLTAGE**
   ____ Volts

   The positive sequence voltage should be $V_{POS} \approx V_A \approx V_C$ or $V_{AB} \approx V_{BC} \approx V_{CA}$.

10. Press ENTER until the unit displays:

    **NEG SEQUENCE VOLTAGE**
    ____ Volts

    The negative sequence voltage should be $V_{NEG} \approx 0$.

11. Press ENTER until the unit displays:

    **ZERO SEQUENCE VOLTAGE**
    ____ Volts

    The zero sequence voltage should be $V_{ZERO} \approx 0$.

    If the negative sequence voltage shows a high value and the positive sequence voltage is close to zero, the phase sequence is incorrect and proper phases must be reversed to obtain correct phase sequence. If the phase sequence is incorrect, frequency- and power-related functions will not operate properly and the **Frequency Status** menu will read **DISABLE**.

    If positive, negative and zero sequence voltages are all present, check the polarities of the VT connections and change connections to obtain proper polarities.
12. Press **ENTER** until the unit displays:

```
3RD HARMONIC NTRL VOLT
______ Volts
```

13. Press **ENTER** until the unit displays:

```
FIELD GND MEAS. CIRCUIT
________ mV
```

14. Press **EXIT** until the unit displays:

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

15. Press the right arrow to display:

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

16. Press **ENTER** to display line currents (I_a, I_b, I_c). The unit should display:

```
PHASE CURRENT
A=  B=  C=
```

Compare these currents with the measured values using a meter. If there is a discrepancy, check the CT connections to the rear terminal block of the unit.

17. Press **ENTER** for the unit to display:

```
PHASE CURRENT
a=  b=  c=
```

Compare these currents with the measured values using a meter. If there is a discrepancy, check the CT connections to the rear terminal block of the unit.

18. Press **ENTER** for the unit to display:

```
DIFFERENTIAL CURRENT
A=  B=  C=
```

Differential current should be near zero amps. If a significant amount of differential current is present, check the CT polarities.

19. Press **ENTER** for the unit to display:

```
NEUTRAL CURRENT
______ Amps
```

20. Press **ENTER** for the unit to display:

```
GND DIFFERENTIAL CURRENT
______ Amps
```

21. Press **ENTER** for the unit to display:

```
STATOR LOW FREQ INJECT.
I=____ mAmps
```

22. Press **ENTER** to display:

```
POS SEQUENCE CURRENT
______ Amps
```

The positive sequence current should be I_{pos} ≈ I_a ≈ I_b ≈ I_c.

23. Press **ENTER** to display:

```
NEG SEQUENCE CURRENT
______ Amps
```

Negative sequence current should near zero amperes.

24. Press **ENTER** to display:

```
ZERO SEQUENCE CURRENT
______ Amps
```

The zero sequence current should be I_{zero} ≈ 0 A. If a significant amount of negative or zero sequence current (greater than 25% of I_a, I_b, I_c) then either the phase sequence or the polarities are incorrect. Modify connections to obtain proper phase sequence and polarities.

25. Press **ENTER** to display:

```
F49 THERMAL CURRENT #1
______ Amps
```

Press **ENTER** once more to display:

```
F49 THERMAL CURRENT #2
______ Amps
```
26. Press **EXIT**, then the Right arrow to display:

   **FREQUENCY STATUS**  
   volt curr FREQ v/hz →

27. Press **ENTER** to display:

   **FREQUENCY**  
   _________ Hz

28. Press **ENTER** to display:

   **RATE OF CHANGE FREQUENCY**  
   ___ Hz/Sec

29. Press **EXIT**, then right arrow to display:

   **V/HZ STATUS**  
   volt curr freq V/HZ →

30. Press **ENTER** to display:

   **VOLTS PER HERTZ**  
   _________ %

31. Press **EXIT**, then right arrow to display:

   **POWER STATUS**  
   ← POWR imped sync brkr →

32. Press **ENTER** to display real power and check its sign. The unit should display:

   **REAL POWER**  
   _________ PU _______W

   The sign should be positive for forward power and negative for reverse power. If the sign does not agree with actual conditions, check the polarities of the three neutral-end CTs and/or the PTs.

33. Press **ENTER** for the unit to display:

   **REACTIVE POWER**  
   _________ PU _____VAr

34. Press **ENTER** for the unit to display:

   **APPARENT POWER**  
   _________ PU _______VA

35. Press **ENTER** to display:

   **POWER FACTOR**  
   ___ Lag/Lead

36. Press **EXIT** and then right arrow to display:

   **IMPEDANCE STATUS**  
   ← powr IMPED sync brkr →

37. Press **ENTER** to display:

   **IMPEDEABCE Zab (Ohms)**  
   R= ____ X= 

   Press **ENTER** once more to display:

   **IMPEDEABCE Zbc (Ohms)**  
   R= ____ X= 

   Press **ENTER** once more to display:

   **IMPEDEABCE Zca (Ohms)**  
   R= ____ X= 

38. Press **ENTER** to display:

   **IMPEDEABCE POS SEQ (Ohms)**  
   R= ____ X= 

39. Press **ENTER** to display:

   **FIELD GND RESISTANCE**  
   _______ Ohms

40. Press **EXIT** and then right arrow to display:

   **SYNC CHECK STATUS**  
   ← powr imped SYNC brkr →

41. Press **ENTER** to display:

   **PHASE ANGLE**  
   ____ DEGREES

42. Press **ENTER** to display:

   **DELTA VOLTAGE**  
   _____ Volts LO
43. Press ENTER to display:

DELTA FREQUENCY
______ Hz HI

44. Press EXIT, then right arrow until unit displays:

BREAKER MON ACC. STATUS
← power imped sync BRKR →

45. Press ENTER to display:

BREAKER MON ACC. STATUS
A= A-cycles

Press ENTER to cycle through Acc. Status screens for B and C.

46. Press EXIT, then right arrow until unit displays:

81A ACCUMULATORS STATUS
← FREQ_ACC i/o timer →

47. Press ENTER to display:

81A #1 ACCUMULATORS STAT
_____ Cycles

Pressing ENTER will display a status screen for each of the six elements.

48. Press ENTER to display:

81A #1 ACC. STARTUP TIME
00-20XX 00:00:00:000

Pressing ENTER will display a status screen for each of the six elements.

49. Press EXIT, then right arrow until unit displays:

IN/OUT STATUS
← freq_acc I/O timer →

50. Press ENTER to display:

FL I6 I5 I4 I3 I2 I1

Press ENTER again to view outputs:

08 07 06 05 04 03 02 01

51. Press EXIT, then arrow button to display:

TIMER STATUS
← freq_acc i/o TIMER →

52. Press ENTER to display:

51V DELAY TIMER
A= B= C=

53. Press ENTER to display:

51N DELAY TIMER
________ %

54. Press ENTER to display:

46IT DELAY TIMER
________ %

55. Press ENTER to display:

24IT DELAY TIMER
________ %

56. Press EXIT, then right arrow until unit displays:

RELAY TEMPERATURE
← TEMP count powerup →

57. Press ENTER to display:

RELAY TEMPERATURE
________ C
58. Press EXIT, then right arrow until unit displays:

COUNTERS
← temp COUNT powerup →

59. Press ENTER to display:

OUTPUT COUNTER 1

Pressing ENTER will display a status screen for each of the 23 outputs.

60. Press ENTER to display:

ALARM COUNTER

61. Press EXIT, then right arrow until the unit displays:

TIME OF LAST POWER UP
← temp count POWERUP →

62. Press ENTER to display:

TIME OF LAST POWER UP
05-Jan-2003 20:39:29

■NOTE: The CT and VT polarities can be easily verified by looking at the oscillographic waveforms, using M-3801D IPSplot® PLUS analysis software.

63. Press EXIT, then right arrow until the unit displays:

ERROR CODES
← ERROR check

64. Press ENTER to display:

ERROR CODES (LAST)

Pressing ENTER will display a status screen for three previous error codes.

65. Press ENTER to display:

RST LOCATION
0000 CBR=___ BBR=___

66. Press ENTER to display:

COMM ERROR CODE (LAST)

67. Press ENTER to display:

COMM PACKET COUNTER

68. Press ENTER to display:

COMM RX ERROR COUNTER

69. Press ENTER to display:

SELFTEST COUNTER

70. Press ENTER to display:

RESET COUNTER

71. Press ENTER to display:

POWERLOSS COUNTER

72. Press EXIT, then right arrow until the unit displays:

CHECKSUMS
← error CHECK

73. Press ENTER to display:

SETPOINTS CHECKSUM
EECS= BBCS= CAL=

74. Press ENTER to display:

CALIBRATION CHECKSUM
EECS= BBCS= CAL=

75. Press ENTER to display:

ROM CHECKSUM


### 5.5 Circuit Board Switches and Jumpers

See Figure 5-13, M-3425A Circuit Board for Jumper and Switch locations.

#### Accessing Switches and Jumpers

- **WARNING:** Operating personnel must not remove the cover or expose the printed circuit board while power is applied. IN NO CASE may the circuit-based jumpers or switches be moved with power applied.

- **WARNING:** The protective grounding terminal must be connected to an earthed ground any time external connections have been made to the unit. See Figure 5-8, Note #4.

- **CAUTION:** This unit contains MOS circuitry, which can be damaged by static discharge. Care should be taken to avoid static discharge on work surfaces and service personnel.

1. De-energize the M-3425A.
2. Remove the screws that retain the front cover.
3. Remove the "J" connectors from the corresponding plugs, P4, 5, 6, 7, 9 and 11.
4. Loosen the two circuit board retention screws (captured).
5. Remove the circuit board from the chassis.
6. Jumpers J5, J18, J20, J21, J22, J46, J60, and J61 are now accessible. See Figure 5-13, M-3425A Circuit Board for locations.
7. Dipswitch SW1 is now accessible. See Figure 5-13 for location.
8. Insert circuit board into chassis guides and seat firmly.
9. Tighten circuit board retention screws.
10. Reconnect "J" connectors to corresponding plugs.
11. Reinstall cover plate.

#### Jumper Position Description

<table>
<thead>
<tr>
<th>Jumper</th>
<th>Position</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>J5</td>
<td>A to B</td>
<td>Demodulated IRIG-B TTL signal on Pin 6 COM2</td>
</tr>
<tr>
<td></td>
<td>B to C</td>
<td>Modulated IRIG-B signal BNC (Default)</td>
</tr>
<tr>
<td>J18</td>
<td>A to B</td>
<td>COM3 200 ohm termination resistor inserted</td>
</tr>
<tr>
<td></td>
<td>B to C</td>
<td>COM3 no termination (Default)</td>
</tr>
<tr>
<td>J46</td>
<td>A to B</td>
<td>COM3 shares Baud Rate with COM1</td>
</tr>
<tr>
<td></td>
<td>B to C</td>
<td>COM3 shared Baud Rate with COM2 (Default)</td>
</tr>
<tr>
<td>J60</td>
<td>A to B</td>
<td>Connects DCD signal to Pin 1 of COM2 (Default)</td>
</tr>
<tr>
<td></td>
<td>A to C</td>
<td>Connects +15V to Pin 1 of COM2</td>
</tr>
<tr>
<td>J61</td>
<td>B to C</td>
<td>Connects -15V to Pin 9 of COM2</td>
</tr>
<tr>
<td></td>
<td>A to B</td>
<td>COM2 Pin 9 float (Default)</td>
</tr>
</tbody>
</table>

**NOTE:** Short circuit protection (100 ma limit) is incorporated on pins 1 and 9 when used for +/- 15V.

*Table 5-1 Jumpers*
Switches should not be changed while unit is energized.

▲ CAUTION: A loss of calibration, setpoints, and configuration will occur when the EEPROM is initialized to default.

Table 5-2  Dip Switch SW-1

Table 5-3  Trip Circuit Monitor Input Voltage Select Jumper Configuration

* Default as shipped from factory.
Figure 5-14  M-3425A Circuit Board (Expanded I/O)
5.6 Low Frequency Signal Injection Equipment

Figure 5-15 represents typical connections for the Low Frequency Signal Injection Equipment. Figures 5-16 through 5-20 illustrate equipment mounting dimensions.

* For applications with a transformer secondary rating that will result in 50/60 Hz phase ground fault voltages >200 V ac, use the "High Voltage" connection for the 59N Function.

** If 20 Hz Signal Generator is prior to Model EE a step down transformer is necessary for voltages >120 VAC.
Figure 5-16  20 Hz Frequency Generator Housing Panel Surface Mount
Figure 5-17  20 Hz Frequency Generator Housing Panel Flush Mount
Figure 5-18  20 Hz Band Pass Filter Housing Panel Surface Mount
Figure 5-19  20 Hz Band Pass Filter Housing Panel Flush Mount
Figure 5-20  20 Hz Measuring Current Transformer 400-5 A CT
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# 6 Testing

## 6.1 Equipment/Test Setup

<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power On Self Tests</td>
<td>6–7</td>
</tr>
<tr>
<td>21 Phase Distance</td>
<td>6–8</td>
</tr>
<tr>
<td>24 Volts per Hertz</td>
<td>6–9</td>
</tr>
<tr>
<td>25D/25S Sync Check</td>
<td>6–12</td>
</tr>
<tr>
<td>27 Phase Undervoltage</td>
<td>6–16</td>
</tr>
<tr>
<td>27TN Third-Harmonic Undervoltage, Neutral</td>
<td>6–17</td>
</tr>
<tr>
<td>32 Directional Power, 3-Phase</td>
<td>6–21</td>
</tr>
<tr>
<td>40 Loss of Field</td>
<td>6–24</td>
</tr>
<tr>
<td>46 Negative Sequence Overcurrent Definite Time</td>
<td>6–26</td>
</tr>
<tr>
<td>46 Negative Sequence Overcurrent Inverse Time</td>
<td>6–27</td>
</tr>
<tr>
<td>49 Stator Overload</td>
<td>6–28</td>
</tr>
<tr>
<td>50 Instantaneous Phase Overcurrent</td>
<td>6–30</td>
</tr>
<tr>
<td>50BF/50BF-N Breaker Failure</td>
<td>6–31</td>
</tr>
<tr>
<td>50/27 Inadvertent Energizing</td>
<td>6–33</td>
</tr>
<tr>
<td>50DT Definite Time Overcurrent for Split-Phase Differential</td>
<td>6–34</td>
</tr>
<tr>
<td>50N Instantaneous Neutral Overcurrent</td>
<td>6–35</td>
</tr>
<tr>
<td>51N Inverse Time Neutral Overcurrent</td>
<td>6–36</td>
</tr>
<tr>
<td>51V Inverse Time Phase Overcurrent with Voltage Control/Restraint</td>
<td>6–37</td>
</tr>
<tr>
<td>59 Phase Overvoltage</td>
<td>6–39</td>
</tr>
<tr>
<td>59D Third Harmonic Voltage Differential</td>
<td>6–40</td>
</tr>
<tr>
<td>59N Overvoltage, Neutral Circuit or Zero Sequence</td>
<td>6–41</td>
</tr>
<tr>
<td>59X Multipurpose Overvoltage</td>
<td>6–42</td>
</tr>
<tr>
<td>60FL VT Fuse Loss Detection</td>
<td>6–43</td>
</tr>
<tr>
<td>64F Field Ground Protection</td>
<td>6–44</td>
</tr>
<tr>
<td>64B Brush Lift Off Detection</td>
<td>6–46</td>
</tr>
<tr>
<td>64S 100% Stator Ground Protection by Injection</td>
<td>6–47</td>
</tr>
<tr>
<td>67N Residual Directional Overcurrent</td>
<td>6–50</td>
</tr>
<tr>
<td>78 Out of Step</td>
<td>6–54</td>
</tr>
<tr>
<td>81 Frequency</td>
<td>6–56</td>
</tr>
<tr>
<td>81A Frequency Accumulator</td>
<td>6–57</td>
</tr>
<tr>
<td>81R Rate of Change of Frequency</td>
<td>6–58</td>
</tr>
<tr>
<td>87 Phase Differential</td>
<td>6–60</td>
</tr>
<tr>
<td>87GD Ground Differential</td>
<td>6–62</td>
</tr>
<tr>
<td>Breaker Monitoring</td>
<td>6–64</td>
</tr>
<tr>
<td>Trip Circuit Monitoring</td>
<td>6–66</td>
</tr>
<tr>
<td>IPSLogic</td>
<td>6–67</td>
</tr>
</tbody>
</table>

## 6.2 Functional Test Procedures

<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPSLogic</td>
<td>6–67</td>
</tr>
</tbody>
</table>

## 6.3 Diagnostic Test Procedures

<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto-Calibration</td>
<td>6–77</td>
</tr>
</tbody>
</table>
6.1 Equipment/Test Setup

No calibration is necessary, as the M-3425A Generator Protection Relay is calibrated and fully tested at the factory. If calibration is necessary because of a component replacement, follow the auto calibration procedure detailed in Section 6.4, Auto Calibration (or see Section 4.7, Calibration subsection for units without an HMI). These test procedures are based on the prerequisite that the functions are enabled and have settings as described in Chapter 2, Application, and that the unit is fitted with the optional HMI module.

Equipment Required

The following equipment is required to carry out the test procedures:

1. Two Digital Multimeters (DMM) with 10 A current range.
2. 120 V ac or 0 to 125 V dc variable supply for system power.
3. Three-phase independent voltage sources (0 to 250 V) variable phase to simulate VT inputs.
4. Three-phase independent current sources (0 to 25 A) variable phase to simulate CT inputs.
5. Electronic timer accurate to at least 8 ms.

6. For relays with the 64F/B option:
   a. Resistor decade box capable of 500 ohms to 150 kOhms, able to step in 100 ohm increments.
   b. Capacitors ranging from 0.15 mf to 10 mf.

7. For relays with the 64S option:
   a. 20 Hz Voltage Generator (variable) 0 to 40 V.
   b. 20 Hz Current Generator (variable) 0 to 40 mA.

Setup

1. Connect system power to the power input terminals 62 (hot) and 63 (neutral). The relay can be ordered with a nominal input power supply of 110/120/230/240 Vac, 110/125/220/250 Vdc or 24/48 Vdc. An optional redundant power supply is available.

**NOTE:** The proper voltage for the relay is clearly marked on the power supply label affixed to the rear panel.

2. For each test procedure, connect the voltage and current sources according to the configuration listed in the test procedure and follow the steps outlined.
■ **NOTE:** The phase angles shown here use leading angles as positive and lagging angles as negative. Some manufacturers of test equipment have used lagging angles as positive, in which case $V_B = 120\,\text{V} \angle 120^\circ$ and $V_C = 120\,\text{V} \angle 240^\circ$. Similarly other voltages and currents phase angles should be adjusted. These test configurations are for ABC phase rotation. They must be adjusted appropriately for ACB phase rotation.

![Diagram of Voltage Inputs: Configuration V1](image1)

**Figure 6-1** Voltage Inputs: Configuration V1

![Diagram of Voltage Inputs: Configuration V2](image2)

**Figure 6-2** Voltage Inputs: Configuration V2
Figure 6-3  Current Inputs: Configuration C1

Figure 6-4  Current Inputs: Configuration C2
Figure 6-5  Current Configuration C3

Figure 6-6  64S Test Configuration
6.2 Functional Test Procedures

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

In all test descriptions, a process for calculating input quantities to test the actual settings of the function will be given if needed. Disable all other functions not being tested at the time. This action is to prevent the operation of multiple functions with one set of input quantities, which could cause confusion of operation of outputs or timers. The complete description of the method to disable/enable functions may be found in detail in Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection or Chapter 4, Remote Operation. The complete description of the method to install setting quantities may be found in Section 3.4, System Data, Setpoints and Time Settings subsection.

It is desirable to record and confirm the actual settings of the individual functions before beginning test procedures. Use Figure A-3, Functional Configuration Record Form and Figure A-4, Setpoint & Timing Record Form, found in Appendix A, Configuration Record Forms, to record settings. It is also possible to download the relay settings into a file using IPScom®.

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

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Table 6-1, Output Contacts.

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

| Input Configurations – pg 6–3 to 6-5 |
| Output Contact Numbers – pg 6–68 |
| Relay Configuration Table – pg A–2 |
| Setpoint & Timing Record Form – pg A–20 |
Power On Self Tests

VOLTAGE INPUTS: none
CURRENT INPUTS: none

1. Apply proper power to the power input terminals (60 HOT and 61 NEUTRAL).
2. The following sequence of actions will take place in the following order:
   a. The unit will display the following:

          POWER ON SELFTESTS
          xxxxxxxxxxxxxxxxxxxxxx

   b. All LEDs will illuminate for approximately 1 second.
   c. The **POWER** and **RELAY OK** LEDs will remain illuminated, all other LEDs will extinguish.
   d. The unit will display the following:

          POWER ON SELFTESTS
          PASS

   e. The unit will display the model number:

          BECKWITH ELECTRIC CO.
          M-3425A Expanded

   f. The unit will display the firmware version.

          BECKWITH ELECTRIC
          D-0150xx.xx.xx

   g. The unit will display the serial number.

          BECKWITH ELECTRIC CO.
          SERIAL NUMBER xxx

   h. The **POWER** LED(s) will illuminate.
   i. The **RELAY OK** LED will flash (or stay on as programmed in the diagnostic menu).
   j. The **BREAKER CLOSED** LED will remain illuminated. If the relay breaker position contact IN1 is connected to a breaker position contact (52b) and the breaker is open the LED will be extinguished.

3. The power-on self-tests end with the unit displaying the system date, time and default logo.
4. If there are any recorded targets they are then displayed.
## 21 Phase Distance (#1, #2 or #3)

**VOLTAGE INPUTS:**  
Configuration V1

**CURRENT INPUTS:**  
Configuration C1

**TEST SETTINGS:**  
- Diameter: P Ohms (0.1 to 100)
- Offset: O Ohms (−100 to 100)
- Impedance Angle: A Degrees (0 to 90)
- Time Delay: D Cycles (1 to 8160)
- Programmed Outputs: Z Output (1 to 8)
  
  Expanded I/O: (9 to 23)

**VT Configuration**  
Line-Ground or Line-Line

### NOTE:
It would be efficient to disable the element with the higher “reach” (Diameter plus Offset) setting first (lower current), and test the lower reach setting operation, since the higher reach setting operation can be tested without disabling the lower setting.

### Test Setup:
1. Determine the Function 21 Phase Distance settings to be tested.
2. Enter the Function 21 Phase Distance settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
6. The level of current at which pickup operation is to be expected for an individual setting is determined as follows:
   a. Define “reach” as \( R \) ohms = \( P \) ohms + \( O \) ohms \[O, \text{ usually set at zero ohms}\].
   b. For Line-Ground configuration, define “current” as \( I = ((\text{Selected Voltage}) \frac{I}{R} \text{ ohms}) \). The voltage level may be selected based on the desired test current level. For Line-Line configuration, define “current” as \( I = ((\text{Selected Voltage}/\sqrt{3}) \frac{I}{R} \text{ ohms}) \).

### Pickup Test:
1. Set the three-phase voltages to the Selected Voltage value from Step 6b above.
2. Set the phase angle between the voltage and current inputs at (A) degrees from settings above (for Line-Line configuration, set the phase angle at (A−30°)).
3. Press and hold the TARGET RESET pushbutton, then slowly increase the three-phase input currents until the 21 PHASE DISTANCE LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   
   The level at which the 21 PHASE DISTANCE actuates should be equal to \( I \) calculated in Step 6 with the resulting impedance ±0.1 ohms or 5%.
4. Release the TARGET RESET pushbutton, then decrease the three-phase input currents. The assigned OUTPUT LEDs will extinguish.
5. Press the TARGET RESET pushbutton to reset targets.

### Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately 110% of the current (I) found in Step 6, and start timing. The contacts will close after D cycles within ±1 cycle or ±1%. 

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**M-3425A Instruction Book**

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6–8
24 Volts/Hz Definite Time (#1 or #2)

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: None
TEST SETTINGS: Definite Time Pickup \( P \% \) (100 to 200)
Time Delay \( D \) Cycles (30 to 8160)
Programmed Outputs \( Z \) Output (1 to 8)
Expanded I/O (9 to 23)

**NOTE:** It would be efficient to disable the 24 Definite Time element with the lower pickup setting first and test the higher setting operation, since the lower setting operation can be tested without disabling the higher setting.

**Test Setup:**

1. Determine the Function 24 Volts/Hz Definite Time settings to be tested.
2. Enter the Function 24 Volts/Hz Definite Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. The Volts per Hertz pickup level at a percentage setting at Nominal Frequency (50 or 60 Hz) is:
   
   \[
   \text{Pickup voltage} = \left( \frac{P\%}{100} \right) \times (\text{Nominal Voltage})
   \]

   where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and are recorded on Figure A-3, Functional Configuration Record Form.

**Pickup Test:**

1. Press and hold the TARGET RESET pushbutton, then slowly increase the voltage on Phase A until the 24 VOLTS/Hz LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level of operation will equal to \( P \) volts ±1%.
2. Release the TARGET RESET pushbutton, then decrease the Phase A voltage. The assigned OUTPUT LED(s) will extinguish.
3. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**

1. Connect a timer to output contacts \( Z \) so that the timer stops timing when the contacts \( Z \) close.
2. Apply approximately \((P + 10 \text{ volts})\) volts, and start timing. The contacts will close after \( D \) cycles ± 25 cycles.
3. Repeat Pickup Test and Time Test for Phase B and C.
**24 Volts/Hz Inverse Time**

**VOLTAGE INPUTS:** Configuration V1

**CURRENT INPUTS:** None

**TEST SETTINGS:**
- Inverse Time Pickup \( P \) % (100 to 200)
- Inverse Time Curve \( C \) (1 to 4)
- Time Dial (Curve 1) \( K \) (1 to 100)
- Time Dial (Curves 2-4) \( K \) (0.0 to 9.0)
- Reset Rate \( R \) Seconds (1 to 999)
- Programmed Outputs \( Z \) OUT (1 to 8)
  - Expanded I/O (9 to 23)

**Test Setup:**
1. Determine the Function 24 Volts/Hz Inverse Time settings to be tested.
2. Enter the Function 24 Volts/Hz Inverse Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Enter a Function 24 Volts/Hz Definite Time Pickup #1 setting of 140%, with a Delay of 1200 cycles.
4. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
5. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
6. The Volts/Hz pickup level of a percentage setting at nominal frequency (50 or 60 Hz) is: Pickup voltage = \( \frac{P\%}{100} \times \text{Nominal Voltage} \) where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and are recorded on Figure A-3, Functional Configuration Record Form.
7. Test levels may be chosen at any percentages of Nominal Voltage which are a minimum of 5% higher than the pickup percentage, \( P\% \). (Suggest 4 or 5 test levels chosen and calculated in Step 6.)

**Pickup Test:**
1. Press and hold the TARGET RESET pushbutton, then slowly increase the voltage on Phase A until the 24 VOLTS/Hz LED light illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level of operation will equal \( P \) volts ±1%.
2. Release the TARGET RESET pushbutton, then decrease the Phase A voltage. The assigned OUTPUT LED(s) will extinguish.
3. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply a voltage equal to the chosen test level calculated in Step 6 to Phase A and start timing.
   The operating time will be as read from the appropriate Inverse Curve Family and \( K \) (Time Dial) setting (refer to Appendix D, Inverse Time Curves). The measured time should be within the time corresponding to ±1% of the pickup value.
3. Press and hold the **TARGET RESET** pushbutton.
4. Reduce the applied voltage and start timing when the voltage drops below the pickup value, stop timing when the **TARGET** LED extinguishes. The time should be the reset time within ±1%.
5. Repeat Pickup Test and Time Test for all chosen test levels. The curve portion extending to lower than P% V/Hz values are inactive and can be ignored. The tested points verify the operating times of the function.

**NOTE:** If retesting is required, remove power from the unit or wait for the programmed reset time period before the next test to assure resetting of the timer.
25D Dead Check

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: None
TEST SETTINGS:
- Dead V1 See Below
- Dead Vx See Below
- Dead V1 & Vx See Below
- Dead Input Enable DIN Input (1 to 6)
  Expanded I/O (7 to 14)
- Dead Time Delay DD Cycles (1 to 8160)
- Dead Voltage Limit DVL Volts (0 to 60)
- Programmed Outputs Z Output (1 to 8)
  Expanded I/O (9 to 23)

Test Setup:
1. Determine the Function 25D Dead Check settings to be tested.
2. Enter the Function 25D Dead Check settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. The 25D function requires positive sequence voltage and Vx for testing. The following tests will reference the positive sequence voltage as V1.
5. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
6. Set V1 and Vx to the Nominal Voltage.

The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

Dead V1 Hot Vx Test:
1. Enable Dead V1 Hot Vx and disable Dead Vx Hot V1 (if enabled) utilizing either the HMI or IPScom Communications Software.
2. Set V1 to DVL +5 V.
3. Press and hold the TARGET RESET pushbutton, then slowly decrease the voltage applied to V1 until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level should be equal to DVL ± 0.5 V or ± 0.5 %.
4. Release the TARGET RESET pushbutton, then increase the voltage applied to V1. The OUTPUT LED will extinguish.
5. Set V1 to the Nominal Voltage.
6. Decrease Vx to less than DVL, verify that the function does not operate.
**Dead V_x Hot V1 Test:**
1. Enable Dead V_x Hot V1 and disable Dead V1 Hot V_x (if enabled) utilizing either the HMI or IPScom Communications Software.
2. Set V1 to the Nominal Voltage.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
3. Set V_x to DVL +5 V.
4. Press and hold the TARGET RESET pushbutton, then slowly decrease the voltage applied to V_x until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level should be equal to DVL ± 0.5 V or ± 0.5 %.
5. Release the TARGET RESET pushbutton, then increase the voltage applied to V_x. The OUTPUT LED will extinguish.
6. Set V_x to the Nominal Voltage.
7. Decrease V1 to less than DVL, verify that the function does not operate.

**Dead V1 Dead V_x Test:**
1. Enable Dead V1 Dead V_x utilizing either the HMI or IPScom Communications Software.
2. Disable Dead V_x Hot V1 and Dead V1 Hot V_x (if enabled).
3. Set V1 and V_x to DVL +5 V.
4. Press and hold the TARGET RESET pushbutton, then slowly decrease the voltage applied to V1 and V_x until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level should be equal to DVL ± 0.5 V or ± 0.5 %.
5. Release the TARGET RESET pushbutton, then increase the voltage applied to V1 and V_x. The OUTPUT LED will extinguish.
6. Set V1 to Nominal Voltage.
7. Decrease V_x to less than DVL, then verify that the function does not operate.
8. Set V_x to Nominal Voltage.
9. Decrease V1 to less than DVL, then verify that the function does not operate.

**Dead Input Enable Test:**
1. Select one of the Dead Inputs (DIN) and activate it.
2. Repeat the Dead V_x Hot V1 Test and Dead V1 Hot V_x Test, verify that the function operates as in Dead V_x Hot V1 Test and Dead V1 Hot V_x Testing.
3. Deactivate the DIN and repeat the Dead V_x Hot V1 Test and Dead V1 Hot V_x Test once more. Verify that the function does not operate.
4. Disable Dead Input feature.

**Dead Timer Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Enable Dead V1 Dead V_x, utilizing either the HMI or IPScom Communications Software.
3. Set V1 and V_x to DVL +5 V.
4. Remove V1 and V_x and start timing. The contacts will close within −1 to +3 cycles or ± 1%.
**25S Sync Check**

**VOLTAGE INPUTS:** Configuration V1

**CURRENT INPUTS:** None

**TEST SETTINGS:**

- **Phase Angle Limit**
  - **PA** Degrees
  - Range: (0 to 90)

- **Voltage Limits**
  - **Upper Limit**
  - **UL** Volts
  - Range: (60 to 140)

  - **Lower Limit**
  - **LL** Volts
  - Range: (40 to 120)

- **Sync Check Time Delay**
  - **SD** Cycles
  - Range: (1 to 8160)

- **Delta Voltage Limit**
  - **DV** Volts
  - Range: (1.0 to 50.0)

- **Delta Frequency Limit**
  - **DF** Hz
  - Range: (0.001 to 0.500)

- **Phase Select**
  - (AB, BC, CA)

- **Programmed Outputs**
  - **Z** Output
  - Range: (1 to 8)

  - **Expanded I/O**
  - Range: (9 to 23)

**Test Setup:**

1. Determine the Function 25S Sync Check settings to be tested.
2. Enter the Function 25S Sync Check settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. The 25 function requires only one phase voltage and Vₓ for testing in the Line-to-Ground configuration. The phase voltage used for reference may be selected through the System Setup menu. The following tests will reference the phase voltage as V1, although any phase may be used for testing. Line-to-Line testing will follow the same procedures, with V1 representing the proper Line-to-Line phase input. Each test below can be performed using any of the three phases as a reference.
5. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
6. Set V1 and Vₓ to the Nominal Voltage.

   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Phase Angle Limit Test:**

1. Establish a phase angle difference of more than PA +5°.
2. Press and hold the TARGET RESET pushbutton, then slowly decrease the phase angle difference until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom® Function Status screen. The phase angle difference should be equal to PA ±1°.
3. Release the TARGET RESET pushbutton, then increase the phase angle difference. The OUTPUT LED will extinguish.
**Upper Voltage Limit Test:**
1. Apply a voltage 5 V greater than UL to V1.
2. Ensure Vx voltage is less than UL but greater than LL. Slowly decrease the voltage applied to V1 until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage should be equal to UL ± 0.5 V or ±0.5 %.
3. Increase the voltage applied to V1. The OUTPUT LED will extinguish. If desired, repeat this test using Vx.

**Lower Voltage Limit Test:**
1. Apply a voltage 5 V less than LL to V1.
2. Ensure Vx voltage is greater than LL but less than UL. Slowly increase the voltage applied to V1 until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level should be equal to LL ± 0.5 V or ±0.5 %.
3. Decrease the voltage applied to V1. The OUTPUT LED will extinguish. If desired, repeat this test using Vx.

**Sync Check Time Delay Test:**
1. Set V1 and Vx to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
2. Establish a phase angle difference of more than PA +5°.
3. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
4. Remove the phase angle difference and start timing. The contacts will close after SD cycles within −1 to +3 cycles or ± 1 %.

**Delta Voltage Test:**
1. Set the Upper and Lower Voltage limits to their maximum and minimum values, respectively.
2. Set Vx to 140 V and V1 to 40 V.
3. Press and hold the TARGET RESET pushbutton, then slowly increase the voltage applied to V1 until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage difference should be equal to DV ± 0.5 V.
4. Release the TARGET RESET pushbutton, then decrease the voltage applied to V1. The OUTPUT LED will extinguish. If desired, repeat the test using Vx with V1 at 140 volts.

**Delta Frequency Test:**
1. Set V1 and Vx to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
2. Set the frequency of V1 to 0.05 less than Nominal Frequency –DF.
3. Press and hold the TARGET RESET pushbutton, then slowly increase the frequency of V1 until Output Z LED illuminates, or the pickup indicator illuminates on the IPScom® Function Status screen. The frequency difference value should be equal to DF ± 0.0007 Hz or 5 %.
4. Release the TARGET RESET pushbutton, then decrease the frequency of V1. The OUTPUT LED will extinguish. If desired, repeat the test using Vx with V1 at Nominal Frequency.
27 Phase Undervoltage, 3 Phase (#1, #2, #3)

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: None

TEST SETTINGS:
- Pickup P Volts (5 to 180)
- Time Delay D Cycles (1 to 8160)
- Programmed Outputs Z OUT (1 to 8)
- Expanded I/O (9 to 23)

**NOTE:** If 27 #1 and 27 #2 have different pickup settings, it would be efficient to disable the one with the higher setting first and test the lower setting operation. The higher setting operation could then be tested without disabling the lower setting.

**Test Setup:**
1. Determine the Function 27 Phase Undervoltage settings to be tested.
2. Enter the Function 27 Phase Undervoltage settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.

**Pickup Test:**
1. Press and hold the TARGET RESET pushbutton, then slowly decrease the Phase A input voltage until the 27 PHASE UNDERVOLTAGE LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The voltage level should be equal to \( P \) volts ±0.5 V or ±0.5%. When both RMS and Line-Ground to Line-Line is selected, the accuracy is ±0.8V or ±0.75%.
2. Release the TARGET RESET pushbutton, then increase the Phase A input voltage to the nominal voltage, the OUTPUT LEDs will extinguish.
3. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately \( (P - 1) \) volts and start timing.
   The contacts will close after \( D \) cycles ≤ 20 cycles or ±1%(RMS), or ±1 cycle or ±0.5% (DFT), whichever is greater.
3. Repeat Pickup Test and Time Test for Phase B and C.
27TN Third-Harmonic Undervoltage, Neutral (#1 or #2)

VOLTAGE INPUTS: Configuration V2
CURRENT INPUTS: See Below
TEST SETTINGS:

<table>
<thead>
<tr>
<th>Component</th>
<th>Symbol</th>
<th>Unit</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup</td>
<td>P</td>
<td>Volts</td>
<td>(0.10 to 14.0)</td>
</tr>
<tr>
<td>Positive Sequence Volt Block</td>
<td>PSV</td>
<td>Volts</td>
<td>(5 to 180)</td>
</tr>
<tr>
<td>Forward Power Block</td>
<td>FP</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
<tr>
<td>Reverse Power Block</td>
<td>RP</td>
<td>PU</td>
<td>(–1.00 to –0.01)</td>
</tr>
<tr>
<td>Lead VAR Block</td>
<td>–VAR</td>
<td>PU</td>
<td>(–1.00 to –0.01)</td>
</tr>
<tr>
<td>Lag VAR Block</td>
<td>+VAR</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
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<td>Lead Power Factor Block</td>
<td>PFLed</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
<tr>
<td>Lag Power Factor Block</td>
<td>PFLag</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
<tr>
<td>High Band Forward Power Block</td>
<td>HFP</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
<tr>
<td>Low Band Forward Power Block</td>
<td>LFP</td>
<td>PU</td>
<td>(0.01 to 1.00)</td>
</tr>
<tr>
<td>Time Delay</td>
<td>D</td>
<td>Cycles</td>
<td>(1 to 8160)</td>
</tr>
<tr>
<td>Programmed Outputs</td>
<td>Z</td>
<td>OUT</td>
<td>(1 to 8)</td>
</tr>
<tr>
<td>Expanded I/O</td>
<td></td>
<td></td>
<td>(9 to 23)</td>
</tr>
</tbody>
</table>

■NOTE: If 27TN #1 and 27 #2 have different pickup settings, it would be efficient to disable the one with the higher setting first and test the lower setting operation. The higher setting operation could then be tested without disabling the lower setting.

Test Setup:
1. Determine the Function 27TN Third-Harmonic Undervoltage, Neutral settings to be tested.
2. Enter the Function 27TN Third-Harmonic Undervoltage, Neutral settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-2, Voltage Inputs: Configuration V2.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly decrease the neutral voltage input until the 27TN/59D 100% STATOR GND LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level should be equal to P volts ±0.1 V or ±1%.
2. Release the TARGET RESET pushbutton, then increase the neutral voltage to nominal voltage. The OUTPUT LED(s) will extinguish.
3. Press TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately (P –1) volts and start timing. The contacts will close after D cycles within ± 1 cycle or ±1%.
**Positive Sequence Voltage Block Test:**

1. Decrease the neutral voltage input to less than $P$ volts.
2. Apply a three phase voltage input greater than $PSV$ volts.
   The 27TN/59D 100% STATOR GND LED will illuminate, then the OUTPUT LED will illuminate when the delay setting has timed out.
3. Enable the Positive Sequence Voltage Block utilizing either the HMI or IPScom® Communications Software.
4. Decrease the applied three phase voltage until the OUTPUT LED(s) extinguishes.
   The voltage level should be equal to $PSV$ volts ±0.5 V or ±0.5%.
5. Disable the Positive Sequence Voltage Block utilizing either the HMI or IPScom Communications Software.

**Forward/Reverse Power Block Test:**

1. Apply a three phase nominal voltage input.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
2. Apply a nominal current input consistent with Figure 6-3, Current Inputs: Configuration C1.
   The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.
   ■ NOTE: The POWER Real p.u. value can be obtained utilizing either the HMI (Status/Power Status) or IPScom® Communications Software (Relay/Monitor/Secondary Status).
3. Adjust three phase voltage and current inputs to obtain a Power Real p.u. value greater than $FP$.
4. Enable the Forward Power Block utilizing either the HMI or IPScom Communications Software.
5. Decrease the applied three phase current until the OUTPUT LED(s) extinguishes.
   The Power Real p.u. value should be equal to $FP$ ±0.01 PU or ±2%.
6. Utilizing either the HMI or IPScom Communications Software disable the Forward Power Block and then enable the Reverse Power Block.
7. Adjust three phase voltage and current inputs to obtain a Power Real p.u. value greater than $RP$.
8. Decrease the applied three phase current until the OUTPUT LED(s) extinguishes.
   The Power Real p.u. value should be equal to $RP$ ±0.01 PU or ±2%.
9. Enable the Reverse Power Block utilizing either the HMI or IPScom Communications Software.

**Lead/Lag VAR Block Test:**

1. Apply a three phase nominal voltage input.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
2. Apply a nominal current input consistent with Figure 6-3, Current Inputs: Configuration C1.
   The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.
NOTE: The POWER Reactive var value can be obtained utilizing either the HMI (Status/Power Status) or IPScom® Communications Software (Relay/Monitor/Secondary Status).

3. Adjust three phase voltage and current inputs to obtain a Power Reactive VAR value greater than –VAR.
   The 27TN/59D 100% STATOR GND LED will illuminate, then the OUTPUT LED will illuminate when the delay setting has timed out.
4. Enable the Lead VAR Block utilizing either the HMI or IPScom® Communications Software.
5. Adjust the applied three phase current phase angles until the OUTPUT LED(s) extinguishes.
   The Power Reactive var value should be equal to –VAR ±0.01 PU or ±2%.
6. Utilizing either the HMI or IPScom® Communications Software disable the Lead VAR Block and then enable the Lag VAR Block.
7. Adjust three phase voltage and current inputs to obtain a Power Reactive var value greater than +VAR.
8. Adjust the applied three phase current phase angles until the OUTPUT LED(s) extinguishes.
   The Power Reactive var value should be equal to +VAR ±0.01 PU or ±2%.
9. Disable the Lag VAR Block utilizing either the HMI or IPScom Communications Software.

Lead/Lag Power Factor Block Test:

1. Apply a three phase nominal voltage input.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
2. Apply a nominal current input consistent with Figure 6-3, Current Inputs: Configuration C1.
   The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.
3. Adjust three phase voltages and currents to obtain a Lead Power Factor Block value greater than PFLead.
   The 27TN/59D 100% STATOR GND LED will illuminate, then the OUTPUT LED will illuminate when the delay setting has timed out.
4. Enable the Power Factor Lead Block utilizing either the HMI or IPScom Communications Software.
5. Adjust three phase voltage phase angles until the OUTPUT LED(s) extinguishes.
   The Power Factor Lead Block value should be equal to PFLead ± 0.03 or ± 3%.
6. Disable the Power Factor Lead Block.
7. Enable the Power Factor Lag Block.
8. Adjust three phase voltages and currents to obtain a Lag Power Factor Block value greater than PFLag.
   The 27TN/59D 100% STATOR GND LED will illuminate, then the OUTPUT LED will illuminate when the delay setting has timed out.
9. Enable the Power Factor Lag Block utilizing either the HMI or IPScom Communications Software.
10. Adjust three phase voltage phase angles until the OUTPUT LED(s) extinguishes.
    The Power Factor Lag Block value should be equal to PFLag ± 0.03 PU or ± 3%.
11. Disable the Power Factor Lag Block.
Forward Power Block (Band) Test:

1. Apply a three phase nominal voltage input.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

2. Apply a nominal current input consistent with Figure 6-3, Current Inputs: Configuration C1.
   The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.

3. Enable the High/Low Band Forward Power Block utilizing either the HMI or IPScom Communications Software.

4. Adjust three phase voltages and currents to obtain a High/Low Forward Power Block value either greater than the Low Band Forward Power Block LFP, or less than the High Band Forward Power Block HFP.
   The 27TN/59D 100% STATOR GND LED will illuminate, then the OUTPUT LED will illuminate when the delay setting has timed out.

5. Adjust the three phase current until the OUTPUT LED(s) extinguishes.
   The Power Real p.u. value should be within the High Band and Low Band setpoint band ±0.1 PU or ±2%.

6. Disable the High/Low Band Forward Power Block.
32 Directional Power, 3 Phase (#1, #2, #3)

**VOLTAGE INPUTS:** Configuration V1

**CURRENT INPUTS:** Configuration C1

**TEST SETTINGS:**
- Pickup: P PU (−3.000 to +3.000)
- Time Delay: D Cycles (1 to 8160)
- Programmed Outputs: Z OUT (1 to 8)
- Expanded I/O: (9 to 23)
- VT Configuration: Line-Ground
- Power Sensing: (Over/Under)
- #3 Directional Power Sensing: (Real/Reactive)

**NOTE:** It would be efficient to disable the element with the lower pickup setting first and test the higher setting operation, since the lower setting operation can be tested without disabling the higher setting.

**Test Setup:**

1. Determine the Function 32 Directional Power settings to be tested.
2. Enter the Function 32 Directional Power settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
6. The level of current at which operation is to be expected for an individual power setting is given by multiplying the PU pickup value (P above) by the Nominal Current value previously input to the relay. The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.
7. Set the three phase voltages to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Pickup Test, Positive/Forward Over Power Flow:**

1. Press and hold the TARGET RESET pushbutton, then slowly increase the three phase currents until the 32 DIRECTIONAL POWER LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   
   The level of operation will be equal to that calculated in Step 6, ±2% or ±0.002 PU, whichever is greater.
2. Release the TARGET RESET pushbutton.
3. Decrease the currents. The OUTPUT LED(s) will extinguish.
4. Press TARGET RESET pushbutton to reset targets.
**Pickup Test, Negative/Reverse Over Power Flow:**

1. Set the phase currents at 180 degrees from the respective phase voltages.
2. Press and hold the **TARGET RESET** pushbutton, then slowly increase the three phase currents until the **32 DIRECTIONAL POWER** LED illuminates, or the pickup indicator illuminates on the IPScom® Function Status screen. The level of operation will be equal to that calculated in Step 6, ±2% or ±0.002 PU, whichever is greater.
3. Release the **TARGET RESET** pushbutton.
4. Decrease the three phase currents. The **OUTPUT** LED(s) will extinguish.
5. Press the **TARGET RESET** pushbutton to reset targets.

**Pickup Test, Positive Forward Under Power Flow:**

1. Set the phase currents in phase with the respective phase voltages.
2. Select Underpower sensing utilizing either the HMI or IPScom Communications Software.
3. Press and hold the **TARGET RESET** pushbutton, then slowly decrease the three phase currents until the **32 DIRECTIONAL POWER** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The level of operation will be equal to that calculated in Step 6, ±2% or ±0.002 PU, whichever is greater.
4. Release the **TARGET RESET** pushbutton.
5. Increase the three phase currents. The **OUTPUT** LED(s) will extinguish.
6. Press the **TARGET RESET** pushbutton to reset targets.

**Pickup Test, Negative/Reverse Under Power Flow:**

1. Set the phase currents at 180 degrees from the respective phase voltages.
2. Press and hold the **TARGET RESET** pushbutton, then slowly decrease the three phase currents until the **32 DIRECTIONAL POWER** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The level of operation will be equal to that calculated in Step 6, ±2% or ±0.002 PU, whichever is greater.
3. Release the **TARGET RESET** pushbutton.
4. Increase the three phase currents. The **OUTPUT** LED(s) will extinguish.
5. Press the **TARGET RESET** pushbutton to reset targets.

**Pickup Test, Reactive Over Power (Element #3 Only):**

1. Set the Three phase voltages, current magnitudes and phase angles to less than the **Reactive p.u.** pickup level.
2. Press and hold the **TARGET RESET** pushbutton, then slowly swing current angles until the **32 DIRECTIONAL POWER** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The level of operation will be equal to the Reactive Pickup ±2% or ±0.002 PU, whichever is greater.
3. Release the **TARGET RESET** pushbutton.
4. Adjust phase angles until the **OUTPUT** LED(s) extinguish.
5. Press the **TARGET RESET** pushbutton to reset targets.
**Pickup Test, Reactive Under Power (Element #3 Only):**

1. Set the Three phase voltages, current magnitudes and phase angles to greater than the Reactive p.u. pickup level.
2. Press and hold the TARGET RESET pushbutton, then slowly swing current angles until the 32 DIRECTIONAL POWER LED illuminates, or the pickup indicator illuminates on the IPScom® Function Status screen. The level of operation will be equal to the Reactive Pickup ±2% or ±0.002 PU, whichever is greater.
3. Release the TARGET RESET pushbutton.
4. Adjust phase angles until the OUTPUT LED(s) extinguish.
5. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately 110% of the pickup current and start timing. The contacts will close after D cycles within +16 cycles or ±1%. 
40 Loss of Field (#1 or #2, VC #1 or #2)

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: Configuration C1
TEST SETTINGS:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Symbol</th>
<th>Units</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circle Diameter</td>
<td>P</td>
<td>Ohms</td>
<td>0.1 to 100</td>
</tr>
<tr>
<td>1 Amp CT Rating</td>
<td></td>
<td></td>
<td>0.5 to 500</td>
</tr>
<tr>
<td>Offset</td>
<td>O</td>
<td>Ohms</td>
<td>–50 to 50</td>
</tr>
<tr>
<td>1 Amp CT Rating</td>
<td></td>
<td></td>
<td>–250 to 250</td>
</tr>
<tr>
<td>Time Delay</td>
<td>D</td>
<td>Cycles</td>
<td>1 to 8160</td>
</tr>
<tr>
<td>Voltage Control</td>
<td>V</td>
<td>Volts</td>
<td>5 to 180</td>
</tr>
<tr>
<td>Delay with VC</td>
<td></td>
<td>Cycles</td>
<td>1 to 8160</td>
</tr>
<tr>
<td>Directional Element</td>
<td>E</td>
<td>Degrees</td>
<td>0 to 20</td>
</tr>
<tr>
<td>Programmed Outputs</td>
<td>Z</td>
<td>OUT</td>
<td>1 to 8</td>
</tr>
<tr>
<td>Expanded I/O</td>
<td></td>
<td></td>
<td>9 to 23</td>
</tr>
<tr>
<td>VT Configuration</td>
<td></td>
<td></td>
<td>Line-Ground</td>
</tr>
</tbody>
</table>

NOTE: It would be efficient to disable the function with the higher “reach” (diameter minus offset) setting first (lower current) and test the lower “reach” setting operation. Since the higher setting operation can be tested without disabling the lower setting, the 40 functions will be enabled when the tests are complete.

Test Setup:

1. Determine the Function 40 Loss of Field settings to be tested.
2. Enter the Function 40 Loss of Field settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

NOTE: For proper testing, use I \geqslant 3 \times CT rating.

6. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define “reach” as \( R \text{ ohms} = (P - O \text{ ohms}) \) where \( O \) is usually negative.
   b. Define “trip current” as \( I = (\text{Selected Voltage} \div R \text{ ohms}) \). The voltage level may be selected based on the desired test current level.
   c. Define “offset current” as \( IO = (\text{Selected Voltage} \div O \text{ ohms}) \).
7. Set the three-phase voltages \( V_A, V_B, \) and \( V_C \) to the Selected Voltage value from Step 6, and set the phase angle between the voltage and current inputs to 90° (current leading voltage).
**Testing – 6**

**Pickup Test:**
1. Press and hold the **TARGET RESET** pushbutton, then slowly increase the three-phase currents until the **40 LOSS OF FIELD** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The level will be equal to “I” calculated in Step 6 with the resulting impedance within ±0.1 ohms or ±5%.
2. If the offset setting is negative, continue to increase the three-phase currents until the **40 LOSS OF FIELD** LED light extinguishes, or the pickup indicator extinguishes on the IPScom® Function Status screen. The level will be equal to “IO” calculated in Step 6 with the resulting offset impedance within ±0.1 ohms or ±5%.
3. Release the **TARGET RESET** pushbutton.
4. Decrease the three-phase currents. The **OUTPUT LED(s)** will extinguish.
5. Press the **TARGET RESET** pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Set the three-phase voltages $V_A$, $V_B$, and $V_C$ to the **Selected Voltage** value from Step 6, and set the phase angle between the voltage and current inputs to $90^\circ$ (current leading voltage).
3. Apply $I + 10\%$ Amps and start timing. Contacts will close after $D$ cycles ±1 cycle or ±1%.

**Time Test With Voltage Control:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Enable the Voltage Control setting utilizing either the HMI or IPScom Communications Software.
3. Set the three-phase voltages $V_A$, $V_B$, and $V_C$ to a voltage where the positive sequence voltage is less than the Voltage Control setting.
4. Set phase currents and phase angles to establish the impedance value within the mho pickup and start timing. Contacts will close after $D$ cycles ±1 cycle or ±1%.
46 Negative Sequence Overcurrent Definite Time

VOLTAGE INPUTS: None
CURRENT INPUTS: Configuration C1 (MODIFIED)
TEST SETTINGS: Pickup Def Time P % (3 to 100)
Time Delay D Cycles (1 to 8160)
Programmed Outputs Z OUT (1 to 8)
Expanded I/O (9 to 23)

■NOTE: Although no voltage input is required for the testing of the 46 function, it is suggested that Nominal Voltage be applied to restrain the functions which use both voltage and current inputs for operation.

Test Setup:
1. Determine the Function 46 Negative Sequence Overcurrent Definite Time settings to be tested.
2. Enter the Function 46 Negative Sequence Overcurrent Definite Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1 (Modified). Modify Configuration C1 by exchanging Current Input 2 and 3 (Phase B current = Input 3 and Phase C current = Input 2).

■NOTE: For proper testing, use $I \leq 3 \times CT$ rating.

5. The level of current at which operation is to be expected for an individual setting is given by; Pickup current = ($P\% / 100$) x Nominal Current previously input to the relay. The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly increase the three-phase currents until the NEG SEQ OVERCURRENT 46 LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The level will be equal to pickup current calculated in Step 5, $\pm 0.5\%$ of 5 A.
2. Release the TARGET RESET pushbutton.
3. Decrease the three-phase currents. The OUTPUT LED(s) will extinguish.
4. Press TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply current of at least ($1.1 \times$ pickup) amps and start timing. The contacts will close after D cycles within $\pm 1$ cycle or $\pm 1\%$. 
Testing – 6

46 Negative Sequence Overcurrent Inverse Time

VOLTAGE INPUTS: None
CURRENT INPUTS: Configuration C1 (MODIFIED)
TEST SETTINGS:
- Pickup Inv Time: \( P \) \%
- Time Dial Setting: \( K \)
- Maximum Trip Time: \( D \) Cycles
- Reset Time: \( R \) Seconds
- Programmed Outputs: \( Z \) OUT
- Expanded I/O: (9 to 23)

**NOTE:** Although no voltage input is required for the testing of the 46 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation.

**Test Setup:**

1. Determine the Function 46 Negative Sequence Overcurrent Inverse Time settings to be tested.
2. Enter the Function 46 Negative Sequence Overcurrent Inverse Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1 (Modified). Modify Configuration C1 by exchanging Current Input 2 and 3 (Phase B current = Input 3 and Phase C current = Input 2).

**NOTE:** For proper testing, use \( I \leq 3 \times CT \) rating.

5. The current pickup level at a percentage setting is: Pickup current = \( \left( \frac{P\%}{100} \right) \times \text{Nominal Current} \) previously input to the relay.
   a. Test levels may be chosen at any percentages of Nominal Current which are a minimum of 5% higher than the pickup percentage, \( P\% \). (Suggest 4 or 5 test levels chosen and calculated in amps.)
   b. The Nominal Current value is described in Section 2.1, Configuration and should be recorded on Figure A-3, Functional Configuration Record Form.

**Time Test:**

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply currents equal to the chosen test levels calculated in Step 5 and start timing. The operating time will be as read from Figure 2-31, Negative Sequence Inverse Time Curves, negative sequence current in % of Nominal Current and appropriate \( K \) (Time Dial) setting, or the maximum trip time (whichever is faster).

**NOTE:** If retesting is required, power should be removed from the unit or wait \( R \) seconds before the next test to assure resetting of the timer.

3. Repeat Step 2 for all test levels chosen.

**Reset Time Test:**

1. Press and hold the TARGET RESET pushbutton.
2. Reduce the applied voltage and start timing when the voltage decreases to less than the pickup value, stop timing when the TARGET LED extinguishes, or the pickup indicator extinguishes on the IPSCom Function Status screen. The time should be approximately equal to the reset time setting \( R \).

**NOTE:** If retesting is required, power should be removed from the unit or wait for the reset time before the next test to assure resetting of the timer.
**49 Stator Overload Protection (#1, #2)**

**VOLTAGE INPUTS:** None  
**CURRENT INPUTS:** Configuration C1  
**TEST SETTINGS:**  
- Time Constant $\tau$ Minutes (1.0 to 999.9)  
- Max Overload Current $I_{\text{max}}$ Amps (1 to 10)  
- 1 Amp CT Rating (.2 to 2)  
- Programmed Outputs $Z$ OUT (1 to 8)  
- Expanded I/O (9 to 23)

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

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

**Pickup Test:**
1. Press and hold the **TARGET RESET** pushbutton, then slowly increase the current until the **STATOR OVERLOAD 49** LED illuminates or the pickup indicator illuminates on the IPScom Function Status screen. The current level of operation will be $(I_{\text{max}})$ Amps $\pm 0.1$ A ($\pm 0.02$ Amp for 1 A CT) or $\pm 3\%$.
2. Release the **TARGET RESET** pushbutton, then decrease the current. The **OUTPUT** LED will extinguish.
3. Press **TARGET RESET** button to remove targets.
**Time Test (Cold Start):**

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

**NOTE:** The 49 Stator Overload 49 #1 and 49 #2 current values can be obtained utilizing either the HMI (Status/Current Status) or IPScom® Communications Software (Relay/Monitor/Secondary Status).

2. Determine the 49 Stator Overload 49 #1 and 49 #2 current values. If the either value is greater than 0.00 A, then remove power from the relay and then reapply power to reset the current values.

3. Apply a three phase current (I) to the relay greater than \( I_{\text{max}} \) Amps and start timing.
   The time to trip should be \( t \) minutes ± 5 %.

---

**Time Test (Preload):**

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

**NOTE:** The 49 Stator Overload 49 #1 and 49 #2 current values can be obtained utilizing either the HMI (Status/Current Status) or IPScom Communications Software (Relay/Monitor/Secondary Status).

2. Determine the 49 Stator Overload 49 #1 and 49 #2 current values. If the either value is greater than 0.00 A, then remove power from the relay and then reapply power to reset the current values.

3. Apply a three phase preload current to the relay equal to \( I_{o} \) Amps and allow current readings to stabilize.

4. Apply a three phase current (I) to the relay greater than \( I_{\text{max}} \) Amps and start timing.
   The time to trip should be \( t \) minutes ± 5 %.
50 Instantaneous Phase Overcurrent (#1, #2)

VOLTAGE INPUTS: None
CURRENT INPUTS: Configuration C1
TEST SETTINGS:

- Pickup P Amps (0.1 to 240.0)
- 1 Amp CT Rating (0.1 to 48.0)
- Delay Cycles (1 to 8160)
- Programmed Outputs Z OUT (1 to 8)
  Expanded I/O (9 to 23)

Note: Although no voltage input is required for the testing of the 50 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation.

Test Setup:
1. Determine the Function 50 Instantaneous Phase Overcurrent settings to be tested.
2. Enter the Function 50 Instantaneous Phase Overcurrent settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly increase Current Input 3 (Phase C) until the PHASE OVERCURRENT 50 LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The current level of operation will be (P) amps ±0.1 amps or ±3%.
2. Release the TARGET RESET pushbutton.
3. Decrease the current input. The OUTPUT LED(s) will extinguish.
4. Press the TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately 110% of P amps and start timing. The operating time will be ±1 cycle or 1%.
3. Reduce Current Input 3, to 0 amps.
4. Test may be repeated using Current Inputs 1 (Phase A) and 2 (Phase B) individually.
50BF/50BF-N Breaker Failure

VOLTAGE INPUTS: None
CURRENT INPUTS: Configuration C3
TEST SETTINGS:
- 50BF-Ph Pickup P Amps (0.10 to 10.00)
- 1 Amp CT Rating (0.02 to 2.00)
- 50BF-N Pickup N Amps (0.10 to 10.00)
- 1 Amp CT Rating (.02 to 2.00)
- Time Delay D Cycles (1 to 8160)
- Breaker Failure Initiate B OUT (1 to 8)
- Input Initiate I IN (1 to 6)
- Expanded I/O (7 to 14)
- Programmed Outputs Z OUT (1 to 8)
- Expanded I/O (9 to 23)

Test Setup:
1. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
2. Connect test current inputs as shown in Figure 6-5, Current Inputs: Configuration C3. Current Input #2 only.

Test Setup for 50BF-Ph Generator Breaker Failure Operation:
1. Determine the Function 50BF-Ph Generator Breaker Failure settings to be tested.
2. Utilizing either the HMI or IPScom® Communications Software enter the following settings:
   a. Enable the 50BF-Phase Element and disable the 50BF-Neutral Element
   b. 50BF-Ph Pickup Setting > P amps, Time delay setting = D cycles.

Testing 50BF-Ph Generator Breaker Failure Operation:
1. Externally short any ONE set of contacts (I) IN shown above.
2. Short IN1 (connect contacts 10 & 11) to simulate 52b contact closure (breaker open). Alternatively, the external contact may be operated if all connections are made.
3. Press and hold the TARGET RESET pushbutton, then slowly increase Current Input 3 until the 50BF BREAKER FAILURE LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The current level of operation will be (P) amps ±0.1 amps or ±2%.
4. Release the TARGET RESET pushbutton.
5. Decrease the current input. The OUTPUT LED(s) extinguish.
6. Press the TARGET RESET pushbutton to reset targets.

Time Test 50BF-Ph Generator Breaker Failure Operation:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately 110% of P amps and start timing. The operating time will be D cycles within ±1 cycle or ±1%.
3. Reduce Current Input 3, to 0 amps.
Test Setup for 50BF-N Generator Breaker Failure Operation:

1. Determine the Function 50BF-Ph Generator Breaker Failure settings to be tested.
2. Utilizing either the HMI or IPScom© Communications Software enter the following settings:
   a. Enable the 50BF-Neutral Element and the 50BF-Phase Element
   b. 50BF-N Pickup Setting > \(N\) amps, 50BF-Ph Pickup Setting < \(P\) amps, Time delay setting = \(D\) cycles.

Testing 50BF-N Generator Breaker Failure Operation:

1. Short IN1 (connect contacts 10 & 11) to simulate 52b contact closure (breaker open).
3. Press and hold the TARGET RESET pushbutton, then slowly increase Current Input 3 until the 50BF BREAKER FAILURE LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The current level of operation will be \((N)\) amps ±0.1 amps or ±2%.
4. Release the TARGET RESET pushbutton.
5. Decrease the current input. The OUTPUT LED(s) extinguish.
6. Press the TARGET RESET pushbutton to reset targets.

Time Test 50BF-N Generator Breaker Failure Operation:

1. Connect a timer to output contacts \((Z)\) so that the timer stops timing when the contacts \((Z)\) close.
2. Apply approximately 110% of \(N\) amps and start timing. The operating time will be \(D\) cycles within ±1 cycle or ±1%.
3. Reduce Current Input 3, to 0 amps.

Test Setup for HV Breaker Failure Operation:

1. Utilizing either the HMI or IPScom Communications Software enter the following settings:
   a. Disable the 50BF-Neutral Element and 50BF-Phase Element.
   b. Select 1 input initiate from #2 to #6, utilizing either the HMI or IPScom Communications Software.
   c. Time delay setting = \(D\) cycles
   d. Input 1 IN breaker closed state.

Testing HV Breaker Failure Operation:

1. Connect a timer to output contacts \((Z)\) so that the timer stops timing when the contacts \((Z)\) close.
2. Initiate operation by externally shorting any ONE set of contacts \((I)\) IN except Input 1 above. Remove short from Input \((1)\) IN. The operating time will be \(D\) cycles within ±1 cycle or ±1%.
50/27 Inadvertent Energizing

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: Configuration C1

TEST SETTINGS:
- 50 Pickup P Amps (0.50 to 15.00)
- 1 Amp CT Rating (0.01 to 3.00)
- 27 Pickup V Volts (5 to 130)
- Pickup Delay D Cycles (1 to 8160)
- Dropout Delay T Cycles (1 to 8160)
- Programmed Outputs Z OUT (1 to 8)
- Expanded I/O (9 to 23)

Test Setup:
1. Determine the Function 50/27 Inadvertent Energizing settings to be tested.
2. Enter the Function 50/27 Inadvertent Energizing settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.

50 Overcurrent Test and 27 Undervoltage Test:
1. Set Voltage inputs to zero volts, then verify the Pickup Time Delay times out after a minimum of D cycles.
2. Press and hold the TARGET RESET pushbutton, then slowly increase the Phase A current (Input 1) until the 50/27 INADVERTENT ENRGNG LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The level of operation will be (P) amps ±0.1 A or ±2%.
3. If desired, set the dropout time delay (T) to minimum setting.
4. Press and hold the TARGET RESET pushbutton, then slowly increase the voltage input in stages (waiting at least T cycles between each voltage change) until the 50/27 INADVERTENT ENRGNG LED extinguishes, or the pickup indicator extinguishes on the IPScom Function Status screen.
   The level of operation will be V volts ±0.5 Volts.

27 Pickup Delay and Dropout Delay Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Input approximately 110% of P amps (pickup setting).
3. Reduce voltage to 20% below D setting and start timing. The operating time to close will be D cycles within ± 1 cycle or ± 1%.
4. Input approximately 110% of V volts (pickup setting) and start timing. The operating time to open will be T cycles within ± 1 cycle or ± 1%.

NOTE: When RMS (total waveform) is selected, timing accuracy is ≤ 20 cycles or ±1%.
50DT Definite Time Overcurrent (for split-phase differential), #1 or #2

**VOLTAGE INPUTS:** None

**CURRENT INPUTS:** Configuration C2

**TEST SETTINGS:**
- **Pickup A Phase**
  - A Amps
  - 1 Amp CT Rating
    - (0.20 to 240.00)
    - (0.04 to 48.00)
- **Pickup B Phase**
  - B Amps
  - 1 Amp CT Rating
    - (0.20 to 240.00)
    - (0.04 to 48.00)
- **Pickup C Phase**
  - C Amps
  - 1 Amp CT Rating
    - (0.20 to 240.00)
    - (0.04 to 48.00)
- **Delay**
  - Cycles
    - (1 to 8160)
- **Programmed Outputs**
  - Z OUT
    - (1 to 8)
  - Expanded I/O
    - (9 to 23)

**NOTE:** Although no voltage input is required for the testing of the 50DT function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they will need to also be disabled for the test and enabled after the tests are complete.

**Test Setup:**
1. Determine the Function 50DT Definite Time Overcurrent settings to be tested.
2. Enter the Function 50DT Definite Time Overcurrent settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable the functions listed above. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-4, Current Inputs: Configuration C2.
5. Set the three-phase voltages $V_A$, $V_B$, and $V_C$ to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Pickup Test:**
1. Press and hold the TARGET RESET pushbutton, then slowly increase the Phase A Current Input until the PHASE OVERCURRENT 50 LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   - The current level of operation will be (A) amps ±0.1 amps or ±3%.
2. Release the TARGET RESET pushbutton.
3. Decrease the Phase A Current Input. The OUTPUT LED(s) will extinguish.
4. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply approximately 110% of A amps and start timing. The operating time will be ±1 cycle or ±1%, whichever is greater.
3. Reduce Phase A Current Input to 0 amps.
4. Repeat Steps 2 and 3 for Phase B & C.
5. If testing is complete, enable any functions disabled for this test.
### 50N Instantaneous Neutral Overcurrent

**VOLTAGE INPUTS:** None

**CURRENT INPUTS:** As described

**TEST SETTINGS:**
- Pickup \( P \) Amps \( (0.1 \text{ to } 240.0) \)
- 1 Amp CT Rating \( (0.1 \text{ to } 48.0) \)
- Time Delay \( D \) Cycles \( (1 \text{ to } 8160) \)
- Programmed Outputs \( Z \) OUT \( (1 \text{ to } 8) \)
- Expanded I/O \( (9 \text{ to } 23) \)

**NOTE:** Although no voltage input is required for the testing of the 50N function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation.

**Test Setup:**

1. Determine the Function 50N Instantaneous Neutral Overcurrent settings to be tested.
2. Enter the Function 50N Instantaneous Neutral Overcurrent settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.

**Pickup Test:**

1. Press and hold the TARGET RESET pushbutton, then slowly increase Current Input \( I_n \) (terminals 53 and 52) until the NEUTRAL O/C 50N/51N LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   
   The current level of operation will be \( (P) \) amps ±0.1 amps or ±3%.

2. Release the TARGET RESET pushbutton.

3. Decrease Current Input \( I_n \). The OUTPUT LED(s) will extinguish.

4. Press the TARGET RESET pushbutton to reset targets.

**Time Test:**

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

2. Apply approximately 110% of \( P \) amps to Current Input \( I_n \) (terminals 53 and 52) and start timing. The operating time will be \( D \) cycles ±1 Cycle or ±1%.

3. Reduce Current Input \( I_n \) to 0 amps.
51N Inverse Time Neutral Overcurrent

VOLTAGE INPUTS: None
CURRENT INPUTS: As described
TEST SETTINGS:
- Pickup P Amps (0.25 to 12.00)
- 1 Amp CT Rating (0.05 to 2.40)
- BECO Time Curves
  - (definite time/inverse/very inverse/extremely inverse)
- Time Dial Setting K (0.5 to 11.0)
- IEC Inverse Time Curves:
  - (inverse/very inverse/extremely inverse/long time inverse)
- IEE Curves
  - (moderately inverse/very inverse/extremely inverse)
- Time Dial Setting K (0.5 to 15.0)
- Programmed Outputs Z OUT (1 to 8)
- Expanded I/O

^ Either a standard curve or an IEC curve must be selected.

NOTE: Although no voltage input is required for the testing of the 51N function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation.

Test Setup:
1. Determine the Function 51N Inverse Time Neutral Overcurrent settings to be tested.
2. Enter the Function 51N Inverse Time Neutral Overcurrent settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Refer to Appendix D, Figures D5–D12, or Tables D-1A and D-1B. Test levels may be chosen in terms of multiples of pickup value and associated time in seconds. (Suggest 4 or 5 test levels chosen and calculated in amps.)

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply current equal to the chosen test level calculated in Step 6 to Current Input (Terminals 53 and 52) and start timing.
   Operating time will be within ±3 cycles or ±3% whichever is greater.
3. Repeat Steps 2 and 3 for all test levels chosen. The tested points verify the operating times of the function.
**51V Inverse Time Phase Overcurrent with Voltage Control/Restraint**

<table>
<thead>
<tr>
<th>VOLTAGE INPUTS:</th>
<th>Configuration V1</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURRENT INPUTS:</td>
<td>Configuration C1</td>
</tr>
<tr>
<td>TEST SETTINGS:</td>
<td></td>
</tr>
<tr>
<td>Pickup</td>
<td>P Amps</td>
</tr>
<tr>
<td>1 Amp CT Rating</td>
<td>(0.10 to 2.40)</td>
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<tr>
<td>BECO Time Curves</td>
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<tr>
<td>(definite time/inverse/very inverse/extremely inverse)</td>
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</tr>
<tr>
<td>Time Dial Setting</td>
<td>K</td>
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<tr>
<td>IEC Inverse Time Curves:¹</td>
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<tr>
<td>(inverse/very inverse/extremely inverse/long time inverse)</td>
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<tr>
<td>IEE Curves</td>
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<tr>
<td>(moderately inverse/very inverse/extremely inverse)</td>
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<tr>
<td>Time Dial Setting</td>
<td>K</td>
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<tr>
<td>Programmed Outputs</td>
<td>Z OUT</td>
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<td></td>
<td>Expanded I/O</td>
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<td></td>
<td>(1 to 8)</td>
</tr>
<tr>
<td></td>
<td>(9 to 23)</td>
</tr>
</tbody>
</table>

¹ Either a standard curve or an IEC curve must be selected.

**Test Setup:**
1. Determine the Function 51V Inverse Time Phase Overcurrent settings to be tested.
2. Enter the Function 51V Inverse Time Phase Overcurrent settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1
6. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P Amps**. It is suggested that the user select 4 or 5 test levels to verify curve.

**Pickup Test:**
1. If Voltage Control or Voltage Restraint is enabled, then disable 51V Voltage Control/Restraint utilizing either the HMI or IPScom Communications Software.
2. Press and hold the **TARGET RESET** pushbutton, then slowly increase the Phase A Current Input until the **PHASE OVERCURRENT 51V** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.

The current level of operation will equal **P Amps ±0.1A** or **±1%**.
3. Release the **TARGET RESET** pushbutton.
4. Reduce the Phase A Current Input to 0 amps. The assigned **OUTPUT** LED(s) will extinguish.
5. Press the **TARGET RESET** pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts **(Z)** so that the timer stops timing when the contacts **(Z)** close.
2. If Voltage Control or Voltage Restraint is enabled, then disable 51V Voltage Control/Restraint utilizing either the HMI or IPScom Communications Software.
3. Apply current equal to the chosen test level calculated in Step 6 to Phase A Current Input and start timing. The operating time will be as read from the appropriate Inverse Curve Family and \( K \) (Time Dial) setting in Appendix D, Figures D-5 through D-8, or Tables D-1A through D-1B. The accuracy specified is valid for currents above 1.5 times the pickup current.

4. Reduce Phase A Current Input to 0 amps. The **OUTPUT** LED(s) will extinguish.

5. Press the **TARGET RESET** pushbutton to reset targets.

6. Repeat Steps 3, 4 and 5 for all test levels chosen.

**Voltage Control Test:**

1. If Voltage Control is disabled, then enable 51V Voltage Control utilizing either the HMI or IPScom® Communications Software.

2. Press and hold the **TARGET RESET** pushbutton, then slowly increase the Phase A (B,C) Current Input until the **PHASE OVERCURRENT 51V** LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.

3. Release the **TARGET RESET** pushbutton.

4. When the assigned **OUTPUT** LED(s) illuminates, then increase the Phase A(B,C) Input Voltage to at least 0.5 Volts greater than \( V \) Volts.

   The assigned **OUTPUT** LED(s) will extinguish at \( V \) Volts ±0.5 V or ±0.5%.

5. Press the **TARGET RESET** pushbutton to reset targets.

6. Reduce Phase A (B,C) Current Input to 0 amps.

7. Decrease the Phase A (B,C) Input Voltage to **Nominal Voltage**.

   The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Voltage Restraint Test:**

1. If Voltage Restraint is disabled, then enable 51V Voltage Restraint utilizing either the HMI or IPScom Communications Software.

2. Set **P Amps** equal to 2 Amps utilizing either the HMI or IPScom Communications Software.

3. Apply current equal to 1.5 Amps to the Phase Current Input.

4. Increase the Phase A (B,C) Input Voltage to 75% of **Nominal Voltage**. The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

   The **PHASE OVERCURRENT 51V** LED will illuminate, or the pickup indicator illuminates on the IPScom Function Status screen.

5. Repeat Steps 2, 3 and 4 with reduced input voltage values and current reduced by the same percentage as value (see Figure 2-44).
59 Phase Overvoltage, 3-Phase (#1, #2, #3)

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: None
TEST SETTINGS:
- Pickup
- Time Delay
- Input Voltage Select
- Programmed Outputs
- Expanded I/O

NOTE: If 59 #1 and 59 #2 have different pickup settings, it would be efficient to disable the one with the lower setting first and test the higher setting operation. The lower setting operation could then be tested without disabling the higher setting.

Test Setup:
1. Determine the Function 59 RMS Overvoltage settings to be tested.
2. Enter the Function 59 RMS Overvoltage settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Set the three-phase voltages V_A, V_B, and V_C to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly increase the Phase A Voltage Input until the 59 PHASE OVERVOLTAGE LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen. The voltage level of operation should be equal to P Volts ±0.5 V or ±0.5%. When both RMS and Line-Ground to Line-Line is selected, the accuracy is ±0.8V or ±0.75%
2. Release the TARGET RESET pushbutton.
3. Decrease the Phase A Voltage Input to Nominal Voltage. The OUTPUT LED(s) will extinguish.
4. Press the TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply (P+1) Volts to the Phase A (B,C) Voltage Input and start timing. The contacts will close after D cycles ±1 cycle or ±1% (DFT) or within ±20 cycles or ±1% (RMS).
3. Reduce Phase A (B,C) Voltage Input to Nominal Voltage.
4. Repeat Steps 2 and 3 for Phase B & C.
59D Third-Harmonic Voltage Differential

VOLTAGE INPUTS: As described
CURRENT INPUTS: None
TEST SETTINGS:
- Ratio (0.1 to 5.0)
- Time Delay *D* Cycles (1 to 8160)
- Line Side Voltage LSV (*V*<sub>X</sub> or 3*V*<sub>0</sub> Calculated)
- Programmed Outputs Z*<sub>OUT</sub> (1 to 8)
- Expanded I/O (9 to 23)

Test Setup:
1. Determine the Function 59D Third-Harmonic Voltage Differential settings to be tested.
2. Enter the Function 59D Third-Harmonic Voltage Differential settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect a voltage input to *V*<sub>N</sub> at 180 Hz (150 Hz for 50 Hz unit) terminal numbers 44 and 45.

Pickup Test:
- **NOTE:** If 3*V*<sub>0</sub> is being used, then use anyone of the phase voltages or all three at zero sequence.
  1. Apply a voltage less than *V*<sub>N</sub> to the selected line side voltage (*V*<sub>X</sub> or 3*V*<sub>0</sub>) at 180 Hz (150 Hz for 50 Hz unit).
  2. Press and hold the TARGET RESET pushbutton, then slowly increase Voltage to the selected line side input (*V*<sub>X</sub> or 3*V*<sub>0</sub>) until the 59D THIRD HARM VOLT DIFF LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
  3. Release the TARGET RESET pushbutton.
  4. Decrease the Voltage Input (*V*<sub>X</sub> or 3*V*<sub>0</sub>) to less than the ratio pickup level. The OUTPUT LED(s) will extinguish.
  5. Press the TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply a voltage greater than the ratio pickup level and start timing. The contacts will close after *D* cycles within ±1 cycle or ±1%.
- **NOTE:** When RMS (total waveform) is selected, timing accuracy is ±20 cycles or ±1%.
## 59N Overvoltage, Neutral Circuit or Zero Sequence (#1, #2, #3)

**VOLTAGE INPUTS:**  As described

**CURRENT INPUTS:**  None

**TEST SETTINGS:**
- Pickup  \( P \) Volts  (5.0 to 180)
- Time Delay  \( D \) Cycles  (1 to 8160)
- Programmed Outputs  \( Z \) OUT  (1 to 8)
  - Expanded I/O  (9 to 23)

**NOTE:** If 59N #1 and 59N #2 have different pickup settings, it would be efficient to disable the one with the lower setting first and test the higher setting operation. The lower setting operation could then be tested without disabling the higher setting.

### Test Setup:
1. Determine the Function 59N RMS Overvoltage settings to be tested.
2. Enter the Function 59N RMS Overvoltage settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect a voltage input to \( V_n \) terminal numbers 44 and 45.

### Pickup Test:
1. Press and hold the **TARGET RESET** pushbutton, then slowly increase Voltage Input \( V_n \) until the 59N NEUT/GND OVERVOLT LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The voltage level of operation should be equal to \( P \) Volts \( \pm 0.5 \) V or \( \pm 0.5\% \).
2. Release the **TARGET RESET** pushbutton.
3. Decrease the Voltage Input \( V_n \) to 0 volts. The **OUTPUT** LED(s) will extinguish.
4. Press the **TARGET RESET** pushbutton to reset targets.

### Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply \( (P+1) \) Volts and start timing. The contacts will close after \( D \) cycles within \( \pm 1 \) cycle or \( \pm 1\% \). When 64S is purchased, the time delay accuracy is \( -1 \) to \( +5 \) cycles.
59X Multi-purpose Overvoltage (#1 or #2)

VOLTAGE INPUTS: As described
CURRENT INPUTS: None
TEST SETTINGS:
- Pickup: P____Volts (5.0 to 180.0)
- Time Delay: D____Cycles (1 to 8160)
- Programmed Outputs: Z____OUT (1 to 8)
  Expanded I/O: (9 to 23)

NOTE: If 59X #1 and 59X #2 have different pickup settings, it would be efficient to disable the one with the lower setting first and test the higher setting operation. The lower setting operation could then be tested without disabling the higher setting.

Test Setup:
1. Determine the Function 59X Overvoltage settings to be tested.
2. Enter the Function 59X Overvoltage settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect a voltage input to V_x terminal numbers 64 and 65.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly increase Voltage Input V_x until the 59N NEUT/GND OVERVOLT LED illuminates, or the pickup indicator illuminates on the IPScom Function Status screen.
   The voltage level of operation should be equal to P Volts ±0.5 V or ±0.5%.
2. Release the TARGET RESET pushbutton.
3. Decrease the Voltage Input V_x to 0 volts. The OUTPUT LED(s) will extinguish.
4. Press the TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply (P+1) Volts and start timing. The contacts will close after D cycles within ±1 cycle or ±1%.
**60FL VT Fuse Loss Detection**

| VOLTAGE INPUTS: | Configuration V1 |
| CURRENT INPUTS: | Configuration C1 |
| TEST SETTINGS: | Time Delay D____Cycles (1 to 8160) |
| | Programmed Outputs Z____OUT (1 to 8) |
| | Expanded I/O (9 to 23) |

**NOTE:** It is necessary for “FL” to be designated as an initiating input (see Section 2.3, Setpoints and Time Settings) before this function can be tested.

**NOTE:** Refer to Figure 2-52, Fuse Loss (60FL) Function Logic, for single phase and three phase fuse loss.

**Test Setup:**

1. Determine the Function 60FL VT Fuse Loss Detection settings to be tested.
2. Enter the Function 60FL VT Fuse Loss Detection settings to be tested utilizing either the HMI or IPScom® Communications Software. (FL initiate must be selected for this test.)
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Connect test current inputs as shown in Figure 6-3, Current Inputs: Configuration C1.
6. Set the three-phase voltages V_A, V_B, and V_C to the Nominal Voltage. The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Time Test:**

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Disconnect the Phase A (B,C) Voltage Input and start timing. The 60FL V.T. FUSE LOSS LED and Output Z LEDs will illuminate, or the pickup indicator illuminates on the IPScom Function Status screen.
   The operating time will be D cycles within ±1 cycle or ±1%.
3. Reconnect the Phase A (B,C) Voltage Input.
4. Press the TARGET RESET pushbutton to reset targets.
5. Repeat Steps 2, 3 and 4 for Phase B and C.

**Time Test - Three Phase Fuse Loss:**

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Enable Three Phase Fuse Loss Detection utilizing either the HMI or IPScom Communications Software.
3. Disconnect Phase A, B and C Voltage Inputs and start timing. The 60FL V.T. FUSE LOSS LED and Output Z LEDs will illuminate, or the pickup indicator illuminates on the IPScom Function Status screen. The operating time will be D cycles within ±1 cycle or ±1%.
4. Reconnect the Phase A, B and C Voltage Inputs.
5. Press the TARGET RESET pushbutton to reset targets.
64F Field Ground Protection (#1 or #2)

VOLTAGE INPUTS: None
CURRENT INPUTS: None
TEST SETTINGS:
- Pickup \( P \) kOhms \( (5 \text{ to } 100) \)
- Time Delay \( D \) Cycles \( (1 \text{ to } 8160) \)
- Injection Frequency \( IF \) Hz \( (0.10 \text{ to } 1.00) \)
- Programmed Outputs: \( Z \) \( \text{OUT} \) (1 to 8)
  Expanded I/O (9 to 23)

Test Setup:
1. Determine the Function 64F Field Ground Protection settings to be tested.
2. Enter the Function 64F Field Ground Protection settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect an M-3921 Field Ground Coupler and decade box as described in Figure 6-7, Field Ground Coupler.
5. Set decade box resistance to 10% greater than pickup \( P \) kOhms.

Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly decrease the resistance on the decade box until the FIELD GND/BRUSH LIFT 64F/B LED illuminates or the pickup indicator on the IPScom Function Status screen illuminates.
   The level of operation will be \( P \) kOhms ±1 kOhms or ±10%.
2. Release the TARGET RESET pushbutton.
3. Increase the resistance on the decade box. The OUTPUT LED(s) will extinguish.
4. Press the TARGET RESET pushbutton to reset targets.

Time Test:
1. Connect a timer to output contacts \( Z \) so that the timer stops timing when the contacts \( Z \) close.
2. Set the resistance on the decade box to 90% of \( P \) and start timing. The operating time will be after \( D \) cycles, within ±(2/\( IF \) + 1).
When the capacitance value and the operating frequency have been determined, the actual insulation resistance can be verified by installing a variable resistor (5 to 100 KΩ) and a discrete capacitor to the coupler module (M-3921).

**WARNING:** When auto-calibrating, the jumper used to short pins 2 & 3 **must** be removed when calibration is complete. Placing the M-3921 in service with this jumper installed will result in serious damage.

*The value of Cf should approximate the rotor capacitance.*

*Figure 6-7  Field Ground Coupler*
**64B Brush Lift-Off Detection**

**VOLTAGE INPUTS:** None

**CURRENT INPUTS:** None

**TEST SETTINGS:**

- Pickup \( P \) mV (0 to 5000)
- Time Delay \( D \) Cycles (1 to 8160)
- Injection Frequency \( IF \) Hz (0.10 to 1.00)
- Programmed Outputs \( Z \) OUT (1 to 8)
  - Expanded I/O (9 to 23)

**Test Setup:**

1. Determine the Function 64F Field Ground Protection settings to be tested.
2. Enter the Function 64F Field Ground Protection settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect a M-3921 Field Ground Coupler and the test equipment described in Figure 6-7, Field Ground Coupler.
5. Set \( R_f \) to open (infinity) and \( C_f \) to 1 \( \mu \)F.

**Pickup Test:**

1. Access the **FIELD GND MEAS. CIRCUIT** display under the **VOLTAGE** menu in **STATUS**. Set the pickup \( P \) to 110% of the displayed value. Refer to Section 3.3, Status/Metering, for details that describe how to access the **STATUS MENU** which contains the **FIELD GND MEAS. CIRCUIT** value in mV.
2. Press and hold the **TARGET RESET** pushbutton, then Open the Test Switch. The **FIELD GND/BRUSH LIFT 64F/B** LED will illuminate or the pickup indicator on the IPScom Function Status screen will illuminate.
3. Close the Test Switch. The **FIELD GND/BRUSH LIFT 64F/B** LED will extinguish or the pickup indicator on the IPScom Function Status screen will extinguish.

**Time Test:**

1. Connect a timer to output contacts \( Z \) so that the timer stops timing when the contacts \( Z \) close.
2. Remove the capacitance connected to the decade box and start timing. The operating time will be after \( D \) cycles, within \( \pm (2/IF + 1) \) sec.
64S 100% Stator Ground Protection by Low Frequency Injection

VOLTAGE INPUTS: Adjustable 20 Hz Voltage Source (0 to 40 V)
CURRENT INPUTS: Adjustable 20 Hz Current Source (0 to 100 mA)
TEST SETTINGS:
- Total Current Pickup \( P \) mA (2 to 75)
- Real Component Pickup \( P/2 \) mA (2 to 75)
- Time Delay \( D \) Cycles (1 to 8160)
- Voltage Restraint (Enabled/Disabled)
- Under Frequency Inhibit (Enabled/Disabled)
- Programmed Outputs \( Z \) OUT (1 to 8)
- Expanded I/O (9 to 23)

Test Setup:
1. Determine settings for F64S to be tested.
2. Enter the settings for F64S into the relay to be tested using either the HMI or IPScom Communications software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.

Pickup Test (Voltage Restraint Disabled and Under Frequency Inhibit Disabled):
1. Enable the Total Current Pickup.
2. Disable the Real Component of Current Pickup.
3. Adjust the 20 Hz voltage generator to apply 25 \( 0^\circ \) volts across terminals 44 and 45.
4. Press and hold the TARGET RESET pushbutton in, then slowly increase the 20 Hz current applied to terminals 52 and 53 until the 27TN/59D/64S STATOR GND LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.
   The 20 Hz current level should be equal to \( P \) mA ± 2 mA or ±10%.
5. Release the TARGET RESET pushbutton.
6. Disable the Total Current Pickup.
7. Enable the Real Component of Current Pickup.
8. Adjust the 20 Hz Voltage Generator to apply 25 \( 0^\circ \) Volts across terminals 44 and 45.
9. Press and hold the TARGET RESET pushbutton in, then slowly increase the 20 Hz current at an angle of 60 degrees leading the 20 Hz voltage applied to terminals 52 and 53 until the 27TN/59D/64S STATOR GND LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.
   The 20 Hz current level should be equal to \( P \) mA ± 2 mA or ±10%.
10. Release the TARGET RESET pushbutton.
11. Decrease the applied 20 Hz current to 0 mA and the applied 20 Hz voltage to 0 Volts.
**Pickup Test (Voltage Restraint Enabled and Under Frequency Inhibit Disabled):**

1. Enable the Total Current Pickup.
2. Disable the Real Component of Current Pickup.
3. Adjust the 20 Hz voltage generator to apply 25 \(0^\circ\) volts across terminals 44 and 45.
4. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current applied to terminals 52 and 53 until the **27TN/59D/64S STATOR GND** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The 20 Hz current level should be equal to \(P\) mA \(\pm 2\) mA or \(\pm 10\%\).

5. Release the **TARGET RESET** pushbutton.
6. Adjust the 20 Hz Voltage Generator to apply 35 \(0^\circ\) Volts across terminals 44 and 45.
7. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current at an angle of 60 degrees leading the 20 Hz voltage applied to terminals 52 and 53 until the **27TN/59D/64S STATOR GND** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The 20 Hz current level should be equal to \(1.4\) \(P\) mA \(\pm 2\) mA or \(\pm 10\%\).

8. Release the **TARGET RESET** pushbutton.
11. Adjust the 20 Hz voltage generator to apply 25 \(0^\circ\) volts across terminals 44 and 45.
12. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current at an angle of 60 degrees leading the 20 Hz voltage applied to terminals 52 and 53 until the **27TN/59D/64S STATOR GND** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The 20 Hz current level should be equal to \(P\) mA \(\pm 2\) mA or \(\pm 10\%\).

13. Release the **TARGET RESET** pushbutton.
14. Adjust the 20 Hz Voltage Generator to apply 35 \(0^\circ\) Volts across terminals 44 and 45.
15. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current at an angle of 60 degrees leading the 20 Hz voltage applied to terminals 52 and 53 until the **27TN/59D/64S STATOR GND** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The 20 Hz current level should be equal to \(1.4(P)\) mA \(\pm 2\) mA or \(\pm 10\%\).

16. Release the **TARGET RESET** pushbutton.
17. Decrease the applied 20 Hz test voltage and current to zero.
Pickup Test (Voltage Restraint Disabled and Under Frequency Inhibit Enabled):

1. Apply balanced nominal three-phase voltage to $V_A (V_{AB})$, $V_B (V_{BC})$, and $V_C (V_{CA})$ at nominal frequency (that is, 50 or 60 Hz).
2. Enable the Total Current Pickup.
3. Disable the Real Component of Current Pickup.
4. Adjust the 20 Hz voltage generator to apply 25 $\circ 0^\circ$ volts across terminals 44 and 45.
5. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current applied to terminals 52 and 53 until the 27TN/59D/64S STATOR GND LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

The 20 Hz current level should be equal to $P \ mA \pm 2 \ mA$ or $\pm 10\%$. The functions should pickup and close the trip contact output.

6. Release the **TARGET RESET** pushbutton.
7. Decrease the applied 20 Hz test voltage and current to zero.
8. Enable under frequency inhibit.
9. Decrease the frequency of the balanced nominal three-phase voltage to $V_A (V_{AB})$, $V_B (V_{BC})$, and $V_C (V_{CA})$ to 30 Hz.
10. Adjust the 20 Hz Voltage Generator to apply 25 $\circ 0^\circ$ Volts across terminals 44 and 45.
11. Press and hold the **TARGET RESET** pushbutton in, then slowly increase the 20 Hz current applied to terminals 52 and 53 until the 20 Hz current level is equal to $P \ mA$. This function should not pick up.

12. Release the **TARGET RESET** pushbutton.
13. Decrease the applied 20 Hz test voltage and current to zero.

Timer Test:

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Enable the Total Current Pickup.
3. Disable the Real Component of Current Pickup.
5. Disable Under Frequency Inhibit.
6. Adjust the 20 Hz Voltage Generator to apply 25 $\circ 0^\circ$ Volts across terminals 44 and 45.
7. Step the 20 Hz current applied to terminals 52 and 53 to a value greater than $P$ and start timing. The contacts will close after D cycles within $\pm 1 \ cycle$ or $\pm 1\%$. Time delay accuracy in cycles is based on 20 Hz frequency.
67N Residual Directional Overcurrent, Definite Time

**VOLTAGE INPUTS:**
See Below

**CURRENT INPUTS:**
See Below

**TEST SETTINGS:**

<table>
<thead>
<tr>
<th>Setting</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup</td>
<td>P Amps (0.50 to 240.0)</td>
</tr>
<tr>
<td></td>
<td>1 Amp (0.1 to 48.0)</td>
</tr>
<tr>
<td>Directional Element</td>
<td>See Below</td>
</tr>
<tr>
<td>Time Delay</td>
<td>D Cycles (1 to 8160)</td>
</tr>
<tr>
<td>Max Sensitivity Angle</td>
<td>MSA Degrees (0 to 359)</td>
</tr>
<tr>
<td>Operating Current</td>
<td>3I₀ or Iₙ</td>
</tr>
<tr>
<td>Polarization Type*</td>
<td>Vₙ, Vₓ, 3V₀ (Calculated)</td>
</tr>
<tr>
<td>Programmed Outputs</td>
<td>Z Output (1 to 8)</td>
</tr>
<tr>
<td></td>
<td>Expanded I/O (9 to 23)</td>
</tr>
</tbody>
</table>

*Vₓ cannot be selected if Function 25 (Sync) is enabled. 3V₀ can only be used with Line-Ground VT.

**Test Setup:**

1. Determine the Function 67NDT Residual Directional Overcurrent, Definite Time settings to be tested.
2. Enter the Function 67N Residual Directional Overcurrent, Definite Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Disable the Directional Element.
5. Connect inputs for the polarization type and operating current selected for testing.

**Pickup Test (non-directional):**

1. Apply current 10% less than pickup P to the operating current. If 3I₀, use any one of Iₐ, Iᵦ, or I₉, or all three in zero sequence.
2. Press and hold the TARGET RESET pushbutton in, then slowly increase the current applied to the selected operating current until the GND DIFF/DIR O/C 87GD/67N LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up. The level should be equal to P13 Amps ± 0.1A or ± 3%.
3. Release the TARGET RESET pushbutton.
4. Decrease the current applied to all phases of the selected operating current. The OUTPUT LED will extinguish.
**Directional Test:**

1. Enable the Directional Element utilizing either the HMI or IPScom Communications Software.
2. Press the **TARGET RESET** pushbutton to reset targets.
3. Set the voltage of the selected polarization type to the **Nominal Voltage** (If 3V, is selected, use any one of the phase voltages, or all three in zero sequence.) The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
4. Set the current angle to an angle greater than 100° from **MSA**.
5. Apply current 10% greater than **P** to the input of the selected operating current.
6. Press and hold the **TARGET RESET** pushbutton, then slowly swing the angle of the selected operating current applied towards the **MSA** until the **GND DIFF/DIR O/C 87GD/67N** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.
   The angle should be equal to A –90° or +90°, depending to which side of **MSA** the current has been set.
7. Release the **TARGET RESET** pushbutton.
8. Swing the current angle away from the **MSA**. The **OUTPUT** LED will extinguish.

**Timer Test:**

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Disable the Directional Element utilizing either the HMI or IPScom Communications Software.
3. Apply **P** +10% Amps to the input of the selected operating current, and start timing. The contacts will close after **D** cycles within –1 to +3 cycles or ±1%. 
67N Residual Directional Overcurrent, Inverse Time

VOLTAGE INPUTS: See Below
CURRENT INPUTS: See Below
TEST SETTINGS:

Pickup P Amps (0.25 to 12.0)
1 Amp CT Rating (0.05 to 2.40)
Directional See Below

BECO Inverse Time Curves
Definite Time\Inverse\Very Inverse\Extremely Inverse
Time Dial TD (0.5 to 11.0)

IEC Inverse Time Curves
\IECI / \IECVI / \IECEI / \IECLTI
Time Dial TD (0.05 to 1.10)

IEEE Inverse Time Curves
\IEEEI / \IEEEVI / \IEEEEI
Time Dial TD (0.5 to 15)
Operating Current $3I_o$ or $I_N$
Max Sensitivity Angle MSA Output (0 to 359)

Polarization Type $V_N$, $V_X$, $3V_O$ (Calculated)
Programmed Outputs Z Output (1 to 8)
Expanded I/O (9 to 23)

* $V_X$ cannot be selected if Function 25 (Sync) is enabled. $3V_O$ can only be used with Line-Ground VT.

Test Setup:

1. Determine the Function 67N Residual Directional Overcurrent, Inverse Time settings to be tested.
2. Enter the Function 67N Residual Directional Overcurrent, Inverse Time settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Disable Directional Element.
5. Refer to Appendix D, Inverse Time Curves, and IEC equations below to calculate test times for levels represented on the graphs. It is suggested that 4 or 5 test levels be chosen.

IEC Class A
Standard Inverse
$t = \frac{0.14}{M^{0.02} - 1}$

IEC Class B
Very Inverse
$t = TD \times \frac{13.5}{M - 1}$

IEC Class C
Extremely Inverse
$t = TD \times \frac{80}{M^2 - 1}$

IEC Class D
Long Time Inverse
$t = TD \times \frac{120}{M - 1}$

Curve 5 Curve 6 Curve 7 Curve 8

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

Time Delay Test:

1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply the input current used in the calculations from Step 5 to the input of the selected operating current, and start timing.
   
   The operating time will be ±3 cycles or ±5% of the calculated time. Repeat this step for each test level chosen. The points tested verify the operation of this function.
Directional Test:

1. Enable Directional Element.
2. Press the TARGET RESET pushbutton to reset targets.
3. Apply Nominal Voltage to the input of the selected Polarization Type. If 3V_o, use any one of the phase voltages, or all three at zero sequence.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
4. Set the current angle to an angle greater than 100° from MSA.
5. Apply current 10% greater than PI3, (for type 3, use P) to all three phases.
6. Press and hold the Target Reset pushbutton, then slowly swing the angle of the selected operating current towards the MSA until the GND DIFF/DIR O/C 87GD/67N LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.
   The angle should be equal to A –90° or +90°, depending to which side of MSA the current has been set.
7. Release the TARGET RESET pushbutton.
8. Swing the current angle away from the MSA. The OUTPUT LED will extinguish.
78 Out of Step

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: Configuration C1
TEST SETTINGS:
- Circle Diameter P Ohms (0.1 to 100)
- Time Delay D Cycles (1 to 8160)
- Impedance Angle A Degrees (0 to 90)
- Time Delay D Cycles (1 to 8160)
- Pole Slip Counter
- Pole Slip Reset Cycles (1 to 20)
- Trip on MHO Exit See Below
- Programmed Output Z OUT (1 to 8)
- Expanded I/O

Test Setup:
1. An accurate stopwatch is required for this test.
2. Determine the Function 78 Out of Step settings to be tested.
3. Establish communications with the relay utilizing IPScom® Communications Software.
4. Enter the Function 78 Out of Step settings to be tested utilizing IPScom Communications Software.
5. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
6. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
7. Connect test current inputs as shown in Figure 6-4, Current Inputs: Configuration C1.
8. Set the three-phase voltages $V_A$, $V_B$, and $V_C$ to the Nominal Voltage.
   The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

Pickup Test:
1. Disable the Function 78 Out of Step TRIP ON MHO EXIT setting, then set the delay, D, to a minimal setting (2–3 cycles).
2. Open the IPScom Out-of-Step Dialog Box, Figure 4-32 (Relay/Monitor/Out of Step Dialog Box).
3. While monitoring the Positive Sequence Impedance, set the magnitude and phase angle of the Input Currents to a point similar to point $Z_p$ in Figure 2-61.
4. Press and hold the TARGET RESET pushbutton, then sweep the current angle towards point $Z_1$.
   When the impedance passes through point $Z_1$, verify that the 78 OUT OF STEP LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.
5. Pause testing until the delay timer has time to expire, then continue to sweep the current angle to point $Z_2$, and verify output $Z$ operates as point $Z_2$ is crossed, and resets after the seal-in time delay.

6. If testing is complete, then reduce voltages and currents to zero.

**Blocking on Stable Swing Test:**

1. While monitoring the Positive Sequence Impedance, set the magnitude and phase angle of the Input Currents to a point outside of the mho circle.

2. While monitoring the Positive Sequence Impedance, set the magnitude and phase angle of the Input Currents to point $Z_0$ in Figure 2-61.

3. Press and hold the **TARGET RESET** pushbutton, then sweep past point $Z_1$.

   When the impedance passes through point $Z_1$, verify that the **78 OUT OF STEP** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

4. Pause testing until the delay timer has time to expire, then reverse the sweep direction and sweep the current angle to point $Z_1$.

   As point $Z_1$ is crossed, verify output $Z$ does not operate and the **78 OUT OF STEP** LED extinguishes or the function status indicator on the **Monitor Function Status** screen indicates that the function has reset.

6. If testing is complete, then reduce voltages and currents to zero.

**Pickup Test (Trip on mho Exit):**

1. Enable the **TRIP ON MHO EXIT** setting.

2. While monitoring the Positive Sequence Impedance, set the magnitude and phase angle of the Input Currents to point $Z_0$ in Figure 2-61.

3. Press and hold the **TARGET RESET** pushbutton, then sweep the current angle towards point $Z_1$.

   When the impedance passes through point $Z_1$, verify that the **78 OUT OF STEP** LED illuminates or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

4. Pause testing until the delay timer has time to expire, then continue to sweep the current angle to beyond point $Z_2$. Verify that output $Z$ does not operate as point $Z_2$ is crossed.

5. Sweep the impedance further towards point $Z_3$. Verify output $Z$ operates as point $Z_3$ is crossed, and resets after the seal-in time delay has timed out.

6. If testing is complete, then reduce voltages and currents to zero.
**81 Frequency (#1, #2, #3, #4)**

**VOLTAGE INPUTS:** Configuration V1  
**CURRENT INPUTS:** None  
**TEST SETTINGS:**  
- Pickup P Hz (50.00 to 67.00)  
- 50 Hz Relay (40.00 to 57.00)  
- Time Delay D Cycles (3 to 65,500)  
- Programmed Outputs Z OUT (1 to 8)  
- Expanded I/O (9 to 23)

**NOTE:** It would be efficient to disable the elements with the settings nearest to nominal frequency first (testing over or underfrequency functions).

**Test Setup:**
1. Determine the Function 81 Frequency settings to be tested.
2. Enter the Function 81 Frequency settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Set the three-phase voltages V_A, V_B, and V_C to the Nominal Voltage (nominal frequency). The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

**Pickup Test:**
1. Press and hold the TARGET RESET pushbutton, then slowly increase/decrease the Input Voltage (V_A, V_B, and V_C) Frequency until the FREQUENCY/ROCOF 81/81R LED illuminates or the function status indicator on the Monitor Function Status screen indicates that the function has picked up. The frequency level will be equal to P Hz ±0.02 Hz only if P is within 3 Hz of F_nom, otherwise, ±0.1 Hz.
2. Increase/decrease the Input Voltage (V_A, V_B, and V_C) Frequency to nominal input frequency. The OUTPUT LED(s) will extinguish.
3. Press TARGET RESET pushbutton to reset targets.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply (P + or – 0.5) Hz and start timing. The contacts will close after D cycles within ±2 cycles or ±1%, whichever is greater.
81A Frequency Accumulator (Band #1, #2, #3, #4, #5, #6)

VOLTAGE INPUTS: V1
CURRENT INPUTS: None
TEST SETTINGS:
- High Pickup (#1 only) P Hz (50.00 to 67.00)
- 50 Hz Relay
- Low Pickup P Hz (50.00 to 67.00)
- 50 Hz Relay
- Delay D Cycles (3 to 360,000)
- Acc Status Cycles (0 to 360,000)
- Programmed Outputs Z OUT (1 to 8)
- Expanded I/O (9 to 23)

Test Setup:
1. Determine the Function 81A Frequency Accumulator settings to be tested.
2. Enter the Function 81A Frequency Accumulator settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
5. Set the three-phase voltages $V_a$, $V_b$, and $V_c$ to the Nominal Voltage (nominal frequency). The Nominal Voltage value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

Output Test:
1. Connect a timer to output contacts Z so that the timer stops timing when the contacts Z close.
2. Set the frequency to a value between the upper and lower limits of the selected band under test and start timing.
3. Utilizing either the HMI (Status/81A Accumulator Status) or IPScom Communications Software (Relay/Monitor/Accumulator Status), verify that the Accumulator Status value for the band under test is incrementing.
   - Output Contacts Z will close after D cycles within ±2 cycles or 1%.
4. Repeat Steps 1 to 3 for the remaining bands if desired.
81R Rate of Change of Frequency (#1, #2)

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: None
TEST SETTINGS:
- Pickup P Hz/Sec (0.10 to 20.00)
- Time Delay D Cycles (3 to 8160)
- Negative Sequence Voltage Inhibit N % (0 to 99)
- Programmed Outputs Z OUT (1 to 8)
  - Expanded I/O (9 to 23)

**Test Setup:**

1. It is recommended that the 81 Function be used to establish a window of operation for the 81R Function which is smaller than the actual sweep range of the frequency applied. This is accomplished as follows:
   - **NOTE:** The frequencies given are suggested for testing rates below 10 Hz/Sec. Higher rates will require consideration of the capabilities of the test equipment involved.
     a. Enable the 81#1 with a unique Output assigned, a Pickup Setting of 1 Hz greater than the minimum frequency of the ramp and a time delay and seal-in time setting at minimum (This will result in an operational window that is free of erroneous Hz/Sec measurements when the voltage source begins or ends the sweep.).
     b. Enable the 81#2 with a unique Output assigned, a Pickup Setting of 1 Hz less than the maximum frequency of the ramp and a time delay and seal-in time setting at minimum (This will result in an operational window that is free of erroneous Hz/Sec measurements when the voltage source begins or ends the sweep.).
   - **NOTE:** Using this setup, it is important to remember that the 81 elements being used will be operating in the 81R blocking regions, and the 81R contact operation must be distinguished from the 81 contacts.

2. Determine the Function 81R Rate of Change of Frequency settings to be tested.
3. Enter the Function 81R Rate of Change of Frequency settings to be tested utilizing either the HMI or IPScom Communications Software.
4. Disable all other functions prior to testing with the exception of Function 81. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
   - **NOTE:** Testing of the 81R function requires a 3-phase voltage source capable of smoothly sweeping the frequency of all voltages at a variable rate, continuously.
5. Connect test voltage inputs as shown in Figure 6-1, Voltage Inputs: Configuration V1.
6. Set the three-phase voltages $V_A$, $V_B$, and $V_C$ to the **Nominal Voltage** (nominal frequency). The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
**Pickup Test:**

1. Calculate the time for the pickup setting, then apply a sweep rate of 25% less than the Pickup (P) to all three phases.

2. Press and hold the **TARGET RESET** pushbutton, then slowly decrease the sweep time until the **FREQUENCY/ROCOF 81/81R** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.
   
The level should be equal to P ± 0.05 Hz/Sec. or ± 5%.

3. Release the **TARGET RESET** pushbutton, then increase the sweep time. The **OUTPUT** LED will extinguish.

**Negative Sequence Voltage Inhibit Test:**

1. Press the **TARGET RESET** pushbutton to reset targets.

2. Apply **Nominal Voltage** to all three phases at a sweep rate 25% above P. The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.
   
   Verify that the **FREQUENCY/ROCOF 81/81R** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

3. Swing the phase angle of a Phase Voltage and monitor the Positive and Negative Sequence Voltage levels. The **81R OUTPUT** should reset when the negative sequence voltage is N %, ±0.5% of the positive sequence voltage.

**Timer Test:**

1. Press the **TARGET RESET** pushbutton to reset targets.

2. Apply **Nominal Voltage** to all three phases at a sweep rate 25% below P. The **Nominal Voltage** value previously input to the relay is described in Section 2.1 and should be recorded on Figure A-3, Functional Configuration Record Form.

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

4. Apply a sweep rate 25% above P and start timing. The contacts will close after D cycles within +20 cycles.
**87 Phase Differential (#1 or #2)**

**VOLTAGE INPUTS:** None

**CURRENT INPUTS:** Configuration C3

**TEST SETTINGS:**
- Minimum Pickup: \( P \) Amps (0.20 to 3.00)
- 1 Amp CT Rating: (0.04 to 0.60)
- Percent Slope: \( S \) \% (1 to 100)
- Time Delay: \( D \) Cycles (1 to 8160)
- CT Correction: (0.5 to 2.0)
- Programmed Outputs: \( Z \) OUT (1 to 8)
- Expanded I/O: (9 to 23)

**NOTE:** Although a voltage input is not required for the testing of the 87 function, it is suggested that Nominal Voltage be applied to restrain the functions which use both voltage and current inputs for operation.

**Test Setup:**

1. Determine the Function 87 Phase Differential settings to be tested.
2. Enter the Function 87 Phase Differential settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect test current inputs as shown in Figure 6-5, Current Inputs: Configuration C3.

**Minimum Pickup Test:**

1. Set Current Input 1 \((I_a)\) to 0 Amps.
2. Press and hold the **TARGET RESET** pushbutton, then slowly increase Current Input 2 \((I_a)\) until the **PHASE DIFF CURRENT 87** LED illuminates, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.
   The current level of operation will be equal to \( P \) amps ±0.1 A or ±5%.
3. Release the **TARGET RESET** pushbutton, then decrease the Current Input 2 \((I_a)\). The **OUTPUT** LED(s) will extinguish.
4. Press **TARGET RESET** pushbutton to reset targets.
5. Repeat Steps 1,2,3 and 4 for each remaining phase exchanging \( I_a(B,C) \) and \( I_{a(b,c)} \) as appropriate.

**Timer Test:**

1. Connect a timer to output contacts \((Z)\) so that the timer stops timing when the contacts \((Z)\) close.
2. Apply a current level to Current Input 2 \((I_a)\) at least 10% greater than the minimum current pickup level and start timing. The contacts will close after \( D \) cycles within ±1 cycle or ±1%. When the Time Delay is set to 1 cycle, the relay operation is less than 1-1/2 cycles.
Slope Test:

1. Define a representative number of testing points to verify the trip curve.
2. For each $I_a$ (Current Input 1) test point defined in Step 1, calculate the expected operating current $I_A$ (Current Input 2) as follows:

\[
\frac{(I_A - I_a)}{(I_A + I_a)} > \frac{(I_A + I_a)}{2} \times \text{Slope/100} \div 2
\]

or $I_A = \left(\frac{(1 + K)}{(1 - K)}\right) \times I_a$ where $K = S/200$ and where $S$ is % slope input above.

**NOTE:** For tests above the restraint current $((I_A + I_a)/2)$ value of 2X Nominal Current; use a slope % value equal to 4 times the input slope value ($S$) for these computations.

3. Set Current Input 1 ($I_a$) and Current Input 2 ($I_A$) to the values chosen in Step 1 and calculated in Step 2 respectively.
4. Press and hold the TARGET RESET pushbutton, then slowly increase either Current Input 1 or 2 until the PHASE DIFF CURRENT 87 LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.

The current level of operation will be equal to $I_a \pm 0.1$ A or $\pm 2\%$ slope calculation. The difference in current must be greater than minimum pickup current for proper operation.

5. Release the TARGET RESET pushbutton, then decrease the larger CURRENT. The OUTPUT LED(s) will extinguish.
6. Press TARGET RESET pushbutton to reset targets.
87GD Ground Differential

VOLTAGE INPUTS: None
CURRENT INPUTS: As described
TEST SETTINGS:

<table>
<thead>
<tr>
<th>Setting</th>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickup P Amps</td>
<td></td>
<td></td>
<td>(0.20 to 10.00)</td>
</tr>
<tr>
<td>1 Amp CT Rating</td>
<td></td>
<td></td>
<td>(0.04 to 2.00)</td>
</tr>
</tbody>
</table>

▲ CAUTION: Do NOT set the delay to less than 2 Cycles

<table>
<thead>
<tr>
<th>Setting</th>
<th>Symbol</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Delay D Cycles</td>
<td></td>
<td></td>
<td>(1 to 8160)</td>
</tr>
<tr>
<td>CT Ratio Correction</td>
<td></td>
<td></td>
<td>(0.10 to 7.99)</td>
</tr>
<tr>
<td>Programmed Outputs Z OUT</td>
<td></td>
<td></td>
<td>(1 to 8)</td>
</tr>
<tr>
<td>Expanded I/O</td>
<td></td>
<td></td>
<td>(9 to 23)</td>
</tr>
</tbody>
</table>

Test Setup:
1. Determine the Function 87GD Ground Differential settings to be tested.
2. Enter the Function 87GD Ground Differential settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
4. Connect a current input to I\(_N\) terminals 53 and 52.
5. Connect a current input to I\(_A\) terminals 46 and 47, or I\(_B\) terminals 48 and 49.

Non–Directional Pickup Test:
1. Press and hold the TARGET RESET pushbutton, then slowly increase Current Input I\(_N\) (terminals 53 and 52) until the GND DIFF/DIR O/C 87GD/67N LED illuminates, or the function status indicator on the Monitor Function Status screen indicates that the function has picked up.
   
   The current level of operation will be equal to \(P\) amps ±0.1 A or ±5%.

2. Release the TARGET RESET pushbutton, then decrease the Current Input I\(_N\) to 0 Amps. The OUTPUT LED(s) will extinguish.

3. Press TARGET RESET pushbutton to reset targets.

Timer Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply a current level to Current Input I\(_N\) at least 10% greater than the minimum current pickup level and start timing. The contacts will close after D cycles within +1 to -2 cycles or ±1%.
3. Decrease the Current Input I\(_N\) to 0 Amps.

Directional Time Test:
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Apply a current of 1.0 Amp with a phase angle of 0 degrees to Current Input I\(_N\) (terminals 53 and 52).
3. Apply a current of \(P – 0.9\) amps with a phase angle of 180 degrees to either Current Input I\(_A\) or I\(_B\) and start timing.
   
   The contacts will close after D cycles within ±1 cycle or ±1%.
4. Decrease the applied currents to 0 Amps.
5. Press the **TARGET RESET** pushbutton to reset targets.

6. Set the phase angle of the Current Input selected in Step 3, to 0 degrees, the Current Inputs are now in phase.

7. Reapply a current of 1.0 Amp to Current Input \( I_a \) (terminals 53 and 52).

8. Reapply a current of \( P - 0.9 \) Amps to the Current Input selected in Step 3, and start timing.
   
   The relay will not operate. If the \( I_a \) or \( I_b \) current input value is reduced to 140 ma or less and the difference current exceeds the pickup value, the relay will operate regardless of polarities of the currents.

9. Decrease the applied currents to 0 Amps.
**BM Breaker Monitoring**

**VOLTAGE INPUTS:** None

**CURRENT INPUTS:** As Described

**TEST SETTINGS:**
- Pickup \( P \) kAmps (kA\(^2\)) \(^*\) (0 to 50,000)
- Delay \( D \) Cycles (0.1 to 4095.9)
- Timing Method \( (I_T \text{ or } I^2T) \)
- Preset Accumulators
  - Phase A, B, or C \( k\text{Amp} (kA^2) \text{ Cycles} \) \(^*\) (0 to 50,000)
- Programmed Outputs \( Z \) OUT (1 to 8)
- Blocking Inputs
  - Expanded I/O (1 to 6)
  - Expanded I/O (7 to 14)
- Output Initiate
  - Expanded I/O (1 to 8)
  - Expanded I/O (9 to 23)
- Input Initiate
  - Expanded I/O (1 to 6)
  - Expanded I/O (7 to 14)

* \( k\text{A}/k\text{A} \) cycles or \( k\text{A}^2/k\text{A}^2 \) cycles is dependent on the Timing Method that is selected.

**Test Setup:**
1. Determine the Breaker Monitoring Function settings to be tested (Input Initiate or Output Initiate).
2. Enter the Breaker Monitoring Function settings to be tested utilizing either the HMI or IPScom® Communications Software.
3. Connect a current input to \( I_A \) terminals 46 and 47, \( I_B \) terminals 48 and 49, and \( I_C \) terminals 50 and 51.
4. Connect inputs for the polarization type selected for testing.

**Accumulator Test:**
1. Apply a current value that considers Timing Method and Pickup Setting to current input \( I_A \).
2. Place a jumper between the designated input and/or energize output contact selected as initiate.
3. Utilizing either the HMI (Status/Breaker Monitor Accumulator Status) or IPScom Communications Software (Relay/Monitor/Accumulator Status), verify that the Accumulator Status value for Phase A increments in \( D \) cycles \( \pm 1 \text{ cycles or } \pm 1\% \).
4. De-energize the output and/or remove the jumper placed in Step 2.
5. Decrease applied \( I_A \) current to 0 amps.
6. If desired, repeat test for \( I_B \) and \( I_C \).
**Pickup Test:**

1. Apply a current value that considers Timing Method and Pickup Setting to current input $I_A$.

   **NOTE:** If the target pickup setting is a large value (0 to 50,000) the Preset Accumulator Settings feature can be used to pre-set the accumulator values to just below the target setting.

2. Utilizing either the HMI (Status/Breaker Monitor Accumulator Status) or IPScom Communications Software (Relay/Monitor/Accumulator Status) to monitor the accumulator value, place a jumper between the designated input or energize the output contact selected as initiate and then remove the jumper and/or de-energize the output.

   Following the time out of the Delay the accumulator will increment, repeat the placement and removal of the jumper as necessary to increment the accumulator to a point where the pickup setting is exceeded.

3. When the accumulator value exceeds the pickup value the **OUTPUT** LED(s) will illuminate, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up.

   The output contacts $Z$ will operate in $D$ cycles $\pm 1$ cycle or $\pm 1\%$ from the last initiate.

4. If desired, repeat test for $I_B$ and $I_C$. 


Trip Circuit Monitoring

VOLTAGE INPUTS: As Described
CURRENT INPUTS: None
TEST SETTINGS: Delay D Cycles (1 to 8160)
               Programmed Outputs Z OUT (1 to 8)
               Expanded I/O (9 to 23)

Test Setup:
1. Determine the Trip Circuit Monitoring function settings to be tested.
2. Disable all other functions prior to testing. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for details that describe disabling/enabling functions.
3. Connect a DC voltage supply capable of supplying 24/48/125/250 V dc (marked on the rear of the relay) to terminals 1 (–) and 2 (+) on the relay.
4. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.

Pickup Test:
1. Apply the applicable DC voltage (24/48/125/250 V dc marked on the rear of the relay) to terminals 1 and 2.
2. Enable the Trip Circuit Monitoring function and then enter the settings to be tested utilizing either the HMI or IPScom Communications Software.
3. Remove the DC voltage applied in Step 1. The OUTPUT LED will illuminate, or the function status indicator on the Monitor Function Status screen will indicate that the Trip Circuit Monitoring function has actuated.
   The contacts will close after D cycles within ±1 cycle or 1%.
4. Simulate a 52b contact open by connecting a jumper between terminal 11 (INRTN) and terminal 10 (IN1) which the BRKR CLOSED and OUTPUT LEDs on the front of the relay should extinguish.
   Also, the function status indicator on the Monitor Function Status screen will indicate that the Trip Circuit Monitoring function has cleared and the Secondary Status screen will indicate that the breaker is closed.
5. Remove the jumper installed in Step 4.
   The contacts will close after D cycles within ±1 cycle or 1%.
**IPSlogic™ (#1, #2, #3, #4, #5, #6)**

**VOLTAGE INPUTS:** As Needed

**CURRENT INPUTS:** As Needed

**TEST SETTINGS:**
- Time Delay: D Cycles (1 to 8160)
- Programmed Outputs: Z OUT
  - Expanded I/O (9 to 23)
- Blocking Inputs
  - Expanded I/O (1 to 6)
- Output Initiate
  - Expanded I/O (7 to 14)
- Function Initiate Pickup
  - Expanded I/O (1 to 8)
- Function Initiate Time Out
  - Expanded I/O (9 to 23)

**Test Setup:**
1. Refer to Figure 2-75, IPSlogic Function Setup, for logic gate configurations.
2. Select gate configuration (AND/OR/NAND/NOR) for Output Initiate, Function Initiate, Blocking Inputs and Inputs Main.
3. Select Initiating Inputs for each gate (if AND gate is selected, ensure at least two outputs are chosen). It will be necessary to enable and operate other functions to provide inputs for the Function Initiate and Output Initiate gates.

**Time Test:**
1. Connect a timer to output contacts (Z) so that the timer stops timing when the contacts (Z) close.
2. Connect a jumper from IN RTN (Terminal 11) to the designated Inputs (Terminals 1–6) for the IPSlogic gates and start timing. The **IPS LOGIC** LED and the **OUTPUT** LED will illuminate, or the function status indicator on the **Monitor Function Status** screen indicates that the function has picked up. The operating time will be D cycles ±1 cycle or ±1%.

**Blocking Input Test:**
1. Press and hold the **TARGET RESET** pushbutton, then place a jumper from IN RTN (terminal 11) to the designated Blocking Inputs (terminals 1-6) to be tested. The **EXTERNAL #1 EXT 1** LED will extinguish.
2. Repeat Step 1 for each designated external triggering contact.
6.3 Diagnostic Test Procedures

Overview
The diagnostic test procedures perform basic functional relay tests to verify the operation of the front-panel controls, inputs, outputs, and communication ports.

**WARNING:** Do not enter DIAGNOSTIC MODE when protected equipment is in service. Entering DIAGNOSTIC MODE when protected equipment is in service removes all protective functions of the relay.

The diagnostic menu includes the following tests:
- OUTPUT (Output Test Relay)
- INPUT (Input Test Status)
- LED (Status LED Test)
- TARGET (Target LED Test)
- EX, IO (Expanded I/O Test, Not Available at this time)
- BUTTON (Button Test)
- DISP (Display Test)
- COM1 (COM1 Loopback Test)
- COM2 (COM2 Loopback Test)
- COM3 (COM3 Echo Test 2-Wire)

Each test is described individually in this section.

The diagnostic menu also provides access to the following relay feature settings:
- CLOCK (Clock On/Off)
- LED (Relay OK LED Flash/Solid)
- CAL (Auto Calibration)
- FACTORY (Factory Use Only)

Auto Calibration is described in detail in Section 6.4, Auto Calibration.

Entering Relay Diagnostic Mode

**WARNING:** Do not enter DIAGNOSTIC MODE when protected equipment is in service. Entering DIAGNOSTIC MODE when protected equipment is in service removes all protective functions of the relay.

1. Press **ENTER** to access the main menu.

2. Press the right arrow pushbutton until the following is displayed:

   SETUP UNIT
   ← SETUP exit

3. Press **ENTER**, the following will be displayed:

   SOFTWARE VERSION
   VERS sn access number →

4. Press the right arrow pushbutton until the following is displayed:

   DIAGNOSTIC MODE
   ← time error DIAG

5. Press **ENTER**, the following warning will be displayed:

   PROCESSOR WILL RESET!
   ENTER KEY TO CONTINUE

**WARNING:** Do not enter DIAGNOSTIC MODE when protected equipment is in service. Entering DIAGNOSTIC MODE when protected equipment is in service removes all protective functions of the relay.

6. Press **ENTER**, the relay will reset and DIAGNOSTIC MODE will be temporarily displayed followed by:

   OUTPUT TEST (RELAY)
   OUTPUT input led target →
   ← button disp →
   ← com1 com2 com3 clock →
   ← led cal factory

This marks the beginning of the diagnostic menu. The left arrow and right arrow pushbuttons are used to navigate within the diagnostic menu. Exiting the diagnostic menu is accomplished by pressing **EXIT**; PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then pressing **EXIT** a second time.
Output Relay Test (Output Relays 1–23 and 25)

**NOTE:** This test does not include testing of Power Supply Relay (Output Relay 24).

1. Ensure the protected equipment is in a configuration/state that can support relay output testing.
2. Confirm the positions of the outputs in the unoperated or **OFF** position. This can be accomplished by connecting a DMM (Digital Multimeter) across the appropriate contacts and confirming open or closed. The de-energized or **OFF** position for outputs 1 through 25 are listed in Table 6-1.

<table>
<thead>
<tr>
<th>Relay Output Number</th>
<th>Normally Open Contact</th>
<th>Normally Closed Contact*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33-34</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>31-32</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>29-30</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>27-28</td>
<td>--</td>
</tr>
<tr>
<td>5</td>
<td>25-26</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>23-24</td>
<td>--</td>
</tr>
<tr>
<td>7</td>
<td>21-20</td>
<td>21-22</td>
</tr>
<tr>
<td>8</td>
<td>17-18</td>
<td>18-19</td>
</tr>
<tr>
<td>9</td>
<td>104-105</td>
<td>--</td>
</tr>
<tr>
<td>10</td>
<td>102-103</td>
<td>--</td>
</tr>
<tr>
<td>11</td>
<td>100-101</td>
<td>--</td>
</tr>
<tr>
<td>12</td>
<td>98-99</td>
<td>--</td>
</tr>
<tr>
<td>13</td>
<td>96-97</td>
<td>--</td>
</tr>
<tr>
<td>14</td>
<td>94-95</td>
<td>--</td>
</tr>
<tr>
<td>15</td>
<td>92-93</td>
<td>--</td>
</tr>
<tr>
<td>16</td>
<td>90-91</td>
<td>--</td>
</tr>
<tr>
<td>17</td>
<td>88-89</td>
<td>--</td>
</tr>
<tr>
<td>18</td>
<td>86-87</td>
<td>--</td>
</tr>
<tr>
<td>19</td>
<td>84-85</td>
<td>--</td>
</tr>
<tr>
<td>20</td>
<td>82-83</td>
<td>--</td>
</tr>
<tr>
<td>21</td>
<td>80-81</td>
<td>--</td>
</tr>
<tr>
<td>22</td>
<td>78-79</td>
<td>--</td>
</tr>
<tr>
<td>23</td>
<td>76-77</td>
<td>--</td>
</tr>
<tr>
<td>Power Supply (24)</td>
<td>--</td>
<td>12-13</td>
</tr>
<tr>
<td>Self-Test (25)</td>
<td>14-15</td>
<td>15-16</td>
</tr>
</tbody>
</table>

* *“Normal” position of the contact corresponds to the OFF (de-energized) state of the relay.

3. If the relay is already in the Diagnostic Mode, then go to Step 4.
   If the relay is **NOT** in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 4.

4. Ensure that the Diagnostic Menu is selected to **OUTPUT** (Upper Case).

   ![OUTPUT TEST (RELAY)
   OUTPUT input led target → ← button disp → ← com1 com2 com3 clock → ← led cal factory]

   If OUTPUT is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select OUTPUT.

5. Press `ENTER`, the relay will display the following:

   RELAY NUMBER 1

6. Select the Output Relay (from Table 6-1) to be tested, utilizing the Up/Down arrow pushbuttons.

7. Press `ENTER`. The following will be displayed for the selected relay:

   RELAY NUMBER 1
   OFF on

8. Select **ON** (Upper Case) utilizing the Right arrow pushbutton. The relay will respond as follows:
   a. Output relay energizes (On position)
   b. Appropriate red **OUTPUT** LED illuminates, if equipped.

   If testing all output relays, then press `EXIT` to return to the output relay selection menu, then repeat Steps 6, 7 and 8 for each output relay.

9. The DMM can now be used to verify that the output relay contact is in the operated or **ON** position. The readings should be the opposite of the initial reading determined in Step 2.

10. When output relay testing is complete then restore all output relays to their de-energized or **OFF** positions listed in Table 6-1 and press `EXIT` to return to the Diagnostic Menu.
11. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing **EXIT, PRESS EXIT TO EXIT DIAGNOSTIC MODE** is displayed, then press **EXIT** a second time.

**Output Relay Test (Power Supply Relay 24)**
The power supply output relay can be tested by performing the following:

**NOTE:** For this test the relay is not required to be in the Diagnostic Mode.

1. Ensure the protected equipment is in a configuration/state that can support relay output testing.

2. Confirm the position of output relay 24 in the unoperated or **OFF** position. This can be accomplished by connecting a DMM (Digital Multimeter) across the appropriate contacts and confirming open or closed. The de-energized or **OFF** position for Output 24 is listed in Table 6-1.

3. Remove power from the relay. The DMM can now be used to verify that output relay 24 contact is in the operated or **ON** position. The reading should be the opposite of the initial reading determined in Step 2.

4. Restore power to the relay.

**Input Test (Control/Status)**
The **INPUT TEST** menu enables the user to determine the status of the individual control/status inputs. Individual inputs can be selected by number using the up and down arrow pushbuttons. The status of the input will then be displayed.

<table>
<thead>
<tr>
<th>Input Number</th>
<th>Common Terminal</th>
<th>Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (52b)</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>5</td>
</tr>
</tbody>
</table>

**Expanded I/O Inputs**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>66 or 67</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>66 or 67</td>
<td>74</td>
</tr>
<tr>
<td>9</td>
<td>66 or 67</td>
<td>73</td>
</tr>
<tr>
<td>10</td>
<td>66 or 67</td>
<td>72</td>
</tr>
<tr>
<td>11</td>
<td>66 or 67</td>
<td>71</td>
</tr>
<tr>
<td>12</td>
<td>66 or 67</td>
<td>70</td>
</tr>
<tr>
<td>13</td>
<td>66 or 67</td>
<td>69</td>
</tr>
<tr>
<td>14</td>
<td>66 or 67</td>
<td>68</td>
</tr>
</tbody>
</table>

**Table 6-2 Input Contacts**

1. Ensure the protected equipment is in a configuration/state that can support relay input testing.

2. If the relay is already in the Diagnostic Mode, then go to Step 3.

   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 3.

3. Ensure that the Diagnostic Menu is selected to **INPUT** (Upper Case).

   **INPUT TEST (RELAY)**

   output INPUT led target →
   ← button disp →
   ← com1 com2 com3 clock →
   ← led cal factory

   If INPUT is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select INPUT.
4. Press ENTER. The following is displayed:

   INPUT NUMBER
   1

5. Select the Input Relay (from Table 6-2) to be tested utilizing the Up/Down arrow pushbuttons.

6. Press ENTER. The following is displayed for the selected relay:

   INPUT NUMBER 1
   CIRCUIT OPEN

7. If no external control/status inputs are connected to the relay, then place a jumper between the IN RTN terminal (terminal #11 for Inputs 1–6, and either terminal #66 or #67 for Inputs 7–14) and the IN1 terminal (terminal #10). See Table 6-2 for terminals for inputs 2 through 14.

   Alternatively, if this specific input is being used in this application and the external wiring is complete, the actual external control/status input contact can be manually closed. This will test the input contact operation and the external wiring to the input contacts.

   The following is immediately displayed:

   INPUT NUMBER 1
   CIRCUIT CLOSED

8. Remove the jumper between the IN RTN terminal (terminal #11 for Inputs 1–6, and either terminal #66 or #67 for Inputs 7–14) and the IN1 terminal (terminal #10).

   The following is immediately displayed:

   INPUT NUMBER 1
   CIRCUIT OPEN

9. If testing all inputs, press EXIT to return to the input selection menu, then repeat Steps 5, 6, 7 and 8 for each input.

10. When input testing is complete then insure all jumpers have been removed and press EXIT to return to the Diagnostic Menu.

11. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT, PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

---

### Status LED Test

The STATUS LED TEST menu enables the user to check the front-panel LEDs individually.

**Figure 6-8 Status LED Panel**

1. If the relay is already in the Diagnostic Mode, then go to Step 2.

   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to LED (Upper Case).

   STATUS LED TEST
   output input LED target →
   ← button disp →
   ← com1 com2 com3 clock →
   ← led cal factory

   If LED is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select LED.

3. Press ENTER. LED #1 (RELAY OK) illuminates and the following is displayed:

   STATUS LED TEST
   LED NUMBER 1 = ON

4. If testing all Status LEDs, press the right arrow pushbutton to toggle through the remaining LEDs illustrated in Figure 6-8, with the exception of the PS1 and PS2 LEDs.
5. When Status LED testing is complete press EXIT to return to the Diagnostic Menu.

6. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT. PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

Target LED Test
The TARGET LED TEST menu allows the user to check the M-3925A Target Module LEDs individually.

**TARGETS**

<table>
<thead>
<tr>
<th>Target</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>24 VOLTS/Hz</td>
</tr>
<tr>
<td>27</td>
<td>PHASE OVERCURRENT</td>
</tr>
<tr>
<td>50</td>
<td>PHASE UNDERVOLTAGE</td>
</tr>
<tr>
<td>69</td>
<td>PHASE OVERVOLTAGE</td>
</tr>
<tr>
<td>56</td>
<td>NEUTRAL OR C</td>
</tr>
<tr>
<td>50N/51N</td>
<td>50N/51N</td>
</tr>
<tr>
<td>50G</td>
<td>GROUND</td>
</tr>
<tr>
<td>50D</td>
<td>DIRECTIONAL OVERVOLT</td>
</tr>
<tr>
<td>50S</td>
<td>SPLIT PHASE DIFF</td>
</tr>
<tr>
<td>50R</td>
<td>STAT OR GND</td>
</tr>
<tr>
<td>50H</td>
<td>STOR OVERLOAD</td>
</tr>
<tr>
<td>60</td>
<td>60FL V.T. FUSE LOSS</td>
</tr>
</tbody>
</table>

**OUTPUTS**

<table>
<thead>
<tr>
<th>Output</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT 1</td>
<td>OUT 2</td>
</tr>
<tr>
<td>OUT 3</td>
<td>OUT 4</td>
</tr>
<tr>
<td>OUT 5</td>
<td>OUT 6</td>
</tr>
<tr>
<td>OUT 7</td>
<td>OUT 8</td>
</tr>
</tbody>
</table>

3. Press ENTER. Target LED #1 lights and the following is displayed:

```
TARGET LED TEST
LED NUMBER 1 = ON
```

4. If testing all Target LEDs, press the right arrow pushbutton to toggle through the remaining Target LEDs illustrated in Figure 6-9.

5. When Target LED testing is complete press EXIT to return to the Diagnostic Menu.

6. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT. PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

Button Test
The BUTTON TEST menu selection allows the user to check the M-3931 HMI Module buttons. As each pushbutton is pressed, its name is displayed.

1. If the relay is already in the Diagnostic Mode, then go to Step 2.

   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to TARGET (Upper Case).

   **TARGET LED TEST**

   output input led TARGET →
   button disp →
   com1 com2 com3 clock →
   led cal factory

   If TARGET is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select TARGET.

---

**Figure 6-9**  M-3925A Target Module Panel

**Figure 6-10**  M-3931 Human-Machine Interface Module

---

6–72
2. Ensure that the Diagnostic Menu is selected to BUTTON (Upper Case).

| BUTTON TEST        | output input led target | → | BUTTON disp | ——— | ———— | | <- com1 com2 com3 clock | ——— | ———— | | ———— | led cal factory |

If BUTTON is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select BUTTON.

3. Press ENTER. The following is displayed:

| BUTTON TEST        | 0 |

**NOTE:** Pressing the EXIT pushbutton will exit from this test, and therefore should be last pushbutton tested. If it is pushed before this test sequence is completed, the test may be restarted by pushing ENTER. Notice that the word EXIT is displayed temporarily before the test sequence is exited.

4. Press each pushbutton for test. As each button is pressed, the display will briefly show the name for each key (“RIGHT ARROW”, “UP ARROW”, etc).

5. When pushbutton testing is complete press EXIT to return to the Diagnostic Menu.

6. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT. PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

**Display Test**

The DISPLAY TEST menu selection enables the user to check the display. This test cycles through varying test patterns until EXIT is pressed.

1. If the relay is already in the Diagnostic Mode, then go to Step 2.

   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to DISPLAY TEST (Upper Case).

| DISPLAY TEST        | output input led target | → | button DISP | ——— | ———— | | <- com1 com2 com3 clock | ——— | ———— | | ———— | led cal factory |

If DISP is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select DISP.

3. Press ENTER, the unit will display a sequence of test characters until EXIT is pushed.

4. After the test has cycled through completely, press EXIT to return to the Diagnostic Menu.

5. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT. PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

**COM1/COM2 Loopback Test**

The COM1 LOOPBACK TEST menu allows the user to test the front-panel RS-232 port. COM2 LOOPBACK TEST menu tests the rear panel RS-232 port.

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

**M-3425A**

| COM1/COM2 |
| DB9P |
| RX | 2 |
| TX | 3 |
| | 4 |
| SGND | 5 |
| | 6 |
| RTS | 7 |
| CTS | 8 |
| | 9 |

*Figure 6-11  COM1/COM2 Loopback Plug*
1. If the relay is already in the Diagnostic Mode, then go to Step 2. If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to COM1 LOOPBACK TEST (Upper Case).

3. Press ENTER. The following is displayed:

4. Connect the loop-back plug to COM1, the front-panel RS-232C connector.

5. Press ENTER, the relay will initiate the loopback test. If the COM Port passes the loopback test the following will be displayed:

6. Press EXIT to return to the DIAGNOSTIC Menu.

7. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing EXIT. PRESS EXIT TO EXIT DIAGNOSTIC MODE is displayed, then press EXIT a second time.

8. Ensure that the Diagnostic Menu is selected to COM2 LOOPBACK TEST (Upper Case).

If COM2 is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select COM2.

8. Press ENTER, then repeat Steps 3 through 6 for COM2.

**COM3 Test (2-Wire)**

The COM3 Echo Test 2-Wire allows the user to test the RS-485 rear terminal connections for proper operation.

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

1. If the relay is already in the Diagnostic Mode, then go to Step 2. If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to COM3 ECHO TEST 2 WIRE (Upper Case).

3. Press ENTER. The following is displayed:
4. From the rear of the unit, connect a PC to the relay at terminals 3(-) and 4(+) using an RS-485 converter set for 2-wire operation. See Figure 6-12 for diagram.

![Diagram](image)

**Figure 6-12  RS-485 2-Wire Testing**

5. Set the following PC communications parameters:
   - Baud Rate: 9600
   - Parity: None
   - Data Bits: 8
   - Stop Bits: 1
   - Duplex: Half

6. Open the terminal emulator program on the PC, then open the COM port for the RS-485 converter.

7. Press a key on the PC keyboard, then verify the following:
   - a. The character pressed is displayed temporarily on the relay display.
   - b. The character pressed is displayed on the PC monitor.

8. When communication has been verified, press **EXIT**, the following is displayed:

   COM3 ECHO TEST 2WIRE
   -DONE-

9. Press **EXIT** to return to the DIAGNOSTIC Menu.

10. Close the COM port on the PC, and exit the terminal program.

11. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing **EXIT**, **PRESS EXIT TO EXIT DIAGNOSTIC MODE** is displayed, then press **EXIT** a second time.

---

**Clock ON/OFF**

This feature provides the user with the ability to either start or stop the clock.

1. If the relay is already in the Diagnostic Mode, then go to Step 2.
   - If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to CLOCK ON/OFF (Upper Case).

   CLOCK START/STOP
   output input led target →
   ← button disp →
   ← com1 com2 com3 CLOCK →
   ← led cal factory

   If CLOCK is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select CLOCK.

   **NOTE:** '80' will be displayed in the seconds place when the clock is stopped.

3. Press **ENTER**, the following is displayed:
   - a. If the clock is already running the following will be displayed and will continue to update.

   CLOCK TEST
   01-Jan-2003 01:01:01

   b. If the clock was NOT running the following will be displayed:

   CLOCK TEST
   01-Jan-2003 01:01:80

4. To start or stop the clock press **ENTER**, the following is displayed:
   - a. If the clock is already running the following will be displayed:

   CLOCK TEST
   CLOCK STOP
   CLOCK TEST
   01-Jan-2003 01:01:80
b. If the clock was NOT running the following will be displayed:

```
CLOCK TEST
CLOCK START
CLOCK TEST
01-Jan-2003 01:01:01
```

**NOTE:** To preserve battery life the clock should be OFF if the unit is to be left de-energized for a long period of time.

5. The clock can be toggled ON or OFF by pressing any arrow pushbutton or **ENTER**.

To exit the Clock ON/OFF mode press **EXIT**, the following will be displayed:

```
CLOCK TEST
-DONE-
```

6. To exit the CLOCK ON/OFF Diagnostic Menu press **EXIT**.

7. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing **EXIT**, **PRESS EXIT TO EXIT DIAGNOSTIC MODE** is displayed, then press **EXIT** a second time.

**Auto Calibration**

Refer to the following Section 6.4, Auto Calibration, for more information on that function.

**Factory Use Only**

This function is provided to allow access by factory personnel.

```
AUTO CALIBRATION
← clock led cal FACTORY
```

**Relay OK LED Flash/Illuminated**

This feature provides the user with the ability to set the relay OK LED to either Flash or be Illuminated when the relay is working properly.

1. If the relay is already in the Diagnostic Mode, then go to Step 2.

   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to FLASH RELAY OK LED (Upper Case).

```
FLASH RELAY OK LED
output input led target →
← button disp →
← com1 com2 com3 clock →
← LED cal factory
```

If LED (to the left of cal) is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select LED.

3. Press **ENTER**, the following will be displayed:

```
FLASH RELAY OK LED
OFF on
```

4. Select (upper case) either ON (to flash) or OFF (to illuminate) by pressing the right/left arrow pushbutton once.

5. Press **ENTER**, the following will be displayed:

```
FLASH RELAY OK LED
-DONE-
```

6. To exit the FLASH RELAY OK LED Diagnostic Menu press **EXIT**.

7. If all Diagnostic Testing is complete, then exit the diagnostic menu by pressing **EXIT**, **PRESS EXIT TO EXIT DIAGNOSTIC MODE** is displayed, then press **EXIT** a second time.
6.4 Auto Calibration

**NOTE:** The M-3425A Generator Protection Relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to initial installation. However, in-system calibration of the 64F function may be needed for units purchased with the 64F Field Ground option. Calibration can be initiated using the HMI or IPSutil™ program.

Phase and Neutral Fundamental Calibration

1. If the relay is already in the Diagnostic Mode, then go to Step 2.
   
   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to CAL (upper case).

   ![FLASH RELAY OK LED output input led target → ← button disp ← com1 com2 com3 clock → ← led CAL factory](image)

   If CAL is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select CAL.

3. Press **ENTER**, the following will be displayed:

   60 HZ CALIBRATION
   60_HZ field_gnd

4. Ensure that the 60 HZ Calibration Menu is selected to 60_HZ (Upper Case).

   If 60_HZ is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select 60_HZ.

5. Press **ENTER**, the following will be displayed:

   60 HZ CALIBRATION
   NOM_F 3rdh_F 64s_f

6. Ensure that NOM_F is selected (Upper Case).

   If NOM_F is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select NOM_F.

7. Press **ENTER**, the following will be displayed:

   **CONNECT REFERENCE INPUTS**
   PRESS ENTER TO CALIBRATE

8. Connect $V_A = V_B = V_C = V_N = V_X = 120.0$ (±0.01) V at 0° phase. (See Figure 6-14.)

9. Connect $I_a=I_b=I_c=I_n^* = 5.00$ Amps at 0° (see Figure 6-13).

   **For a 1 A CT rating, use 1 A.

   *If 64S is purchased, do not put nominal current in the IN channel. The IN input is calibrated separately (see 64S procedure.)

The calibration can be verified by exiting from the Diagnostic menu and reading status:

$V_A = V_B = V_C = V_N = V_X = 120$ V

$I_a = I_b = I_c = 5$ A

Real=1 pu Reactive=0.0 pu

Power Factor = 1.0

$I_{diff} = I_{diff} = 0$

Where subscript 0, 1, and 2 represent zero, positive, and negative sequence quantities, respectively.

**For a 1 A CT rating, use 1 A.

**NOTE:** The phase angle difference between voltage and current input source should be 0°, ±0.05°, and an accurate low-distortion source should be used. (THD less than 1%).

10. Press **ENTER**, the following will be displayed while the relay is being calibrated:

   **CALIBRATING**
   WAIT

   When the calibration is complete, the following will be displayed:

   **CALIBRATING**
   **DONE**

11. Remove the calibration source inputs.
Third Harmonic Calibration

1. If it is desired to calibrate the third harmonic only and the relay is already in the Diagnostic Mode, then go to Step 2.

If it is desired to calibrate the third harmonic only and the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to CAL (upper case).

FLASH RELAY OK LED
output input led target →
← button disp →
← com1 com2 com3 clock →
← led CAL factory

If CAL is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select CAL.

3. Press ENTER, the following will be displayed:

60 HZ CALIBRATION
60_HZ field_gnd

4. Ensure that the 60 HZ Calibration Menu is selected to 60_HZ (Upper Case).

If 60_HZ is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select 60_HZ.

5. Press ENTER, the following will be displayed:

60 HZ CALIBRATION
nom_f 3RDH_F 64s_f

6. Ensure that 3RDH_F is selected (Upper Case).

If 3RDH_F is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select 3RDH_F.

7. Press ENTER, the following will be displayed:

INPUT 180 HZ
PRESS ENTER TO CALIBRATE

(150 Hz for 50 Hz units)

8. Connect Voltage Inputs as follows:
   a. Connect \( V_N = V_X = 10.0 \text{ V}, \text{ 180 Hz} \) (150 Hz for 50 Hz units). See Figure 6-15.
   b. Connect \( V_A = V_B = V_C = 120.0 \text{ V}, \text{ 180 Hz} \) (150 Hz for 50 Hz units). See Figure 6-16.

9. Press ENTER, the following will be displayed while the Third Harmonic is calibrated:

CALIBRATING
WAIT

When the calibration is complete, the following will be displayed:

AUTO CALIBRATION
DONE

10. Remove the voltage from \( V_N \) and \( V_X \).

11. Remove the calibration source inputs.

64S 100% Stator Ground by Low Frequency Injection Calibration

1. If it is desired to calibrate the 64S 100% Stator Ground by Low Frequency Injection only and the relay is already in the Diagnostic Mode, then go to Step 2.

If it is desired to calibrate the 64S 100% Stator Ground by Low Frequency Injection only and the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 2.

2. Ensure that the Diagnostic Menu is selected to CAL (upper case).

FLASH RELAY OK LED
output input led target →
← button disp →
← com1 com2 com3 clock →
← led CAL factory

If CAL is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select CAL.

3. Press ENTER, the following will be displayed:

60 HZ CALIBRATION
60_HZ field_gnd

4. Ensure that the 60 HZ Calibration Menu is selected to 60_HZ (Upper Case).

If 60_HZ is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select 60_HZ.
5. Press **ENTER**, the following will be displayed:

```
60 HZ CALIBRATION
nom_f 3rdh_f 64S_F
```

6. Ensure that 64S_F is selected (Upper Case).
   
   If 64S_F is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select 64S_F.

7. Press **ENTER**, the following will be displayed:

```
INPUT 20 HZ
PRESS ENTER TO CALIBRATE
```

8. Connect \( V_N = 20.0 \text{ V} \) (±0.01 V) 20 Hz, \( I_N = 20.0 \text{ mA} \) (±0.01 mA) 20 Hz. See Figure 6-6.

9. Press **ENTER**, the following will be displayed:

```
CALIBRATING
WAIT
```

When the calibration is complete, the following will be displayed:

```
CALIBRATING
DONE
```

10. Remove the voltage from \( V_N \) and \( I_N \).

11. Remove the calibration source inputs.

---

**Field Ground Calibration**

Field Ground Calibration only applies to units purchased with the 64F Field Ground option. Calibration is necessary for long cable lengths (greater than 100 feet) to compensate for cabling losses from the M-3425A and the M-3921 Coupler module, and therefore should be accomplished in system, after all wiring is complete.

1. Connect the M-3921 Field Ground Coupler box as shown in Figure 6-7, Field Ground Coupler.

2. If the relay is already in the Diagnostic Mode, then go to Step 3.
   
   If the relay is NOT in the Diagnostic Mode, then enter the relay diagnostic mode by performing the steps described in the Entering Relay Diagnostic Mode section of this chapter, then go to Step 3.

3. Ensure that the Diagnostic Menu is selected to CAL (upper case).

```
FLASH RELAY OK LED
output input led target →
← button disp →
← com1 com2 com3 clock →
← led CAL factory
```

If CAL is not selected (Upper Case), then use the Right/Left arrow pushbuttons to select CAL.

4. Press **ENTER**, the following will be displayed:

```
60 HZ CALIBRATION
60_HZ field_gnd
```

5. Ensure that the 60 HZ Calibration Menu is selected to FIELD_GND (Upper Case).
   
   If FIELD_GND is not selected (Upper Case), then use the Right arrow pushbutton to select FIELD_GND.

6. Press **ENTER**, the following will be displayed:

```
CONNECT 1 KOHM REF.
PRESS ENTER TO CALIBRATE
```

7. Set the decade box for 1 k\( \Omega \) resistance, then press **ENTER**, the following will be displayed:

```
CALIBRATING
WAIT
```

8. When the calibration is complete the following will be displayed:

```
CALIBRATING
DONE
```

9. Press **ENTER**, the unit will display the next resistance in the calibration sequence to be tested.

10. Set the decade box to the resistance specified by the HMI, then press **ENTER**. When the display shows DONE press **ENTER**.

11. Repeat Step 10 until the calibration is complete for 100 k\( \Omega \).

12. Press **EXIT** twice to exit the Diagnostic Mode.
Figure 6-13  Current Input Configuration

Figure 6-14  Voltage Input Configuration

Figure 6-15  Voltage Input Configuration
Figure 6-16  Voltage Input Configuration
Appendix A – Configuration Record Forms

This Appendix contains photocopy-ready forms for recording the configuration and setting of the M-3425A Generator Protection Relay. The forms can be supplied to field service personnel for configuring the relay, and kept on file for future reference.

A copy of the *Relay Configuration Table* (Table A-1) is provided to define and record the blocking inputs and output configuration. For each function; check the D (disabled) column or check the output contacts to be operated by the function, and check the inputs designated to block the function operation.

Figure A-2, Communication Data & Unit Setup Record Form reproduces the Communication and Setup unit menus. This form records definition of the parameters necessary for communication with the relay, as well as access codes, user logo lines, date & time setting, and front panel display operation.

Figure A-3, Functional Configuration Record Form reproduces the Configure Relay menus. For each function or setpoint, refer to the configuration you have defined using the Relay Configuration Table, and circle whether it should be enabled or disabled, the output contacts it will activate, and the inputs that will block its operation.

Figure A-4, Setpoint & Timing Record Form allows recording of the specific values entered for each enabled setpoint or function. The form follows the main menu selections of the relay.

Unpurchased or unavailable functions will not be visible within the menus. If a function is DISABLED, the input/output screens for that function will not be displayed.
Check each box applicable: ✓  (See page A-1 for information on using this table.)

**D Column** = Function Disabled.

**OUTPUTS Columns** = Designated function output(s)

**fl Column** = Function blocked by fuse loss.

**INPUTS Columns** = Designated function blocking input(s)

Table A-1  Relay Configuration Table (page 1 of 4)
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>D</th>
<th>OUTPUTS</th>
<th>INPUTS</th>
</tr>
</thead>
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<tr>
<td>60FL</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>87GD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCKT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check each box applicable: ✓ (See page A-1 for information on using this table.)

**D Column** = Function Disabled.
**OUTPUTS Columns** = Designated function output(s)
**fi Column** = Function blocked by fuse loss.
**INPUTS Columns** = Designated function blocking input(s)
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>EXPANDED OUTPUTS</th>
<th>EXPANDED INPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23 22 21 20 19 18 16 15 14 13 12 11 10 9 14 13 12 11 10 9 8 7</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>2</td>
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<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>27TN</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>1</td>
<td></td>
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<td>40</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>DEF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INV</td>
<td></td>
</tr>
<tr>
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<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>50BF</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>50N</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>50DT</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>50/27</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>51N</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>51V</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>59</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>59D</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>59N</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

*Table A-1  Relay Configuration Table (page 3 of 4)*
<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>EXPANDED OUTPUTS</th>
<th>EXPANDED INPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>59X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60FL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>64F</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>67N</td>
<td>DEF</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INV</td>
<td></td>
</tr>
<tr>
<td>64S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>81</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>81A</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
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<tr>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>81R</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>87</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>87GD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TCKT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPS</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
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<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

*Table A-1  Relay Configuration Table - Expanded I/O (page 4 of 4)*
KEY TO INPUT DATA RECORD FORMS

A. All heavily bordered screens are either MENU screens which have horizontal choices (made with right - left arrows) or screens displaying a result of a choice previously made.

B. Dashed boxes enclose screens which bound areas that pushbutton ENTER will move in. In order to move out of one of the dotted boxes it is necessary to either push EXIT or make a menu choice change using the Right - Left arrow.

C. The Up/Down arrows only adjust value or letter (lower/upper case) inputs; they do not move within the menus or between menu displays.

D. The Right/Left arrows are used only to make horizontally displayed choices. These can be either menu choices or input value digit choices. The previous choice or location in a menu is highlighted immediately.

E. The ENTER pushbutton records the setting change (whatever is in that screen when ENTER is pressed will be installed in memory) and moves down within a menu. The operator will notice that after the last menu item, ENTER moves to the top of the same menu but does not change menu positions.

F. Pressing EXIT at any time will exit the display screen to the last screen containing a horizontal choice. (Return to the preceding menu).

G. The symbol → or ← in a screen indicates additional horizontal menu choices are available in the indicated direction. As previously described, the Right and Left arrows will move the operator to those additional choices.

■ NOTE: Unpurchased or unavailable functions will not be visible within the menus.
<table>
<thead>
<tr>
<th>COM1 SETUP</th>
<th>COM3 SETUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM1 BAUD RATE</td>
<td>COM3 DEAD SYNC TIME</td>
</tr>
<tr>
<td>baud_300 baud_600 baud_1200</td>
<td>________ MS</td>
</tr>
<tr>
<td>baud_4800 BAUD_9600</td>
<td></td>
</tr>
<tr>
<td>COM1 PARITY</td>
<td>COM3 PROTOCOL</td>
</tr>
<tr>
<td>none odd even</td>
<td>beco2200 MODBUS</td>
</tr>
<tr>
<td>COM1 STOP BITS</td>
<td>COM3 STOP BITS</td>
</tr>
<tr>
<td>________</td>
<td>________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COM2 SETUP</th>
<th>COM2 SETUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>COM2 BAUD RATE</td>
<td>COM2 DEAD SYNC TIME</td>
</tr>
<tr>
<td>baud_300 baud_600 baud_1200</td>
<td>________ MS</td>
</tr>
<tr>
<td>baud_4800 BAUD_9600</td>
<td></td>
</tr>
<tr>
<td>COM2 PARITY</td>
<td>COM2 PROTOCOL</td>
</tr>
<tr>
<td>none odd even</td>
<td>beco2200 MODBUS</td>
</tr>
<tr>
<td>COM2 STOP BITS</td>
<td>COM2 STOP BITS</td>
</tr>
<tr>
<td>________</td>
<td>________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMMUNICATION ADDRESS</th>
<th>COMMUNICATION ADDRESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>com1 com2 com3 COM_ADR</td>
<td>RESPONSE TIME DELAY</td>
</tr>
<tr>
<td></td>
<td>← DLY accss eth eth_ip</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMM ACCESS CODE</th>
<th>COMM ACCESS CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>← dly ACCSS eth eth_ip</td>
<td>________</td>
</tr>
</tbody>
</table>

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-2  Communication Data & Unit Setup Record Form (page 1 of 3)*
<table>
<thead>
<tr>
<th><strong>COMMUNICATION</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>←targets osc_rec COMM→</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ETHERNET</strong></th>
<th><strong>ETHERNET PROTOCOL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>← dly access ETH eth_ip</td>
<td>tcp PROT</td>
</tr>
<tr>
<td>ETHERNET</td>
<td>SELECT PROTOCOL</td>
</tr>
<tr>
<td>disable ENABLE</td>
<td>modbus serconv</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>TCP/IP SETTINGs</strong></th>
<th><strong>ETHERNET ADDRESS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>TCP prot</td>
<td>← access eth ETH_IP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DHCP PROTOCOL</strong></th>
<th><strong>ETHERNET IP ADDRESS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>disable ENABLE</td>
<td>XX.XX.XX.XX</td>
</tr>
<tr>
<td>DHCP PROTOCOL</td>
<td>After EXIT to Comm menu, the following will be displayed (if any changes have been made in ETHERNET menu)</td>
</tr>
<tr>
<td>DISABLE enable</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>IP ADDRESS</strong></th>
<th><strong>CONFIGURING ETH...</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>ETH_IP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>NET MASK</strong></th>
<th><strong>ETHERNET IP ADDRESS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>XX.XX.XX.XX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>GATEWAY</strong></th>
<th><strong>ETHERNET IP ADDRESS</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>____________</td>
<td>XX.XX.XX.XX</td>
</tr>
</tbody>
</table>

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.
<table>
<thead>
<tr>
<th><strong>SOFTWARE VERSION</strong></th>
<th>VERS sn access number →</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOFTWARE VERSION</td>
</tr>
<tr>
<td></td>
<td>D-xxxxv__.<strong>.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>SERIAL NUMBER</strong></th>
<th>vers SN access number →</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SERIAL NUMBER</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ALTER ACCESS CODES</strong></th>
<th>vers sn access number →</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENTER ACCESS CODE</td>
</tr>
<tr>
<td></td>
<td>LEVEL#1 level#2 level#3</td>
</tr>
<tr>
<td></td>
<td>LEVEL #1</td>
</tr>
<tr>
<td></td>
<td>ENTER ACCESS CODE</td>
</tr>
<tr>
<td></td>
<td>level#1 level#2 level#3</td>
</tr>
<tr>
<td></td>
<td>LEVEL #2</td>
</tr>
<tr>
<td></td>
<td>ENTER ACCESS CODE</td>
</tr>
<tr>
<td></td>
<td>level#1 level#2 level#3</td>
</tr>
<tr>
<td></td>
<td>LEVEL #3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>USER CONTROL NUMBER</strong></th>
<th>vers sn access NUMBER →</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USER CONTROL NUMBER</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>USER LOGO LINE 1</strong></th>
<th>← LOGO1 logo2 out alrm→</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>USER LOGO LINE 2</strong></th>
<th>← logo1 LOGO2 out alrm→</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>CLEAR OUTPUT COUNTERS</strong></th>
<th>← logo1 logo2 OUT alrm→</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLEAR OUTPUT COUNTERS</td>
</tr>
<tr>
<td></td>
<td>PRESS ENTER KEY TO CLEAR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>CLEAR ALARM COUNTER</strong></th>
<th>← logo1 logo2 out ALRM→</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CLEAR ALARM COUNTER</td>
</tr>
<tr>
<td></td>
<td>PRESS ENTER KEY TO CLEAR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>DATE &amp; TIME</strong></th>
<th>←TIME error eth_ver →</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE &amp; TIME</td>
<td>01-Jan-2001 12:00:00</td>
</tr>
<tr>
<td>DATE &amp; TIME</td>
<td>_______ YEAR</td>
</tr>
<tr>
<td>DATE &amp; TIME</td>
<td>_______ DATE</td>
</tr>
<tr>
<td>DATE &amp; TIME</td>
<td>_______ HOUR</td>
</tr>
<tr>
<td>DATE &amp; TIME</td>
<td>_______ MINUTES</td>
</tr>
<tr>
<td>DATE &amp; TIME</td>
<td>_______ SECONDS</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th><strong>CLEAR ERROR CODES</strong></th>
<th>← time ERROR eth_ver →</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLEAR ERROR CODES</td>
<td>PRESS ENTER KEY TO CLEAR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>ETHERNET FIRMWARE VER</strong></th>
<th>← time error ETH_VER →</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETHERNET FIRMWARE VER</td>
<td>D-<strong><strong>v</strong>.</strong>.<em>.</em>._</td>
</tr>
</tbody>
</table>

| **DIAGNOSTIC MODE**      | ← DIAG                 |
|                          | PROCESSOR WILL RESET!  |
|                          | ENTER KEY TO CONTINUE   |

Figure A-2  Communication Data & Unit Setup Record Form (page 3 of 3)
### CONFIGURE RELAY

#### 27 #1 PHASE UNDERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

#### 59 #1 PHASE OVERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

#### 27 #2 PHASE UNDERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

#### 59 #2 PHASE OVERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

#### 27 #3 PHASE UNDERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

#### 59 #3 PHASE OVERVOLTAGE
- **Enable**: ENABLE
- **Inputs**: f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12
- **Outputs**: o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

---

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (1 of 18)*
### CONFIGURE RELAY

**VOLTAGE_RELAY**

<table>
<thead>
<tr>
<th>27TN #1 NEUTRAL UNDERVOLT</th>
<th>59X #2 OVERVOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>disable ENABLE</td>
<td>disable ENABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>27TN #1 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>27TN #1 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59X #2 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59X #2 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>27TN #2 NEUTRAL UNDERVOLT</th>
<th>59N #1 OVERVOLTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>disable ENABLE</td>
<td>disable ENABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>27TN #2 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>27TN #2 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59N #1 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59N #1 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59X #1 OVERVOLTAGE</th>
<th>59N #1 NEUTRAL OVERVOLT</th>
</tr>
</thead>
<tbody>
<tr>
<td>disable ENABLE</td>
<td>disable ENABLE</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59X #1 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59X #1 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59N #1 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
<tr>
<td>i11 i10 i9 i8 i7</td>
</tr>
<tr>
<td>i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>59N #1 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
<tr>
<td>014 013 012 011 010 09</td>
</tr>
<tr>
<td>019 018 017 016 015</td>
</tr>
<tr>
<td>023 022 021 020</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

**Figure A-3** Functional Configuration Record Form (2 of 18)
Figure A-3  Functional Configuration Record Form (3 of 18)

NOTE: Unpurchased or unavailable functions will not be visible within the menus.
Figure A-3  Functional Configuration Record Form (4 of 18)

NOTE: Unpurchased or unavailable functions will not be visible within the menus.
**50DT#1 DEF TIME OVERCURR**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**50DT#2 DEF TIME OVERCURR**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**50N NTRL INST OVERCURRNT**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**51N NTRL OVERCURRNT INV**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**49#1 STATOR OVERLOAD**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**49#2 STATOR OVERLOAD**

- **Block Input**:
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **Relay Output**:
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.
### 51V OVERCURRENT INV
**Disable**: ENABLE

**51V BLOCK INPUT**
- f1, i6, i5, i4, i3, i2, i1
- i11, i10, i9, i8, i7
- i14, i13, i12

**51V RELAY OUTPUT**
- 08, 07, 06, 05, 04, 03, 02, 01
- 014, 013, 012, 011, 010, 009
- 019, 018, 017, 016, 015
- 023, 022, 021, 020

### 87GD GND DIFFERENTIAL
**Disable**: ENABLE

**87GD BLOCK INPUT**
- f1, i6, i5, i4, i3, i2, i1
- i11, i10, i9, i8, i7
- i14, i13, i12

**87GD RELAY OUTPUT**
- 08, 07, 06, 05, 04, 03, 02, 01
- 014, 013, 012, 011, 010, 009
- 019, 018, 017, 016, 015
- 023, 022, 021, 020

### 87 #1 DIFF CURRENT
**Disable**: ENABLE

**87 #1 BLOCK INPUT**
- f1, i6, i5, i4, i3, i2, i1
- i11, i10, i9, i8, i7
- i14, i13, i12

**87 #1 RELAY OUTPUT**
- 08, 07, 06, 05, 04, 03, 02, 01
- 014, 013, 012, 011, 010, 009
- 019, 018, 017, 016, 015
- 023, 022, 021, 020

### 67NDT RES DIR OVERCURR
**Disable**: ENABLE

**67NDT BLOCK INPUT**
- f1, i6, i5, i4, i3, i2, i1
- i11, i10, i9, i8, i7
- i14, i13, i12

**67NDT RELAY OUTPUT**
- 08, 07, 06, 05, 04, 03, 02, 01
- 014, 013, 012, 011, 010, 009
- 019, 018, 017, 016, 015
- 023, 022, 021, 020

### 67NIT RES DIR OVERCURR
**Disable**: ENABLE

**67NIT BLOCK INPUT**
- f1, i6, i5, i4, i3, i2, i1
- i11, i10, i9, i8, i7
- i14, i13, i12

**67NIT RELAY OUTPUT**
- 08, 07, 06, 05, 04, 03, 02, 01
- 014, 013, 012, 011, 010, 009
- 019, 018, 017, 016, 015
- 023, 022, 021, 020

---

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (6 of 18)*
**81 #4 FREQUENCY**

disable ENABLE

**81 #4 BLOCK INPUT**

f1 i6 i5 i4 i3 i2 i1
i11 i10 19 i8 i7
i14 i13 i12

**81 #4 RELAY OUTPUT**

o8 07 06 05 04 03 02 01
o14 o13 o12 o11 o10 09
o19 o18 o17 o16 o15
o23 o22 o21 o20

**81R #1 RATE OF CHNG FREQ**

disable ENABLE

**81R #1 BLOCK INPUT**

f1 i6 i5 i4 i3 i2 i1
i11 i10 19 i8 i7
i14 i13 i12

**81R #1 RELAY OUTPUT**

o8 07 06 05 04 03 02 01
o14 o13 o12 o11 o10 09
o19 o18 o17 o16 o15
o23 o22 o21 o20

**81R #2 RATE OF CHNG FREQ**

disable ENABLE

**81R #2 BLOCK INPUT**

f1 i6 i5 i4 i3 i2 i1
i11 i10 19 i8 i7
i14 i13 i12

**81R #2 RELAY OUTPUT**

o8 07 06 05 04 03 02 01
o14 o13 o12 o11 o10 09
o19 o18 o17 o16 o15
o23 o22 o21 o20

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.*
**Configure Relay**

81A #1 Freq Accumulator

disable ENABLE

81A #1 Block Input

\[
\begin{array}{ccccccc}
\text{f1} & \text{i6} & \text{i5} & \text{i4} & \text{i3} & \text{i2} & \text{i1} \\
n11 & n10 & n9 & n8 & n7 & n6 & n5
\end{array}
\]

81A #1 Relay Output

\[
\begin{array}{cccccccc}
o8 & o7 & o6 & o5 & o4 & o3 & o2 & o1 \\
o14 & o13 & o12 & o11 & o10 & o9 & o19 & o18 & o17 & o16 & o15 & o23 & o22 & o21 & o20
\end{array}
\]

81A #2 Freq Accumulator

disable ENABLE

81A #2 Block Input

\[
\begin{array}{ccccccc}
\text{f1} & \text{i6} & \text{i5} & \text{i4} & \text{i3} & \text{i2} & \text{i1} \\
n11 & n10 & n9 & n8 & n7 & n6 & n5
\end{array}
\]

81A #2 Relay Output

\[
\begin{array}{cccccccc}
o8 & o7 & o6 & o5 & o4 & o3 & o2 & o1 \\
o14 & o13 & o12 & o11 & o10 & o9 & o19 & o18 & o17 & o16 & o15 & o23 & o22 & o21 & o20
\end{array}
\]

81A #3 Freq Accumulator

disable ENABLE

81A #3 Block Input

\[
\begin{array}{ccccccc}
\text{f1} & \text{i6} & \text{i5} & \text{i4} & \text{i3} & \text{i2} & \text{i1} \\
n11 & n10 & n9 & n8 & n7 & n6 & n5
\end{array}
\]

81A #3 Relay Output

\[
\begin{array}{cccccccc}
o8 & o7 & o6 & o5 & o4 & o3 & o2 & o1 \\
o14 & o13 & o12 & o11 & o10 & o9 & o19 & o18 & o17 & o16 & o15 & o23 & o22 & o21 & o20
\end{array}
\]

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

Figure A-3 Functional Configuration Record Form (8 of 18)
**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3 Functional Configuration Record Form (9 of 18)*
CONFIGURE RELAY

<table>
<thead>
<tr>
<th>CONFIG sys stat</th>
</tr>
</thead>
</table>

### 32 #1 DIRECTIONAL POWER
disable  ENABLE

### 32 #1 BLOCK INPUT
f1  i6  i5  i4  i3  i2  i1
i11  i10  i9  i8  i7  i14  i13  i12

### 32 #1 RELAY OUTPUT
o8  o7  o6  o5  o4  o3  o2  o1
o14  o13  o12  o11  o10  o9  o19  o18  o17  o16  o15
o23  o22  o21  o20

### 32 #2 DIRECTIONAL POWER
disable  ENABLE

### 32 #2 BLOCK INPUT
f1  i6  i5  i4  i3  i2  i1
i11  i10  i9  i8  i7  i14  i13  i12

### 32 #2 RELAY OUTPUT
o8  o7  o6  o5  o4  o3  o2  o1
o14  o13  o12  o11  o10  o9  o19  o18  o17  o16  o15
o23  o22  o21  o20

### 32 #3 DIRECTIONAL POWER
disable  ENABLE

### 32 #3 BLOCK INPUT
f1  i6  i5  i4  i3  i2  i1
i11  i10  i9  i8  i7  i14  i13  i12

### 32 #3 RELAY OUTPUT
o8  o7  o6  o5  o4  o3  o2  o1
o14  o13  o12  o11  o10  o9  o19  o18  o17  o16  o15
o23  o22  o21  o20

Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (10 of 18)*
### CONFIGURE RELAY

<table>
<thead>
<tr>
<th>40 #1 LOSS OF FIELD</th>
<th>40 #2 LOSS OF FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>disable ENABLE</td>
<td>disable ENABLE</td>
</tr>
</tbody>
</table>

**CONFIG sys stat**

<table>
<thead>
<tr>
<th>40 #1 BLOCK INPUT</th>
<th>40 #2 BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
<td>i11 i10 i9 i8 i7 i14 i13 i12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>40 #1 RELAY OUTPUT</th>
<th>40 #2 RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
<td>o14 o13 o12 o11 o10 o9 o19 o18 o17 o16 o15 o23 o22 o21 o20</td>
</tr>
</tbody>
</table>

### 40VC #2 LOF WITH VC

<table>
<thead>
<tr>
<th>disable ENABLE</th>
</tr>
</thead>
</table>

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

---

**CONFIGURE RELAY**

<table>
<thead>
<tr>
<th>60FL V.T. FUSE LOSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>disable enable</td>
</tr>
</tbody>
</table>

**CONFIG sys stat**

<table>
<thead>
<tr>
<th>60FL BLOCK INPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>f1 i6 i5 i4 i3 i2 i1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>60FL RELAY OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>o8 o7 o6 o5 o4 o3 o2 o1</td>
</tr>
</tbody>
</table>

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.
### 21 #1 PHASE DISTANCE
- **Disableable**: ENABLE
- **Input Block**: f1 i6 i5 i4 i3 i2 i1
- **Output Block**: o8 o7 o6 o5 o4 o3 o2 o1

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>i11 i10 i9 i8 i7</td>
<td>o14 o13 o12 o11 o10 o9</td>
</tr>
<tr>
<td>i14 i13 i12</td>
<td>o19 o18 o17 o16 o15</td>
</tr>
<tr>
<td>o23 o22 o21 o20</td>
<td>o23 o22 o21 o20</td>
</tr>
</tbody>
</table>

### 21 #2 PHASE DISTANCE
- **Disableable**: ENABLE
- **Input Block**: f1 i6 i5 i4 i3 i2 i1
- **Output Block**: o8 o7 o6 o5 o4 o3 o2 o1

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>i11 i10 i9 i8 i7</td>
<td>o14 o13 o12 o11 o10 o9</td>
</tr>
<tr>
<td>i14 i13 i12</td>
<td>o19 o18 o17 o16 o15</td>
</tr>
<tr>
<td>o23 o22 o21 o20</td>
<td>o23 o22 o21 o20</td>
</tr>
</tbody>
</table>

### 21 #3 PHASE DISTANCE
- **Disableable**: ENABLE
- **Input Block**: f1 i6 i5 i4 i3 i2 i1
- **Output Block**: o8 o7 o6 o5 o4 o3 o2 o1

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>i11 i10 i9 i8 i7</td>
<td>o14 o13 o12 o11 o10 o9</td>
</tr>
<tr>
<td>i14 i13 i12</td>
<td>o19 o18 o17 o16 o15</td>
</tr>
<tr>
<td>o23 o22 o21 o20</td>
<td>o23 o22 o21 o20</td>
</tr>
</tbody>
</table>

### 78 OUT OF STEP
- **Disableable**: ENABLE
- **Input Block**: f1 i6 i5 i4 i3 i2 i1
- **Output Block**: o8 o7 o6 o5 o4 o3 o2 o1

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>i11 i10 i9 i8 i7</td>
<td>o14 o13 o12 o11 o10 o9</td>
</tr>
<tr>
<td>i14 i13 i12</td>
<td>o19 o18 o17 o16 o15</td>
</tr>
<tr>
<td>o23 o22 o21 o20</td>
<td>o23 o22 o21 o20</td>
</tr>
</tbody>
</table>

---

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (12 of 18)*
Figure A-3  Functional Configuration Record Form (13 of 18)
### BM BREAKER MONITOR

- **disable**
- **ENABLE**

**BM BLOCK INPUT**

<table>
<thead>
<tr>
<th>i14</th>
<th>i13</th>
<th>i12</th>
</tr>
</thead>
<tbody>
<tr>
<td>i11</td>
<td>i10</td>
<td>i9</td>
</tr>
<tr>
<td>i14</td>
<td>i13</td>
<td>i12</td>
</tr>
</tbody>
</table>

**BM RELAY OUTPUT**

<table>
<thead>
<tr>
<th>o23</th>
<th>o22</th>
<th>o21</th>
<th>o20</th>
</tr>
</thead>
<tbody>
<tr>
<td>o14</td>
<td>o13</td>
<td>o12</td>
<td>o11</td>
</tr>
<tr>
<td>o19</td>
<td>o18</td>
<td>o17</td>
<td>o16</td>
</tr>
</tbody>
</table>

### TCM TRIP CIRCUIT MON

- **disable**
- **ENABLE**

**TCM BLOCK INPUT**

<table>
<thead>
<tr>
<th>i11</th>
<th>i10</th>
<th>i9</th>
<th>i8</th>
<th>i7</th>
</tr>
</thead>
<tbody>
<tr>
<td>i14</td>
<td>i13</td>
<td>i12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TCM RELAY OUTPUT**

<table>
<thead>
<tr>
<th>o23</th>
<th>o22</th>
<th>o21</th>
<th>o20</th>
</tr>
</thead>
<tbody>
<tr>
<td>o14</td>
<td>o13</td>
<td>o12</td>
<td>o11</td>
</tr>
<tr>
<td>o19</td>
<td>o18</td>
<td>o17</td>
<td>o16</td>
</tr>
</tbody>
</table>

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (14 of 18)*

Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.
Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.

NOTE: Unpurchased or unavailable functions will not be visible within the menus.
**INPUT ACTIVATED PROFILES**

IN ap cpy volt curr vt →

disable ENABLE

**ACTIVE SETPOINT PROFILE**

in AP cpy volt curr vt →

**COPY ACTIVE PROFILE**

in ap CPY volt curr vt →

**NOMINAL VOLTAGE**

in ap cpy VOLT curr vt →

**NOMINAL CURRENT**

in ap cpy volt CURR vt →

**V.T. CONFIGURATION**

in ap cpy volt curr VT →

line_line line_ground → line_gnd_to_line_line

**DELTA-Y TRANSFORM**

← D_YTX rot mag splt→

dis delta_ab delta_ac

**PHASE ROTATION**

← d_ytx ROT mag splt→

a-c-b a-b-c

**59/27 MAGNITUDE SELECT**

← d_ytx rot MAG splt→

r ms d ft

**50DT SPLIT-PHASE DIFF**

← d_ytx rot mag splt→

disable enable

**PULSE RELAY**

← PLSE latch seal in→

**LATCHED OUTPUTS**

← plse LATCH seal in→

Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.

NOTE: Unpurchased or unavailable functions will not be visible within the menus.

Figure A-3 Functional Configuration Record Form (16 of 18)
**RELAY SEAL-IN TIME**

1. Please latch SEAL in→

<table>
<thead>
<tr>
<th>RELAY SEAL-IN TIME OUT1</th>
<th>&gt;&gt;&gt; Cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>RELAY SEAL-IN TIME OUT2</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT3</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT4</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT5</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT6</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT7</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT8</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT9</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT10</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
<tr>
<td>RELAY SEAL-IN TIME OUT11</td>
<td>&gt;&gt;&gt; Cycles</td>
</tr>
</tbody>
</table>

| RELAY SEAL-IN TIME OUT12| >>> Cycles |
| RELAY SEAL-IN TIME OUT13| >>> Cycles |
| RELAY SEAL-IN TIME OUT14| >>> Cycles |
| RELAY SEAL-IN TIME OUT15| >>> Cycles |
| RELAY SEAL-IN TIME OUT16| >>> Cycles |
| RELAY SEAL-IN TIME OUT17| >>> Cycles |
| RELAY SEAL-IN TIME OUT18| >>> Cycles |
| RELAY SEAL-IN TIME OUT19| >>> Cycles |
| RELAY SEAL-IN TIME OUT20| >>> Cycles |
| RELAY SEAL-IN TIME OUT21| >>> Cycles |
| RELAY SEAL-IN TIME OUT22| >>> Cycles |
| RELAY SEAL-IN TIME OUT23| >>> Cycles |

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3  Functional Configuration Record Form (17 of 18)*

Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.
**ACTIVE INPUT STATE**

\[ \text{plse latch seal IN} \]

**ACTIVE INPUT OPEN/close**

f1 f6 i6 i4 i3 i2 i1
i11 i10 i9 i8 i7
i14 i13 i12

**V.T. PHASE RATIO**

\[ \text{VT vt_n vt_x ct ct_n} \]

**V.T. PHASE RATIO**

\[ \underline{\text{_____ :1}} \]

**V.T. NEUTRAL RATIO**

\[ \text{vt VT_N vt_x ct ct_n} \]

**V.T. NEUTRAL RATIO**

\[ \underline{\text{_____ :1}} \]

**V.T. VX RATIO**

\[ \text{vt vt_n VT_X ct ct_n} \]

**V.T. VX RATIO**

\[ \underline{\text{_____ :1}} \]

**C.T. PHASE RATIO**

\[ \text{vt vt_n vt_x CT ct_n} \]

**C.T. PHASE RATIO**

\[ \underline{\text{_____ :1}} \]

**C.T. NEUTRAL RATIO**

\[ \text{VT vt_n vt_x CT CT_N} \]

**C.T. NEUTRAL RATIO**

\[ \underline{\text{_____ :1}} \]

---

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-3 Functional Configuration Record Form (18 of 18)*
<table>
<thead>
<tr>
<th><strong>27 PHASE UNDervoltage</strong></th>
<th><strong>59 PHASE OVervoltage</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PHASE_UNDER</strong> →</td>
<td><strong>PHASE_OVER</strong> →</td>
</tr>
<tr>
<td>27 #1 PICKUP</td>
<td>59 #1 INPUT VOLTAGE SEL</td>
</tr>
<tr>
<td>__________ Volts</td>
<td>phase_volT pos_seq_volt</td>
</tr>
<tr>
<td>27 #1 DELAY</td>
<td>59 #1 PICKUP</td>
</tr>
<tr>
<td>__________ Cycles</td>
<td>__________ Volts</td>
</tr>
<tr>
<td>27 #2 PICKUP</td>
<td>59 #1 DELAY</td>
</tr>
<tr>
<td>__________ Volts</td>
<td>__________ Cycles</td>
</tr>
<tr>
<td>27 #2 DELAY</td>
<td>59 #2 INPUT VOLTAGE SEL</td>
</tr>
<tr>
<td>__________ Cycles</td>
<td>phase_volT pos_seq_volt</td>
</tr>
<tr>
<td>27 #3 PICKUP</td>
<td>59 #2 PICKUP</td>
</tr>
<tr>
<td>__________ Volts</td>
<td>__________ Volts</td>
</tr>
<tr>
<td>27 #3 DELAY</td>
<td>59 #2 DELAY</td>
</tr>
<tr>
<td>__________ Cycles</td>
<td>__________ Cycles</td>
</tr>
<tr>
<td>27 #3 PICKUP</td>
<td>59 #3 INPUT VOLTAGE SEL</td>
</tr>
<tr>
<td>__________ Volts</td>
<td>phase_volT pos_seq_volt</td>
</tr>
<tr>
<td>27 #3 DELAY</td>
<td>59 #3 PICKUP</td>
</tr>
<tr>
<td>__________ Cycles</td>
<td>__________ Volts</td>
</tr>
<tr>
<td>27 #3 DELAY</td>
<td>59 #3 DELAY</td>
</tr>
<tr>
<td>__________ Cycles</td>
<td>__________ Cycles</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4 Setpoint & Timing Record Form (1 of 15)*
<table>
<thead>
<tr>
<th>Item</th>
<th>Setting 1</th>
<th>Setting 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>27TN #1 Pickup</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 POS SEQ Volt BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 POS SEQ Volt BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Fwd Power BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Fwd Power BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Rev Power BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Rev Power BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Lead Var BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Lead Var BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Lag Var BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Lag Var BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Lead PF BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Lead PF BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Lag PF BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Lag PF BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Band Fwd Pwr BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Band Fwd Pwr BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Lo B Fwd Pwr BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Lo B Fwd Pwr BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Hi B Fwd Pwr BLK</td>
<td>disable</td>
<td>ENABLE</td>
</tr>
<tr>
<td>27TN #1 Hi B Fwd Pwr BLK</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>27TN #1 Delay</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

Figure A-4  Setpoint & Timing Record Form (2 of 15)
**VOLTAGE RELAY**

VOLT curr freq v/Hz →

### 59X OVERVOLTAGE

- **59X #1 PICKUP**
  - ________ Volts
- **59X #1 DELAY**
  - ________ Cycles
- **59X #2 PICKUP**
  - ________ Volts
- **59X #2 DELAY**
  - ________ Cycles

### 59N NEUTRAL OVERVOLTAGE

- **59N #1 PICKUP**
  - ________ Volts
- **59N #1 DELAY**
  - ________ Cycles
- **59N #2 PICKUP**
  - ________ Volts
- **59N #2 DELAY**
  - ________ Cycles
- **59N #3 PICKUP**
  - ________ Volts
- **59N #3 DELAY**
  - ________ Cycles
- **59N 20HZ INJECTION MODE**
  - disable ENABLE

### 59D VOLT DIFF 3RD HAR

- **59D RATIO**
  - ________
- **59D LINE SIDE VOLTAGE**
  - 3vo vx
- **59D POS SEQ VOLT BLK**
  - disable ENABLE
- **59D POS SEQ VOLT BLK**
  - ________ VOLTS
- **59D DELAY**
  - ________ Cycles

---

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (3 of 15)*
## Appendix A

### 50/27 INADVERTANT ENRGNG

- **INADVTNT_ENG brk_fail**
- **PICKUP**
  - _______ Amps
- **VOLTAGE CONTROL**
  - _______ Volts
- **PICKUP DELAY**
  - _______ Cycles
- **DROPOUT DELAY**
  - _______ Cycles

### 46 NEG SEQ OVERCURRENT

- **NEG_SEQ inst**
  - **PICKUP**
    - _______ %
  - **DELAY**
    - _______ Cycles
  - **PICKUP**
    - _______ %
  - **MAX DELAY**
    - _______ Cycles
  - **RESET TIME**
    - _______ Seconds
  - **TIME DIAL**
    - _______

### 50 INST OVERCURRENT

- **neg_seq INST**
  - **PICKUP**
    - _______ Amps
  - **DELAY**
    - _______ Cycles

### 50BF BREAKER FAILURE

- **inadvntnt_eng BRK_FAIL**
  - **PHASE ELEMENT**
    - disable ENABLE
  - **PICKUP PHASE**
    - _______ Amps
  - **NEUTRAL ELEMENT**
    - disable ENABLE
  - **PICKUP NEUTRAL**
    - _______ Amps
  - **INPUT INITIATE**
    - f1 i6 i5 i4 i3 i2 i1
      - i11 i10 i9 i8 i7
      - i14 i13 i12
  - **OUTPUT INITIATE**
    - o8 o7 o6 o5 o4 o3 o2 o1
      - o14 o13 o12 o11 o10 o9
      - o19 o18 o17 o16 o15
      - o23 o22 o21 o20
  - **DELAY**
    - _______ Cycles

---

**NOTE**: Unpurchased or unavailable functions will not be visible within the menus.

---

**Figure A-4** Setpoint & Timing Record Form (4 of 15)
**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (5 of 15)*
**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (6 of 15)*
### 81A FREQUENCY ACCUM.

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>81A SET FREQUENCY ACC.</td>
<td>SET reset</td>
</tr>
<tr>
<td>81A #1 HIGH BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #1 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #1 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81A #2 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #2 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81A #3 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #3 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81A #4 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #4 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81A #5 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #5 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81A #6 LOW BAND PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81A #6 DELAY</td>
<td>________ Cycles</td>
</tr>
</tbody>
</table>

### 81 FREQUENCY

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>81 #1 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #1 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81 #2 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #2 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81 #3 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #3 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81 #4 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #4 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81 #5 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #5 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81 #6 PICKUP</td>
<td>________ Hz</td>
</tr>
<tr>
<td>81 #6 DELAY</td>
<td>________ Cycles</td>
</tr>
</tbody>
</table>

### 81R RATE OF CHANGE FREQ

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>81R #1 PICKUP</td>
<td>________ Hz/s</td>
</tr>
<tr>
<td>81R #1 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81R #2 PICKUP</td>
<td>________ Hz/s</td>
</tr>
<tr>
<td>81R #2 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>81R NEG SEG VOLT INHIBIT</td>
<td>________ %</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4 Setpoint & Timing Record Form (7 of 15)*
### 81A RESET ACCUMULATORS

<table>
<thead>
<tr>
<th>Function</th>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>81A #1</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
<tr>
<td>81A #2</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
<tr>
<td>81A #3</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
<tr>
<td>81A #4</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
<tr>
<td>81A #5</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
<tr>
<td>81A #6</td>
<td>yes/no</td>
<td>ACCUMULATOR RESET</td>
</tr>
</tbody>
</table>

**Figure A-4  Setpoint & Timing Record Form (8 of 15)**

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.
### VOLTS PER HERTZ RELAY

<table>
<thead>
<tr>
<th>24 DEF TIME VOLTS/HERTZ</th>
<th>24 INV TIME VOLTS/HERTZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEF V/HZ inv_v/hz</td>
<td>def_v/hz INV_V/HZ</td>
</tr>
<tr>
<td>24DT #1 PICKUP</td>
<td>24IT #1 PICKUP</td>
</tr>
<tr>
<td>________ %</td>
<td>________ %</td>
</tr>
<tr>
<td>24DT #1 DELAY</td>
<td>24IT CURVE</td>
</tr>
<tr>
<td>________ Cycles</td>
<td>crv#1 crv#2 crv#3 crv#4</td>
</tr>
<tr>
<td>24DT #2 PICKUP</td>
<td>24IT TIME DIAL</td>
</tr>
<tr>
<td>________ %</td>
<td>________</td>
</tr>
<tr>
<td>24DT #2 DELAY</td>
<td>24IT RESET RATE</td>
</tr>
<tr>
<td>________ Cycles</td>
<td>________ Seconds</td>
</tr>
</tbody>
</table>

### POWER RELAY

<table>
<thead>
<tr>
<th>32 DIRECTIONAL POWER</th>
<th>32 #3 PICKUP</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWR</td>
<td>________ PU</td>
</tr>
<tr>
<td>32 #1 PICKUP</td>
<td>32 #3 DELAY</td>
</tr>
<tr>
<td>________ PU</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>32 #1 DELAY</td>
<td>32 #3 TARGET LED</td>
</tr>
<tr>
<td>________ Cycles</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>32 #1 TARGET LED</td>
<td>32 #3 UNDER/OVER POWER</td>
</tr>
<tr>
<td>disable enable</td>
<td>over under</td>
</tr>
<tr>
<td>32 #1 UNDER/OVER POWER</td>
<td>32#3 DIR POWER SENSING</td>
</tr>
<tr>
<td>over under</td>
<td>real reactive</td>
</tr>
<tr>
<td>32 #2 PICKUP</td>
<td></td>
</tr>
<tr>
<td>________ PU</td>
<td></td>
</tr>
<tr>
<td>32 #2 DELAY</td>
<td></td>
</tr>
<tr>
<td>________ Cycles</td>
<td></td>
</tr>
<tr>
<td>32 #2 TARGET LED</td>
<td></td>
</tr>
<tr>
<td>disable ENABLE</td>
<td></td>
</tr>
<tr>
<td>32 #2 UNDER/OVER POWER</td>
<td></td>
</tr>
<tr>
<td>over under</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

Figure A-4  Setpoint & Timing Record Form (9 of 15)
**LOSS OF FIELD RELAY**

- **#1 DIAMETER**
  - _______ Ohms

- **#1 OFFSET**
  - _______ Ohms

- **#1 DELAY**
  - _______ Cycles

- **#1 DELAY WITH VC**
  - _______ Cycles

- **#1 VOLTAGE CONTROL**
  - _______ Volts

- **#1 DIRECTIONAL ELEMENT**
  - _______ Degrees

- **#2 DIAMETER**
  - _______ Ohms

- **#2 OFFSET**
  - _______ Ohms

---

**V.T. FUSE LOSS RELAY**

- **INPUT INITIATE**
  - fl i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **IPSCOM INPUT INIT**

- **3 PHASE DETECT**
  - disable enable

- **DELAY**
  - _______ Cycles

---

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.
<table>
<thead>
<tr>
<th>Function</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>21#1 DIAMETER</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#1 OFFSET</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#1 IMPEDANCE ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#1 LOAD ENCROACHMENT</td>
<td>disable</td>
</tr>
<tr>
<td>21#1 LOAD ENCR ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#1 LOAD ENCR R REACH</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#1 OC SUPERVISION</td>
<td>disable</td>
</tr>
<tr>
<td>21#1 OC SUPERVISION</td>
<td>________ Amps</td>
</tr>
<tr>
<td>21#1 OUT OF STEP BLOCK</td>
<td>disable</td>
</tr>
<tr>
<td>21#1 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>21#2 DIAMETER</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#2 OFFSET</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#2 IMPEDANCE ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#2 LOAD ENCROACHMENT</td>
<td>disable</td>
</tr>
<tr>
<td>21#2 LOAD ENCR ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#2 LOAD ENCR R REACH</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#2 OC SUPERVISION</td>
<td>disable</td>
</tr>
<tr>
<td>21#2 OUT OF STEP BLOCK</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>21#2 DELAY</td>
<td>________ Cycles</td>
</tr>
<tr>
<td>21#3 DIAMETER</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#3 OFFSET</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#3 IMPEDANCE ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#3 LOAD ENCROACHMENT</td>
<td>disable</td>
</tr>
<tr>
<td>21#3 LOAD ENCR ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>21#3 LOAD ENCR R REACH</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>21#3 OC SUPERVISION</td>
<td>disable</td>
</tr>
<tr>
<td>21#3 OC SUPERVISION</td>
<td>________ Amps</td>
</tr>
<tr>
<td>21#3 LOAD ENCR R REACH</td>
<td>________ Cycles</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (11 of 15)*
**PHASE DISTANCE RELAY**

<table>
<thead>
<tr>
<th>78 OUT OF STEP</th>
<th>dist OSTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>78 DIAMETER</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>78 OFFSET</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>78 BLINDER IMPEDANCE</td>
<td>________ Ohms</td>
</tr>
<tr>
<td>78 IMPEDANCE ANGLE</td>
<td>________ Degrees</td>
</tr>
<tr>
<td>78 DELAY</td>
<td>________ CYCLES</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>78 TRIP ON MHO EXIT</th>
<th>disable ENABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>78 POLE SLIP COUNT</td>
<td>________ Slips</td>
</tr>
<tr>
<td>78 POLE SLIP RESET TIME</td>
<td>________ Cycles</td>
</tr>
</tbody>
</table>

**FIELD GROUND RELAY**

<table>
<thead>
<tr>
<th>64B/F FIELD GROUND FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>64F #1 PICKUP</td>
</tr>
<tr>
<td>64F #1 DELAY</td>
</tr>
<tr>
<td>64F # 2 PICKUP</td>
</tr>
<tr>
<td>64F # 2 DELAY</td>
</tr>
<tr>
<td>64B PICKUP</td>
</tr>
<tr>
<td>64B DELAY</td>
</tr>
<tr>
<td>64B/F FREQUENCY</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (12 of 15)*
### 64S 100% STATOR GROUND STATOR

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>64S PICKUP mAmps</td>
<td></td>
</tr>
<tr>
<td>64S VOLT INHIBIT</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>64S DELAY</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

### 25S SYNC CHECK

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>25S PHASE LIMIT</td>
<td>Degrees</td>
</tr>
<tr>
<td>25S UPPER VOLT LIMIT</td>
<td>Volts</td>
</tr>
<tr>
<td>25S LOWER VOLT LIMIT</td>
<td>Volts</td>
</tr>
<tr>
<td>25S SYNC CHECK DELAY</td>
<td>Cycles</td>
</tr>
<tr>
<td>25S DELTA VOLT</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>25S DELTA VOLT LIMIT</td>
<td>Volts</td>
</tr>
<tr>
<td>25S DELTA FREQUENCY</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>25S DELTA FREQ LIMIT</td>
<td>Hz</td>
</tr>
<tr>
<td>25S SYNC-CHECK PHASE</td>
<td>ab bc ca</td>
</tr>
</tbody>
</table>

### 25D DEAD VOLT

<table>
<thead>
<tr>
<th>Function</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>25D DEAD VOLT LIMIT</td>
<td>Volts</td>
</tr>
<tr>
<td>25D DEAD V1 HOT VX</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>25D DEAD VX HOT V1</td>
<td>disable ENABLE</td>
</tr>
<tr>
<td>25D DEAD INPUT ENABLE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>i1 i2 i3 i4 i5 i6 i7 i8 i9 i10 i11 i12</td>
</tr>
<tr>
<td>25D DEAD DELAY</td>
<td>Cycles</td>
</tr>
</tbody>
</table>

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

**Figure A-4  Setpoint & Timing Record Form (13 of 15)**
### Breaker Monitor

**BRKR prst clr**

- **BM PICKUP**
  - ________ kA-cycles

- **BM INPUT INITIATE**
  - f1 i6 i5 i4 i3 i2 i1
  - i11 i10 i9 i8 i7
  - i14 i13 i12

- **BM OUTPUT INITIATE**
  - o8 o7 o6 o5 o4 o3 o2 o1
  - o14 o13 o12 o11 o10 o9
  - o19 o18 o17 o16 o15
  - o23 o22 o21 o20

- **BM DELAY**
  - ________ Cycles

- **BM TIMING METHOD**
  - it i2t

**Inputs 7 to 14 and Outputs 9 to 23 must be set through IPScom®.**

### Preset Accumulators

**brkr PRST clr**

- **ACC. PHASE A SET**
  - PH_A ph_b ph_c

- **BRKR. ACCUMULATOR**
  - ________ kA-cycles

- **ACC. PHASE B SET**
  - ph_A PH_B ph_c

- **BRKR. ACCUMULATOR**
  - ________ kA-cycles

- **ACC. PHASE C SET**
  - ph_a PH_B PH_C

- **BRKR. ACCUMULATOR**
  - ________ kA-cycles

### Clear Accumulators

**brkr prst CLR**

- **ACC. PHASE A CLEAR**
  - PH_A ph_b ph_c

- **ACC. PHASE B CLEAR**
  - ph_a PH_B ph_c

- **ACC. PHASE C CLEAR**
  - ph_a ph_b PH_C

**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

---

**Figure A-4  Setpoint & Timing Record Form (14 of 15)**
**NOTE:** Unpurchased or unavailable functions will not be visible within the menus.

*Figure A-4  Setpoint & Timing Record Form (15 of 15)*
The M-3425A Generator Protection Relay incorporates three serial ports and an optional RJ 45 Ethernet port for intelligent, digital communication with external devices. 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 Human-Machine Interface module is accessible remotely through the BECO 2200 or MODBUS data exchange protocol. These protocol documents and the database-specific protocol document are available from the factory or from our website at www.beckwithelectric.com.

The M-3820D IPScom® Communication Software package has been supplied for communication to any IBM compatible computer running under Microsoft® Windows 95 or higher.

The communication protocols implement serial, byte oriented, asynchronous communication and can be used to fulfill the following communications functions:
- Real time monitoring of line status.
- Interrogation and modification of setpoints.
- Downloading of recorded oscillograph data.
- Reconfiguration of relay functions.

**NOTE:** The following restrictions apply for MODBUS protocol use:
1. MODBUS protocol is not supported on COM1.
2. Parity is supported on COM2 and COM3; valid selections are 8,N,2; 8,O,1; 8,E,1; 8,N,1; 8,O,2 or 8,E,2.
3. ASCII mode is not supported (RTU only).
4. Standard baud rates from 300 to 9600 are supported.
5. Only the following MODBUS commands are supported:
   a. read holding register (function 03)
   b. read input register (function 04)
   c. force single coil (function 05)
   d. preset single register (function 06)

For detailed information on IPScom communications, refer to Chapter 4, Remote Operation.

**Serial Ports**
The relay has both front and rear panel RS-232 ports and a rear RS-485 port. The front and rear panel RS-232 ports are 9-pin (DB9S) connector configured as DTE (Data Terminal Equipment) per the EIA-232D standard. Signals are defined in Table B-1, Communication Port Signals.

The 2-wire RS-485 port is assigned to the rear panel terminal block pins 3 (-) and 4 (+).

Each communication port may be configured to operate at any of the standard baud rates (300, 600, 1200, 2400, 4800, and 9600). The RS-485 port shares the same baud rate with COM 2 (for COM1 see Section 5.4, Circuit Board Switches and Jumpers).

A null modem cable is also shown in Figure B-1, Null Modem Cable: M-0423, if direct connection to a PC (personal computer) is desired.

**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 communications. The demodulated IRIG-B may still be used via the COM2 Port when ethernet is enabled. 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 port COM2 (Ethernet) or COM3 may be used to remotely set and interrogate the relay using a local area network, modem or other direct serial connection.
### Table B-1 Communication Port Signals

<table>
<thead>
<tr>
<th>Signal</th>
<th>COM1</th>
<th>COM2</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX</td>
<td>Pin 2</td>
<td>Pin 2</td>
</tr>
<tr>
<td>TX</td>
<td>Pin 3</td>
<td>Pin 3</td>
</tr>
<tr>
<td>RTS</td>
<td>Pin 7</td>
<td>Pin 7</td>
</tr>
<tr>
<td>CTS</td>
<td>Pin 8</td>
<td></td>
</tr>
<tr>
<td>DTR</td>
<td>Pin 4</td>
<td>Pin 4</td>
</tr>
<tr>
<td>DCD</td>
<td>Pin 1*</td>
<td></td>
</tr>
<tr>
<td>GND</td>
<td>Pin 5</td>
<td>Pin 5</td>
</tr>
<tr>
<td>+15 V</td>
<td>Pin 1*</td>
<td></td>
</tr>
<tr>
<td>-15 V</td>
<td>Pin 9*</td>
<td></td>
</tr>
<tr>
<td>TTL IRIG-B (+)</td>
<td></td>
<td>Pin 6*</td>
</tr>
</tbody>
</table>

* Optional: See Section 5.5, Circuit Board Switches and Jumpers, ±15V (±15%) @ 100 mA maximum.

**NOTE:** Also see Tables 5-1, 5-2 and Figure 5-12.

---

**Figure B-1** Null Modem Cable: M-0423
Echo Cancel On

25 pin or 9-25 pin Straight-Through Cable

DYMEC Fiber Optic Link / Repeater

Slave #1 Address 1
Slave #2 Address 2
Slave #3 Address 3

9-25 pin "Straight-Through" Cables

Figure B-2 RS-232 Fiber Optic Network
RS-485 2-Wire Network

▲ CAUTION: Due to the possibility of ground potential difference between units, all units should be mounted in the same rack. If this is not possible, fiber optics with the appropriate converters should be used for isolation.

■ NOTE: Each address on the network must be unique. Only the last physical slave on the network should have the termination resistor installed. This may be completed externally or using a jumper internal to the unit. See Section 5.5, Circuit Board Switches and Jumpers.

Figure B-3 RS-485 Network

Figure B-4 COM Pinout for Demodulated TTL Level Signal
Appendix C – Self-test Error Codes

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Battery backed RAM test fail</td>
</tr>
<tr>
<td>2</td>
<td>EEPROM write power-up fail</td>
</tr>
<tr>
<td>3</td>
<td>EEPROM read back power-up fail</td>
</tr>
<tr>
<td>4</td>
<td>Dual port RAM test fail</td>
</tr>
<tr>
<td>5</td>
<td>EEPROM write calibration checksum fail</td>
</tr>
<tr>
<td>6</td>
<td>EEPROM write setpoint checksum fail</td>
</tr>
<tr>
<td>7</td>
<td>EEPROM write setpoint checksum fail</td>
</tr>
<tr>
<td>8</td>
<td>Loss of battery backed RAM</td>
</tr>
<tr>
<td>9</td>
<td>DMA checksum/physical block fail</td>
</tr>
<tr>
<td>10</td>
<td>Oscillograph Memory Test fail</td>
</tr>
<tr>
<td>11</td>
<td>DSP external program RAM fail</td>
</tr>
<tr>
<td>12</td>
<td>DSP A/D convert fail</td>
</tr>
<tr>
<td>13</td>
<td>DSP ground channel fail</td>
</tr>
<tr>
<td>14</td>
<td>DSP reference channel fail</td>
</tr>
<tr>
<td>15</td>
<td>DSP PGA gain fail</td>
</tr>
<tr>
<td>16</td>
<td>DSP DSP -&gt; HOST interrupt 1 fail</td>
</tr>
<tr>
<td>17</td>
<td>DSP DSP -&gt; HOST interrupt 2 set fail</td>
</tr>
<tr>
<td>18</td>
<td>DSP DSP -&gt; HOST interrupt 2 reset fail</td>
</tr>
<tr>
<td>19</td>
<td>DSP program load fail</td>
</tr>
<tr>
<td>20</td>
<td>DSP not running run mode code</td>
</tr>
<tr>
<td>21</td>
<td>DSP not running primary boot code</td>
</tr>
<tr>
<td>22</td>
<td>DSP DPRAM pattern test fail</td>
</tr>
<tr>
<td>23</td>
<td>EEPROM write verify error</td>
</tr>
<tr>
<td>26</td>
<td>WARNING calibration checksum mismatch warning</td>
</tr>
<tr>
<td>27</td>
<td>WARNING setpoint checksum mismatch warning</td>
</tr>
<tr>
<td>28</td>
<td>WARNING low battery (BBRAM) warning</td>
</tr>
<tr>
<td>29</td>
<td>Supply/mux PGA running test fail</td>
</tr>
<tr>
<td>30</td>
<td>External DSP RAM test fail</td>
</tr>
<tr>
<td>31</td>
<td>Unrecognized INT1 code</td>
</tr>
<tr>
<td>32</td>
<td>Values update watchdog fail</td>
</tr>
<tr>
<td>33</td>
<td>Abort Error</td>
</tr>
<tr>
<td>34</td>
<td>Restart Error</td>
</tr>
<tr>
<td>35</td>
<td>Interrupt Error</td>
</tr>
<tr>
<td>36</td>
<td>Trap Error</td>
</tr>
<tr>
<td>37</td>
<td>Calibration running check fail</td>
</tr>
<tr>
<td>38</td>
<td>Ethernet Board not running (Warning)</td>
</tr>
<tr>
<td>39</td>
<td>Not used</td>
</tr>
<tr>
<td>40</td>
<td>Interrupt noise INT2</td>
</tr>
<tr>
<td>41</td>
<td>Interrupt noise INT1</td>
</tr>
<tr>
<td>42</td>
<td>Not used</td>
</tr>
<tr>
<td>43</td>
<td>Not used</td>
</tr>
<tr>
<td>44</td>
<td>Oscillograph buffer overflow</td>
</tr>
<tr>
<td>45</td>
<td>Oscillograph buffer underflow</td>
</tr>
<tr>
<td>46</td>
<td>Failure of DSP to calculate calibration phasors</td>
</tr>
<tr>
<td>47</td>
<td>Unable to calibrate input (gain)</td>
</tr>
<tr>
<td>48</td>
<td>Unable to calibrate input (phase)</td>
</tr>
<tr>
<td>49</td>
<td>Not used</td>
</tr>
<tr>
<td>50</td>
<td>Stack Overflow</td>
</tr>
<tr>
<td>51</td>
<td>Setpoint Write Overflow</td>
</tr>
<tr>
<td>52</td>
<td>Field Ground Error</td>
</tr>
</tbody>
</table>

Table C-1  Self-Test Error Codes
<table>
<thead>
<tr>
<th><strong>Error Code</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Comm Channel Lock</td>
<td>An incorrect pass word supplied to the control will result in this message.</td>
</tr>
<tr>
<td>Control in Local Mode</td>
<td>This message indicates that the control is being operated locally and serial communication is suspended.</td>
</tr>
<tr>
<td>Echo Timeout</td>
<td>This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.</td>
</tr>
<tr>
<td>Invalid Data</td>
<td>This error results if incorrect or out-of-range data is entered.</td>
</tr>
<tr>
<td>Invalid ID</td>
<td>This message is displayed when attempting to communicate with a device other than the M-3425 series.</td>
</tr>
<tr>
<td>Invalid Number of Points</td>
<td>This error results if an incompatible version of IPScom software is used. This is a communication protocol error. Contact a Beckwith Electric Co. factory representative.</td>
</tr>
<tr>
<td>Invalid Point Number</td>
<td>This error results if an incompatible version of IPScom software is used. This is a communication protocol error. Contact a Beckwith Electric Co. factory representative.</td>
</tr>
<tr>
<td>Read Invalid Checksum</td>
<td>This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.</td>
</tr>
<tr>
<td>Read Packet Timeout</td>
<td>This error results when communication with the control is lost while attempting to read data to the control.</td>
</tr>
<tr>
<td>Response Timeout</td>
<td>This error results when communication with the control is lost while attempting to read data from the control.</td>
</tr>
<tr>
<td>Unknown System Error</td>
<td>This error could be caused by a malfunction of the control.</td>
</tr>
<tr>
<td>User Cancel</td>
<td>This message displays when the escape (ESC) key is pressed.</td>
</tr>
<tr>
<td>Write Invalid Checksum</td>
<td>This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.</td>
</tr>
<tr>
<td>Write Packet Timeout</td>
<td>This error results when communication with the control is lost while attempting to write data to the control.</td>
</tr>
</tbody>
</table>

*Table C-2  IPScom® Error Messages*
Appendix D – Inverse Time Curves

This Appendix contains two sets of Inverse Time Curve Families. The first set is used for Volts per Hertz functions (Figures D-1 through D-4), and the second set is for the M-3425A functions which utilize the Inverse Time Overcurrent curves (Figures D-5 through D-12).

NOTE: Table D-1A and D-1B on pages D–6 and D–7 contains a list of the data that characterizes Definite Time, Inverse Time, Very Inverse Time, and Extremely Inverse Time Overcurrent Curves.

Expression for Time Delay Setting
Operating time defined by IEC and ANSI/IEEE:

IEC Equation

\[ t = TD A \left( \frac{M^p - 1}{M^p} \right) \]

IEEE Equation

\[ t = TD A \left( \frac{M^p - 1}{M^p} \right) + B \]

where

- \( t \) = Relay operating time in seconds
- \( TD \) = Time dial, or time multiplier setting
- \( I \) = Fault current level in secondary amps
- \( I_p \) = Tap or pickup current selected
- \( B \) = Constant
- \( p \) = Slope constant
- \( A \) = Slope constant
- \( M = \frac{I}{I_p} \)

Setting Time Delay on Overcurrent Relays ANSI/IEEE and IEC constants for overcurrent relays

<table>
<thead>
<tr>
<th>IDMT Curve Description</th>
<th>Standard</th>
<th>p</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderately Inverse</td>
<td>IEEE</td>
<td>0.02</td>
<td>0.0515</td>
<td>0.114</td>
</tr>
<tr>
<td>Very Inverse</td>
<td>IEEE</td>
<td>2</td>
<td>19.61</td>
<td>0.491</td>
</tr>
<tr>
<td>Extremely Inverse</td>
<td>IEEE</td>
<td>2</td>
<td>28.2</td>
<td>0.1217</td>
</tr>
<tr>
<td>Standard Inverse</td>
<td>IEC</td>
<td>0.02</td>
<td>0.14</td>
<td>-</td>
</tr>
<tr>
<td>Very Inverse</td>
<td>IEC</td>
<td>1.0</td>
<td>13.5</td>
<td>-</td>
</tr>
<tr>
<td>Extremely Inverse</td>
<td>IEC</td>
<td>2.0</td>
<td>80.0</td>
<td>-</td>
</tr>
</tbody>
</table>
Figure D-1  Volts/Hz (24) Inverse Curve Family #1 (Inverse Square)
Figure D-2  Volts/Hz (24) Inverse Family Curve #2
Figure D-3  Volts/Hz (24IT) Inverse Curve Family #3
Figure D-4: Volts/Hz (24IT) Inverse Curve Family #4
### Table D-1A M-3425A Inverse Time Overcurrent Relay Characteristic Curves (1 of 2)

<table>
<thead>
<tr>
<th>Multiple of Tap Setting</th>
<th>Definite Time</th>
<th>Inverse Time</th>
<th>Very Inverse Time</th>
<th>Extremely Inverse Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.50</td>
<td>0.69999</td>
<td>4.53954</td>
<td>3.46570</td>
<td>4.82520</td>
</tr>
<tr>
<td>1.55</td>
<td>0.64862</td>
<td>4.15533</td>
<td>3.11203</td>
<td>4.28747</td>
</tr>
<tr>
<td>1.60</td>
<td>0.60539</td>
<td>3.81903</td>
<td>2.81228</td>
<td>3.62562</td>
</tr>
<tr>
<td>1.65</td>
<td>0.56803</td>
<td>3.52265</td>
<td>2.55654</td>
<td>3.45706</td>
</tr>
<tr>
<td>1.70</td>
<td>0.53558</td>
<td>3.25987</td>
<td>2.39607</td>
<td>3.12573</td>
</tr>
<tr>
<td>1.75</td>
<td>0.50725</td>
<td>3.02558</td>
<td>2.14431</td>
<td>2.85994</td>
</tr>
<tr>
<td>1.80</td>
<td>0.48245</td>
<td>2.81566</td>
<td>1.97620</td>
<td>2.62094</td>
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**NOTE:** The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.
### Table D-1B  M-3425A Inverse Time Overcurrent Relay Characteristic Curves (2 of 2)

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<th>Very Inverse Time</th>
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**NOTE:** The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.
Figure D-5  BECO Definite Time Overcurrent Curve
Figure D-6  BECO Inverse Time Overcurrent Curve
Figure D-7  BECO Very Inverse Time Overcurrent Curve
Figure D-8  BECO Extremely Inverse Time Overcurrent Curve
Figure D-9  IEC Curve #1  Inverse

\[ t = T_D \times \left[ \frac{0.14}{M^{0.02} - 1} \right] \]
Inverse Time Curves: Appendix– D

Figure D-10  IEC Curve #2 Very Inverse

\[ t = TD \times \left[ \frac{13.5}{M - 1} \right] \]
Figure D-11  IEC Curve #3 Extremely Inverse

\[ t = TD \times \left[ \frac{80}{M^2 - 1} \right] \]
Figure D-12  IEC Curve #4 Long-Time Inverse

\[ t = TD \times \left[ \frac{120}{M - 1} \right] \]
Figure D-13  IEEE (Moderately) Inverse Time Overcurrent Curves
Figure D-14  IEEE Very Inverse Time Overcurrent Curves
Figure D-15  IEEE Extremely Inverse Time Overcurrent Curves

\[
t = \frac{TD}{5} \left[ \frac{28.2}{M^2 - 1} + 0.1217 \right]
\]
Appendix E – Layup and Storage

Appendix E includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3425A Generator Protection Relay.

Storage Requirements (Environment)
The recommended storage environment parameters for the M-3425A are:

- The ambient temperature where the M-3425A is stored is within a range of 5°C to 40°C
- The maximum relative humidity is less than or equal to 80% for temperatures up to 31°C, decreasing to 31°C linearly to 50% for relative humidity at 40°C.
- The storage area environment is free of dust, corrosive gases, flammable materials, dew, percolating water, rain and solar radiation.

Storage Requirements (Periodic Surveillance During Storage)
The M-3425A power supply contains electrolytic capacitors. It is recommended that power be applied to the relay (PS1 and optional PS2 redundant power supply when installed and PS2 on extended output units) every three to five years for a period of not less than one hour to help prevent the electrolytic capacitors from drying out.

Layup Configuration
The M-3425A includes a removable lithium battery backed TIMEKEEPER® module (Beckwith Electric component U25, Figure 5-17). The TIMEKEEPER module is the M-3425A real-time clock and also provides power to the unit's nonvolatile memory when power is not applied to the unit.

Layup of the M-3425A requires verifying that the system clock is stopped. The steps necessary to verify system clock status are as follows:

▲ CAUTION: Do not use the diagnostic mode in relays that are installed in an active protection scheme.

For units with the optional HMI panel:

1. Verify that the Power Supply (PS) fuses are installed.
2. Determine the unit power supply rating by observing the check box below the PS terminals on the rear of the unit.
3. Apply power to the unit consistent with the rating determined in Step 2 (see Section 5.3, External Connections). The unit will enter the selftest mode.
4. When the selftests are complete, then press ENTER to begin main menu.
5. Press the right arrow pushbutton until SETUP UNIT is displayed.
6. Press ENTER to access the SETUP UNIT menu.
7. Press the right arrow pushbutton until DIAGNOSTIC MODE is displayed.
8. Press ENTER. A reset warning will be displayed:

PROCESSOR WILL RESET!
ENTER KEY TO CONTINUE

- WARNING: All relay functions and protection will be inoperative while the relay is in diagnostic mode.

9. Press ENTER. Unit will now reset and DIAGNOSTIC MODE will be temporarily displayed, followed by OUTPUT TEST (RELAY). This is the beginning of the diagnostic menu.
10. Press the right arrow pushbutton until the following is displayed:

   CLOCK TEST  
   ← com1 com2 com3 CLOCK

11. Press ENTER. The following is displayed:

   CLOCK TEST  
   03-JAN-1998 09:00:00.000

12. If the clock is running, press ENTER to stop the clock. The following is displayed:

   CLOCK TEST  
   -CLOCK STOP-

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

13. Press ENTER and verify the relay clock is stopped. A display similar to the following is shown with the seconds stopped:

   CLOCK TEST  
   03-JAN-09:01:80.000

14. When the clock has been verified to be stopped, then press EXIT until the following message appears:

   PRESS EXIT TO  
   EXIT DIAGNOSTIC MODE

15. Press EXIT again to exit DIAGNOSTIC MODE. The relay will reset and normal running mode will resume.

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

16. Remove power from the unit. The unit can now be placed in storage.

For units **without** the optional HMI panel:

1. Verify that the Power Supply (PS) fuses are installed.

2. Determine the unit power supply rating by observing the check box(s) below the PS terminals on the rear of the unit.

3. Apply power to the unit consistent with the rating determined in Step 2 (see Section 5.3, External Connections). The unit will enter the selftest mode.

4. Install IPScom™ Communications Software (see Section 4.2, Installation and Setup) on a PC that includes the following:
   - Microsoft Windows™ 95 Operating System or above
   - Equipped with a serial port

5. Connect a null modem cable from COM1 of the relay to the PC serial port.

6. Open communications with the relay (see Section 4.3 Operation, Activating Connections).

7. Select “Relay/Setup/Set Date/Time” from the menu bar. IPScom will display the “Unit Date/Time Dialog Screen” Figure 4-16.

8. Verify that “Start Clock” is displayed, then proceed as follows:
   a. If “Start Clock” is displayed, then select “Save” and go to Step 9.
   b. If “Stop Clock” is displayed, then select “Stop Clock” and then select “Save”.

9. Close communications with the unit by selecting “Comm” from the menu bar and then select “Exit”.

10. Disconnect the null modem cable and then remove power from the unit. The unit can now be placed in storage.

Storage of the M-3425A greater than five years may require replacement of the lithium battery prior to placing the unit in service. Contact Beckwith Electric Customer Service for replacement procedure.
Appendix F – Index

2

21 Phase Distance, 2-14, 3-4, 6-8, A-38
25 Sync Check, 2-11, 2-21, 5-13
27 Phase Undervoltage, 2-25, 3-4, 6-16, A-28
27TN Third Harmonic Undervoltage, Neutral, 2-26

3

32 Directional Power, 3-4, 6-21:6-23, A-36

4

40 Loss of Field, 3-4, 6-24:6-25, A-37
46 Negative Sequence Overcurrent, 2-37, 6-26:6-27
49 Stator Overload Protection, 2-39, 6-28

5

50/50N Instantaneous Overcurrent, Phase & Neutral Circuits, 2-42
50BF Generator Breaker Failure/HV Breaker Flashover, 2-44
51N Inverse Time Neutral Overcurrent, 2-49, 6-36
59 Phase Overvoltage, 2-52, 3-4, 6-39, A-28
59D Third Harmonic Voltage Differential, 2-53, SP-2
59N Overvoltage, Neutral Circuit or Zero Sequence, 2-55, 6-41

6

60FL VT Fuse Loss, 2-59, 6-43
64B Brush Lift-Off Detection, 2-64, 6-46
64B/F Field Ground Protection, 2-62, 5-11,
SP-This Page Left Intentionally Blank18:SP-19
64F Field Ground Protection, 6-44, 6-46
64S 100% Stator Ground by Low Frequency Injection Calibration, 6-77
64S 100% Stator Ground Protection by Low Frequency signal Injection, 2-66, SP-29
67N Residual Directional Overcurrent, 2-21, 2-69, 6-49, 6-51

7

78 Out of Step, 3-4, 6-53:6-54, A-21, A-39

8

81 Frequency, 2-75, 3-4, 6-55, A-34
81R Rate of Change of Frequency, 2-80, 6-57
87 Phase Differential, 2-81, 6-59

A

Accessories, 1-1
Activating Communications, 4-9
Alphanumeric Display, 3-1
Arrow Pushbuttons, 3-1, 6-71
Auto Calibration, 6-75:6-77

B

Breaker Closed LED, 3-2
Breaker Monitoring, 3-4, 6-63:6-64, A-41, SP-2, SP-10
Button Test, 6-71

C

Cautions, 4-1, 4-28
Checkout Status/Metering, 4-1, 4-18, 4-23
Circuit Board Switches and Jumpers, 2-85, 3-6, 3-9, 4-3, 5-1:5-30, B-1, B-4, SP-18:SP-19
Clock Command, 4-31
Clock ON/OFF, 6-67, 6-74:6-75
COM1/COM2 Loopback Test, 6-72
COM Port Security, 4-3
Comm Menu, 4-7, 4-9:4-11, 4-28, 4-31, A-8
Commissioning Checkout, 1-1, 5-1:5-30
Communications Settings, 3-8:3-9
Configuration Record Forms, A-1
Configure Relay Data, 3-1:3-12
D
Declaration of Conformity, 1-2, G-1
Default Message Screens, 3-2
DHCP Protocol, 1-3, 4-4:4-7, 4-33, A-8
Diagnostic LED, 3-2
Diagnostic Test Procedures, 6-67:6-75
Direct Connection, 4-2, 4-10, 4-31, B-1
Display Test, 6-72
Dropout Delay Timer, 2-90

E
Enter Pushbutton, 3-1
Equipment/Test Setup, 6-2
Ethernet Command, 4-31
Ethernet Communication Settings, 4-3
Ethernet Port, 4-1, 4-3:4-7, B-1:B-4, SP-2, SP-14
Ethernet Port Setup with DHCP, 4-7
Ethernet Port Setup without DHCP, 4-7
Ethernet Protocols, 4-3
Exit Pushbutton, 3-1
External Connections, 5-10:5-15, SP-17:SP-19

F
Field Ground Calibration, 6-78
File Menu, 4-10
Front Panel Controls, 1-4, 3-1:3-3

H
Help Menu, 4-9, 4-22, 4-33

I
Initial Setup Procedure/Settings, 3-5
Input Test, 6-66:6-67, 6-69:6-70
Installation, 1-1, 5-1:5-30
Installation and Setup (IPScom), 4-8
Installing the Modems, 4-6
Inverse Time Curves, 2-38, D-1:D18
IPSlogic, 2-86:2-88, 2-90, 3-4, 6-66, SP-2, SP-10,
SP-13:SP-15
IPSutil Communications Software, 4-1, 4-30
IPSutil Installation and Setup, 4-30

K
Keyboard Shortcuts, 4-1, 4-29

L
Layup and Storage, 1-2, E-1:E-2, SP-17
Low Frequency Signal Injection Equipment, 2-65:2-66, 5-25:5-30

M
M-3890 IPSutil, 4-30
Manual Configuration of Ethernet Board, 4-4:4-5
Mechanical/Physical Dimensions, 5-1:5-30
Miscellaneous Menu, 4-32

O
Operation, 4-3:4-26
Oscillograph Recorder Data, 3-8:3-9
Output Relay Test, 6-68:6-69

P
Phase and Neutral Fundamental Calibration, 6-76
Power On Self Tests, 6-7
Profiles, 2-3:2-4, 4-21, A-25, SP-12, SP-14

R
Relay Comm Command, 4-31
Relay Setup Menu, 2-6, 4-10:4-11
Relay OK LED, 3-2, SP-14
Relay OK LED Flash/Illuminated, 6-75
Relay System Setup, 2-3, 2-14, 2-25, 2-29, 2-46,
2-50, 2-52, 3-6, 4-11
Remote Operation, 4-1
Reset Delay Timer, 2-90
Appendix – F

Screen Blanking, 3-1
Security Menu, 4-32
Self Test Error Codes, 1-2, C-1:C-2
Serial Communication Settings, 4-3
Serial Port, 4-1:4-4, 4-7:4-8, 4-28, 4-31, B-1, E-2
Setpoints and Time Settings, 2-14:2-15,
Setup System Data, 3-6:3-9
Setup Unit Data, 3-5:3-6
Status LED Test, 6-70:6-71
Status/Metering, 3-9, 4-22
System Diagrams, 2-1, 2-8:2-9, SP-20:SP-21
System Setup, 3-6:3-9, 4-11

Target & Status Indicators and Controls, 3-1:3-12
Target History, 3-10:3-11, 4-19
Target Indicators, 3-2
Target LED Test, 6-71
Target Reset, 3-2, 4-17, SP-14
Test Procedures, 6-6, 6-73
Third Harmonic Calibration, 6-77
Time Sync LED, 3-2, 4-18, 4-34, SP-14
Trip Circuit Monitoring, 2-85, 5-10:5-11, 6-65,
SP-2, SP-10, SP-18:SP-19

Window Menu/Help Menu, 4-22
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Appendix G–Declaration of Conformity
DECLARATION OF CONFORMANCE
(in accordance to ISO/IEC 17050-1:2004)

No. M-3425A  Manufacturer’s Name: Beckwith Electric CO, INC.
Manufacturer’s Address: 6190 118th Avenue North
Largo, FL 33773-3724

The manufacturer hereby declares under our sole responsibility that the M-3425A product conforms to the following product standard as of January 14th, 2004 in accordance to Directive 2004/108/EC for equipment incorporated into stationary installations:

BS EN 50263:2000
Electromagnetic compatibility (EMC)
Product standard for measuring relays and protection equipment

Conducted 150 kHz to 30MHz
Radiated 30MHz to 1000MHz
Class A Limits

Electromagnetic Immunity

1 MHz Disturbance
EN 60255-22-1:1988
(ANSI C37.90.1:2002)

Electrostatic Discharge 8kV Contact; 15kV Air
EN 60255-22-2:1997

Radiated RF 80MHz to 1000MHz 10V/m, 80% AM (1kHz)
EN 60255-22-3:2001

Fast Transients 5ns/50ns Bursts @ 5kHz for 15ms 300ms for 1 min.
2kV power supply lines and earth 2kV signal data and control lines
EN 60255-22-4:2002

Surge 1kV Line to Line coupling, 2kV Line to Earth coupling power supply lines 12Ω source impedance
EN 61000-4-5:1995

Conducted RF 150KHz to 80MHz 10V emf
EN 60255-22-6:2001

Power frequency magnetic field immunity test
30 A/m continuous
EN 61000-4-8:1994

Voltage dips, short interruptions and voltage variations immunity tests
EN 61000-4-11:1994

EN 61010-1: 2001 Safety requirements for electrical equipment for measurement, control, and laboratory use Part 1. General requirements European Safety Directive

Manufacturers Contact:
Engineering Manager
6190 118th Ave North
Largo, FL 33773-3724
Tel (727) 544-2326
Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringement of United States Letters Patent or rights accruing therefrom or trademarks, whether federal, state, or common law, arising from the Seller’s compliance with Buyer’s designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of five years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to perform in accordance with Seller’s specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller’s facility. The Seller’s responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantability and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

In no event shall the Seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstances shall the Seller be liable for any personal injury whatsoever.

It is agreed that when the equipment furnished hereunder are to be used or performed in connection with any nuclear installation, facility, or activity, Seller shall have no liability for any nuclear damage, personal injury, property damage, or nuclear contamination to any property located at or near the site of the nuclear facility. Buyer agrees to indemnify and hold harmless the Seller against any and all liability associated therewith whatsoever whether based on contract, tort, or otherwise. Nuclear installation or facility means any nuclear reactor and includes the site on which any of the foregoing is located, all operations conducted on such site, and all premises used for such operations.

Notice:

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