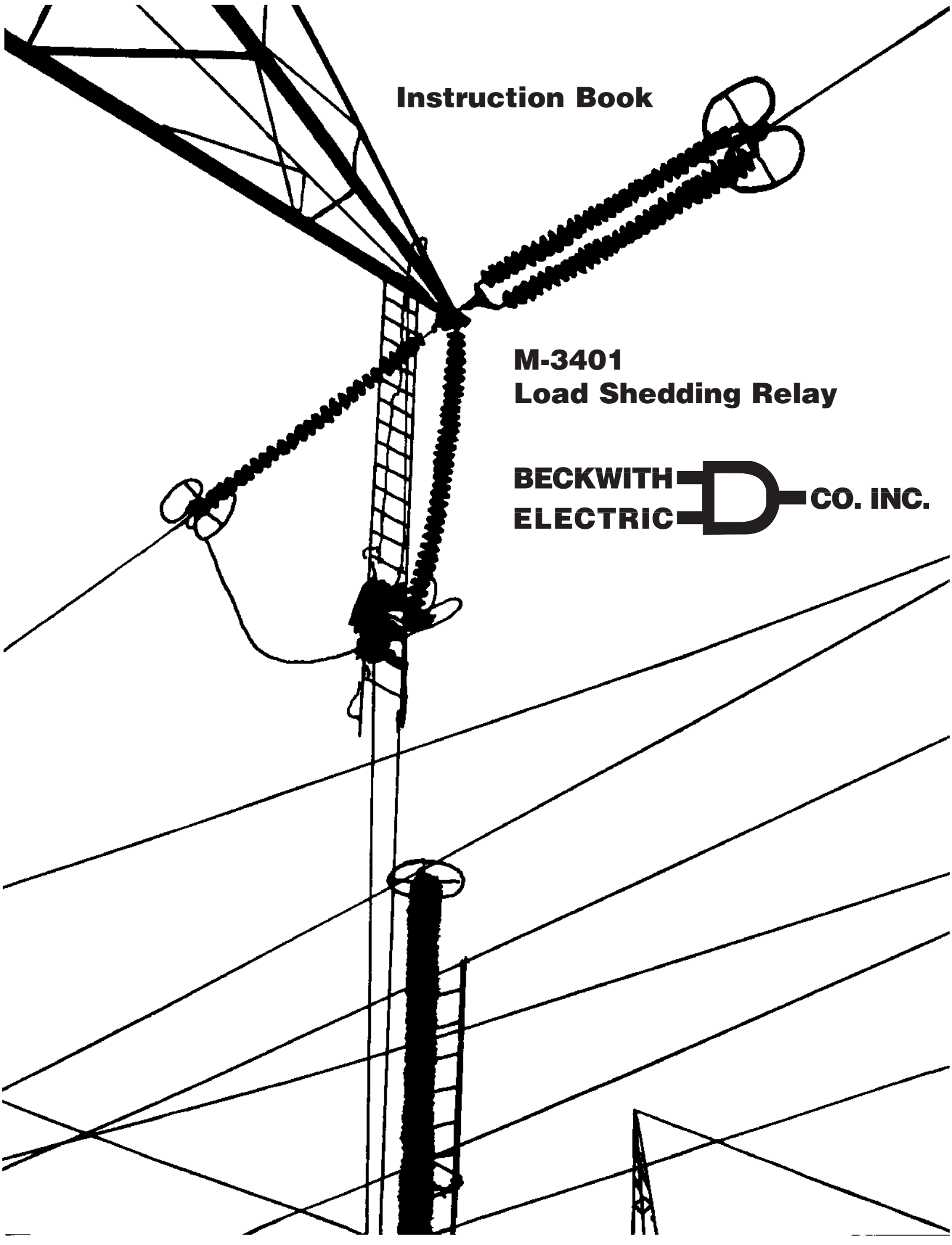
# Instruction Book

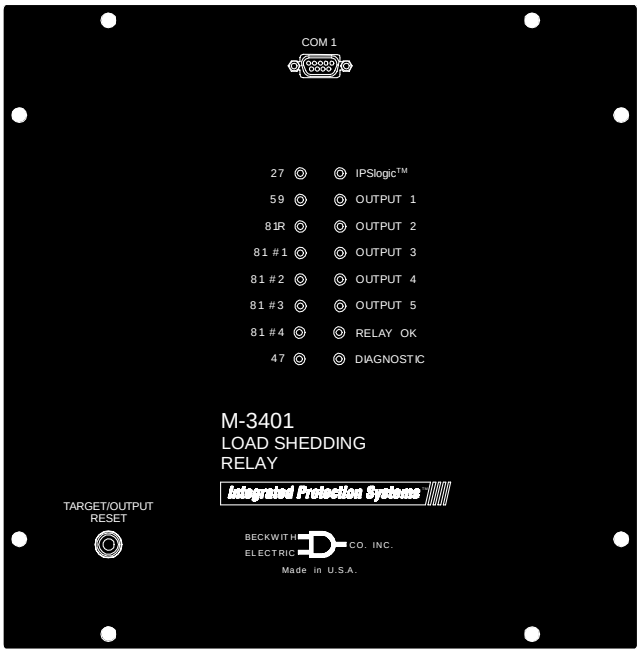


## M-3401
## Load Shedding Relay

BECKWITH ELECTRIC CO. INC.

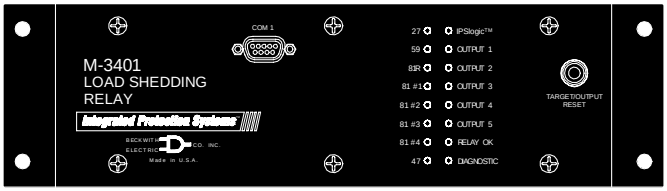
# Load Shedding Relay M-3401

## Integrated Protection System®




*M-3401 Standard Panel*


*M-3401 Vertical Panel (Optional)*




*M-3401 Horizontal Panel (Optional)*

- **Voltage Collapse Mitigation providing 4-step undervoltage and 4-step underfrequency load shedding functions**
- **Undervoltage blocking and negative sequence overvoltage blocking for system faults provides load shedding security**
- **Local and remote serial communications (MODBUS Protocol) for monitoring and control functions**
- **5 programmable outputs and 2 programmable inputs**

## Protective Functions

- 4-Step Phase undervoltage (27) protection, single-phase and positive sequence
- 4-Step Phase undervoltage, selectable as single phase or positive sequence responding, with Negative sequence overvoltage and three phase undervoltage supervision
- Phase overvoltage (59) protection
- Four-step over/under frequency (81) protection
- Rate of Change of Frequency (81R) protection
- IPSlogic™ takes the contact INPUT status and function status and generates OUTPUTS by employing (OR, AND, and NOT) boolean Logic and a timer.

## Standard Features

- 5 programmable outputs, 2 programmable inputs, and 1 self-test output
- Oscillographic recording (COMTRADE file format)
- Time-stamped sequence of events (SOE) recording for 32 events
- Metering of Voltage and Frequency
- One RS-232 port (COM1) on front and one RS-232 or 485 port (COM2) on rear
- M-3812 IPScom® For Windows™ Communications Software
- MODBUS protocol
- Supports both 50 and 60 Hz applications
- Relay voltage inputs can be directly connected (no VT required) for voltages ≤ 480 V ac
- Continuous Self-Diagnostics

## Optional Features

- M-3801D IPSplot® *PLUS* Oscillograph Analysis Software
- Horizontal and Vertical panel mount versions available (see Figures 2 and 4)

## PROTECTIVE FUNCTIONS

| Device Number | Function | Setpoint Ranges | Increment | Accuracy |
|---|---|---|---|---|
| | **Phase Undervoltage** | | | |
| 27 | Pickup #1, #2, #3, #4 | 4 to 100%* | 0.1% | ±0.5 V or ±0.5% |
| | Time Delay #1, #2, #3, #4 | 1 to 8160 Cycles | 1 Cycle | ±2 Cycles** |
| | Supervision | | | |
| 47S | Pickup | 4 to 100%* | 0.1% | ±0.5 V or ±0.5% |
| | Time Delay | 1 to 8160 Cycles | 1 Cycle | ±2 Cycles** |
| 27S | Pickup | 4 to 100%* | 0.1% | ±0.5 V or ±0.5% |
| | Time Delay | 1 to 8160 Cycles | 1 Cycle | ±2 Cycles** |

** Of nominal voltage.*

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

*27 element response is selectable as positive sequence voltage or phase-to-phase voltage.*

| | | | | |
|---|---|---|---|---|
| | **Negative Sequence Overvoltage** | | | |
| 47 | Pickup #1, #2 | 4 to 100%* | 0.1% | ±0.5 V or ±0.5% |
| | Time Delay #1, #2 | 1 to 8160 Cycles | 1 Cycle | ±2 Cycles |

** Of nominal voltage.*

| | | | | |
|---|---|---|---|---|
| | **Phase Overvoltage** | | | |
| 59 | Pickup #1, #2 | 100 to 150%* | 0.1% | ±0.5 V or ±0.5% |
| | Time Delay #1, #2 | 1 to 8160 Cycles | 1 Cycle | ±2 Cycles** |

** Of nominal voltage.*

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

| | | | | |
|---|---|---|---|---|
| | **Over/Under Frequency** | | | |
| 81 | Pickup #1, #2, #3, #4 | 50.00 to 67.00 Hz (40.00 to 57.00 Hz*) | 0.01 Hz | ±0.03 Hz |
| | Time Delay #1,#2, #3, #4 | 2 to 65,500 Cycles | 1 Cycle | ±2 Cycles or ±0.01% |

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

*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. The accuracy is ±0.15 Hz for a range of 52 to 57 Hz and 63 to 67 Hz (for 60 Hz nominal) and 42 to 47 Hz and 53 to 57 Hz (for 50 Hz nominal).*

| | | | | |
|---|---|---|---|---|
| | **Rate of Change of Frequency** | | | |
| 81R | Pickup #1, #2 | 0.10 to 20.00 Hz/Sec. | 0.01 Hz/Sec. | ±0.05 Hz/Sec. or ±5% |
| | Time Delay #1, #2 | 3 to 8160 Cycles | 1 Cycle | + 20 Cycles |
| | Negative Sequence Voltage Inhibit | 0 to 99% | 1% | ±0.5% |

## PROTECTIVE FUNCTIONS (*cont.*)

| Device Number | Function | Setpoint Ranges | Increment | Accuracy |
|---|---|---|---|---|
| | **IPSlogic™** | | | |
| IPS | **IPSlogic uses element trip commands, control/status input state changes, communication points, output contact close signals to develop 2 programmable logic schemes.** | | | |
| | Time Delay #1–#2 | 1 to 8160 Cycles | 1 Cycle | ±1 Cycle or ±1% |
| | **Nominal Settings** | | | |
| | Nominal Voltage | 50 to 500 V* | 1 V | — |
| | VT Configuration | Line-Line/Line-Ground/Line-Ground-to-Line-Line** | | |
| | Seal-in Delay | 2 to 8160 Cycles | 1 Cycle | ±1 Cycle or ±1% |

** Maximum measured range for (59) function setting is ≤ 600 V.*

*** When line-ground-to-line-line is selected, the relay internally calculates the line-line voltage from the line-ground voltages for all voltage-sensitive functions. When line-ground-to-line-line selection is applied, the nominal voltage selection should be the line-line nominal voltage (not line-ground nominal voltage).*

## Description

The M-3401 Load Shedding Relay provides voltage load shedding, frequency load shedding or supervised voltage or frequency load shedding to assist in voltage collapse mitigation. The M-3401 Load Shedding Relay can be integrated into load shedding schemes that are part of an Energy Management System (EMS), or into automatic load shedding schemes as defined by the IEEE Power System Relaying Committee, Substation Protection Subcommittee, Working Group K-12.

In load shedding as part of EMS application, a control signal is sent to multiple remote switches at participating blocks of customers to interrupt loads for predetermined intervals. This method of load shedding can be manually performed by dispatchers at the EMS control station, or they may be automatic from the EMS using the logic, measurement and intelligence of the M-3401.

In the Automatic Load Shedding scheme where voltage instability is caused by sudden loss of critical transmission equipment or VAr generating equipment (i.e. very short collapse time), the M-3401 provides the means to quickly arrest fast voltage drop by disconnecting selected large blocks of customer load allowing voltage to recover.

The security of an undervoltage load setting scheme is increased with multiple phase detection rather than single phase, proper time coordination between fault clearing and the time delay for load shedding and also by using various supervision techniques that prevent nuisance tripping for voltage conditions that do not lead to collapse. This M-3401 offers three-phase line to line or line to ground configuration, optimal pickup/seal-in time delays from 2 to 8160 cycles, and negative sequence voltage (47S) as well as undervoltage (27S) supervisory functions that ensure security and reliable operation.

To ensure that all data is collected during a load-shedding event the M-3401 has oscillographic recording, storing 180 cycles of all measured parameters. Additionally, the M-3401 has a Sequence of Events (SOE) recorder built-in to capture and store a total of 32 events with 1mSec resolution time stamp.

## Undervoltage Load Shedding

Area undervoltage can occur when there is a lack of reactive support for the load. This lack of reactive support manifests itself as an undervoltage condition, with the undervoltage most severe at the load area requiring the reactive support. As load in the transmission systems are approximately symmetrical on all three phases, the undervoltage condition is seen on all three phases. If the power system voltage profile over the system is viewed as a plane, the undervoltage event from lack of reactive support can be conceptualized as a depression from the 1.0 pu level nominal) to some lower level, with the lowest point the area of highest reactive support requirement.

A method of gaining selectivity for load shedding is to employ multiple time undervoltage elements. In that manner, the localized areas with the lowest voltage (highest reactive power support requirements) are shed first.

When implementing an undervoltage load shedding scheme, it must be secure from asymmetrical voltage depressions occurring from unbalanced faults; single phase-to-ground, phase-to-phase, and phase-phase to phase-ground faults as well as three-phase faults and complete system de-energizations.

- Asymmetrical voltage depressions occurring from single to phase-to-ground, phase-to-phase, and phase-phase to ground faults are detected by using a negative sequence overvoltage element (47S) as a supervision. Typically set to 0.05 to 0.1 pu of nominal voltage, if the adjustable threshold is exceeded, the undervoltage load shedding is blocked.
- Three-phase faults that decrease the voltage symmetrically across all three phases, as well as complete de-energizations of the parts of the power system due to fault clearing or other sectionalizing, are detected by using undervoltage supervision (27S) on all phases. The undervoltage supervision is typically set lower than the lowest survivable undervoltage that could occur from lack of reactive support before the entire system voltage collapses, typically from 0.9 to 0.7 pu. If any phase voltage is lower than the adjustable setting, it is assumed that the condition is from a fault (any type, including three-phase) or complete de-energization of that part of the system.

## Metering

The relay provides metering of voltages and frequency.

*Metering Accuracies are:*

**Voltage**: ±0.5 V or ±0.5%, whichever is greater (Range 0 to 600 V)

**Frequency**: ±0.03 Hz (from 57 to 63 Hz for 60 Hz models; from 47 to 53 Hz for 50 Hz models)

## Oscillographic Recorder

The oscillographic recorder provides comprehensive data recording of all monitored waveforms, input contacts and output contacts, storing up to 120 cycles of data. The total record length is configured for one or two partitions. A programmable post trigger delay (5 to 95%) is incorporated to capture breaker operation. The oscillograph is triggered either remotely using the serial interface, or designated status input signals or M-3401 programmable output operations. Storage of oscillographic records is nonvolatile, and will be retained even without power, as long as the on-board battery is healthy.

Oscillographic data can be downloaded via serial communication in Common Format For Transient Data Exchange (COMTRADE) format as specified by IEEE Standard C37.111-1999.

## Sequence of Events

A total of 32 nonvolatile events can be stored. The recorded information includes the function(s) operated, the function(s) picked up, input/output contact status and time stamp. The events can be retrieved through the communications port. After the 32nd event is stored, additional events result in the oldest event being dropped (FIFO). The information is time-stamped to 1 ms resolution.

## Calculations

The M-3401 uses discrete fourier transform (DFT) algorithm on sampled (32 times per cycle) voltage signals to extract fundamental frequency phasors for calculations. The 59/27 function, when set for RMS measurement, uses a time domain algorithm to calculate the voltage magnitude.

## Power Input Options

| Nominal | Range | Burden |
|---|---|---|
| 12/24 V dc | 9 to 36 V dc | <5 VA |
| 48 V dc | 36 to 75 V dc | <5 VA |
| 120 V ac/125 V ac | 85 to 150 V ac/V dc | <5 VA |

## Sensing Inputs

*3 Voltage Inputs*: Rated nominal voltage of 69 V ac to 480 V ac, 60 Hz (50 Hz user configurable). Will withstand 600 V continuous voltage. Source voltages may be line-to-ground or line-to-line connected. Phase sequence ABC/ACB is selectable. Voltage transformer burden less than 0.25 VA at 120 V ac.

## Control/Status Inputs

The control/status inputs, INPUT1 and INPUT2, can be programmed to block any of the M-3401 functions and trigger the oscillograph recorder. The control/status inputs accept only dry contacts and are internally wetted (9 V dc) by the relay's power supply. A minimum current of 1.3 mA is required to avoid spurious triggering of the input.

## Output Contacts

The five programmable output relays, each with a contact, are rated as per ANSI/IEEE C37.90-1989 for tripping: make 30 A for 0.2 seconds.

The hardware configuration consists of the following:

- 1 self-test alarm output contact (form 'c') with a rating of 8 A at 120 V ac, 5 A at 30 V dc, 125 V dc 0.15 A resistive, 0.1 A inductive.
- 2 (form 'a') contacts which carry 8A, break 6A at 120 V ac, break 0.1A at 125 V dc, inductive break at 0.1A.
- 3 (form 'c') contacts with a rating of 8A at 120 V ac, 5A at 30 V dc, 125 V dc 0.15A resistive, 0.1A inductive.

Any of the M-3401 protective functions can be individually programmed to activate the five programmable outputs. The user can configure the five programmable outputs to either energize or de-energize to issue an output command.

The outputs (excluding the self-test) can have two modes of operation, LATCHING and NORMAL. The LATCHING mode requires an operator intervention to deactivate the outputs after the condition for operation has been removed. In the NORMAL mode, when the condition for tripping has been removed, the output(s) will deactivate automatically after the corresponding seal-in timers have expired.

## 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 microprocessor. The **DIAGNOSTIC** LED provides indication of the error code (when flashing). The **OSC TRIGGER** LED indicates that the oscillograph has been triggered. The remaining LEDs are used to indicate which protective function(s) have been tripped. **OUTPUT 1** and **OUTPUT 2** are used to indicate the status of the output contacts. The output LEDs will illuminate when the output contact relays are tripped. The **TARGET/OUTPUT RESET** button resets the target LEDs if the conditions causing the operation have been removed. Holding the **TARGET/OUTPUT RESET** button displays the present pickup status of the M-3401 functions. The **TARGET/OUTPUT RESET** button will deactivate the tripped output contact if the **LATCHING** mode was selected. (If the seal in timer has already expired, the output contact will deactivate immediately.)

## Communication

Communications ports include a front panel RS-232 port and a rear port user configurable to RS-232 or RS-485. The RS-232 ports are connected physically with a DB-9 connector and the RS-485 port utilizes 4-wire interface mounting screw terminals.

M-3812 IPScom® For Windows™ utilizing the MODBUS communications protocol in RTU mode, implements serial, byte-oriented asynchronous communication with the M-3401 and provides the following functions:

- Interrogation and modification of setpoints
- Time-stamped sequence of events information for the 32 most recent events
- Real-time metering of all quantities measured
- Downloading of recorded oscillographic data
- Relay Setup

# 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

■ **NOTE**: 1,500 V dc for power supply voltage options (12, 24, 48 V dc inputs).

### *Impulse Voltage*

IEC 60255-5 Power supply input voltages, 120 V ac/125 V dc:
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

Power supply input voltages, 12, 24, 48 V dc:
3,000 V pk, +/- polarity applied to each independent circuit to earth
3,000 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 Megaohms

## Electrical Environment

### *Electrostatic Discharge Test*

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

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

### *Fast Transient Disturbance Test*

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

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

■ **NOTE**: The signal is applied to the digital data circuits (RS-232, RS-485) through capacitive coupling clamp.

ANSI/IEEE C37.90.2 80-1000 Mhz @ 35 V/m

### *Output Contacts*

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

## Atmospheric Environment

### *Temperature*

IEC 60068-2-1 Cold, –20° C
IEC 60068-2-2 Dry Heat, +70° C
IEC 60068-2-78 Damp Heat, +40° C @ 93% RH

## Mechanical Environment

### *Vibration*

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

### *Shock*

MIL-STD-810C Method 516.2, Procedure 1, 11 ms, 15 g, 1/2 sine pulse, 3 pulses per axis

## Compliance

cULus-Listed per 508 – Industrial Control Equipment

– Industrial Control Equipment Certified for Canada CAN/CSA C22.2 No. 14-M91

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

## Physical

*Panel Mount*

**Size**: 12.20" high x 12.00" wide x 2.56" deep (30.99 cm x 30.48 cm x 7.27 cm)
**Approximate Weight**: 5 lbs, 11 oz (2.11 kg)
**Approximate Shipping Weight:** 9 lbs, 13 oz (4.48 kg)

*Horizontal/Vertical Panel Mount*

**Size**: 3.46" high x 10.50" wide x 11.63" deep (8.8 cm x 26.7 cm x 29.54 cm)
**Approximate Weight**: 6 lbs, 4 oz (2.84 kg)
**Approximate Shipping Weight:** 10 lbs, 4 oz (10.7 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-3401 Instruction Book, Appendix D, Layup and Storage for additional information.*

## Patent & Warranty

The M-3401 Load Shedding Relay is covered by U.S. Patent 5,592,393.

The M-3401 Load Shedding Relay is covered by a five year warranty from date of shipment.

## External Connections

M-3401 external connection points are illustrated in Figure 1, Standard Panel Layout External Connections and Figure 2 for the optional Horizontal and Vertical Panel External Connection Layouts.

*Specification is subject to change without notice.*

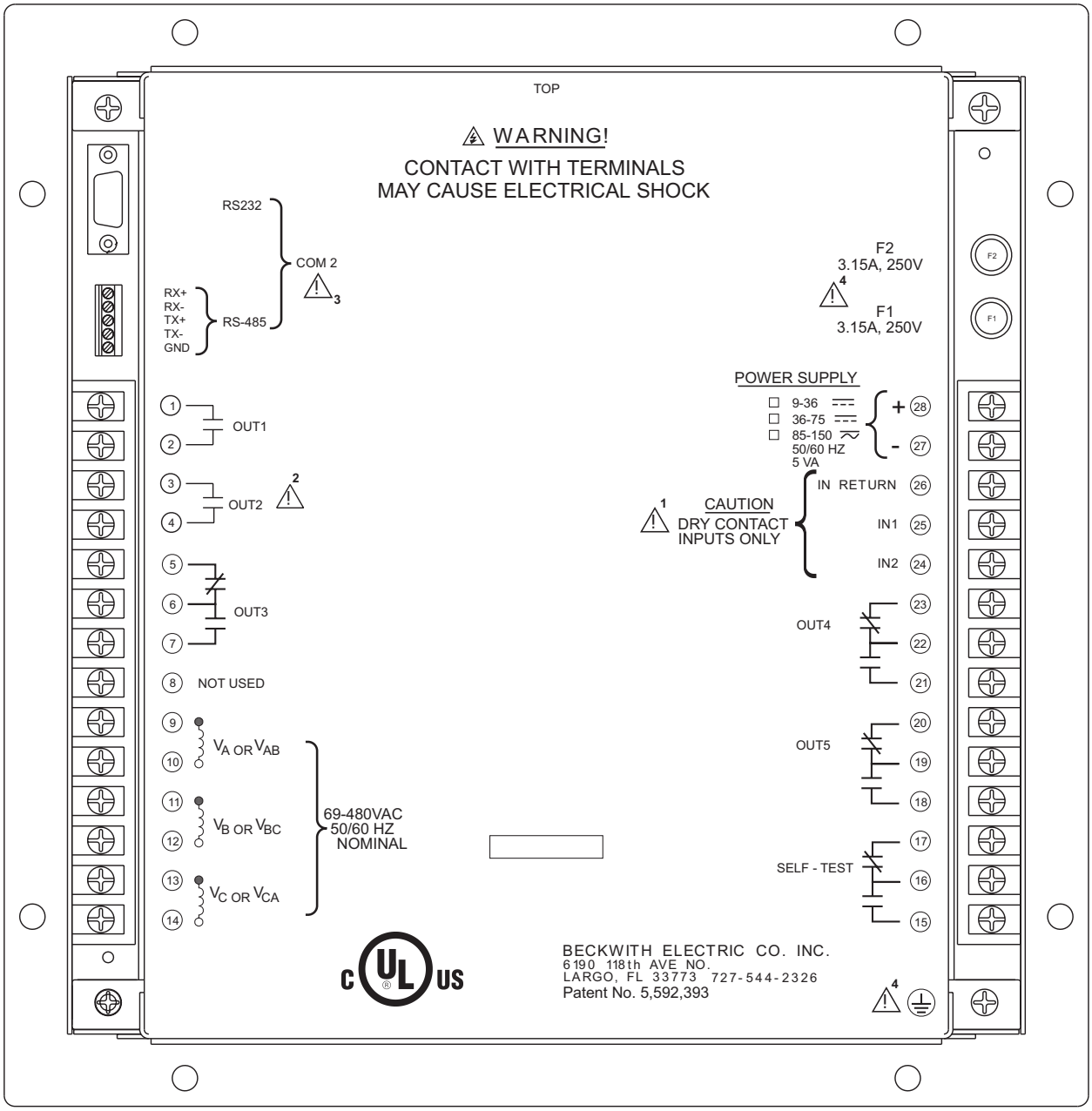



*Figure 1 Standard Panel Layout External Connections (Elevation View)*

■ **NOTES**:

1. See M-3401 Instruction Book, Section 2.3, External Connections.
2. See M-3401 Instruction Book, Section 3.1, Relay Configuration, Output Contact Mode.
3. See M-3401 Instruction Book, Section 2.8, Relay Remote Communication Setup (PC), COM2 Configuration.
4. See M-3401 Instruction Book, Section 2.3, External Connections.

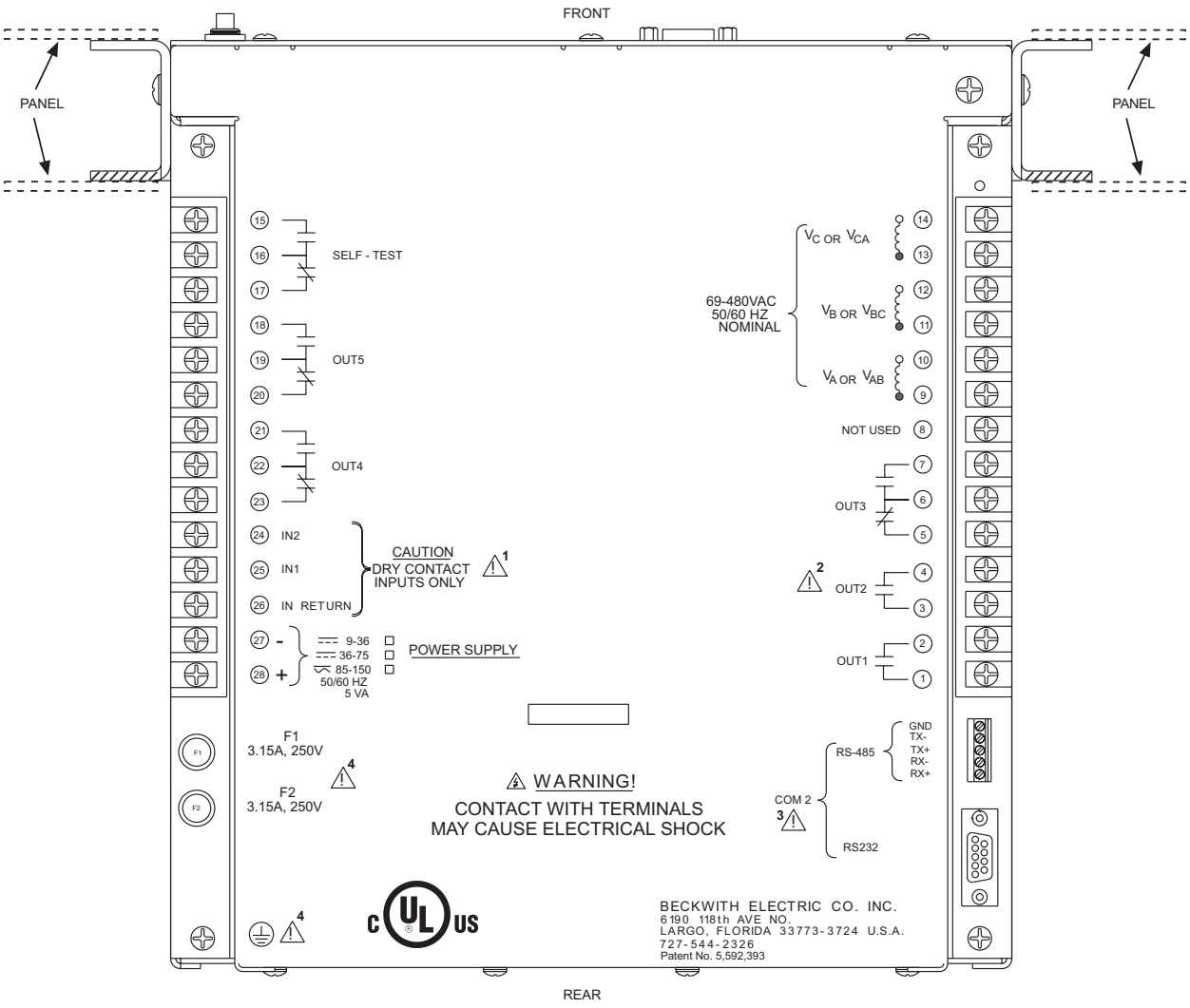



*Figure 2 Optional Horizontal and Vertical Panel External Connection Layout (Plan View)*

## ■ NOTES:

1. See M-3401 Instruction Book, Section 2.3, External Connections.
2. See M-3401 Instruction Book, Section 3.1, Relay Configuration, Output Contact Mode.
3. See M-3401 Instruction Book, Section 2.8, Relay Remote Communication Setup (PC), COM2 Configuration.
4. See M-3401 Instruction Book, Section 2.3, External Connections.

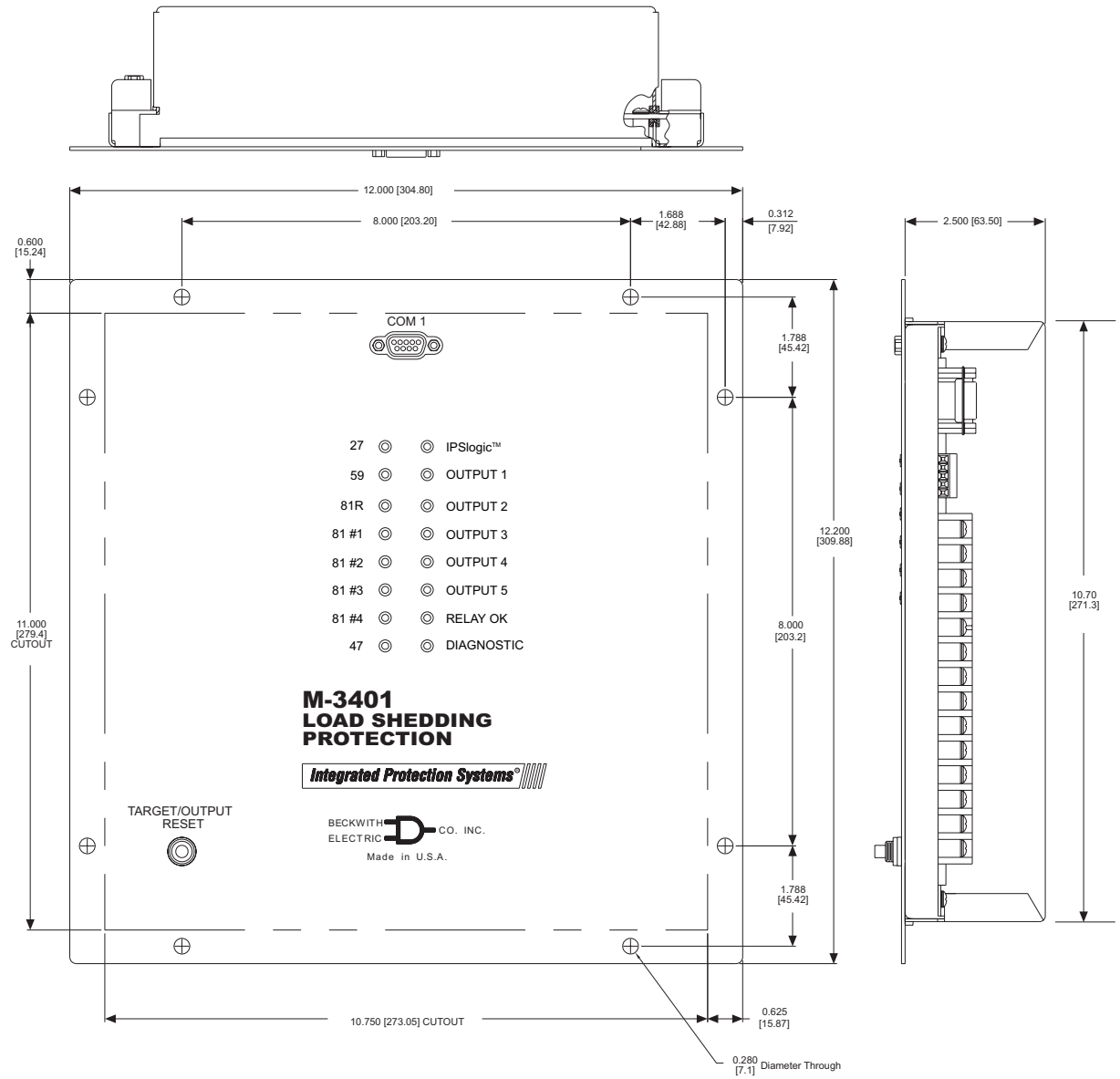



*Figure 3 Standard Panel Mounting Dimensions*

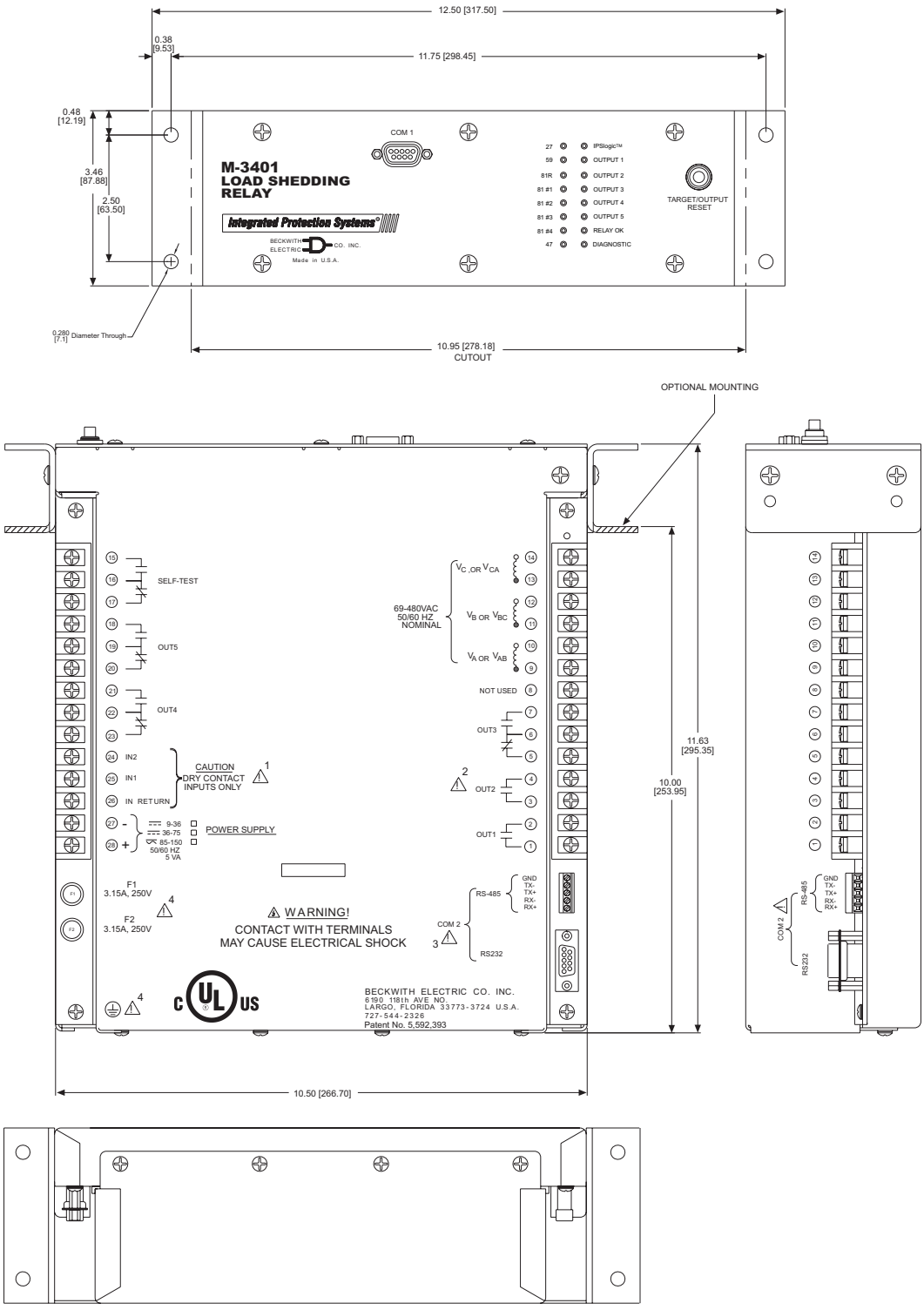



*Figure 4 Optonal Horizontal/Vertical Panel Mounting Dimensions*

## ■ NOTES: ⚠

1. See M-3401 Instruction Book, Section 2.3, External Connections
2. See M-3401 Instruction Book, Section 3.1, Relay Configuration, Output Contacts Mode.
3. See M-3401 Instruction Book, Section 2.8, Relay Remote Communication Setup (PC), COM2 Configuration
4. See M-3401 Instruction Book, Section 2.3, External Connections.

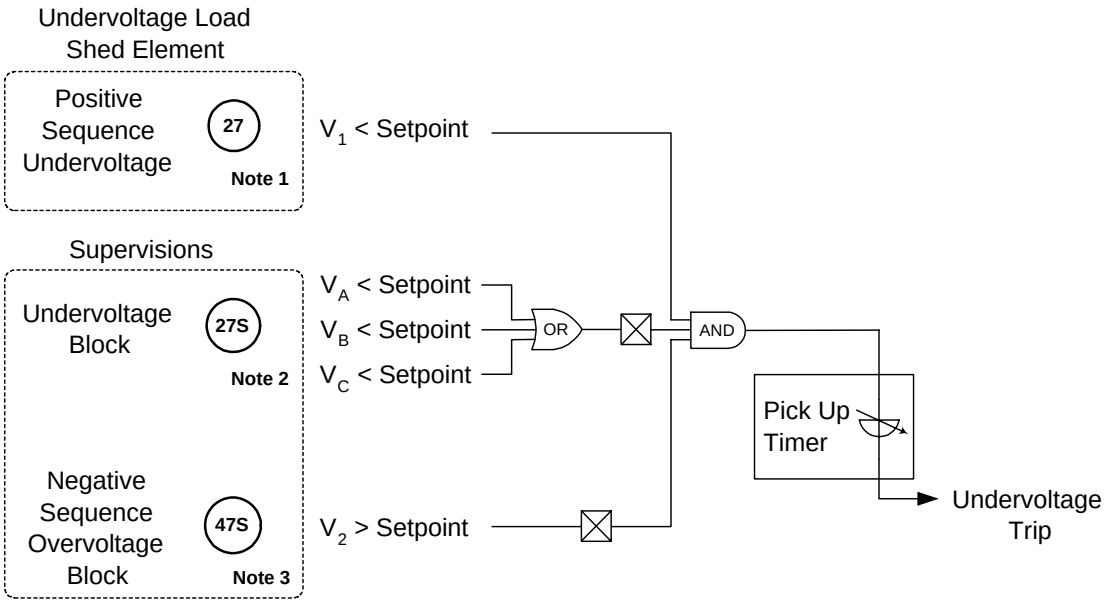



*Figure 5 Positive Sequence Undervoltage Element*

■ **NOTES**:

1. The undervoltage load shed element is selectable as either positive sequence undervoltage or three phase undervoltage.
2. The 27S supervises and blocks undervoltage load shedding when the system is de-energized or during three-phase faults.
3. The 47S supervises and blocks undervoltage load shedding during single and two-phase faults.

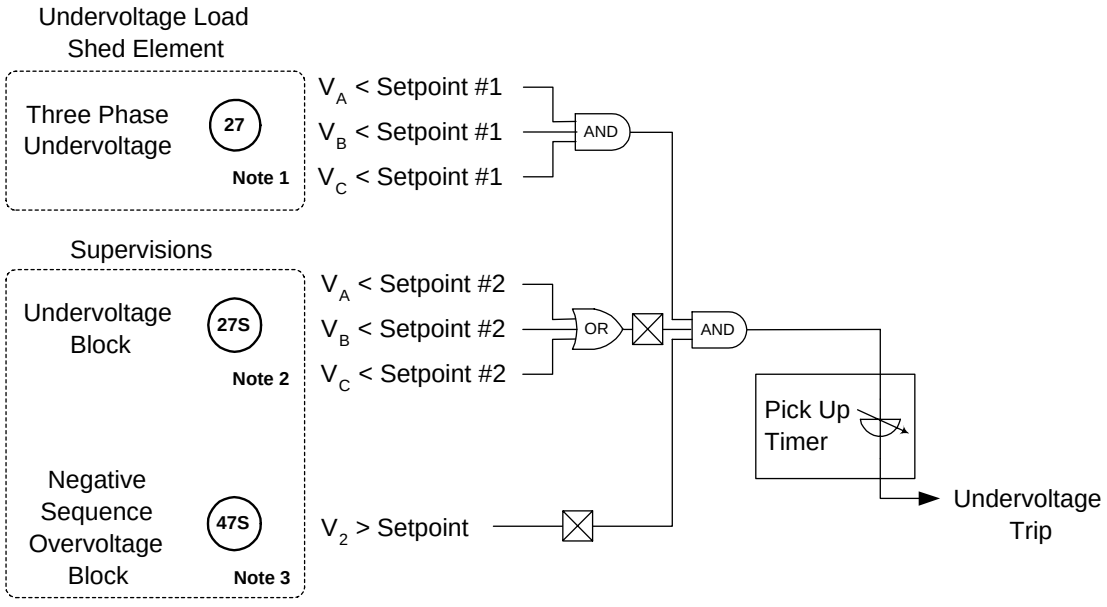



*Figure 6 Three Phase Undervoltage Element*

■ **NOTES**:

1. The undervoltage load shed element is selectable as either positive sequence undervoltage or three phase undervoltage.
2. The 27S supervises and blocks undervoltage load shedding when the system is de-energized or during three-phase faults.
3. The 47S supervises and blocks undervoltage load shedding during single and two-phase faults.

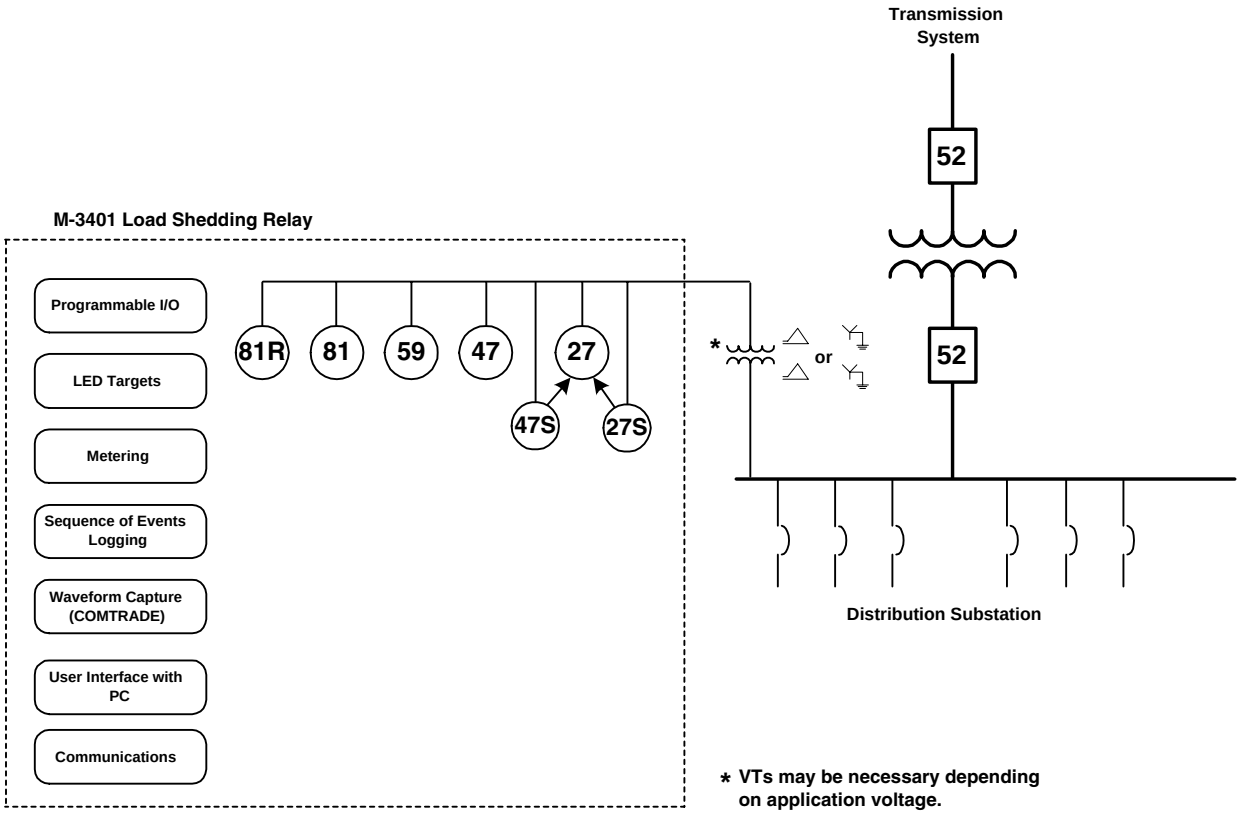



*Figure 7 Typical One-Line Diagram Load Shedding - Distribution*

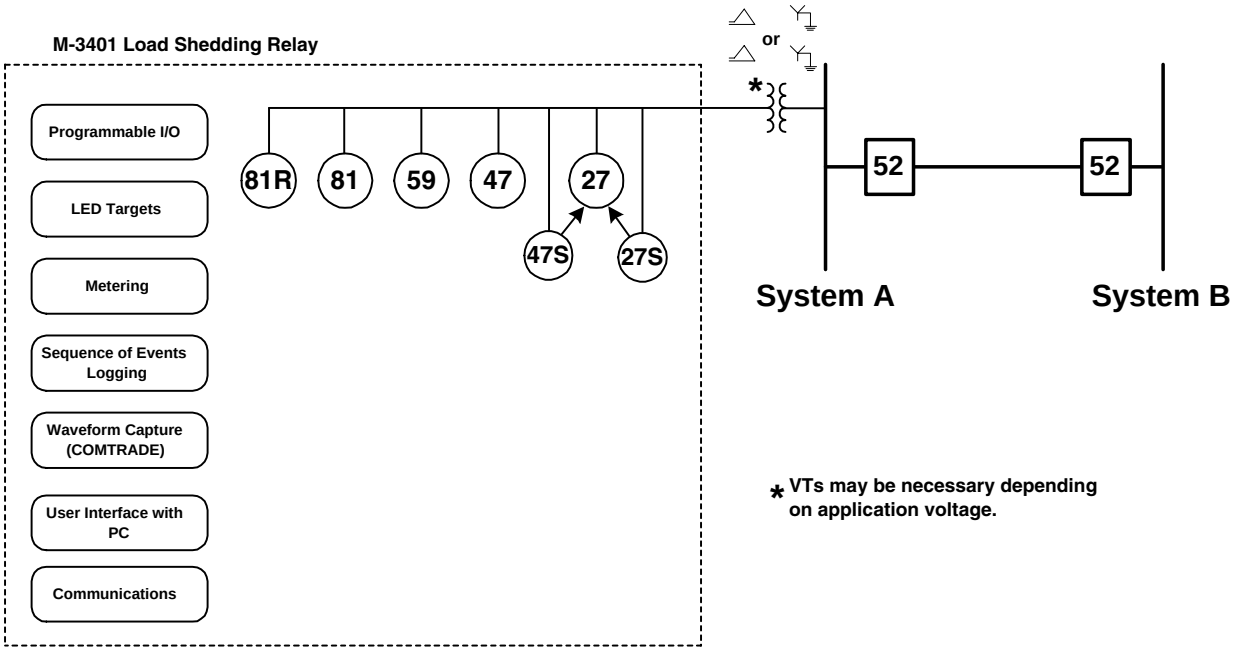



*Figure 8 Typical One-Line Diagram Load Shedding - Transmission/Sub-transmission*

# M-3401 Typical Connection Diagram

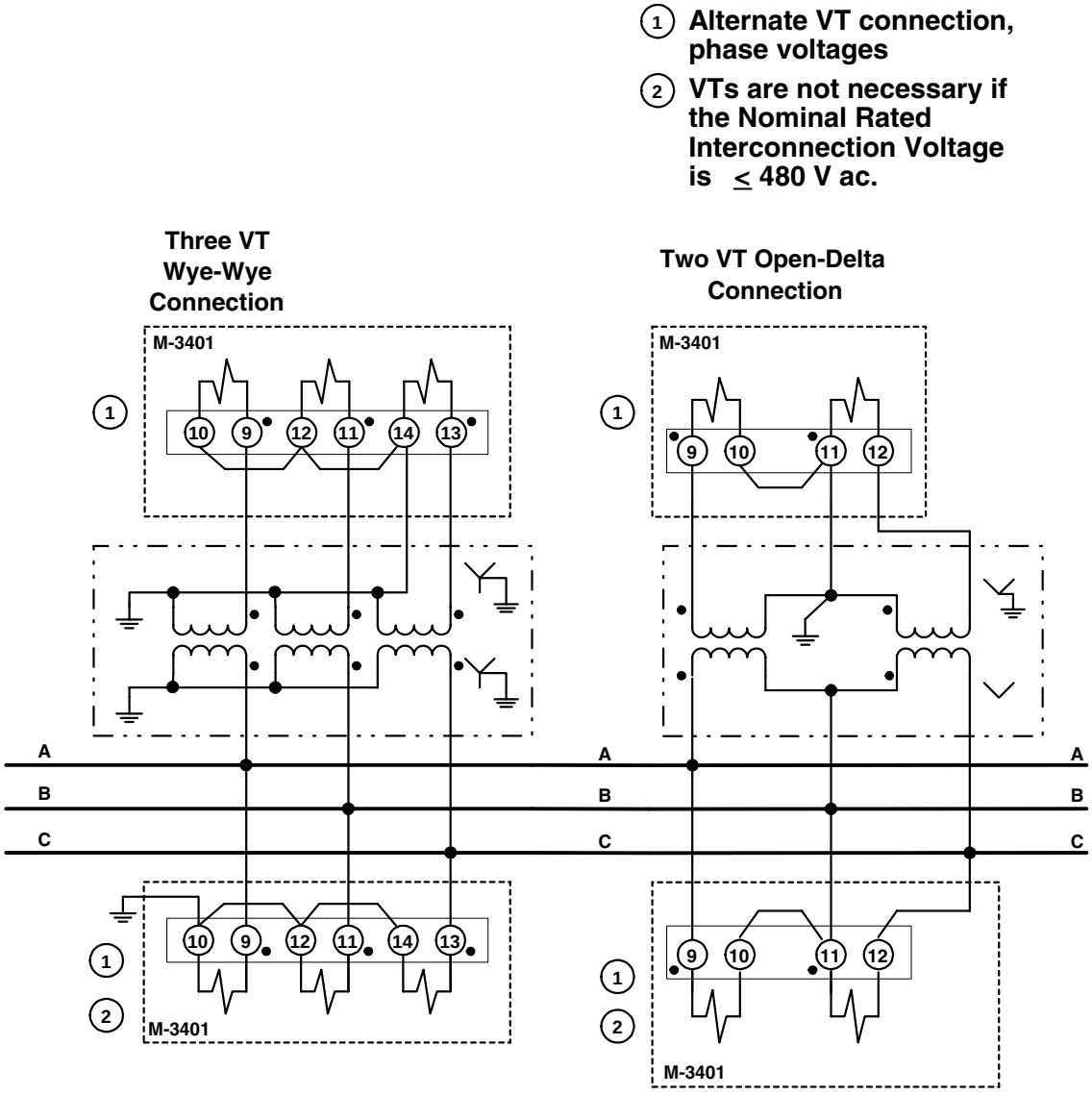



*Figure 9 Typical Three-Line Diagram Load Shedding Application*


ISO 9001:2000 Registered

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# WARNING

**DANGEROUS VOLTAGES, capable of causing death or serious injury, are present on the external terminals and inside the equipment. Use extreme caution and follow all safety rules when handling, testing or adjusting the equipment. However, these internal voltage levels are no greater than the voltages applied to the external terminals.**

## DANGER! HIGH VOLTAGE

– This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

## PERSONNEL SAFETY PRECAUTIONS

*The following general rules and other specific warnings throughout the manual must be followed during application, test or repair of this equipment. Failure to do so will violate standards for safety in the design, manufacture, and intended use of the product. Qualified personnel should be the only ones who operate and maintain this equipment. Beckwith Electric Co., Inc. assumes no liability for the customer's failure to comply with these requirements.*

– This sign means that you should refer to the corresponding section of the operation manual for important information before proceeding.

### Always Ground the Equipment

To avoid possible shock hazard, the chassis must be connected to an electrical ground. When servicing equipment in a test area, the Protective Earth Terminal must be attached to a separate ground securely by use of a tool, since it is not grounded by external connectors.

### Do NOT operate in an explosive environment

Do not operate this equipment in the presence of flammable or explosive gases or fumes. To do so would risk a possible fire or explosion.

### Keep away from live circuits

Operating personnel must not remove the cover or expose the printed circuit board while power is applied. In no case may components be replaced with power applied. In some instances, dangerous voltages may exist even when power is disconnected. To avoid electrical shock, always disconnect power and discharge circuits before working on the unit.

### Exercise care during installation, operation, & maintenance procedures

The equipment described in this manual contains voltages high enough to cause serious injury or death. Only qualified personnel should install, operate, test, and maintain this equipment. Be sure that all personnel safety procedures are carefully followed. Exercise due care when operating or servicing alone.

### Do not modify equipment

Do not perform any unauthorized modifications on this instrument. Return of the unit to a Beckwith Electric repair facility is preferred. If authorized modifications are to be attempted, be sure to follow replacement procedures carefully to assure that safety features are maintained.

# PRODUCT CAUTIONS

*Before attempting any test, calibration, or maintenance procedure, personnel must be completely familiar with the particular circuitry of this unit, and have an adequate understanding of field effect devices. If a component is found to be defective, always follow replacement procedures carefully to that assure safety features are maintained. Always replace components with those of equal or better quality as shown in the Parts List of the Instruction Book.*

## Avoid static charge

This unit contains MOS circuitry, which can be damaged by improper test or rework procedures. Care should be taken to avoid static charge on work surfaces and service personnel.

## Use caution when measuring resistances

Any attempt to measure resistances between points on the printed circuit board, unless otherwise noted in the Instruction Book, is likely to cause damage to the unit.

# TABLE OF CONTENTS
## M-3401 Load Shedding Relay Instruction Book

## Chapter 3 Configuration and Settings

## Chapter 4 Operation and Interface

## Chapter 5 Testing

## Appendix A Configuration Record Forms

## Appendix B–Communications



## C Appendix C–Self-Test Error Codes



## D Appendix D–Layup and Storage



800-3401-IB-00MC3 10/07

# 1 Introduction



## 1.1 Instruction Book Contents

This instruction book consists of five chapters and three Appendices.

**Chapter 1: Introduction**

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

**Chapter 2: Installation**

Chapter Two is designed for the person or group responsible for the installation of the M-3401 Load Shedding Relay. It includes the following elements necessary to affect the proper installation and commissioning of the relay:

- Functional and connection diagrams for a typical installation of the relay
- Provides instructions for the installation of M-3812 IPScom® for Windows™ Communication Software and establishes both local and remote communications with the relay
- Provides instructions for relay Commissioning Checkout.
- Configures the rear port COM2 for RS-485 or RS-232 communications.

**Chapter 3: Configuration and Settings**

Chapter Three is designed for the person or group responsible for the configuration and setting of the M-3401 Load Shedding Relay. It 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 relay and describes the individual function setpoints and time settings.

**Chapter 4: Operation and Interface**

This chapter is designed for the person or group responsible for relay operation and interface maintenance. Relay operation and interface access is described as a function of the M-3812 IPScom for Windows Communications Software.

**Chapter 5: Testing**

This chapter provides step-by-step test procedures for each function.

**Appendix A: Configuration Record Forms**

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

**Appendix B: Communications**

This Appendix describes communication port signals, protocols, 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: Layup and Storage**

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

## 1.2 M-3401 Load Shedding Relay

The M-3401 Load Shedding Relay is a microprocessor-based unit that uses digital signal processing technology to provide up to five protective relaying functions for Load Shedding.

Any of the protective functions can be individually programmed to activate the five programmable output contacts. The user can configure the five programmable output contacts to either energize or de-energize to issue an output command.

**Undervoltage Load Shedding**

Area undervoltage can occur when there is a lack of reactive support for the load. This lack of reactive support manifests itself as an undervoltage condition, with the undervoltage most severe at the load area requiring the reactive support. As load in the transmission system is approximately symmetrical on all three phases, the undervoltage event is seen on all three phases. If the power system voltage profile over the system is viewed as a plane, the undervoltage event from lack of reactive support can be conceptualized as a depression from the 1.0 pu level (nominal) to some lower level, with the lowest point the area of highest reactive support requirement.

A method of gaining selectivity for load shedding is to employ multiple time undervoltage elements. In that manner, the localized areas with the lowest voltage (highest reactive power support requirements) are shed first.

When implementing an undervoltage load shedding scheme, it must be secure from asymmetrical voltage depressions occurring from single to phase-to-ground, phase-to-phase, and phase-phase to phase-ground faults as well as three-phase faults and complete system de-energizations.

- Asymmetrical voltage depressions occurring from single to phase-to-ground, phase-to-phase, and phase-phase to phase-ground faults are detected by using a negative sequence overvoltage element (47S) as a supervision. Typically set to 0.05 to 0.1 pu of nominal voltage, if the adjustable threshold is exceeded, the undervoltage load shedding is blocked.
- Three-phase faults that decrease the voltage symmetrically across all three phases, as well as complete de-energizations of the parts of the power system due to fault clearing or other sectionalizing, are detected by using undervoltage supervision (27S) on all phases. The undervoltage supervision is typically set lower than the lowest survivable undervoltage that could occur from lack of reactive support before the entire system voltage collapses, typically from 0.9 to 0.7 pu. If any phase voltage is lower than the adjustable setting, it is assumed that the condition if from a fault (any type, including three-phase) or complete de-energization of that part of the system.

**M-3812 IPScom® for Windows™ Communications Software**

IPScom for Windows is shipped with every M-3401 relay. This software runs on a PC-compatible computer operating under Windows™ 95/98, NT or higher. When properly connected using either direct serial connection or modem, IPScom can provide the following functions:

- Real time monitoring of measured parameters
- Interrogation and modification of setpoints
- Line status real-time monitoring
- Recorded oscillograph data downloading
- This data can be analyzed using the M-3801D IPSplot® *PLUS* Oscillograph Analysis Software or a third-party viewing software employing the COMTRADE format

## 1.3 Accessories

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

The IPSplot *PLUS* Oscillograph Analysis Software runs in conjunction with the IPScom® software package on any IBM PC-compatible computer, enabling the plotting, printing, and analysis of waveform data downloaded from the M-3401 Load Shedding Relay.

| Function | Description |
|---|---|
| 27 | Phase Undervoltage |
| 47 | Negative Sequence Overvoltage |
| 59 | Phase Overvoltage |
| 81 | Over/Under Frequency |
| 81R | Rate of Change of Frequency |
| IPS | IPSlogic |

*Table 1-1 M-3401 Protection Functions*

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# 2 Installation



## 2.1 General Information

The person or group responsible for the installation of the relay and communications software will find herein all information required for the installation of the relay and the IPScom Communications Software.

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.

For reference, this chapter contains typical electrical One-Line and Three-Line Connection Diagrams as well as dimensional drawings for mounting, equipment ratings and IPScom Communications Software installation instructions.

Further, a commissioning checkout procedure is included utilizing IPScom Communications Software to check the external connections. Additional tests which may be desirable at the time of installation are described in Chapter 5, **Testing**.

## 2.2 Mechanical/Physical Dimensions

Figures 2-1 and 2-2, M-3401 Mounting Dimensions, contain physical dimensions of the relay that may be required for mounting the unit.

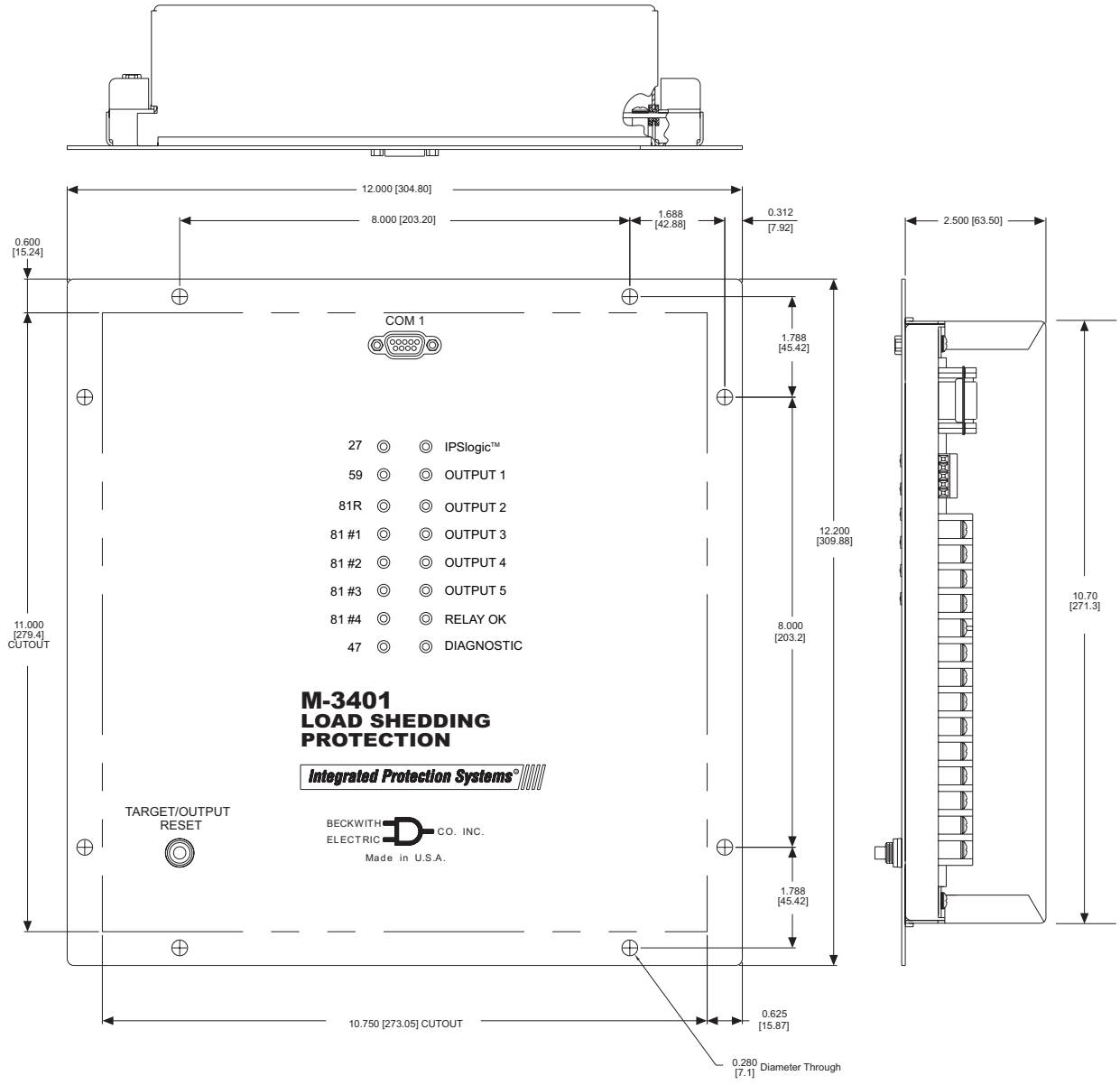



*Figure 2-1 M-3401 Standard Mounting Dimensions*

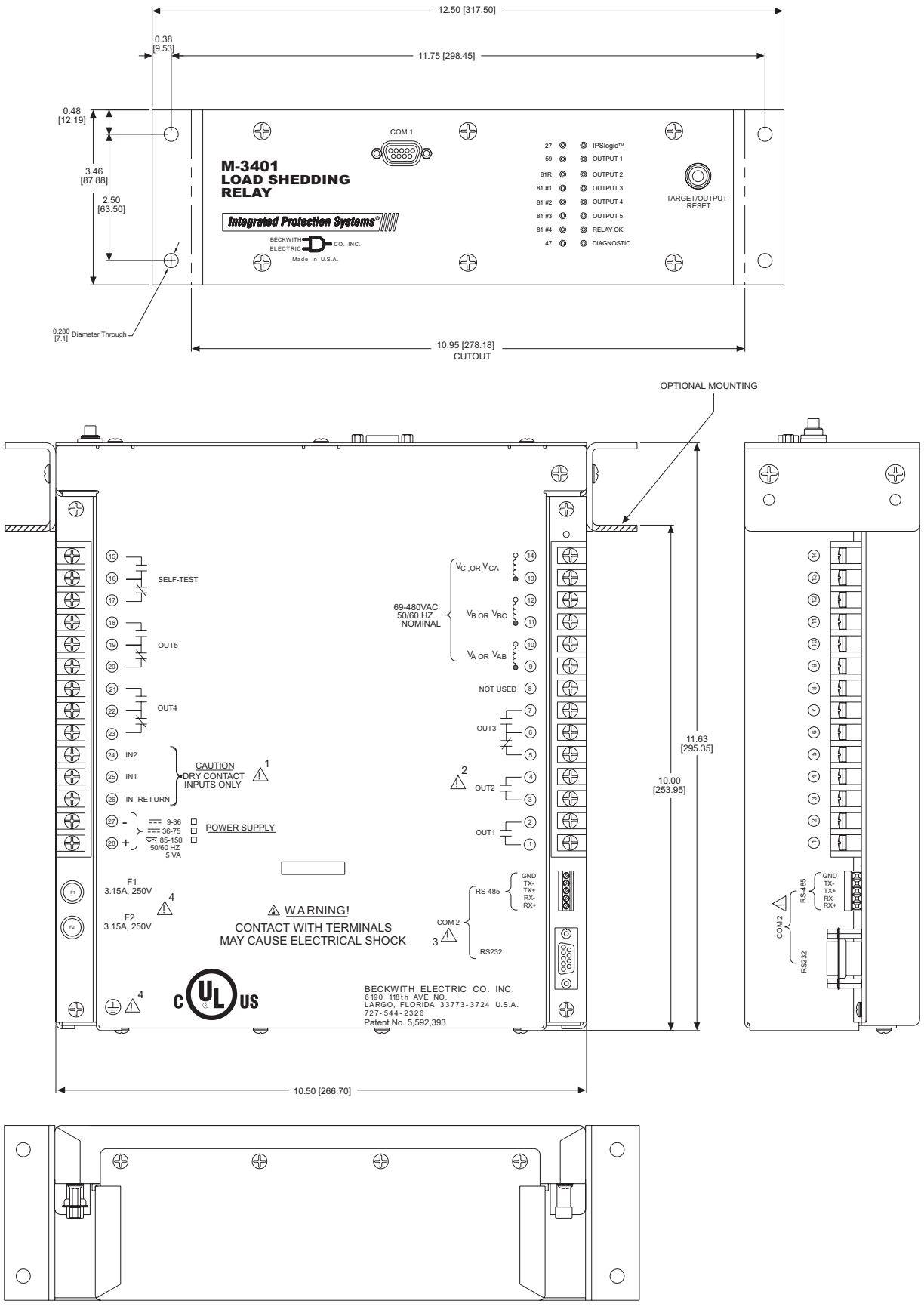



*Figure 2-2 Optional Horizontal/Vertical Panel Mounting Dimensions*

## 2.3 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 are to be connected to inputs (terminals TB-24, TB-25, and TB-26) because these contact inputs are internally wetted by the M-3401. Application of external voltage to these inputs may result in damage to the unit.**

Figures 2-3, 2-4 and 2-7 contain external connection information that may be required for installation.

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.

### Grounding Requirements

The M-3401 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-3401'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: 69 V to 480 V, Installation Category IV, Transient Voltages not to exceed 5,000 V
- Power Supply Mains: Installation Category II, Transient Voltages not to exceed 2,500 V

### Torque Requirements

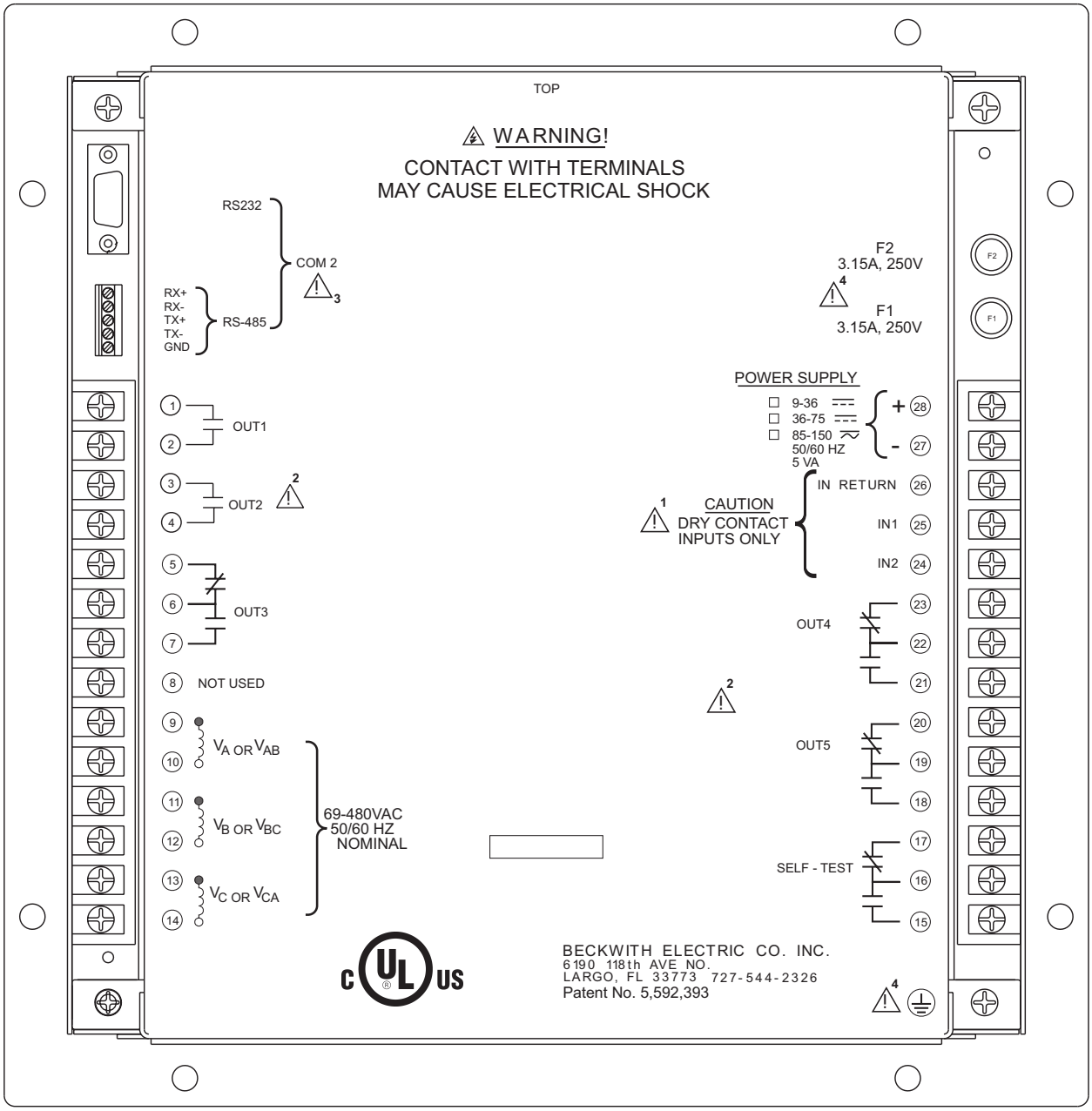
Terminals 1 to 28: 8.5 in-lbs (0.9605 Nm) minimum, and 9.0 in-lbs (1.0170 Nm) maximum

### 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.

### Replacement Fuses

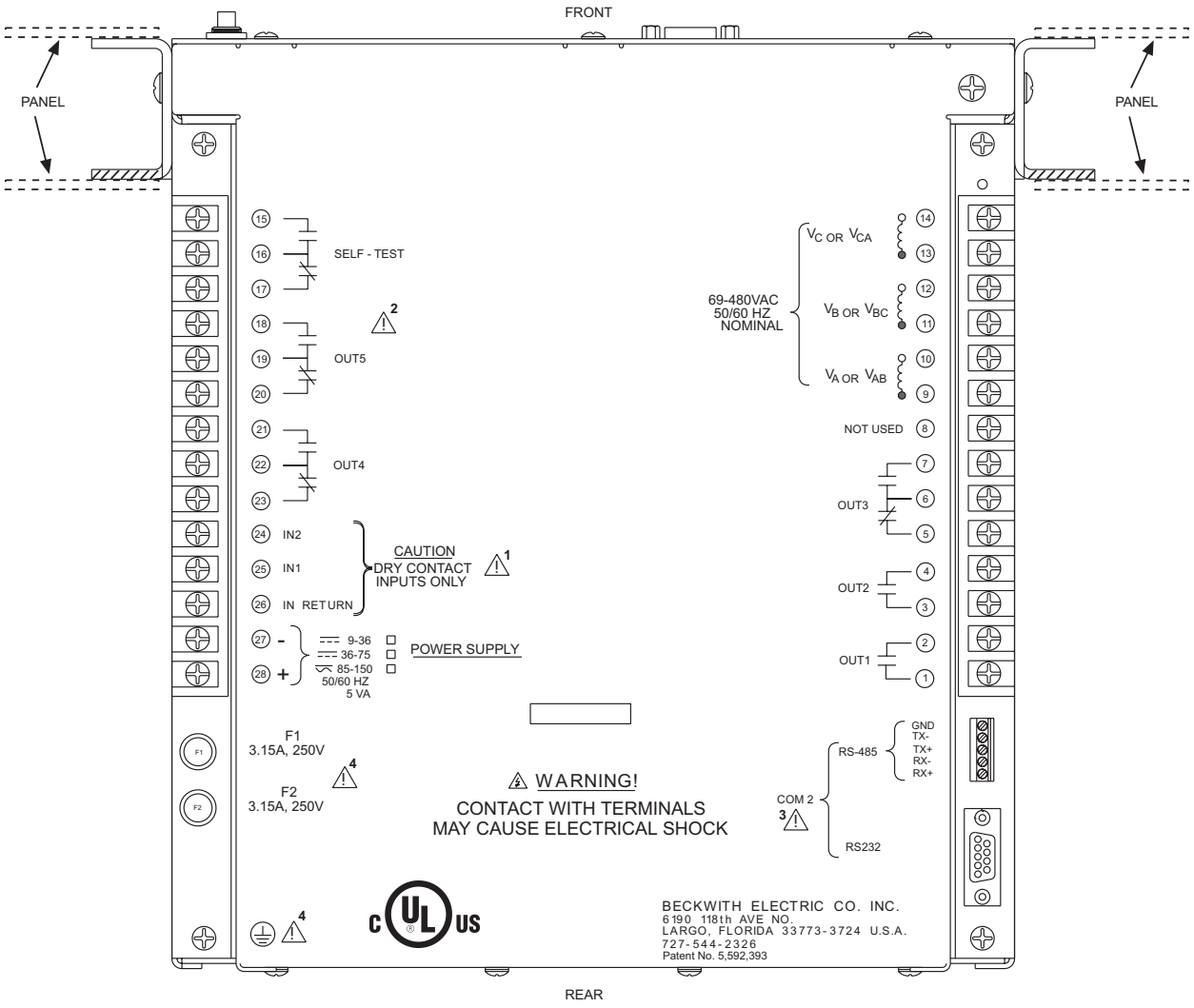
F1 and F2 replacement fuses must be Wickmann Model TR5, rated at 250 V, 3.15 A (Beckwith Electric Part Number 420-00902).




■ **NOTES**: ⚠

1. See Section 2.3, External Connections.
2. See Section 3.1, Relay Configuration, Output Contact Mode.
3. See Section 2.8, Relay Remote Communication Setup (PC), COM2 Configuration.
4. See Section 2.3, External Connections.

*Figure 2-3 External Connections*




■ **NOTES**: ⚠

1. See Section 2.3, External Connections.
2. See Section 3.1, Relay Configuration, Output Contact Mode.
3. See Section 2.8, Relay Remote Communication Setup (PC), COM2 Configuration.
4. See Section 2.3, External Connections.

*Figure 2-4 Optional Horizontal and Vertical Panel External Connection Layout*

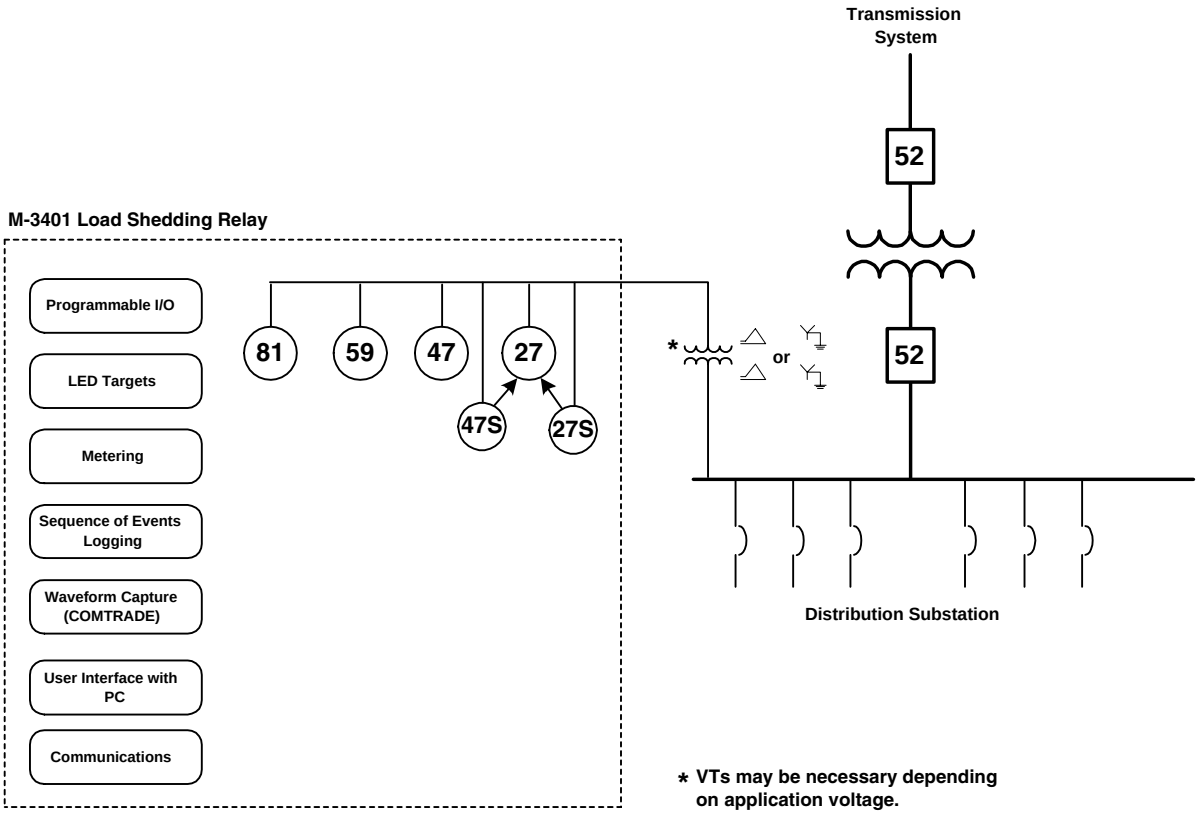



*Figure 2-5 Typical One-Line Connection Diagram Load Shedding - Distribution*

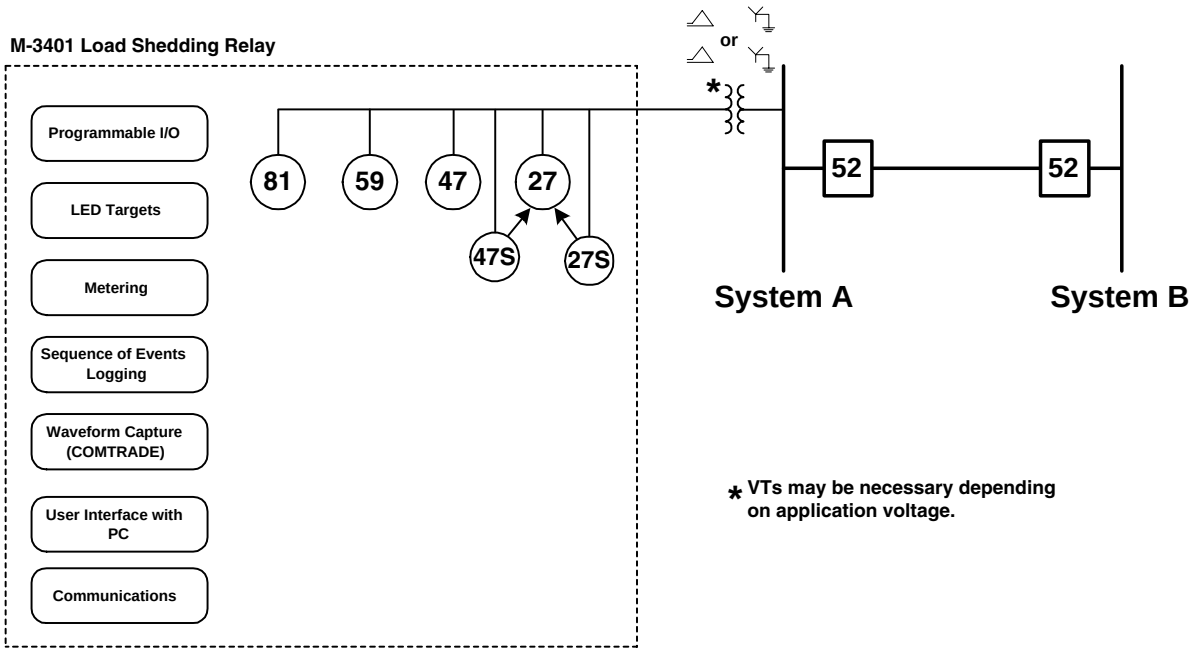



*Figure 2-6 Typical One-Line Diagram Load Shedding - Transmission/Sub-Transmission*

# M-3401 Typical Connection Diagram

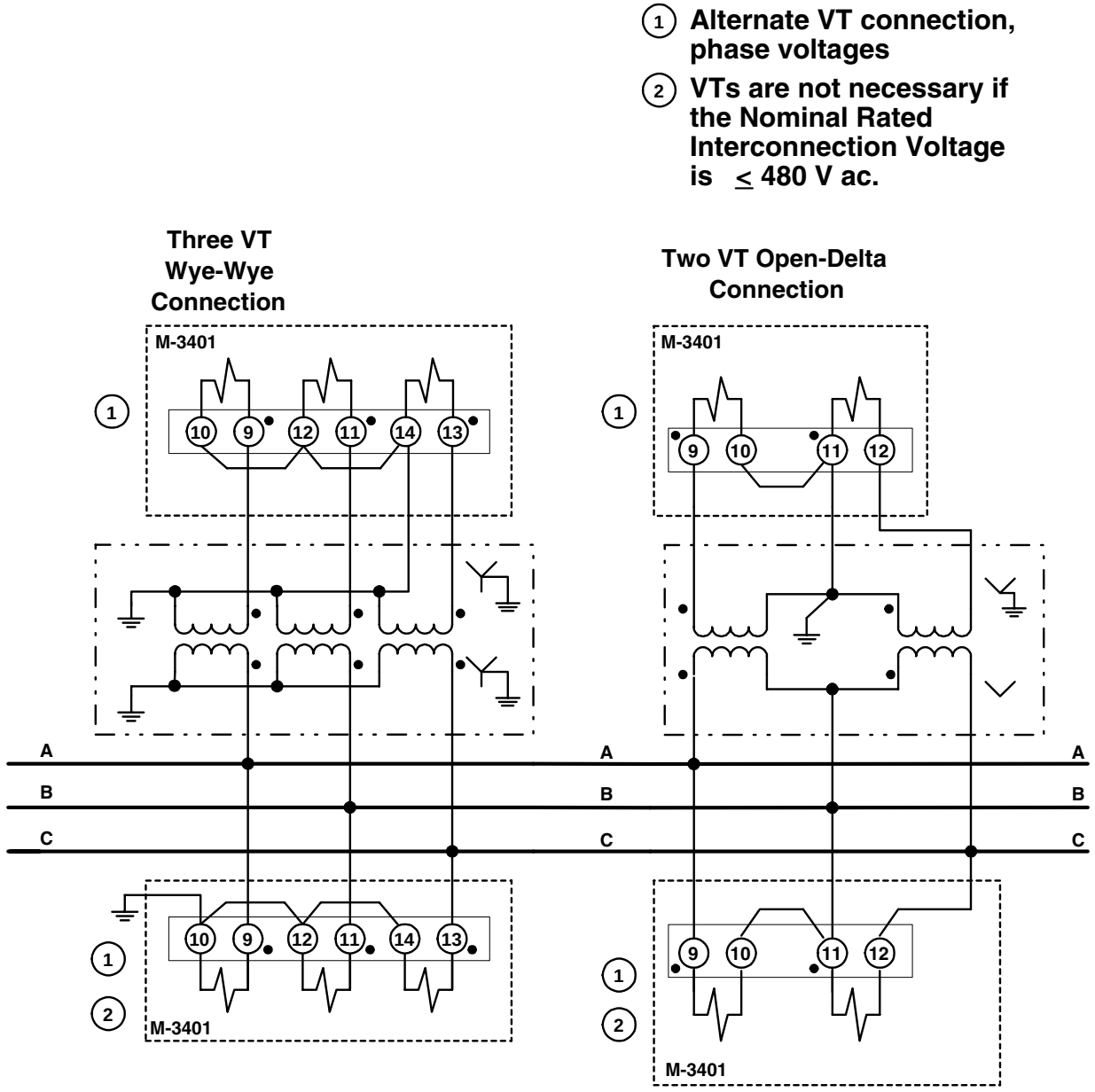



*Figure 2-7 Three-Line Connection Diagram - Load Shedding Application*

## 2.4 IPScom® Communications Software

### Overview

M-3812 IPScom for Windows™ Communications Software provides both local and remote communication with the M-3401 Load Shedding Relay using a PC.

This section describes how to establish initial local communication with the relay. Remote communication with the relay utilizing modems is addressed in Section 2.8, **Relay Remote Communication Setup (PC)**.

Equipment such as RTU's, PLC's, Communication/ Logic Processors, data concentrators, modems, or computers can be interfaced for direct, on-line, real time data acquisition and control.

The M-3401 Load Shedding Relay provides a front panel RS-232 communication port COM1 and a rear port COM2 that may be configured by the user to RS-232 (default) or RS-485. The front panel serial interface port, COM1, is a standard 9-pin, RS-232, DTE-configured port. 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. Either port, COM1 or COM2, may be used to remotely set and interrogate the relay using a modem or other direct serial connection.

### Communication Protocol

MODBUS communication protocol is implemented in the relay. Only the RTU mode of the MODBUS protocol is supported. The following functions are implemented in IPScom using MODBUS protocol:

- Real-time monitoring of measured parameters
- Interrogation and modification of setpoints
- Downloading of recorded oscillograph data and sequence of events data
- Configuration of all relay functions

### System Requirements

M-3812 IPScom for Windows runs with the Microsoft Windows 95 operating system or later.

IPScom is available on the following media:

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

The M-3812 IPScom for Windows Communications Software is not copy-protected and can be copied to a hard disk. For more information about your specific rights and responsibilities, see the licensing agreement enclosed with your software or contact Beckwith Electric at www.beckwithelectric.com.

### Hardware Requirements

M-3812 IPScom for Windows will run on any IBM PC-compatible computer that provides at least the following:

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

## 2.5 M-3812 IPScom for Windows Installation and Setup

1. Insert the software into your CD ROM.
2. Select Run from the Start Menu.
3. In the Run dialog box, initiate software installation by typing either **D:\Setup** or **other drive designator\Setup**, depending on the drive in which the software is inserted.
4. The installation utility establishes a program folder (Becoware) and subdirectory (IPScom). The default location for the application files is on drive C:, in the new subdirectory "IPScom" (C:\Program Files\Becoware\ IPScom\M-3812). After installation, the IPScom program icon (located in the Becoware directory) can be placed on the desktop.


*Figure 2-8 IPScom Program Icon*

## 2.6 IPScom® Communications Setup

### Direct Connection

Local communication with the relay using direct serial connection requires the use of IPScom Communications Software and a serial cable. A "null modem" serial 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 port COM1, 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, such as RS-485 or fiber optics.

### Relay Setup for Local Communication

The initial setup of the relay for communication must be completed by direct serial connection.

Ensure the following conditions exist:

- Power is available to the relay
- Communications cable is installed
- IPScom Communications Software installed

The communications parameters are set from the IPScom Communication Dialog Box on a PC.

Select the **Comm/Connect** menu in IPScom and set the following communication parameters in the **Communications** Dialog Screen (Figure 2-9).

■ **NOTE:** This instruction addresses the initial communication between IPScom and the M-3401. Therefore, factory default values are given in parentheses.

- **PC Port** (IPScom for Windows)
- **Baud Rate**: Standard baud rates from 9600 to 19200
- **Parity**: None, odd or even (None)
- **Stop Bits**: 1 or 2 (1)

**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.

**Relay Address**: The relay address allows IPScom to communicate with multiple relays. The factory default value is one.

**Echo Cancel**: The Echo Cancel feature is used in conjunction with Fiber Optic networks and 2-wire RS-485 Applications and should not be selected for local communication.

Initiate communication with the relay by performing the following:

1. Select **OPEN COM** for the active PC COM port for PC.
2. If communication with the target relay is successful, IPScom will then respond with "Access Granted" confirmation screen.
3. If communication with the target relay is not successful, then verify the applicable steps and settings of this section.

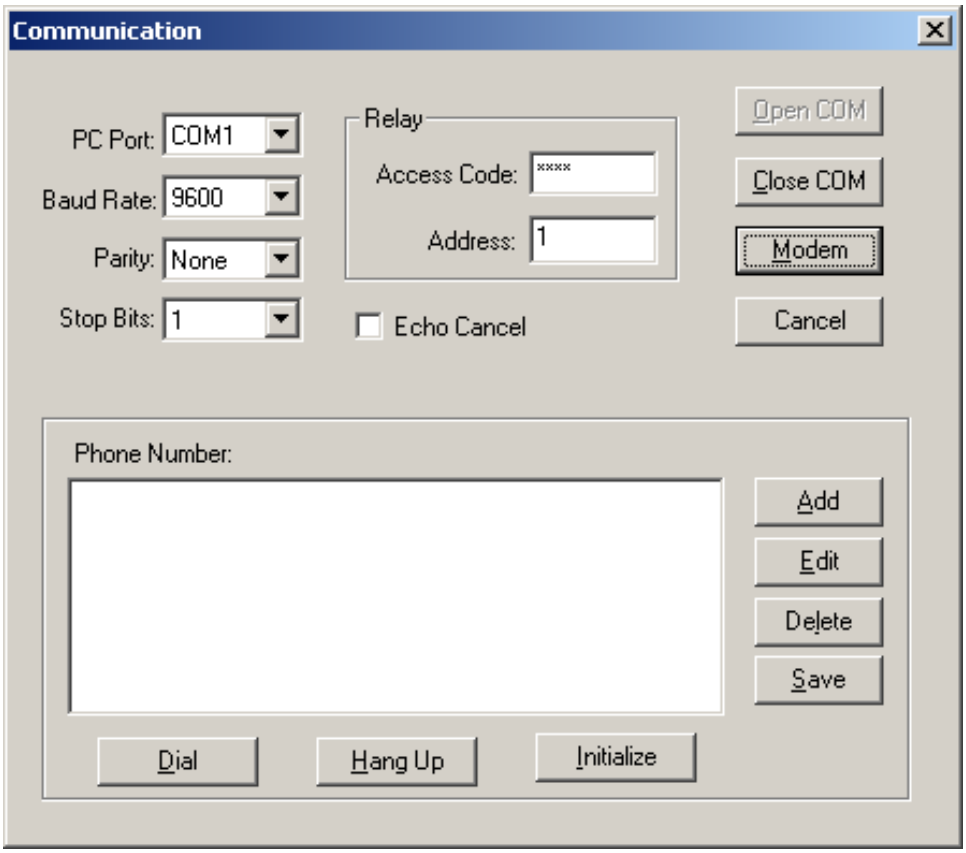



*Figure 2-9 Communication Dialog Screen*

## 2.7 Commissioning Checkout

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

1. If using M-3812 IPScom®, then select the **RELAY/MONITOR** drop down menu and choose **Secondary Status** (see Figure 2-10)**.**
2. Compare these voltages with actual measurements using a meter. 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 the line-ground voltages applied.
3. The positive sequence voltage should be $V_{POS} \approx V_A \approx V_B \approx V_C$ or $V_{AB} \approx V_{BC}$.
4. The negative sequence voltage should be $V_{NEG} \approx 0$.
5. 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 related functions will not operate properly.

   If positive, negative and zero sequence voltages are all present, check the polarities of the VT connections and change connections to obtain proper polarities.

■ **NOTE:** The VT polarities can be easily verified by observing the oscillographic waveforms using optional M-3801D IPSplot® *PLUS* Oscillograph Analysis software or with third party COMTRADE Format Viewer software.

6. Ensure all Error Codes are cleared (see Appendix C, **Self-Test Error Codes**).

If relay INPUT and OUTPUT tests are desired, then see Section 5.2, Diagnostic Test Procedures, for details.

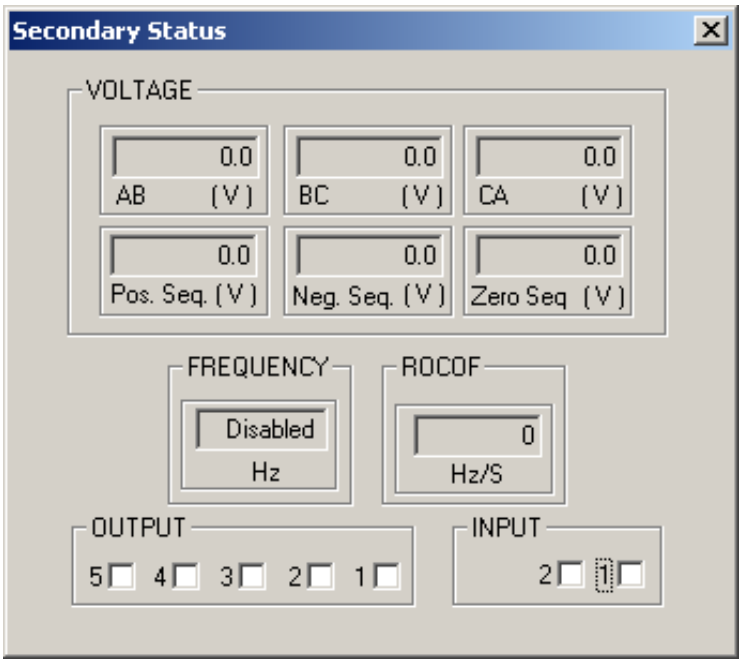



*Figure 2-10 Secondary Status Screen*

## 2.8 Relay Remote Communication Setup (PC)

### Overview

M-3812 IPScom® Communications Software provides remote communication with one or more M-3401 Load Shedding Relays. This section contains the information necessary to configure IPScom and remote communications equipment for remote communication with multiple relays.

Equipment such as RTU's, data concentrators, modems, or computers can be interfaced for direct, on-line, real time data acquisition and control.

### Communication Protocol

MODBUS communication protocol is implemented in the relay. Only the RTU mode of the MODBUS protocol is supported. The following functions are implemented in IPScom using MODBUS protocol:

- Real-time monitoring of measured and calculated parameters
- Interrogation and modification of setpoints
- Downloading of recorded oscillographic data and sequence of events data
- Configuration of all relay functions

### Multiple System Application

The individual addressing capability of IPScom and the relay allows multiple systems to share a direct or modem connection when connected using a communications-line splitter (see Figure 2-10). A typical device enables 2 to 6 units to share one communications line. The 6 unit limit is not a limit of the relay, but of the communications line splitter.

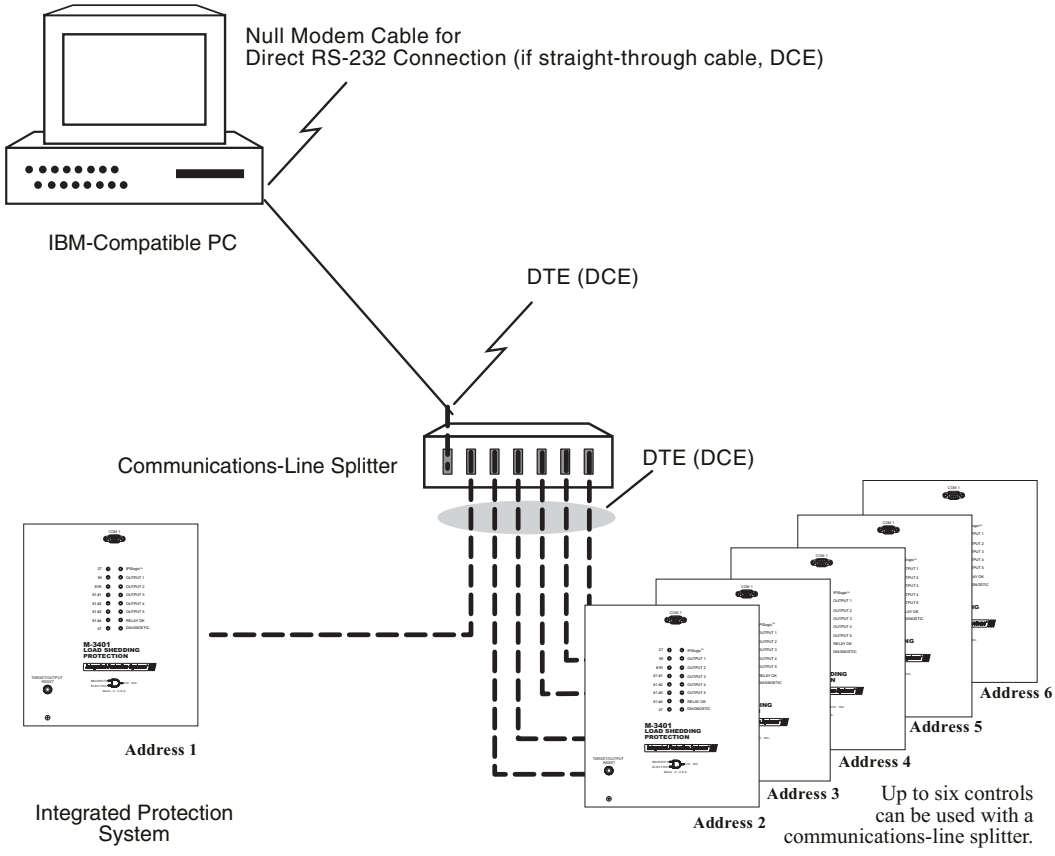



*Figure 2-11 Multiple System Addressing Using Communications-Line Splitter*

### Serial Multidrop Network Application

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

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

Other communication topologies are possible using the M-3401 Load Shedding Relay. An Application Note, "*Serial Communication with Beckwith Electric's Integrated Protection System Relays*" is available by contacting Beckwith Electric Co., Inc., at www.beckwithelectric.com.

### 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 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 at the relay location:

■ **NOTE**: Any Hayes compatible modem may be used; however, the relay communicates between 9600 - 19200 baud.

- An external modem, capable of understanding standard AT commands.
- Serial modem cable with 9-pin connector for the relay and the applicable connector for the modem.

Similarly, the computer running IPScom must contain an internal modem or have access to an external compatible modem.

The local modem (PC) 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 256 serial ports (COM1 through COM256), some computers may support only COM1 and COM2.
   c. Connect the modem to the telephone line and energize the modem.
2. Connecting the Modem to the Relay:

   Setup of the modem attached to the relay involves programming the parameters (using the AT command set), and storing this profile in the modem's nonvolatile memory.

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

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

   a. Connect the relay to an external modem by attaching a standard RS-232 modem cable to the appropriate serial communications port on both the relay and the modem.
   b. Connect the modem to the telephone line and energize the modem.

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

| | |
|---|---|
| E0 | No Echo |
| Q1 | Don't return result code |
| &D0 | DTR, always on |
| &S0 | DSR, always on |
| &C1 | DCD ON when detected |
| S0=2 | Answer on second ring |

The following commands may also be required at the modem:

| | |
|---|---|
| &Q6 | Constant DTE to DCE |
| N0 | Answer only at specified speed |
| W | Disable serial data rate adjust |
| \Q3 | Bidirectional 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 the steps necessary to issue these commands.

**Communications Address**: For multidrop networks, each device must have a unique address.Individual relay communication addresses should be between 1 and 247.

### Activating Communications

After any modems have been initialized, and M-3812 IPScom® configured, communication with the M-3401 is activated as follows:

1. Choose the IPScom for Windows icon from the Becoware folder.
2. The IPScom for Windows 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 in 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.
   b. Select the **Initialize** command button from the communication dialog screen.
   c. Choose the desired relay location, then choose the **Dial** button. This action establishes contact and automatically opens communication to the relay.
   d. If the computer is connected through the front com port, choose the **Open COM** button. This action establishes communications.
4. Enter 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 screen. To close the communication channel when connected locally, choose the **Close COM** command button.

### COM2 Configuration

COM2 is default configured for RS-232. To configure COM2 to RS-485, see Table 2-1.

## 2.9 Circuit Board Switches and Jumpers

See Figure 2-12, M-3401 I/O Board, Figure 2-13, M-3401 Top-View CPU Board or M-3401 Bottom-View CPU Board. Figure 2-14, for Jumper locations.

| JUMPER | POSITION | DESCRIPTION |
|---|---|---|
| IO Board JP2 | 1 to 2 | RS-485 Terminator Off |
| | 2 to 3 | RS-485 Terminator On |
| IO Board JP3 | 1 to 2 | COM2 RS-485 |
| | 2 to 3 | COM2 RS-232 |
| IO Board JP4 | 1 to 2 | COM2 RS-232 |
| | 2 to 3 | COM2 RS-485 |
| CPU Board JP21 | B-C | Flash Program Update ENABLED |
| CPU Board JP21 | A-B | Flash Program Update DISABLED |

*Table 2-1 Jumpers*

**Accessing 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 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.**

▲ **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-3401.
2. Remove power, current, and potential inputs from the relay.

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

3. Remove the screws that retain the rear/top cover, lift the rear/top cover off the relay.
4. Reconnect protective grounding terminal (bottom right cover screw) to an earth ground.
5. JP2, JP3, and JP4 are now accessible. See Figure 2-12, M-3401 I/O board for locations.
6. JP21 is now accessible. See Figure 2-13, M-3401 CPU Board.
9. Reinstall the rear cover on the relay; insert the screws that retain the rear cover.
10. Connect power, current, and potential inputs to the relay.

**Factory Default Reset**

To reset all function settings to factory defaults, perform the following:

**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 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.**

▲ **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-3401.

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

2. Remove the screws that retain the rear cover, lift the rear cover off the relay.
3. Reconnect protective grounding terminal (bottom right cover screw) to an earth ground.
4. Connect a jumper across JP11 (Figure 2-14).
5. Apply power to the unit, then wait for the power-on self test to complete.

6. Remove power from the unit, then remove jumper from JP11.
7. Resinstall the rear cover on the relay; insert the screws that retain the rear cover.

To reset Communications setting to factory default, perform the following:

**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 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.**

▲ **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-3401.

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

2. Remove the screws that retain the rear cover, lift the rear cover off the relay.
3. Reconnect protective grounding terminal (bottom right cover screw) to an earth ground.
4. Connect a jumper across JP13 (Figure 2-14).
5. Apply power to the unit, then wait for the power-on self test to complete.
6. Remove power from the unit, then remove jumper from JP14.
7. Reinstall the rear cover on the relay; insert the screws that retain the rear cover.

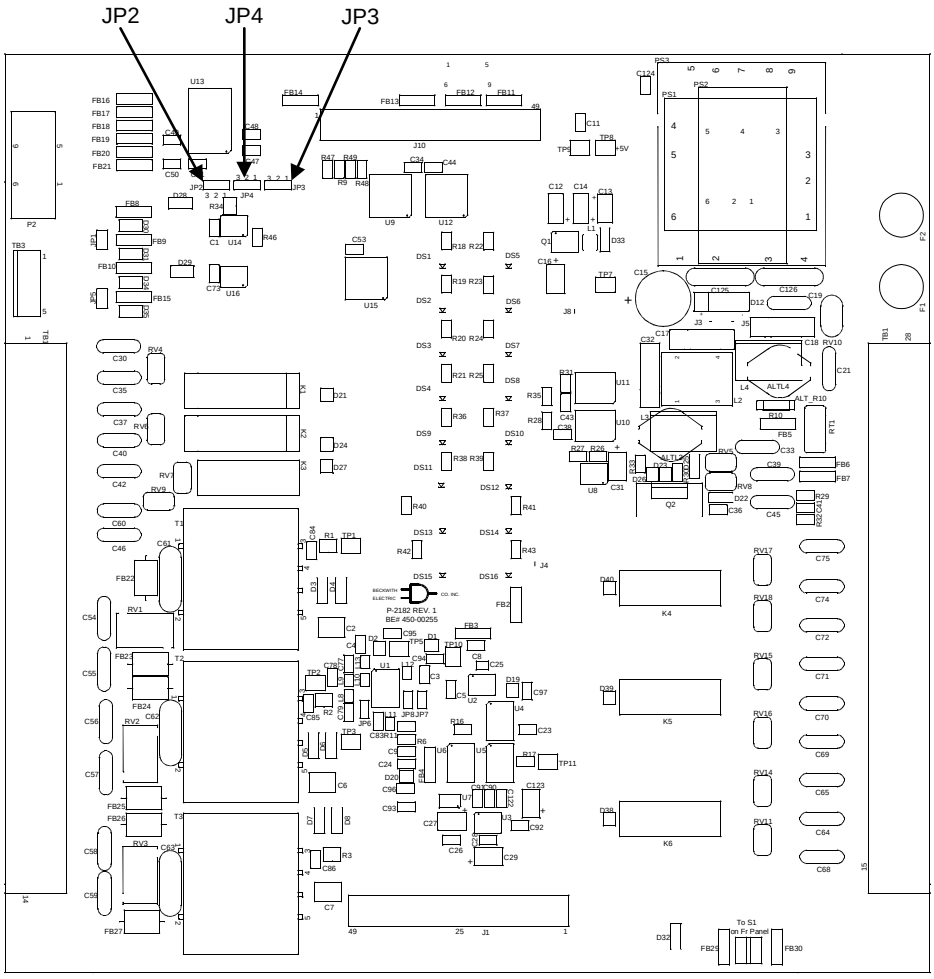



*Figure 2-12 M-3401 I/O Board*

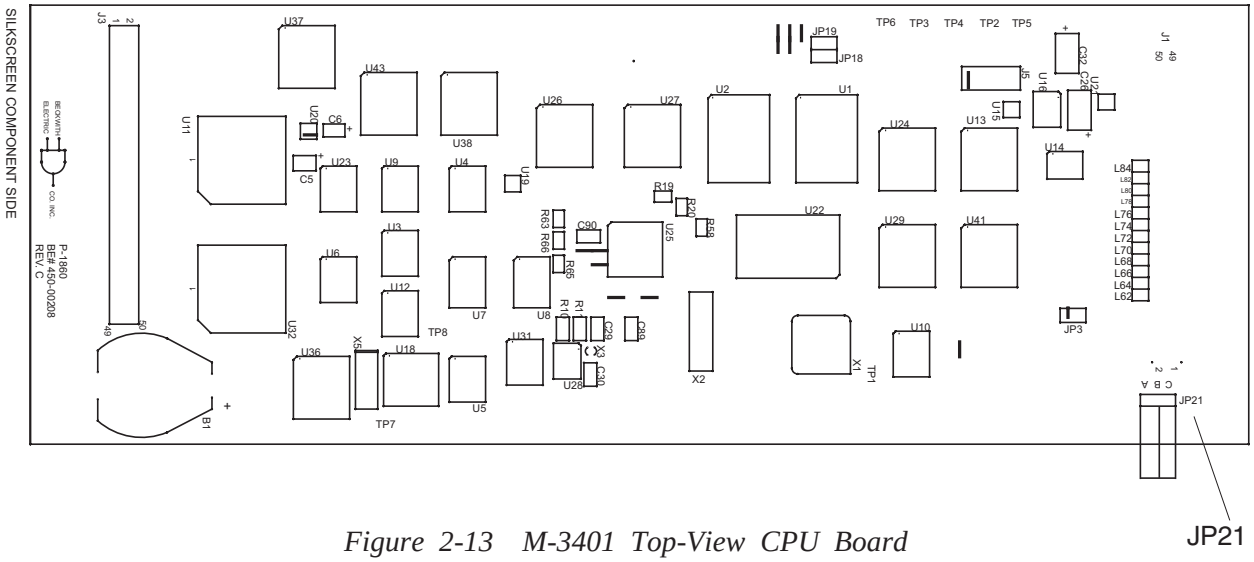



*Figure 2-13 M-3401 Top-View CPU Board*

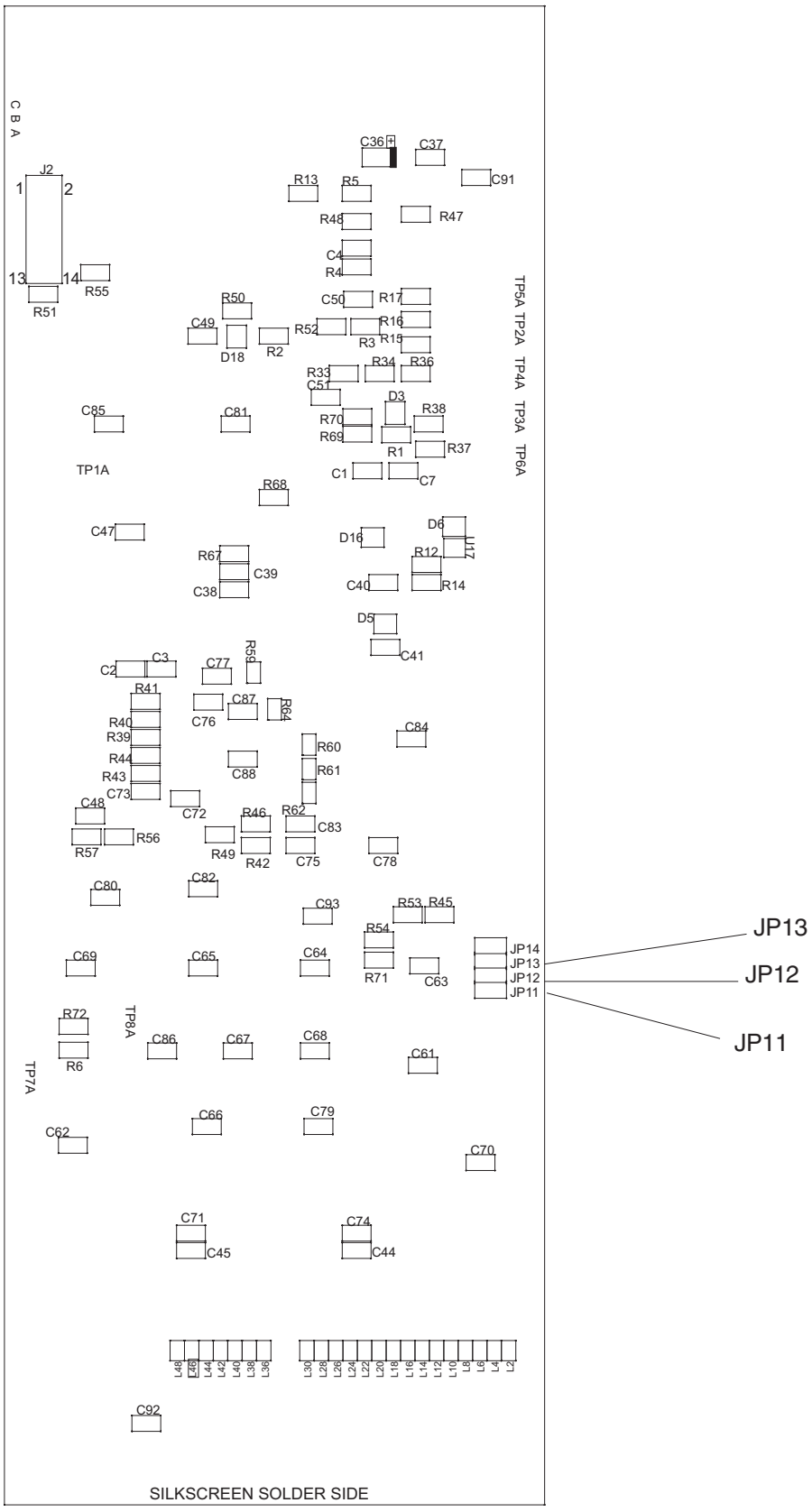



*Figure 2-14 M-3401 Bottom-View CPU Board*

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# 3 Configuration and Settings



Chapter Three is designed for the person or group responsible for the configuration of the M-3401 Load Shedding Relay. This chapter 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, equipment characteristics required by the protective relay and describes the individual function settings.

Settings may be entered utilizing M-3812 IPScom® Communications Software (see Chapter 4, **Operation and Interface**).

## 3.1 Relay Configuration

### 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 five programmable output contacts (OUT1–OUT5) and two programmable inputs (IN1 and IN2). A self-test alarm contact is also provided.

Enabling a relay protective function consists of entering the required settings in the individual function screens. Disabling a protective function (whether settings have been entered or not) is accomplished by deselecting the individual protective function element numbers. When a protective function is disabled, screen values are grayed out.

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

The relay configuration also includes the setup of the Oscillographic Recorder and Sequence of Events Recorder features. The oscillographic recorder provides the user with comprehensive data recording of all monitored waveforms, control/status input and output status, storing up to 120 cycles of nonvolatile data. The event recorder provides 32 nonvolatile, time stamped events that include functions operated, functions picked up, functions dropped out and control/status input and output status.

### Relay Setup

The relay setup consists of defining all pertinent information regarding certain relay actions and system quantities. The M-3812 IPScom® Setup Relay screen, Figure 3-1, is accessed through the **Relay/Setup, Setup Relay** menu. Regardless of the functions enabled or disabled, all information shown is required. Several functions require the proper setting of these values for correct operation. The Nominal Voltage setting is needed for proper normalization of per unit quantities. VT phase ratio is used only in monitoring and displaying system primary quantities.

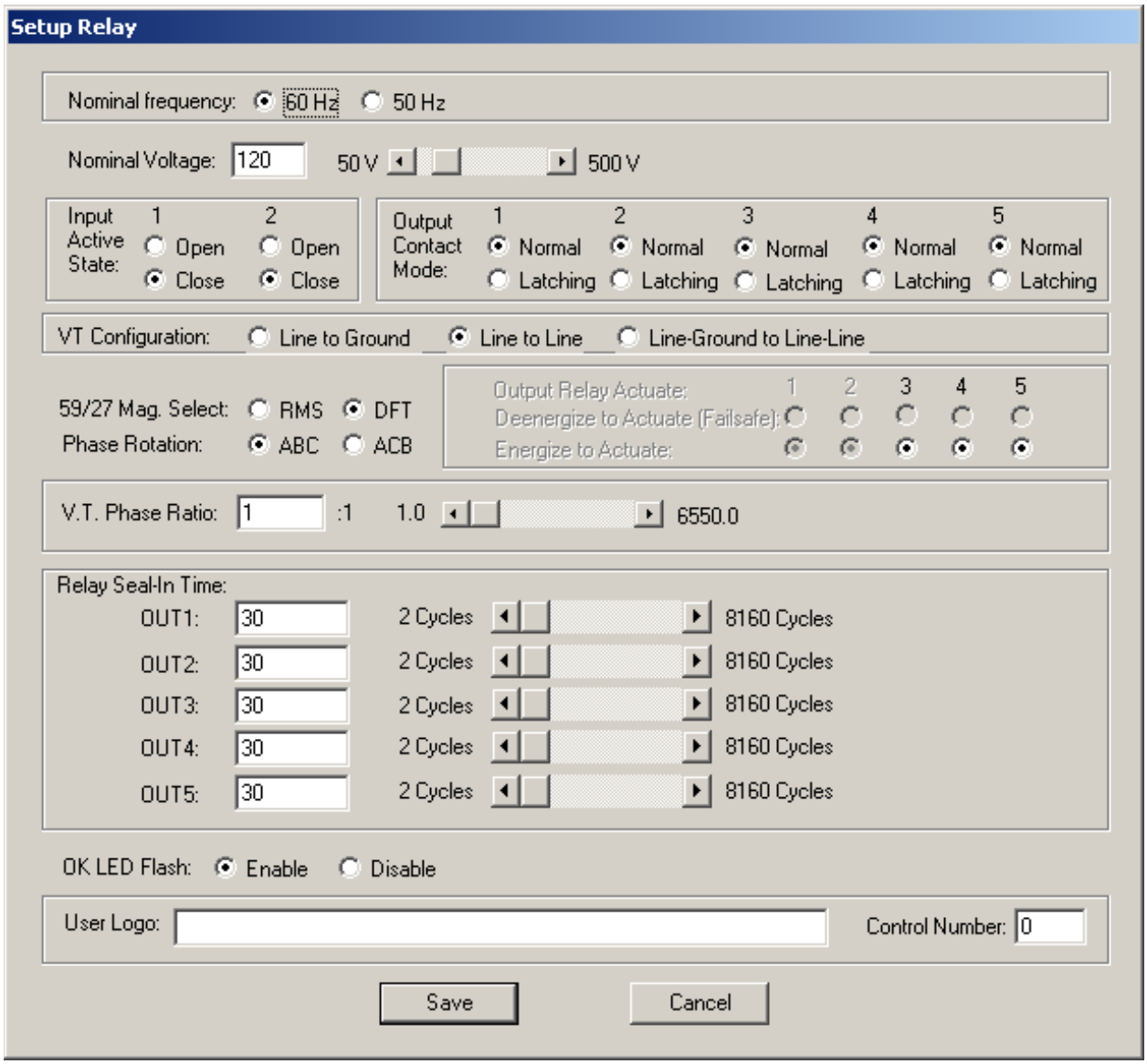



*Figure 3-1 Setup Relay Dialog Screen*

**Path:** Relay menu / Setup submenu / Setup Relay command

**COMMAND BUTTONS**

**Save** When connected to a protection system, sends the currently displayed information to the relay. When working offline (not connected to a relay) but modifying a file, saves the currently displayed information.

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

■ **NOTES:** The “active” or asserted states for the individual status inputs are:

1. Selecting Close causes the “active” or “operated” condition to be initiated by the external contact *closing*.
2. Selecting Open causes the “active” or “operated” condition to be initiated by the external contact *opening*.

### Nominal Frequency

This function allows the user to select the nominal frequency of the M-3401 to match the power system. Changes to Nominal Frequency will reset the 81 Function setpoints to their default values. Therefore, ensure that 81 Function setpoints are properly set any time the Nominal Frequency is changed.

### Nominal Voltage

The Nominal Voltage ($V_{nom}$) is defined as the phase voltage measured at relay terminals when the distribution/transmission system is at rated voltage ($V_{rated}$). When line-gnd or line-line selection is used, $V_{nom} = V_{rated}/VT_{ratio}$. When line-ground-to-line-line selection is used, $V_{nom} = \sqrt{3} \times V_{rated}/VT_{Ratio}$.

### Input Active State

This designates the “active” or asserted state for the individual status input:

- Selected Closed causes the “active” or “operated” condition to be initiated by the external contact *closing*.
- Selecting Open causes the “active” or “operated” condition to be initiated by the external contact *opening*.

### Output Contact Mode

In the “normal” mode, when the condition for assertion has been removed, the energized relay coil will de-energize automatically after the corresponding seal-in timers have expired. If the seal-in timer has already expired, the output contact will de-energize immediately.

If “latching” is selected, the output will stay energized until manually reset from IPScom® or by pressing the **TARGET/OUTPUT RESET** pushbutton. The latch condition is maintained as long as power is applied to the relay.

### VT Configuration

Indicates VT connection. (See Figure 2-7, Three-Line Connection Diagram - Load Shedding Application.) When line-ground voltages are used, functions 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 nominal secondary voltage of 277 V or below. For this selection, the nominal voltage setting entered should be line-line nominal voltage, which is $\sqrt{3}$ times line-ground nominal voltage.

### 59/27 Magnitude Select

This function allows the use of RMS (Root-Mean-Squared) or DFT (Discrete Fourier Transform) derived values for the 59 and 27 functions. The impact of the selection:

- RMS – provides RMS value of the total waveform, including all harmonics.
- DFT– provides the RMS value of the fundamental waveform (50 or 60 Hz, depending on system nominal frequency)

When the RMS option is selected, the resulting calculation is accurate over a wide frequency range (10 to 80 Hz), and the 27 or 59 element time response can be slowed by up to 20 cycles. When the DFT option is selected, the resulting calculation is accurate near the fundamental frequency (50 or 60 Hz, depending on system nominal frequency), and the element time response is accurate to $\pm 2$ cycles. The factory default setting for this option is RMS.

### Phase Rotation

This function allows the user to select the phase rotation of the M-3401 to match that of the power system (ABC or ACB).

### Ratio of the Phase VTs

This ratio is used to calculate the primary values displayed in the Primary Status Screen, See Figure 4-10, Primary Status Dialog Screen.

### Relay Seal-in Time

For outputs that are operated by protective functions, the 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.

### OK LED Flash

This function allows the user to select the OK LED to flash (instead of solid) when the relay self-test does not detect an error condition.

### User Logo

Allows the user to input text to identify the relay by name.

### 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 IPScom communications interface, and can be read remotely.

### Oscillograph Setup

The oscillograph recorder is capable of storing 120 cycles of data. The total record length can be configured for one (120 cycles) or two (80 cycles each) partitions. When untriggered, the recorder continuously records waveform data, keeping the data in a buffer memory. A programmable post trigger delay (5 to 95%) is incorporated to capture breaker operation. Storage of oscillograph records is nonvolatile and will be retained even without power as long as the on-board battery is healthy.

The general information required to complete the oscillograph setup includes:

- **Recorder Partitions**: The recorder's memory may be partitioned into 1 record of 120 cycles, or 2 records of 80 cycles each. When triggered, the time stamp is recorded, and the recorder continues recording for a user-defined period (5 to 95%).

  The snapshot of the waveform is stored in memory for later retrieval using IPScom Communications Software. If additional events or triggers occur before downloading, and the number of events exceeds the number of partitions being used, then the oldest record will be overwritten.
- **Trigger Inputs and Outputs**: The oscillograph recorder can be triggered remotely through the serial communications interface or automatically using the assertion of control/status inputs (IN1 or IN2) or outputs (OUT1 through OUT5), if designated to do so.
- **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 rearming for the next record. For example, a setting of 80% will result in a record with 20% pretrigger data, and 80% post-trigger data.

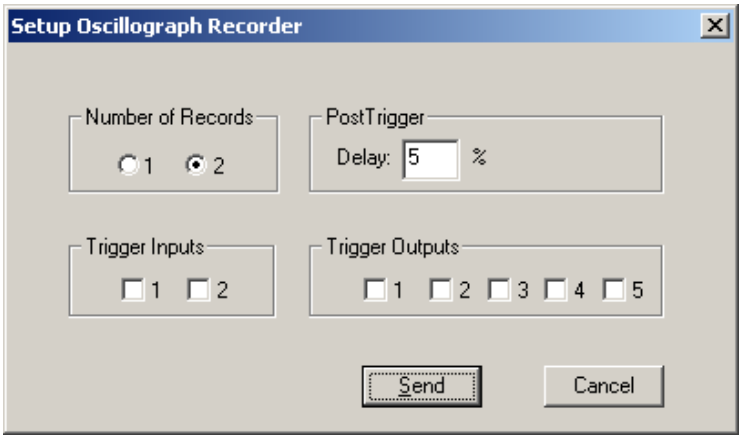



*Figure 3-2 Setup Oscillograph Recorder Dialog Screen*

**Path**: Relay/Oscillograph/Setup

**COMMANDS**

| | |
|---|---|
| **Send** | Sends all entered information to the relay. |
| **Cancel** | Returns you to the previous window; any changes to displayed information are lost. |

### Event Recorder Setup

The event recorder is designed to record sequence of events in the M-3401 relay. A total of 32 events can be recorded. After 32 events have been recorded the earliest events will be overwritten with new events (FIFO). The stored events are retained during power failure to the relay. The event recorder records a new event when an output contact is asserted.

In addition, the event recorder can be configured to trigger on the pickup of the desired functions, timeout of desired functions, dropout of desired functions, or change of the control/status inputs.

The M-3401 includes two event recorder modes of operation. Mode 1 records all events, and Mode 2 records events that are only succeeded by an operation of an output contact. If a function picks up but does not time-out (does not cause a contact to operate) no events are recorded. Select the event recorder operational mode.

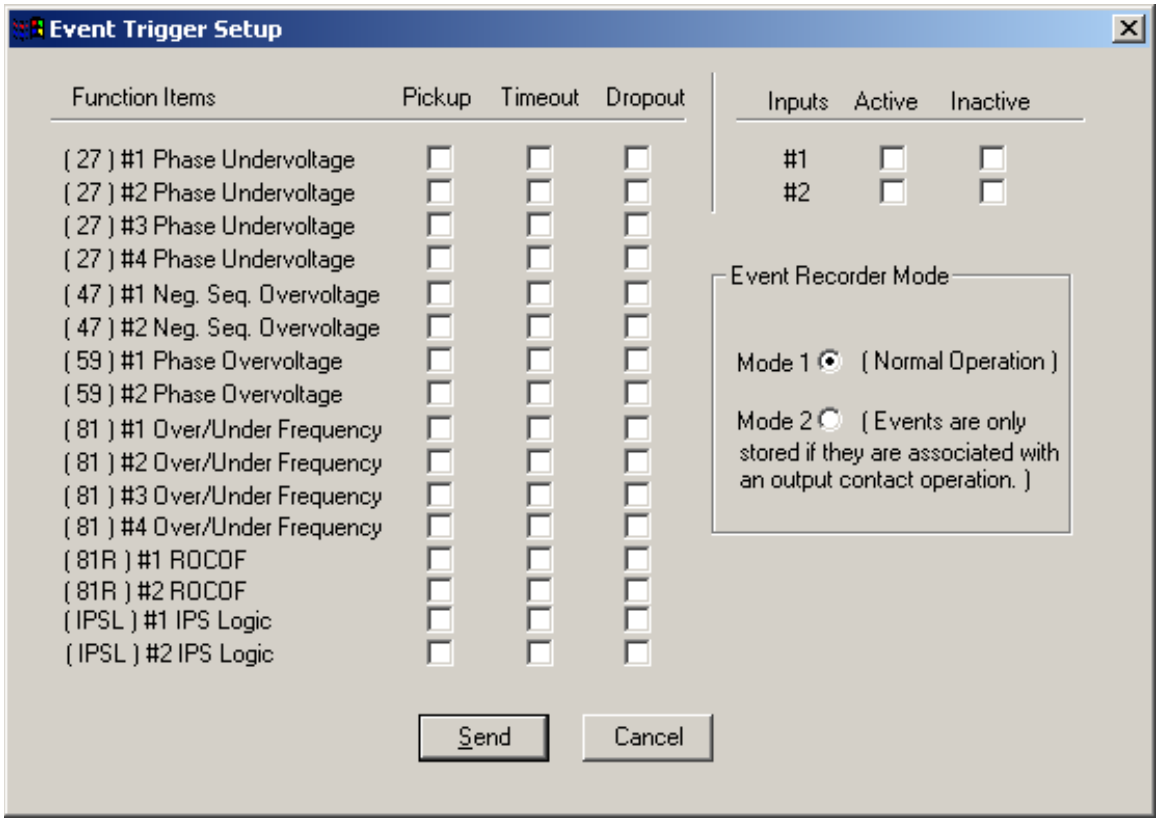



*Figure 3-3 Setup Event Recorder Trigger Dialog Screen*

**Path**: Relay/Event Recorder/Setup

**COMMAND BUTTONS**

**Send** Sends all displayed changes to relay.

**Cancel** Returns to previous window; any changes made to displayed information will be lost.

## 3.2 Setpoints and Time Settings

The individual protective functions, along with their magnitude and timing settings are described in the following pages. Settings are entered utilizing the M-3812 IPScom® Communications Software.

Enabling a relay protective function consists of entering the required settings in the individual function screens. Disabling a protective function from IPScom (whether settings have been entered or not) is accomplished by deselecting the individual protective function element numbers. When a protective function is disabled, screen values are grayed out.

### 27 Phase Undervoltage, 3-Phase

The Undervoltage function (27) may be used to detect any condition causing long- or short-term undervoltage. This 27S supervision function is a true three-phase function in that each phase has an independent timing element.

Magnitude measurement depends on the 59/27 Magnitude Select setting. (See Section 3.1, Relay Configuration, Relay Setup.) When the RMS option is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and an additional time delay of 20 cycles (beyond the set delay) may occur. If DFT is selected, the magnitude calculation is accurate near 50 or 60 Hz, and the timer accuracy is ±2 cycles. RMS selection is recommended as RMS calculations are accurate over a wide frequency range.

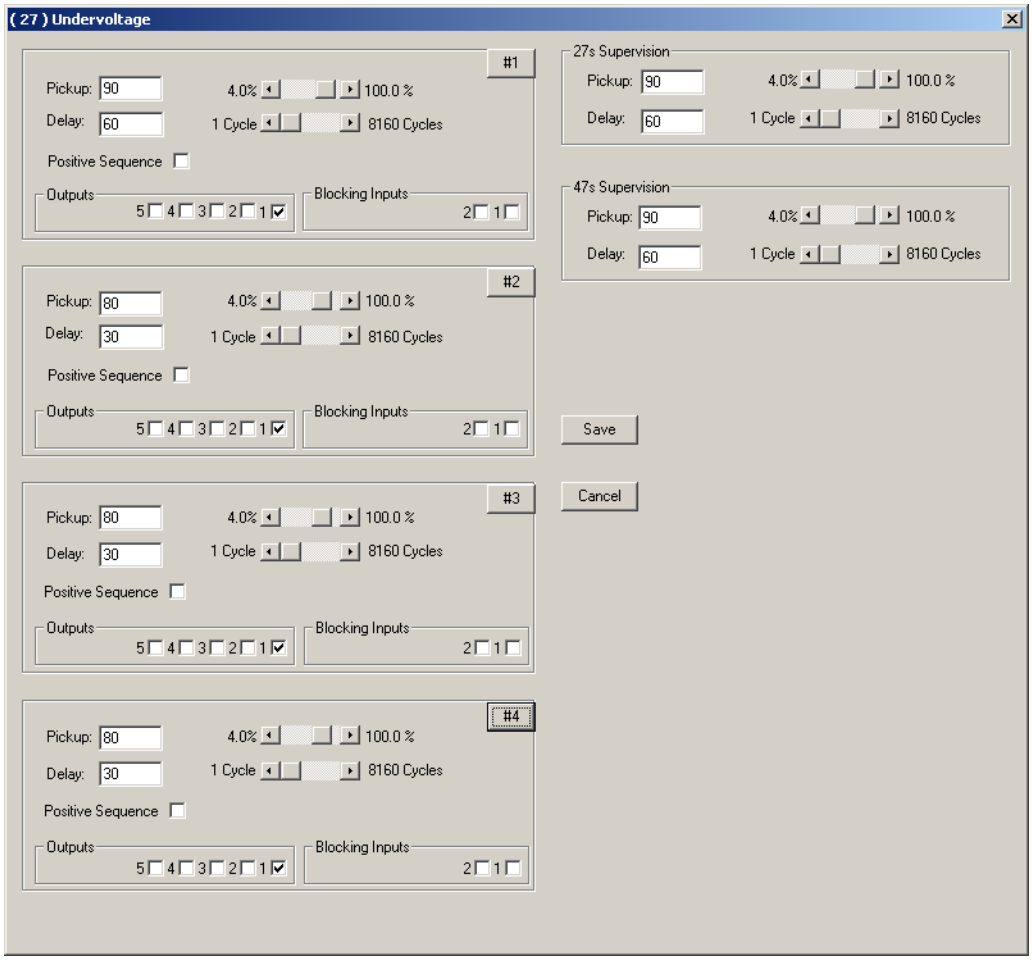



*Figure 3-4 Phase Undervoltage (27) Setup Dialog Screen*

**Path**: Relay/Setup/Setpoints/27 Undervoltage

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

■ **NOTE**: Pickup ranges (4% to 100%) are of Nominal Voltage.

### 47 Negative Sequence Overvoltage (Voltage Unbalance)

The Negative Sequence Overvoltage function (47) provides protection for voltage unbalance and reverse phase sequence.

Voltage unbalance can occur from blown fuses on transformers, open conductors, load unbalance and other single-phase events. Phase reversal may occur when lines are repaired and conductors are inadvertently swapped.

A pickup setting in the range of 8 to 25% can reliably detect open phases and reverse phase sequence.

A minimum time delay of 6 to 10 cycles will prevent mis-operation during switching transients.

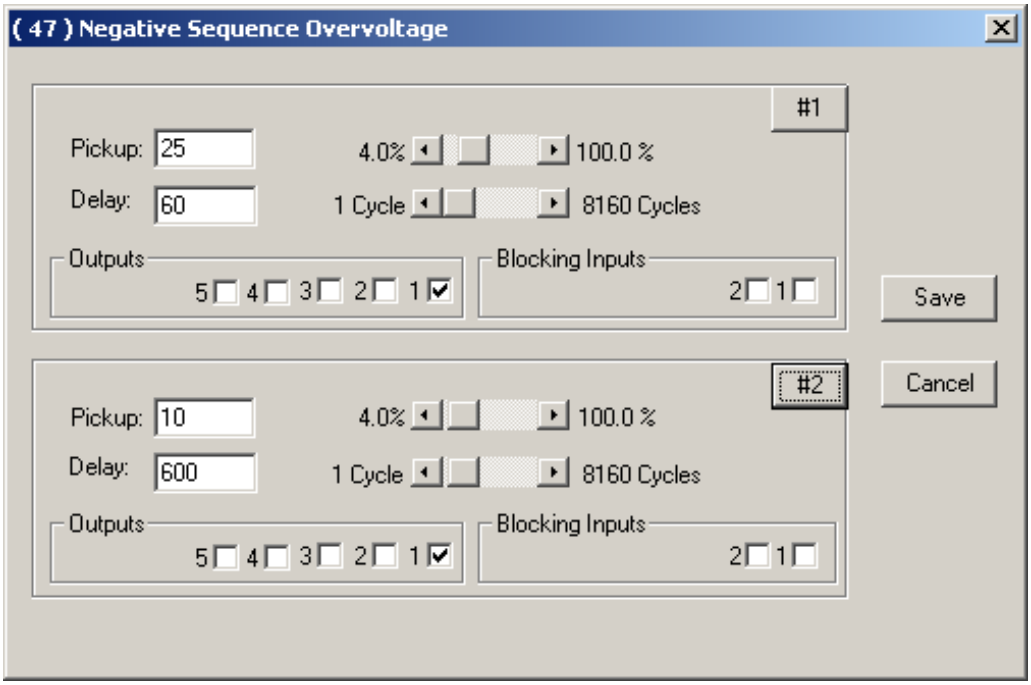



*Figure 3-5 Negative Sequence Undervoltage (47) Setup Dialog Screen*

**Path**: Relay/Setup/Setpoints/47 Negative Sequence Undervoltage

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

■ **NOTE**: Pickup percentage is based on Nominal Voltage.

### 59 Phase Overvoltage, 3-Phase

The RMS Overvoltage function (59) may be used to provide overvoltage protection. The relay provides overvoltage protection functions with two voltage levels and two definite-time setpoints, either 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.

Magnitude measurement depends on the 59/27 Magnitude Select setting (See Section 3.1, Relay Configuration, Relay Setup). When the RMS option is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and an additional time delay of 20 cycles (beyond the set delay) may occur. If DFT is selected, the magnitude calculation is accurate near 50 or 60 Hz, and the timer accuracy is ±2 cycles.

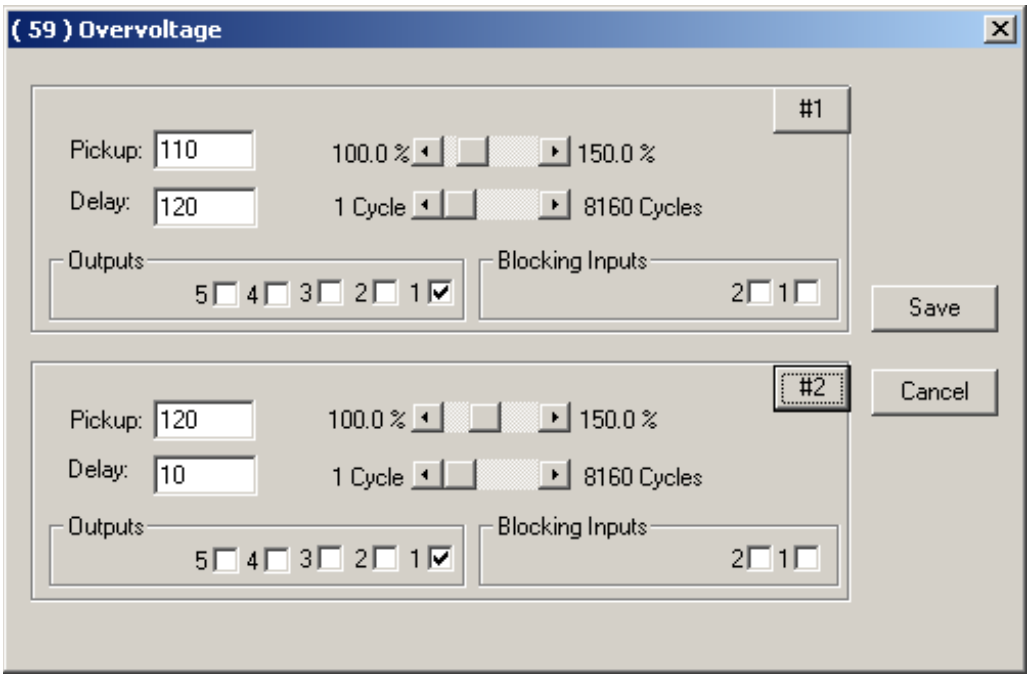



*Figure 3-6 Phase Overvoltage (59) Setup Dialog Screen*

**Path**: Relay/Setup/Setpoints/59 Phase Overvoltage

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

■ **NOTE**: Pickup percentage is based on Nominal Voltage.

### 81 Over/Under Frequency

The Over/Under Frequency function (81) provides overfrequency or underfrequency protection. It has four independent pickup and time delay settings. The overfrequency mode is automatically selected when the frequency setpoint is programmed higher than the nominal frequency (50 or 60 Hz), and the underfrequency mode selected when the setpoint is programmed below the nominal frequency.

A change in the load generation equilibrium of a power system will result in a frequency change. Reestablishing equilibrium is essential to avoid system-wide collapse. Under frequency load shedding is an accepted means to reestablish balance in an unbalanced system within the time constraint necessary to prevent the collapse of the system.

### Example of Setting

According to some studies, load shedding schemes are required for dropping 30% of the system load in response to an under frequency condition in the system. Figure 3-7 depicts a typical setting scheme to achieve a 30% drop in load.

| | |
|---|---|
| Step 1 | When f< 59.5 Hz, shed 10% of system load. |
| Step 2 | When f< 58.9 Hz shed an additional 10% of system load. |
| Step 3 | When f< 58.5 Hz shed an additional 10% of system load for a total of 30% of the total system load. |

Time Delay setting should be at a maximum of 1.0 second (60 cycles of 60 Hz).

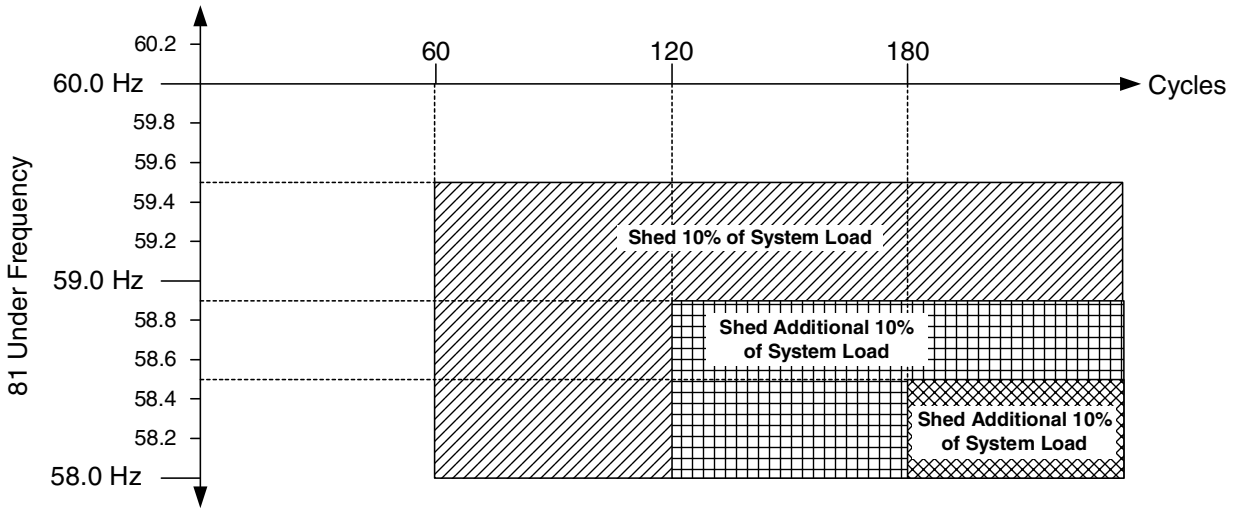



*Figure 3-7 Example of Under Frequency (81) Load Shedding Characteristics*

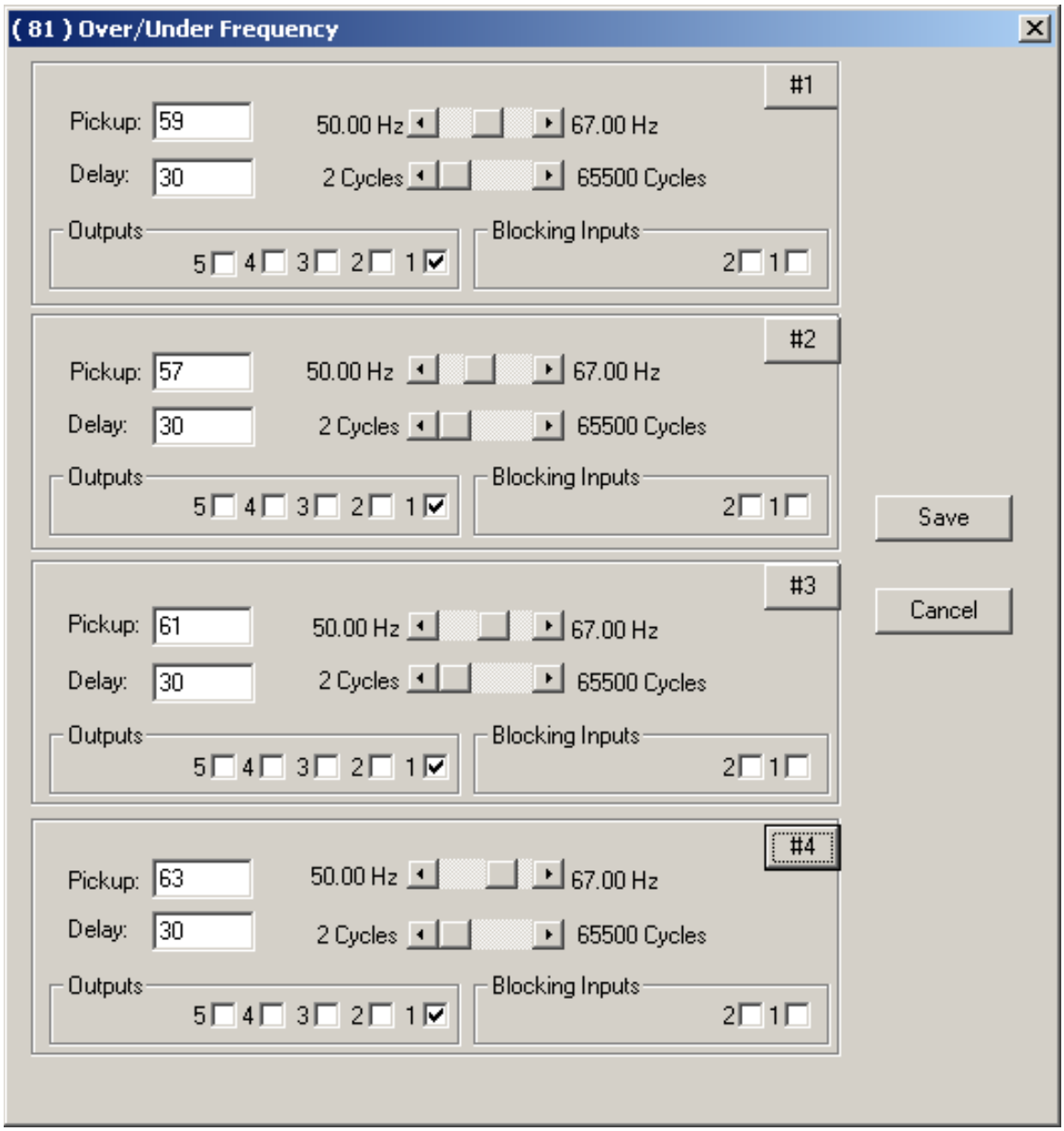



*Figure 3-8 Over/Under Frequency (81) Setup Dialog Screen*

**Path**: Relay/Setup/Setpoints/81 Over/Under Frequency

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

■ **NOTE**: Pickup range for 50 Hz Nominal Frequency models is 40 Hz to 57 Hz.

### 81R Rate of Change of Frequency

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

This 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 3-9.

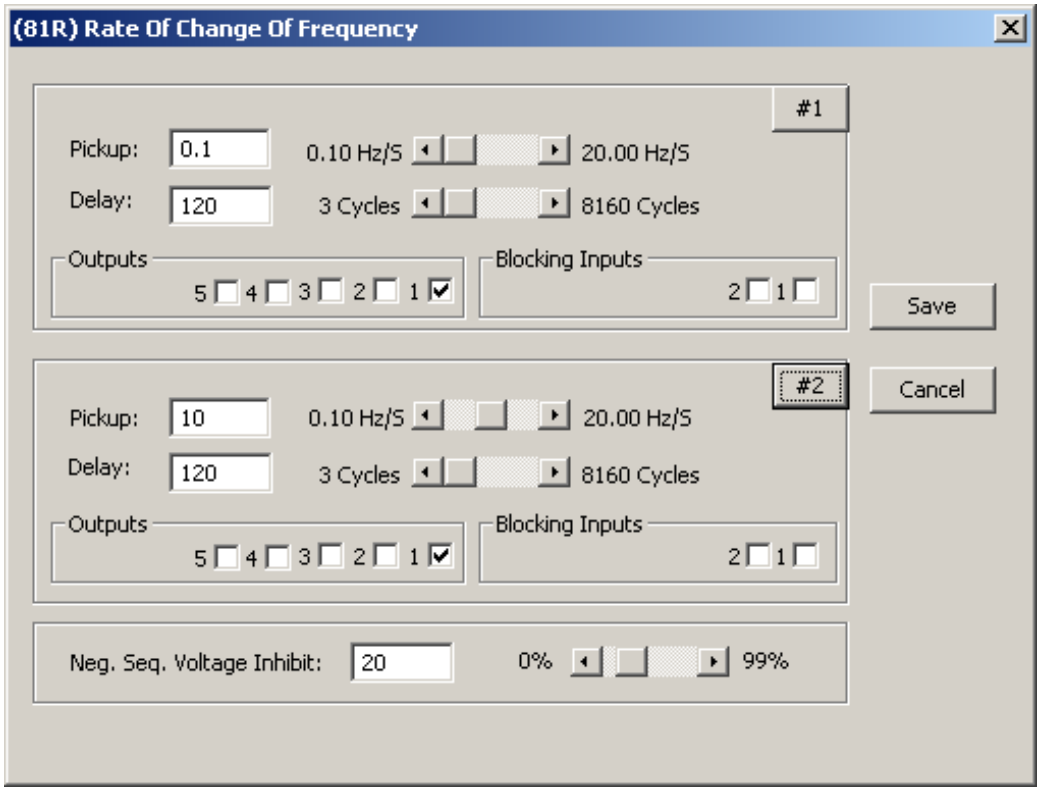



*Figure 3-9 Rate of Change of Frequency (81R) Setpoint Ranges*

**Path**: Relay/Setup/Setpoints/81R Rate of Change of Frequency

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

### IPSlogic™

The relay provides two 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.

Enable-Disable - The top right corner of each IPSlogic tab includes a command button that will disable or enable the function. This selection allows the IPSlogic #1 to be disabled (or enabled) independent from the IPSlogic #2.

### IPSlogic Settings and Logic Functions

IPSlogic includes four Initiating Input sources:

- Initiating Outputs
- Initiating Function Trip
- Initiation by Communication Point
- Initiating Inputs

The only limitation is that an IPSlogic Function may not be used to initiate itself.

There are two Blocking Input sources:

- Blocking Inputs
- Blocking by Communication Point

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:

- Close an Output Contact
- Be activated for use as an input to another External Function

The various combinations of IPSlogic are represented in Figure 3-10. IPSlogic Function programming settings are illustrated in Figure 3-11.

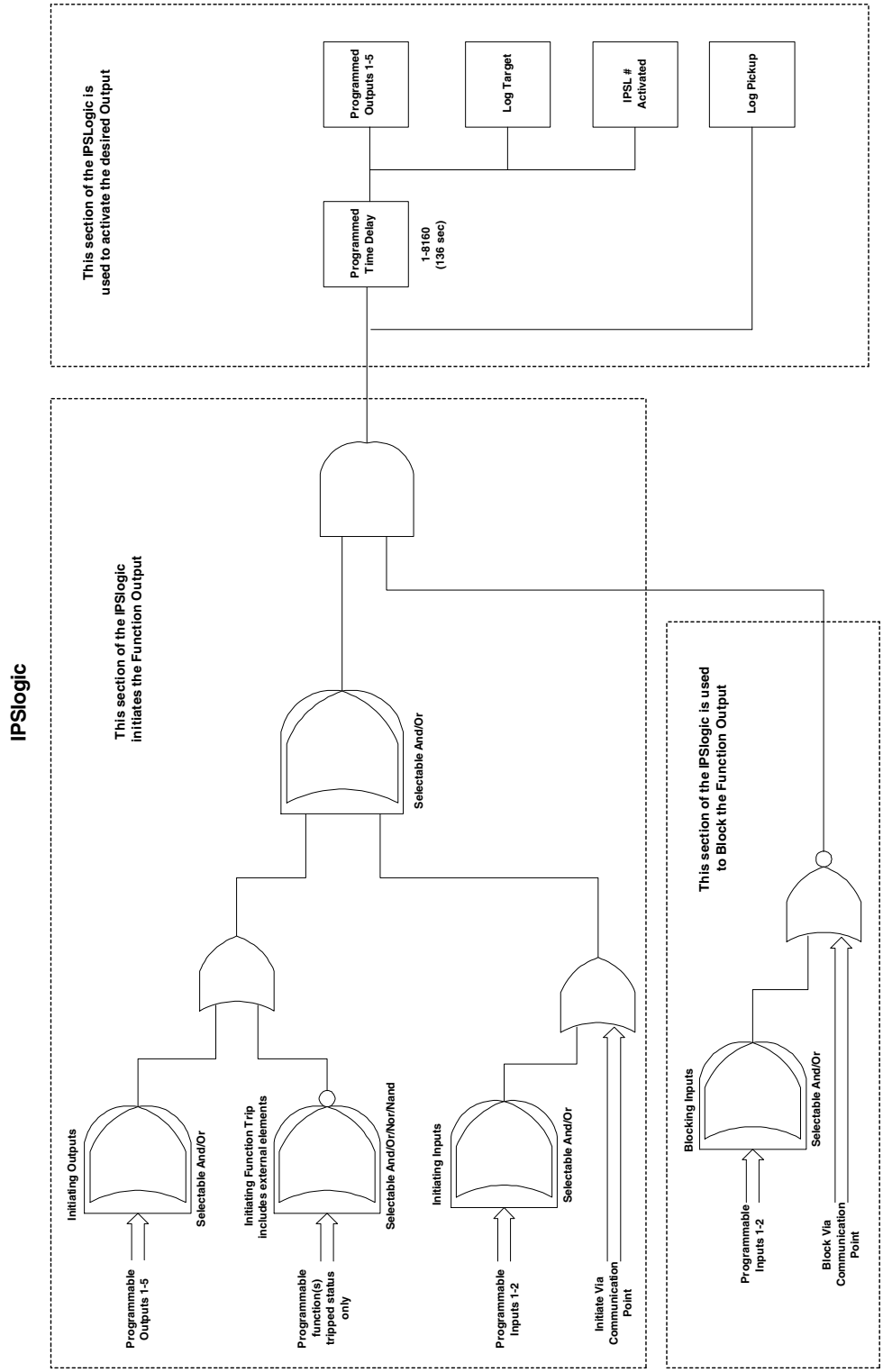



*Figure 3-10 IPSlogic® Function Setup*

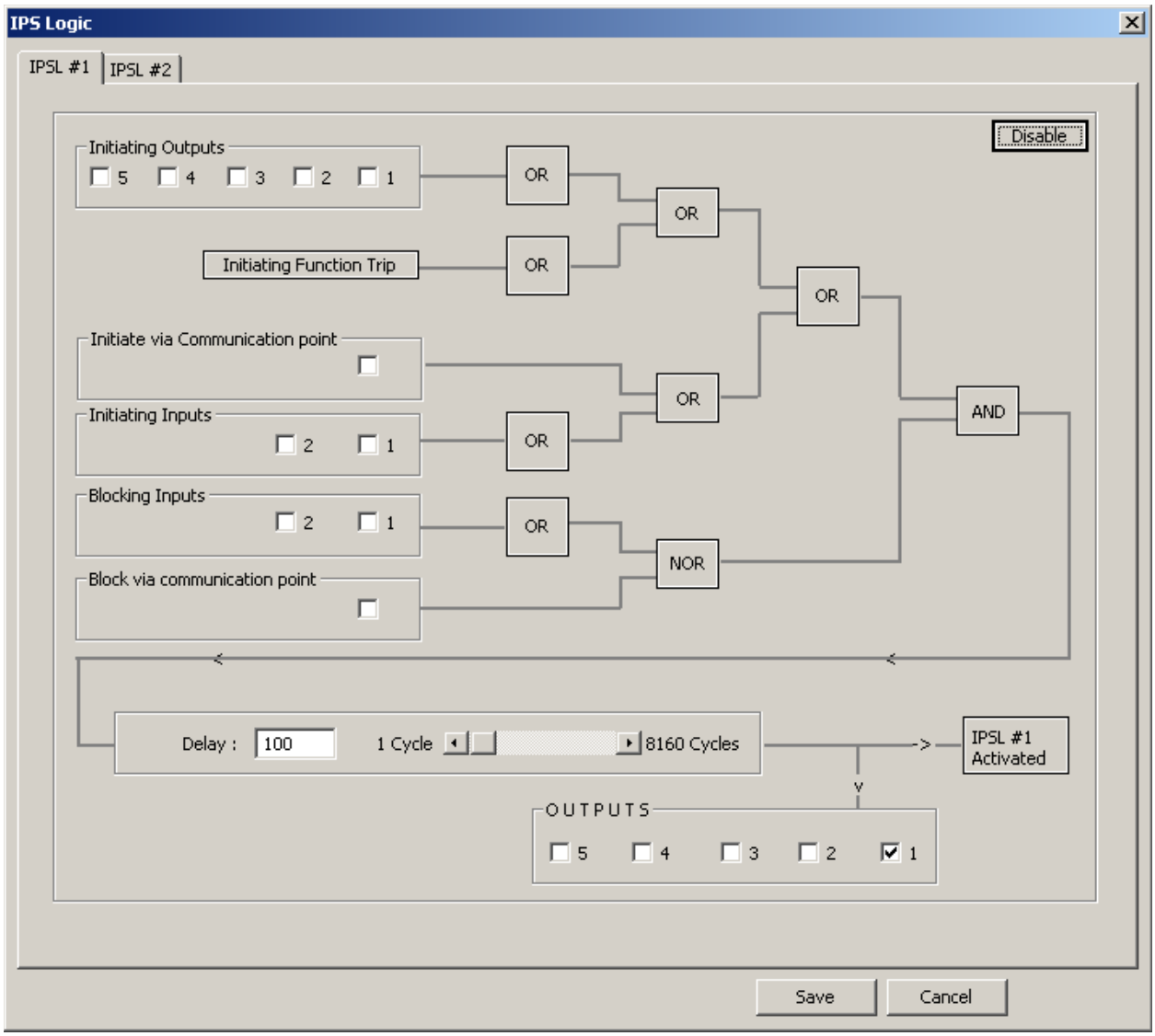



*Figure 3-11 IPSlogic® Function Programming*

**Path**: Relay/Setup/Setpoints/IPS IPS Logic

**COMMAND BUTTONS**

**Save** Saves all entered information to the relay.

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

# 4 Operation and Interface



This chapter is designed for the person or group responsible for both the local and remote operation and setting of the relay using M-3801 IPScom for Windows Communications Software. This chapter also addresses unit battery replacement, and conversion of oscillograph files to COMTRADE format.

## 4.1 General Information

The M-3401 Load Shedding Relay provides two serial communication ports. Serial communication port COM1 is a standard 9-pin, RS-232, DTE-configured port. 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 serial communication port, COM2, is located at the rear of the unit. COM2 can be configured as a standard, 9-pin RS-232, DTE port, or as a 4-wire/ 2-wire RS-485 port (see Chapter 2, **Installation**, for port configuration). Either port COM1 or COM2 may be used to remotely set and interrogate the relay using a 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.

### Communication Protocol

MODBUS communication protocol is implemented in the relay. Only the RTU mode of the MODBUS protocol is supported. The following functions are implemented in IPScom using MODBUS protocol:

- Real-time monitoring of measured parameters
- Interrogation and modification of setpoints
- Downloading of recorded oscillographic data and sequence of events data
- Reconfiguration of all relay functions

### 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 COM1 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, such as RS-485 or fiber optics.

## 4.2 Activating Communications

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

1. Select 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 in the window for the relay to be addressed.
   a. If communication is through a modem, choose the **Modem** command to expand the communications dialog screen.
   b. Select the **Initialize** command button.
   c. Choose the desired relay location, then select **Dial**. This action establishes contact and automatically opens communication to the relay.
   b. If the computer is directly connected to the relay through either COM1 or COM2, select **Open COM**. 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 from the expanded Communication dialog screen. To close the communication channel when connected locally, choose the **Close COM** command.

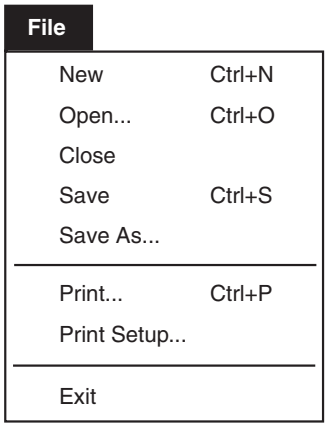
## 4.3 M-3812 IPScom Functional Description

### Overview

When IPScom is run, a menu and status bar is displayed, as shown in Figure 4-1, IPScom Menu Selections. This section describes each IPScom menu selection and explains each IPScom command in the same order as they are displayed in the software program.

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.

When not connected to one of the protection systems, using the **New** command, a new file is established with the New Device Profile dialog screen (see Figure 4-2). Choosing the **Save** command allows the new data file to be named by using the **Save** or **Save As**...commands.

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

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 **Print Setup** commands allow the 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.

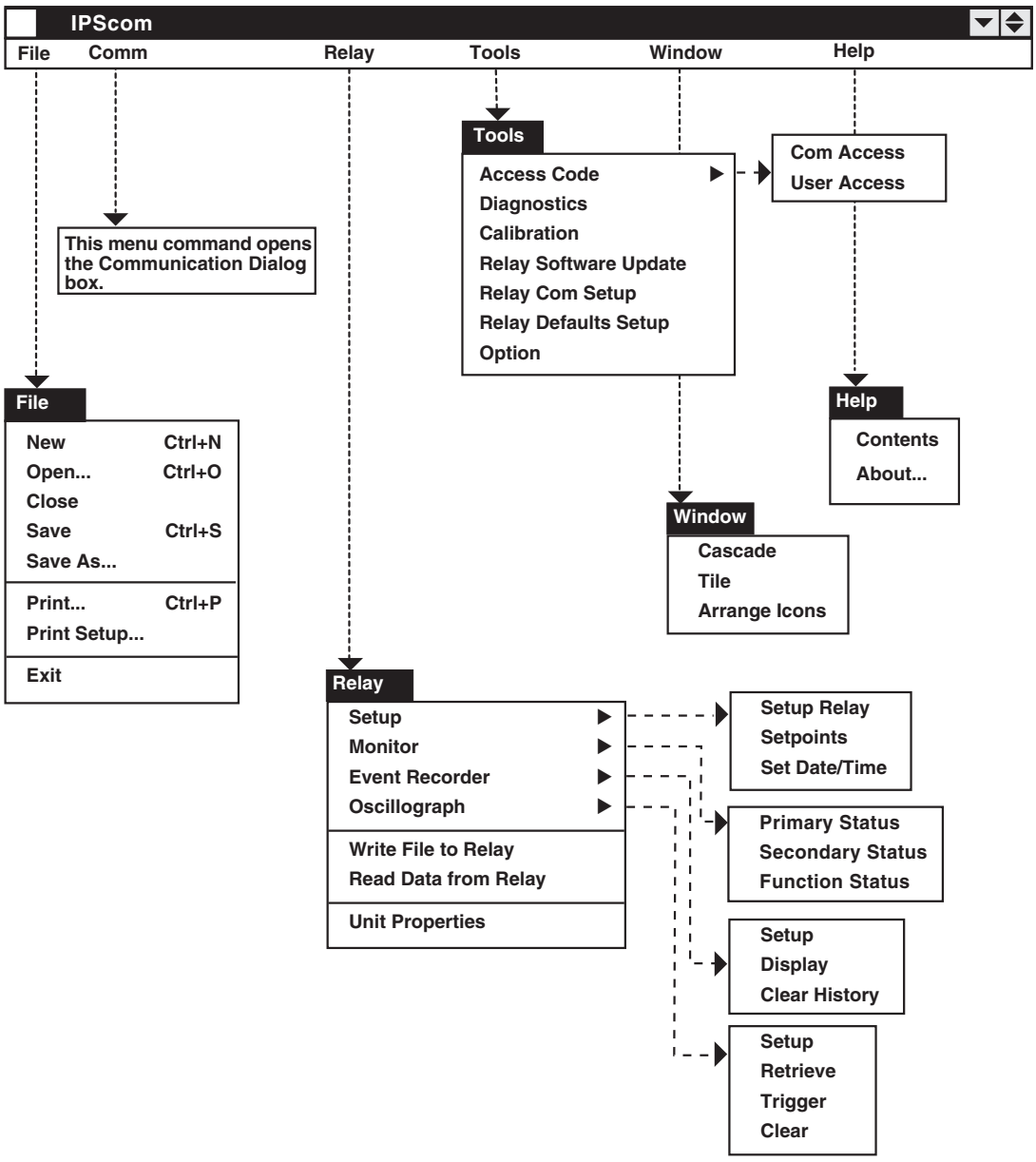



*Figure 4-1 IPScom® Menu Selections*

### Comm Menu

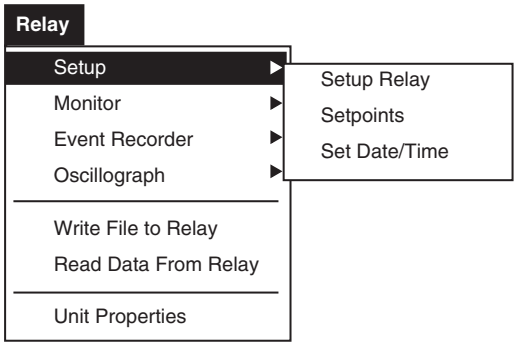

The Communication dialog box (see Figure 4-3) allows setup of the IPScom communication data to coordinate with the relay and by choosing **Modem**, to establish contact for remote locations. When communicating by way of a fiber optic loop network, echo cancelling is available by checking the Echo Cancel box. This command masks the sender's returned echo.

If communication is established through the modem, **Initialize** should be selected. If communication cannot be established with the default string, the AT &F may be selected to initialize. Following initialization, select an entry from the modem list and select **Dial** to dial out.

If the modem was not used to establish communication (direct connection), select **Open COM** to start. If the relay has a default communication access code of 9999, a message window will appear showing Access Level #3 was granted. Otherwise, another dialog box will appear to prompt the user to enter the access code in order to establish the communication. **Close COM** discontinues communication.

### Relay Menu


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



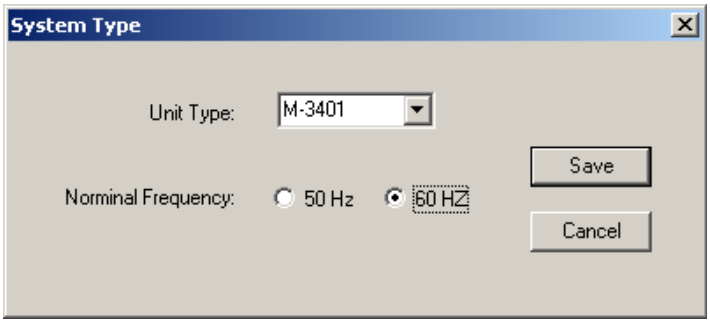




*Figure 4-2 IPScom New Device Profile Dialog Screen*

**Path:** File menu / New command

**COMMAND BUTTONS**

**Save** Saves the currently displayed information.

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

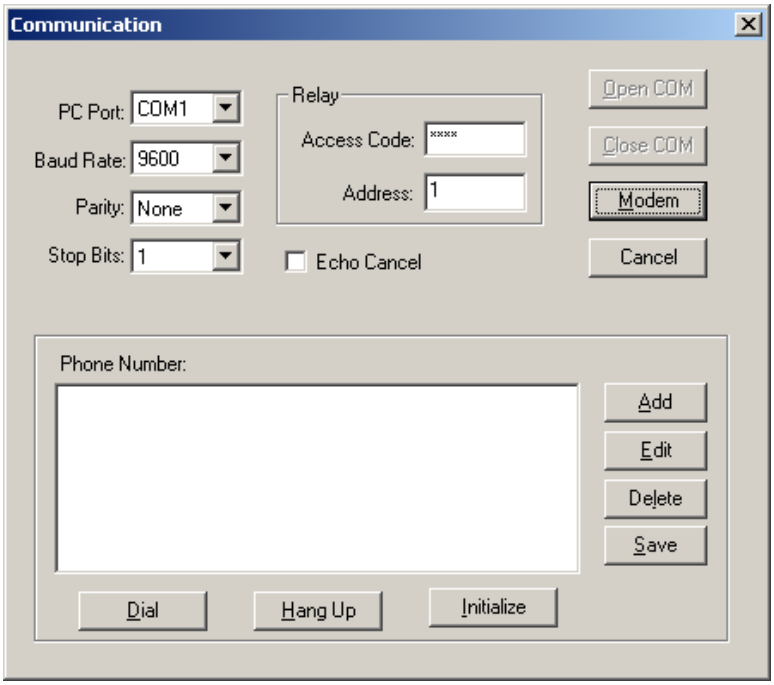



*Figure 4-3 IPScom® Communication Dialog Screen*

**Path:** Comm menu

**COMMAND BUTTONS**

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

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

**Modem** Displays the expanded Communication dialog box.

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

**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 telephone numbers

**Dial** Dials the entry selected from the directory and establishes modem communications.

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

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

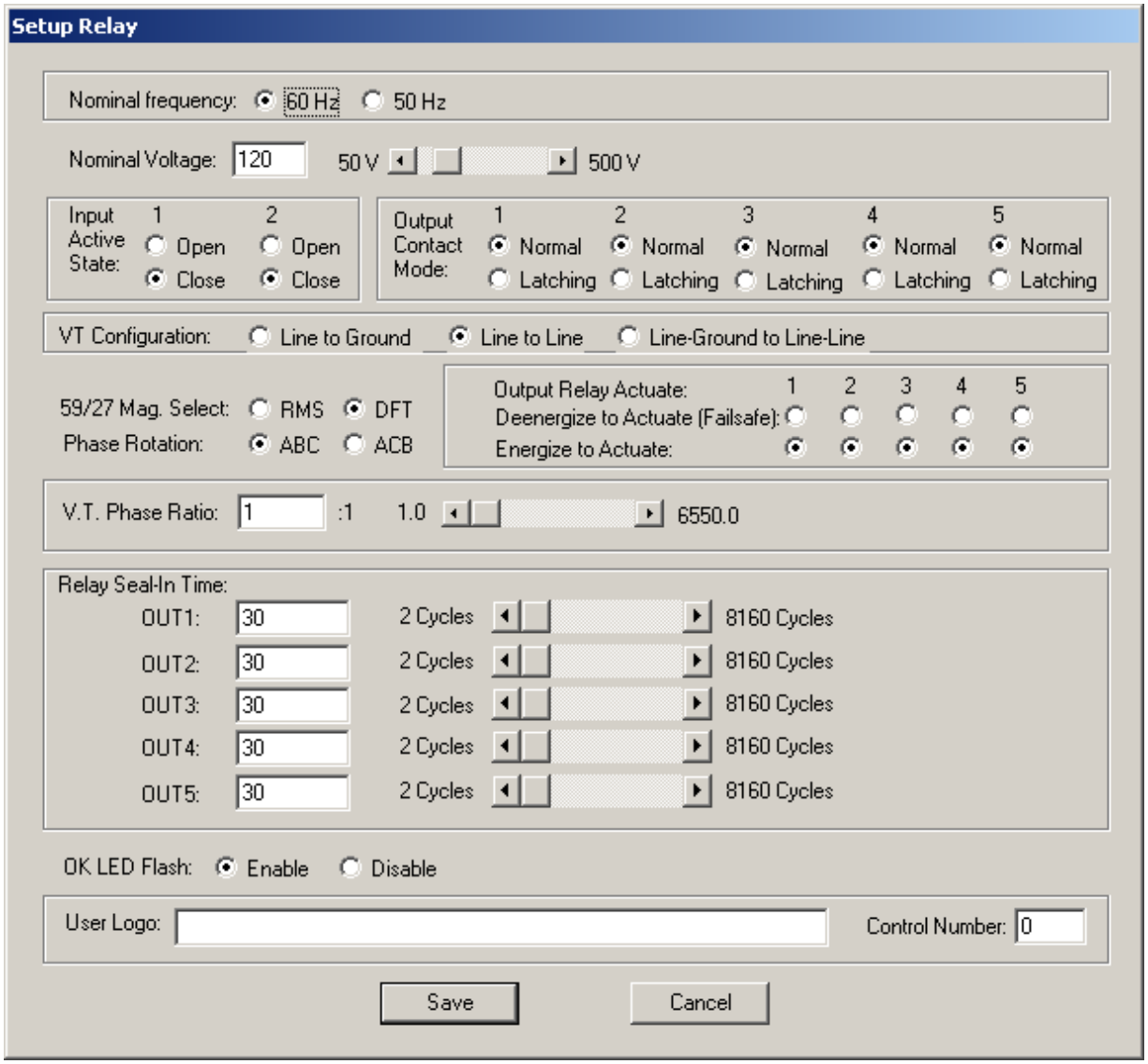



*Figure 4-4 IPScom® Setup Relay Dialog Screen*

**Path:** Relay menu / Setup submenu / Setup Relay command

**COMMAND BUTTONS**

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

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

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

The **Setup** submenu provides three commands: **Setup Relay**, **Setpoints**, and **Set Date/Time**. The **Setup Relay** command displays the Setup Relay dialog box, allowing the input of the pertinent information regarding the system on which the protective relay is applied (see Section 3.1, **Relay Configuration**, Relay System Setup).

The **Setpoints** command displays the Relay Setpoints dialog screen (see Figure 4-5) from which the individual relay function dialog screens can be accessed. Choosing a Relay function will display the corresponding function dialog screen (see Figure 4-6 for example).

The Relay Setpoints dialog screen provides access to two additional dialog screens: **Display All** and **Configure**.

Choosing the **Display All** command displays the All Setpoints Table dialog screen (see Figure 4-7). This dialog screen contains a list of settings for each relay function within a single window to allow scrolling through all relay setpoint configuration values. Choosing the **Configure** command displays the Configure dialog screen (see Figure 4-8), 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 screens (All Setpoint Table and Configure), feature hotspots which allows the user to jump from a scrolling dialog screen to an individual relay function dialog screen and return to the scrolling dialog screen again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog screen from either scrolling dialog screen.

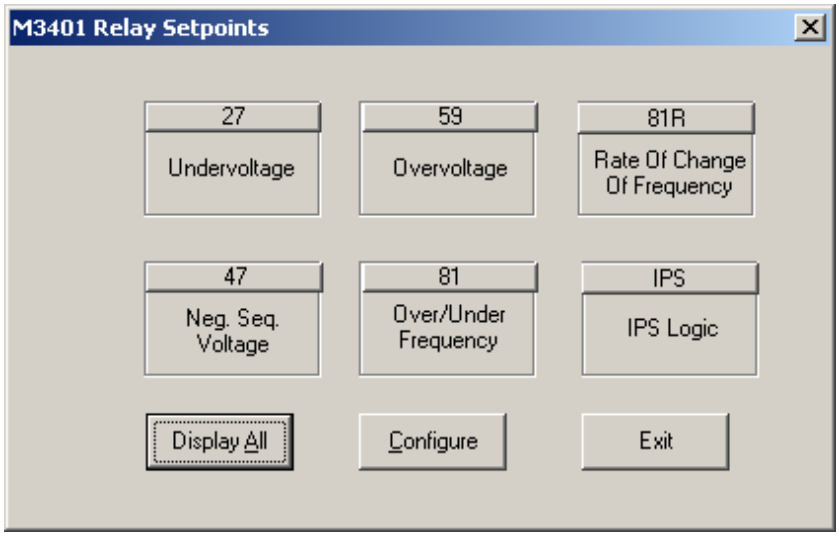



*Figure 4-5 IPScom® Relay Setpoints Dialog Screen*

**Path:** Relay menu / Setup submenu / Setpoints window

**COMMAND BUTTONS**

**Display All** Opens the All Setpoints Table dialog screen.

**Configure** Opens the Configure dialog screen.

**Exit** Saves the currently displayed information and returns you to the IPScom main window.

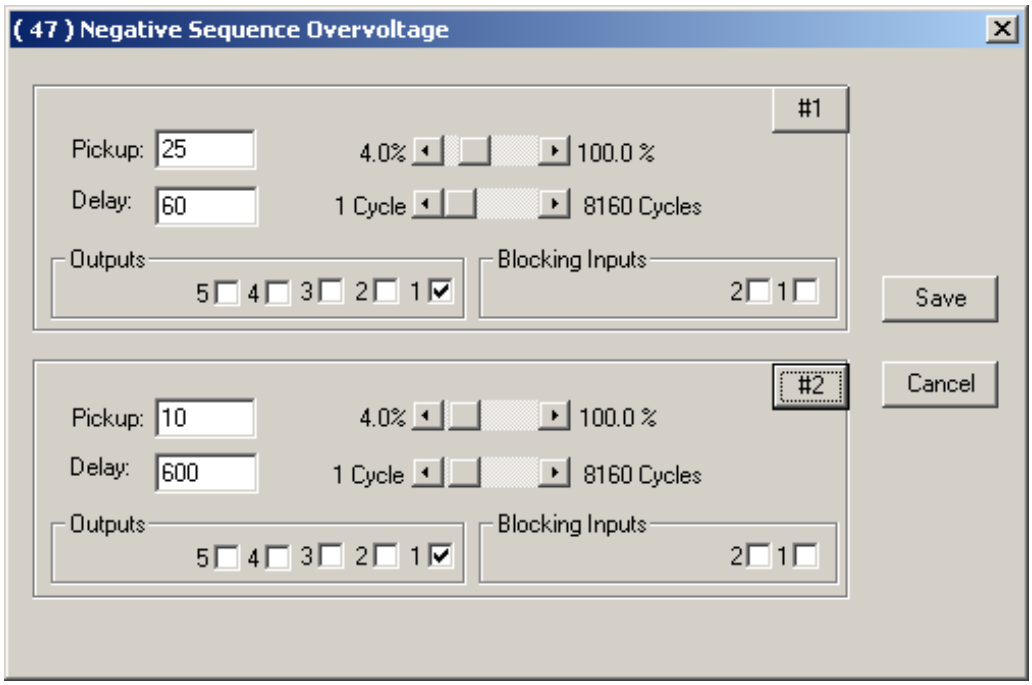



*Figure 4-6 IPScom® Negative Sequence Overcurrent (47) Setpoint Dialog Screen*

**Path:** Relay menu / Setup submenu / Setpoints window/
47 command button

**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 screen.

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

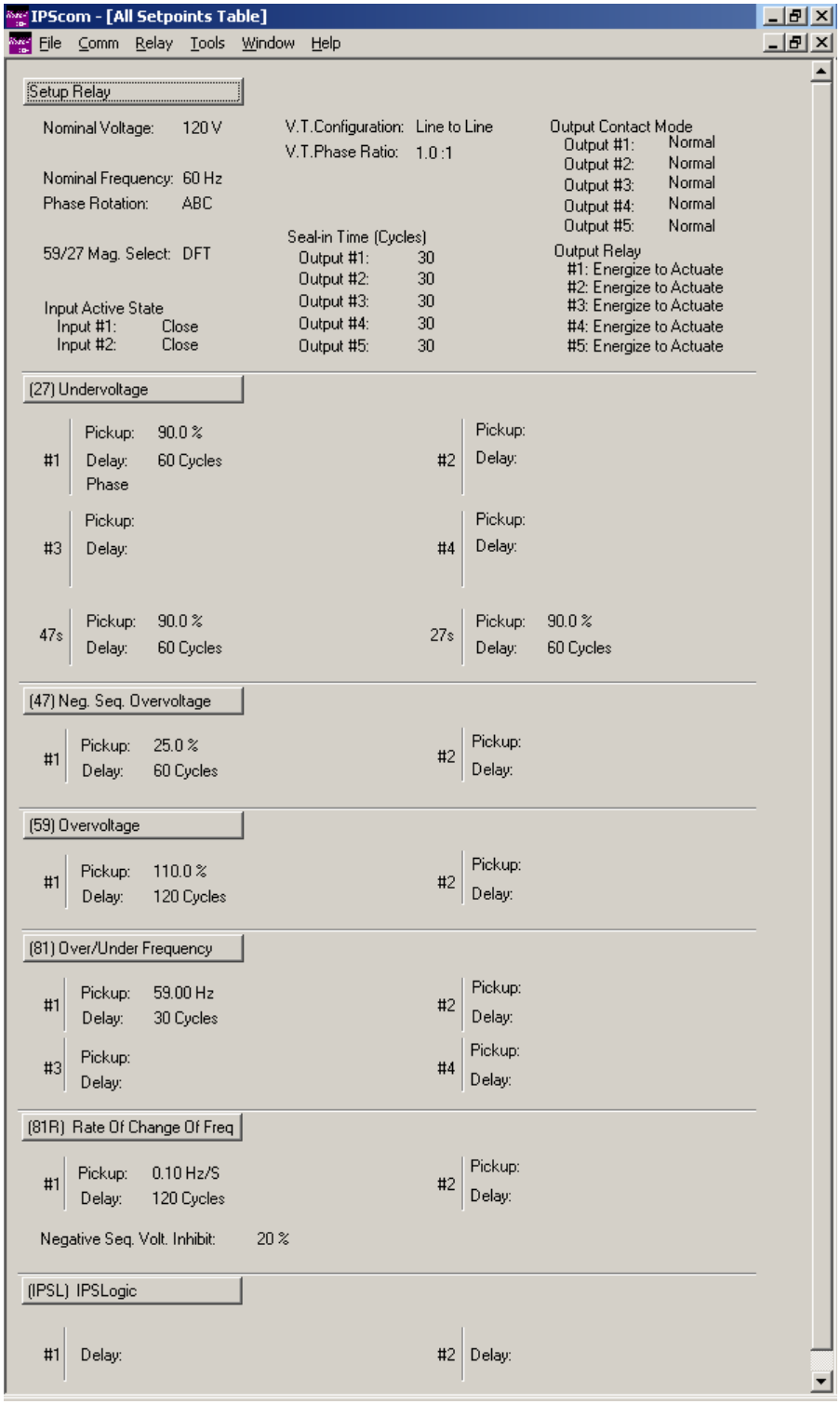



*Figure 4-7 IPScom® All Setpoints Table Dialog Screen*

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

**CONTROL MENU**

**Close** Returns you to the Relay Setpoints dialog screen.

**Move** Allows you to reposition the dialog screen.

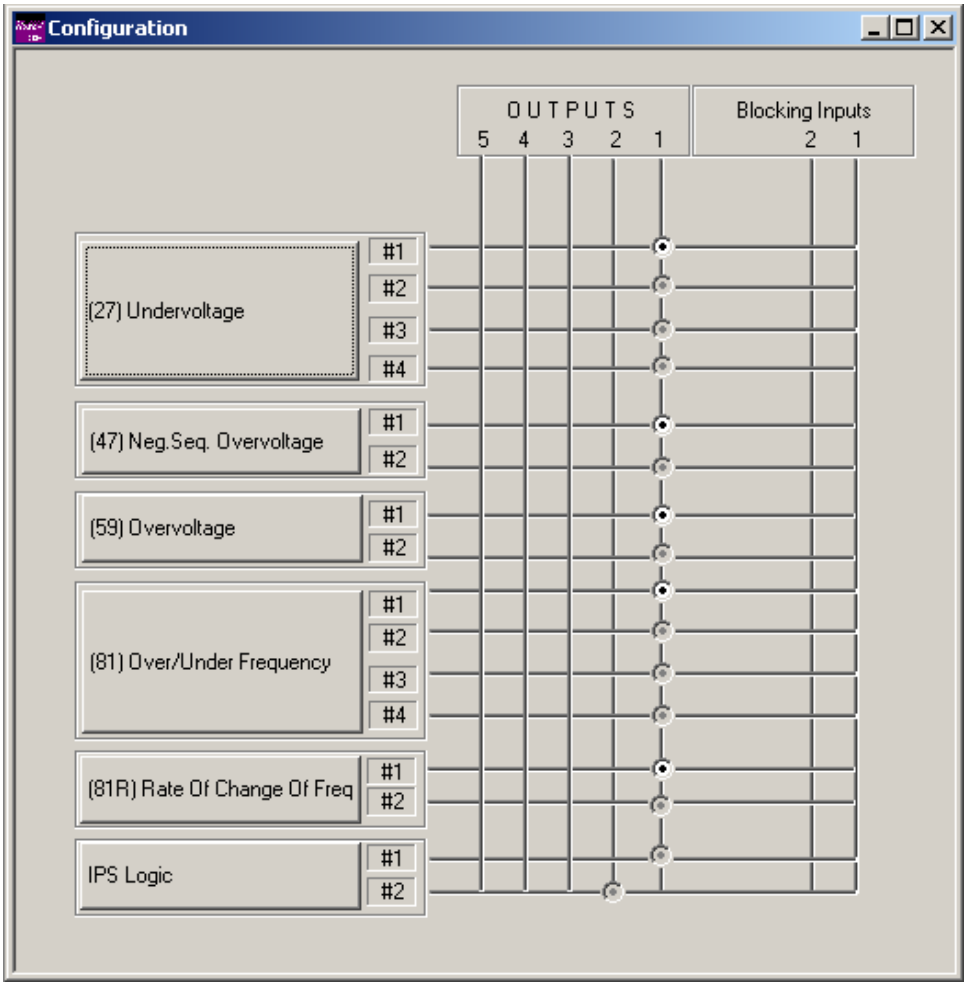



*Figure 4-8 IPScom® Configure Dialog Screen*

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

The **Set Date/Time** command allows relay date and time to be set.

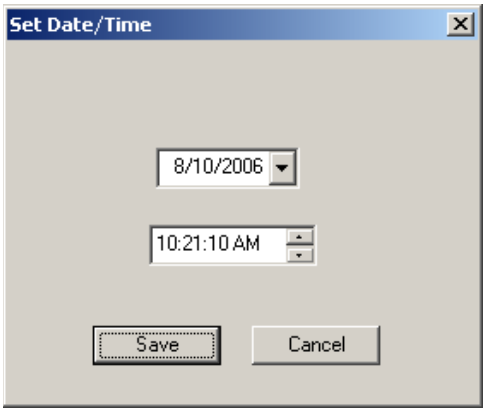



*Figure 4-9 IPScom® Set Date/Time Dialog Screen*

**Path**: Relay menu/ Setup submenu/ Set Date/Time Command

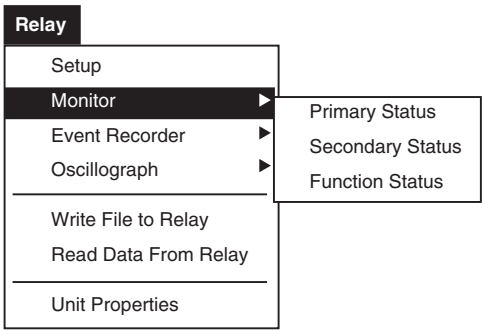
The time field in the dialog screen is not updated continuously. The time at which the dialog screen was opened is the time that is displayed and remains as such.

**COMMAND BUTTONS**

**Save** Saves all input.

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

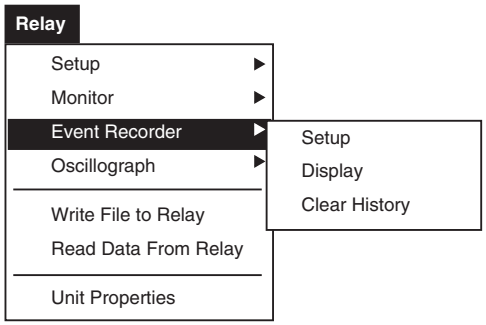
**Monitor**




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. A cascading menu appears, providing several command options, **Primary Status**, **Secondary Status** and **Function Status**.

Primary and Secondary Status screens will display calculated values based on the VT inputs.

**Function Status** screen displays the status of various functions, including trip and pickup status (see Figure 4-12).




**Event Recorder**

The **Event Recorder** submenu provides three command options: **Setup, Display,** and **Clear History**.

The **Setup** command displays the Event Trigger settings dialog box.

The **Display** command displays the Event List dialog box. An “Event” consists of a time-stamp, the status of the contact outputs, state of the control/status inputs, the magnitude of the voltages at the time the event occurred and a description of the event itself.

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

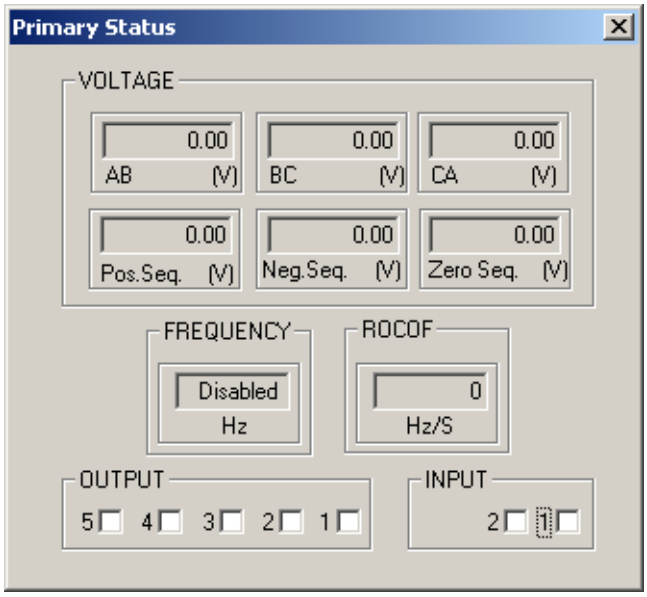



*Figure 4-10 IPScom® Primary Status Dialog Screen*

**Path**: Relay menu/Monitor submenu/ Primary Status window

These are calculated values based on the VT inputs.

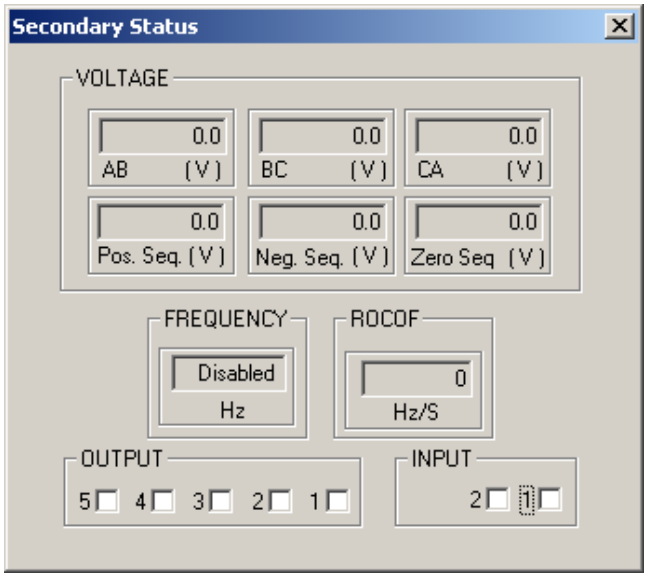



*Figure 4-11 IPScom Secondary Status Dialog Screen*

**Path:** Relay menu/ Monitor submenu/ Secondary Status screen

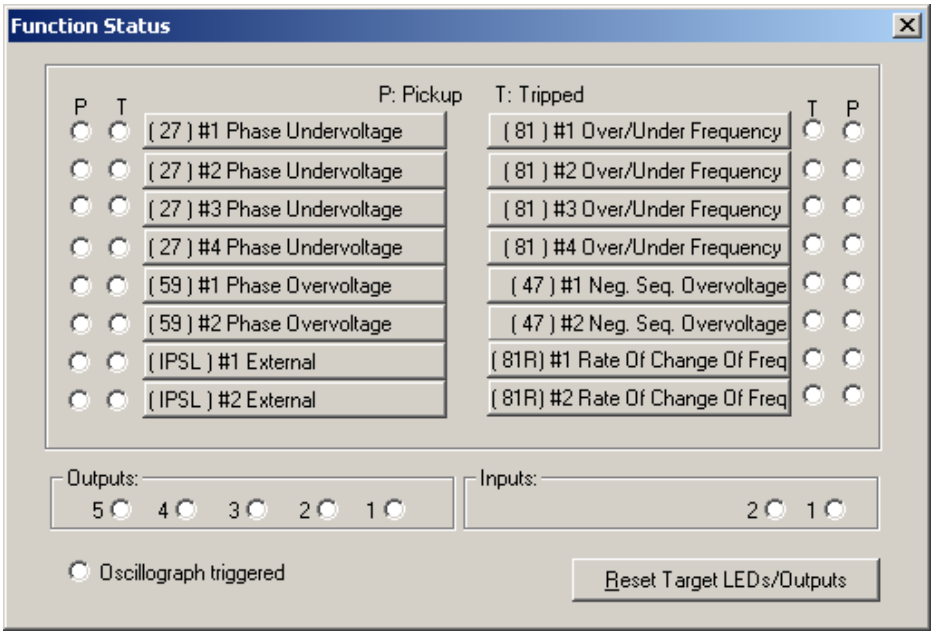



*Figure 4-12 IPScom® Function Status Dialog Box*

**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.

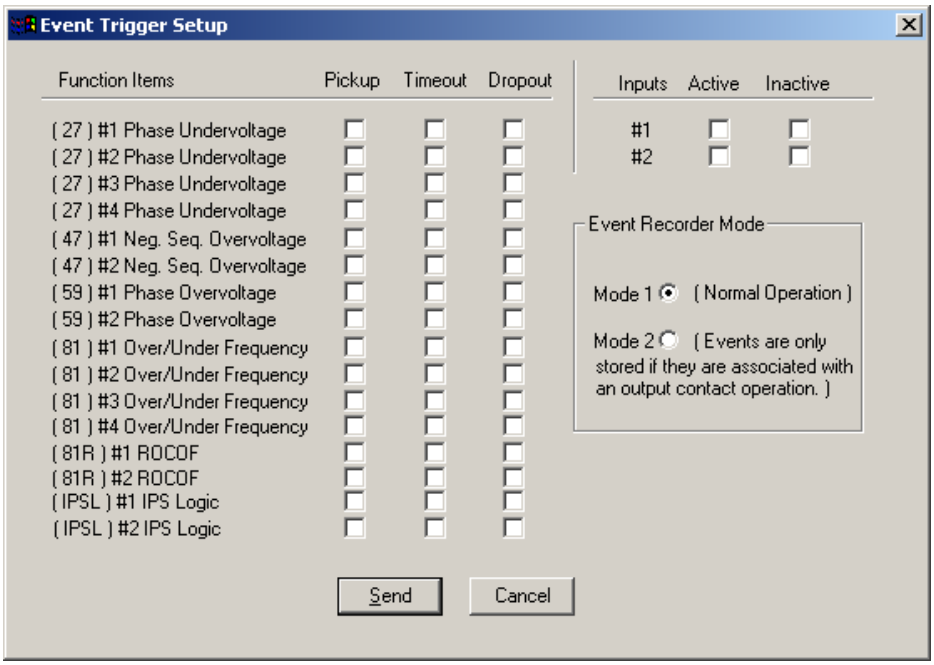



*Figure 4-13 IPScom® Event Trigger Setup*

**Path**: Relay/Event Recorder/Setup

### COMMAND BUTTONS

**Send** Sends all displayed changes to relay.

**Cancel** Returns to previous window; any changes made to displayed information will be lost.

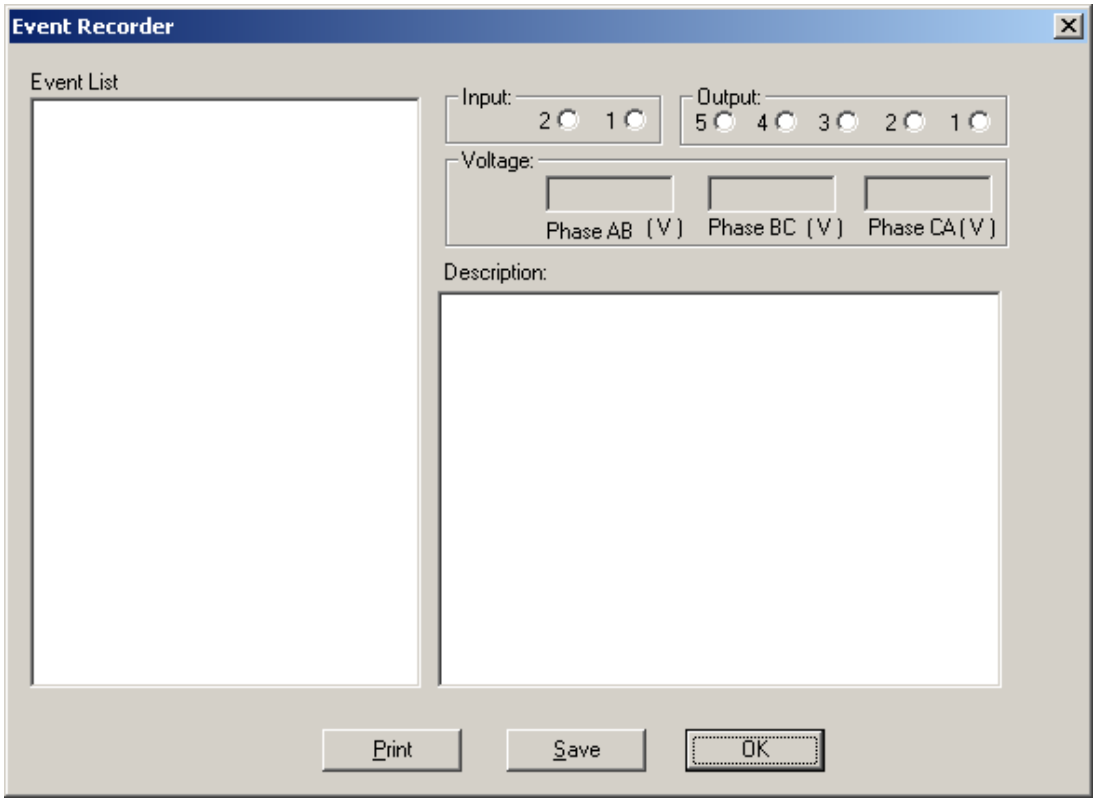



*Figure 4-14 IPScom® Event List Dialog Screen*

**Path**: Relay/Event Recorder/Display

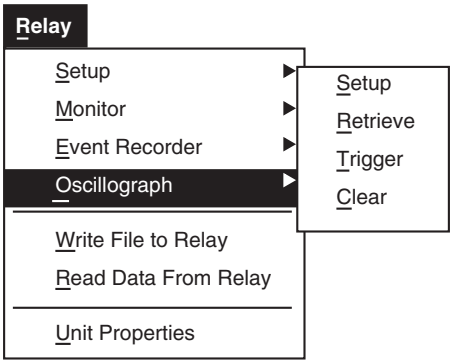
**COMMAND BUTTONS**

**Print** Prints all entered information to the relay.

**Save** Saves all entered information to the relay.

**OK** Exits the currently displayed dialog box.

The **Oscillograph** submenu allows selected parameter data to be displayed for review and plotting at a later time.




The **Setup** command allows the user to set the number of records and triggering designations to be made.

The **Retrieve** command downloads and stores collected data to a file; The optional M-3801D IPSplot® *PLUS* Oscillograph Analysis Software program can be used to view the downloaded oscillograph files or by third party Common Format for Transient Data Exchange (COMTRADE) format viewer software.

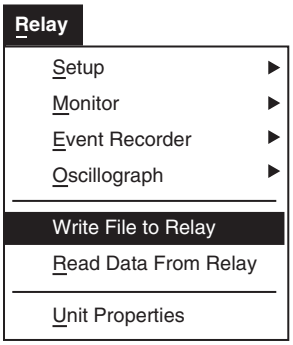
### Retrieving Oscillograph Records

Perform the following to retireve Oscillograph records:

1. Select Relay\Oscillograph\Retireve from the IPScom menu. IPScom will display the retrieve oscillograph record screen (Figure 4-17) and any available oscillograph records.
2. Select the record to be retrieved, and the desired data format.
3. Input the file name and destination, or browse the host PC for the desired destination.
4. Select **Retrieve**, IPScom will start the retrieval process.
   a. The retrieving status bar will update to indicate the progress of the retrieval.
   b. When the retireval is complete, IPScom will display the information screen (Figure 4-18) indication that the Comtrade file has been retrieved.
5. Select **OK** and IPScom will return to the main screen. If an additional oscillograph file is to be retireved, then repeat steps 1 through 4 for the target file.

**Trigger** allows the manual triggering of the recorder; **Clear** erases the existing records.

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.




### Unit Properties

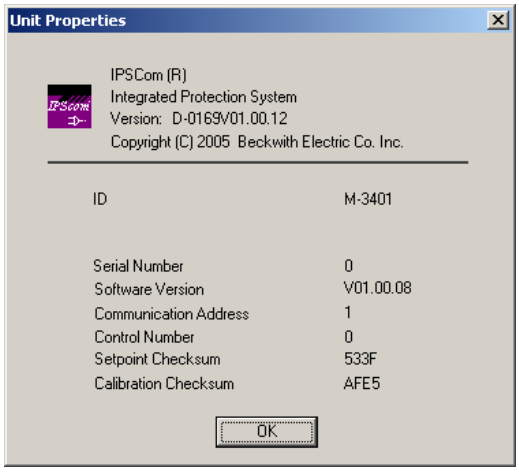
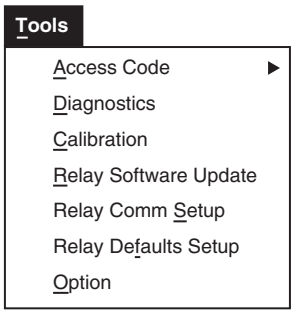



*Figure 4-15 Unit Properties Screen*

### Tools Menu

The Tools menu provides an **Access Code** submenu and six commands: **Diagnostics, Calibration, Relay Software Update, Relay Com Setup**, **Relay Defaults Setup**, and **Option**.



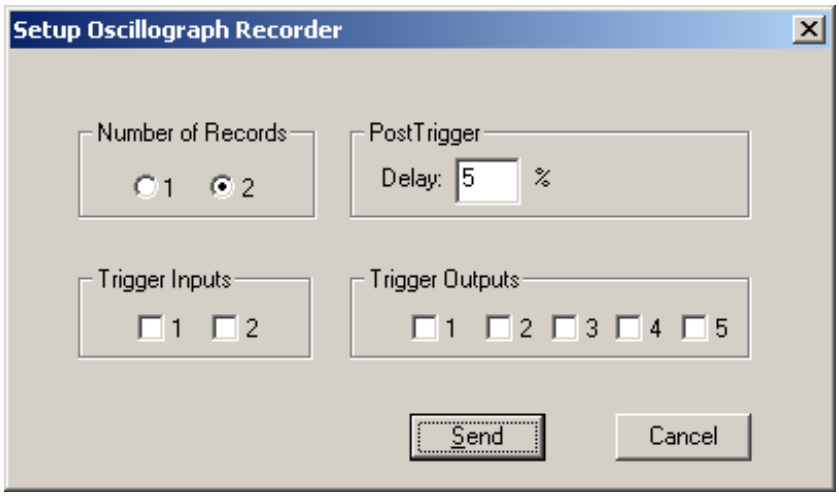



*Figure 4-16 IPScom® Setup Oscillograph Recorder Dialog Screen*

**Path**: Relay/Oscillograph/Setup

**COMMAND BUTTONS**

**Send** Sends all displayed changes to relay.

**Cancel** Returns to previous window; any changes made to displayed information will be lost.

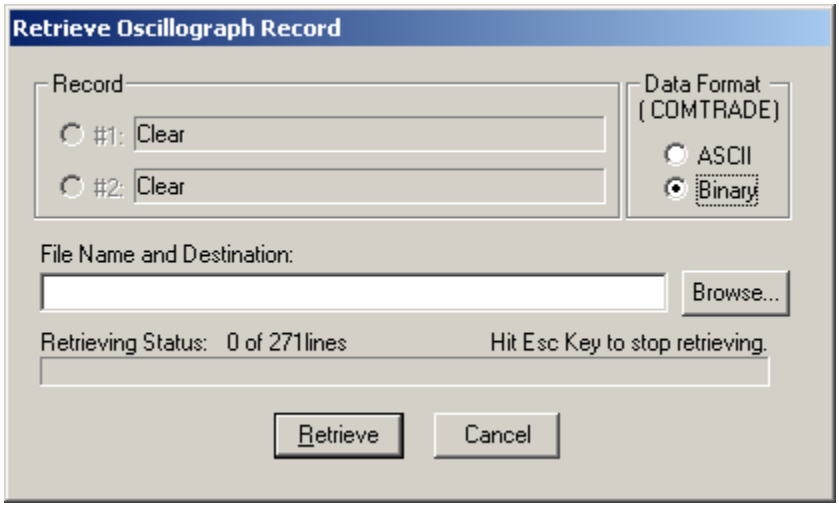



*Figure 4-17 IPScom Retrieve Oscillograph Record Screen*

**Path**: Relay/Oscillograph/Retrieve

**COMMAND BUTTONS**

**Retrieve** Retrieves all displayed changes to relay.

**Cancel** Returns to previous window; any changes made to displayed information will be lost.

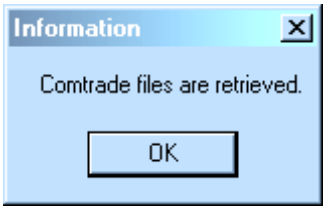



*Figure 4-18 IPScom Oscillograph Information Screen*


*Figure 4-19 IPScom Trigger Oscillograph Recorder Command Sent Screen*

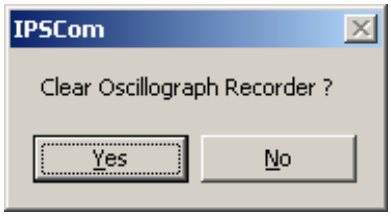
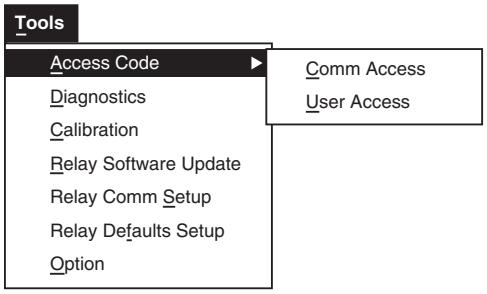



*Figure 4-20 IPScom Clear Oscillograph Recorder Prompt Screen*


*Figure 4-21 IPScom Clear Oscillograph Recorder Confirmation Screen*

## Access Code Submenu




The **Access Code** submenu includes two commands: **Comm Access** and **User Access**, which allow authorized users to define or revise access levels for the relay and for individual system users.

There are four (4) access codes, all default (9999):

- **Communication Access Code**
- **User Access Level 1 Code**
- **User Access Level 2 Code**
- **User Access Level 3 Code**

| Function | Level 1 | Level 2 | Level 3 |
|---|---|---|---|
| File (All Features) | R | R | R |
| Comm (All Features) | R | R | R |
| Relay/Setup/Setup Relay | R | R | R/W |
| Relay/Setup/Setpoints | R | R/W | R/W |
| Relay/Setup/Set Date/Time | R | R/W | R/W |
| Relay/Monitor (All Features) | R/W* | R/W* | R/W* |
| Relay/Event Recorder/Setup | R | R/W | R/W |
| Relay/Event Recorder/Display | R | R/W | R/W |
| Relay/Event Recorder/Clear History | R | R/W | R/W |
| Relay/Oscillograph/Setup | R | R/W | R/W |
| Relay/Oscillograph/Retrieve | R | R/W | R/W |
| Relay/Oscillograph/Trigger | R | R/W | R/W |
| Relay/Oscillograph/Clear | R | R/W | R/W |
| Relay/Write File to Relay | | | R/W |
| Relay/Read Data from Relay | R | R | R |
| Relay/Unit Properties | R | R | R |
| Tools (All Features) | | | R/W |
| Window (All Features) | R | R | R |
| Help (All Features) | R | R | R |
| ** W = Reset LED Capability* | | | |

*Table 4-1 IPScom® User Access Code Level Privileges*

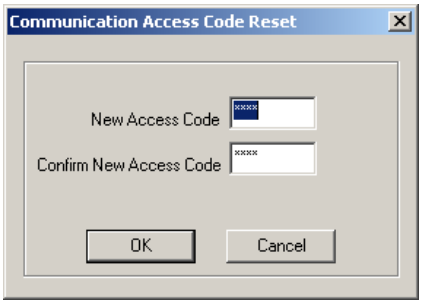



*Figure 4-22 IPScom Comm Access Code Reset*

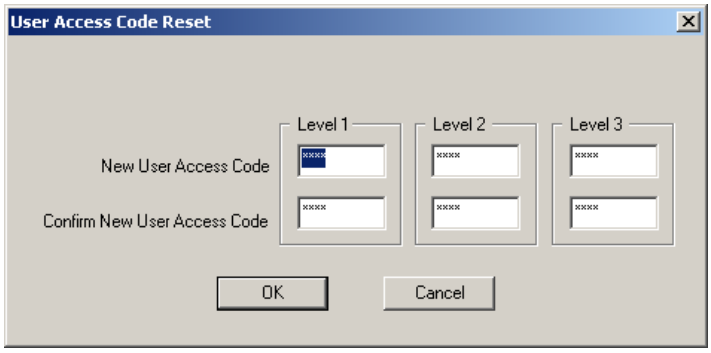
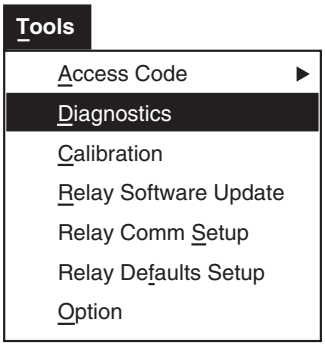



*Figure 4-23 IPScom User Access Code Reset*

### Diagnostics Command




The Diagnostics command displays the Relay Test window that includes three relay tests which provide a means to test input and outputs and relay communication ports.

Also included in Diagnostics is a Current Status screen which includes a time stamped relay software error log that can be reset, an output counter that also can be reset and the time and date of the last relay power up.

### Input/Output Test

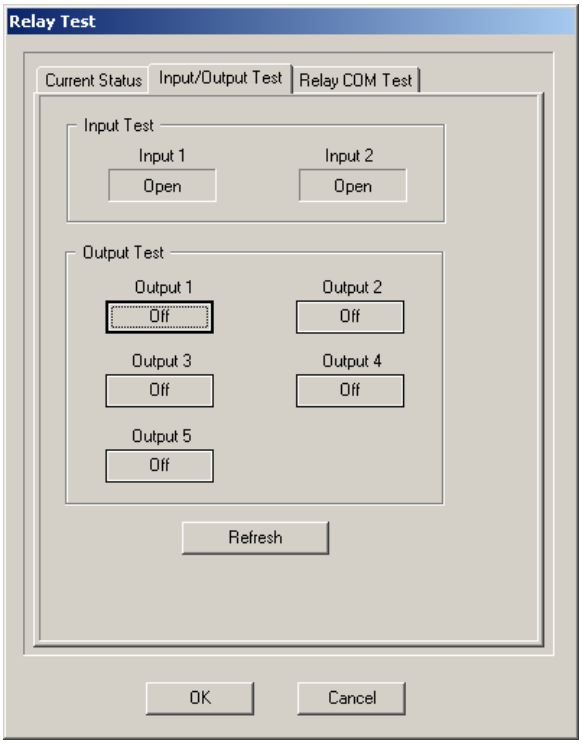



*Figure 4-24 IPScom® Input/Output Test Panel*

### COM Test

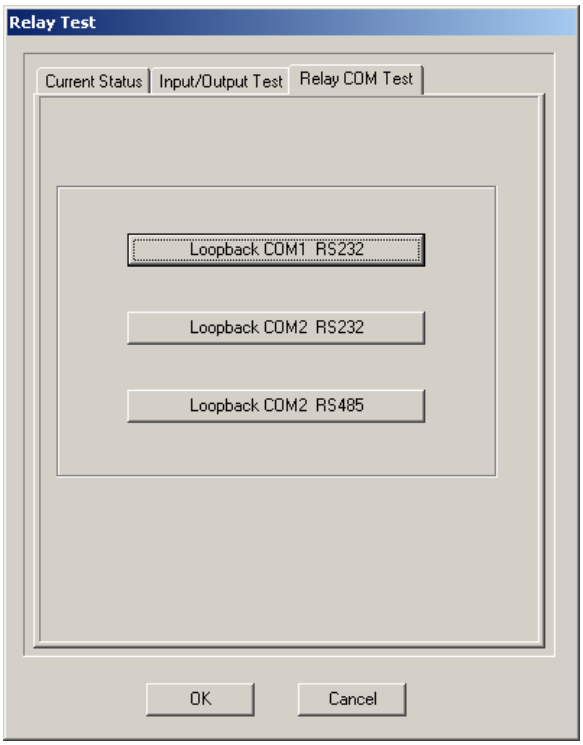



*Figure 4-25 IPScom COM Test Panel*

### Current Status

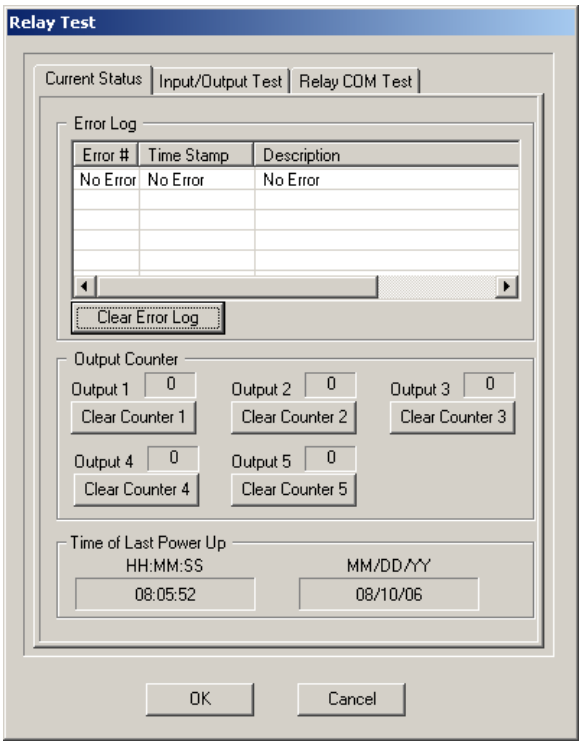



*Figure 4-26 IPScom Current Status Panel*

### Calibration Command

The Calibration command permits the user to recalibrate the relay. Since Beckwith Electric relays are factory calibrated for optimum operation, we recommend that you contact Beckwith Electric Co. prior to utilizing this command.

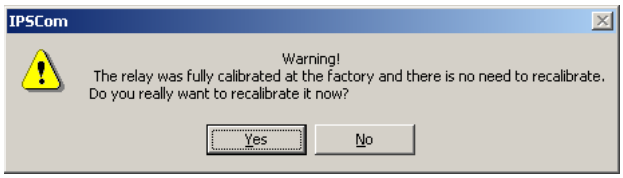



*Figure 4-27 IPScom® Calibration*

### Relay Software Update Command

This command automatically downloads and installs any updates to the relay resident software.

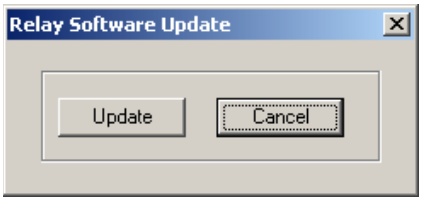



*Figure 4-28 IPScom Relay Software Update*

### Relay Comm Setup

This command displays the Relay COMM Setup Window, which provides the means to select the relay Com port, baud rate, stop bits, parity, and relay address.

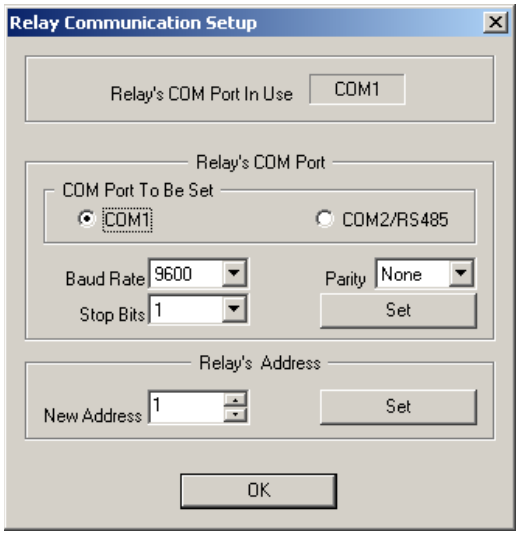



*Figure 4-29 IPScom Relay COM Setup Window*

### Relay Defaults Setup

The Relay Defaults Setup command allows the user to load factory setpoint and calibration defaults.

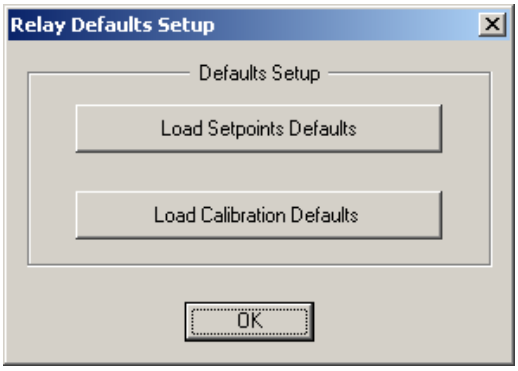



*Figure 4-30 IPScom Relay Defaults Setup*

### Option Command

The Option command displays the Option Window, which provides the means to select Time Delays displayed in either cycles or milliseconds.

The Communication Retry feature sets the number of the times that IPScom will attempt to establish communication with the relay. The number of retry attempts can be set from 0 to 5, with 0 setting not allowing a retry. The Communication Timeout setting establishes the duration in seconds that IPScom will wait to establish communication with the relay. The Timeout value can be set to 1, 2, 4, 8, or 16 seconds.

The Packet Size setting determines packet size when retrieving Oscillographic data from the relay. It can be set to either Regular (communication driver will try large packet size to reduce transfer time) or Minimum (communication driver uses smaller packet size if line is noisy).

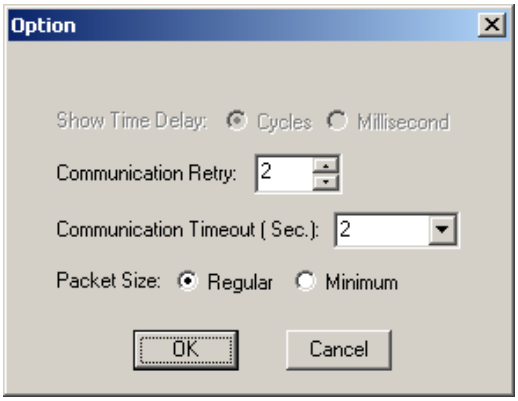
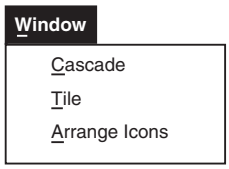


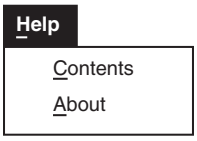

*Figure 4-31 IPScom Option Dialog Screen*

### 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. Selecting an inactive window activates that window.

The **Help** menu provides two commands. The **About** command provides information about the version of IPScom currently installed.




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-3401 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** IPScom® Dialog Screen displays IPScom version and development information.

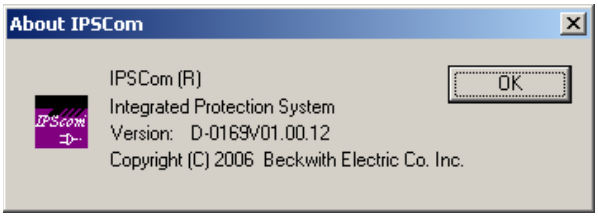



*Figure 4-32 IPScom About IPScom Dialog Screen*

**Path:** Help menu / About... command

**COMMAND BUTTONS**

**OK** Exits the currently displayed dialog Screen.

The **Reset Target LED/Outputs** command, when selected, issues an unlatch command to reset output contacts when the output contact mode is set to "Latching" and clears target LEDs of previously tripped functions.

## 4.4 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.

### 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 the user to manually set the unit's clock.

### Echo Cancel

The **Echo Cancel** check box, under the **Comm** menu, should only be used when several relays are connected using a fiber optic loop network. Otherwise, echo cancel must *not* be selected or communication will be prevented.

### Serial Port Connections

If the serial port is connected to something other than a modem, and an IPScom modem command is executed, the results are unpredictable. In some cases, the computer may have to be reset.

## 4.5 M-3401 Battery Replacement

▲ **CAUTION:** Personnel performing this procedure should be trained in Electrostatic Discharge prevention to prevent damage to ESD sensitive components. Check and comply with appropriate regulations regarding the disposal of lithium batteries.

**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 be moved with power applied.**

**WARNING: Dangerous voltages may exist even when power is disconnected! Power must be removed, and circuits discharged, before working on the unit.**

**WARNING: The protective grounding terminal must be connected to earth any time external connections have been made to unit.**

1. Remove power and potential inputs from the relay.
2. Remove the screws that retain the rear cover, lift the rear cover off the relay.

**WARNING: The protective grounding terminal must be connected to an earth line any time external connections have been made to unit.**

3. Remove the six screws that retain the CPU board to the I/O board.
4. Disconnect the CPU board from the I/O board by pulling the board away from the I/O board. Moderate force will be needed to accomplish this.

**WARNING: Danger of explosion if battery is incorrectly replaced!**

5. Remove the old battery from the CPU board and replace with a fresh CR 2032 (Beco #430-00402) or equivalent.
6. Reinstall the CPU board onto the I/O board by reversing the removal process.
7. Insert the six screws that retain the CPU board to the I/O board.
8. Reinstall the rear cover on the relay; insert the screws that retain the rear cover.
9. Reapply power and potential inputs to the relay.
10. Reset unit time and date (from the **Relay** menu, select **Set Date/Time**).
11. Verify proper operation of the relay.
12. Properly dispose of battery, following local requirements.

# 5 Testing

## 5.1 Equipment/Test Setup

No calibration is necessary, as the M-3401 Load Shedding 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 5.3, Auto Calibration.

### Equipment Required

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

1. One Digital Multimeter (DMM).
2. Appropriate power supply for system power.
3. Three-phase independent voltage sources (0 to 150% of nominal voltage) with variable phase and frequency to simulate VT inputs.
4. Electronic timer accurate to at least 8 ms.

### Setup

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

1. Connect system power to the power input terminals TB1-28 (hot) and TB1-27 (neutral). The relay can be ordered with a nominal input power supply of 12 V dc, 24 V dc, 48 V dc, or 120 V ac/125 V dc.
2. For each test procedure, connect the voltage sources according to the configuration listed in the test procedure and follow the steps outlined. When the testing of one function may cause another function to operate depending on the particular settings, it is recommended the untested function be disabled. (See Table 5-1, Functions to Disable When Testing.)

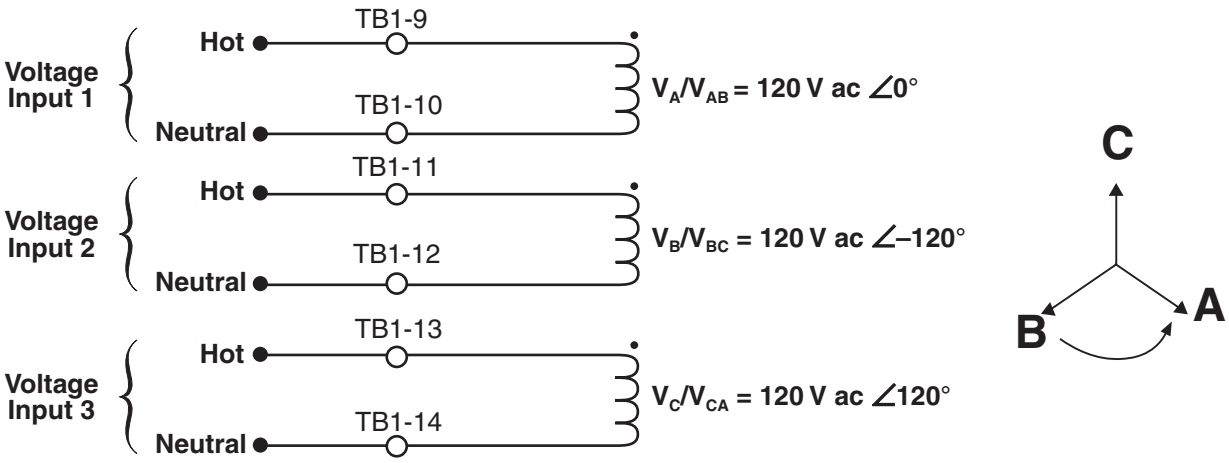



*Figure 5-1 Voltage Inputs: Configuration V1*

■ **NOTE**: Line-Ground and Line-Ground-to-Line-Line VT configuration uses $V_A$, $V_B$ and $V_C$ inputs and L-L VT configuration uses $V_{AB}$, $V_{BC}$, and $V_{CA}$ inputs.

## 5.2 Diagnostic Test Procedures

▲ **CAUTION:** These tests should NOT be performed when the relay is connected to the system. Failure to isolate the relay from the system can result in trip signals to the system.

The diagnostic procedures perform basic functional tests to verify the operation of the front-panel indicators, inputs and outputs, and communication ports. These tests are performed in relay test mode, which is entered by selecting **Diagnostics** from the **Tools** Menu of M-3812 IPScom® for Windows™.

### Output Test (Relay)

■ **NOTE**: All outputs are shown in the de-energized state for standard reference. Relay standard reference is defined as protective elements in the non-trip or power to the relay is removed.

The first step in testing the operation of the relay outputs is to verify the positions of the outputs in the unoperated or standard reference position. This is accomplished by connecting a DMM (Digital Multimeter) across the appropriate contacts and verifying open or close condition. The standard reference (unasserted) position for each output is listed in Table 5-2.

Following verification of output contact positions in the standard reference position, the output can be asserted by selecting the appropriate output from the **Output Test** section of the **Input/Output** test screen.

The DMM can now be used to verify the position of the output contacts in the asserted position. The readings should be the opposite of the initial reading in Table 5-2. All outputs should be returned to their initial unasserted positions.

| | FUNCTION TO BE DISABLED | | | | |
|---|---|---|---|---|---|
| **FUNCTION BEING TESTED** | **27** | **47** | **59** | **81** | **81R** |
| **27** | ■ | | ✓ | | |
| **47** | ✓ | ■ | | | |
| **59** | ✓ | | ■ | | |
| **81** | ✓ | | ✓ | ■ | ✓ |
| **81R** | | | | | ■ |

*Table 5-1 Functions to Disable When Testing*

| Relay | Contact | Option B1 | Option B2 | Option B3 |
|---|---|---|---|---|
| OUT 1 | TB1-1 and TB1-2 | NO | NC | NC |
| OUT 2 | TB1-3 and TB1-4 | NO | NO | NC |
| OUT 3 | TB1-6 and TB1-5<br>TB1-6 and TB1-7 | NC<br>NO | NC<br>NO | NC<br>NO |
| OUT 4 | TB1-22 and TB1-21<br>TB1-22 and TB1-23 | NO<br>NC | NO<br>NC | NO<br>NC |
| OUT 5 | TB1-19 and TB1-18<br>TB1-19 and TB1-20 | NO<br>NC | NO<br>NC | NO<br>NC |

*Table 5-2 Output Contacts*

### Control/Status Input Test

The **INPUT/OUTPUT Test** menu allows the user to determine the status of the individual status inputs.

| Input Number | Common Terminal | Terminal |
|---|---|---|
| 1 | TB1-26 | TB1-25 |
| 2 | TB1-26 | TB1-24 |

*Table 5-3 Control/Status Inputs*

Alternatively, if this specific input is being used in this application and the external wiring is complete, the actual external status contact can be manually exercised. This will test the external status contact operation *and* the external wiring to the control/ status inputs. The status of the appropriate input is displayed on the **INPUT/OUTPUT Test** screen after selecting **REFRESH**.

### Output Test (Self-Test Relay)

Testing the Relay Self-Test Output Contacts is accomplished as follows:

1. Verify that power has been removed from the relay.
2. Verify that Self-Test Relay contact status is consistent with Table 5-4.

| Relay Output Number | Form 'C' Contact |
|---|---|
| SELF-TEST | TB1-16 to TB1-17 NC<br>TB1-16 to TB1-15 NO |
| **Normal position of the contact corresponds to the standard reference state of the relay* | |

*Table 5-4 Self-Test Ouput Contacts*

3. While monitoring self-test contact status, apply power to the relay and verify the following:
   a. Diagnostic LED illuminates momentarily.
   b. Relay OK LED flashes quickly during relay self-test.
   c. Relay OK LED flashes at a slower rate, indicating completion of self-test.
4. If Self-Test routine does not identify any relay errors, the self-test relay contact status will be energized.
5. If Self-test routine identifies a relay error, the self-test relay will de-energize, with the contact status consistent with the information in Table 5-4.

### COM Test

This feature allows the user to verify the operation of the front panel RS-232 COM1 port and the rear panel COM2 port when configured for either RS-232 or RS-485.

### COM1 Loopback Test

1. Verify that the following conditions exist:
   - Power is available to the relay.
   - An RS-232 Loopback Plug (Figure 5-2) is connected to the COM1 port.

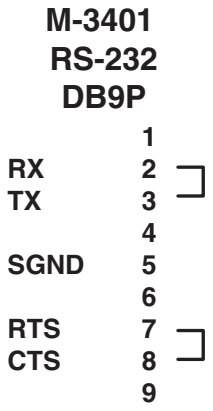



*Figure 5-2 RS-232 Loopback Plug*

■ **NOTE**: The loopback plug required 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.

   - Communication with the relay has been established through COM2 (either RS-232 or RS-485)

2. Select **Loopback COM1 RS232** from the **Relay/Diagnostics/Relay Com Test** menu.
3. The system will report back either “Pass” or “Fail”.

**COM2 RS-232 Loopback Test**

1. Verify that the following conditions exist:
   - Power is available to the relay
   - An RS-232 Loopback Plug (See Figure 5-2, COM1/COM2 Loopback Plug) is connected to the COM2 port.
   - IO Board jumpers JP3 and JP4 are configured for COM2 = RS-232 (See Table 2-1, Jumpers)
   - Communication with the relay has been established though COM1.
2. Select **Loopback COM2 RS-232** from the M-3812 IPScom® for Windows™ **Tools/Diagnostics/Relay Com Test** menu.
3. The system will report back either "Pass" or "Fail"

**COM2 RS-485 Loopback Test**

1. Verify that the following conditions exist:
   - Power is available to the relay.
   - The RS-485 terminals have been configured for Loopback testing (See Figure 5-3.)
   - IO Board jumpers JP3 and JP4 are configured for COM2 = RS-485 (See Table 2-1, Jumpers)
   - Communication with the relay has been established through COM1.

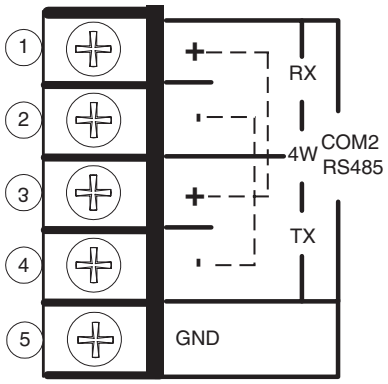



*Figure 5-3 RS-485 4-Wire Loopback Configuration*

2. Select **Loopback COM2 RS-485** from the M-3812 IPScom for Windows **Tools/ Diagnostics/Relay Com Test** menu.
3. The system will report back either "Pass or "Fail"

## 5.3 Auto Calibration

■ **NOTE:** The M-3401 Load Shedding Relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to initial installation. Calibration can be initiated using the IPScom® program.

Use a voltage source consistent with the accuracies stated in the M-3401 Specification. The Auto Calibration feature is accessed from the **Tools** Menu. Auto Calibration of the relay is accomplished by performing the following:

1. Ensure the protected component is either not running/open or Auto Start/Closure has been disabled.
2. Ensure communication has been established with the relay.
3. Verify that nominal frequency, nominal voltage rating and ratios (if applicable) have been entered in the IPScom **Setup Relay** screen.
4. Configure voltage input sources as indicated in Figure 5-4.
5. Utilizing a voltage source, apply the nominal voltage to the unit.
6. Select **Calibration** from the M-3812 IPScom for Windows™ **Tools** drop-down menu.
7. Select **Yes** at the recalibrate warning screen.
8. Select **OK** at the **Apply Nom Volt Nom Freq** screen.
9. Select **YES** at the **Ready Message** screen.
10. Select **START** from the M-3812 IPScom for Windows **AutoCal Process** screen.
11. Upon completion of the **AutoCal Process** the relay will report status.
12. Calibration complete.
13. Check metering to insure correct calibration.

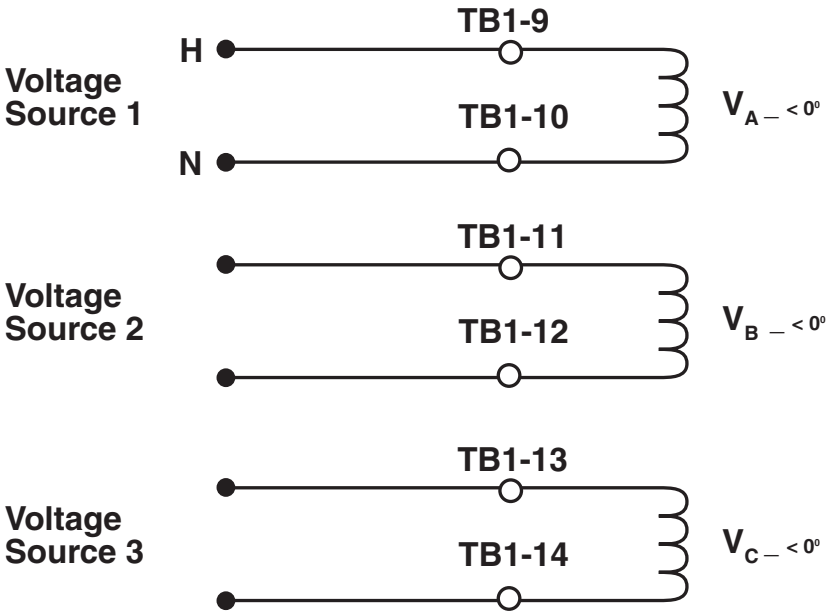



*Figure 5-4 Voltage Configuration for Auto Calibration*

## 5.4 Functional Test Procedures

▲ **CAUTION:** These tests should NOT be performed when the relay is connected to the system. Failure to isolate the relay from the system can result in trip signals to the system.

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. 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. In many test cases it will be necessary to disable other functions not being tested at the time. This action is to prevent the operation of multiple functions with one set of input quantities, which could cause confusion of operation of outputs or timers. The complete description of the method to disable/enable functions may be found in detail in Section 3.1, Configure Relay subsection, or Chapter 4, **Operation and Interface**. The complete description of the method to install setting quantities may be found in Section 3.2, Setpoints and Time Settings subsection.

It is desirable to *record and confirm* the actual settings of the individual functions before beginning test procedures. Use Table A-3, System Setup Record Form and Table A-4, Relay Setpoints and Settings 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®.

It may be desirable to save the relay settings in IPScom to preserve desired setup, and then load the test settings. After testing is completed, the desired relay settings can be loaded into the relay from the stored file.

The tests are described in this section in ascending function number order. Depending on which functions are to be tested at a given time, an order may be determined with the aid of Table 5-1, Functions to Disable When Testing. This may result in the fewer changes in connections and disable/enable operations.

During the lifetime of the relay, testing of individual functions due to changes in application settings will be more likely than an overall testing routine. An index of the individual test procedures is illustrated at the beginning of this chapter.

■ **NOTE**: Care must be taken to reset or enable any functions that have been changed from their intended application settings when the test procedures are complete.

It is suggested that test personnel print the Display All Setpoints screen and label it "As Found" prior to starting testing, and again when all testing is complete (marking the second "As Left") to ensure that all settings have been restored.

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.

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

Relay Configuration Table A-1 – pg A–2
Communication Data and Unit Setup Record Form Table A-2 – pg A–3
System Setup Record Form Table A-3 – pg A–4
Relay Setpoints & Settings Form
Table A-4 – pg A–5

## 27 Phase Undervoltage, Single-Phase (#1 or #2)

| | | | | |
|---|---|---|---|---|
| **VOLTAGE INPUTS**: | Configuration V1 | | | |
| **TEST SETTINGS**: | Pickup | P | % | (4 to 100)* |
| | *(*Of Nominal Voltage*) | | | |
| | Time Delay | D | Cycles | (1 to 8160) |
| | Programmed Outputs | Z | OUT | (1 - 5) |
| | Function 27 (#1, #2, #3, #4) (see Note, below) | Disable | | |
| | Function 59 | Disable | | |
| | Positive Sequence | Disable | | |
| | 27s | X | % | (4 to 100)* |
| | Time Delay | D | Cycles | (1 to 8160) |
| | 47s | Y | % | (4 to 100)* |
| | Time Delay | D | Cycles | (1 to 8160) |

■ **NOTE**: If 27 #1, #2, #3 and #4 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.

1. Disable functions as shown. See Section 3.2, Setpoints and Time Settings, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 5.1, Equipment/Test Setup for configuration. Set at Nominal Voltage (see Table A-3, System Setup Record Form).
4. ***Pickup Test***: Hold the **TARGET/OUTPUT RESET** pushbutton in and slowly decrease the input voltage on Phase A, B, C until **PHASE UV 27** LED light illuminates (or the pickup indicator operates on the Function Status screen). The voltage level should be equal to **P** ±0.5 V or ±0.5 %. Release the **TARGET/OUTPUT RESET** pushbutton and increase the input to the nominal voltage. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.
5. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately (**P** – 5) % and start timing. The contacts will close after **D** cycles within +20 cycles (RMS), or ±2 cycles (DFT).
6. ***27S Blocking Test:***

   Test the Function 27S Blocking Feature as follows:

   a. Disable Function 47S by setting the Function 47S pickup to 100%.

   b. Set 27S Function Time Delay to 1 Cycle

   c. Set 27 Function Time Delay to 1 Cycle

   d. Set $V_B$ <X, Lower $V_{ABC}$ <P

   e. Verify that 27 does not pickup.

   f. Decrease $V_{ABC}$ to a value >P.

7. ***47S Blocking Test:***

   Test the Function 47S Blocking Feature as follows:

   a. Disable Function 27S by setting the Function 27S pickup to 4%.

   b. Set the 47S Function Time Delay to 1 Cycle.

   c. Set Function 47S pickup Y to $\leq$ 95%.

   d. Set Phase Rotation to ABC.

   e. Apply Voltage Phase angles as follows:

      1.) Line-Ground or Line-Ground to Line-Line: $V_A = \angle 0°$, $V_B = \angle 120°$, $V_C = \angle -120°$

      2.) Line-to-Line: $V_{AB} = \angle 0°$, $V_{BC} = \angle 120°$, $V_{CA} = \angle -120°$

   f. Lower $V_{ABC}$ <P, verify that 27 does not pickup.

   g. Increase $V_{ABC}$ to a value >P.

8. Test phases A and C (or AB, CA in case of Line-Line VT configuration) by repeating Step 6.

9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

## 27 Phase Undervoltage, Positive Sequence (#1 or #2)

| | | | | |
|---|---|---|---|---|
| **VOLTAGE INPUTS**: | Configuration V1 | | | |
| **TEST SETTINGS**: | Pickup | P | % | (4 to 100)* |
| | *(*Of Nominal Voltage*) | | | |
| | Time Delay | D | Cycles | (1 to 8160) |
| | Programmed Outputs | Z | OUT | (1 - 5) |
| | Function 27 (#1, #2, #3, #4) (see Note, below) | Disable | | |
| | Function 59 | Disable | | |
| | Positive Sequence | Enabled | | |
| | 27s | X | % | (4 to 100)* |
| | Time Delay | D | Cycles | (1 to 8160) |
| | 47s | Y | % | (4 to 100)* |
| | Time Delay | D | Cycles | (1 to 8160) |

■ **NOTE**: If 27 #1, #2, #3 and #4 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.

1. Disable functions as shown. See Section 3.2, Setpoints and Time Settings, for procedure.
2. Confirm settings to be tested.

   a. Set 47S Function to 100%

   b. Set 27S Function to 4%

   c. Set P to a value >27S Pickup Setting

3. Connect inputs in Configuration V1 designated above. See Section 5.1, Equipment/Test Setup for configuration. Set at Nominal (Balanced) Voltage (see Table A-3, System Setup Record Form).
4. ***Pickup Test***: Hold the **TARGET/OUTPUT RESET** pushbutton in and slowly decrease the input voltage on all phases until **PHASE UV 27** LED light illuminates (or the pickup indicator operates on the Function Status screen). The voltage level should be equal to **P** ±0.5 V or ±0.5 %. Release the **TARGET/OUTPUT RESET** pushbutton and increase the input to the nominal voltage. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.
5. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately (**P** – 5) % and start timing. The contacts will close after **D** cycles within +20 cycles (RMS), or ±2 cycles (DFT).
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

## 47 Negative Sequence Overvoltage (Voltage Unbalance) (#1 or #2)

| | | | | |
|---|---|---|---|---|
| **VOLTAGE INPUTS**: | Configuration V1 | | | |
| **TEST SETTINGS**: | Pickup (**of Nominal Voltage*) | P | % | (4 to 100)* |
| | Time Delay | D | Cycles | (1 to 8160) |
| | Programmed Outputs | Z | Output | (1 - 5) |
| | Function 47 (#1 or #2)<br>Function 27 | Disable<br>Disable | | |

■ **NOTE**: If 47 #1 and 47 #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.

1. Disable functions as shown. Refer to Section 3.2, Setpoints and Time Settings, for procedure.
2. Confirm settings to be tested.
3. Set Phase Rotation to ABC.
4. Connect inputs in configuration V1 and apply the voltage phase angles as follows:
   a. Line-Ground or Line-Ground to Line-Line: $V_A = \angle 0°$, $V_B = \angle 120°$, $V_C = \angle -120°$
   b. Line-to-Line: $V_{AB} = \angle 0°$, $V_{BC} = \angle 120°$, $V_{CA} = \angle -120°$
5. ***Pickup Test:*** Apply 3-phase voltage 5% below pickup **(P)**. Hold the **TARGET/OUTPUT RESET** pushbutton in and slowly increase the voltage applied until the **VOLT UNBALANCE 47** LED illuminates or the pickup indicator operates on the Function Status screen. The level should be equal to **P**% ±0.5% or ±0.5 V. Release the **TARGET/OUTPUT RESET** pushbutton and decrease applied voltage. Press the **TARGET/OUTPUT RESET** pushbutton again to remove targets.
6. ***Time Test***: Apply voltage 10% less than pickup (**P**) to all three phases. With output contacts connected to a timer, apply **P** + 10% and start timing. The contacts will close after **D** cycles, within ±2 cycles.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

## 59 Phase Overvoltage, 3-Phase (#1 or #2)

| | | | | |
|---|---|---|---|---|
| **VOLTAGE INPUTS**: | Configuration V1 | | | |
| **TEST SETTINGS**: | Pickup (**of Nominal Voltage*) | P | % | (100 to 150)* |
| | Time Delay | D | Cycles | (1 to 8160) |
| | Programmed Outputs | Z | OUT | (1 - 5) |
| | Function 59 (#1 or #2) (see Note, below) | Disable | | |
| | Function 27 | Disable | | |

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

1. Disable functions as shown. See Section 3.2, Setpoints and Time Settings, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 5.1, Equipment /Test Setup for configuration. Set Voltages = Nominal Voltage (see Table A-3, System Setup Record Form).
4. ***Pickup Test***: Press and hold the **TARGET/OUTPUT RESET** pushbutton and slowly increase the input voltage on phase A until **59/59I PHASE OV** LED illuminates or the pickup indicator operates on the Status Function screen. The level should be equal to **P** ±0.5 V or ±0.5%. Release the **TARGET/OUTPUT RESET** pushbutton and decrease the input voltage to nominal voltage. Press **TARGET/OUTPUT RESET** pushbutton to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply (**P**+5) % on phase A and start timing. The contacts will close after **D** cycles within +20 cycles (RMS) or ±2 cycles (DFT).
6. Test phases B and C (or BC and CA for Line-Line VT configurations) by repeating steps 4 and 5.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

## 81 Over/Under Frequency (#1, #2, #3, #4)

**VOLTAGE INPUTS**: Configuration V1

**TEST SETTINGS**:

| | | | | 60 Hz | 50 Hz |
|---|---|---|---|---|---|
| | Pickup | P | Hz | (50 to 67) | (40 to 57) |
| | Time Delay | D | Cycles | (2 to 65,500) | |
| | Programmed Outputs | Z | OUT | (1 - 5) | |
| | Functions 27, 59, 81R | | Disable | | |

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

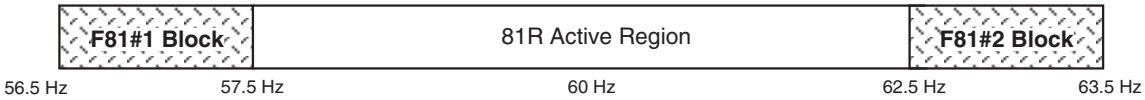
1. Disable functions as shown. See Section 3.2, Setpoints and Time Settings, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 5.1, Equipment/Test Setup for configuration.
4. ***Pickup Test***: Set the voltages $V_A$, $V_B$, and $V_C$ to Nominal Voltage (see Table A-3, System Setup Record Form) (nominal frequency). For over frequency testing, hold the **TARGET/OUTPUT RESET** pushbutton in and slowly increase the frequency on the input voltage(s) until the **81 O/U FREQUENCY** LED illuminates or the pickup indicator operates on the Function Status screen. The level will be equal to **P** Hz ±0.03 Hz only if **P** is within 3 Hz of $F_{nom,}$ otherwise, ±0.15 Hz. Return to nominal input frequency. Press **TARGET/OUTPUT RESET** pushbutton to remove targets. For under frequency testing, decrease the input frequency and return to nominal after operation.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply (**P** ±0.5) Hz and start timing. The contacts will close after **D** cycles within ±2 cycles or ±0.01%.
6. Complete the testing for all 81 functions by repeating the appropriate steps for each one.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

## 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 5) |

***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 by enabling 81#1 to pickup at a frequency 1 Hz higher than the minimum frequency of the ramp, and assign a unique output. Set 81#2 to pickup 1 Hz lower than the maximum frequency of the ramp, and assign a unique output (see figure below). The frequencies given are suggested for testing rates below 10 Hz/Sec. Higher rates will require consideration of the capabilities of the test equipment involved. Connect both of these outputs to an input with jumpers, and set the 81R function to block on this input. Set the time delays and seal-in times of the 81 functions to minimum. This will result in an operational window that is free of erroneous Hz/Sec measurements when the voltage source begins or ends the sweep.




   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 the IPScom Communications Software.
4. Disable all other functions prior to testing. Refer to Section 3.2, Setpoint and Time Settings 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 5-1, 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 3.1 and should be recorded on Table A-3, System Setup 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.

***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 3.1 and should be recorded on Table A-3, System Setup 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.

***Negative Sequence Voltage Inhibit Test***:

1. Reset targets, then apply Nominal Voltage to all three phases at a sweep rate 25% above **P**.
2. Verify that the **FREQUENCY/ROCOF 81/81R** LED illuminates, or the pickup indicator operates on the computer target screen.
3. Swing the phase angle of a phase voltage, then 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.

## IPSlogic™ (#1, #2)

| | | | | |
|---|---|---|---|---|
| **VOLTAGE INPUTS:** | As Needed | | | |
| **TEST SETTINGS:** | Time Delay | D | Cycles | (1 to 8160) |
| | Programmed Outputs | Z | OUT | (1 to 5) |
| | Blocking Inputs | | | (1, 2) |
| | Output Initiate | | | (1, 2) |
| | Initiate by Communication | | | |
| | Input Initiate | | | (1, 2) |
| | Block from Communication | | | |
| | Initiating Function Trip | | | |

***Test Setup:***

1. Refer to Figure 3-10, IPSlogic Function Setup, for logic gate configurations.
2. Select gate configuration (AND/OR/NAND/NOR) for Output Initiate, Function Trip Initiate, Input Initiate, Blocking Inputs and Communication Point.
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 26) to the designated Inputs (Terminals 24 and/or 25) 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 26) to the designated Blocking Inputs (Terminals 24 and/or 25) to be tested. The **EXTERNAL #1 EXT 1** LED will extinguish.
2. Repeat Step 1 for each designated external triggering contact.

# A Appendix A

# Configuration Record Forms

This Appendix contains photocopy–ready forms for recording the configuration and setting of the M-3401 Load Shedding 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 *t*o be operated by the function, and check the inputs designated to block the function operation.

Table A-2, Communication Data & Unit Setup Record Form reproduces the Communication setup menus. This form records definition of the parameters necessary for communication with the relay, as well as access codes.

Table A-3, System Setup Record Form, allows recording of the specific relay system parameters.

Table A-4, Setpoints and Settings 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.

| Function | D | OUTPUTS | | INPUTS | |
|---|---|---|---|---|---|
| | | 2 | 1 | 2 | 1 |
| 27 | 1 | | | | |
| | 2 | | | | |
| 47 | 1 | | | | |
| | 2 | | | | |
| 59 | 1 | | | | |
| | 2 | | | | |
| 81 | 1 | | | | |
| | 2 | | | | |
| | 3 | | | | |
| | 4 | | | | |
| 81R | 1 | | | | |
| | 2 | | | | |
| IPSL | 1 | | | | |
| IPSL | 2 | | | | |

Check each box applicable : ✓ (See page A-1 for information on using this table.)

**D** Column = Function Disabled.

OUTPUTS Columns = Designated function output(s)

INPUTS Columns = Designated function blocking input(s)

*Table A-1 Relay Configuration Table*

## PC COM1 Setup

| | | | | | |
|---|---|---|---|---|---|
| Baud Rate | ❑ 19200 | ❑ 9600 | ❑ 4800 | ❑ 2400 | ❑ 1200 |
| Parity | ❑ None | ❑ Odd | ❑ Even | | |
| Stop Bits | ❑ 1 | ❑ 2 | | | |

## PC COM2 Setup

| | | | | | |
|---|---|---|---|---|---|
| Baud Rate | ❑ 19200 | ❑ 9600 | ❑ 4800 | ❑ 2400 | ❑ 1200 |
| Parity | ❑ None | ❑ Odd | ❑ Even | | |
| Stop Bits | ❑ 1 | ❑ 2 | | | |

## Communication Address

Relay Com Access Code ( )
*Default 9999 until changed by operator.*

Relay Communication Address 1,2,3... _____

*Table A-2 Communication Data & Unit Setup Record Form*

## Relay Setup

| | | | |
|---|---|---|---|
| Nominal Frequency | ❑ 60 Hz | ❑ 50 Hz | |
| Nominal Voltage | 50 to 500 Volts ( ) | | |
| Input Active State #1 | ❑ Open | ❑ Close | |
| Input Active State #2 | ❑ Open | ❑ Close | |
| Output Contact Mode #1 | ❑ Normal<br>❑ Latching | | |
| Output Contact Mode #2 | ❑ Normal<br>❑ Latching | | |
| Output Contact Mode #3 | ❑ Normal<br>❑ Latching | | |
| Output Contact Mode #4 | ❑ Normal<br>❑ Latching | | |
| Output Contact Mode #5 | ❑ Normal<br>❑ Latching | | |
| VT Configuration | ❑ L-G | ❑ L-L | ❑ L-G to L-L |
| 59/27 Magnitude Select | ❑ RMS | ❑ DFT | |
| Phase Rotation | ❑ ABC | ❑ ACB | |
| VT Phase Ratio | 1.0 to 6550.0 | (_____) :1 | |
| Relay Out #1 Seal-In Time | 2 to 8160 Cycles | (_____) | |
| Relay Out #2 Seal-In Time | 2 to 8160 Cycles | (_____) | |
| Relay Out #3 Seal-In Time | 2 to 8160 Cycles | (_____) | |
| Relay Out #4 Seal-In Time | 2 to 8160 Cycles | (_____) | |
| Relay Out #5 Seal-In Time | 2 to 8160 Cycles | (_____) | |
| OK LED Flash | ❑ Enable | ❑ Disable | |

User Logo: _____

Control Number: _____

*Table A-3 System Setup Record Form*

## (27) Undervoltage

**#1**

| | | | | | |
|---|---|---|---|---|---|
| #1 Pickup | | 4.0 to 100.0%* | | ( _____ ) | |
| #1 Delay | | 1 to 8160 Cycles | | ( _____ ) | |
| #1 Positive Sequence | ❒ | | | | |
| #1 Outputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #1 Blocking Inputs | ❒ #2 | ❒ #1 | | | |

**#2**

| | | | | | |
|---|---|---|---|---|---|
| #2 Pickup | | 4.0 to 100.0%* | | ( _____ ) | |
| #2 Delay | | 1 to 8160 Cycles | | ( _____ ) | |
| #2 Positive Sequence | ❒ | | | | |
| #2 Outputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #2 Blocking Inputs | ❒ #2 | ❒ #1 | | | |

**#3**

| | | | | | |
|---|---|---|---|---|---|
| #3 Pickup | | 4.0 to 100.0%* | | ( _____ ) | |
| #3 Delay | | 1 to 8160 Cycles | | ( _____ ) | |
| #3 Positive Sequence | ❒ | | | | |
| #3 Outputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #3 Blocking Inputs | ❒ #2 | ❒ #1 | | | |

**#4**

| | | | | | |
|---|---|---|---|---|---|
| #4 Pickup | | 4.0 to 100.0%* | | ( _____ ) | |
| #4 Delay | | 1 to 8160 Cycles | | ( _____ ) | |
| #4 Positive Sequence | ❒ | | | | |
| #4 Outputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #4 Blocking Inputs | ❒ #2 | ❒ #1 | | | |

**27s Supervision**

| | | |
|---|---|---|
| Pickup | 4.0 to 100.0%* | ( _____ ) |
| Delay | 1 to 8160 Cycles | ( _____ ) |

**47s Supervision**

| | | |
|---|---|---|
| Pickup | 4.0 to 100.0%* | ( _____ ) |
| Delay | 1 to 8160 Cycles | ( _____ ) |

**Of Nominal Voltage.*

*Table A-4 Relay Setpoints and Settings Record Form (page 1 of 6)*

## (47) Negative Sequence Overvoltage

**#1**

| | | |
|---|---|---|
| #1 Pickup | 4.0 to 100.0%* | ( _____ ) |
| #1 Delay | 1 to 8160 Cycles | ( _____ ) |
| #1 Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| #1 Blocking Inputs | ❑ #2 ❑ #1 | |

**#2**

| | | |
|---|---|---|
| #2 Pickup | 4.0 to 100.0%* | ( _____ ) |
| #2 Delay | 1 to 8160 Cycles | ( _____ ) |
| #2 OutputsOutputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| #2 Blocking Inputs | ❑ #2 ❑ #1 | |

**(Of Nominal Voltage)*

*Table A-4 Relay Setpoints and Settings Record Form (page 2 of 6)*

## (59) Overvoltage

**#1**

| | | | | | |
|---|---|---|---|---|---|
| #1 Pickup | 100.0 to 150.0%* | | | | (_____) |
| #1 Delay | 1 to 8160 Cycles | | | | (_____) |
| #1 Outputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #1 Blocking Inputs | ❑ #2 | ❑ #1 | | | |

**#2**

| | | | | | |
|---|---|---|---|---|---|
| #2 Pickup | 100.0 to 150.0%* | | | | (_____) |
| #2 Delay | 1 to 8160 Cycles | | | | (_____) |
| #2 OutputsOutputs | ❒ #5 | ❒ #4 | ❒ #3 | ❒ #2 | ❒ #1 |
| #2 Blocking Inputs | ❑ #2 | ❑ #1 | | | |

**Of Nominal Voltage*

*Table A-4 Relay Setpoints and Settings Record Form (page 3 of 6)*

## (81) Over/Under Frequency

**#1**

| | | |
|---|---|---|
| Pickup | 50.00 to 67.00<br>(40.00 to 57.00*) | (_____) |
| Delay | 2 to 65,500 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

**#2**

| | | |
|---|---|---|
| Pickup | 50.00 to 67.00<br>(40.00 to 57.00*) | (_____) |
| Delay | 2 to 65,500 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

**#3**

| | | |
|---|---|---|
| Pickup | 50.00 to 67.00<br>(40.00 to 57.00*) | (_____) |
| Delay | 2 to 65,500 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

**#4**

| | | |
|---|---|---|
| Pickup | 50.00 to 67.00<br>(40.00 to 57.00*) | (_____) |
| Delay | 2 to 65,500 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

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

*Table A-4 Relay Setpoints and Settings Record Form (page 4 of 6)*

## (81R) Rate of Change of Frequency

**#1**

| | | |
|---|---|---|
| Pickup | 0.10 to 20.00 | (_____) |
| Delay | 3 to 8160 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

**#2**

| | | |
|---|---|---|
| Pickup | 0.10 to 20.00 | (_____) |
| Delay | 3 to 65,500 Cycles | (_____) |
| Outputs | ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 | |
| Blocking Inputs | ❑ #2 ❑ #1 | |

*Table A-4 Relay Setpoints and Settings Record Form (page 5 of 6)*

## IPSlogic™

**IPSL #1**

Initiating Outputs ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1 ❒ OR ❒ AND

Initiating Function Trip ❒ OR ❒ AND ❒ NOR ❒ NAND

❒ OR ❒ AND

Initiate via Communication Point ❒

Initiating Inputs ❒ #2 ❒ #1 ❒ AND ❒ OR

Blocking Inputs ❒ #2 ❒ #1 ❒ AND ❒ OR

Block via Communication Point ❒

Delay 1 to 8160 Cycles (_____)

Outputs ❒ #5 ❒ #4 ❒ #3 ❒ #2 ❒ #1

**IPSL #2 (see ISPL #1 above)**

*Table A-4 Relay Setpoints and Settings Record Form (page 6 of 6)*

# B Appendix B–Communications

The M-3401 Load Shedding Relay incorporates two serial ports 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.

The M-3812 IPSCom® Communication Software package has been supplied for communication to any IBM compatible computer running under Microsoft® Windows 95/98/NT/2000/XP.

MODBUS communication protocol is implemented in the relay. Only RTU mode of the MODBUS protocol is supported. The following functions are implemented in IPScom using MODBUS protocol:

- Real time monitoring of measured parameters
- Interrogation and modification of setpoints
- Downloading of recorded oscillograph data and sequence of events data
- Reconfiguration of relay functions

For detailed information on IPScom communications, refer to **Chapter 4, Operation and Interface**.

**Communication Ports**

The relay includes both front and rear panel serial COM ports. The front panel port is a 9-pin RS-232 (DB9S) connector configured as DTE (Data Terminal Equipment) per the EIA-232 standard. The rear port can be configured as an RS-232 or RS-485 port. Signals are defined in Table B-1, Communication Port Signals .

Each communication port may be configured to operate at any of the standard baud rates (9600 and 19200). The RS-485 port shares the same baud rate with COM 2 (see Section 2.9, **Circuit Board Switches and Jumpers**).

While the digital communication ports do include some ESD (Electrostatic Discharge) protection circuitry, they are excluded from passing ANSI/ IEEE C37.90.1-1989. Beckwith Electric recommends the use of RS-232/485 to fiber optic converters to avoid any question of surge-withstand capability or ground potential rise.

A null modem cable is also shown in Figure B-1, Null Modem Cable: M-0423, if direct connection to a PC (personal computer) is desired.

| Circuit | | Signal | COM1 | COM2 |
|---|---|---|---|---|
| BB | RX | Receive Data | Pin 2 | Pin 2 |
| BA | TX | Transmit Data | Pin 3 | Pin 3 |
| CA | RTS | Request to Send | Pin 7 | Pin 7 |
| CB | CTS | Clear to Send | | Pin 8 |
| CD | DTR | Data Terminal Ready | Pin 4 | Pin 4 |
| CF | DCD | Data Carrier Detect | | Pin 1 |
| AB | GND | Signal Ground | Pin 5 | Pin 5 |

*Table B-1 Communication Port Signals*

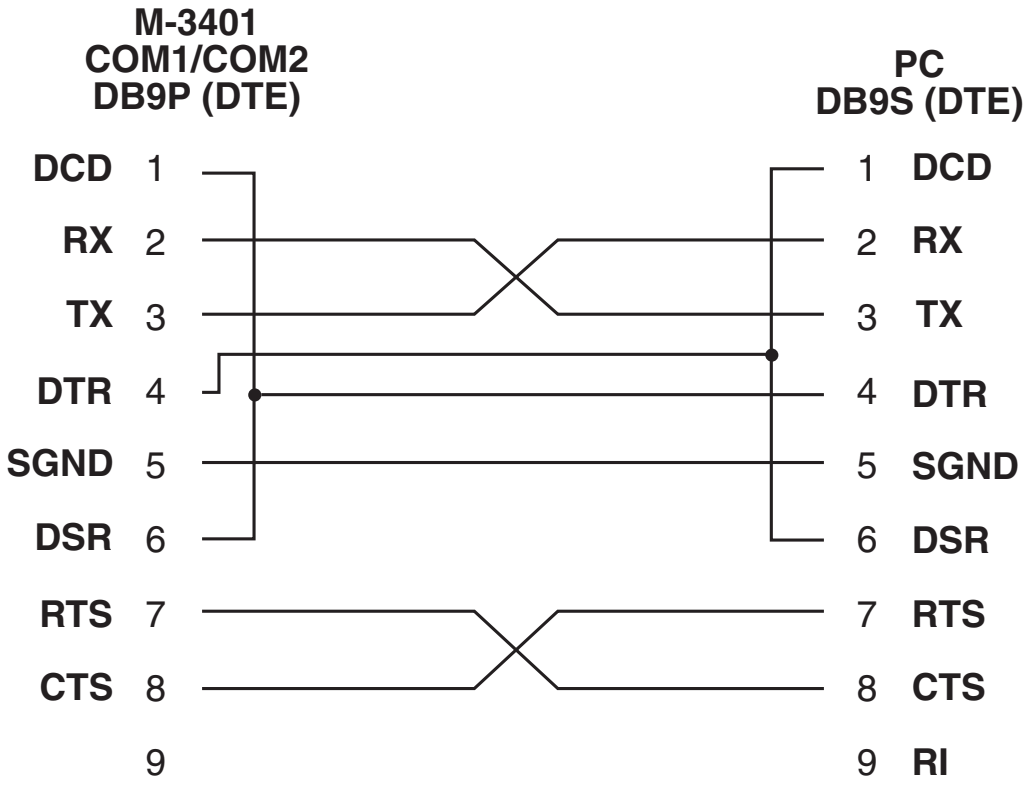
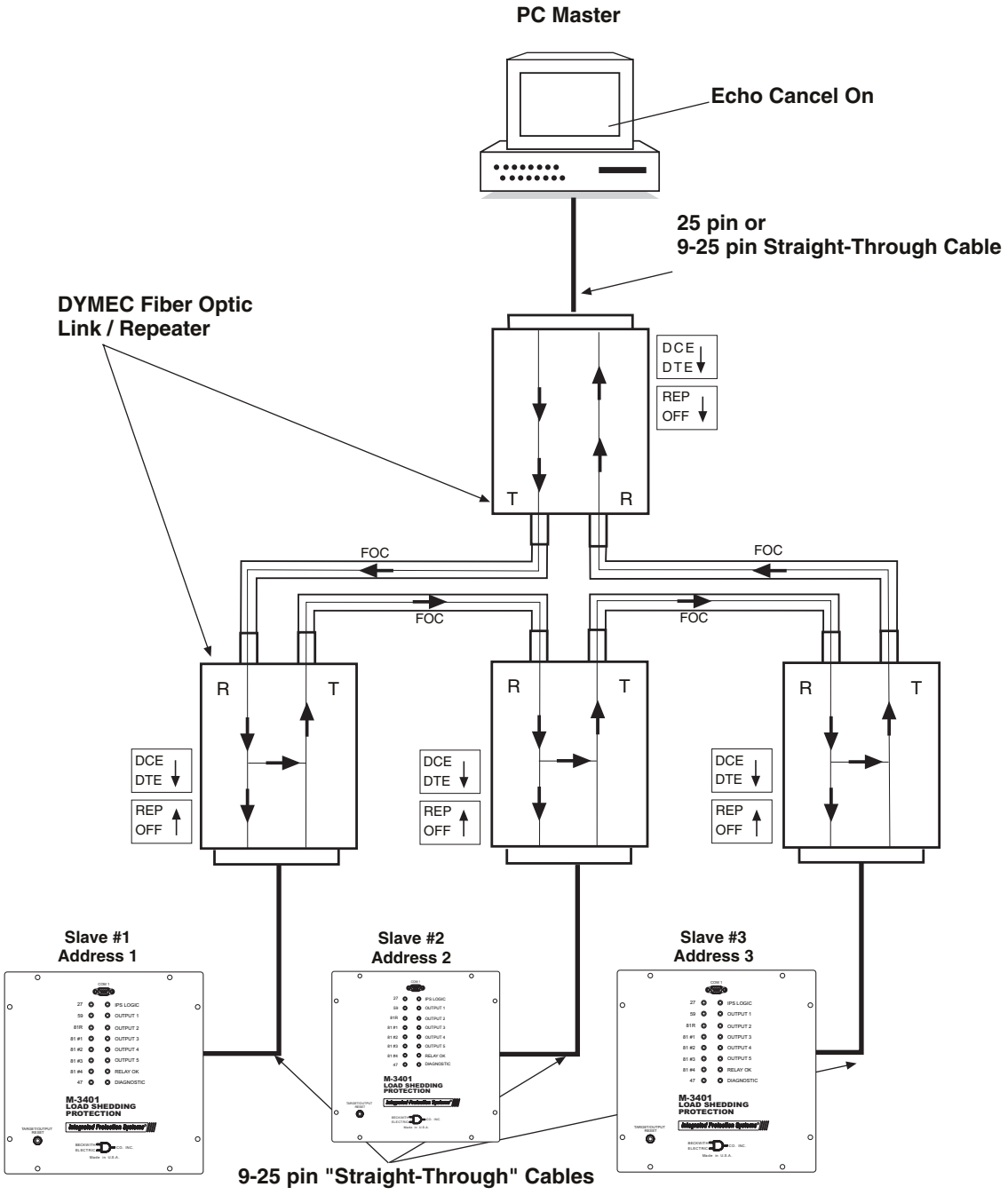


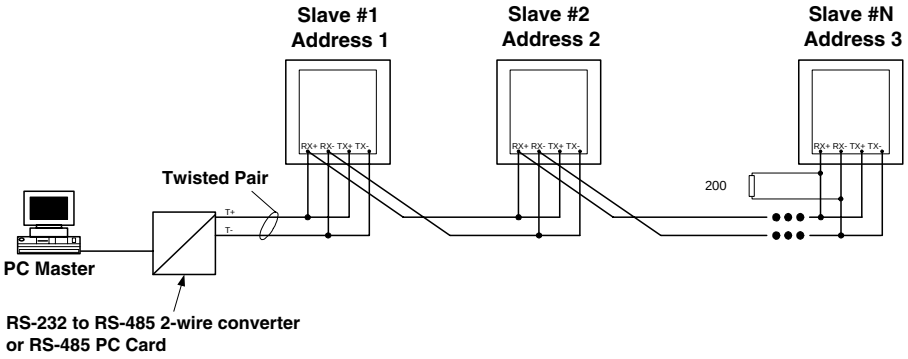

*Figure B-1 Null Modem Cable: M-0423*




■ **NOTE**: DYMEC Fiber Optic Link/Repeater DCE/DTE selector switches are set to DTE (meaning, connecting to a DTE device) utilizing a straight-through cable.

*Figure B-2 RS-232 Fiber Optic Network*

### RS-485 2-Wire Network



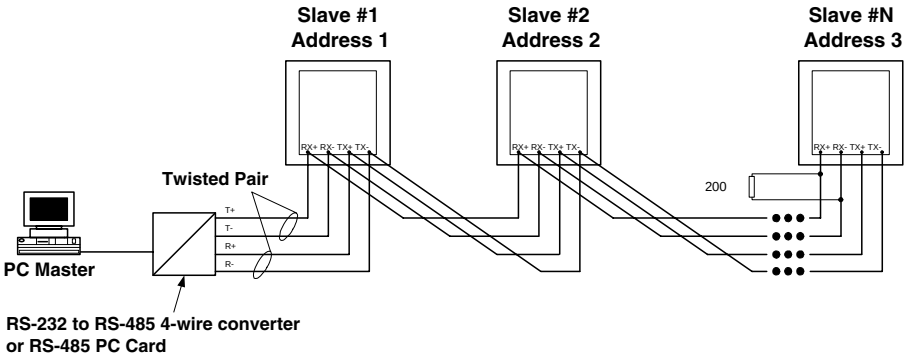

▲ **CAUTION:** Due to the possibility of ground potential difference between units, all units should be mounted in the same rack. If this is not possible, fiber optics with the appropriate converters should be used for isolation.

■ **NOTES**:

1. For 2-wire applications, terminal Tx+ must be jumped to terminal Rx+, and terminal Tx– to terminal Rx–.
2. 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 via a jumper internal to the unit. See Section 2.9, **Circuit Board Switches and Jumpers**.
3. Slave N may be up to 31 relays.
4. The "Echo Cancel" feature should be selected to "ON" in the Communication Dialog Screen (Figure 4-3).

*Figure B-3 RS-485 2-Wire Network*

### RS-485 4-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.

■ **NOTES**:

1. 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 via a jumper internal to the unit. See Section 2.9, **Circuit Board Switches and Jumpers**.
2. Slave N may be up to 31 relays.

*Figure B-4 RS-485 4-Wire Network*

# C Appendix C–Self-Test Error Codes

Whenever the relay is powered up it conducts a Power On Self Test to determine the operability of all functions. If during the Power On Self Test an error condition is detected, the relay will output the corresponding error code listed below.

| Error Code | Description |
|---|---|
| 16 | DSP external program RAM1 fail |
| 25 | EEPROM write verify error |
| 27 | Calibration checksum mismatch warning |
| 28 | Setpoint checksum mismatch warning |
| 29 | Low battery warning |
| 36 | Interrupt Error |
| 37 | Calibration Running Check Fail |
| 47 | DSP Internal RAM error |
| 48 | DSP external program RAM 2 error |
| 49 | COM1 UART Write Verify Error |
| 51 | COM2 UART Write Verify Error |
| 52 | DSP to Microprocessor com error |
| 53 | Analog Front-End Voltage Ref fail |

*Table C-1 Self-Test Error Codes*

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# D Appendix – Layup and Storage

Appendix D includes the recommended storage parameters, periodic surveillance activities and layup configuration for the M-3401 Intertie/Generator Protection Relay.

### Storage Requirements (Environment)

The recommended storage environment parameters for the M-3401 are:

- The ambient temperature where the M-3401 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-3401 power supply contains electrolytic capacitors. It is recommended that power be applied to the relay 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-3401 includes a removable lithium battery (Beckwith Electric component B1, Figure 2-25). The battery provides power to the M-3401 clock and also provides power to the unit's nonvolatile memory when power is not applied to the unit.

Layup of the M-3401 requires removing the battery which stops the system clock. The steps necessary to remove the battery are as follows:

▲ **CAUTION:** Personnel performing this procedure should be trained in Electrostatic Discharge prevention to prevent damage to ESD sensitive components. Check and comply with appropriate regulations regarding the disposal of lithium batteries.

⬢ **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 be moved with power applied.**

1. Remove the screws that retain the rear cover, lift the rear cover off the relay.
2. Remove the six screws that retain the CPU board to the I/O board.
3. Disconnect the CPU board from the I/O board by pulling the board away from the I/O board. Moderate force will be needed to accomplish this.
4. Remove the battery from the CPU board.
5. Reinstall the CPU board onto the I/O board by reversing the removal process.
6. Insert the six screws that retain the CPU board to the I/O board.
7. Reinstall the rear cover on the relay; insert the screws that retain the rear cover.

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# Legal Information

## Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringementof United States Letters Patent or rights accruing thereform or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

## Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of five years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to peform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

*Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantibility and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.*

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

## Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

In no event shall the Seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of purchased power, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstances shall the Seller be liable for any personal injury whatsoever.

It is agreed that when the equipment furnished hereunder are to be used or performed in connection with any nuclear installation, facility, or activity, Seller shall have no liability for any nuclear damage, personal injury, property damage, or nuclear contamination to any property located at or near the site of the nuclear facility. Buyer agrees to indemnify and hold harmless the Seller against any and all liability associated therewith whatsoever whether based on contract, tort, or otherwise. Nuclear installation or facility means any nuclear reactor and includes the site on which any of the foregoing is located, all operations conducted on such site, and all premises used for such operations.

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