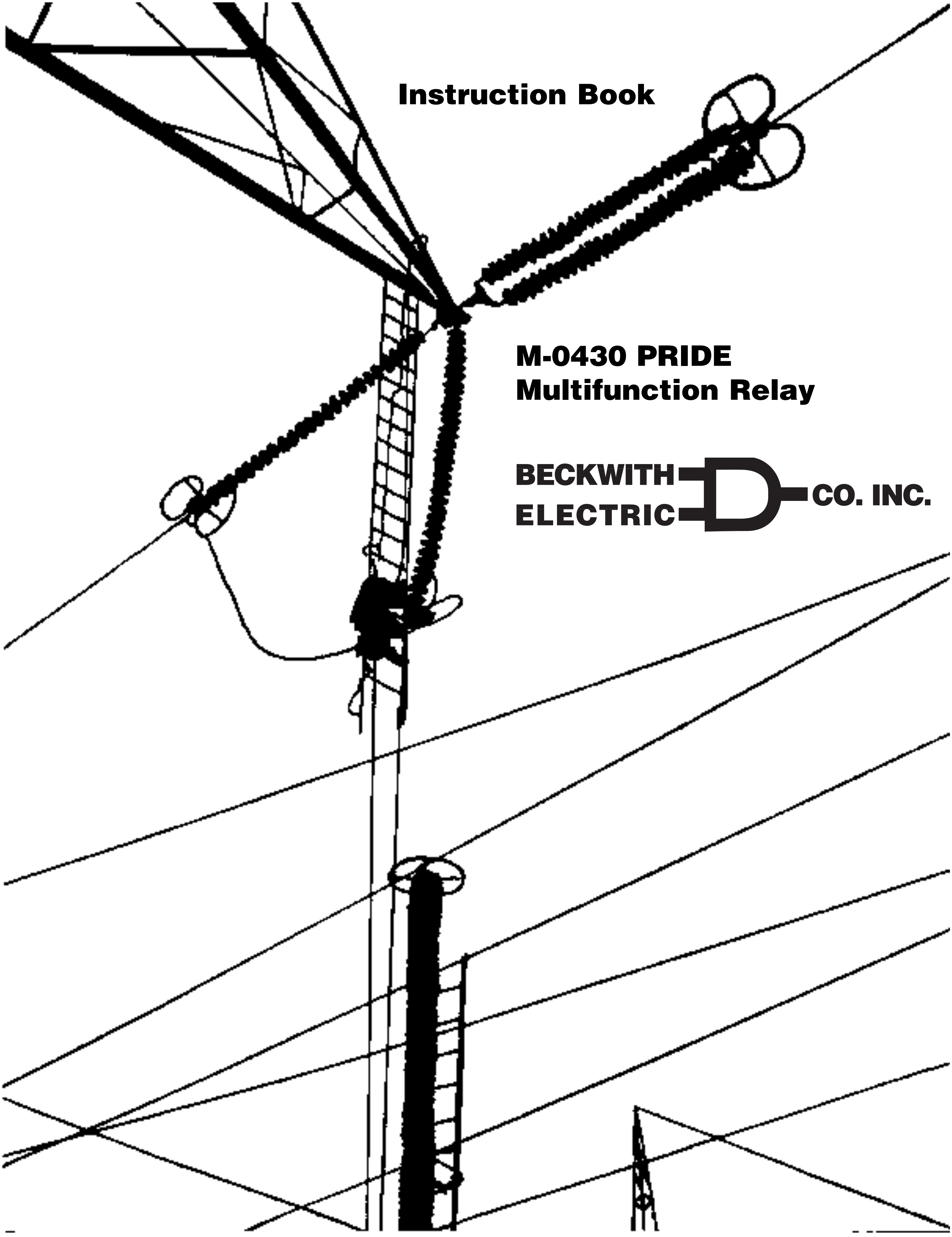


Instruction Book

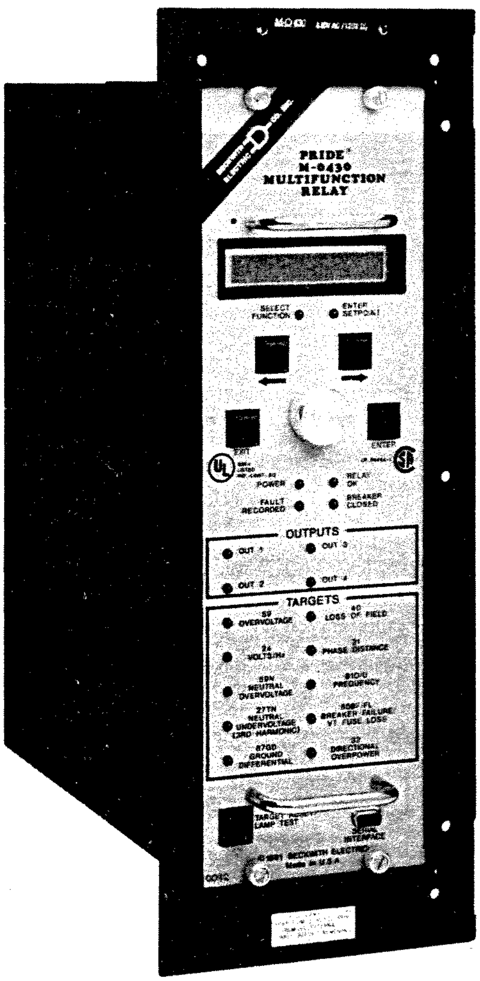
M-0430 PRIDE Multifunction Relay

BECKWITH ELECTRIC CO. INC.

PROTECTIVE RELAYS

BECKWITH ELECTRIC CO. INC.

PRIDE® Multifunction Relay M-0430



- Protects a generator from voltage, frequency, reverse power, loss of field, and overexcitation disturbances.
- 100% stator ground fault protection.
- Two-zone offset mho elements with directional element for Loss-of-Field protection.
- Single-zone phase distance mho element for phase fault backup.
- Uses waveform sampling and digital signal processing for measurement of system parameters.
- Provides easy-to-use human interface with 2-line by 24-character Liquid Crystal Display for local access to relay functions.
- Allows local and remote metering of phase, neutral, and sequence voltages and currents; real and reactive power; power factor; and frequency.
- Provides time-tagged trip target information for the five most recent trips.
- Includes two RS-232-C serial communication ports to connect SCADA interface and external PC.
- Includes capability for capturing fault data for display with an optional external PC program.
- Draw-out case construction.
- Programmable ouput contacts.
- UL listed.

RELAY FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Initial Setting†	Accuracy
40 3Φ	**Loss of Field (offset mho characteristic)**				
	Circle Diameter #1, #2	0.1 – 100 Ω	0.1 Ω	50.0 Ω	
	Offset #1, #2	–50 to +50 Ω	0.1 Ω	–10.0 Ω	
	Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
	Voltage Control (positive sequence)	5 – 200 V	1 V	108 V	
	Frequency Control	60.05 – 67 Hz (50.05 – 57 Hz)	0.05 Hz	66 Hz	
	Directional Element	Fixed at –13°		always enabled	
21 3Φ	**Phase Distance (mho characteristic)**				
	Circle Diameter	0.1 – 100 Ω	0.1 Ω	50.0 Ω	
	Offset	–100 to 100 Ω	0.1 Ω	0 Ω	
	Impedance Angle	0° to 90°	1°	85°	
	Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
24 3Φ	**Volts/Hz**				
	Definite Time				
	V/Hz #1, #2	100% – 200%	1%	110%	
	Time Delay #1, #2	30 – 8160 cycles	1 cycle	360 cycles	+20 cycles
	Inverse Time				
	Characterisitic Curves	Inverse Time #1 – #4	—	#1	
	Pickup	100% – 200%	1%	105%	
	Time Dial: Curve #1 Curves #2 – #4	1 – 100 0 – 9	1 0.1	9	
	Reset Time	1 – 999 sec. (from threshold of trip)	1 sec.	200 sec.	
	Nominal VT Secondary Volt.	100 – 140 V	1 V	120 V	
59 3Φ	**RMS Overvoltage, 3-Phase**				
	Magnitude #1, #2	5 – 200 V	1 V	132 V	±0.5 V
	Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	+20 cycles
59N	**RMS Overvoltage, Neutral Circuit or Zero Sequence**				
	Magnitude #1, #2	5 – 200 V	0.1 V	10 V	±0.1 V or ±0.5%
	Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
27TN	**Third-Harmonic Undervoltage, Neutral Circuit***				
	Magnitude #1, #2	0.3 – 20 V	0.1 V	1.2 V	±0.15 V
	Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
	(27) Undervoltage Inhibit (Positive Sequence)	5 – 200 V	1 V	100 V	±0.5 V

**The 27TN function is provided primarily for high-impedance-grounded generator applications.*

RELAY FUNCTIONS

Device Number	Function	Setpoint Ranges	Increment	Initial Setting†	Accuracy
87GD	**Ground (zero sequence) Differential***				
	Magnitude #1, #2**	0.2 to 10	0.1	0.5	
	Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
	CT Ratio Correction (R_C)	0.1 to 7.99	0.01	1.00	

** The 87GD function is provided primarily for low-impedance-grounded generator applications. It can be programmed as directional or nondirectional.*
***$-3I_0 \bullet I_n \bullet \cos\theta$ for directional or $[(3I_0R_C) - I_n]$ for nondirectional where I_0 is the zero sequence current, I_n the neutral current, θ is the angle between I_0 and I_n, and R_C = (Line CT ratio)/(Neutral CT ratio).*

Device Number	Function	Setpoint Ranges	Increment	Initial Setting†	Accuracy
81O	**Over Frequency**				
	Magnitude #1, #2	60.05 – 67.00 Hz (50.05 – 57.00 Hz)	0.05 Hz	60.50 Hz	±0.02 Hz‡
	Time Delay #1, #2	2 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
81U	**Under Frequency**				
	Magnitude #1, #2	53.00 – 59.95 Hz (43.00 – 49.95 Hz)	0.05 Hz	59.50 Hz	±0.02 Hz‡
	Time Delay #1, #2	2 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
32 3Φ	**Directional Power, 3-Phase**				
	Forward Power Flow Mag.*	0.02 – 3.00 pu	0.01 pu	3.00 pu	±0.01 pu
	Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
	Reverse Power Flow Mag.*	0.02 – 3.00 pu	0.01 pu	3.00 pu	±0.01 pu
	Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles

** 1 pu = 1800 W for Line-to-Neutral input, and 1039 W for Line-to-Line input.*

Device Number	Function	Setpoint Ranges	Increment	Initial Setting†	Accuracy
50BF 3Φ	**Breaker Failure***				
	Pickup Current				
	(50 BF-Ph) Phase Current	0.1 – 10 A	0.1 A	1.0 A	
	(50 BF-N) Neutral Current	0.1 – 10 A	0.1 A	1.0 A	
	Time Delay	1 – 8160 cycles	1 cycle	30 cycles	

** The breaker failure function can be initiated by the programmed outputs of the relay or via the external Breaker Failure Initiate (BFI) input. 50N is used for breaker flashover protection.*

Device Number	Function
60FL 3Φ	**V.T. Fuse Loss Detection**
	During V.T. fuse-loss conditions, as detected either by the internal algorithm or through the BLOCK2 (60FL) external input, the relay can be programmed to block any of the relay functions.

† **Initial Setting**: The value is in setpoint memory until reprogrammed by the operator; functions with two setpoints have only setpoint #1 enabled as shipped from the factory.

‡ The accuracy is based on 3Φ voltage inputs and in the range of 57 to 63 Hz; outside this range the accuracy is ±0.15 Hz.

NOTE: All times specified in cycles are equivalent to 16.67 ms for 60 Hz and 20 ms for 50 Hz.

CALCULATIONS

Current and Voltage RMS Values: Uses discrete Fourier transform on sampled (16 times per cycle) voltage and current signals to extract fundamental frequency phasors for relay calculations. RMS phase voltages for the 59 and 24 functions are obtained using the time domain approach to obtain accuracy over a wide frequency band.

V.T. Fuse Loss Detection: A VT fuse-loss condition is detected by using the positive and negative sequence components of the voltages and currents.

POWER INPUT OPTIONS

- Nominal 120 V ac, 50/60 Hz, or nominal 125 V dc. Operates properly from 90 V ac to 145 V ac and from 90 V dc to 160 V dc. Withstands 240 V ac for 1 second. Burden 24 VA.
- Nominal 24 V dc. Operates properly from 18 V dc to 36 V dc. Burden 24 VA.
- Nominal 48 V dc. Operates properly from 35 V dc to 60 V dc. Burden 24 VA.

SENSING INPUTS

Four Voltage Inputs: Nominal 69 V ac or 120 V ac, 50/60 Hz. Will withstand maximum continuous voltage of 180 V. Source voltages may be line-to-ground or line-to-line connected. Voltage transformer burden less than 0.2 VA.
Four Current Inputs: Nominal 5.0 A, 50/60 Hz. Will withstand maximum continuous current of 10 A. Current transformer burden less than 0.05 VA @ 5A.
Four Status Inputs: **BLOCK1 (52b)**, **BLOCK2 (60FL)**, **BLOCK3 (BFI)**, and Fault Recorder Trigger input **(FLT REC TRIG)**.

STATUS INPUT CONTACTS

The status inputs, **BLOCK1**, **BLOCK2**, and **BLOCK3** can be programmed to block any of the relay functions (except 50BF and FL). **BLOCK1** will also serve as 52b input. **BLOCK2** can also be used as 60FL input. If desired, **BLOCK3** can be used as an external Breaker Fail Input (**BFI**) to the breaker failure function. (If used this way, it cannot be used as a blocking input).

FAULT RECORDER TRIGGER INPUT

The Fault Recorder provides comprehensive fault-data recording for all monitored waveforms (at 16 samples per cycle) and status inputs (at 480 Hz). When armed, the Fault Recorder can be triggered either manually or via the Fault Recorder Trigger input (**FLT REC TRIG**). When Armed and Untriggered, the recorder continuously records waveform data, keeping the most recent 96 cycles of data in its memory. When triggered, the recorder continues recording for a user-defined period, and then goes to Unarmed mode, keeping the 96-cycle snapshot of waveform data in its memory for downloading via the M-0429 BECOCOM® software. Rearming the Fault Recorder restarts the process (overwriting the stored fault data.)

OUTPUT CONTACTS

Five programmable output contacts (**OUT1**, **OUT2**, **OUT3**, **OUT4**, **OUT5**), three of which are rated as per ANSI/IEEE C37.90-1989 for tripping: make 30 A for 0.2 sec, carry 8 A, break 6 A @ 120 V ac, break 0.1 A @ 125 V dc, inductive break 0.1 A. The remaining output contacts are rated as follows: make, carry and break 8 A @ 120/250 V ac, inductive break 1.5 A; make and carry 8, break 1 A @ 125 V dc, inductive break 0.1 A; make and carry 6 A, break 0.1 @ 250 V dc, inductive break 0.05 A. The inductive break is L/R = 0.4. One nonprogrammable diagnostic output contact (**SELF TEST ALARM**) is provided.

Any of the relay functions can individually be programmed to activate any one or more of the 5 available output contacts. The output contact **OUT5** is provided primarily for alarm purposes. It does not activate the targetting system, and hence, will not provide either LCD or LED display of the target.

LED INDICATORS

The **POWER LED** will remain on as long as power is applied to the unit and the power supply is operating properly. A **RELAY OK LED** (user-selectable as flashing or continuously lit) reveals proper cycling of the microcomputer. The LEDs marked **TARGETS** will remain off when conditions are within limits. Appropriate

LEDs will light when an over or under limit condition occurs. The output LEDs indicate the status of the output contacts.

COMMUNICATION PORTS

Two RS–232C communication ports, employing optical isolation for transient surge protection.

SOFTWARE FEATURES

Human Interface: The human interface provides easy-to-use, menu-driven access to all functions via the front-panel controls and the 2-line-by-24-character Liquid Crystal Display. Software functions include the following:

- Individual relay functions can be enabled or disabled.
- User-definable access codes allow three levels of security.
- Time-tagged trip target information for the five most recent trips.
- Metering of various parameters, including 3Φ voltage (RMS and peak), neutral voltage (RMS), 3Φ current (RMS), Neutral Current (RMS), Sequence Voltages (positive, negative, zero), Sequence Currents, Real and Reactive Power, Power Factor, and Frequency.

DIELECTRIC AND SURGE WITHSTAND CAPABILITY

Voltage and current inputs are electrically isolated from each other, from other circuits and from ground. Power input and output circuits withstand 3536 V dc (Hi-Pot) to chassis or instrument ground for one minute. (Communication circuits will withstand 2121 V dc for one minute). The relay meets the requirements of the ANSI/IEEE C37.90–1989 Standard for Protective Relays and Relay Systems.

■ **NOTE**: *Due to the use of transient suppression capacitors from many inputs to chassis, Hi-Pot testing must be conducted with a dc voltage.*

Input and output circuits are protected against system transients. The M-0430 will pass all requirements of ANSI/IEEE C37.90.1-1989, defining oscillatory and fast transient capability.

▲ **CAUTION**: Digital Data Circuits (RS-232 communication ports) are excluded from passing ANSI/IEEE C37.90.1-1989. The use of fiber optic communications lines will avoid any question of surge-withstand capability.

The relay performs properly when subjected to an RF field of 20 V/m at popular VHF and UHF communication frequencies.

ENVIRONMENTAL

Temperature: Stated accuracies are maintained from –20° C to +70° C.
Humidity: Stated accuracies are maintained at up to 90% relative humidity (non-condensing).
Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

PHYSICAL

Mounting: The unit is designed as a drawout case for semiflush panel mounting. A transparent cover is included.
Size: 20-13/16" high x 7-5/8" wide x 14-1/8" deep (52.8 x 19.4 x 35.9 cm).
Approximate Weight: 40 lb (18.2 kg).
Approximate Shipping Weight: 46 lb (20.9 kg).

PATENT & WARRANTY

The M-0430 Multifunction Relay has patents pending and is covered by a two-year warranty from date of shipment.

Typical Application of the M-0430 PRIDE® Multifunction Relay

■ **NOTES**:

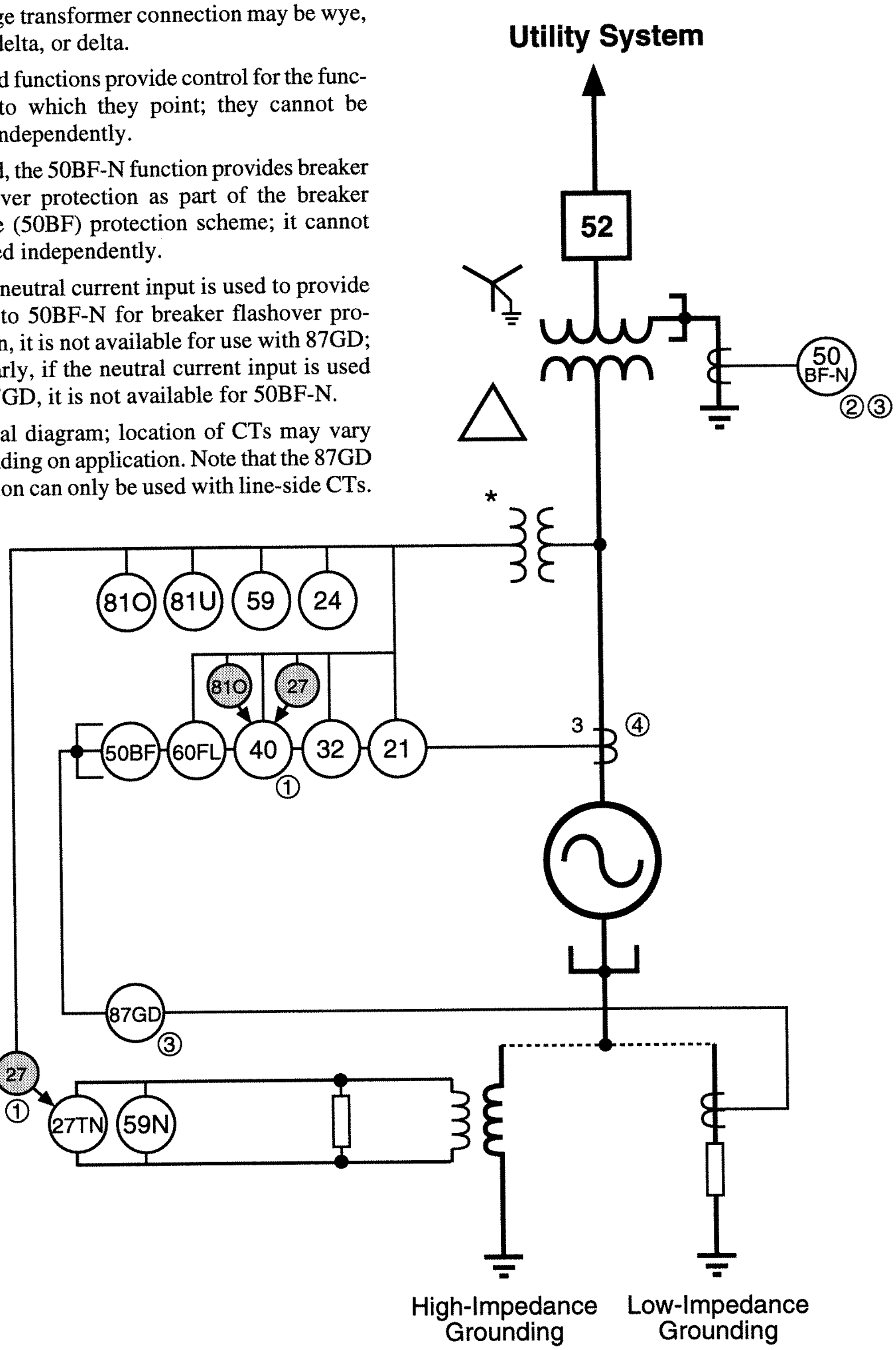
* Voltage transformer connection may be wye, open delta, or delta.

① Shaded functions provide control for the functions to which they point; they cannot be used independently.

② If used, the 50BF-N function provides breaker flashover protection as part of the breaker failure (50BF) protection scheme; it cannot be used independently.

③ If the neutral current input is used to provide input to 50BF-N for breaker flashover protection, it is not available for use with 87GD; similarly, if the neutral current input is used for 87GD, it is not available for 50BF-N.

√ Typical diagram; location of CTs may vary depending on application. Note that the 87GD function can only be used with line-side CTs.



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THERE SHALL BE NO WARRANTIES WHICH EXTEND BEYOND THOSE CONTAINED IN THE BECKWITH ELECTRIC CO., INC. TERMS OF SALE.

WARNING

DANGEROUS VOLTAGES, CAPABLE OF CAUSING DEATH OR SERIOUS INJURY, ARE PRESENT ON THE EXTERNAL TERMINALS AND INSIDE THIS 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.

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.

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 chassis must be attached to a separate ground since it is not grounded by external connections.

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 AND MAINTENANCE PROCEDURES

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

DO NOT MODIFY EQUIPMENT

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

▲ PRODUCT CAUTIONS

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

AVOID STATIC CHARGE

If this unit contains MOS circuitry, it 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.

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M-0430 MULTIFUNCTION PROTECTIVE RELAY INSTRUCTION BOOK

5 MENU REFERENCE

6 INSTALLATION

FOREWARD

Beckwith Electric's multifunction protective relays such as the M-0420 and M-0430 offer a number of advantages to electric utilities seeking to optimize their protective systems:

1. Self-diagnostics.	The relay is constantly checking its own operation. If not functioning correctly, it alerts the operator through an output contact. In contrast, single-function electromechanical relays must be tested periodically by station maintenance personnel.
2. Fault Recording.	The digital electronics in the relay continously record the waveform of the voltage and current inputs, along with the status contact inputs. When the fault recorder trigger input is closed, the waveform data is stored in memory for later review when investigating the cause of the trip.
3. Compact Size.	The M-0430 occupies a panel space less than 8 inches wide and 21 inches high, yet can operate 11 protective functions.
4. Operation.	All settings can be established or changed using the front panel controls and alphanumeric display.
5. Communication.	Through a computer connection, all functions can be monitored and setpoints changed by a PC-compatible computer, or by a laptop PC plugged into the front panel.
6. Functions.	The functions respond in the same manner as do electromechanical relays, including time delays, and the nomenclature is the same.

The M-0430 Instruction Book provides details of the installation and operation of the M-0430. Our team of applications engineers stands ready to assist you in applying this equipment to your electric system. Please don't hesitate to call us at (813) 544-2326

Lew Roberson
Vice President, Marketing

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1
INTRODUCTION

BEFORE YOU BEGIN

The Beckwith Electric M-0430 Multifunction Relay is a sophisticated relay applicable to a wide variety of applications. While it has been carefully designed to be easy to install and configure, if you're a first-time user, we suggest that you acquaint yourself with its operation in the following manner:

- Read this **Introduction** for a general overview of the M-0430 and a description of its capabilities.
- Read Chapter 2, **Application**, for information on using the M-0430 to protect generators.
- Refer to Chapters 3, **Front Panel Controls**, and 4, **Operation**, to familiarize yourself with the layout and operation of the M-0430 front-panel controls.
- Refer to Chapter 5, **Menu Reference,** for detailed information on the functions you will be using in your application.
- Read Chapter 6, **Installation**, for mounting dimensions, external connections, initial setup, and verification routines.
- Refer to Appendix D, **Configuration Record Forms** for forms on which to record your relay configuration and DIP switch settings.
- Refer to publication M-0429A BECOCOM™ /M-0428A BECOPLOT™ User's Guide for information on configuring and interrogating the M-0430 via a personal computer running the optional M-0429A BECOCOM Communications Software package, and for information on plotting downloaded fault data via the optional M-0428A BECOPLOT Fault Data Analysis Software package.

The M-0430 Instruction Book has been organized to address the needs of different parts of your organization. If you are responsible for verifying that the M-0430 conforms to specifications as received, please turn to Chapter 6, **Installation**, for initial setup, and to Chapter 7, **Test Procedures**.

If you are responsible for the operation of the M-0430 in a specific application, please turn to Chapter 2, **Application,** for information on enabling specific functions and entering setpoints. If you are responsible for the mechanical and electrical installation of the M-0430, please refer to Chapter 6, **Installation.**

Please don't hesitate to call your local sales representative or Beckwith's application engineers (813-544-2326) for assistance in resolving any problems.

CONFIGURATION AS SHIPPED

You can become familiar with the basic operation of the M-0430 before it is installed by connecting it to the appropriate power input and setting it up on a bench or desktop. Even without any test voltages connected, you will be able to step through the various menus and note the indications on the liquid crystal display (LCD) and the various light-emitting diodes (LEDs). The formal initial setup information is presented in Chapter 6, **Installation**, which includes Figure 6-5 showing the external connections.

As shipped, the M-0430 is in the following configuration:

- the clock has been disabled
- the second setpoints on various functions have been disabled, and do not appear on the display
- the DIP switch (at bottom of inside case) has been set as follows, as detailed on the blue or green tag attached to the equipment. The blue tag is for 60 Hz; the green tag is for 50 Hz.

1	OFF (not for user selection)
2	ON (normal operation, rather than calibration)
3	ON (normal operation, rather than diagnostic mode)
4	OFF (reverse power initiation—operation set to total three-phase power)
5	ON (VT inputs set for line-to-line)
6	OFF (VT secondary voltage is 120 V ac)
7	OFF (system frequency is 60 Hz—blue tag)
	ON (system frequency is 50 Hz—green tag)
8	OFF (not used)

- the access code feature is disabled
- an option supplied with the equipment is noted on the blue (60 Hz) or green (50 Hz) tag. The option available is:

  input voltage (120 V ac/125 V dc, 48 V dc, 24 V dc)

- a set of replacement fuses is attached to one of the handles. These fuses are mounted on the internal PC board.

DESCRIPTION

The M-0430 Multifunction Relay is a microprocessor-based unit that uses digital signal processing technology to provide 11 different protective relaying functions (see Table 1-1) for generator protection in one compact unit. The M-0430 protects a generator from abnormal voltage, frequency, reverse power, loss-of-field, and overexcitation (V/Hz) disturbances, while also providing loss-of-VT-fuse detection, and breaker failure/flashover protection. Input and output contacts are programmable. The M-0430 also provides capability for local and remote metering of various quantities, including phase, neutral, and sequence voltages and currents; real and reactive power; power factor, and frequency. Additionally, the relay provides time-tagged trip information for the five most recent trips, and records 96 cycles of fault-data information for downloading and subsequent plotting with the M-0428A BECOPLOT Fault Data Analysis Software package. The M-0430 also includes self-test and self-calibration capability. The nomenclature follows the standards of ANSI/IEEE Std. C37.2-1991, Standard Electric Power Systems Device Function Numbers.

FUNCTION	DESCRIPTION	M-0430
21	Phase Distance (Mho characteristic)	✓
24	Volts/Hz (inverse time and definite time)	✓
27TN	Third-Harmonic Undervoltage, Neutral Circuit	✓
32	Directional Power, 3-Phase	✓
40	Loss of Field (two-element offset mho)	✓
50BF	Breaker Failure	✓
50N	Instantaneous Overcurrent, Neutral	*
59	RMS Overvoltage, 3-phase	✓
59N	RMS Overvoltage, Neutral Circuit or Zero Sequence	✓
60FL	VT Fuse Loss	✓
81O	Over Frequency	✓
81U	Under Frequency	✓
87GD	Ground (zero sequence) Differential	✓

** The 50N function on the M-0430 is dedicated to breaker flashover protection.*

TABLE 1-1 M-0430 Device Function Numbers

Since all functions are incorporated into one package, much less panel space and panel wiring is required than for individual relays, as illustrated in Figure 1-1. You can set and examine all functions via a menu-driven 2-line by 24-character LCD display or via remote communication access. Once you reprogram a value, the new value is placed in non-volatile memory where it is unaffected by a loss of power or other system disturbance.

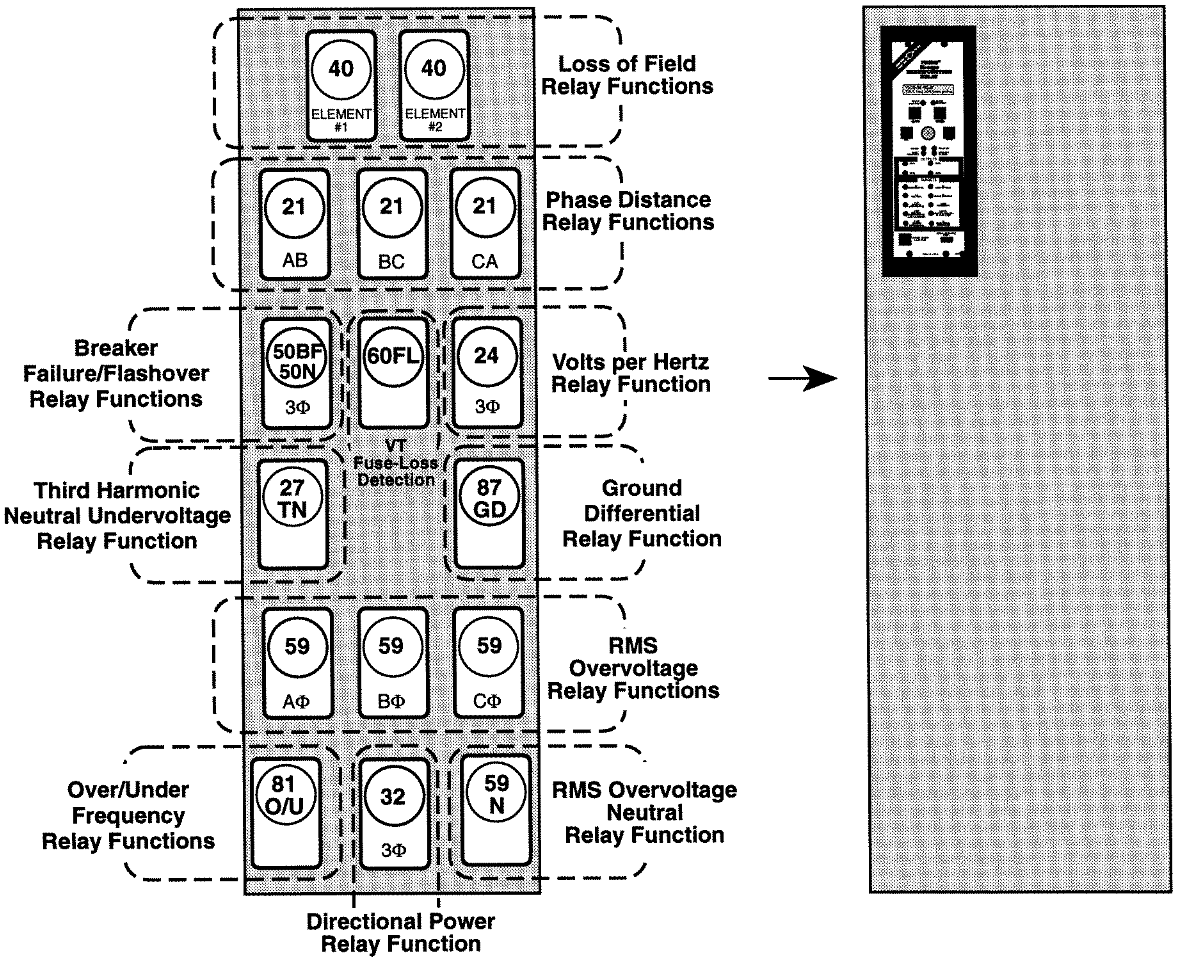

FIGURE 1-1 Traditional Relaying vs. the M-0430 Multifunction Relay

The M-0430 includes multiple output and status input contacts. It can be powered by 24, 48, or 125 V dc/120 V ac, 50/60 Hz power, and is rated according to ANSI/IEEE C37.90 and C37.90.1. The relay includes self-test diagnostics, internal calibration correction, communication capability via two RS-232C ports, real-time display of system parameters, trip targets, and capture of fault data that occur during a system disturbance.

DESIGN CONSIDERATIONS

There are basically two approaches in the design of digital relays. In the first approach, the microprocessor simply replaces the relay logic and does not process the voltage and current signals. The performance of these relays depends on the accuracy of the analog components used, and is subject to dc offsets and gain drift with temperature, supply voltage changes, or aging. In the second approach, the microprocessor both processes the signals and performs the logic, providing a simpler design and offering performance advantages. The advent of low-cost digital signal processors (DSPs), microprocessors designed especially for the efficient numerical procedures required, paved the way for the design of a digital relay using state-of-the-art digital signal processing techniques, thereby eliminating the problems inherent with analog hardware.

The Beckwith Electric M-0430 Multifunction Relay follows this second approach: analog signal-processing hardware is replaced with a DSP. Various parameters of the input signals are estimated using digital signal-processing algorithms. The voltage and current input signals of the relay are modeled as sinusoidal signals corrupted by dc offset and harmonic components. These signals can be characterized by various parameters such as rms value, peak value, rms value/phase angle, and frequency of the fundamental component.

However, while DSPs are highly effective for signal-processing applications, they are not very efficient for general purpose applications and have limited memory space. Therefore, the M-0430 uses a dual-processor architecture. The DSP executes all the signal-processing algorithms, while a general-purpose (host) processor manages input/output and other overhead functions, monitors the keyboard for operator requests, updates memories for setpoint values, facilitates operator interaction via the alphanumeric display, establishes two-way communication using the RS-232C serial ports, analyzes the data from the DSP, and issues the trip commands.

Figures 1-3 and 1-4 present a general overview of the hardware design and functional operation of the M-0430. As shown in these diagrams, the inputs to the M-0430, filtered to remove higher order harmonics, are multiplexed and then passed through an Analog-to-Digital Converter (ADC) to the DSP, which performs a discrete Fourier transform (DFT) 16 times per cycle for each of the inputs. The host processor performs all input/output and overhead functions, including monitoring of the status inputs, and ultimately analyzes the data from the DSP to determine the need for a trip command.

One significant design feature of the M-0430 is automatic correction of the sensing transformer error caused by ambient temperature excursions. Voltage transformers exhibit enough internal resistance so that the internal regulation of the transformer results in a significant error due to changes in temperature. The M-0430 includes a temperature sensor mounted in the enclosure to measure directly and accurately the internal temperature of the relay. This temperature signal is coupled through the ADC to the DSP, which processes the information to determine the appropriate factor required to correct the sensing transformer error.

The M-0430 uses an algorithm based on the DFT to compute the frequency and to determine the phase angle for real/reactive power measurements. The algorithm uses voltage phasor estimates obtained from the DFT to compute reliable estimates of frequency unaffected by dc and harmonic components in the signal. Additionally, deriving the positive sequence voltage phasor from the DFT means that the frequency function will continue to operate should any single- or two-phase fault occur.

The magnitude of voltage and frequency for overvoltage and volts-per-hertz functions are calculated using a time-domain technique instead of a DFT due to the wide dynamic frequency range required for these functions.

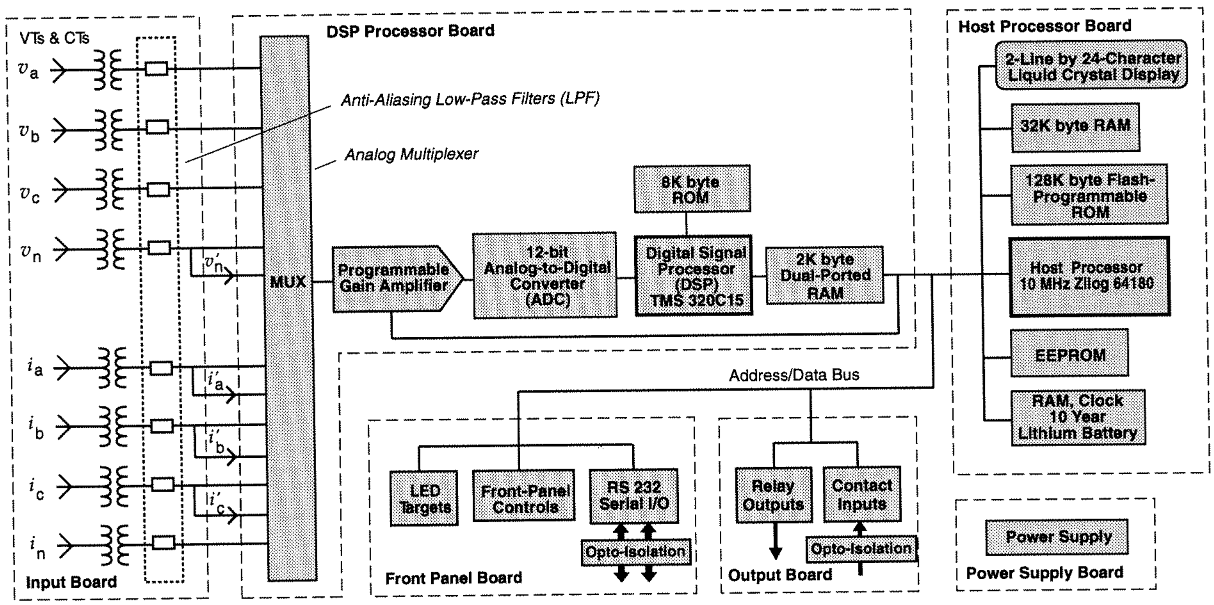

FIGURE 1-3 M-0430 Block Diagram

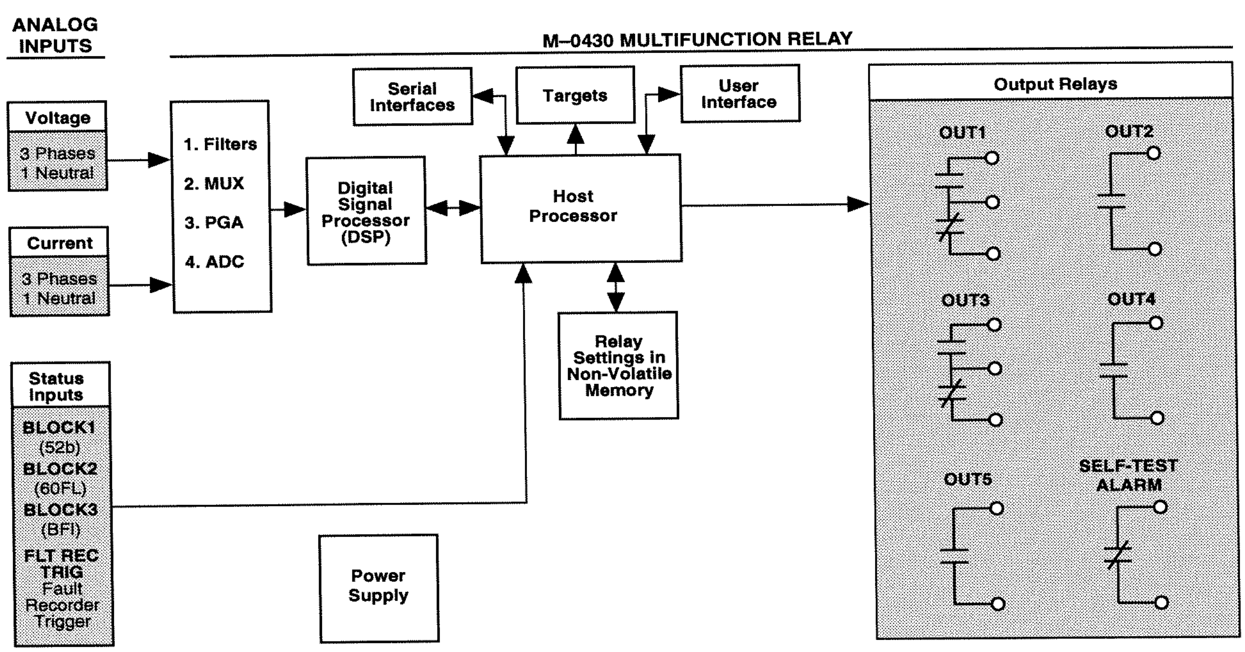

FIGURE 1-4 M-0430 Functional Diagram

HARDWARE OVERVIEW

The M-0430 is based on a dual-microprocessor design, using a digital signal processing chip for analysis of the input waveforms, and a general purpose host microprocessor to control the outputs, the user interface and communications. A number of hardware and software self-tests are provided in order to ensure that the relay will not misoperate.

As shown in the accompanying block diagram, the voltage and current input signals are scaled and isolated using voltage and current transformers (VTs and CTs). The isolated analog signals are low-pass filtered using anti-aliasing filters (two-pole passive) to minimize the effects of harmonics and noise in the frequency range above one half of the sampling frequency. The filtered analog signals are then multiplexed using an analog multiplexer (MUX). A sampling frequency of 16 times the power system frequency (960 Hz for the 60 Hz system) is used in the relay. Such a high sampling frequency provides several advantages, including more accurate detection of peak voltage during ferroresonance conditions, more accurate RMS measurement when the signals contain harmonics, simpler and less expensive anti-aliasing filters, the ability of the fault recorder to capture high-frequency harmonic signals during faults and ferroresonance conditions, and an overall improvement in relay performance.

From the multiplexer, the relay current signals are scaled using a programmable gain amplifier (PGA) to optimize the gain scaling of the phase and neutral current signals. The scaled signals are sampled and converted to digital data using an analog-to-digital converter (ADC) with a built-in sample-and-hold circuit. (Additional sample-and-holds on each analog channel are not used, the sampling skew being corrected in software.) The digital signal processor reads the converted digital data and executes a variety of signal processing algorithms to estimate the relay parameters. The estimated relay parameters are then transferred to the dual-ported RAM which provides a fast communications link between the host and DSP processors.

The host processor is responsible for the tripping logic, the user interface, and other I/O functions. The contact circuit provides the host processor with the status of the input contacts. The relay output circuit provides tripping and alarm functions. LEDs are used for the targets which provide visual indication of the relay status. The user interface is provided by the front-panel pushbuttons, knob, and LCD display. Two serial I/O ports provide the user with remote communication capability. The relay software programs for the host and digital signal processors are stored in read-only memory (ROM), while the random-access memory (RAM) is used for temporary storage of data. Relay settings and calibration coefficients are stored in electrically erasable programmable read-only memory (EEPROM). A switching mode power supply provides the relay with the various power supply voltages required for operation.

USER CONSIDERATIONS

In the design of the M-0430, careful consideration was given to making its use as similar as possible to that of the traditional protective relays that are still found throughout typical power systems.

EASE OF USE AND COMPATIBILITY

In order to provide maximum compatibility with existing equipment, care was taken that traditional electromechanical nomenclature was used for setpoint values and trip characteristics. For example, the loss-of-field and phase distance functions are implemented using the well-known mho characteristics.

The user-friendly controls and display provide easy access to the various functions. The software is completely menu driven through an alphanumeric liquid crystal display (LCD). All functions and values can easily be set using the front-panel pushbuttons and the rotary knob.

COMMUNICATION CAPABILITIES

One of the important features of the M-0430 is its capability for remote communications. The relay provides two RS-232C serial ports for communication via modem or direct serial connection. In a typical communications application, the rear-panel communication port is permanently connected to a modem, while the front-panel port is kept free for on-site programming via a laptop PC.

FAULT RECORDING AND ANALYSIS

The multifunction relay provides up to 96 cycles of fault waveform data with selectable post-trigger delay. This data can be downloaded via an IBM PC-compatible computer running the M-0429A BECOCOM™ Communications Software. Once downloaded, the data can be analyzed using the associated M-0428A BECOPLOT™ Fault Data Analysis Software package.

The fault data analysis software runs on an IBM PC-compatible computer, enabling the user to plot fault data, specifying which waveforms and inputs are displayed, and at what scale. (The sample plot shown in Figure 1-5 displays all waveforms.) A marking feature enables the user to mark any time span and zoom instantly to display it at full screen, and specific points on the waveform may be tagged in order to read actual waveform values. Displayed plots can be printed using the DOS Print Screen command.

SELF-DIAGNOSTICS

To ensure confidence in the relay's operation, the system software provides many hardware and software diagnostic checks, some of which are performed continuously, and others on processor reset. Should a failure occur, the self-test alarm output contact closes, and processing stops in order to prevent misoperation. Likewise, if system power fails, the self-test alarm output contact closes.

INTERNAL CALIBRATION CORRECTION

One of the most important and novel advantages of the M-0430 is its capability for correcting its calibration through internal software. Most existing static and microprocessor controlled relays are designed with a number of trim pots to trim the signal offsets, gain and phase angle inaccuracies. This can be a time-consuming process, during both factory calibration and routine calibration by the customer. The M-0430 does away entirely with trim pots for calibration. The gain and phase angle errors are corrected using precomputed calibration coefficients stored in nonvolatile memory. When the calibration mode is selected, the relay display prompts the operator to connect the voltage inputs to 120 V and the current inputs to 5 A with zero phase angle between the signals. Then, the relay computes the gain and phase angle errors and stores the appropriate correction coefficients for use by the relay software.

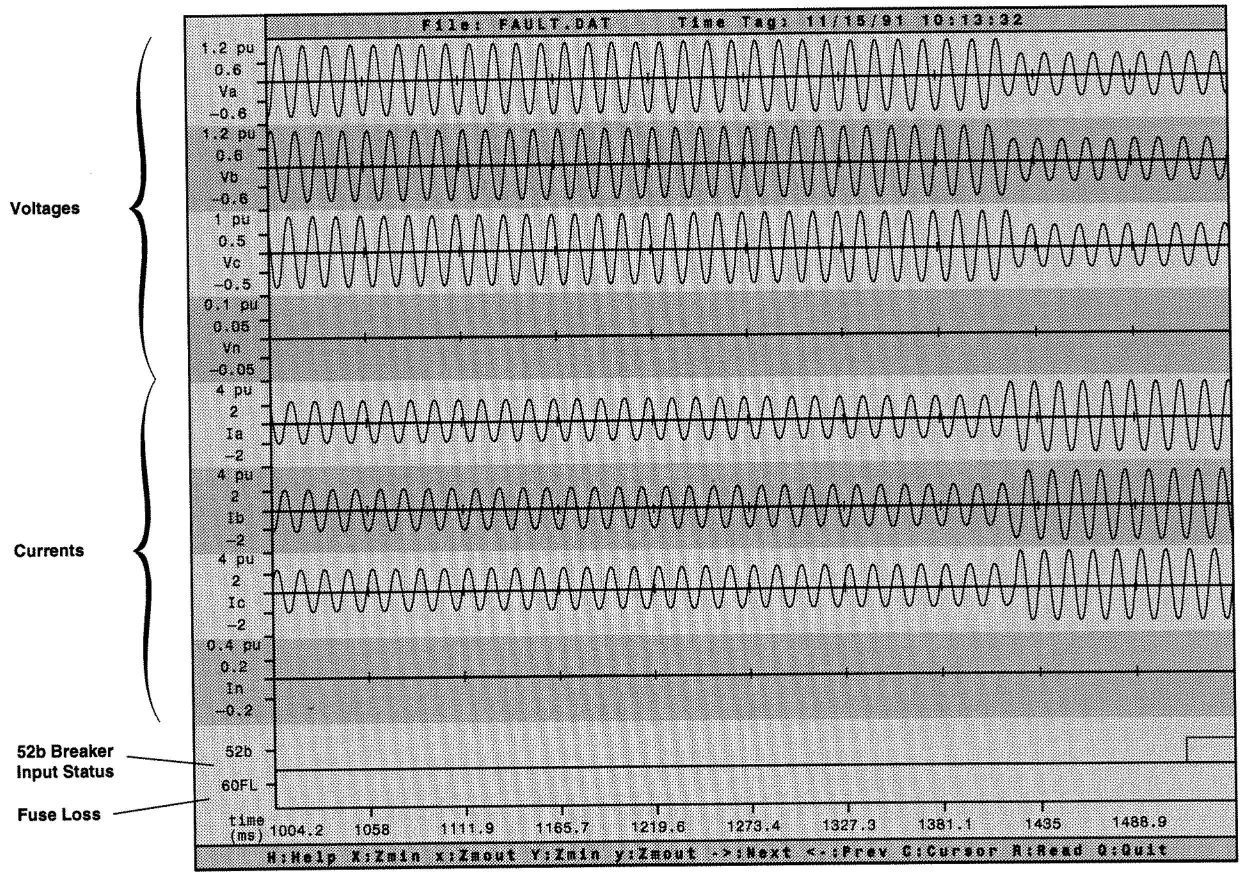

FIGURE 1-5 M-0428A BECOPLOT™ Fault Data Analysis Software Sample Printout

ACCESSORIES

M-0319 DROPPING REGULATOR

The M-0319 dropping regulator is a resistor/zener-diode regulating device used to produce 125 V dc from a 250 V dc battery source. The M-0319 can be used to allow an M-0430 with the 120 V ac/125 V dc power supply option to operate from a 250 V dc source.

M-0421 PRIDE® TEST ADAPTER

The M-0421 test adapter makes bench testing the M-0430 an easy process. The adapter provides a complete set of rear terminals for testing the unit after it has been removed from its draw-out case.

M-0429A BECOCOM® COMMUNICATIONS SOFTWARE PACKAGE

The BECOCOM communications software runs on an IBM PC-compatible computer, providing remote access to the M-0430 via either direct serial connection or modem. BECOCOM provides the following communication functions:

- Setpoint interrogation and modification
- Line status real-time monitoring
- Downloading recorded fault data

BECOCOM also provides remote access to the Beckwith Electric M-0420 Multifunction Relay.

M-0428A BECOPLOT® FAULT DATA ANALYSIS SOFTWARE PACKAGE

The M-0428A BECOPLOT Fault Data Analysis Software runs on any IBM PC-compatible computer, enabling you to plot and print fault data downloaded (using the BECOCOM communications software package) from the M-0420 and M-0430 relays. Figure 1-5 illustrates typical data output.

M-0422/M-0423 SERIAL COMMUNICATIONS CABLES

The M-0422 cable is a 10-foot straight-through RS-232 cable for use between the M-0430 rear-panel (COM2) port and a modem. This cable has DB25 (25-pin) connectors at each end.

The M-0423 cable is a 5-foot null-modem RS-232 cable for direct connection between a PC and the M-0430 front-panel (COM1) port. This cable has DB9 (9-pin) connectors at each end.

REFERENCES

The references that follow provide additional information about generator protection and the use of digital technology in protective relaying. References 5, 7 and 8 are available upon request from Beckwith Electric Co., Inc.

[1] ANSI/IEEE C37.102-1987 "IEEE Guide for AC Generator Protection."

[2] *Protective Relaying, Principles and Applications*, J. Lewis Blackburn, Marcel Dekker, Inc., 1987.

[3] *Electric Utility Systems and Practices*, 4th Edition, Homer M. Rustebakke, John Wiley & Sons, 1983.

[4] M.S. Sachdev (Coordinator), *Microprocessor Relays and Protection Systems*. IEEE Tutorial Text, 88EH0269-1-PWR.

[5] Murty V. V. S. Yalla, "A Tutorial Course on Digital Relaying Concepts and Data Communication Basics," Electric Council of New England (PRC), Needham, Massachusetts, October 1992.

[6] A.G. Phadke, J.S. Thorp, and M.G. Adamiak, "A New Measurement Technique for Tracking Voltage Phasors, Local System Frequency, and Rate-of-Change of Frequency." IEEE Transactions on PAS, vol. PAS-102, No. 5, May 1983, pp. 1025-1038.

[7] Robert D. Pettigrew, "Generator Protection Using Multifunction Digital Relays," Electric Council of New England (PRC), Needham, Massachusetts, October 1992.

[8] Murty V. V. S. Yalla, Donald L. Hornak, "A Digital Multifunction Relay for Intertie and Generator Protection," Canadian Electrical Association 1992 Spring Meeting, Vancouver, B.C., March 1992.

[9] C.F. Henville, "Relay Replacement and Upgrading Projects," Canadian Electrical Association 1991 Spring Meeting, Toronto, Ontario, May, 1991.

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2
APPLICATION

This chapter provides general information for common generator protection applications. A brief discussion of the principal applications of the M-0430—both alone, and in conjunction with the M-0420—is also provided. The **Functions** section discusses the individual functions in detail, presenting setpoint ranges, increments, and the initial default settings.

OVERVIEW

The M-0430 is applicable to almost all generator protection applications—including steam, hydro, gas turbine, and diesel generators—and is cost-effective for both new installations or the retrofitting of older ones. The functions supplied provide a wide range of protection, and have been selected to complement both those supplied in the M-0420 and the discrete relays that might commonly be found in the field.

The loss-of-field function (40) provides protection for the generator from almost no load to full load using a two-element offset mho characteristic with directional element; the diameter, offset, and time delay for each mho element can be set individually.

The wide selection of industry standard curves (four families of inverse curves) supplied in the M-0430 volts-per-hertz function (24) match most existing static overexcitation relays available, providing comprehensive protection.

The M-0430 can also provide 100% stator ground-fault protection for high-impedance-grounded machines with its combination of fundamental neutral overvoltage (59N) and third harmonic neutral undervoltage (27TN) functions. Stator ground-fault protection for low-impedance-grounded machines can be obtained using the generator ground differential function (87GD). Finally, the phase distance function (21) provides backup protection for system faults and redundancy for the 51V function in the M-0420 (if used), or protection against dead machine energization.

The breaker-failure function (50BF) provides both breaker-failure and breaker-flashover protection (via 50N).

SETPOINTS

The M-0430 provides programmable setpoints for each function. Many functions provide two setpoints, each with a magnitude setting and associated time delay. Figure 2–1 illustrates a sample setting for both the over and under frequency functions (81O and 81U).

Some functions provide additional setpoints. The volts-per-hertz function (24) provides both two definite time setpoints and four families of inverse curves from which to choose. Settings for these curve families are chosen using the same nomenclature as used on presently available relays.

As shown in Figures 2–2 and 2–3, the phase distance (21) and loss-of-field (40) functions provide offset mho characteristic circles. For each of these functions, the diameter and offset of the characteristic circles must be specified, as well as the associated time delay. For the phase distance function, the impedance angle must also be specified. For the loss-of-field function, voltage control and frequency control levels can also be specified.

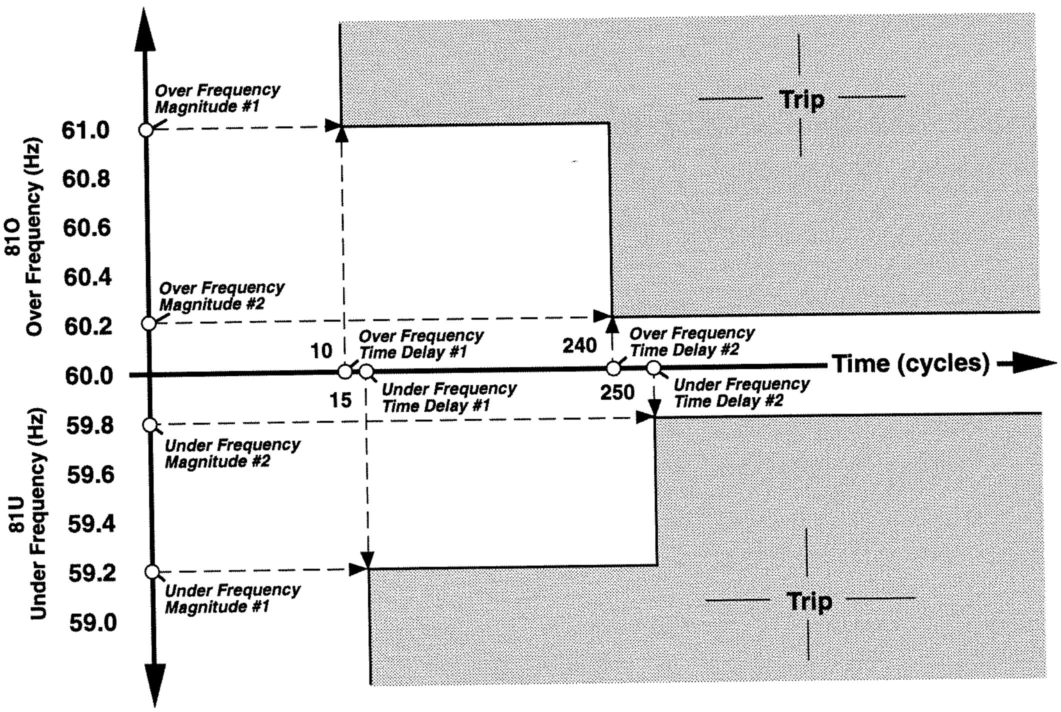


FIGURE 2–1 Example of Over and Under Frequency Setpoints

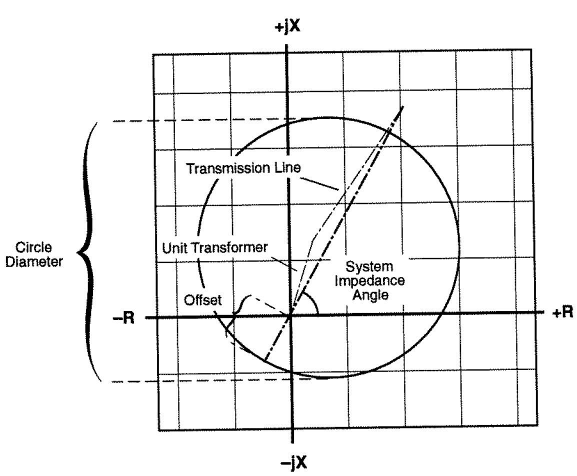


FIGURE 2–2
Phase Distance (21) Characteristic

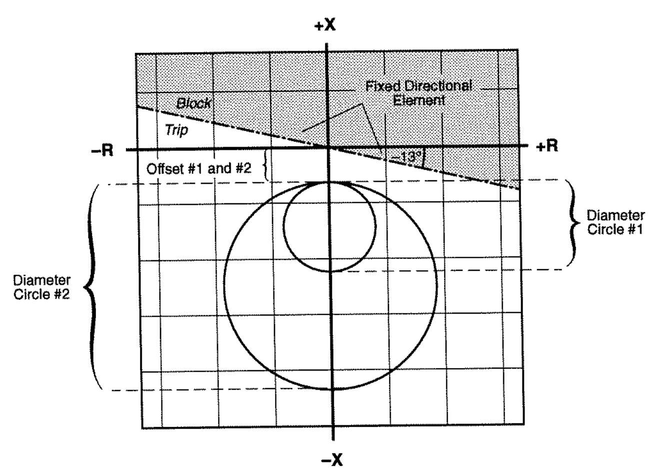


FIGURE 2–3
Loss-of-Field (40) Characteristic

PROGRAMMABLE INPUTS/OUTPUTS

The M-0430 provides user-programmable inputs and outputs. Any relay function can be programmed to activate any combination of the output relays (OUT1, OUT2, OUT3, OUT4, OUT5). Similarly, any function can be programmed to be blocked by any combination of the inputs (BLOCK1, BLOCK2, BLOCK3). Additionally, BLOCK3 can be selected to act as a breaker failure initiate input (BFI); if this is done, it cannot be used for blocking.

Table 2–1 illustrates the relay functions, inputs and outputs in tabular form. This table can be used to specify all possible combinations of input and output logic assignment. Table 2–2 illustrates the logic assignment for a sample application.

Relay Function		OUT1 ①	OUT2	OUT3	OUT4	OUT5	BLOCK1 ② (52b)	BLOCK2 ③ (60FL)	BLOCK3/ ④ BFI
59	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
59N	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
81O	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
81U	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
32	F	O	O	O	O	O	O	O	O
	R	O	O	O	O	O	O	O	O
40	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
21		O	O	O	O	O	O	O	O
24	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
	INV	O	O	O	O	O	O	O	O
27TN	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
87GD	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
60FL		O	O	O	O	O			
50BF		O	O	O	O	O			
Breaker Failure Initiate		O	O	O	O	O			**Configure BLOCK3/BFI**: O*

■ NOTES:

① **OUT1**, **OUT2**, and **OUT3** are rated for tripping per ANSI/IEEE C37.90-1989. **OUT4** and **OUT5** are provided primarily for alarm purposes; they are not rated for tripping.

② **BLOCK1** is usually used for the 52b status input; it illuminates the **BREAKER CLOSED** front-panel LED.

③ **BLOCK2** is usually used for external fuse-loss input; this input is logically OR'd with the internal fuse loss logic (when enabled).

√ **BLOCK3/BFI** can be assigned either to block some combination of functions 59 through 87GD in a manner identical to **BLOCK1** and **BLOCK2**, *or* as **Breaker Failure Initiate** input. To signify this on the chart above, if the circle marked * (**Configure BLOCK3/BFI**) is left undarkened, **BLOCK3/BFI** is assigned as **BLOCK3** and the functions it will block are darkened in the **BLOCK3/BFI** *column* above. If the circle marked * is darkened, **BLOCK3/BFI** is assigned as **Breaker Failure Initiate** input. *In this case, no circle in the* **BLOCK3/BFI** *column above may be darkened.* For either case, however, *outputs* that are to initiate the breaker failure timer are darkened in the **Breaker Failure Initiate** row to the left.

TABLE 2–1 Programmable Input/Output Logic Assignment Table

Relay Function		OUT1	OUT2	OUT3	OUT4	OUT5	BLOCK1 (52b)	BLOCK2 (60FL)	BLOCK3/ BFI
59	#1	●	○	○	○	●	○	○	○
	#2	○	○	○	○	●	○	○	○
59N	#1	○	●	○	○	●	○	○	○
	#2	○	●	○	○	●	○	○	○
81O	#1	●	○	○	○	●	●	○	○
	#2	●	○	○	○	●	●	○	○
81U	#1	●	○	○	○	●	●	○	○
	#2	●	○	○	○	●	●	○	○
32	F	●	○	○	○	●	○	○	○
	R	●	○	○	○	●	○	○	○
40	#1	○	●	○	○	●	●	●	○
	#2	○	●	○	○	●	●	●	○
21		○	●	○	○	●	○	●	○
24	#1	●	○	○	○	●	○	○	○
	#2	○	○	○	○	●	○	○	○
	INV	●	○	○	○	●	○	○	○
27TN	#1	○	●	○	○	●	●	○	○
	#2	○	●	○	○	●	●	○	○
87GD	#1	○	●	○	○	●	●	○	○
	#2	○	●	○	○	●	●	○	○
60FL		○	○	●	○	●			
50BF		○	○	○	●	●			Configure BLOCK3/BFI
Breaker Failure Initiate		●	●	○	○	○			●

OUTPUTS

- **OUT1** and **OUT5** are initiated by functions 59 #1, 81O #1 and #2, 81U #1 and #2, 32R, 32F, and 24 #1 and Inverse.
- **OUT2** and **OUT5** are initiated by functions 59N #1 and #2, 40 #1 and #2, 21, 27TN #1 and #2, and 87GD #1 and #2.
- **OUT3** and **OUT5** are initiated by function 60FL.
- **OUT4** and **OUT5** are initiated by function 50BF.
- **OUT5** is initiated by the above functions plus functions 59 #2 and 24 #2.

INPUTS

- **BLOCK1** (**52b**) blocks 81O #1,#2; 81U #1,#2; 40 #1,#2; 27TN #1,#2; and 87GD #1,#2.
- **BLOCK2** (**60FL**) blocks 40 #1,#2; and 21.
- In this example, **BLOCK3/BFI** is selected as external **Breaker Failure Initiate** (**BFI**); it does not block any functions. The breaker failure timer will be initiated whenever **OUT1**, **OUT2**, or external **BFI** (**BLOCK3**) is activated.

TABLE 2–2 Input/Output Logic Assignment—Example Application

SYSTEM DIAGRAMS

Sample system one-line and three-line diagrams are provided on this and the following pages.

■ **NOTES**:

* Voltage transformer connection may be wye, open delta, or delta.

① Shaded functions provide control for the functions they point to; they cannot be used independently.

② If used, the 50BF-N function provides generator breaker-flashover protection as part of the generator breaker-failure (50BF) protection scheme; it cannot be used independently.

③ Typical diagram; location of CTs may vary depending on application. Note that the 87GD and 50BF function can only be used with line-side CTs.

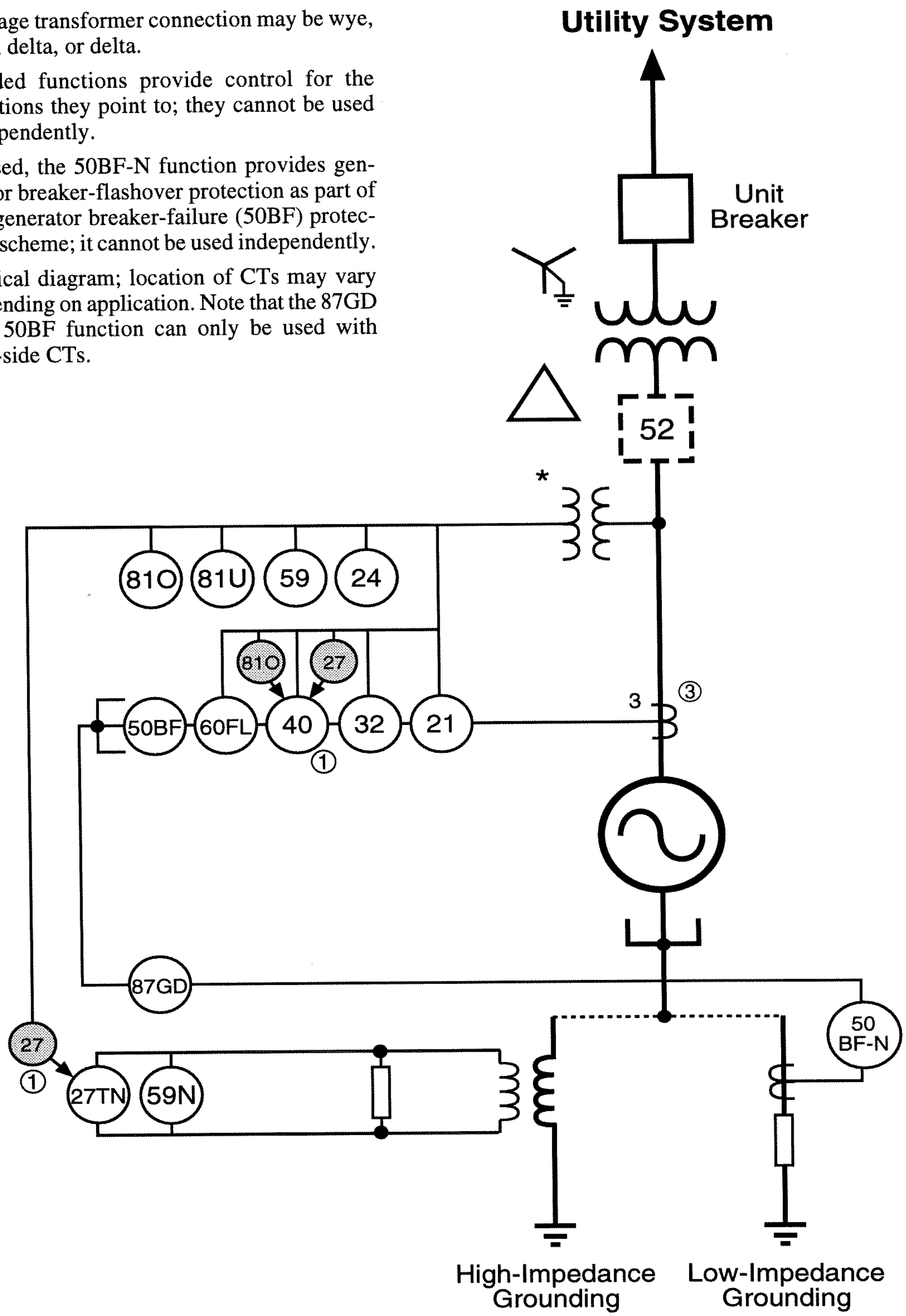
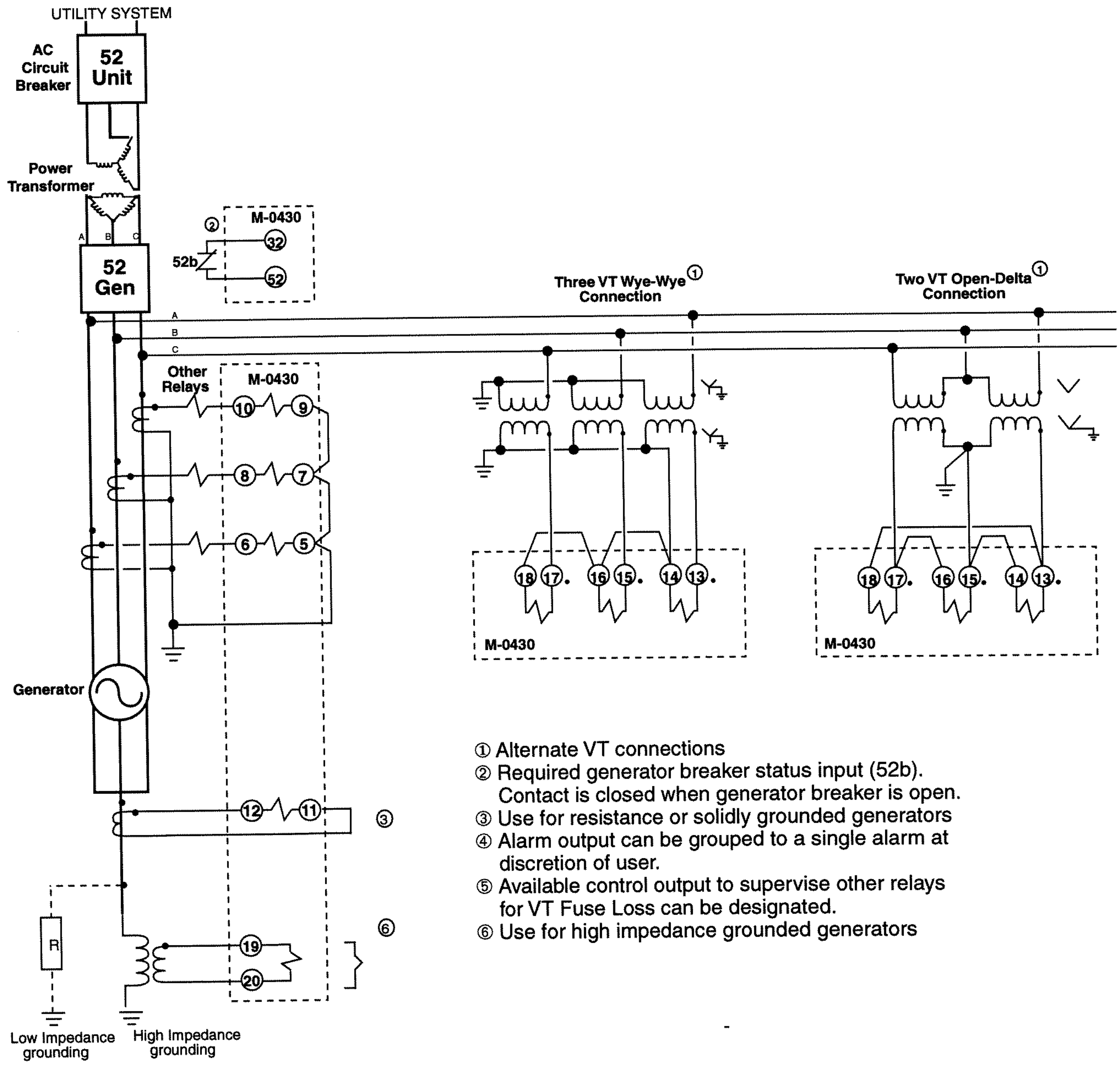


FIGURE 2–4 Typical M-0430 Application—Simplified One-Line Diagram



① Alternate VT connections
② Required generator breaker status input (52b). Contact is closed when generator breaker is open.
③ Use for resistance or solidly grounded generators
④ Alarm output can be grouped to a single alarm at discretion of user.
⑤ Available control output to supervise other relays for VT Fuse Loss can be designated.
⑥ Use for high impedance grounded generators

Example of Control / Output Connections

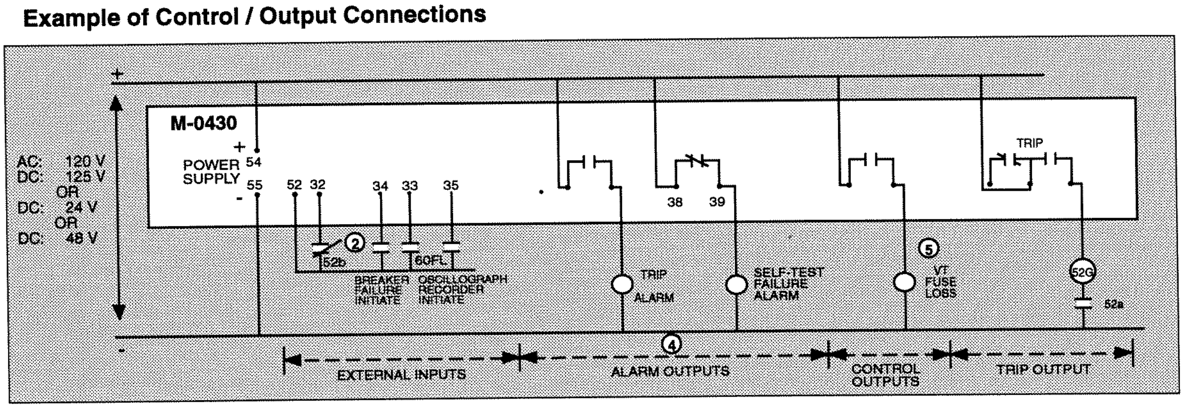


FIGURE 2–5 M-0430 Generator Protection—Typical Three-Line Diagram

■ **NOTES:**

* Voltage transformer connection may be wye, open delta, or delta.

① Shaded functions provide control for the functions they point to; they cannot be used independently.

② Since only one neutral current input is provided in the M-0420, the 50N/51N functions can be used in one of the locations shown, but not all simultaneously. 50N/51N can be used in high- or low-impedance grounding applications or to detect ground-fault currents on the grounded wye side of the power transformer.

③ If used, the 50BF-N function on the M-0430 provides breaker-flashover protection as part of the breaker-failure (50BF) protection scheme; it cannot be used independently.

√ 51V may be either 51VC or 51VR, with or without directional (67) control.

⑤ The 67 (phase directional overcurrent) function is optional.

≈ Typical diagram; location of CTs may vary depending on application. Note that the 87GD and 50BF function can only be used with line-side CTs.

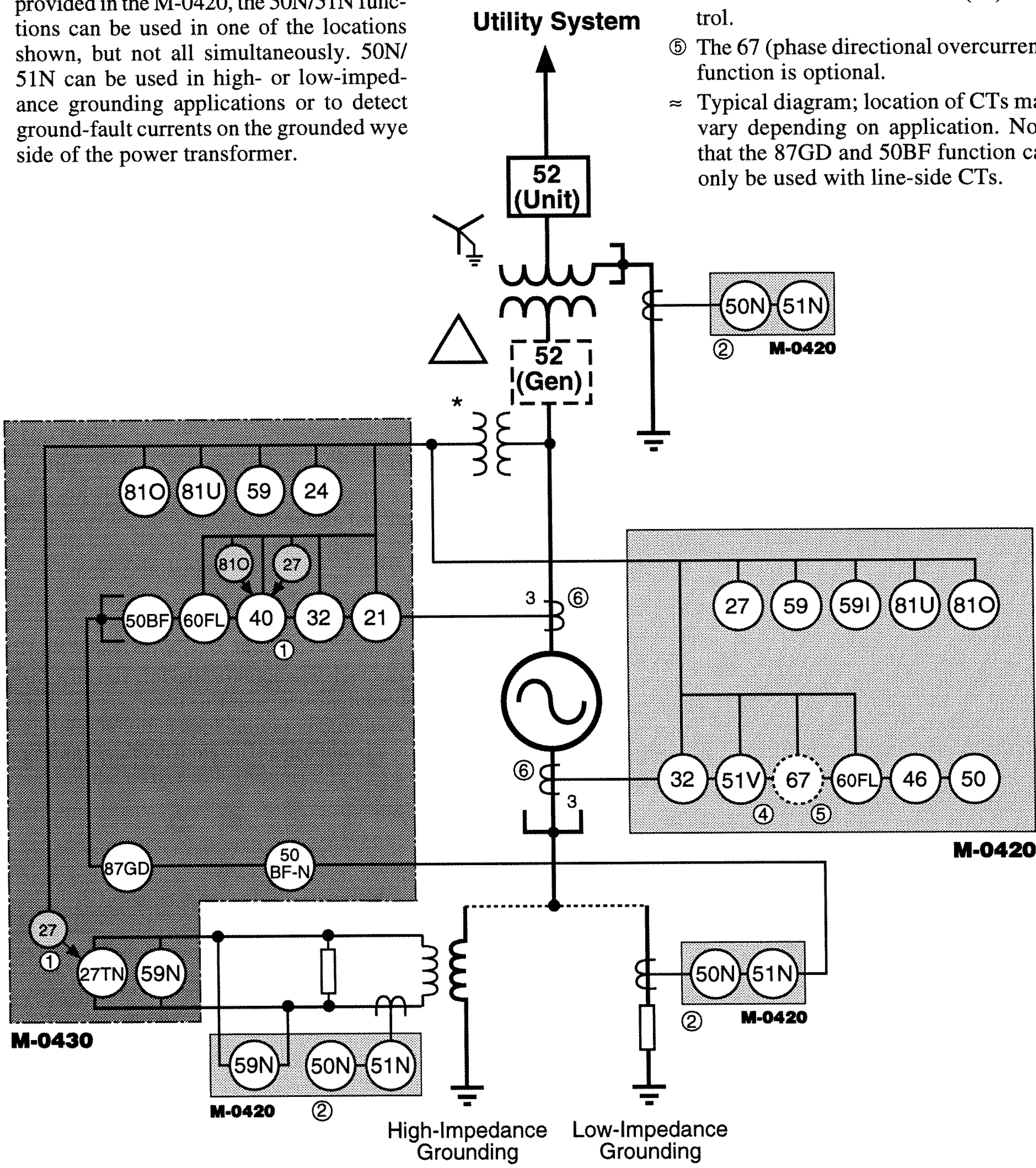


FIGURE 2–6 Combined M-0420/M-0430 Generator Protection Application— Simplified One-Line Diagram

FUNCTIONS

The M-0430 protective functions are discussed individually on the following pages.

21 PHASE DISTANCE

The phase-distance function can be used to provide backup protection for system faults or can be dedicated to protect against inadvertent energization. As a backup for system faults, it can coordinate with existing distance-type line relays.

Theory of Operation

System Fault Backup—A single-zone phase-distance relay with mho characteristic can provide backup protection for phase-to-phase and three-phase faults in the generator, unit transformer, and connected system. As shown in Figure 2–7, when neutral-side CTs are used, the protection includes the generator, and will be available when the generator is both on- and off-line. When line-side CTs are used, the protected area depends on the directional setting: as shown in Figure 2–8, the relay can be set either to look towards the generator or towards the system. When set to look towards the system (as shown in Figure 2–9), proper setting of the offset will allow it to provide some coverage for generator faults.

Inadvertent Energization—If a dead machine is accidentally energized (on turning gear), the machine will act as an induction motor, and significant thermal damage can be caused very quickly. As shown in Figure 2–10, protection against inadvertent energization can be provided by a phase-distance relay set to look into the generator. Because the time delay must be very short in order to adequately protect the generator, this device cannot simultaneously provide system backup protection. The relay may not provide protection if the VTs are disconnected when the machine is taken out of service.

M-0430 Implementation

In the M-0430, the phase-distance function is implemented as a single-zone mho characteristic. Three separate distance elements are implemented to detect AB, BC, and CA fault types. As shown in Table 2–3, the diameter, offset, system impedance angle (relay characteristic angle), and definite time delay can all be selected by the user to suit the specific application.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Phase Distance, mho characteristic (21)				
Circle Diameter	0.1 – 100 Ω	0.1 Ω	50.0 Ω	
Offset	–100 to 100 Ω	0.1 Ω	0 Ω	
Impedance Angle	0° to 90°	1°	85°	
Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles

TABLE 2–3 Phase Distance (21) Setpoint Ranges

The phase-distance functions use the voltage and current phasors obtained using the discrete Fourier transform. The relay calculates the apparent impedances as given below.

$$Z_{AB} = \frac{V_A - V_B}{I_A - I_B},\ Z_{BC} = \frac{V_B - V_C}{I_B - I_C},\ Z_{CA} = \frac{V_C - V_A}{I_C - I_A}$$

The above computed impedances are compared on the R-X diagram with the relay settings and a trip signal is issued if the impedance is inside the operating characteristic for more than the set time delay.

When the generator is connected to the system through a delta/wye transformer, proper voltages and currents (equivalent to the high side of the transformer) must be used in order for the relay to see correct impedances for system faults. By enabling the delta/wye-transform feature, the relay can internally calculate the high-side voltages of the delta-wye unit transformer, saving auxiliary instrument transformers. The voltage and current pairs selected are as shown in Table 2–4. The minimum current sensitivity depends on the relay reach setting as shown in Table 2–5.

Suggested Settings—System Fault Backup

	Direct-Connected		Delta/Wye Transformer Connected	
	VT Connection		VT Connection	
	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground
AB Fault	$\frac{V_{AB}}{I_A - I_B}$	$\frac{V_A - V_B}{I_A - I_B}$	$\frac{V_{AB} - V_{CA}}{I_A}$	$\frac{V_A - V_0}{I_A}$
BC Fault	$\frac{V_{BC}}{I_B - I_C}$	$\frac{V_B - V_C}{I_B - I_C}$	$\frac{V_{BC} - V_{AB}}{I_B}$	$\frac{V_B - V_0}{I_B}$
CA Fault	$\frac{V_{CA}}{I_C - I_A}$	$\frac{V_C - V_A}{I_C - I_A}$	$\frac{V_{CA} - V_{BC}}{I_C}$	$\frac{V_C - V_0}{I_C}$
120 V Z_{sec} =	$Z_{PRI}\left[\frac{R_C}{R_V}\right]$	$Z_{PRI}\left[\frac{R_C}{R_V}\right]$	$Z_{PRI}\left[\frac{R_C}{R_V}\right]3$	$Z_{PRI}\left[\frac{R_C}{R_V}\right]$

TABLE 2–4 Impedance Scaling

All primary impedances (Z_{PRI}) must be reflected to relay quantities (Z_{SEC}). The primary ohms (Z_{PRI}) on the generator base needs to be multiplied by the ratio of the current transformer ratio (R_C) to the voltage transformer ratio (R_V).

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

If line-line V.T.'s are used and the delta / wye transform is enabled, the relay impedance (Z_{SEC}) calculated above must be multiplied by three before inputing to the relay (See Table 2.4) If 69.3 volt V.T.'s are used, the Table 2.4 values are $\sqrt{3}$ times the 120 V (Z_{SEC}) row values.

When applied as backup protection for system faults, the 21 function should be set as shown in Figure 2–9. With neutral-end CTs, the offset can be set to zero and the mho element reach adjusted to provide the zone of coverage required. With line-side CTs, a negative offset adjustment will provide some coverage for the generator and generator zone faults. Protection against generator faults during off-line operation cannot be completely provided with CTs on the line side.

Suggested Settings—Inadvertent Energization

When applied as protection against inadvertent energization, the 21 function should be set as shown in Figure 2–10. The reach of the mho element should be set to detect the negative sequence reactance of the generator. If the machine is taken out of service and the VTs are disconnected, the relay may not provide protection. If the offset is such that the origin is included in the mho characteristic, the impedance unit may operate if the current is above the minimum operate current required, which depends on the mho element reach settings as given in Table 2–5.

Reach Setting	Minimum Current*	Maximum Impedance
<12.5 Ω	0.94 A	40.95 Ω
12.5 Ω to 24.9 Ω	0.47 A	81.91 Ω
25 Ω to 49.9 Ω	0.24 A	163.83 Ω
50 Ω to 100 Ω	0.12 A	327.67 Ω

** Current represents delta current (I_A–I_B, I_B–I_C or I_C–I_A) in case of direct connections and line current (I_A, I_B, or I_C) in case of delta/wye transformer connection. When the current is less than the minimum current, the calculated impedance defaults to its maximum values as shown in the table above.*

TABLE 2–5 Minimum Current Sensitivity as a Function of Relay Reach Setting

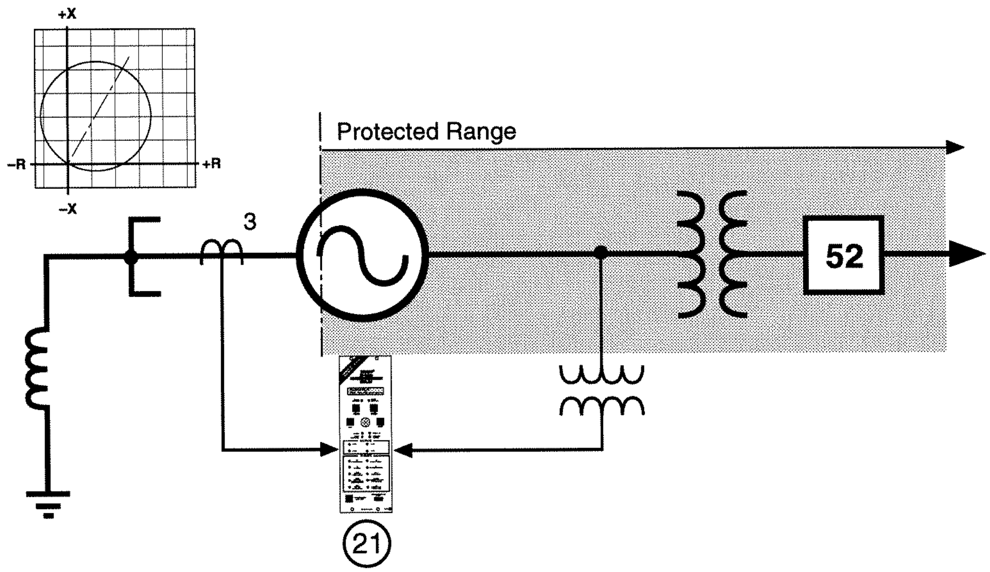


FIGURE 2–7 Phase Distance (21) Coverage—Neutral-Side CTs

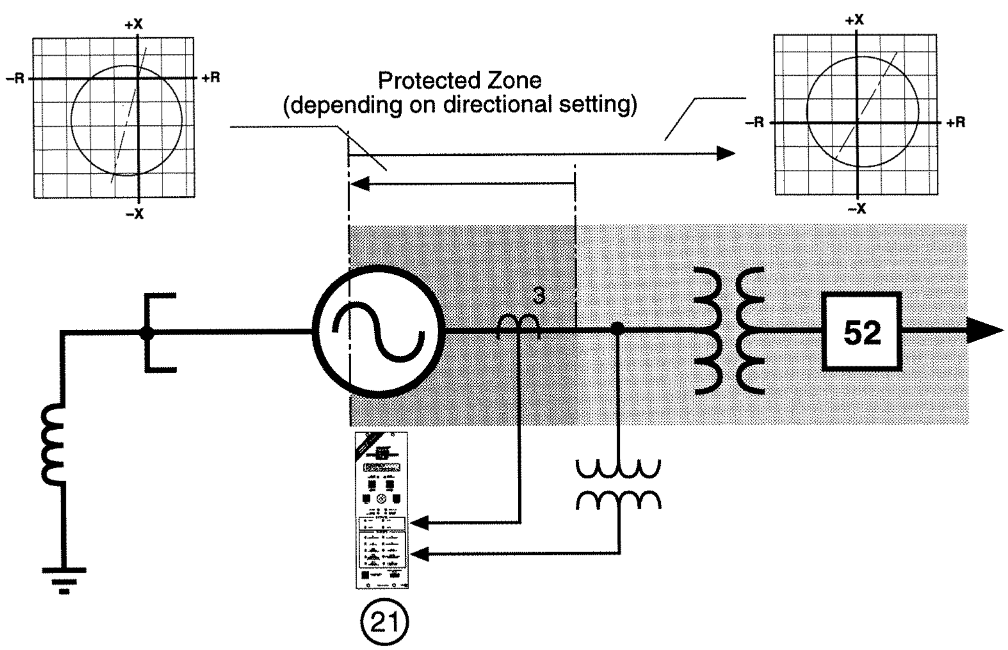
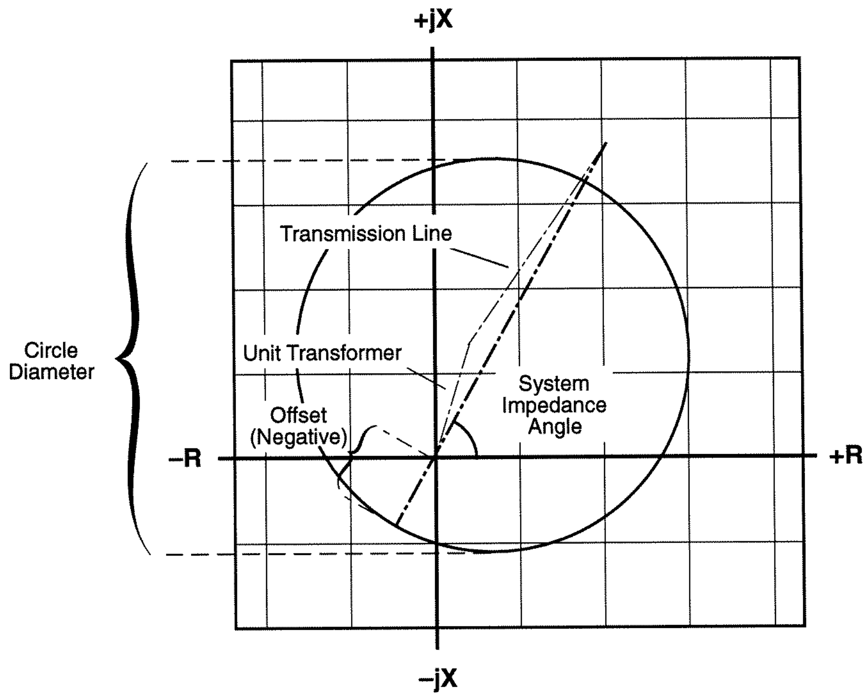


FIGURE 2–8 Phase Distance (21) Coverage—Line-Side CTs



■ **NOTE:** No offset is required for neutral-side CTs

FIGURE 2–9 Phase Distance (21) Function Applied for System Backup

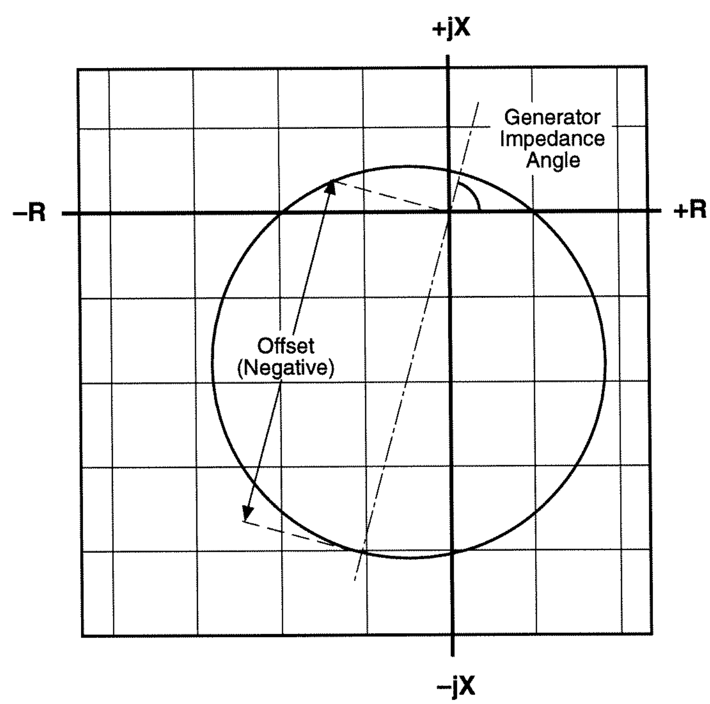


FIGURE 2–10 Phase Distance (21) Function Applied for Dead-Machine Energization

24 VOLTS/HZ

The volts-per-hertz function (24) provides overexcitation protection for the generator. This function provides four families of inverse time curves, two definite time setpoints, and a linear reset time programmable to match specific machine cooling characteristics.

Theory of Operation

Whenever the ratio of the voltage to the frequency (volts/Hz) applied to the terminals of the generator exceeds 1.05 pu (on the generator base), saturation of the magnetic core can occur and stray flux can be induced in components not designed to carry flux. In this situation, severe overheating can occur, causing damage to the generator. Overexcitation most often occurs during start-up, when the generator is operating at reduced frequencies, or during complete load rejection. A similar problem can affect transformers.

As shown in Figure 2–11, the manufacturer of the generator and transformer will define overexcitation capability limits. Depending on their characteristics, these can best be matched by one of the four families of inverse time curves, alone or in conjunction with definite time setpoints.

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

When 69.3 V is chosen for the V.T. secondary voltage, 69.3 V is internally converted to 120 V (1 p.u.) for all calculations and for setting and display purposes.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Volts/Hz (24)				
Definite Time				
V/Hz #1, #2	100% – 200%	1%	110%	
Time Delay #1, #2	30 – 8160 cycles	1 cycle	360 cycles	+20 cycles
Inverse Time				
Characteristic Curves	Inverse Time #1 – #4		#1	
Pickup	100% – 200%	1%	105%	
Time Dial: Curve #1 **Curve #2 – #4**	1 – 100 0 – 9	1 0.1	9	
Reset Time	1 – 999 sec. (from threshold of trip)	1 sec.	200 sec.	
Nominal VT Secondary Voltage	100 – 140 V	1 V	120 V	

TABLE 2–4 Volts-per-Hertz (24) Setpoint Ranges

M-0430 Implementation

In the M-0430, the 24 function provides four families of inverse curves. The pickup and time-dial setting can be adjusted to provide the best match with the generator/unit-transformer combined V/Hz limit curves provided by the manufacturers.

The frequency and the corresponding V/Hz are calculated using the voltage from the phase which has the highest voltage, i.e.:

$$V/Hz = [\textit{Maximum of}\,(V_a, V_b, \text{or } V_c)^*]\ /\ \textit{frequency}$$

*■ **NOTE**: The following is substituted for a line-to-line configuration: (V_{ab}, V_{bc}, or V_{ca}).

The V/Hz calculations used in the relay provide reliable measurements of V/Hz up to 200% for a frequency range of 8 to 80 Hz. The nominal VT voltage setting should be adjusted to provide 100% V/Hz for nominal system voltage and frequency (50 or 60 Hz as selected by the internal configuration DIP switch).

Definite time setpoint #1, when enabled, will become the definite minimum time of the inverse time characteristic; i.e., the relay will follow the inverse time curve until the V/Hz reaches the pickup setting of the definite time setpoint; beyond this V/Hz value, the time delay is fixed at definite time delay #1 (see Figure 2-11).

▲ **CAUTION**: If the inverse time function is enabled, definite time setpoint #1 should not be disabled since it will provide a definite minimum time limit for the inverse time curve. Without a definite minimum time, the inverse time function can give inadvertent tripping due to erroneous volts/Hz measurements during switching transients. The setting for the definite time setpoint #1 should be such that the time delay of this element is less than that of the inverse time curve at the definite time pickup.

Additionally, the M-0430 provides a linear reset characteristic. Reset time (from the 100% trip level) can be set from 1 to 999 seconds.

Suggested Settings

The combined generator/unit-transformer limit curves (provided by the respective manufacturers) should be consulted when determining which curve to use. Refer to the accompanying graphs (Figures 2–12, 2–13, 2–14 and 2–15) to determine the family and curve that provides the best match. The chosen curve can then be selected by entering the corresponding curve family and time-dial setting (K). The pickup setting and reset rates can be selected accordingly.

As shown in Figure 2–11, definite time setpoint #1 can be programmed to trip with a faster time delay than the inverse time curve when the V/Hz reaches a very high level. As stated above, the setting for the definite time setpoint #1 should be such that the time delay of this element is less than that of the inverse time curve at the definite time pickup. Definite time setpoint #2 could be programmed to alarm, alerting the operator to take proper control action so that tripping may be avoided.

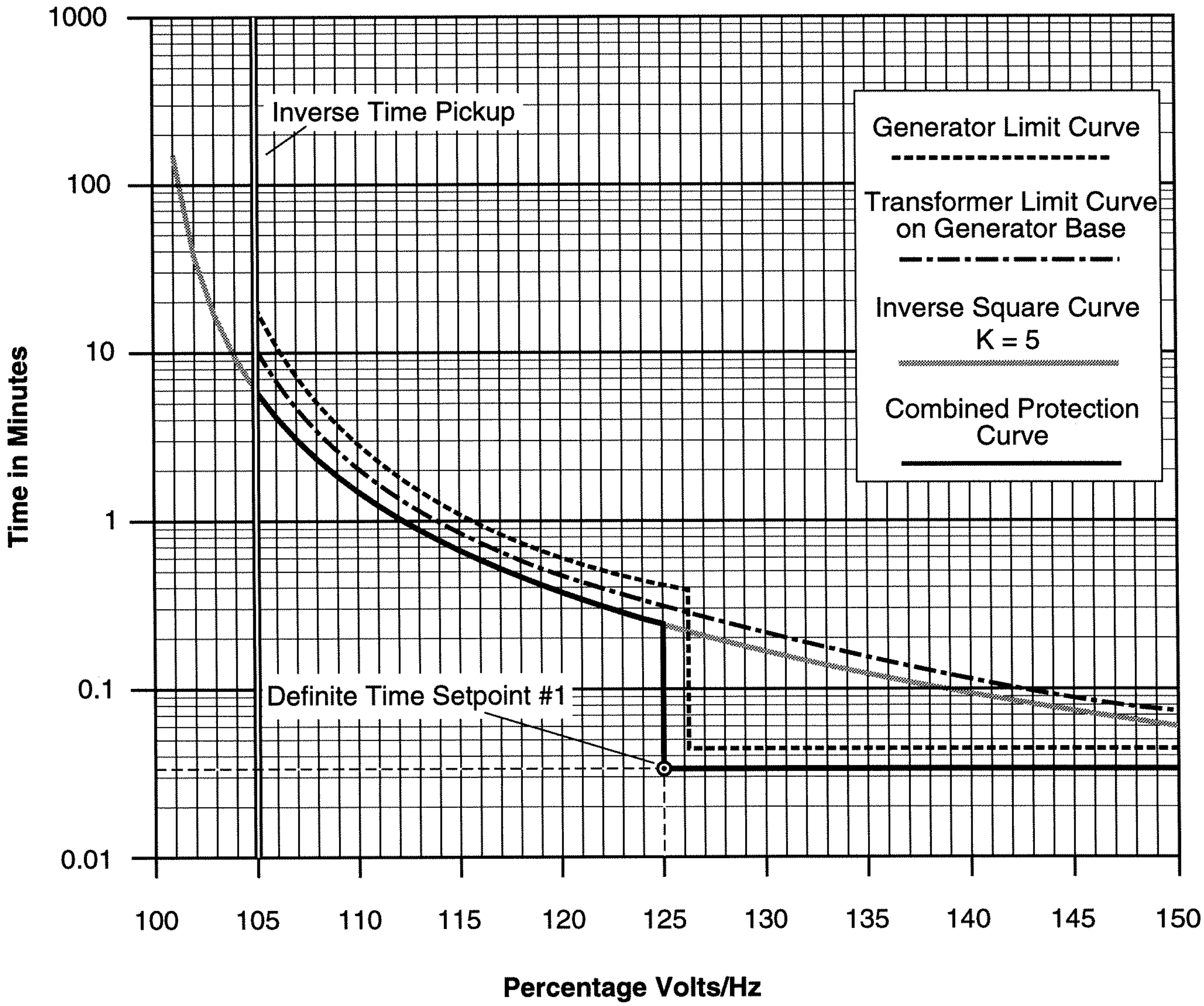


FIGURE 2–11 Example of Capability and Protection Curves

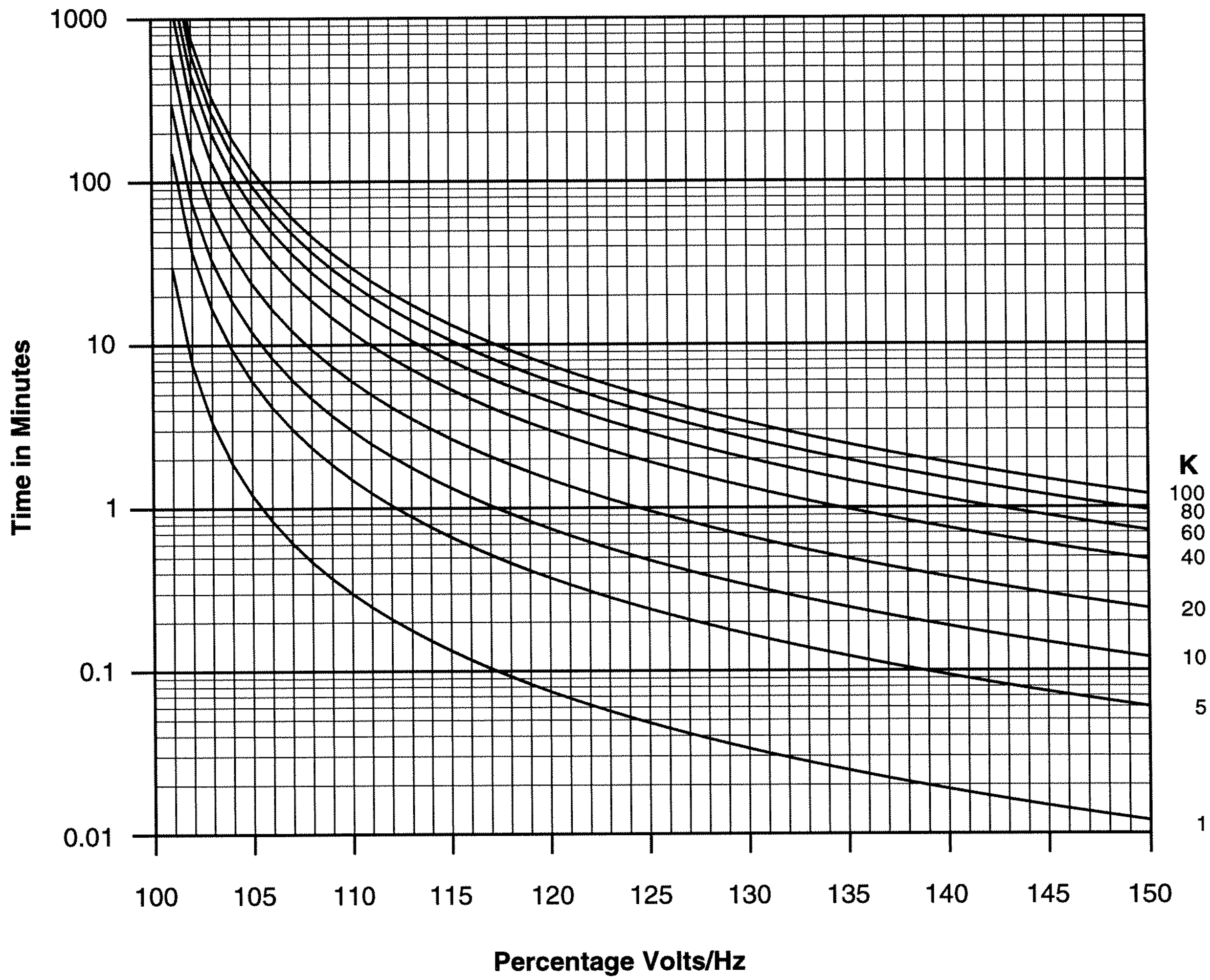


FIGURE 2–12 Volts/Hz (24) Inverse Curve Family #1 (Inverse Square)

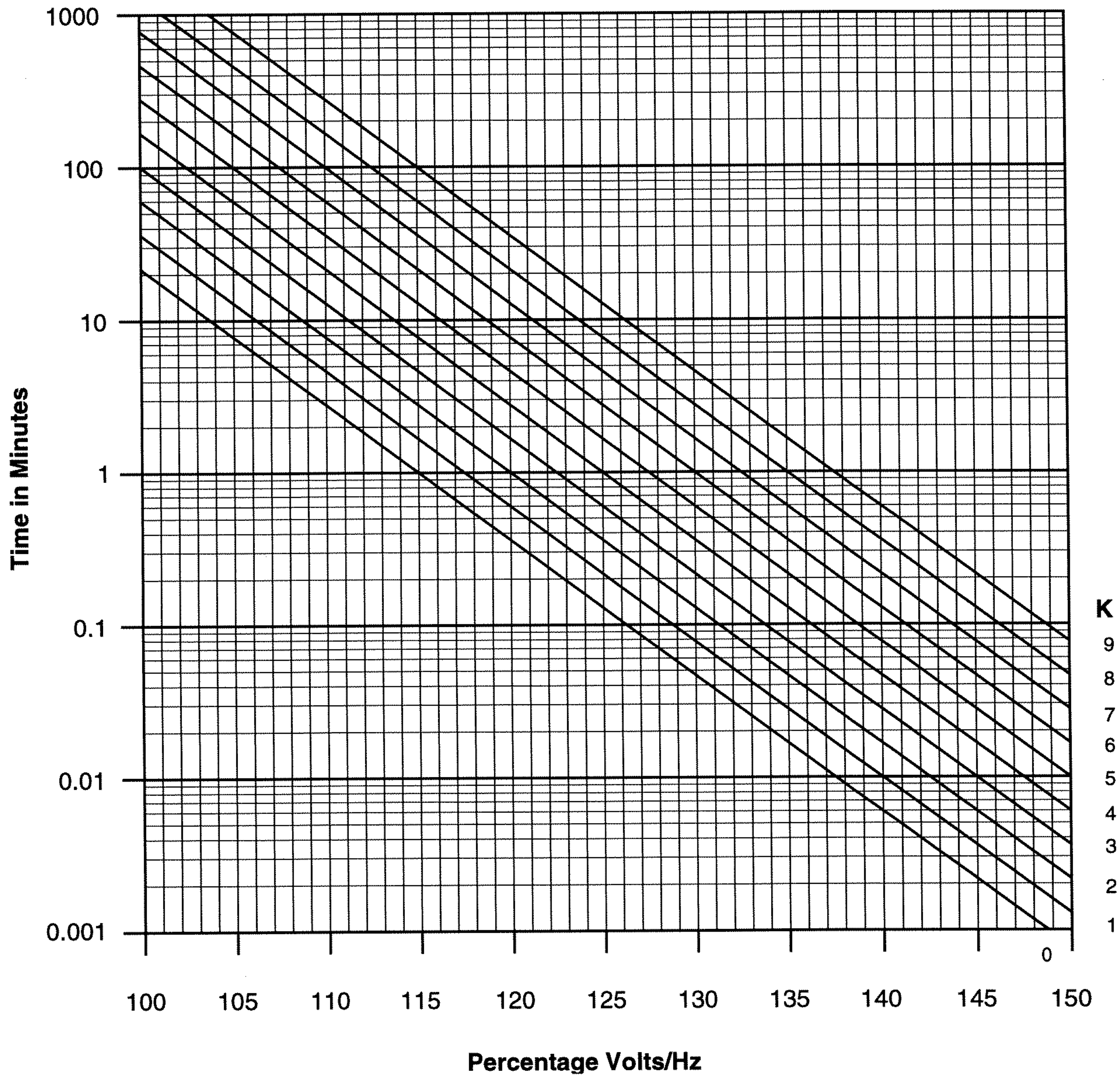


FIGURE 2–13 Volts/Hz (24) Inverse Curve Family #2

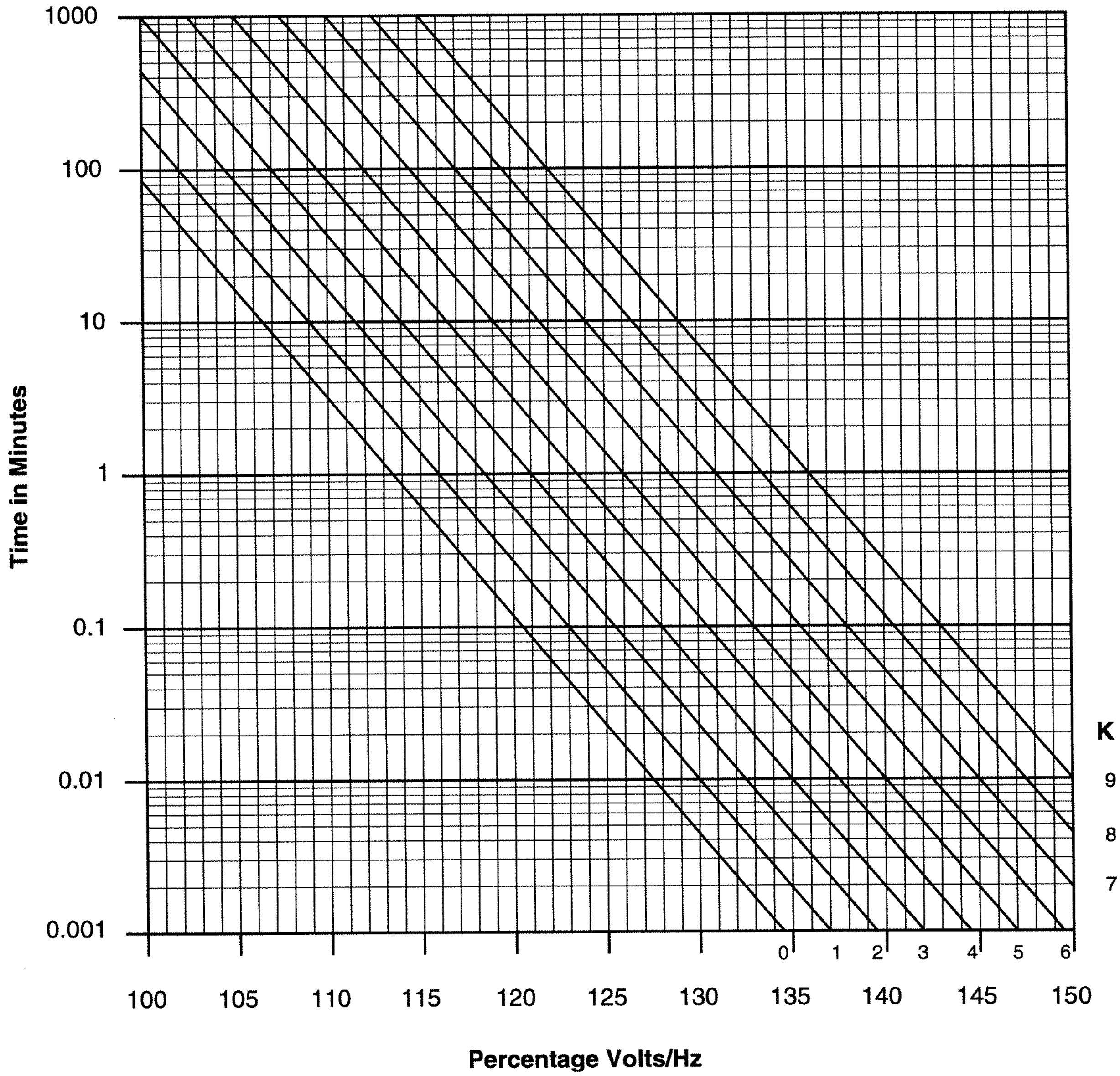


FIGURE 2–14 Volts/Hz (24) Inverse Curve Family #3

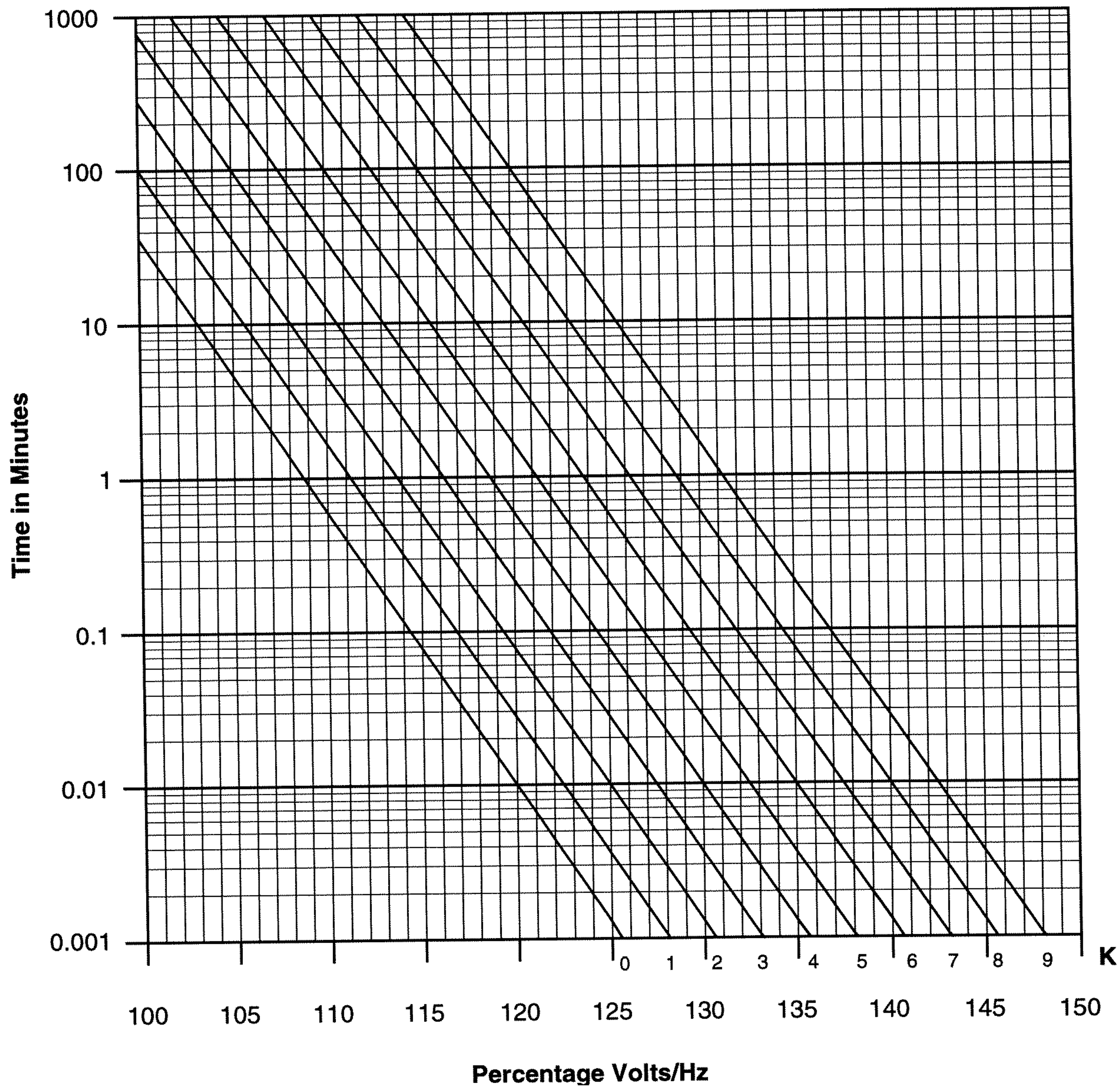


FIGURE 2–15 Volts/Hz (24) Inverse Curve Family #4

27TN THIRD-HARMONIC UNDERVOLTAGE, NEUTRAL CIRCUIT

For ground faults near the stator neutral, the third-harmonic (180/150 Hz) neutral undervoltage function (27TN) provides stator ground-fault protection for high-impedance-grounded generator applications. When used in conjunction with the fundamental (60/50 Hz) neutral overvoltage function (59N), 100% stator ground-fault protection can be provided.

Theory of Operation

In a high-impedance-grounded generator, the 59N function can provide ground-fault protection for 90% to 95% of the stator. However, other methods must be used to provide protection for faults within the final 5% to 10% of the stator neutral. One method is to measure the third harmonic component of the neutral voltage. The third harmonic, will normally be present in the neutral at levels ranging from 1% to 10% of the neutral voltage (depending on the generator design and the load on the generator). During a ground fault within the generator, this third-harmonic neutral voltage will vary depending on the fault's location, increasing for faults toward the generator terminals, and decreasing for faults toward the generator neutral. As shown in Figure 2–16, the decrease in the third-harmonic neutral voltage for a fault near the neutral can be used to signal the presence of a fault in the area of the generator that is not protected by the 59N function.

M-0430 Implementation

In the M-0430, the discrete Fourier transform is used to calculate the magnitude of the third-harmonic neutral voltage. The 27TN function is supervised by the positive-sequence phase-undervoltage element (27) to prevent tripping when the generator field is not energized.

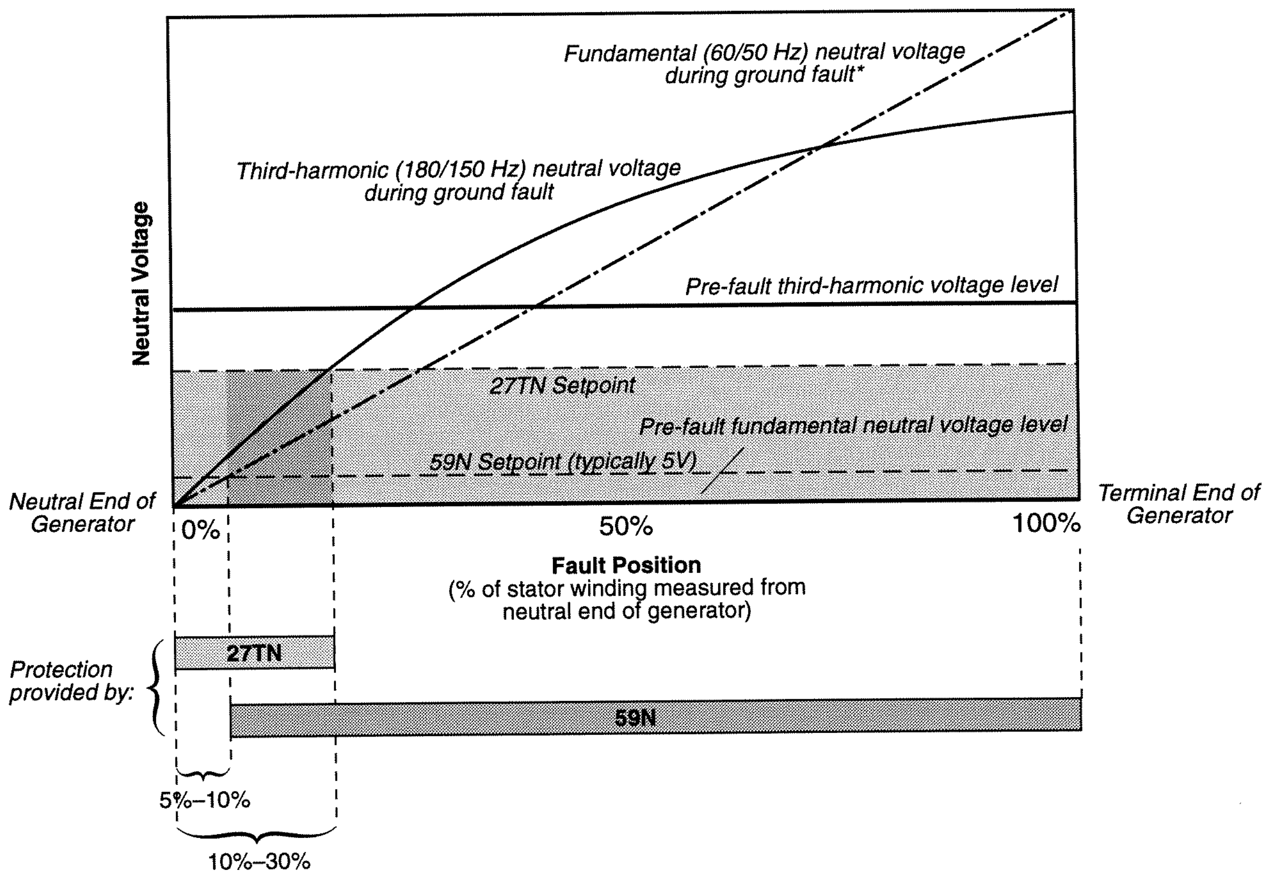
Suggested Settings

The 27TN setting should depend on the actual third-harmonic neutral voltage level seen during normal operation of the generator. The setting should be about 50% of the minimum third-harmonic voltage observed during various loading conditions. The undervoltage inhibit setting should be about 80% to 90% of the nominal voltage. This can be most conveniently measured during commissioning of the relay.

When 69.3 V is chosen for the V.T. secondary voltage, 69.3 V is internally converted to 120 V (1 p.u.) for all calculations and for setting and display purposes.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Third-Harmonic Undervoltage, Neutral Circuit (27TN)				
Magnitude #1, #2	0.3 – 20 V	0.1 V	1.2 V	±0.15 V
Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
Undervoltage Inhibit (Positive Sequence)	5 – 200 V	1 V	12 V	±0.5 V

TABLE 2–5 Third-Harmonic Undervoltage, Neutral Circuit (27TN) Setpoint Ranges



*■ **NOTE:** The fundamental and third-harmonic voltages are not drawn to the same scale.

FIGURE 2–16 Third-Harmonic Undervoltage (27TN) Protection Characteristics

32 DIRECTIONAL POWER, 3-PHASE

The directional-power function can provide antimotoring protection. It provides both a forward and a reverse power setpoint, each with a magnitude setting and a time delay.

Theory of Operation

If the power input to the prime mover is removed while the generator is still on line, the generator will act as a synchronous motor, driving—and possibly damaging—the prime mover. The power required to motor varies with the type of prime mover, ranging from 0.2% to 2% of rated power for hydro-turbines (with blades above the tail-race water level) to up to 50% for a gas turbine.

During the motoring condition of the generator, the VAr component of the power remains at essentially the same level as before the power input to the prime mover was lost, while real power taken by the generator could be very small. This leads to a phase angle between voltage and current close to 90°. The reverse power relay must therefore respond only to real power and be very sensitive.

M-0430 Implementation

Reverse power relays which rely on zero crossings for phase angle information suffer from misoperation during distorted input current signals. To avoid this problem, the power calculation in the M-0430 relay uses the fundamental frequency phasor measurement obtained from the discrete Fourier transform, and hence is immune to harmonics in the voltage and current signals.

For line-to-ground VT inputs, the complex three-phase power (P + jQ) is computed as

$$P + jQ = \overline{V}_{an}\overline{I}_a^* + \overline{V}_{bn}\overline{I}_b^* + \overline{V}_{cn}\overline{I}_c^*$$

where V_{an}, V_{bn}, and V_{cn} are line-to-ground voltages, and I_a, I_b, and I_c are line currents and * denotes the complex conjugate.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Directional Power, 3-Phase (32)				
Forward Power Flow Mag.*	0.02 – 3.00 pu	0.01 pu	3.00 pu	±0.01 pu
Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
Reverse Power Flow Mag.*	0.02 – 3.00 pu	0.01 pu	3.00 pu	±0.01 pu
Time Delay	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
**1 pu = 1800 W for Line-to-Neutral input, and 1039 W for Line-to-Line input.*				

TABLE 2–6 Directional Power, 3-Phase (32) Setpoint Ranges

When the single-phase option is selected (see DIP switch settings), the power is computed as

$$P = minimum\ of\ (P_a, P_b\ and\ P_c)$$

The single-phase option applies only to the reverse power relay function (32R). The forward power function and the status display of real and reactive power always use the total 3Φ power quantities.

For line-to-line VT inputs, the total 3Φ power is computed using the two-Wattmeter method as follows:

$$P + jQ = \overline{V}_{ac}\overline{I}_a^* + \overline{V}_{bc}\overline{I}_b^*$$

where V_{ac} and V_{bc} are line-to-line voltages. The single-phase option is not applicable when line-to-line inputs are used.

Suggested Settings

The reverse power pickup setting should be selected based on the type of prime mover and the losses of the idling prime mover. The settings range from 0.02 pu to 3.0 pu. Reverse power relays should always be applied with a time delay in order to prevent misoperation during power swing conditions. Typical time delay settings are 2 to 10 seconds.

The forward power setting can be used for overload protection, providing either alarm or tripping. If it is programmed to send an alarm, the operator can take control action to avoid tripping. The pickup and time delay setting should be based on the capability limit of the generator.

The base volt-amperes per unit for line-to-line and line-to-neutral operation (selected via the internal configuration DIP switch) are derived as follows:

▲ **CAUTION**: Proper CT polarity is important in defining the direction of power flow.

Line-to-Line Voltage Input Option

	120 V secondary VTs	**69.3 V secondary VTs**
Base volt-amperes (1 pu)	$= \sqrt{3} \times V_L \times I_L$	$= \sqrt{3} \times V_L \times I_L$
	$= \sqrt{3} \times 120 \times 5$	$= \sqrt{3} \times 69.3 \times 5$
	= 1039 VA	= 600 VA

These volt-amperes are used as the base value (1 pu) for forward and reverse power relay functions and for display of real and reactive power.

Line-to-Neutral Voltage Input Option

The forward power function and the display of real and reactive power use three-phase volt-amperes as the base:

	120 V secondary VTs	69.3 V secondary VTs
Base volt-amperes (1 pu)	$= 3 \times V_{Phase} \times I_{Phase}$	$= 3 \times V_{Phase} \times I_{Phase}$
	$= 3 \times 120 \times 5$	$= 3 \times 69.3 \times 5$
	= 1800 VA	= 1039 VA

The reverse power function has single-phase/three-phase options. The base volt-amperes (1 pu) for these options are as follows:

Three-phase reverse power base volt-amperes:

120 V secondary VTs	69.3 V secondary VTs
= 1800 VA	$= 1800/\sqrt{3} = 1039$ VA

Single-phase reverse power base volt-amperes:

120 V secondary VTs	69.3 V secondary VTs
= 600 VA	$= 600/\sqrt{3} = 346$ VA

40 LOSS OF FIELD

The loss-of-field function (40) provides protection for a partial or complete loss of field (excitation). A variety of possible settings make the relay very flexible, providing compatibility with existing industry-standard relays.

Theory of Operation

When a generator loses its field, the impedance as viewed from the generator terminals will vary depending on the initial load and the excitation. As shown in Figure 2–17, from the initial operating value, the impedance will move towards and settle on the dashed curve describing the final impedance locus. This change in impedance during a loss of field can be detected by a distance unit (offset mho) looking into the generator. If the distance unit is set to include the origin, a directional unit is required to supervise the distance unit to prevent relay operation for nearby faults and stable transient swings.

Sometimes, an undervoltage relay may be applied to supervise (control) the distance unit. Additionally, in hydrogenerator applications, where temporary high-speed operation of the generator is possible, additional security can be provided by controlling the distance unit with an overfrequency relay, the distance unit is allowed to pick up when the frequency is below the setting and dropping out when it is above the setting.

M-0430 Implementation

The loss-of-field function in the M-0430 is implemented with two offset mho elements, an undervoltage element (voltage control), an overfrequency element (frequency control), and a directional element. The settings for each mho element (diameter, offset, and time delay) can be adjusted individually. Voltage control, frequency control, and the directional unit affect both elements. Voltage control and frequency control

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Loss of Field, offset mho characteristic (40)				
Circle Diameter #1, #2	0.1 – 100 Ω	0.1 Ω	50.0 Ω	
Offset #1, #2	–50 to + 50 Ω	0.1 Ω	–10.0 Ω	
Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
Voltage Control (positive sequence)	5 – 200 V	1 V	108 V	
Frequency Control	60.05 – 67 Hz (50.05 – 57 Hz)	0.05 Hz	66 Hz	
Directional Unit	*Fixed at –13°*	—	*Always enabled*	

TABLE 2–7 Loss-of-Field (40) Setpoint Ranges

can be enabled individually via the **CONFIGURE RELAYS** menu selection; the directional unit is always enabled. The directional element detects and operates on inductive VAr flow into the machine. Its zero sensitivity (torque) line is placed at −13° from the R axis.

Voltage and current phasors are calculated using the discrete Fourier transform. From these phasors, positive-sequence phasors of the voltages and currents are calculated. By complex division, the positive sequence impedance is obtained. The positive-sequence impedance is compared with the relay characteristic to determine if the impedance is inside the operating zone. The algorithm works for both line-to-ground and line-to-line VT inputs. The 30° phase shift in the case of line-to-line voltage is corrected internally.

The use of positive-sequence voltage and current phasors improves the accuracy of the impedance measurements, especially during off-nominal frequency operation. The relay characteristic does not change with system frequency, as is the case with some electromechanical relays. The impedance is calculated using the following equations:

Line-to-Ground VTs $$Z_1 = \frac{V_{1_{L\text{-}N}}}{I_1}$$

Line-to-Line VTs $$Z_1 = \frac{V_{1_{L\text{-}L}}}{I_1 \cdot 1\angle 30^\circ}$$

where

Z_1 is the positive-sequence impedance, $V_{1L\text{-}N}$ is the positive-sequence line-to-neutral voltage, $V_{1L\text{-}L}$ is the positive-sequence line-to-line voltage, and I_1 is the positive-sequence current.

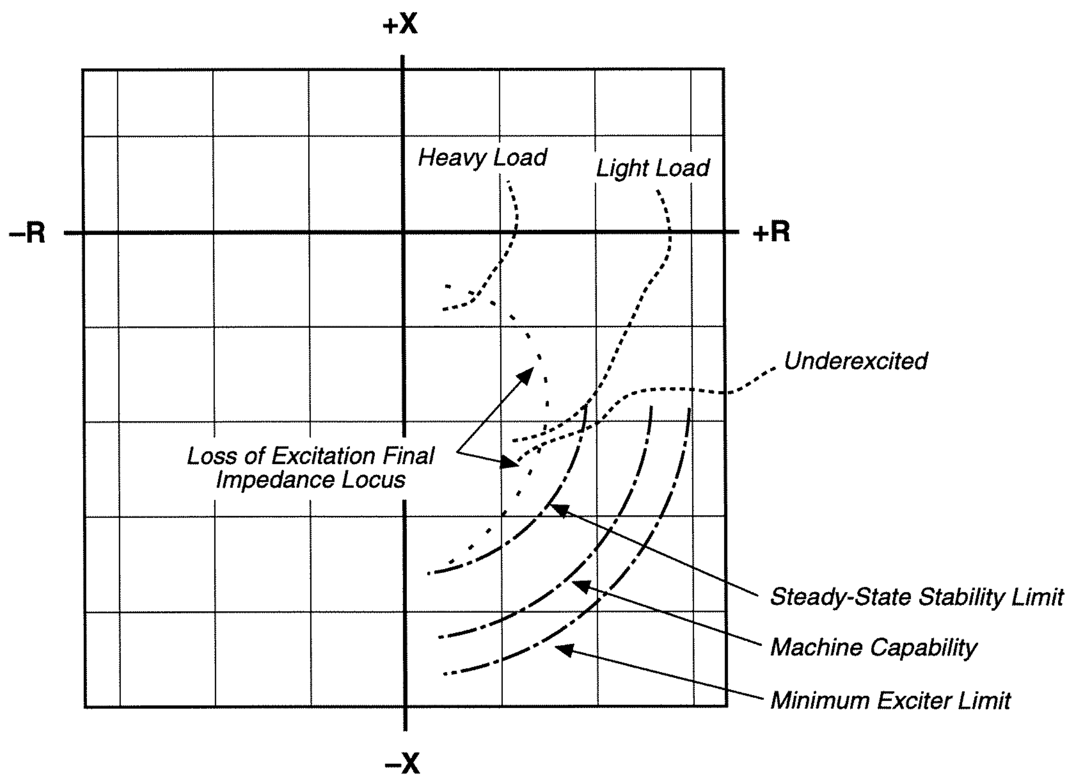


FIGURE 2–17 Loss-of-Field Impedance Characteristics

The impedance calculation saturates to 327.6 Ω when the positive-sequence current is below 0.16 A. This prevents relay chattering when the voltage and current inputs are not connected to the relay.

Suggested Settings

All primary impedances (Z_{PRI}) must be reflected to relay quantities (Z_{SEC}). For applications using line-ground, 120-volt VT's, the primary ohms (Z_{PRI}) on the generator base needs to be multiplied by the ratio of the current transformer ratio (R_C) to the voltage transformer ratio (R_V).

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

If line-line, 120-volt V.T.'s are used or the line-ground rated secondary voltage is 69.3 volts, the relay impedance (Z_{SEC}) calculated above must be multiplied by $\sqrt{3}$ before inputing to the relay.

The settings of the offset mho elements should be such that the relay detects the loss-of-field condition for any loading while not misoperating during power swings and fault conditions. Two approaches are widely used in the industry, both of which are supported by the M-0430. Both approaches require knowledge of the reactances and other parameters of the generator.

The first approach is shown in Figure 2–18. Here, both of the offset mho elements are set with an offset of $-X_d'/2$, where X_d' is the direct axis transient reactance of the generator. The diameter of the smaller circle is set at 1.0 pu impedance on the machine base. This mho element detects loss of field from full load to about 30% load. A small time delay (10 to 20 cycles) provides fast protection.

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

The second approach is shown in Figure 2–19. In this approach, one of the mho elements is set with an offset of $-X_d'/2$, a diameter of $1.1X_d - X_d'/2$, and a time delay of 10 to 30 cycles. The second element is set to coordinate with the generator minimum excitation limit and steady-state stability limit.

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

Voltage and frequency control features can be used with both approaches, with voltage control set typically at 80% to 90% of nominal voltage and frequency control at 110%. The voltage control should be applied after careful study of the system since, depending on the stiffness of the system, the voltage may not be reduced enough to operate the undervoltage element during loss-of-field conditions.

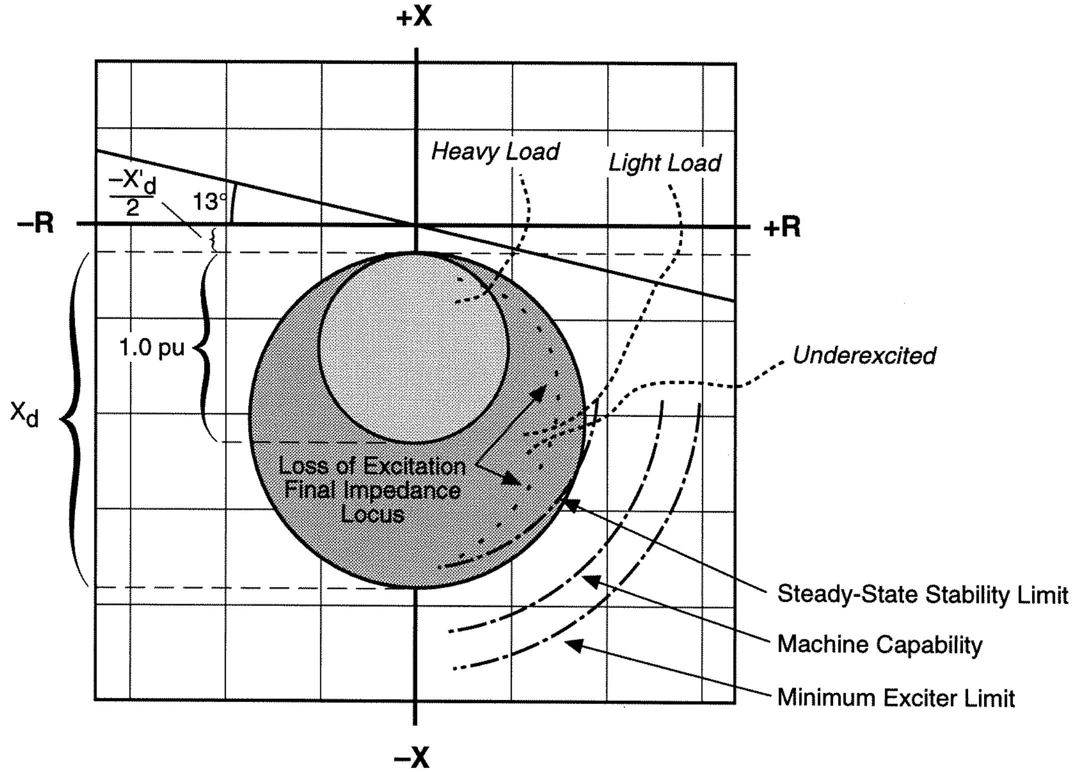


FIGURE 2–18 Loss of Field (40)—Protective Approach 1

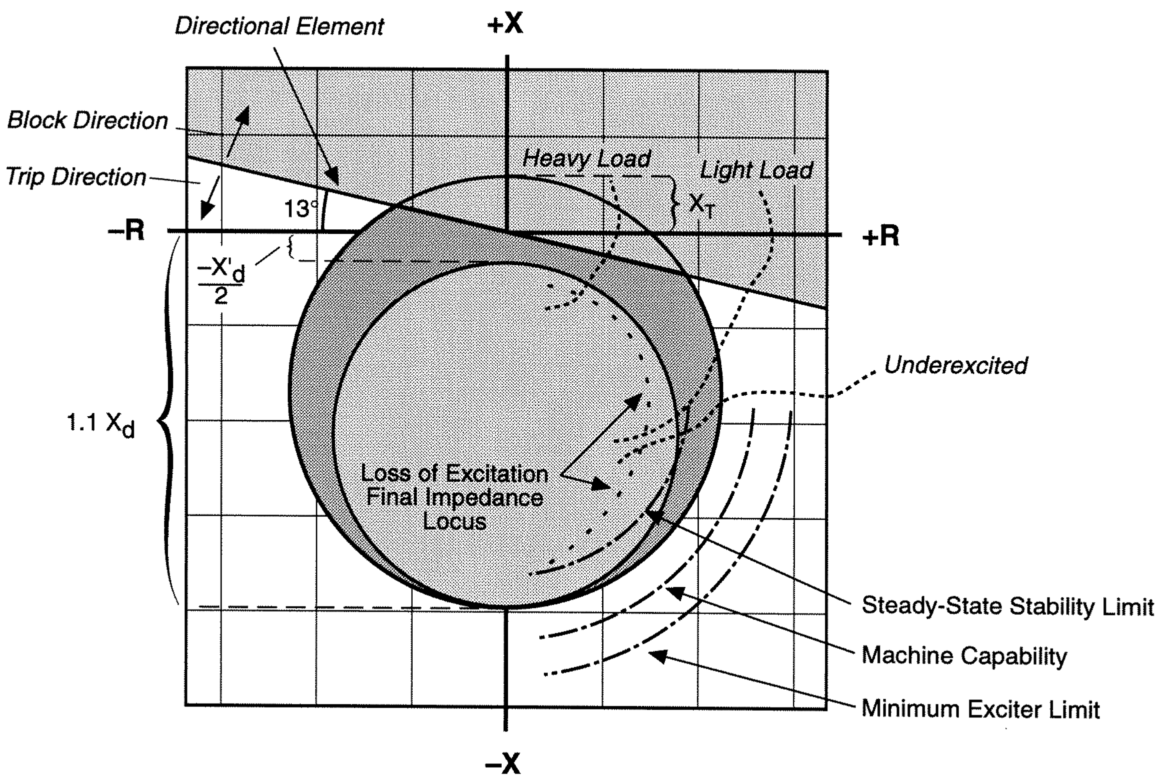


FIGURE 2–19 Loss of Field (40)—Protective Approach 2

50BF GENERATOR BREAKER FAILURE/50N BREAKER FLASHOVER

The breaker failure function includes a phase-overcurrent element (50BF-Ph), a neutral-overcurrent function (50N—used for breaker-flashover protection), and a timer. This function is applicable when a generator breaker is present and line side CT's are being used.

Theory of Operation

When the generator protective relays detect an internal fault or an abnormal operating condition, these relays send a output signal to trip the generator (or unit) breaker. When a generator breaker is used, protection can be provided for the instance where the generator breaker fails to clear the fault or abnormal condition. Such breaker-failure protection should be connected to trip the necessary breakers in order to isolate the generator from the system.

The breaker-failure condition is usually detected by the continued presence of current in any one or more of the phases after a breaker has been tripped. However, the current detector (50BF) may not always give the correct status of the breaker, especially for generator breakers. This is because faults and abnormal operating conditions such as ground faults, overexcitation, over/under frequency, and reverse power may not produce enough current to operate the current detectors. For this reason, the breaker status input via the 52b contact must be used, in addition to the 50BF fault detector, to provide breaker status indication. Misoperation of the protection could occur for faults between the sensing CT's on the generator terminals and the generator breaker. Usually the risk of faults in this limited bus is small enough to be ignored.

Breaker flashover is another form of breaker failure which can cause severe damage to the generator due to inadvertent energization. The risk of flashover is greater just prior to synchronizing or just after the generator is removed from service.

The breaker-flashover condition can be detected by a negative sequence or ground backup overcurrent relay, but the time delay associated with these relays is very long. An instantaneous overcurrent relay (50N) connected at the neutral of the generator and supervised by breaker "b" contacts can provide fast detection of a breaker-flashover condition. When multiple generators are connected to a common bus pole-flashover detection is possible so long as the zero-sequence source is available from other generators connected on the bus.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Breaker Failure* (50BF)				
Pickup Current				
Phase Current (50BF-Ph)	0.1 – 10 A	0.1 A	1.0 A	
Neutral Current (50BF-N)	0.1 – 10 A	0.1 A	1.0 A	
Time Delay	1 – 8160 cycles	1 cycle	30 cycles	

**The breaker failure timer can be initiated by the programmed outputs of the relay or via the external Breaker Failure Initiate (BFI) input. 50N is used for breaker flashover protection.*

TABLE 2–8 Breaker Failure (50BF) Setpoint Ranges

M-0430 Implementation

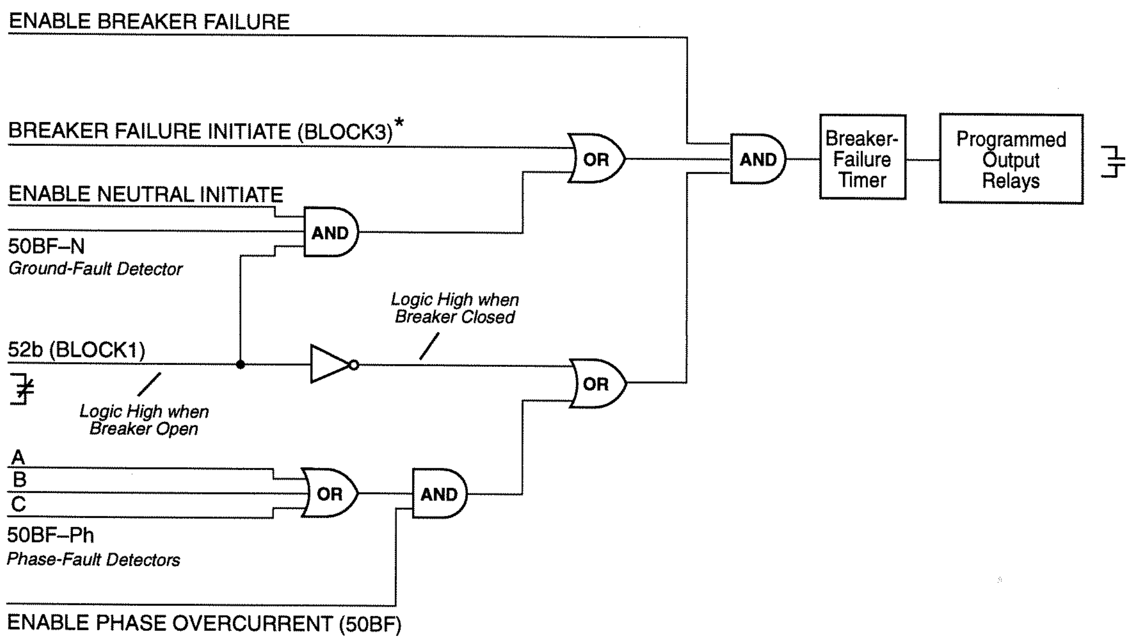
The M-0430 implementation of the generator breaker failure function is illustrated in Figure 2–20. The breaker failure timer will be initiated whenever any one of the output contacts (programmed to initiate the breaker-failure timer) is activated or the external Breaker Failure Initiate (BFI) input contact is closed. The timer continues to time if any one of the phase currents are above the 50BF setting or if the 52b contact indicates that the breaker is still closed; otherwise, the timer is reset.

The phase-fault detector (50BF-Ph) will not be effective when neutral-side CTs are used. This is because for internal generator winding faults the fault current may continue to flow for several seconds even after the generator and field breakers are open. The phase-fault detector (50BF-Ph) should be disabled for this application, in which case the breaker-failure scheme relies on 52b contact to obtain the breaker status. This limited (no-fault detector) breaker failure protection can be provided for a HV unit breaker (when a generator breaker is not present) if the 50BF-Ph and 50BF-N are disabled. In this case, the 52 "b" contact must be from the unit breaker.

Breaker-flashover protection is provided via the 50BF-N function, providing an additional breaker-failure initiate which is active only when the breaker is open. The current detectors (50BF-N and 50BF-Ph) should be set with sufficient sensitivity to detect this condition.

50BF BREAKER FAILURE

▲ **CAUTION:** If BLOCK3 has been programmed to respond as BLOCK3 and *not* as the external Breaker Failure Initiate (BFI) input, the breaker-failure initiate function must be disabled via the **CONFIGURE RELAYS** menu. Otherwise, any BLOCK3 input will initiate the breaker-failure timer and lead to false tripping of the backup breakers.



*■ **NOTE:** Breaker Failure Initiate signal from external BFI input or from internal Breaker Failure Initiate logic via the programmed M-0430 outputs. See Tables 2–1 and 2–2 for information on programming the Breaker Failure Initiate logic.

FIGURE 2–20 Breaker-Failure Logic

59 RMS OVERVOLTAGE, 3-PHASE

The rms overvoltage function can be used to provide overvoltage protection for the generator.

Theory of Operation

Generator overvoltage conditions may occur due to a load-rejection or excitation-control failure. In case of hydrogenerators, upon load rejection, the generator may speed up and the voltage may reach high levels without necessarily exceeding the generator's V/Hz limit. To adequately protect against overvoltage conditions, the overvoltage relay should be accurate over a wide frequency range.

M-0430 Implementation

The M-0430 provides an overvoltage function with two definite-time setpoints, either of which can be programmed to trip the unit or send an alarm. The voltage magnitude calculation does not use the discrete Fourier transform, using instead, the time-domain approach to calculate the rms value of the voltage in order to give accurate results over a wide frequency range (8 Hz to 80 Hz).

When 69.3 V is chosen for the V.T. secondary voltage, 69.3 V is internally converted to 120 V (1 p.u.) for all calculations and for setting and display purposes.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
RMS Overvoltage, 3-Phase (59)				
Magnitude #1, #2	5 – 200 V	1 V	132 V	±0.5 V
Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	+20 cycles

TABLE 2–9 Rms Overvoltage, 3-Phase (59) Setpoint Ranges

59N RMS OVERVOLTAGE, NEUTRAL CIRCUIT OR ZERO SEQUENCE

The neutral overvoltage function (59N) provides stator ground-fault protection for high-impedance-grounded generators. The 59N function can provide ground-fault protection for 90% to 95% of the stator (measured from the terminal end). When used in conjunction with the third-harmonic undervoltage function (27TN), 100% stator ground-fault protection can be provided.

Theory of Operation

Since the grounding impedance in a high-impedance-grounded generator application is large compared to the generator impedance, a phase-to-ground fault at the generator terminals will cause the full phase-to-neutral voltage to appear across the grounding resistance—the actual voltage at the relay being a function of the distribution transformer ratio and the location of the fault. The magnitude of the voltage will be greatest for a fault near the terminals and will decrease as the fault location approaches the generator neutral. A neutral overvoltage relay can be used to sense this voltage. (This relay must react only to fundamental frequency voltage, being insensitive to third-harmonic and other zero-sequence harmonic voltages.) With typical distribution transformer ratios and a typical minimum pickup setting of 5 V, this scheme is capable of detecting ground faults in about 95% of the generator stator winding from the terminal end.

M-0430 Implementation

The 59N function in the M-0430 provides two setpoints. Because the fundamental frequency component of the neutral voltage is extracted using the discrete Fourier transform, the 59N function responds only to the fundamental frequency component, rejecting all other harmonic components.

▲ CAUTION: For the 59N function, because setpoint #1 is used to define the scaling for the programmable gain amplifier, the value of setpoint #1 *must* be greater than or equal to that of setpoint #2.

When 69.3 V is chosen for the V.T. secondary voltage, 69.3 V is internally converted to 120 V (1 p.u.) for all calculations and for setting and display purposes.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
RMS Overvoltage, Neutral Circuit or Zero Sequence (59N)				
Magnitude #1, #2	5 – 200 V	0.1 V	10 V	±0.1 V or ±0.5%
Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles

TABLE 2–10 Rms Overvoltage, Neutral Circuit or Zero Sequence (59N) Setpoint Ranges

60FL VT FUSE-LOSS DETECTION

Since some M-0430 relay functions may send an inadvertent trip signal when a voltage-transformer fuse is blown, the M-0430 incorporates provision for both internal and external VT fuse-loss detection. The status of the fuses can be determined from the front panel or via remote communications.

For internal detection of a fuse-loss condition, an algorithm compares positive and negative sequence voltages and currents. The presence of negative sequence voltage, accompanied by the absence of negative sequence current is considered to signal the fuse-loss condition. The actual algorithm used is provided below:

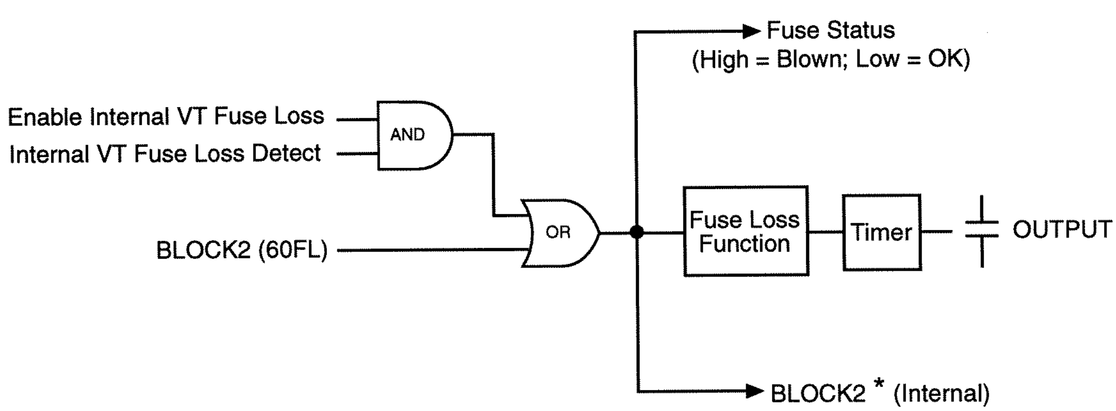
A fuse-loss condition is considered to exist when

$$(V_1 > 12.8 \text{ volts}) \textit{ and } (V_2 > 0.33\ V_1) \textit{ and } [(I_2 < 0.167\ I_1) \textit{ or } (I_1 < 0.33 \text{ amps})]$$

where V_1 = positive sequence voltage, V_2 = negative sequence voltage, I_1 = positive sequence current, *and* I_2 = negative sequence current

The $V_1 > 12.8$ V condition determines if the VT inputs are applied to the relay. For a VT fuse failure condition, the negative-sequence voltage is always greater than 50% of the positive sequence voltage; hence, $V_2 > 0.33\ V_1$ provides a reliable blown VT fuse indication. However, negative sequence voltage will also be present during phase-to-phase fault conditions. The blown VT fuse condition is distinguished from the fault condition by verifying that $I_2 < 0.167\ I_1$. Finally, determining if $I_1 < 0.33$ A prevents the VT fuse output contacts from chattering when a VT fuse blows during a no-load condition.

The above logic can reliably detect a blown VT fuse. However, for any specific application, if the above logic cannot reliably be used (such as when the current inputs to the relay are not connected, the sustained positive sequence current during fault conditions is less than 0.33 A, or the negative-sequence currents are not present during fault conditions ($I_2 < 0.167\ I_1$)), the internal VT fuse-loss detection logic can be disabled via the **SETUP\V.T. FUSE LOSS** submenus under the **CONFIGURE RELAYS** menu selection. In these cases, and since the detection algorithm cannot detect the condition of all three fuses being blown (two in case of open delta), the M-0430's external contact input on terminal 33 (BLOCK2/60FL)—usually from a supplemental device 60—can be used as an external indication of a blown VT fuse.



*■ **NOTE**: BLOCK2 (internal) can be programmed to block any one or more of the relay functions; it is derived as the logical 'or' of the external BLOCK2 (60FL) contact input and the internal VT fuse-loss detection function (if enabled).

FIGURE 2–21 VT Fuse-Loss Logic

81O/81U OVERFREQUENCY / UNDERFREQUENCY

The 81O and 81U functions provide protection against operation of the generator at abnormal frequencies.

Theory of Operation

Full- or partial-load rejection can lead to overspeed of the generator and hence overfrequency operation. In general, overfrequency operation does not pose any serious problems and control action can be taken to reduce the generator speed and frequency to normal without tripping the generator. Additionally, generators are shipped with overspeed detectors. An overfrequency relay (81O) can be used to supplement this overspeed equipment.

Overloading of a generator can lead to prolonged operation of the generator at reduced frequencies. This can cause particular problems for gas or steam turbine generators, which are susceptible to damage from operation outside of their normal frequency band.

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

While load-shedding is the primary protection against generator overloading, underfrequency relays (81U) should be used to provide additional generator protection.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Over Frequency (81O)				
Magnitude #1, #2	60.05 – 67.00 Hz (50.05 – 57.00 Hz)	0.05 Hz	60.50 Hz	±0.02 Hz *
Time Delay #1, #2	2 – 8160 cycles	1 cycle	30 cycles	±1 cycle
Under Frequency (81U)				
Magnitude #1, #2	53.00 – 59.95 Hz (43.00 – 49.95 Hz)	0.05 Hz	59.50 Hz	±0.02 Hz *
Time Delay #1, #2	2 – 8160 cycles	1 cycle	30 cycles	±1 cycle

** The accuracy is based on 3-phase voltage inputs and in the range of 57 to 63 Hz; outside this range, the accuracy is ±0.15 Hz.*

TABLE 2–11 Over Frequency (81O) and Under Frequency (81U) Setpoint Ranges

M-0430 Implementation

The measurement of system frequency in the M-0430 relay is obtained using the positive-sequence voltage phasor. The use of the positive-sequence voltage phasor eliminates any concern about the loss of a sampled phase due to a single phase-to-ground fault or a VT-fuse-loss condition. Also, the positive-sequence voltage is calculated using the discrete Fourier transform and hence the frequency measurement is immune to harmonics and noise on the voltage waveform which shifts zero crossings or creates multiple zero crossings.

The over and under frequency functions (81O and 81U) in the M-0430 each provide two magnitude setpoints with time delays. A typical setting of the 81O and 81U functions is shown in Figure 2–22. The over and under frequency functions are automatically disabled when the input voltage (positive sequence) is less than about 20 V.

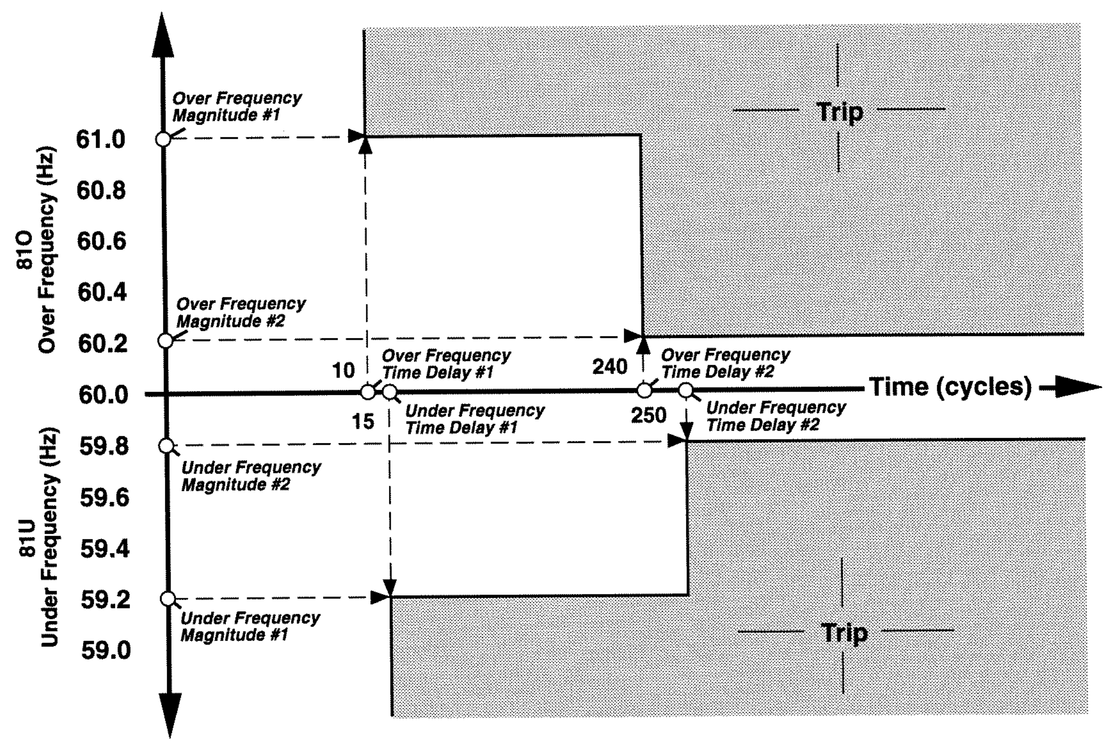


FIGURE 2–22 Over Frequency (81O) and Under Frequency (81U) Trip Characteristics

OVER/UNDER FREQUENCY 81O/U

87GD GROUND (ZERO SEQUENCE) DIFFERENTIAL

The zero-sequence differential element provides ground-fault protection for low-impedance-grounded generator applications. If the M-0430 is used in conjunction with the M-0420, the 51N and 50N functions (in the M-0420) can be used to provide backup ground-fault protection when the 87GD function is used as the primary ground-fault protection.

Theory of Operation

When the generator is grounded through a low impedance, ground-fault protection may be provided by the phase-differential function (87—*not* provided in the M-0430), depending on the fault level and differential relay sensitivity.

Higher sensitivity and fast operation for ground faults can be obtained through the use of an additional zero-sequence differential (87GD). One of the requirements of the zero-sequence differential protection is that the line-side CTs and the neutral CT have the same ratio; otherwise, an auxiliary CT with matching ratio must be used.

When the system can supply zero-sequence current to the ground fault (such as when several generators are bussed together and connected to the system through a single transformer), a directional differential relay (87GD) can be applied.

The directional 87GD can work with a wide range of CT mismatch without requiring the use of an auxiliary CT. It operates on the product of the triple zero-sequence current, the neutral current, and the cosine of the angle between the two. Because the relay is directionally sensitive, it provides security against ratio errors, and CT saturation.

FUNCTION	SETPOINT RANGE	INCREMENT	INITIAL SETTING	ACCURACY
Ground (zero sequence) Differential, low-impedance-grounded generator* (87GD)				
Magnitude #1, #2**	0.2 – 10	0.1	0.5	
Time Delay #1, #2	1 – 8160 cycles	1 cycle	30 cycles	–1 to +3 cycles
CT Ratio Correction (R_C)	0.1 to 7.99	0.01	1.00	

**The 87GD function can be programmed as directional or nondirectional.*
***$-3I_0 \bullet I_n \bullet \cos\theta$ for directional or $(3I_0R_C - I_n)$ for nondirectional;*
where I_0 is the zero sequence current, In the neutral current, and θ is the angle between Io and In, and R_C = (Line CT ratio)/(Neutral CT ratio).

TABLE 2–12 Ground (zero sequence) Differential (87GD) Setpoint Ranges

GROUND DIFFERENTIAL 87GD

M-0430 Implementation

The M-0430 implements both directional and non-directional differential protection; either can be enabled, but not both simultaneously. The directional differential element calculates the product $-3I_0I_nCos\theta$, and compares the product against the relay setting. The relay will pick up if I_0 and I_n have the opposite polarity, which is the case for internal faults, and blocks operation when I_0 and I_n have the same polarity, which is the case for external faults. The trip and blocking regions of the directional element are shown in Figure 2–23. The directional relay can only be applied when a zero-sequence current source is present from the system and it cannot be used when the generator is connected through a delta-wye unit transformer. In such cases, a non-directional differential relay should be used.

The non-directional differential function calculates the difference between the corrected triple zero-sequence current (R_C3I_0) and the neutral current (I_n), and the magnitude of the difference $|(R_C3I_0-I_n)|$ is compared against the relay setting. The M-0430 does away with the need for auxiliary CTs by providing a CT correction factor (R_C) which can be set by the user. The 87GD function cannot be used if the CT ratio correction factor is higher than 7.99. The CT ratio correction factor, R_C, is defined as

$$R_C = (\textit{Ratio of Line-Side CTs}) \,/\, (\textit{Ratio of Neutral CT})$$

For example if the line-side CTs have a ratio of 3000/5, and the neutral CT has a ratio of 600/5, then

$$R_C = (3000/5) \,/\, (600/5) = 5.00$$

Care should be taken in setting the pickup value. For higher values of R_C, the noise can create a high amount of differential current, resulting in inadvertent tripping.

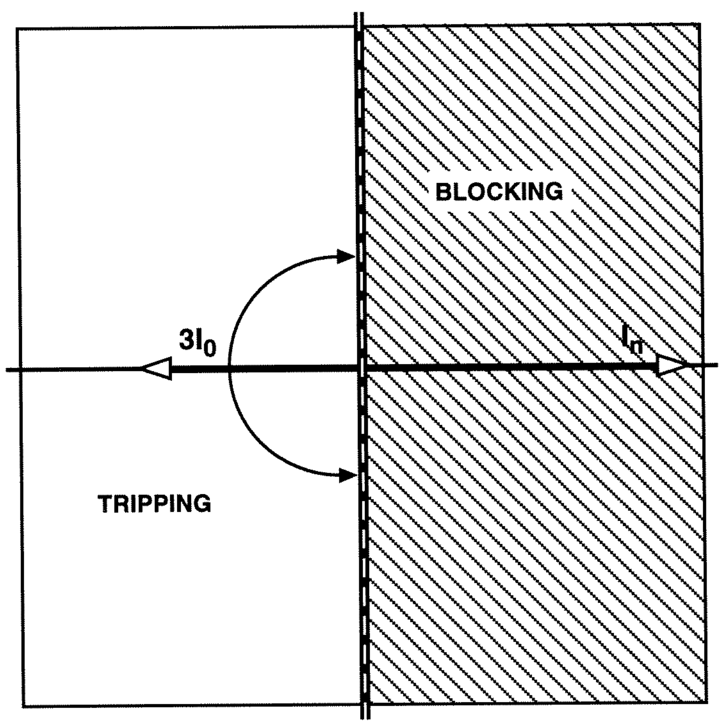


FIGURE 2–23 87GD Directional Element Characteristic

87GD GROUND DIFFERENTIAL

FAULT RECORDER

The fault recorder provides comprehensive fault-data recording for all monitored waveforms (at 16 samples per cycle) and status inputs (at 480 Hz). Fault data can be downloaded via the RS-232C ports to any IBM-compatible personal computer running the M-0429A BECOCOM™ Communications Software package. Once downloaded, the waveform data can be examined and printed using the M-0428A BECOPLOT™ Fault Data Analysis Software package.

Operation

The fault recorder can be either armed or disarmed; if armed, it can be triggered manually through serial communication via BECOCOM, or automatically via the fault recorder trigger input at terminal 35 (**FLT. REC. TRIGGER**). When armed and untriggered, the recorder continuously records waveform data, keeping the most recent 96 cycles of data (at 16 samples per cycle) in its memory. When triggered (with a specified post-trigger delay), the recorder continues recording for a user-defined period and then goes to unarmed mode, keeping the 96-cycle snapshot of waveform data in its memory for downloading via BECOCOM communications software. Rearming the fault recorder restarts the process (overwriting the stored fault data). You can determine the status of the fault recorder (whether armed or not, and if armed, whether triggered or not) through the front panel or via remote communications using BECOCOM. When the third-harmonic neutral voltage is recorded via the fault recorder, the signal magnitude displayed by the BECOPLOT program is approximately 80% of the actual value. This is due to the signal attenuation at 180 Hz caused by the antialiasing filters.

■ **NOTE:** The fault recorder is initially disarmed after power up.

Auto-Rearming

The fault recorder can also be set to rearm itself automatically when the relay detects a closing breaker via the 52b input. When auto-rearming is enabled, the fault recorder is armed when the breaker closes (as indicated by the 52b input).

▲ **CAUTION:** The previous fault record is lost once the recorder is rearmed. *When auto-rearming is enabled, the fault record must be downloaded while the breaker is open.*

FAULT RECORDER

3
FRONT PANEL CONTROLS

INTRODUCTION

The M-0430 has been designed to be quick and easy to set and interrogate. An integral part of this design is the layout and function of the front panel indicators and controls, illustrated in Figure 4–1. For the purposes of this chapter, these controls have been divided into two groups: the user interface indicators and controls, and the target/status indicators and controls.

USER INTERFACE INDICATORS AND CONTROLS

The user interface indicators and controls consist of the Liquid Crystal Display, the **SELECT FUNCTION** and **ENTER SETPOINT** LEDs, the left- and right-arrow pushbuttons, the **EXIT** and **ENTER** pushbuttons, and the front panel knob. These controls are used by the operator to navigate the system software and set and interrogate the unit. Detailed information on using these controls is provided in Chapter 4, **Operation**.

LIQUID CRYSTAL DISPLAY

To assist the operator in setting and interrogating the M-0430, the LCD displays menus which guide the operator to the desired M-0430 function or setpoint value. These menus consist of two lines. The bottom line lists lower case abbreviations of each menu selection with the current menu selection highlighted by being in uppercase. The top menu line provides a description of the current menu selection.

While the unit is not in use, and has not tripped, the LCD is blanked and remains blanked until **ENTER** is pressed, at which time the first-level menu is displayed. If the unit has tripped, the LCD cycles through a sequence of screens summarizing the trip status conditions until **ENTER** is pressed.

SELECT FUNCTION LED

The red **SELECT FUNCTION** LED is lit when a menu is displayed on the LCD, prompting the user to choose a menu selection using either the left- and right-arrow pushbuttons or the front panel knob.

ENTER SETPOINT LED

The red **ENTER SETPOINT** LED lights to prompt the user to enter a value, such as a setpoint magnitude or time delay. Values are entered or changed by using the left- and right-arrow pushbuttons and the front panel knob to increment or decrement the currently displayed value.

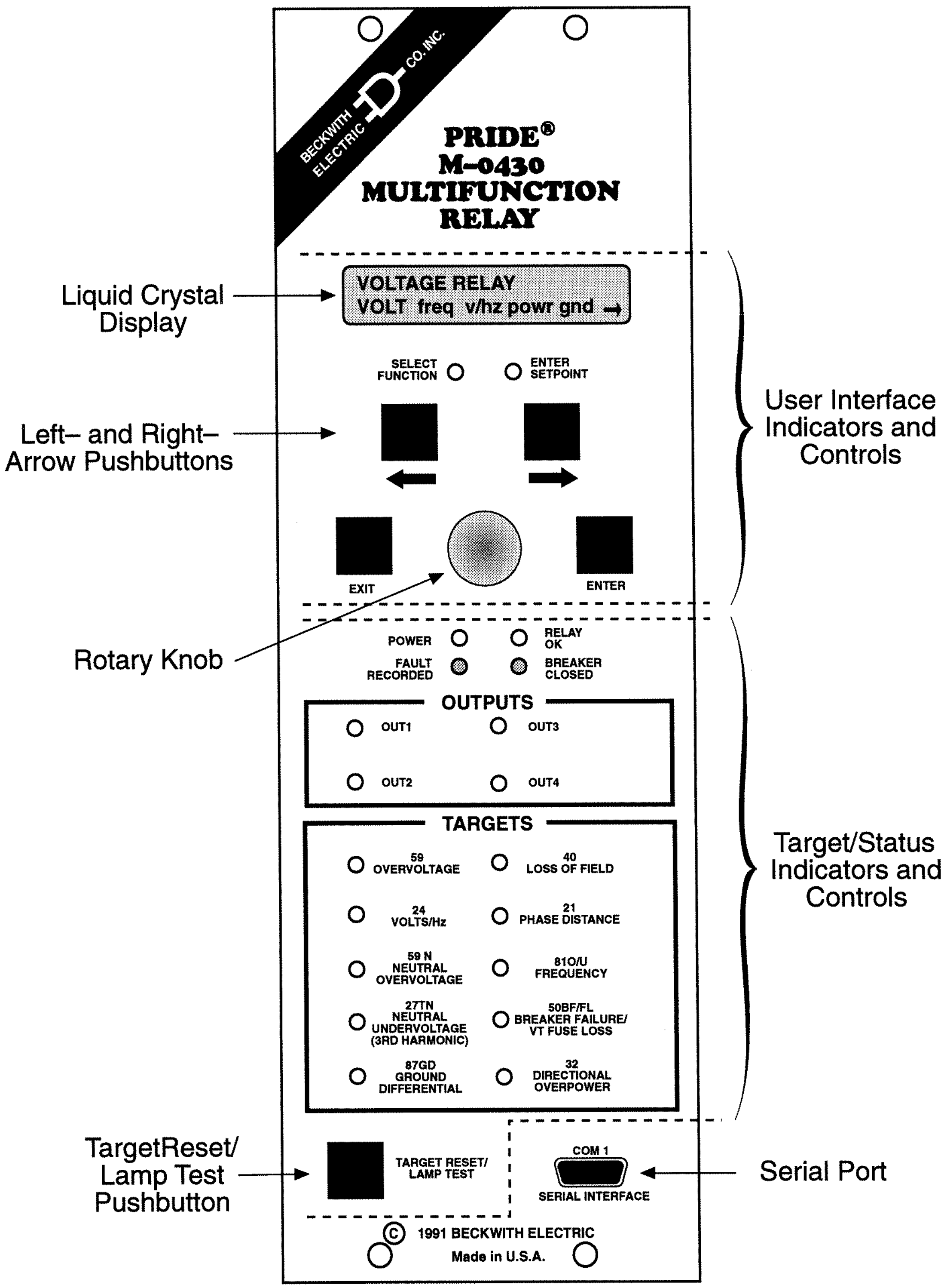


FIGURE 3–1 M-0430 Front Panel

LEFT- AND RIGHT-ARROW PUSHBUTTONS

You use the left- and right-arrow pushbuttons to choose among menu selections displayed on the LCD and, when entering values, to select the digit (by moving the cursor) of the displayed setpoint that will be incremented or decremented by turning the front panel knob.

EXIT PUSHBUTTON

Use the **EXIT** pushbutton to exit from a displayed screen to the immediately preceding menu.

ENTER PUSHBUTTON

The **ENTER** pushbutton is used to choose a highlighted menu selection, to replace a setpoint or other programmable value with the currently displayed value, or to select one of several displayed options, suchas **ENABLE** or **DISABLE** a function.

ROTARY KNOB

Use the the rotary knob to increment (by rotating clockwise) or decrement (by rotating counterclockwise) a value currently displayed on the LCD. (This new value is not stored—and does not affect the unit's calculations—until **ENTER** is pressed.) For values with a large range, the left- and right-arrow pushbuttons can be used to move the cursor (an underline) to any digit. Incrementing and decrementing will then start with the underlined digit.

You can use the rotary knob instead of the left- and right-arrow pushbuttons to choose among menu selections displayed on the LCD.

TARGET/STATUS INDICATORS AND CONTROLS

The target/status indicators and controls consist of the **POWER** and **RELAY OK** LEDs, the **FAULT RECORDED** and **BREAKER CLOSED** LEDs, the ten target LEDs, and the **TARGET RESET/LAMP TEST** pushbutton.

POWER LED

The green **POWER** LED indicator will remain lit whenever power is applied to the unit.

RELAY OK LED

The green **RELAY OK** LED is under control of the M-0430 microprocessor. You can program this LED either to flash or to remain on continuously when the relay is functioning properly. To make this selection, go to the **SETUP UNIT** menu, use the right-arrow pushbutton or rotary knob to display the **RELAY OK LED FLASH** menu, and select either **DISABLE** or **ENABLE**.

FAULT RECORDED LED

The red **FAULT RECORDED** LED will light to indicate that fault data has been recorded in the unit's memory. You can arm and disarm the fault recorder using the **FAULT RECORDER** menu selection.

BREAKER CLOSED LED

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

TARGET INDICATORS AND TARGET RESET/LAMP TEST PUSHBUTTON

Normally, the ten red **TARGET** LEDs are not lit. If the unit trips, the LEDs corresponding to the cause(s) of the trip will light and stay lit until reset, while the four **OUTPUT** LEDs will reflect the present state of the **OUT1**, **OUT2**, **OUT3**, and **OUT4** output relays. Pressing and releasing the **TARGET RESET/LAMP TEST** pushbutton will momentarily light all LEDs (providing a means to test them) and reset the target LEDs if the condition is not present. Detailed information about the cause of the last five trips is, however, retained in the unit's memory for access through the LCD display via the **VIEW TARGET HISTORY** menu.

Pressing and holding the **TARGET RESET/LAMP TEST** pushbutton will display the pick up status of the relay functions

SERIAL INTERFACES (COM 1 AND COM 2)

The **SERIAL INTERFACE COM 1** port is a standard 9-pin RS-232C communications port. This port will normally be used for local setting and interrogating of the M-0430 via a portable computer. An additional port, **COM 2**, is available at the rear of the M-0430. This 25-pin port will normally be used for remote setting and interrogation of the M-0430 via a modem and a compatible communications protocol. Detailed information on the use of the communications ports is provided in Appendix B, **Communications**, and the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

4
OPERATION

INTRODUCTION

While the M-0430 is a sophisticated unit that performs a number of complex functions, care has been taken to make it easy to use. This chapter provides general information on the software flow and the use of the front panel controls to maneuver through the menus, enter values, and set and interrogate the unit. Figure 4-1 illustrates the overall software flow. Detailed information on each menu selection is provided in Chapter 5, **Menu Reference.**

SOFTWARE FLOW

Figure 4–1 illustrates the overall software flow as displayed on the Liquid Crystal Display.

POWER-ON SELF-TEST AND STATUS SCREENS

Each time it is powered up, the M-0430 performs a number of self-tests to ensure its correct operation. During the self-tests, the LCD displays a lower-case “x” for each test successfully executed. If all tests are executed successfully, it will briefly display the word **PASS** and then a series of unit status screens, including the model number, the software version number, the serial number of the unit, the date and time as set in the system clock, and the user logo screen. (Figure 4–2 illustrates this sequence of screens.) If any test should fail, an error code will be displayed and the unit will not allow operation to proceed. In such a case, the error code should be noted and the factory contacted. A list of error codes and their descriptions is provided in the Appendix A, **Self-Test Error Codes**.

DEFAULT MESSAGE SCREENS

Normally, when the M-0430 is powered and unattended, the display is blanked to increase its lifespan. The display is automatically blanked after exiting from the main menu and from *most* other screens after 5 minutes of unattended operation.

However, if the unit has tripped and has not been reset, it will display the time and date of the trip and automatically cycle through status screens for each applicable target. (This sequence is illustrated in Figure 4–3.) In either case, pressing **ENTER** will begin local mode operation, displaying the access code entry screen or, if no access code has been defined, the first-level menu.

■ **NOTE:** Communication through the front- and rear-panel communication ports is suspended while the unit is in local mode. To resume communication and ensure security, you should always exit from the main menu after configuring or interrogating the M-0430 from the front panel.

ACCESS SCREENS

To prevent unauthorized access to the M-0430 functions, the software has the provision for assigning access codes. If access codes have been assigned, the access code entry screen, illustrated in Figure 4–4, will be displayed after **ENTER** is pressed from the default message screen (see above). The M-0430 is shipped with the access code feature disabled.

If a valid access code is entered, the unit will notify the user that access has been granted. However, on the third entry of an invalid code the unit will lock out access through the front-panel for five minutes. Detailed information on defining and entering access codes is provided below and in Chapter 5, **Menu Reference**.

MENU FLOW

If access is granted, the unit will display the first-level menu. This left-to-right scrolling menu provides access to the second-level menu which in turn provides access to the M-0430 functions. Figure 4-5 illustrates the relationship between the menu levels and the use of the front-panel controls to navigate between them. Detailed information on the use of the front-panel controls for moving between menus is provided below.

MOVING BETWEEN MENUS

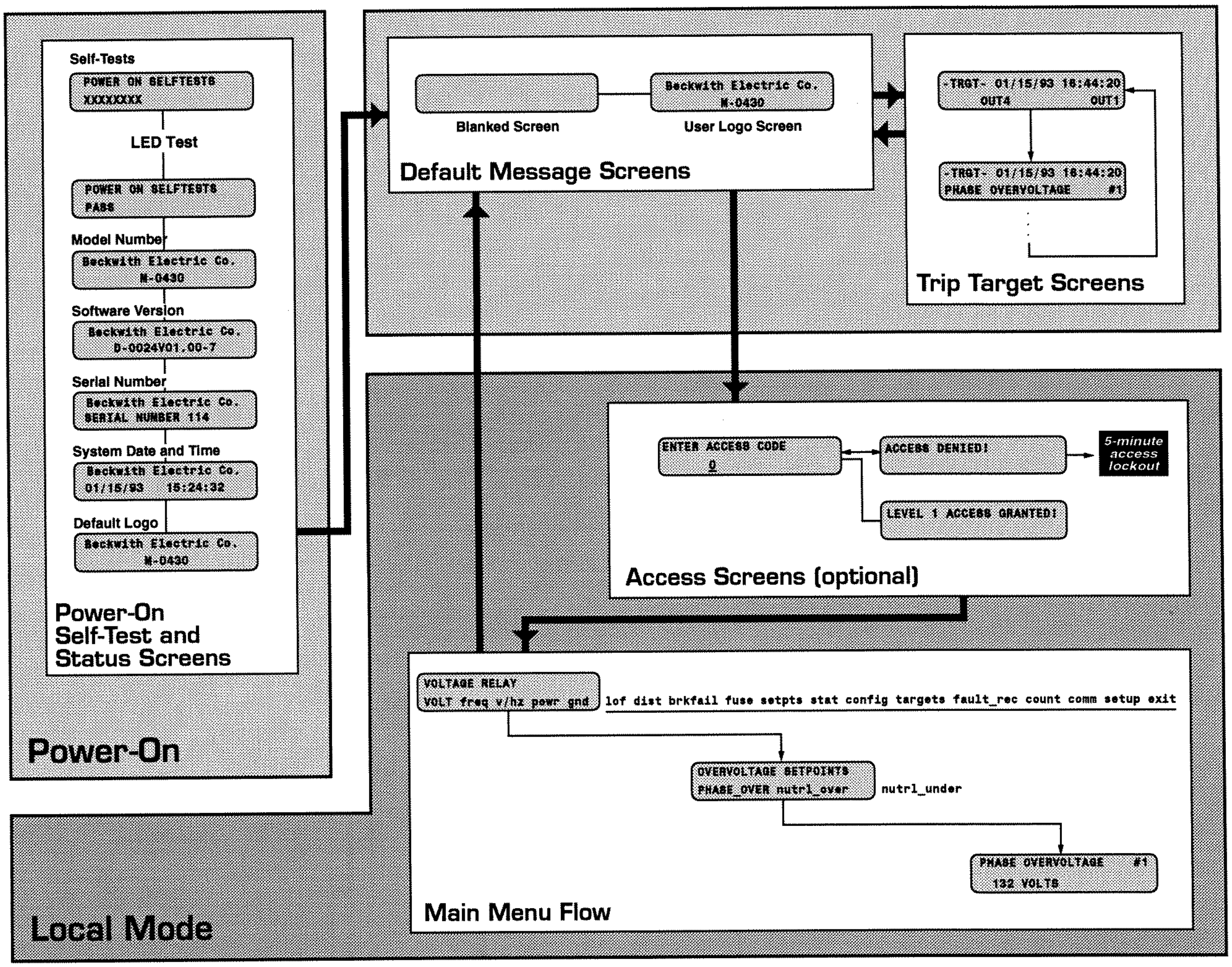
As shown in Figure 4–5, the LCD displays each menu on two lines. On the bottom line appear lower case abbreviations of each menu selection with the current menu selection "highlighted" by being displayed in upper case. A description of the highlighted menu selection is displayed on the top line of the display. The left- and right-arrow pushbuttons are used to highlight the desired menu selection. If more selections exist on a given menu than can be displayed at one time, an arrow is displayed at one or both sides of the LCD to signify that the display will scroll in that direction. As a prompt, the **SELECT FUNCTION** LED lights to signify that a menu selection should be made.

Once the desired menu selection has been highlighted, it is chosen by pressing the **ENTER** pushbutton. Depending on the menu selection chosen, the LCD will then display either a second-level menu (with the **SELECT FUNCTION** LED lit), a value to be inspected or changed, or a choice to be made, such as enable or disable. (If a value can be changed or a selection can be made, the **ENTER SETPOINT** LED will be lit.)

ENTERING VALUES

Numeric values must be entered for the M-0430 setpoints, for certain configuration data, and for access codes. When a value must be entered, the unit will light the **ENTER SETPOINT** LED as a prompt.

A value is entered or changed by incrementing or decrementing the currently displayed value using the rotary knob. Turning the knob clockwise will increment the displayed value. Turning the knob counter-clockwise will decrement the displayed value.



■ NOTE: Communications through the front- and rear-panel communications ports is suspended while the M-0430 is in local mode.

FIGURE 4–1 Software Flow

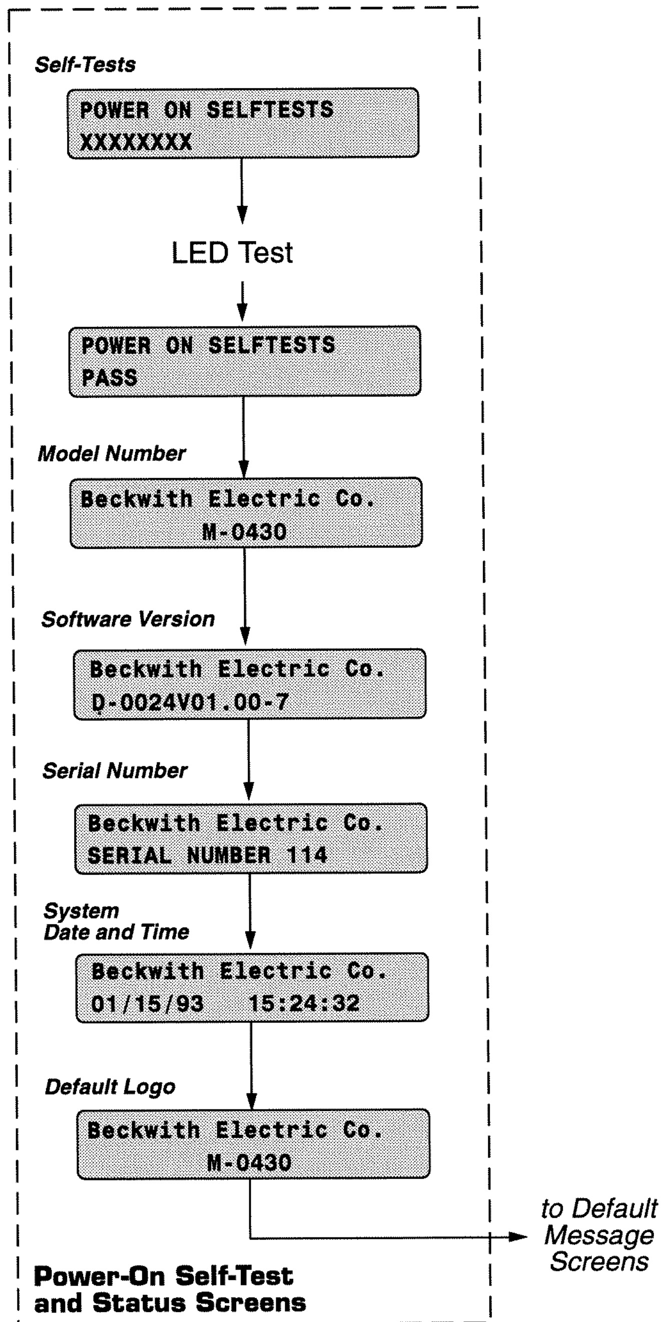


FIGURE 4–2 Power-On Self-Test and Status Screens

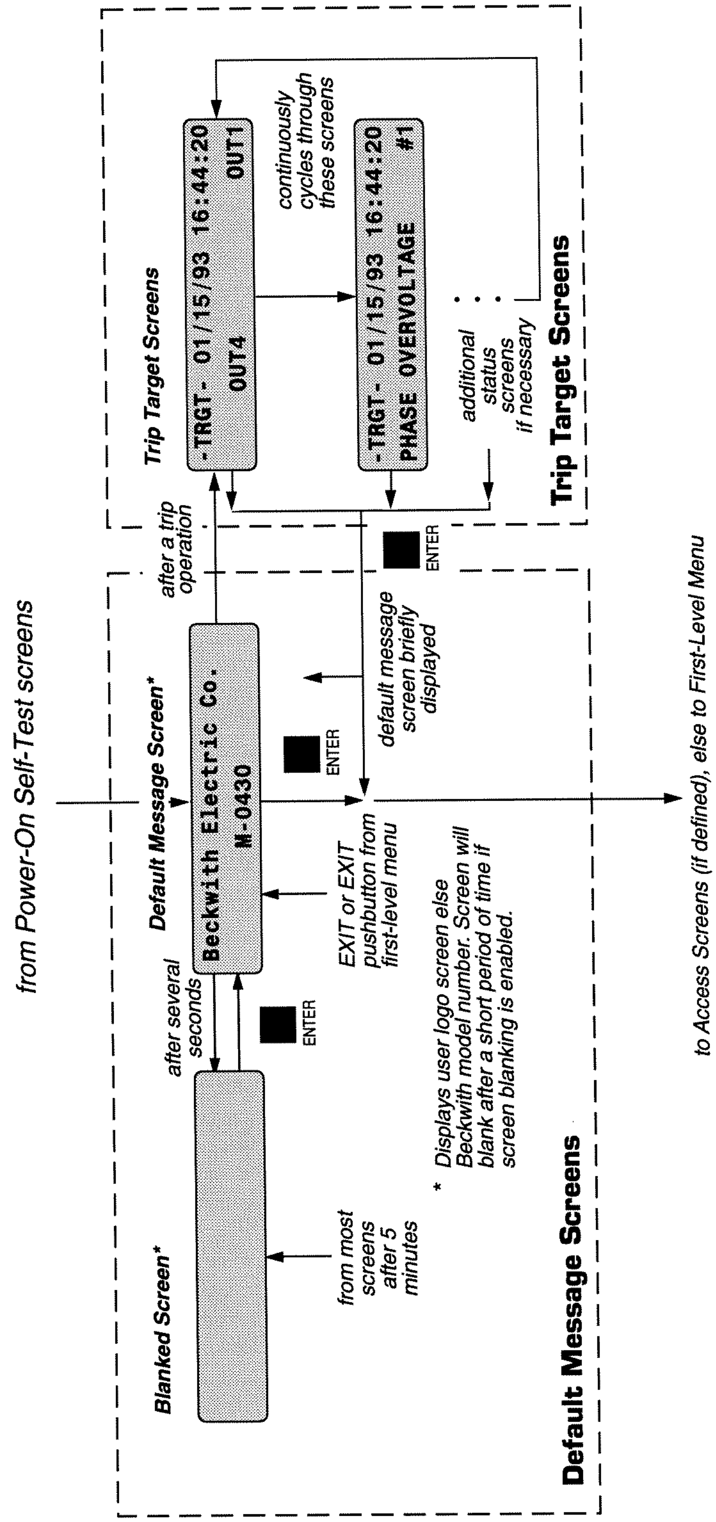


FIGURE 4–3 Default Message Screens

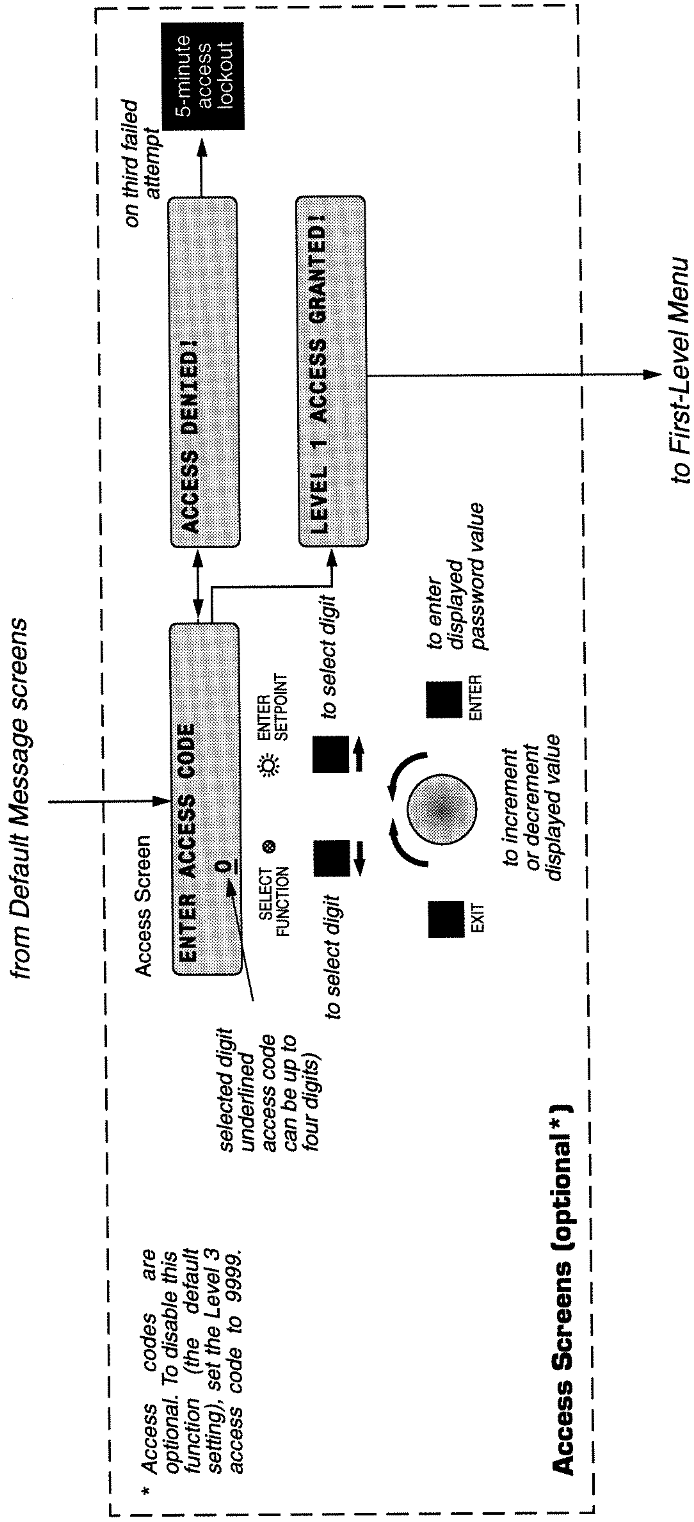


FIGURE 4–4 Access Screens

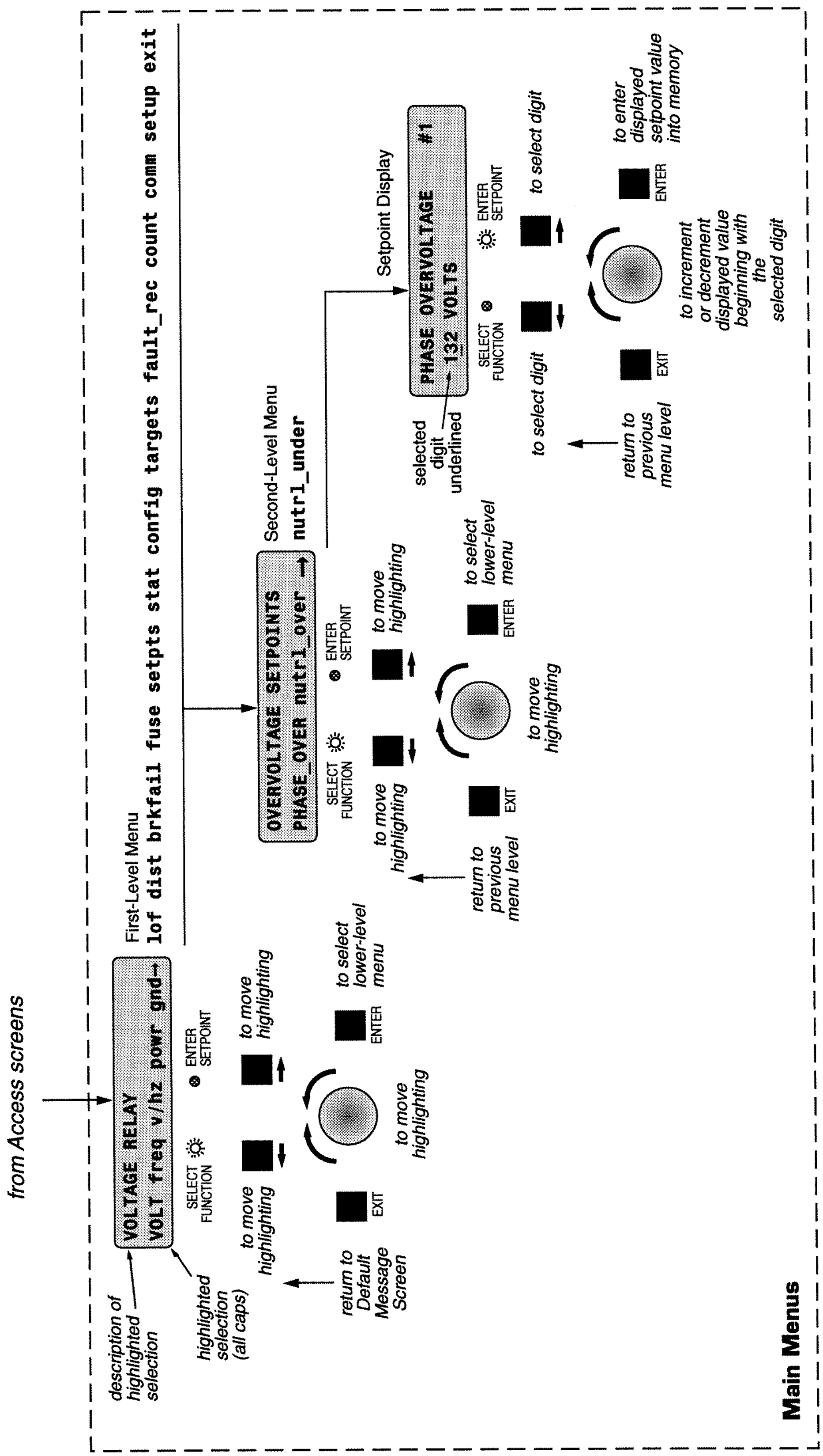


FIGURE 4–5 Front-Panel Operation

■ **NOTE:** While the rotary knob has click detents, these are only to provide tactile feedback to the user. Passing one detent does not necessarily mean that the displayed value will be incremented or decremented by one. Turning the knob too quickly may result in an unanticipated change in the displayed value.

As shown in Figure 4–5, an underline cursor is displayed in the position of the least significant digit of the value to be entered or changed. When the value to be incremented has a wide range, the left- or right-arrow pushbuttons can be used to move the underline to any displayed digit. (Although leading zeros are replaced with spaces, the cursor may be moved to any significant position.) Turning the rotary knob will increment or decrement the value beginning with the underlined digit.

Once the value is set, press the **ENTER** pushbutton to store the new value into the unit's memory. In most cases, it will become the active setpoint as soon as **ENTER** is pressed (unless inhibited by the presence of another function).

■ **NOTE:** The M-0430 will not allow you to enter a digit out of the applicable range of values. See the table of values for each function in Chapter 2, **Application**, for a detailed listing of the setpoint ranges and initial settings.

ACCESS CODES

The M-0430 supports three levels of access codes. Depending on the access code they hold, users have varying levels of access to the M-0430:

⚠3 Level 3 access—access to all relay functions

⚠2 Level 2 access—read and change setpoints, monitor status, view target history

⚠1 Level 1 access—read setpoints, monitor status, view target history

■ **NOTE:** The icons shown above are used in Chapter 5, **Menu Reference**, of this manual to specify the operations available at each access level.

Each access code is a user-defined one- to four-digit number. *If the Level 3 access code is set to 9999, the access code feature is disabled.* When access codes are disabled, the access screens are bypassed. Access codes are entered in the same manner as any other value, using the rotary knob (and the left- and right-arrow pushbuttons, if desired). Access codes can be altered by choosing the **ALTER ACCESS CODES** menu section under the **SETUP UNIT** menu.

▲ **CAUTION**: If you forget your access code, you will have to contact the factory for information on resetting the unit.

ENABLING AND DISABLING RELAY FUNCTIONS

Each function on the M-0430 can be individually enabled or disabled via the **CONFIGURE RELAYS** menu selection. To enable or disable a function, use the rotary knob to select the **ENABLE** or **DISABLE** choice for the appropriate function and press **ENTER**. (The selected choice is displayed in capital letters.) A disabled function *will not appear* under any other menu or screen. The screen below shows the **PHASE OVERVOLTAGE #1** function enabled.

```
PHASE OVERVOLTAGE      #1
disable ENABLE
```

■ NOTE: Functions having two setpoints are shipped with the number second setpoint disabled. Disabling unused functions improves the response time of the indicators and controls.

PROGRAMMABLE OUTPUT CONTACTS

The M-0430 has five programmable output contacts, OUT1, OUT2, OUT3, OUT4, and OUT5. Each *enabled* relay function can be programmed to activate one or more of these contacts.

When a function is enabled via the **CONFIGURE RELAYS** menu selection (see above), the unit will next display the output contact screen for that function. To select an output contact to be activated by that function, use the arrow keys to move the cursor to the desired contact, and then rotate the rotary knob to select or de-select the contact (selected contacts are displayed in capital letters). Repeat the process for each contact you wish to be activated by this function. The screen below illustrates the **PHASE OVERVOLTAGE #1** function (setpoint) programmed to activate output contact OUT1 (only).

```
PHASE OVERVOLTAGE      #1
out5 out4 out3 out2 OUT1
```

■ NOTE: *At least one* output contact must be selected for an enabled function. If no output contact is selected, the unit will disable that function upon the operator leaving this screen.

STATUS INPUT BLOCKING

The M-0430 has three status inputs, BLOCK1, BLOCK2, and BLOCK3. Each *enabled* relay function (except 50BF and FL) can be programmed to be blocked by any, all or none of these inputs. BLOCK1 also serves as the 52b input. BLOCK2 can be used as the 60FL input, and BLOCK3 can be used as an external Breaker Failure Initiate (BFI) to the breaker-failure function.

After the output contact(s) have been selected for a function, the unit will next display the blocking input screen for that function. To select an input to block the displayed function, use the arrow keys to move the cursor to the desired input, and then rotate the rotary knob to select or de-select the input (selected inputs are displayed in capital letters). Repeat the process for each input you wish to have block this function. The screen below illustrates the **PHASE-OVERVOLTAGE #1** function (setpoint) programmed to be blocked by BLOCK1 (nominally the 52b status input).

```
PHASE OVERVOLTAGE     #1
      blk3 blk2 BLK1
```

5
MENU REFERENCE

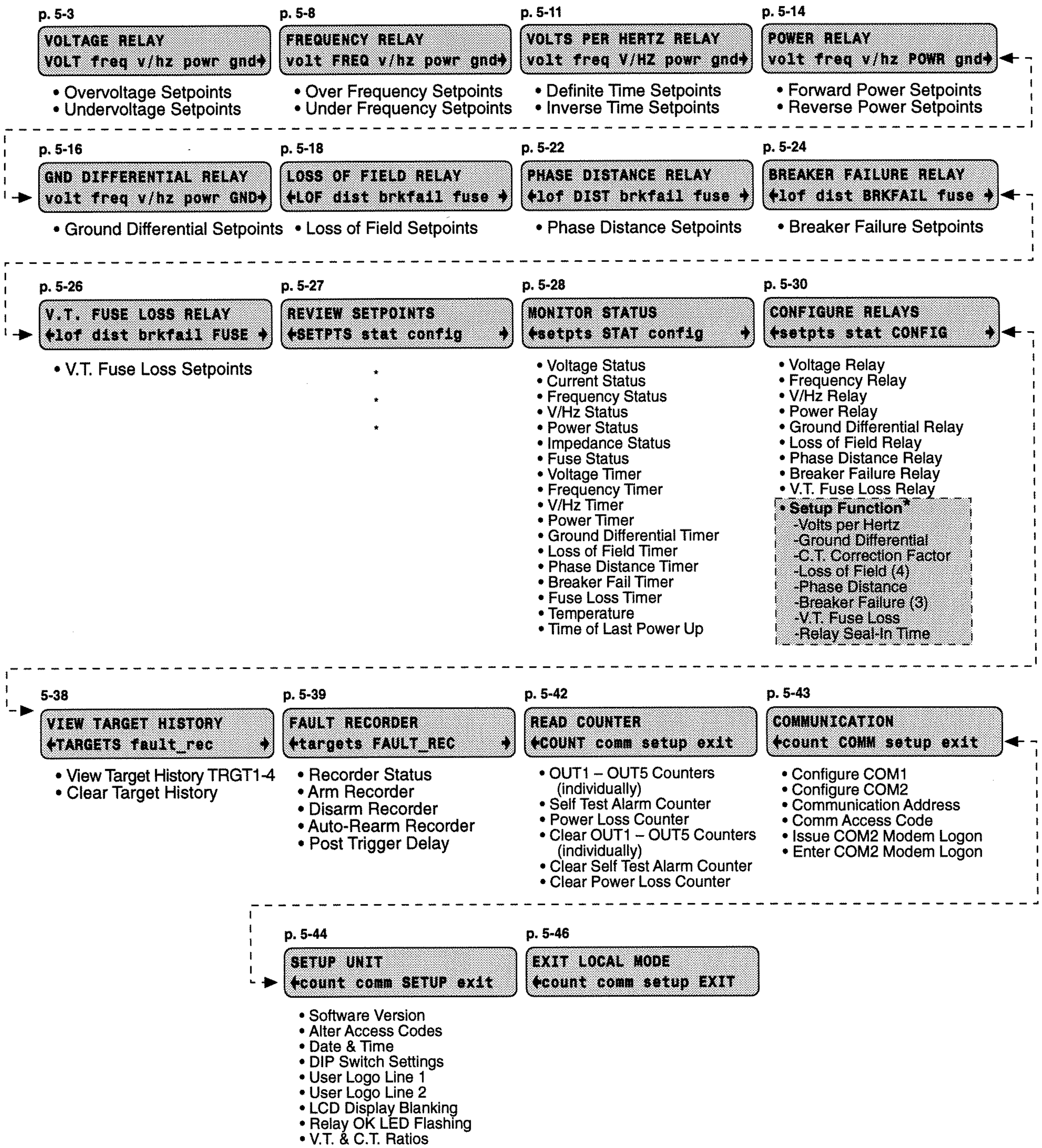
This section provides a short description for each main menu selection available in the M-0430 version 1.00-7 software. Flowcharts are provided for the relay configuration. (Figure 5–1 summarizes the M-0430 main menu flow.) The functions in this chapter are presented in the same order as on the main menu.

■ **NOTES**:

① The flowcharts provided in this chapter provide a *simplified* view of the M-0430 functions. For a detailed explanation of entering and editing values, and configuring relay functions, refer to Chapter 4, Operation in this manual.

② The flowcharts provided illustrate the software flow for the situation where *all* functions are enabled and for a user who has an access level of 3 (or the case where the access level feature has been disabled). On your unit, functions or setpoints that have been disabled will *not* appear except under the **CONFIGURE RELAY** menu selection. (Remember that functions with two setpoints are shipped with the second setpoint disabled.) Users with an access level of 1 or 2 *will not* have access to all features shown and will, in some cases, be able to display but not change values. Notes on what features are available to holders of each access level are provided for each function.

③ Setpoint **Configuration Record Forms** are provided in Appendix D. These forms provide a comprehensive, standardized means of recording setpoint values.



*■ **NOTE**: The **SETUP FUNCTION** submenu under the **CONFIGURE RELAYS** menu provides setup parameters for several relay functions.

FIGURE 5–1 M-0430 Main Menu Flow

VOLTAGE RELAY

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

3 Read and Change Setpoints

2 Read and Change Setpoints

1 Read Setpoints

The **VOLTAGE RELAY** menu selection provides access to the voltage functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

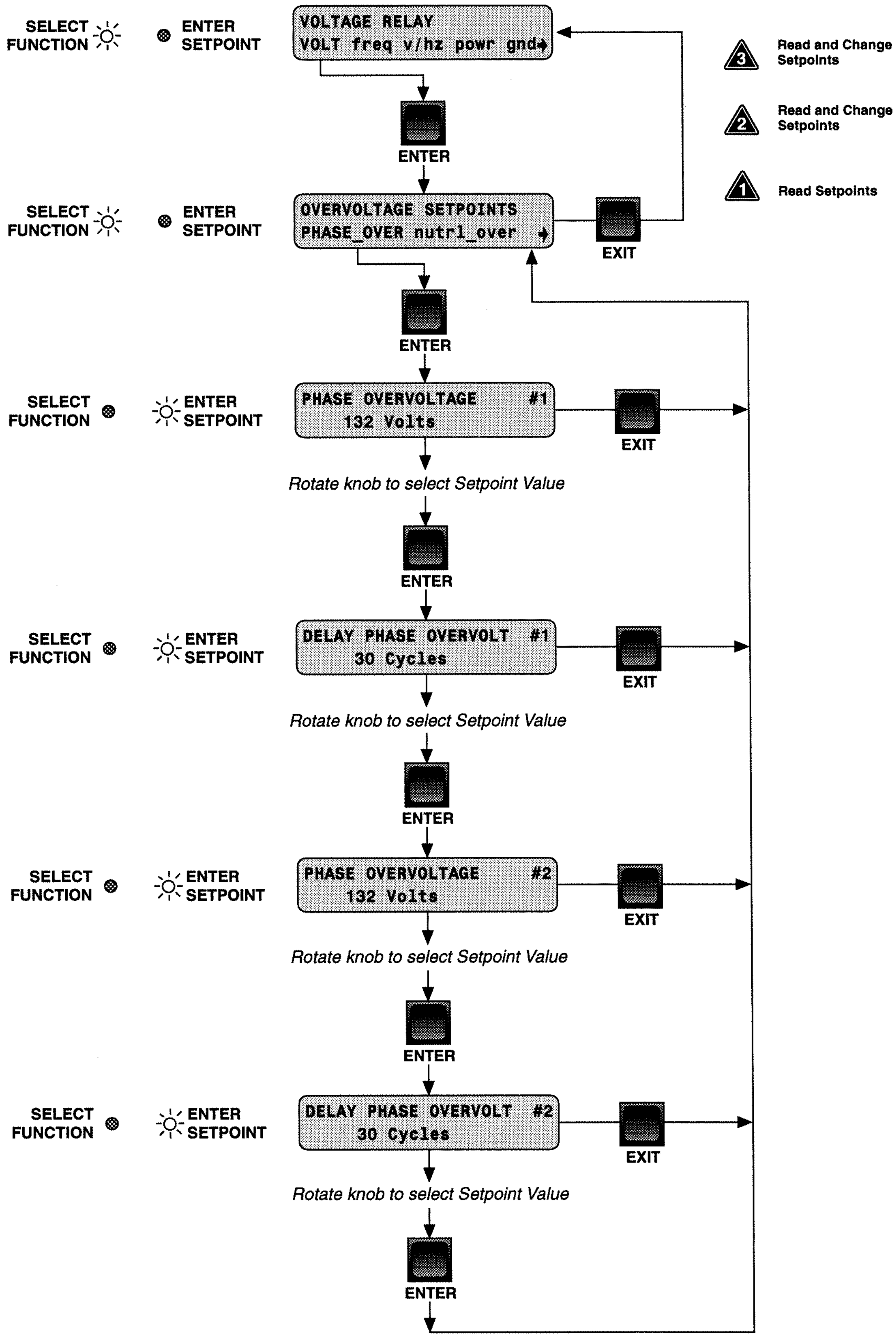


FIGURE 5–2 Voltage Relay: Phase Overvoltage Setpoints

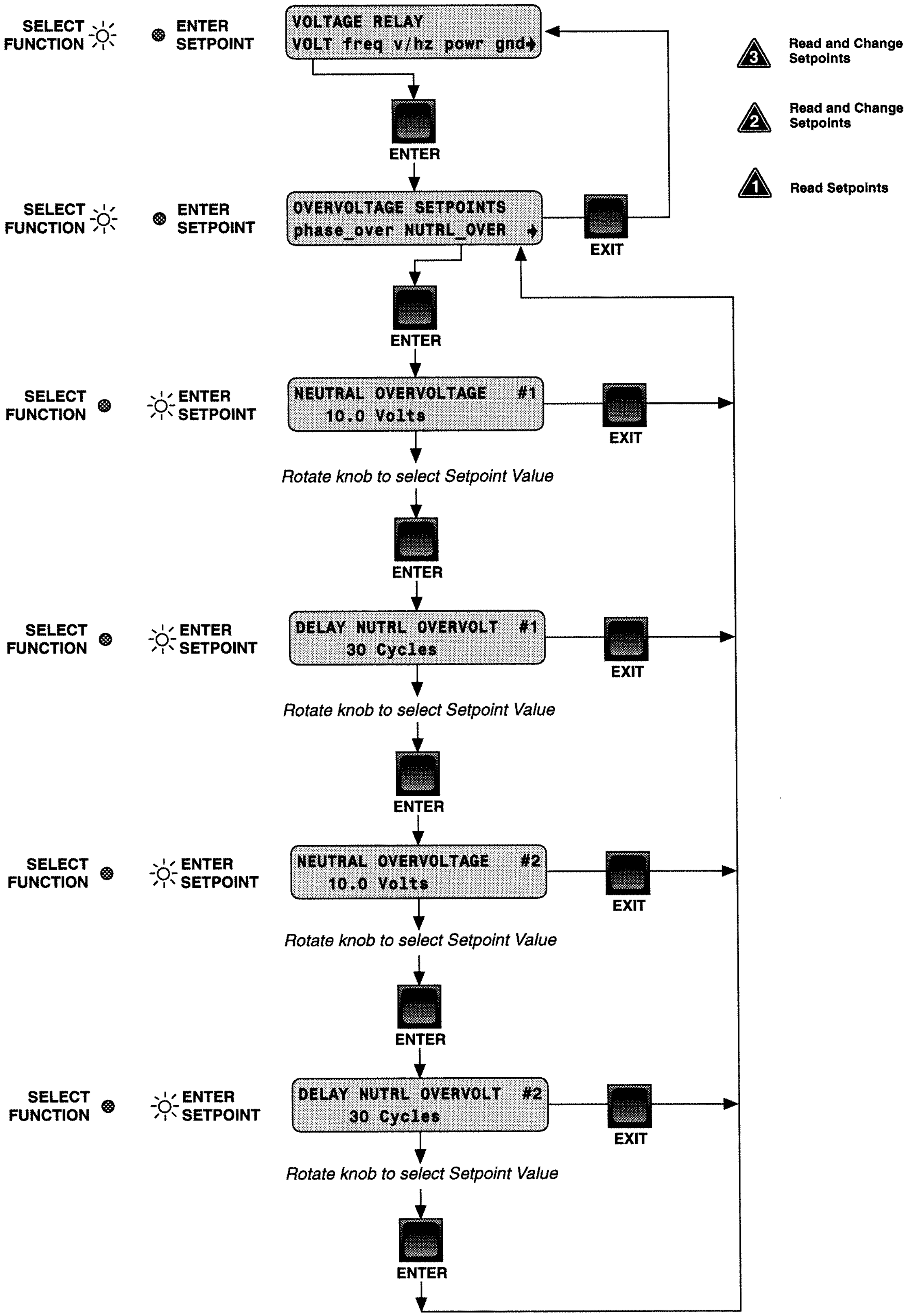


FIGURE 5–3 Voltage Relay: Neutral Overvoltage Setpoints

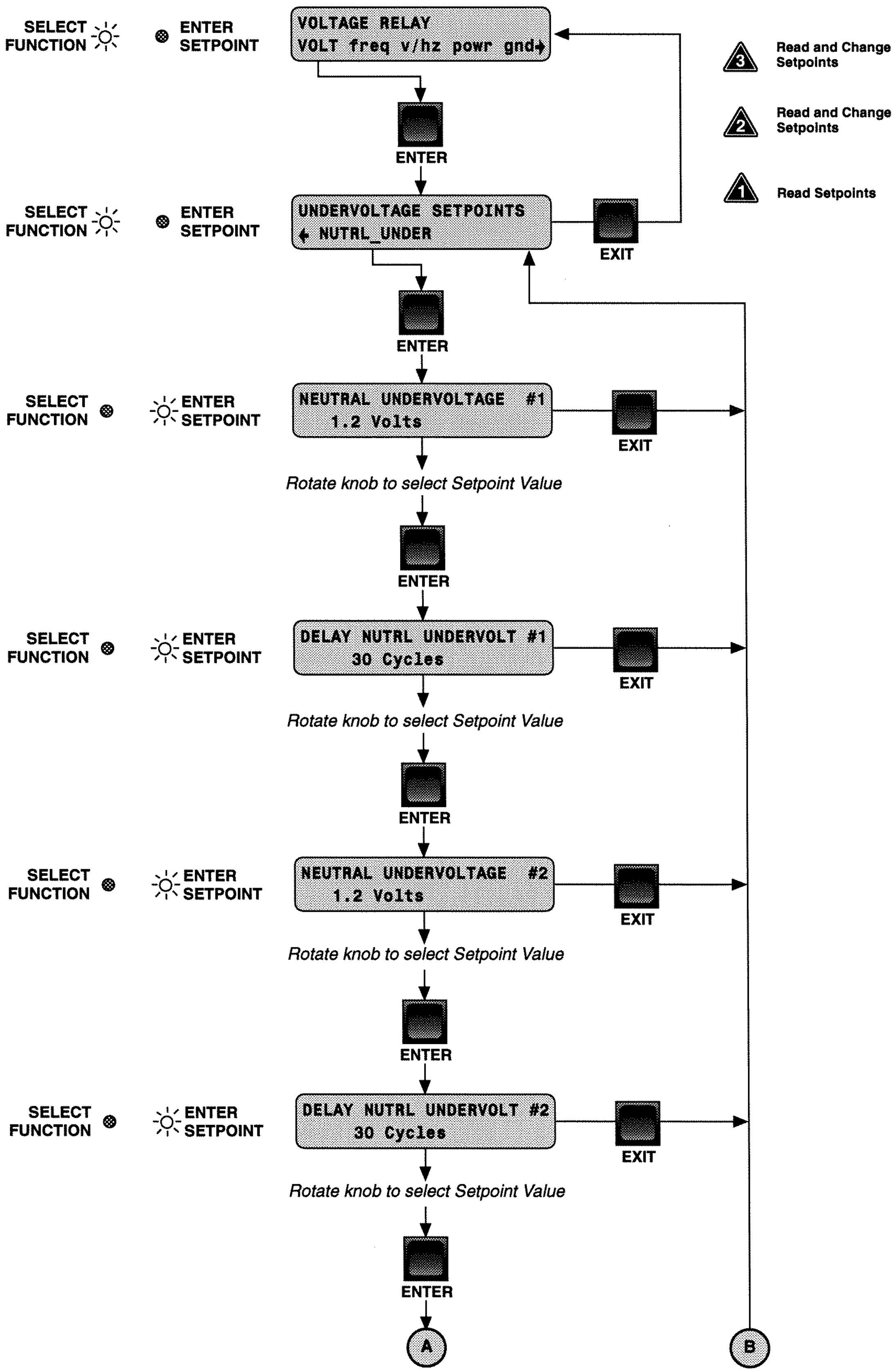


FIGURE 5–4 Voltage Relay: Neutral Undervoltage Setpoints

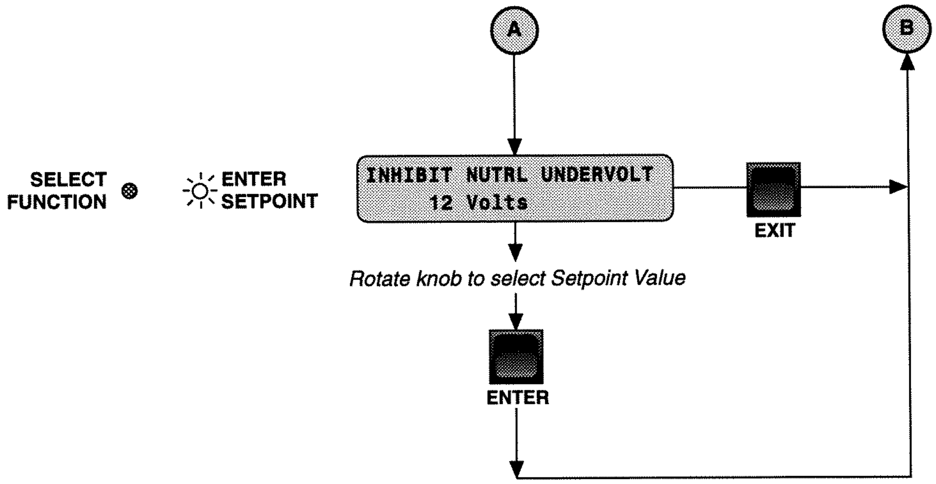


FIGURE 5–5 Voltage Relay: Neutral Undervoltage Setpoints (continued)

FREQUENCY RELAY

```
FREQUENCY RELAY
volt FREQ v/hz powr gnd→
```

3 Read and Change Setpoints

2 Read and Change Setpoints

1 Read Setpoints

The **FREQUENCY RELAY** menu selection provides access to the frequency functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

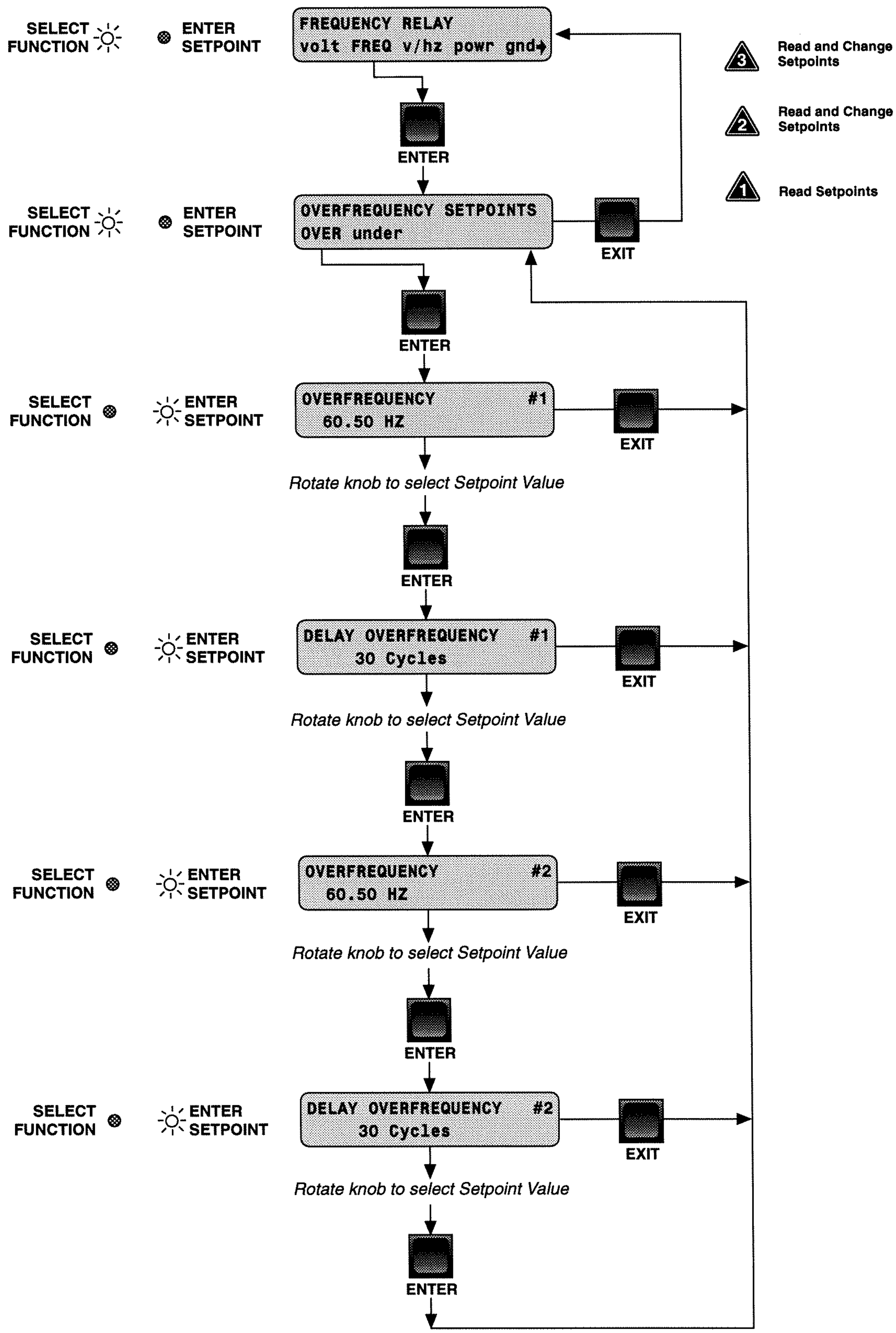


FIGURE 5–6 Frequency Relay: Overfrequency Setpoints

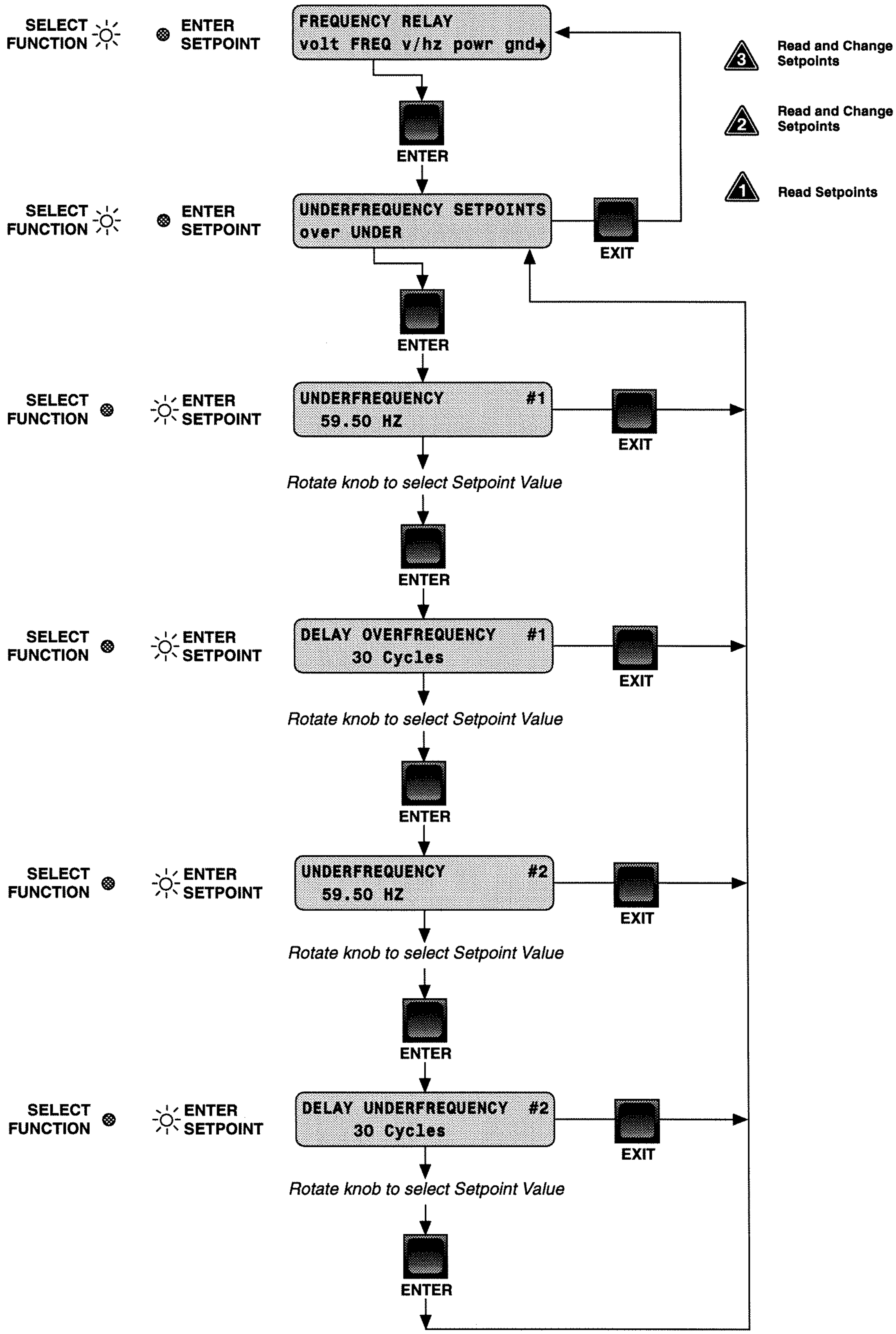


FIGURE 5–7 Frequency Relay: Underfrequency Setpoints

VOLTS PER HERTZ RELAY

```
VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→
```

3 **Read and Change Setpoints**

2 **Read and Change Setpoints**

1 **Read Setpoints**

The **VOLTS PER HERTZ RELAY** menu selection provides access to the volts-per-hertz functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

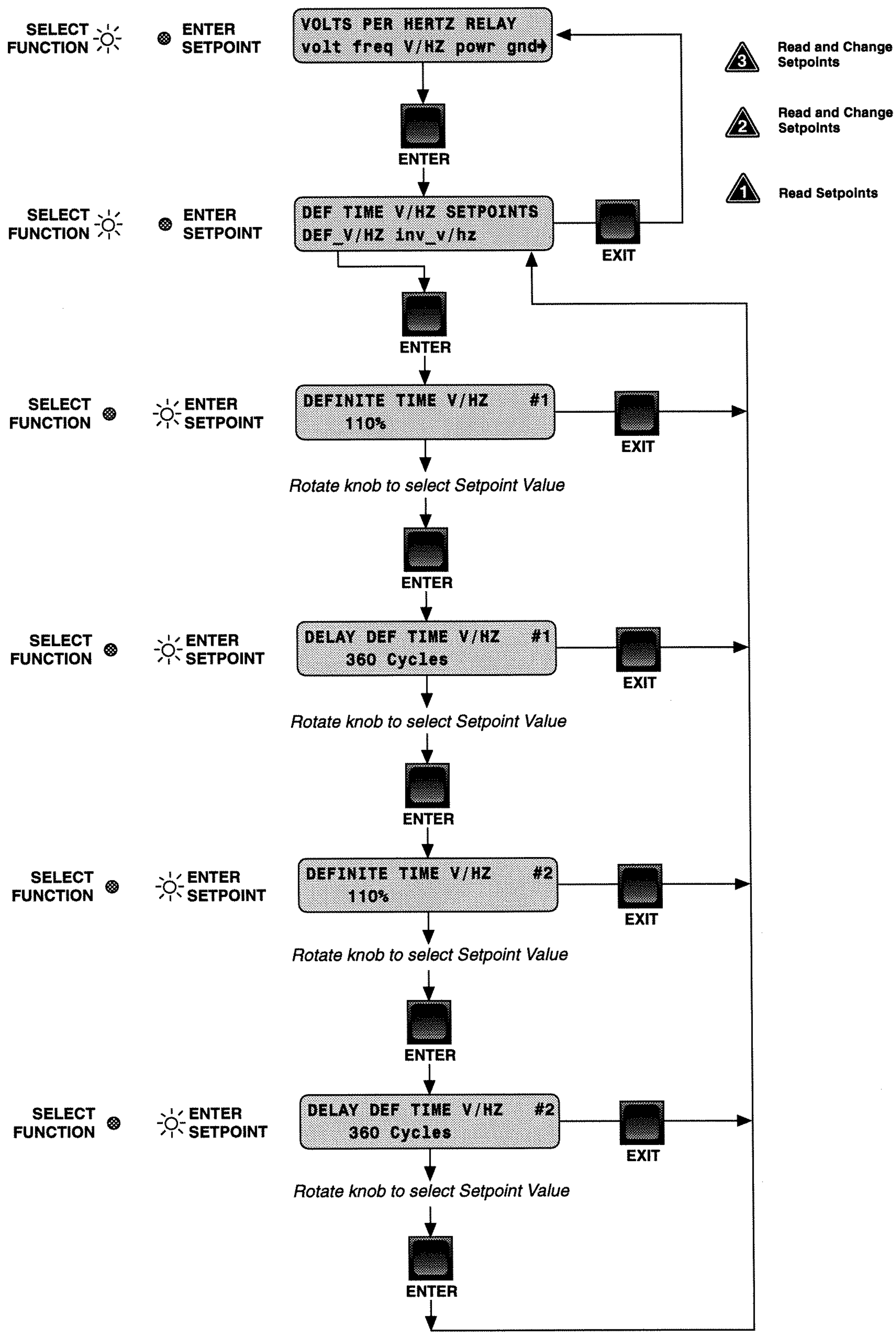


FIGURE 5–8 Volts-per-Hertz Relay: Definite Time Setpoints

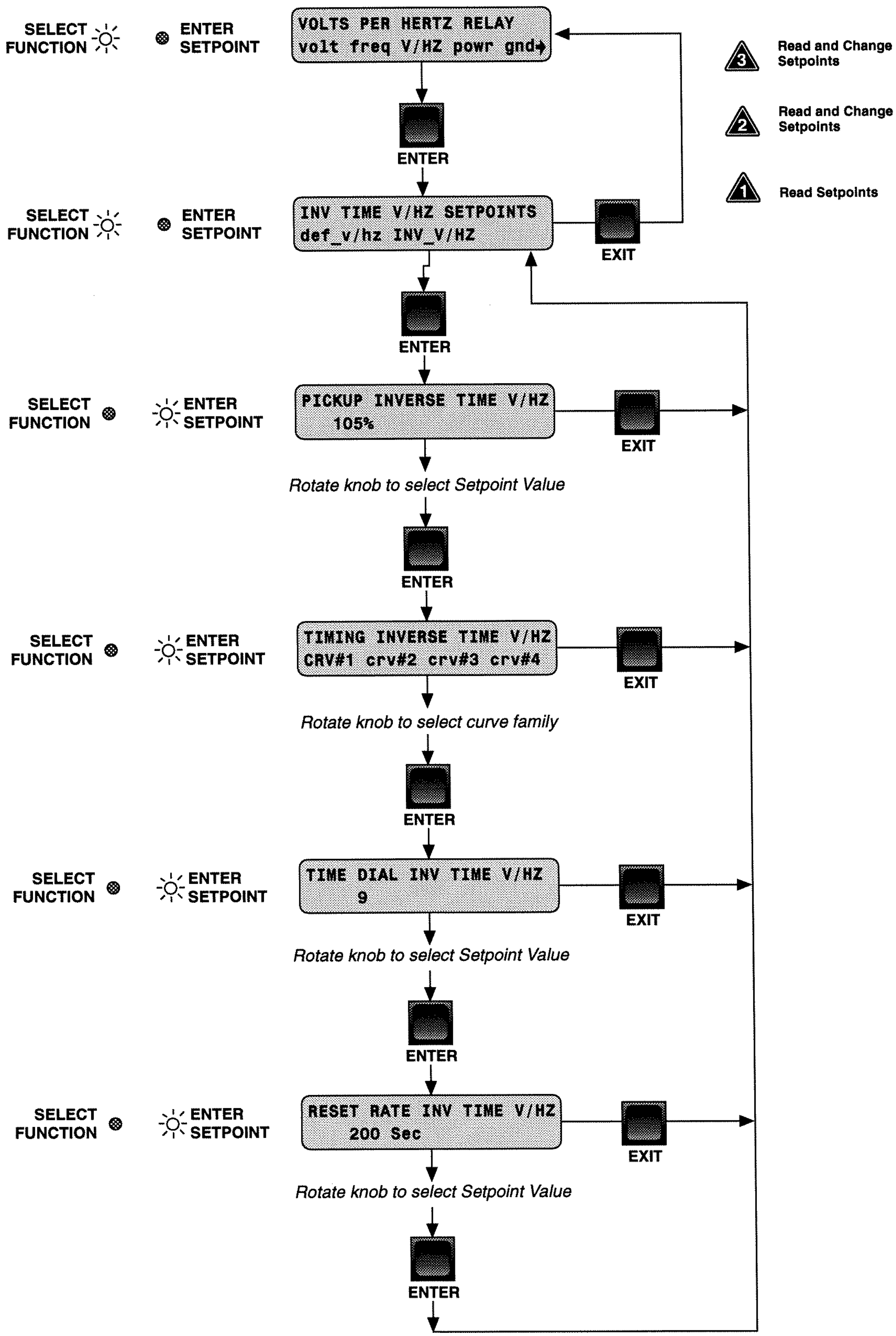
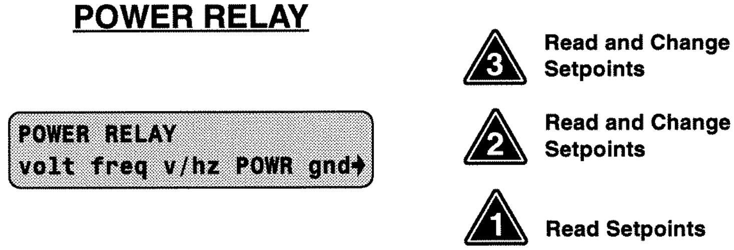


FIGURE 5–9 Volts-per-Hertz Relay: Inverse Time Setpoints

POWER RELAY



The **POWER RELAY** menu selection provides access to the power functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

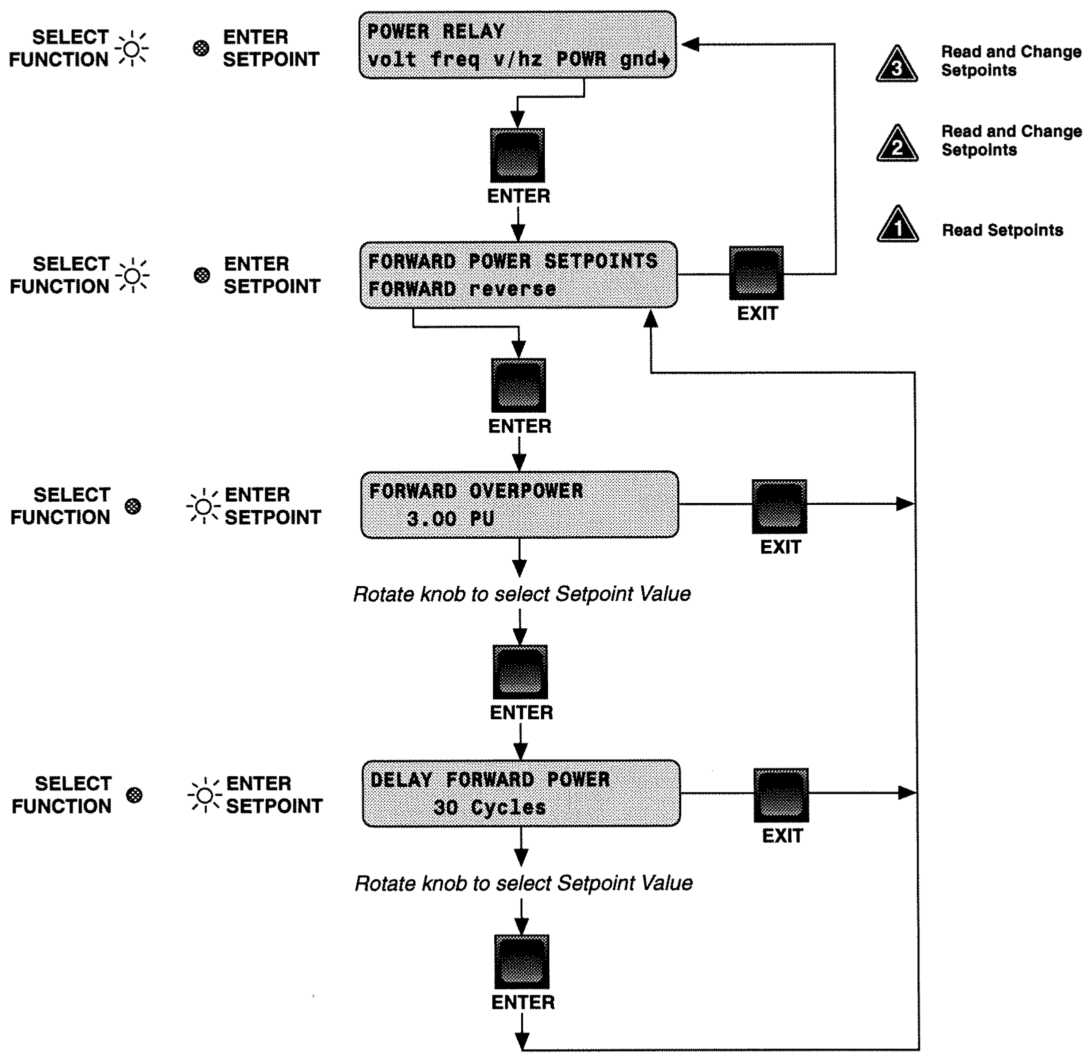


FIGURE 5–10 Power Relay: Forward Power Setpoints

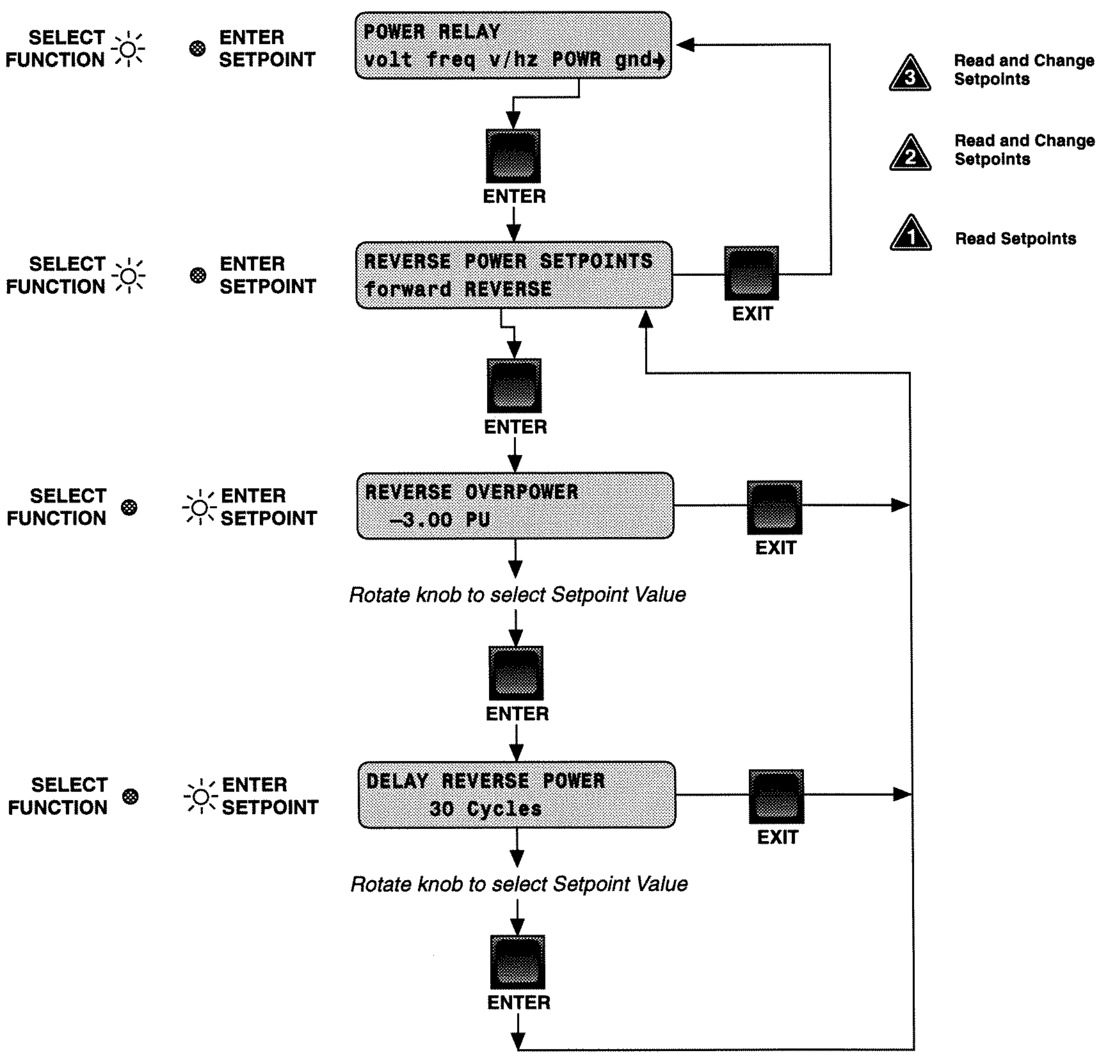


FIGURE 5–11 Power Relay: Reverse Power Setpoints

GROUND DIFFERENTIAL RELAY

```
GND DIFFERENTIAL RELAY
volt freq v/hz powr GND→
```

3 **Read and Change Setpoints**

2 **Read and Change Setpoints**

1 **Read Setpoints**

The **GROUND DIFFERENTIAL RELAY** menu selection provides access to the ground differential functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

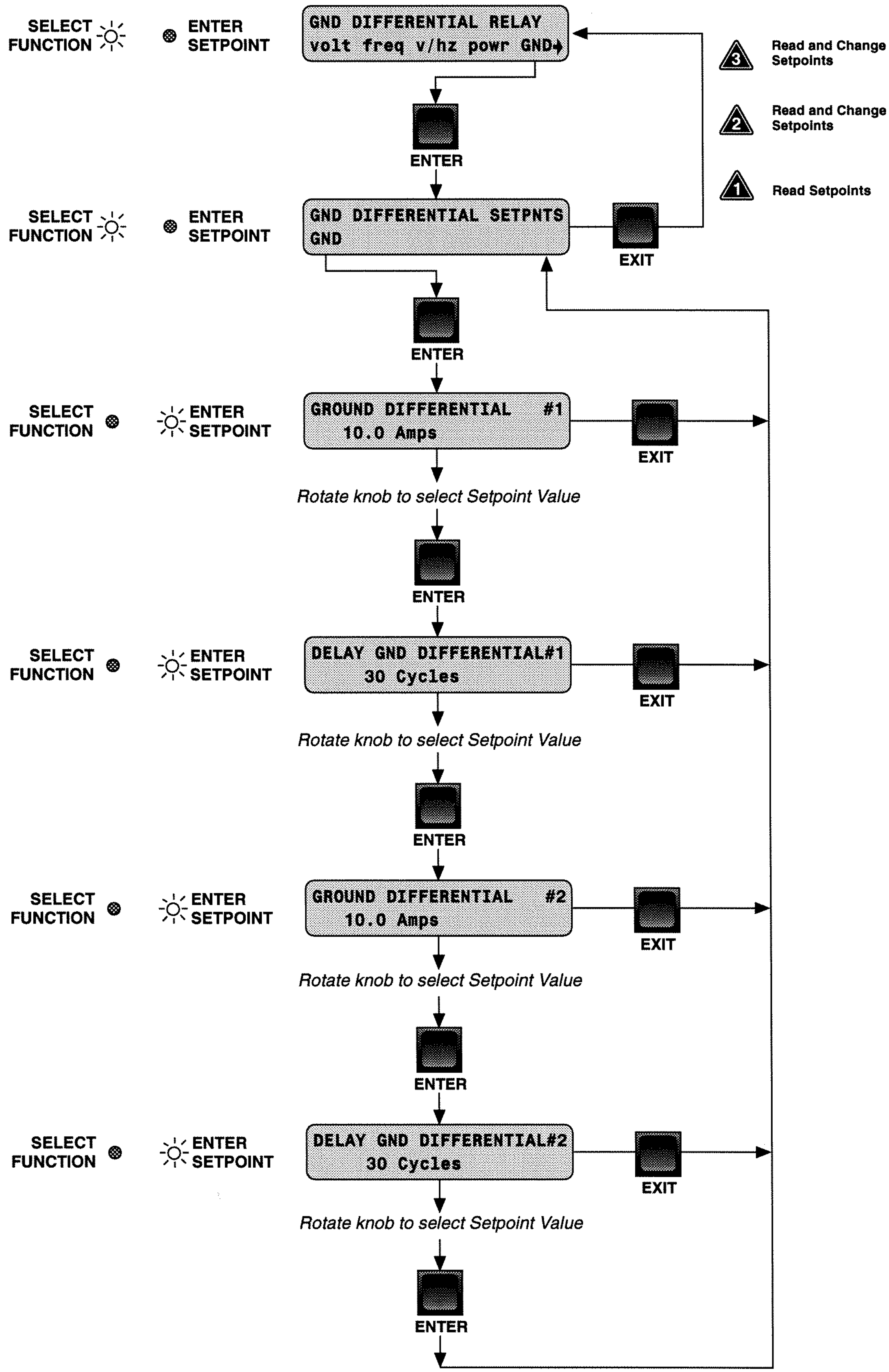


FIGURE 5–12 Ground Differential Relay Setpoints

LOSS OF FIELD RELAY

```
LOSS OF FIELD RELAY
←LOF dist brkfail fuse →
```

3 **Read and Change Setpoints**

2 **Read and Change Setpoints**

1 **Read Setpoints**

The **LOSS OF FIELD RELAY** menu selection provides access to the loss-of-field functions of the M-0430. Setpoint ranges and initial settings are provided in the **M-0430 Application Guide** and **Specifications**.

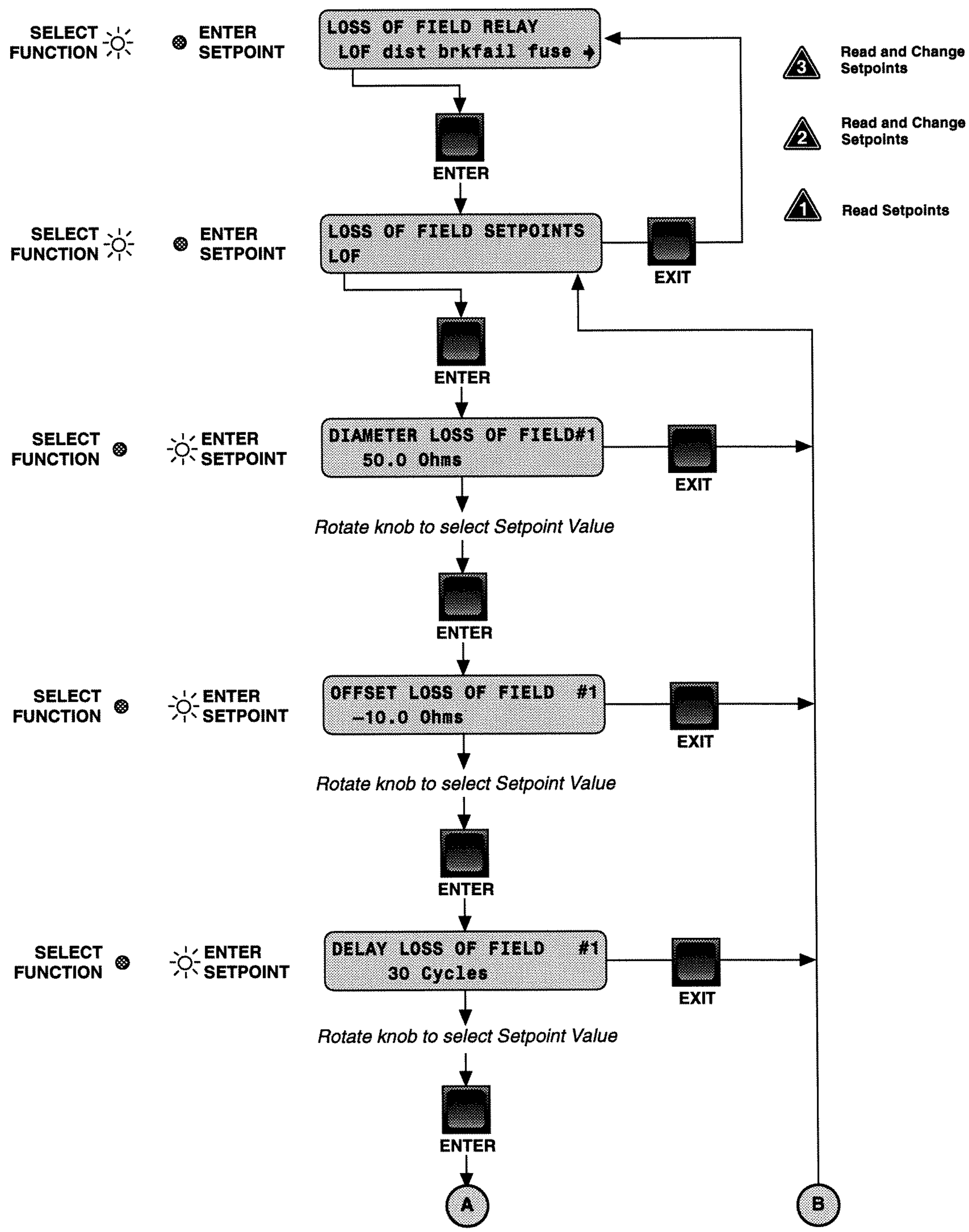


FIGURE 5–13 Loss-of-Field Relay Setpoints

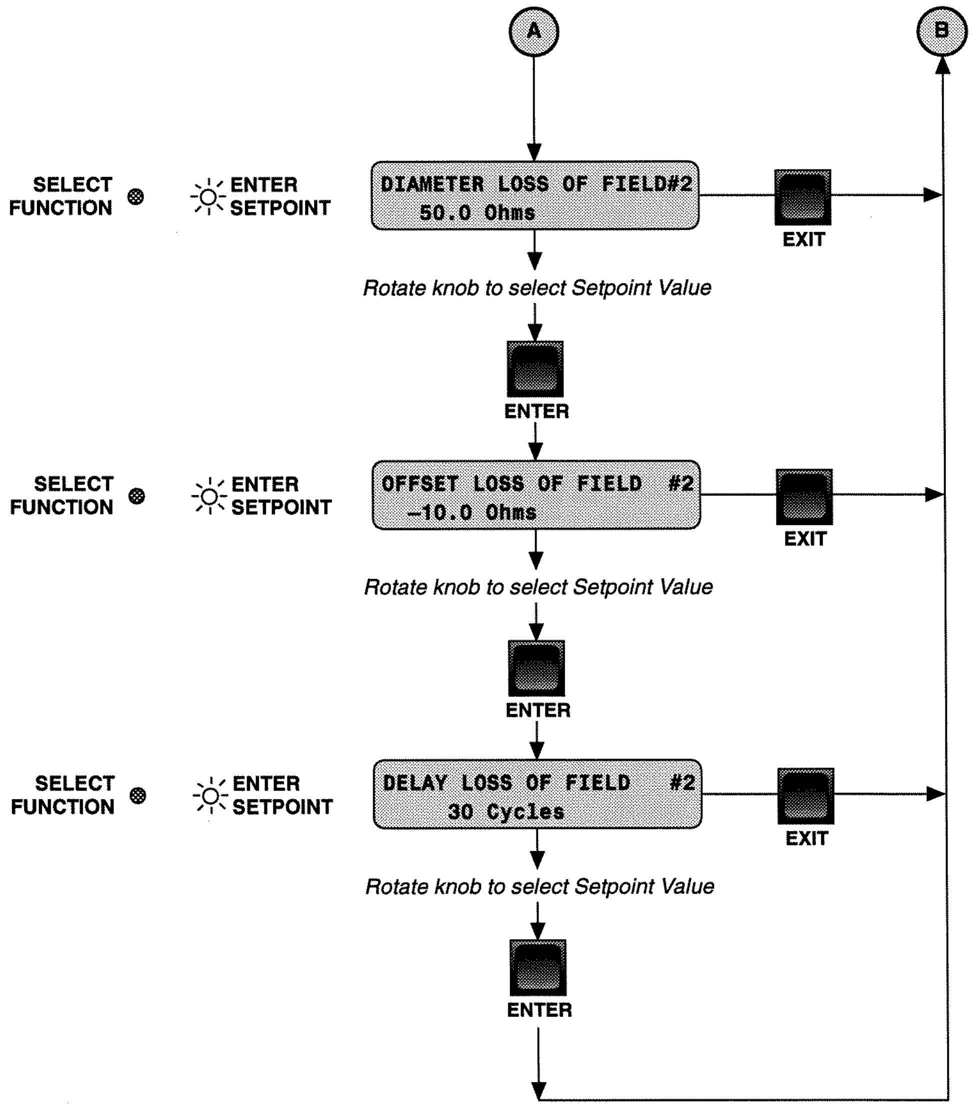


FIGURE 5–14 Loss-of-Field Relay Setpoints (continued)

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PHASE DISTANCE RELAY

Read and Change Setpoints (level 3)

Read and Change Setpoints (level 2)

Read Setpoints (level 1)

```
PHASE DISTANCE RELAY
←lof DIST brkfail fuse →
```

The **PHASE DISTANCE RELAY** menu selection provides access to the phase distance functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

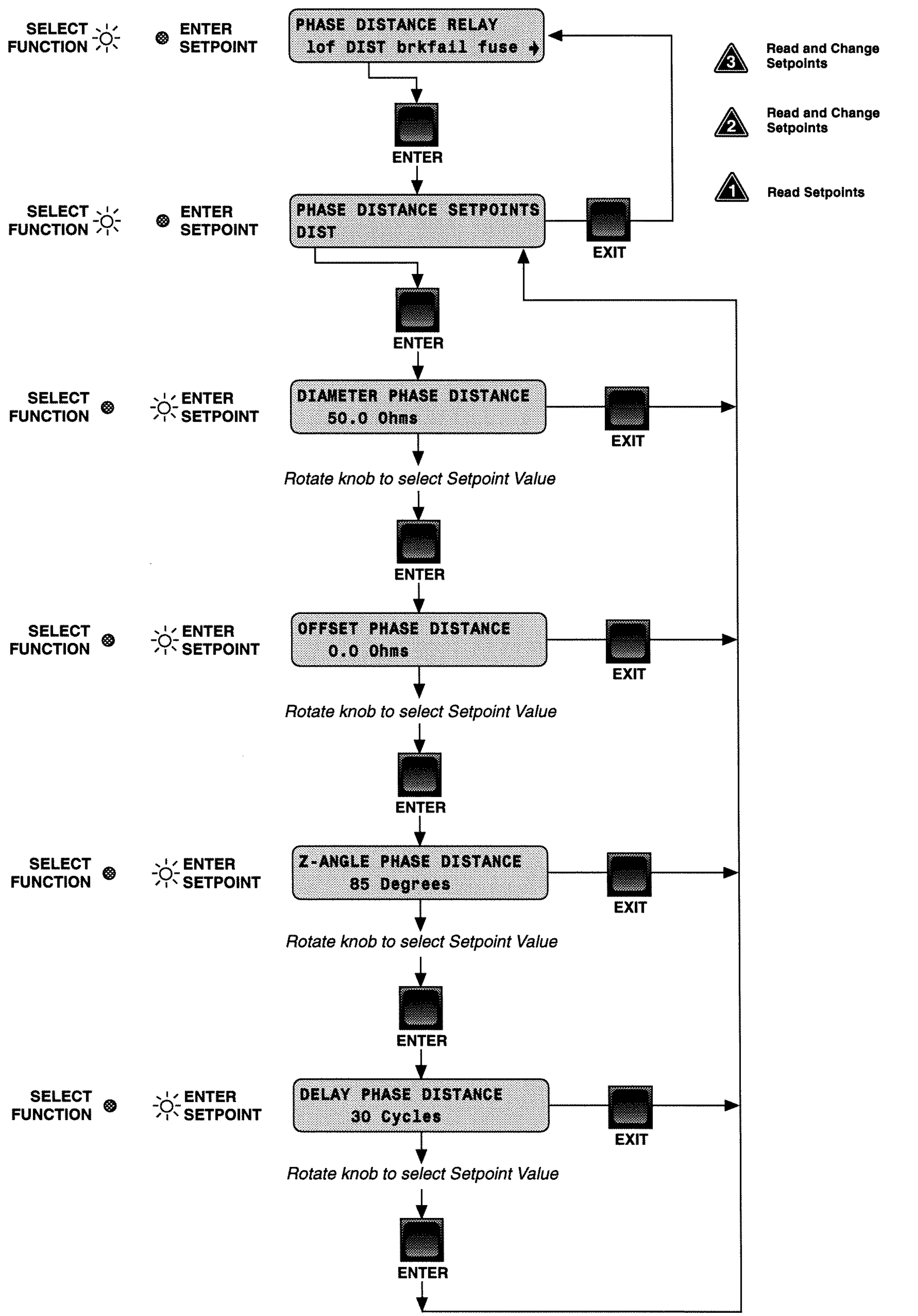


FIGURE 5–15 Phase Distance Relay Setpoints

BREAKER FAILURE RELAY

```
BREAKER FAILURE RELAY
←lof dist BRKFAIL fuse →
```

3 **Read and Change Setpoints**

2 **Read and Change Setpoints**

1 **Read Setpoints**

The **BREAKER FAILURE RELAY** menu selection provides access to the breaker failure functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

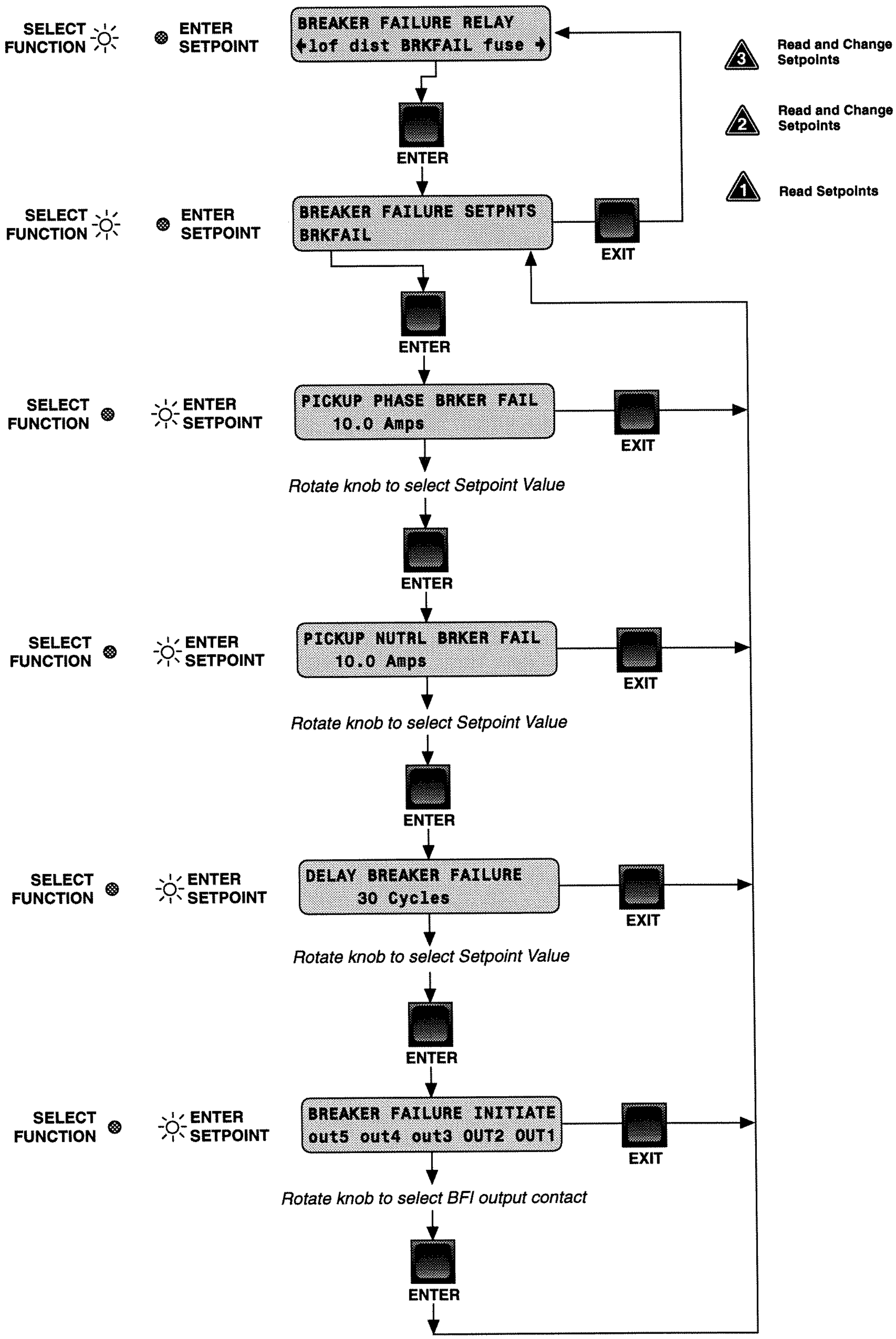
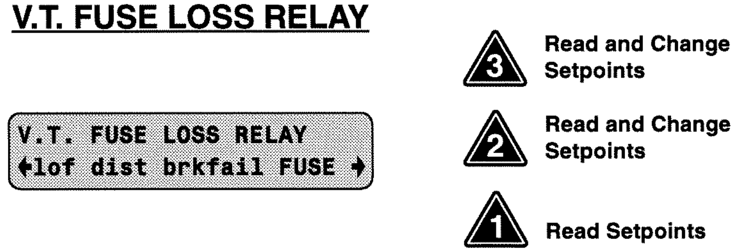


FIGURE 5–16 Breaker Failure Relay Setpoints

V.T. FUSE LOSS RELAY



The **V.T. FUSE LOSS RELAY** menu selection provides access to the fuse-loss functions of the M-0430. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

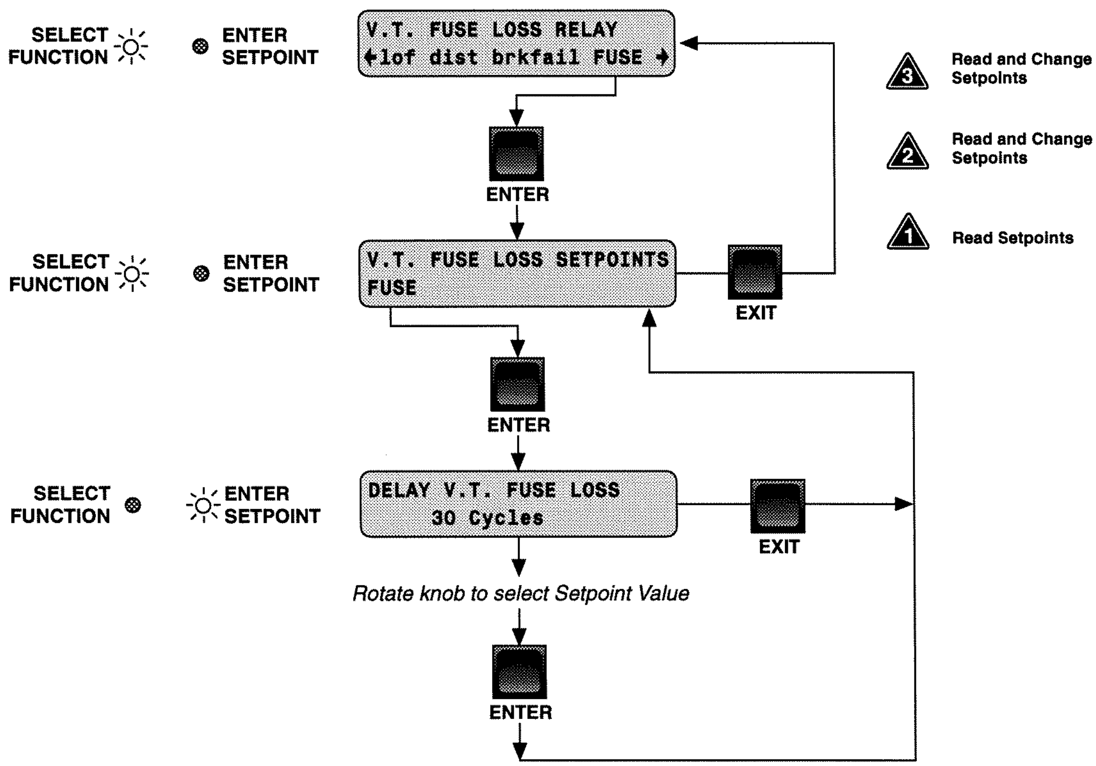


FIGURE 5–17 V.T. Fuse-Loss Relay Setpoints

REVIEW SETPOINTS

REVIEW SETPOINTS
←SETPTS stat config →

3 Review Setpoints

2 Review Setpoints

1 Review Setpoints

The **Review Setpoints** menu selection enables you to review all *currently enabled* setpoints. Setpoint ranges and initial settings are provided in Chapter 2, **Application**, and in the Specifications at the front of this book.

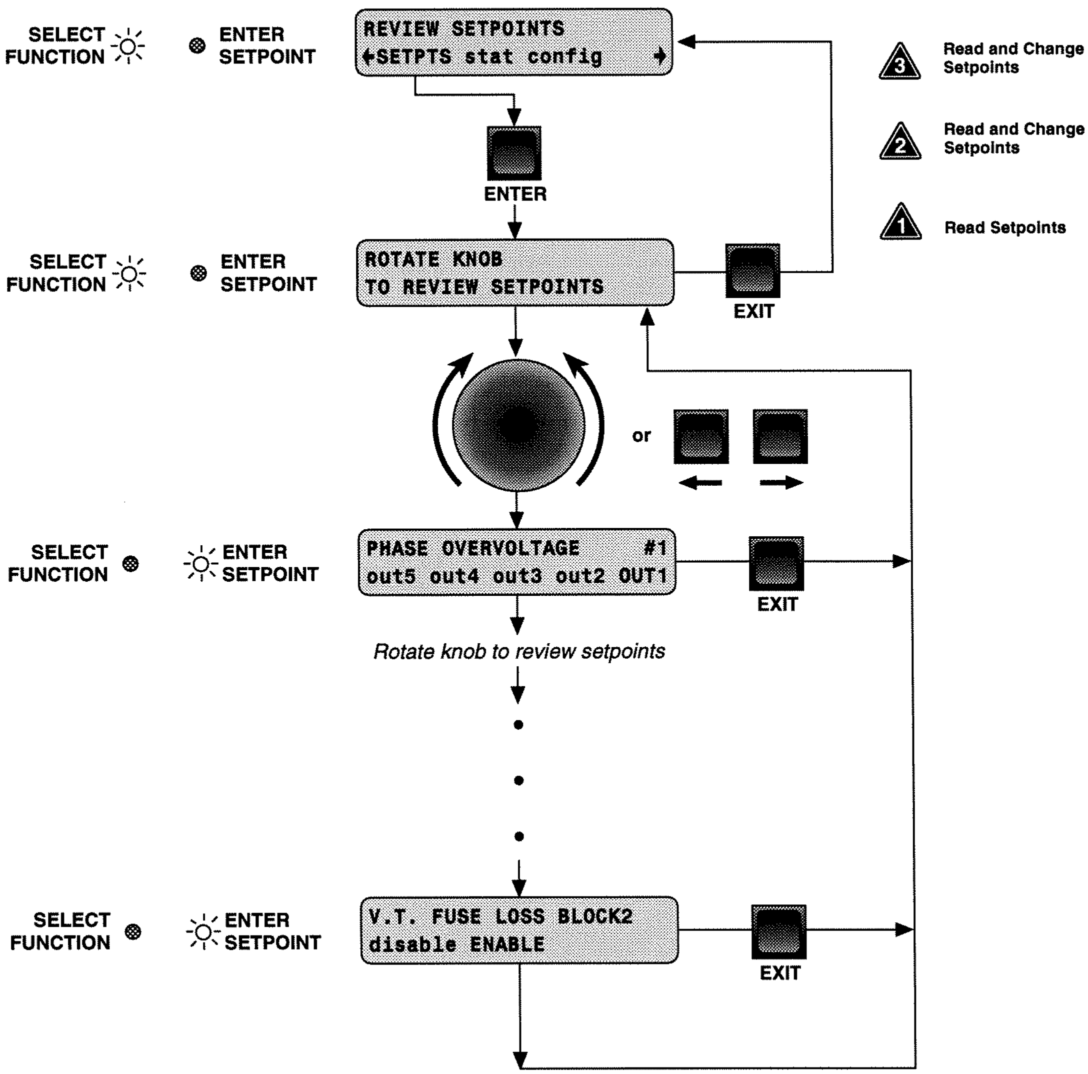


FIGURE 5–18 Review Setpoints Menu Selection

MONITOR STATUS

```
MONITOR STATUS
←setpts STAT config →
```

3 All Status Screens

2 All Status Screens

1 All Status Screens

The **MONITOR STATUS** menu selection enables you to monitor the values and timers that the M-0430 tracks. The second level menu provides the following selections:

- **Voltage Status**: phase voltages, neutral voltage, third-harmonic neutral voltage, positive-sequence voltage, negative-sequence voltage, zero-sequence voltage
- **Current Status**: phase current, neutral current, ground differential current, positive-sequence current, negative-sequence current, zero-sequence current
- **Frequency Status**: frequency
- **Volts per Hertz Status**: Volts per Hertz
- **Power Status**: real power, reactive power, power factor
- **Impedance Status**: Zab, Zbc, Zca, positive-sequence impedance
- **Fuse Status**
- **Voltage Timers**: phase overvoltage #1, #2; neutral overvoltage #1, #2; neutral undervoltage #1, #2
- **Frequency Timers**: overfrequency #1, #2; underfrequency #1, #2
- **Volts per Hertz Timers**: definite time #1, #2; inverse time
- **Power Timers**: forward power; reverse power
- **Ground Differential Timers**: ground differential #1, #2
- **Loss of Field Timers**: loss-of-field #1, #2
- **Phase Distance Timer**
- **Breaker Failure Timer**
- **VT Fuse-Loss Timer**
- **Temperature**
- **Time of Last Power Up**

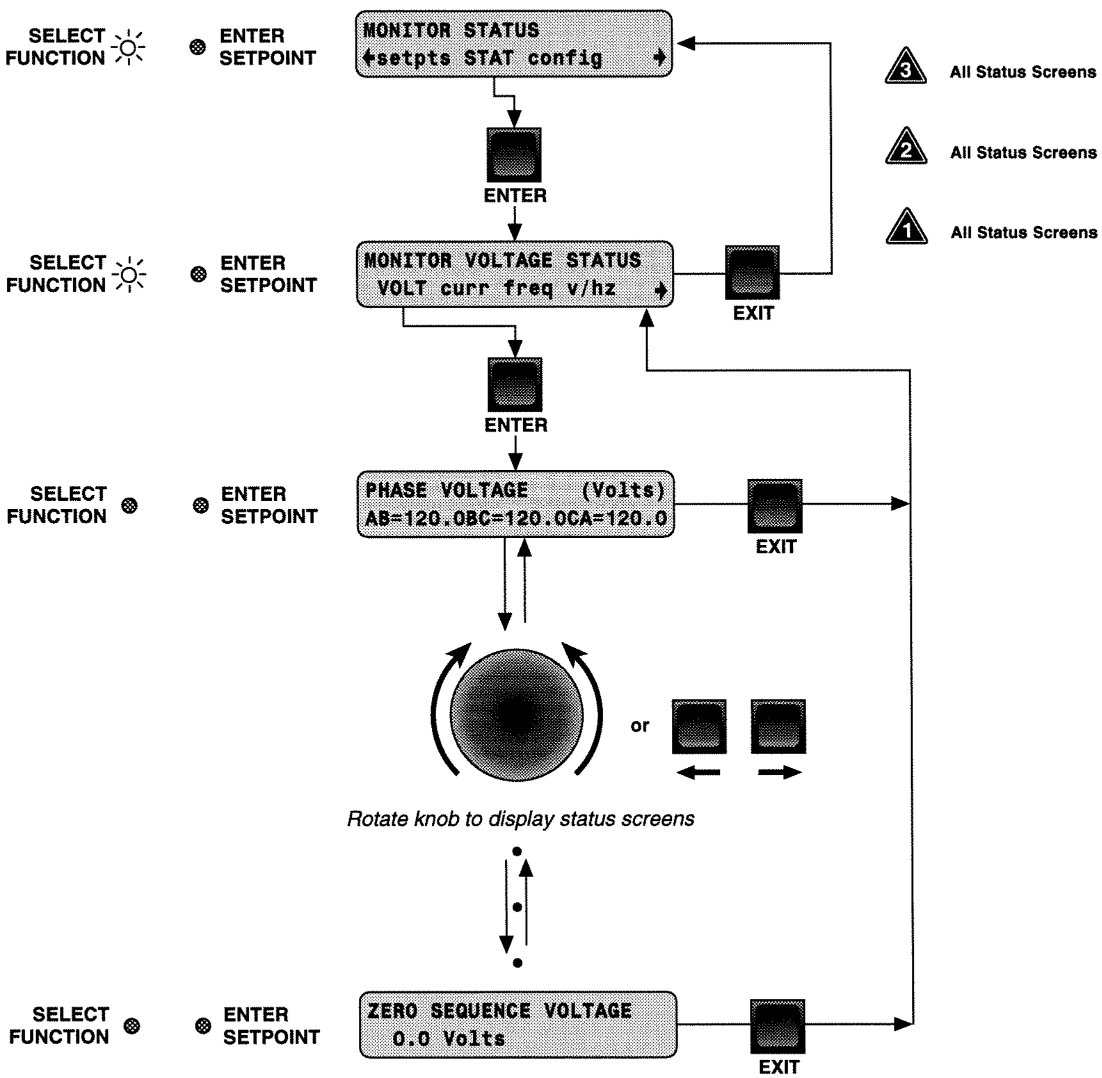


FIGURE 5–19 Monitor Status Menu Selection

CONFIGURE RELAYS

```
CONFIGURE RELAYS
←setpts stat CONFIG     →
```

3 Configure Relays

2 View Configuration

1 View Configuration

The **CONFIGURE RELAYS** menu selection enables the user to individually enable or disable each relay function and, via the **SETUP FUNCTION** submenu, to program certain other characteristics for some of the major functions.

For each enabled function the relay outputs and function blocking inputs can be programmed. Figures 5–21 through 5–25 show the menu flow for configuring the voltage relay functions.

■ NOTE: At least one output must be selected for each enabled function. If no output is selected, the function will remain disabled. (The **BREAKER FAILURE** and **V.T. FUSE LOSS** functions have no blocking menu, but do provide for programming the relay outputs.)

```
SETUP FUNCTION
← SETUP
```

The **SETUP FUNCTION** submenu enables the programming of the following characteristics:

- **Volts per Hertz**— Set the nominal (100%) voltage for V/Hz measurement.
- **Ground Differential**—Configure the function as directional or non-directional; set the correction factor for the neutral CT.
- **Loss-of-Field**—Enable or disable voltage and frequency control for each of the loss-of-field elements.
- **Phase Distance**—Enable or disable delta-Y transform.
- **Breaker Failure**—Enable or disable external Breaker Failure Initiate (BFI) via BLOCK3; enable or disable phase-overcurrent detection (50BF-Ph) and neutral initiate (50BF-N) for the breaker-failure function.
- **VT Fuse Loss**—Enable or disable internal fuse loss logic via BLOCK2.
- **Relay Seal-In Time**—Set the seal-in time (in cycles) of the programmable output relays.

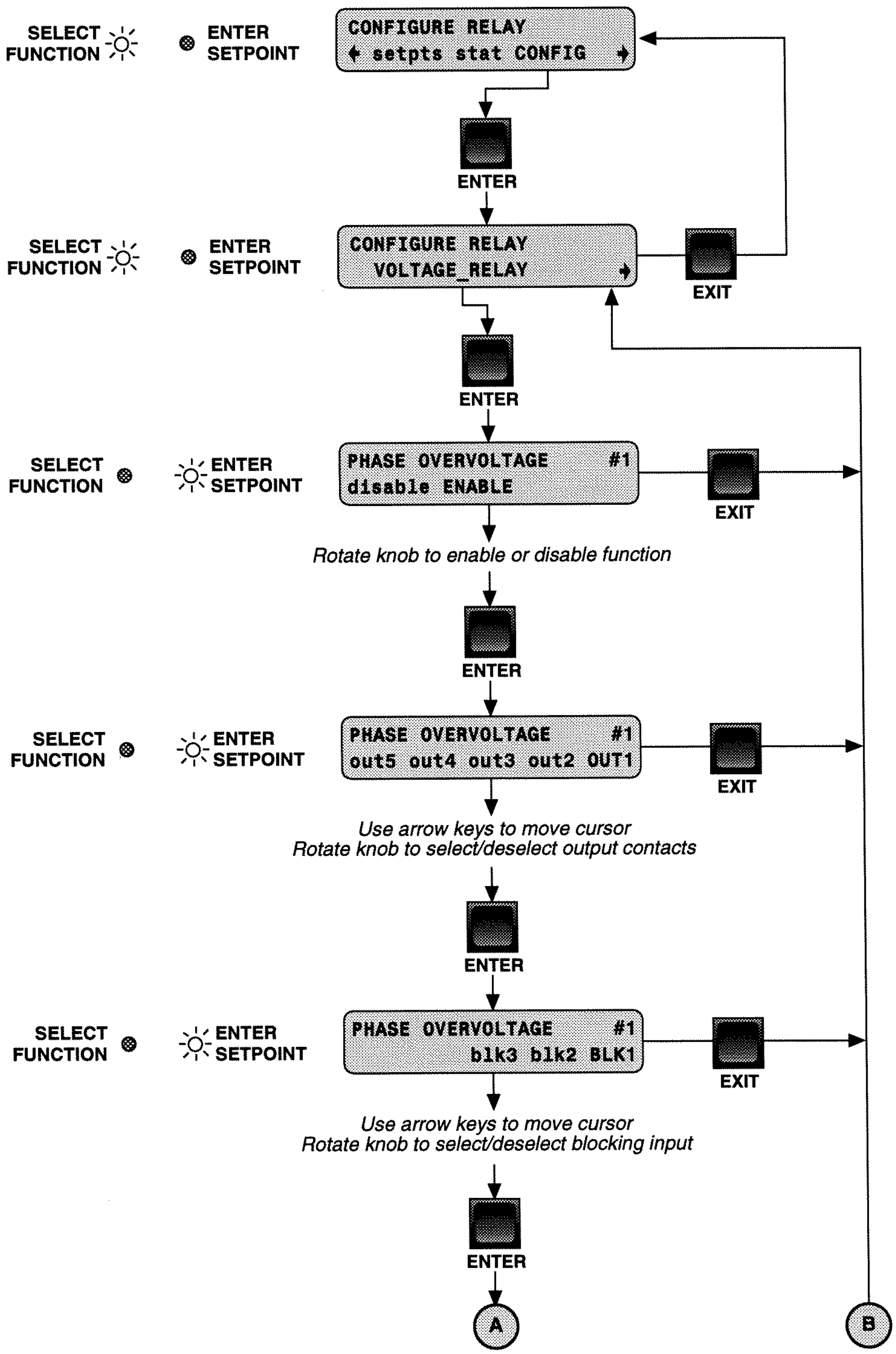


FIGURE 5–21 Configure Voltage Relay Menu Selection

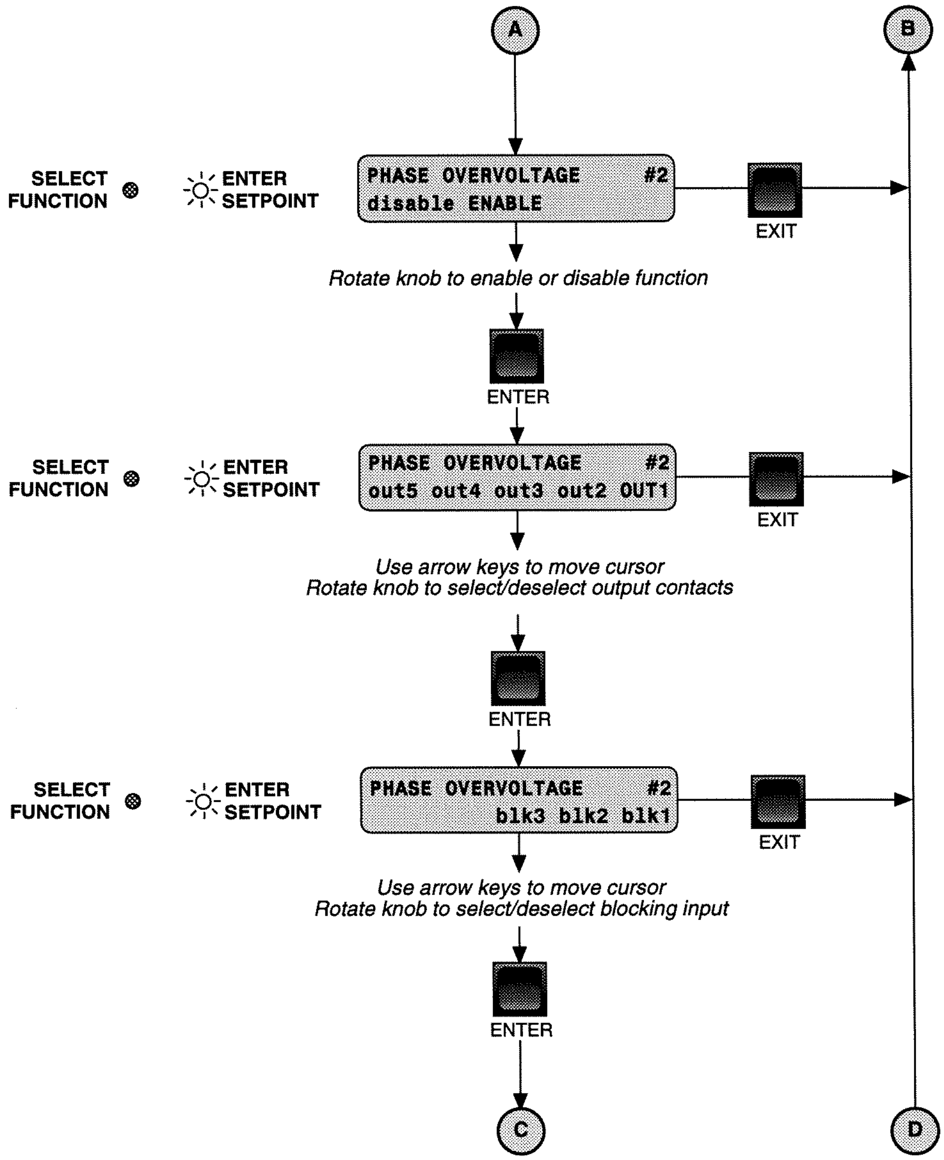


FIGURE 5–21 Configure Voltage Relay Menu Selection (continued)

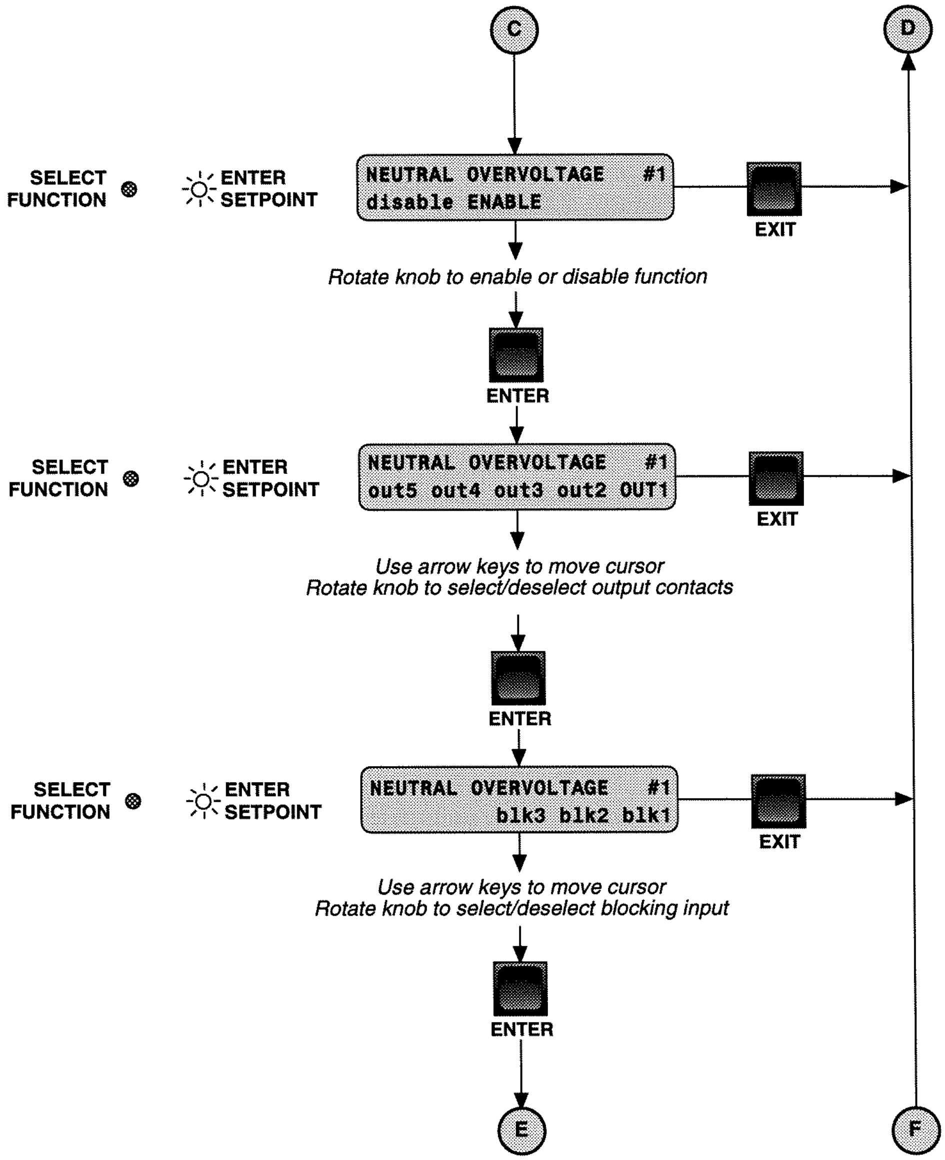


FIGURE 5–22 Configure Voltage Relay Menu Selection (continued)

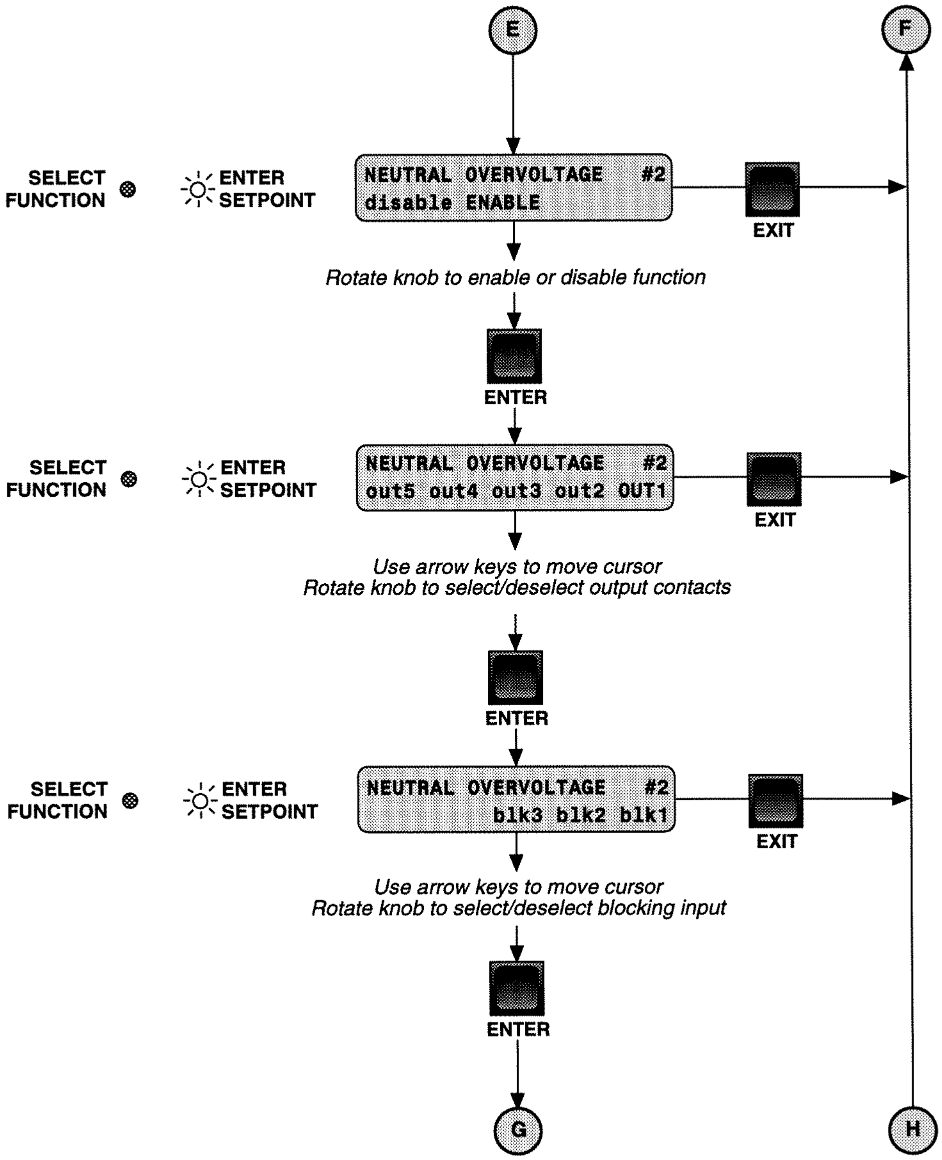


FIGURE 5–23 Configure Voltage Relay Menu Selection (continued)

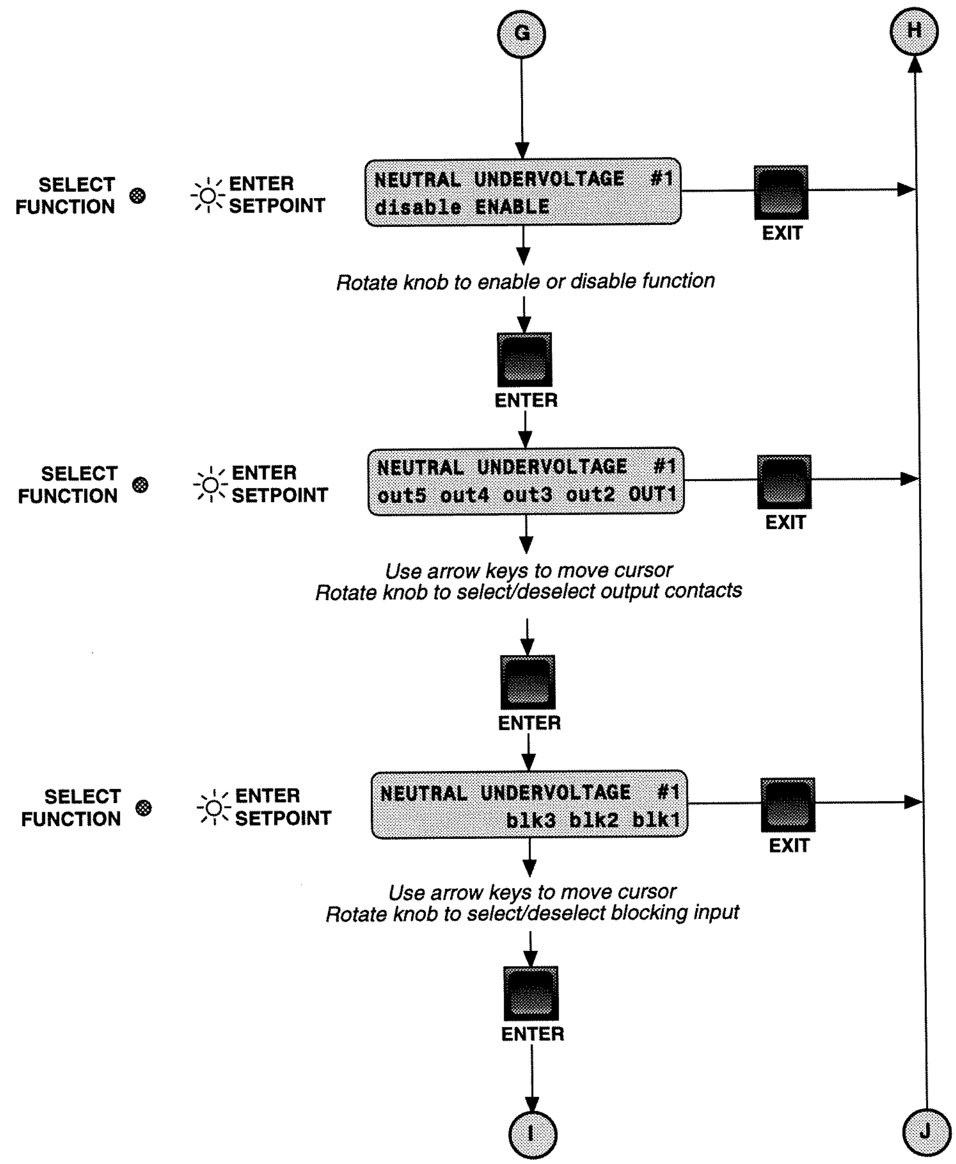


FIGURE 5–24 Configure Voltage Relay Menu Selection (continued)

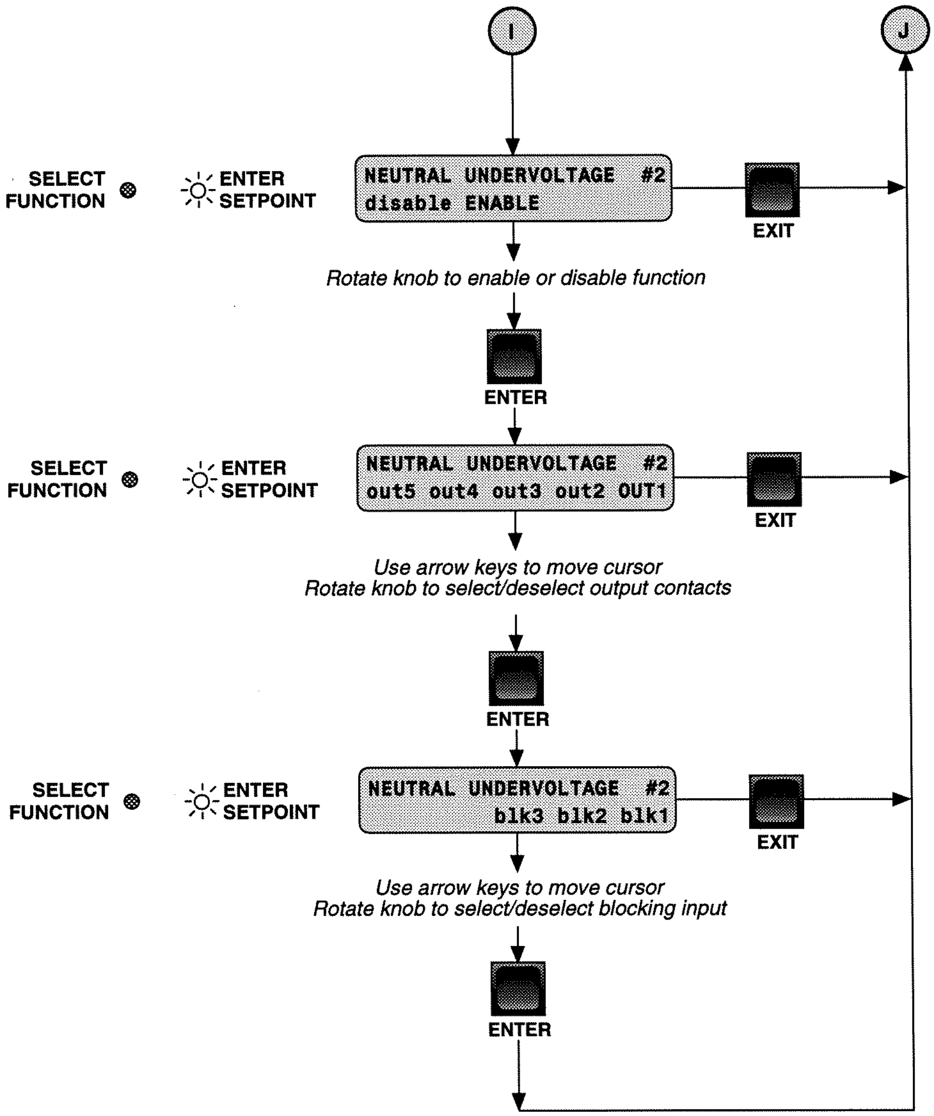


FIGURE 5–25 Configure Voltage Relay Menu Selection (continued)

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VIEW TARGET HISTORY

```
VIEW TARGET HISTORY
←TARGETS fault_rec     →
```

3 View Target History
Clear Targets

2 View Target History
Clear Targets

1 View Target History

The **VIEW TARGET HISTORY** menu selection enables the user to review the targets for the previous five target conditions. As shown in the example below, the target history for each trip cycles continuously through a sequence of screens until **EXIT** is pressed. Both status infomation (which indicates when a value was outside the setpoint range) and timer information (which indicates when a value was outside the setpoint range and the timer expired) are shown, along with individual phase element information where appropriate. A time/date tag and relay activation are also displayed. The final selection allows the user to clear all trip history data to provide a clean starting point for further target recording. The second-level menu presents the following selection, with Trip 0 being the latest trip:

```
VIEW TARGET HISTORY
 TRGT-0 trgt-1 trgt-2  →
```

Choosing this menu selection (**TRGT-0**) will cycle through the status screens for Target 0. Targets 1 through Targets 4 can be displayed in a similar manner. Press **EXIT** to return to the **VIEW TARGET HISTORY** menu.

```
CLEAR TARGET HISTORY
←trgt-3 trgt-4 CLEAR   →
```

Choosing this menu selection will clear all target information.

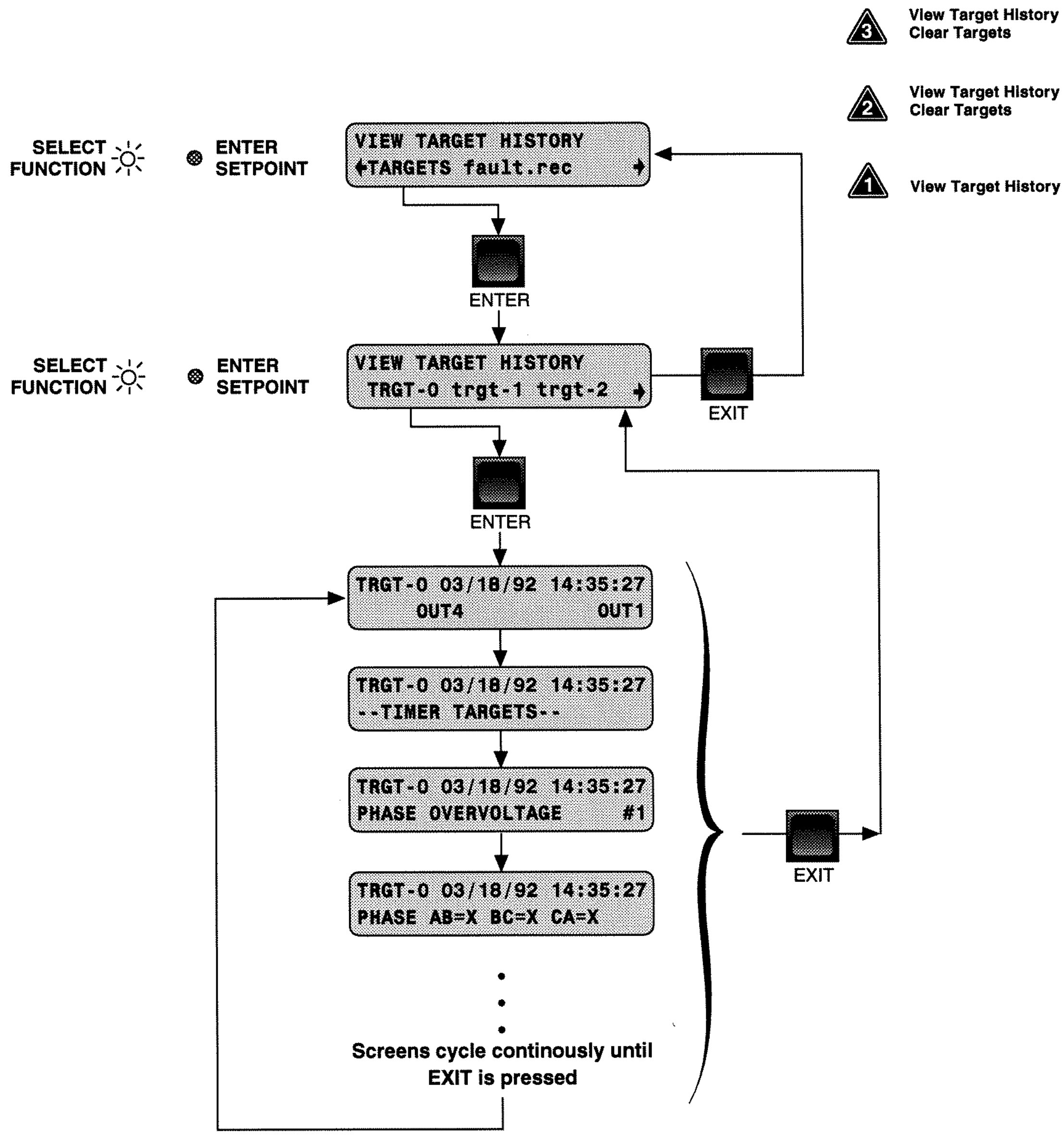


FIGURE 5-26 View Target History Menu Selection

FAULT RECORDER

3 Arm, Disarm, Auto-Rearm, set Post Trigger Delay

2 Arm, Disarm Recorder

1 Recorder Status

```
FAULT RECORDER
←targets FAULT.REC →
```

The fault recorder provides comprehensive fault-data recording for all monitored waveforms (at 16 samples per cycle) and status inputs (at 480 Hz). The **FAULT RECORDER** menu selection enables the user to determine the status of the fault recorder (whether armed or not, and if armed, whether triggered or not), and to arm or rearm the recorder, or to set it to auto-rearm. Additionally, a post-trigger delay can be set. Fault data can be downloaded via the RS-232C ports to any IBM-compatible computer running the M-0429A BECOCOM™ Communications Software package. Once downloaded, the waveform data can be examined and printed using the M-0428A BECOPLOT™ Fault Data Analysis Software package. (Refer to the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide for more information on downloading and analyzing fault data.)

The fault recorder can be either armed or disarmed; if armed, it can be triggered either manually or via the fault recorder trigger input. When armed and untriggered, the recorder continuously records waveform data, keeping the most recent 96 cycles of data (at 16 samples per cycle) in its memory. When the fault recorder trigger input is closed, usually from a 52b contact, the recorder is triggered: it continues recording for a user-programmable period, and then goes to unarmed mode, keeping the 96-cycle snapshot of waveform data in its memory for downloading via the BECOCOM software. (The BECOCOM software can also be used to manually trigger the fault recorder.) Rearming the fault recorder restarts the process (overwriting the stored fault data). The individual fault recorder menu selections are discussed below.

■ **NOTE**: The fault recorder is initially disarmed after power up. To arm the fault recorder, choose the **ARM** menu selection and press **ENTER**; the recorder will be armed.

```
RECORDER STATUS
 STAT arm disarm    →
```

Choosing this menu selection will inform you whether the fault recorder is armed, disarmed, or triggered.

```
ARM RECORDER
 stat ARM disarm    →
```

Choosing this menu selection will arm the fault recorder.

```
DISARM RECORDER
 stat arm DISARM    →
```

Choosing this menu selection will disarm the fault recorder.

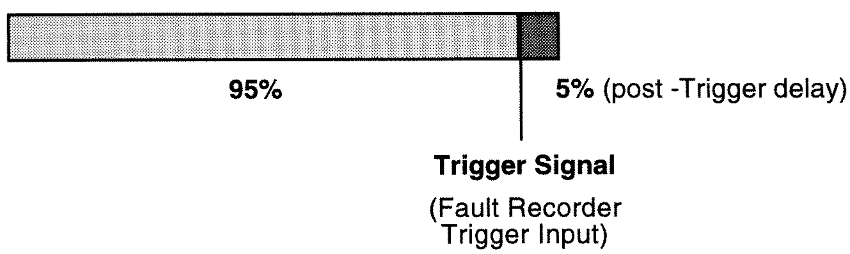
```
AUTO-REARM RECORDER
←AUTO_ARM post_dly    →
```

Choosing this menu selection sets the fault recorder to automatically rearm itself when the breaker closes (as indicated by the opening of the 52b status input).

> ▲ **CAUTION**: The previous fault record is lost once the recorder is rearmed. *When auto-rearming is enabled, the fault record must be downloaded while the breaker is open.*

```
POST TRIGGER DELAY
←auto_arm POST_DLY    →
```

Choosing this menu selection allows you to set the fault recorder post-trigger delay: the length of time (as a percent of the total fault record) that the unit will continue to record after it receives the trigger signal (when armed, the fault recorder is continuously recording). For example, if this is set to 5%, approximately 95% of the fault record will consist of pre-trigger information, and approximately 5% will consist of post-trigger information.



READ COUNTER

3 Read and Clear Counters

2 Read and Clear Counters

1 Read Counters

```
READ COUNTER
←COUNT comm setup exit
```

The **READ COUNTER** menu selection provides access to the counters of the M-0430. Individualy counters can be viewed or cleared. The following second level menu selections are available:

```
OUT1 COUNTER
OUT1 out2 out3 out4   →
```

The **OUT1 COUNTER** through **OUT5 COUNTER** menu selections enable you to view the output relay counters.

```
 SELFTEST ALARM COUNTER
← out5 ST_ALRM power   →
```

The **SELFTEST ALARM COUNTER** menu selection enables you to view the self-test alarm counter.

```
 POWERLOSS COUNTER
← out5 st_alrm POWER   →
```

The **POWERLOSS COUNTER** menu selection enables you to view the powerloss counter.

```
 CLEAR OUT1 COUNTER
← OUT1 out2 out3 out4 →
```

The **CLEAR OUT1 COUNTER** through **CLEAR OUT5 COUNTER** menu selections enable you to clear the output relay counters.

```
 CLEAR ST_ALARM COUNTER
← out5 ST_ALRM power
```

The **CLEAR SELFTEST ALARM COUNTER** menu selections enables you to clear the self-test alarm counter.

```
 CLEAR POWERLOSS COUNTER
← out5 st_alrm POWER
```

The **CLEAR POWERLOSS COUNTER** menu selection enables you to clear the powerloss counter.

COMMUNICATIONS

```
COMMUNICATION
←count COMM setup exit
```

Level 3: All Functions

Level 2: No Access

Level 1: No Access

The **COMMUNICATION** menu selection provides access to the communications functions of the M-0430.

```
CONFIGURE COM1
COM1 com2 com_adr accss→
```

The **CONFIGURE COM1** and **CONFIGURE COM2** menu selections enable you to set the baud rate and parity for the respective communication ports. COM1 is the front-panel port; COM2 is the rear-panel port; parity can either be even (enabled) or none (disabled).

```
COMMUNICATION ADDRESS
com1 com2 COM_ADR accss→
```

The **COMMUNICATION ADDRESS** menu selection enables you to set the relay address. This address is used to access multiple relays via a single communication line using the BECOCOM protocol. For more information, refer to the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

```
COMM ACCESS CODE
com1 com2 com_adr ACCSS→
```

The **COMM ACCESS CODE** is the security access code for the communication channel. Setting this code to zero (0) will disable communication security. For more information refer to the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

```
ISSUE COM2 MODEM LOG ON
← ISSUE enter
```

The **ISSUE COM2 MODEM LOGON** menu selection enables you to send the ASCII string defined via the **ENTER COM2 MODEM LOGON** screen (below).

```
ENTER COM2 MODEM LOG ON
← issue ENTER
```

The **ENTER COM2 MODEM LOGON** menu selection enables you to enter a string of ASCII characters which will be sent via COM2 in order to initialize an external modem. For more information, refer to the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

SETUP UNIT

```
SETUP UNIT
←count comm SETUP exit
```

3 **View and Alter Settings**

2 **View Settings**

1 **View Settings**

The **SETUP UNIT** menu selection provides access to the setup functions of the M-0430.

```
SOFTWARE VERSION
VERS access time dipsw →
```

Choosing the **SOFTWARE VERSION** menu selection will display the version number of the host and DSP software.

```
ALTER ACCESS CODES
vers ACCESS time dipsw →
```

The **ALTER ACCESS CODES** menu selection enables you to define the unit access codes. For more information on access codes, see Chapter 4, **Operation**.

```
DATE & TIME
vers access TIME dipsw →
```

The **DATE & TIME** menu selection enables you to set the date and time of the internal battery-backed clock.

```
DIP SWITCH SETTINGS
vers access time DIPSW →
```

```
1X       8 OFF DIPSWITCH
 XXXXXXX  ON
```

Choosing the **DIP SWITCH SETTINGS** menu selection displays the DIP switch settings screen (above). This screen shows the current position for each DIP switch. For more information on the DIP switches and their settings, refer to the Chapter 6, **Installation**.

```
USER LOGO LINE 1
←LOGO1 logo2 disp okled→
```

The **USER LOGO LINE 1** and **LINE 2** menu selections enable you to enter two alphanumeric strings to identify the unit. These strings are displayed as the default message screen and are automatically transmitted via COM1 and COM2 during remote communications as an aid in identifying the relay (the lines are displayed on the BECOCOM information line). To enter a line, first use the left- and right-arrow keys to move the cursor to the location of the desired character. Next, use the rotary knob to select the desired character from the ASCII character set. Repeat this procedure for each character in the string. When the desired string has been entered, press **ENTER**.

```
LCD DISPLAY BLANKING
←logo1 logo2 DISP okled→
```

The **LCD DISPLAY BLANKING** menu selection enables you to enable or disable blanking of the LCD screen when local mode is exited. When screen blanking is enabled, the LCD will blank shortly after **EXIT** is chosen from the top-level menu and after five minutes of unattended operation from *most* other menus.

```
RELAY OK LED FLASH
←logo1 logo2 disp OKLED→
```

The **RELAY OK LED FLASH** menu selection enables you to enable or disable the flashing of the **RELAY OK** LED. If enabled, the LED will flash to indicate the relay is functioning properly. If disabled, the LED will light continuously to indicate the relay is functioning properly.

```
V.T. & C.T. RATIOS
←RATIO
```

```
V.T. PHASE RATIO
    1.0:1
```

```
V.T. NEUTRAL RATIO
    1.0:1
```

```
C.T. PHASE RATIO
    1.0:1
```

```
C.T. NEUTRAL RATIO
    1.0:1
```

The **V.T. & C.T. RATIOS** menu enables you to set the ratios of the external voltage and current transformers. This information is used only for displaying primary values with BECOCOM. For more information, see the **VT & CT Ratios** submenu selection under the **Relay\Set** menu in the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

EXIT LOCAL MODE

```
EXIT LOCAL MODE
←count comm setup EXIT
```

Choosing the **EXIT LOCAL MODE** menu selection will exit from the main menu and return to the default message screens.

6
INSTALLATION

INITIAL SETUP PROCEDURE

The M-0430 is shipped with the initial relay settings listed in the Specifications at the front of this book and in Chapter 2, **Application**. Select settings that are unique to your application using the **CONFIGURE RELAYS** menu and then the specific settings for each relay function. Review the front-panel operation of the M-0430 described in Chapter 3, **Front Panel Controls**, before you attempt the following procedure.

■ NOTE: The following procedure can be performed before the M-0430 is installed. All settings will remain stored in its memory even after power has been removed.

1. Connect power to the M-0430's rear power terminals (as marked on the rear-panel power supply label and as shown in Figure 6-5, External Connections).
2. As described in Chapter 4, **Operation**, the relay performs a power-on self test routine and ends by cycling through a display of all of the functions that are tripped. Assuming that various voltage functions are enabled, and that there are no test voltage inputs connected, you will see various voltage targets identified as having tripped.
3. To set the system clock, proceed as follows:
   a. Press the **ENTER** pushbutton to go to the beginning of the main menu.
   b. Rotate the knob clockwise until **SETUP UNIT** appears on the first line of the display.
   c. Press **ENTER**, and rotate the knob to **TIME**.
   d. Press **ENTER**. The date and time in the system memory will appear. If the clock is stopped (the as-shipped condition), the seconds digits will not change. If so, press **ENTER** , rotate the knob to **START**, then press **ENTER** again. The **DATE & TIME** menu will return. Push **ENTER**. The selection **SET** will be in capital letters. Press **ENTER** and step through all of the elements of setting the date and time using the rotary knob and saving each entry using the **ENTER** pushbutton. After the last **ENTER**, the **DATE & TIME** menu will appear again. Press **ENTER**, and the new date and time will appear on the display, with the seconds digit incrementing. To synchronize with utility system time, set the time somewhat ahead and use the **SYNC** function. Press **EXIT** to return to the **SETUP UNIT** menu.

   The battery-backed clock will maintain system time when system power is removed. However, if the M-0430 is to be taken out of service and stored, it is best to stop the clock.

4. If desired, set the user logo screen to your company name and location of the relay by pressing **ENTER** from **SETUP UNIT** and rotate the knob clockwise to **USER LOGO LINE 1**. Press **ENTER**. The default Beckwith Electric logo will appear, with the underline cursor under the farthest left character. You can change this character through a complete set of capital and small letters, numbers, and symbols by turning the rotary knob. When the desired character is visible, press the right arrow pushbutton. This moves the cursor to the next location. When all characters are correct, push **ENTER**. The screen **-WAIT-** will appear, then the display returns to the **USER LOGO LINE 1** selection. Select **USER LOGO LINE 2**, repeat the process, then **EXIT**.

■ NOTE: If the M-0430 is to be used with the M-0429A BECOCOM™ Communications Software package, these lines should be set to an unambiguous identifier; for example, Beckwith Electric\62nd St. Substation.

5. If desired, calibrate the unit following the calibration procedure detailed in Chapter 7, **Test Procedures**.

■ **NOTE**: The M-0430 has been fully calibrated at the factory using very precise and accurate test equipment. There is no need to recalibrate the unit before initial installation. Further calibration is only necessary if a component was changed during a repair procedure, and will be only as accurate as the test equipment used.

6. Set the internal configuration DIP switches according to your application. Refer to the **DIP Switches** section following for more information on the location of the DIP switches and for a description of their settings. The default DIP switch configuration is shown on the blue or green tag attached to the unit when shipped. The configuration can also be determined at any time by accessing the **DIP SWITCH SETTINGS** portion of the **SETUP UNIT** menu.

7. If remote communication is required, set the baud rate, parity, and other parameters for the **COM1** and **COM2** ports by following the instructions in Appendix C, **Communications**, and in the M-0429A BECOCOM™/M-0428A BECOPLOT™ User's Guide.

8. Enable the desired relay functions under the **CONFIGURATION** menu.

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

9. Enter the desired setpoints for the enabled functions. See Chapter 5, **Menu Reference**.

10. If security is desired, set the user access codes.

11. Install the unit and connect the external input and output signals to the relay according to the rear panel terminal block markings as shown in Figure 6-5, External Connections.

COMMISSIONING CHECKOUT

During M-0430 field commissioning, check the following to ensure that the CT and VT connections are correct.

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd →
```

2. Turn the rotary knob clockwise until the unit displays

```
MONITOR STATUS
← setpts STAT config →
```

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

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

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

```
PHASE VOLTAGE    (Volts)
A=  0.0 B=  0.0 C=  0.0
```

   Compare these voltages with actual measurements using a voltmeter. If there is a discrepancy, check for loose connections to the rear terminal block of the unit.

5. Display positive-, negative- and zero-sequence voltages. Press **ENTER** until the unit displays

```
POS SEQUENCE VOLTAGE
  0.0 Volts
```

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

6. Press **ENTER** until the unit displays

```
NEG SEQUENCE VOLTAGE
  0.0 Volts
```

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

7. Press **ENTER** until the unit displays

```
ZERO SEQUENCE VOLTAGE
  0.0 Volts
```

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

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

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

8. Press **EXIT** until the unit displays

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

9. Turn the rotary knob clockwise until the unit displays

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

10. Display line currents (I_A, I_B, I_C). Press **ENTER**. The unit should display

```
PHASE CURRENT    (Amps)
A= 00.0 B= 00.0 C= 00.0
```

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

11. Turn the rotary knob clockwise until the unit displays

```
POS SEQUENCE CURRENT
 0.0 Amps
```

The positive-sequence current should be $I_{POS} \approx I_A \approx I_B \approx I_C$.

12. Press **ENTER** until the unit displays

```
NEG SEQUENCE CURRENT
 0.0 Amps
```

Negative-sequence current should be close to zero amperes.

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

```
ZERO SEQUENCE CURRENT
 0.0 Amps
```

The zero-sequence current should be $I_{ZERO} \approx 0$. If the unit displays a significant amount of negative- or zero-sequence current (greater than 25% of I_A, I_B, I_C,), then either the phase sequence or a polarity is incorrect. Modify connections to obtain proper phase sequence and polarities.

14. Press **EXIT**. Turn the rotary knob counterclockwise until the unit displays

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

Turn the rotary knob clockwise until the unit displays

```
MONITOR POWER STATUS
POWR imped fuse →
```

Display real power and check its sign. Press **ENTER**. The unit should display

```
REAL POWER
    .00 PU
```

The sign should be positive for forward power and negative for reverse power. If the sign does not agree with actual conditions, reverse the polarities of all three CTs.

DIP SWITCHES

Certain system conditions and M-0430 operator preferences must be set at the time of installation. These parameters are established using an 8-position DIP switch inside the M-0430.

■ NOTE: The DIP switch settings can be examined from the front panel by using the **DIPSW** selection under the **SETUP** menu. Appendix D, **Configuration Record Forms**, of this manual contains a form for recording the unit's DIP switch settings.

Accessing the Internal Configuration DIP Switch

Release the four captive screws (two each at the top and bottom of the front panel) and pull the internal assembly from the housing. As shown in Figure 6-1, the DIP switch is accessible from the bottom front of the unit.

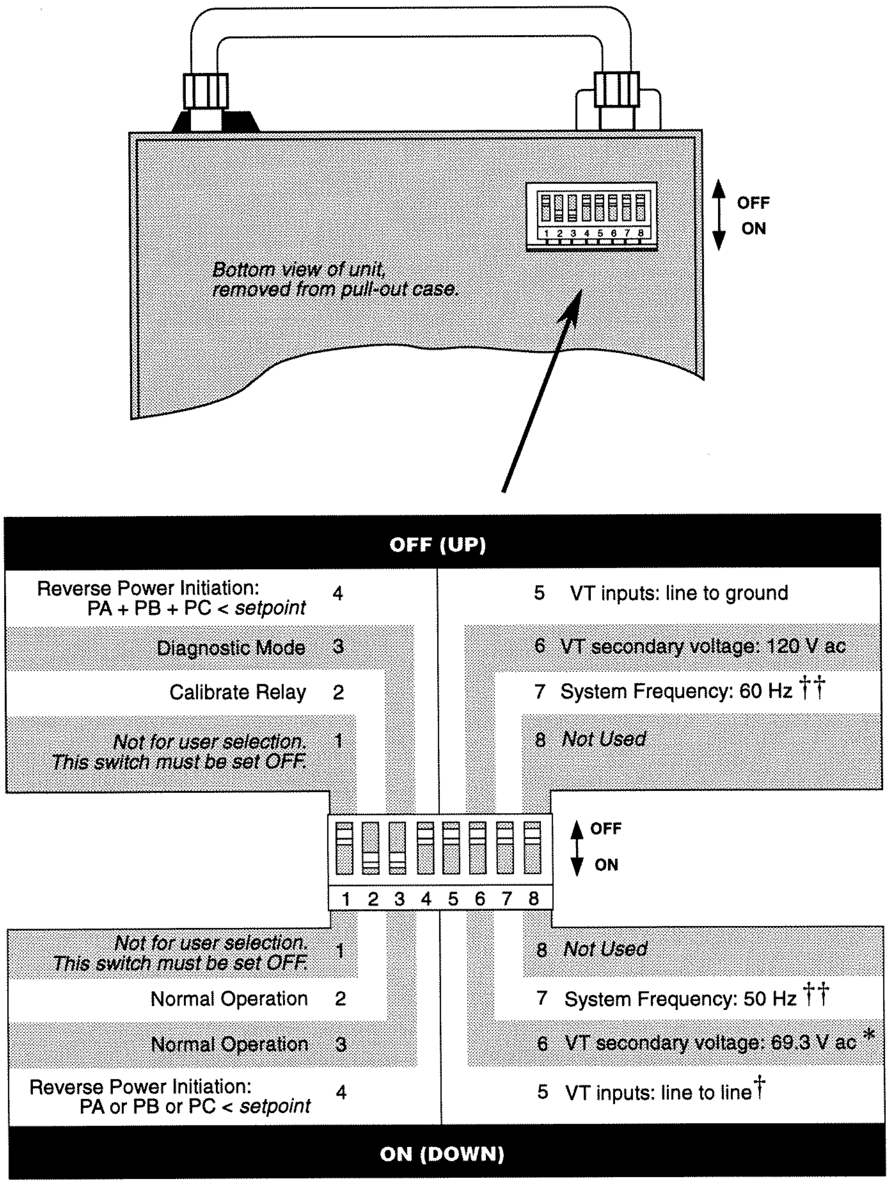
■ **NOTE**: Significant force is required to remove and replace the unit in its housing.

Switch	Description	ON (down)	OFF (up)
1	*Not for user selection. This switch must be set OFF.*		
2	Calibrate Relay	Normal Operation	Calibrate Relay
3	Diagnostic Mode	Normal Operation	Diagnostic Mode
4	Reverse Power	A reversal of power flow in any one phase inititates relay operation (PA or PB or PC < setpoint).	The total 3-phase power must be in the reverse direction for relay initiation (PA + PB + PC < setpoint).
5	Basic VT Inputs	Line to Line	Line to Ground
6	VT Secondary Voltage	69.3 V ac*	120 V ac
7	System Frequency	50 Hz	60 Hz
8	*Not Used*	*Not Used*	*Not Used*

**When the 69.3 V option is selected, the M-0430 internally scales the 69.3 V input to an equivalent 120 V (1 pu) for setting and display purposes.*

■ NOTE: If line-to-line is chosen for the basic VT inputs (DIP switch 5 is ON), reverse power sensing will respond to total three-phase power regardless of the setting of DIP switch 4.

TABLE 6-1 Internal Configuration DIP Switch



■ **NOTES**:

* When 69.3 V is chosen for the VT secondary voltage, 69.3 V is internally converted to 120 V (1 pu) for all calculations and for setting and display options.

† If line-to-line is chosen for the basic VT inputs (DIP switch 5 is ON), reverse power sensing will respond to total three-phase power regardless of the setting of switch 4.

†† If the system frequency selection (DIP switch 7) is changed from the original factory calibration, the unit must be recalibrated (see the self-calibration procedure in Chapter 7, **Test Procedures**).

FIGURE 6-1 Internal Configuration DIP Switch–60 Hz.

MECHANICAL

The M-0430 is designed as a drawout case for semiflush panel mounting. It will directly mount in a panel prepared for either a General Electric L-2 or Westinghouse FT-41 housing. Dimensions for these mounting configurations are provided in Figures 6-2 and 6-3.

■ NOTE: If this is a new installation, choose either mounting configuration and prepare the panel accordingly.

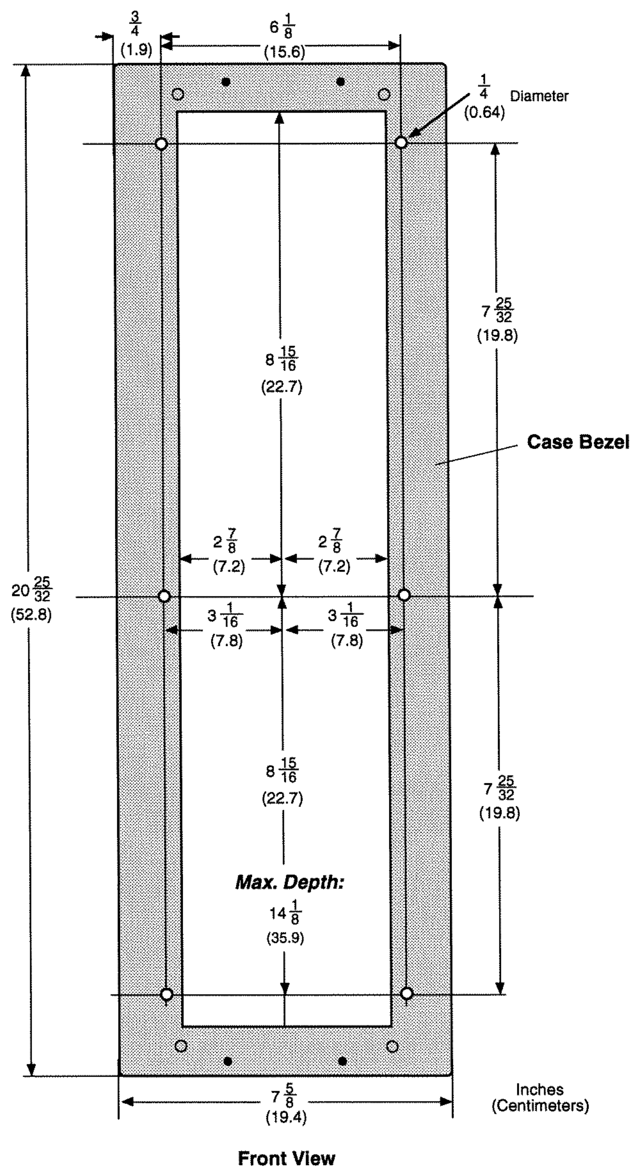
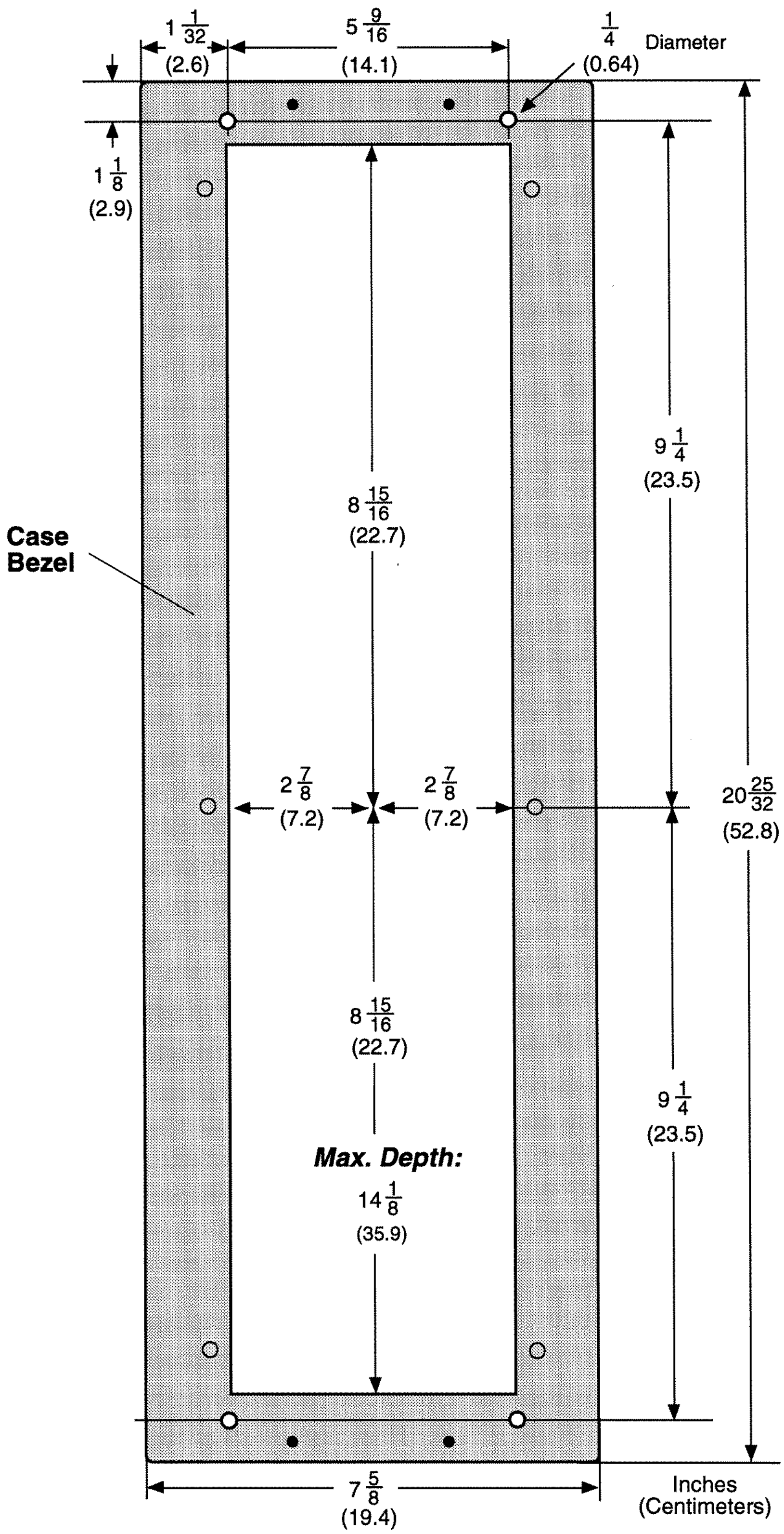


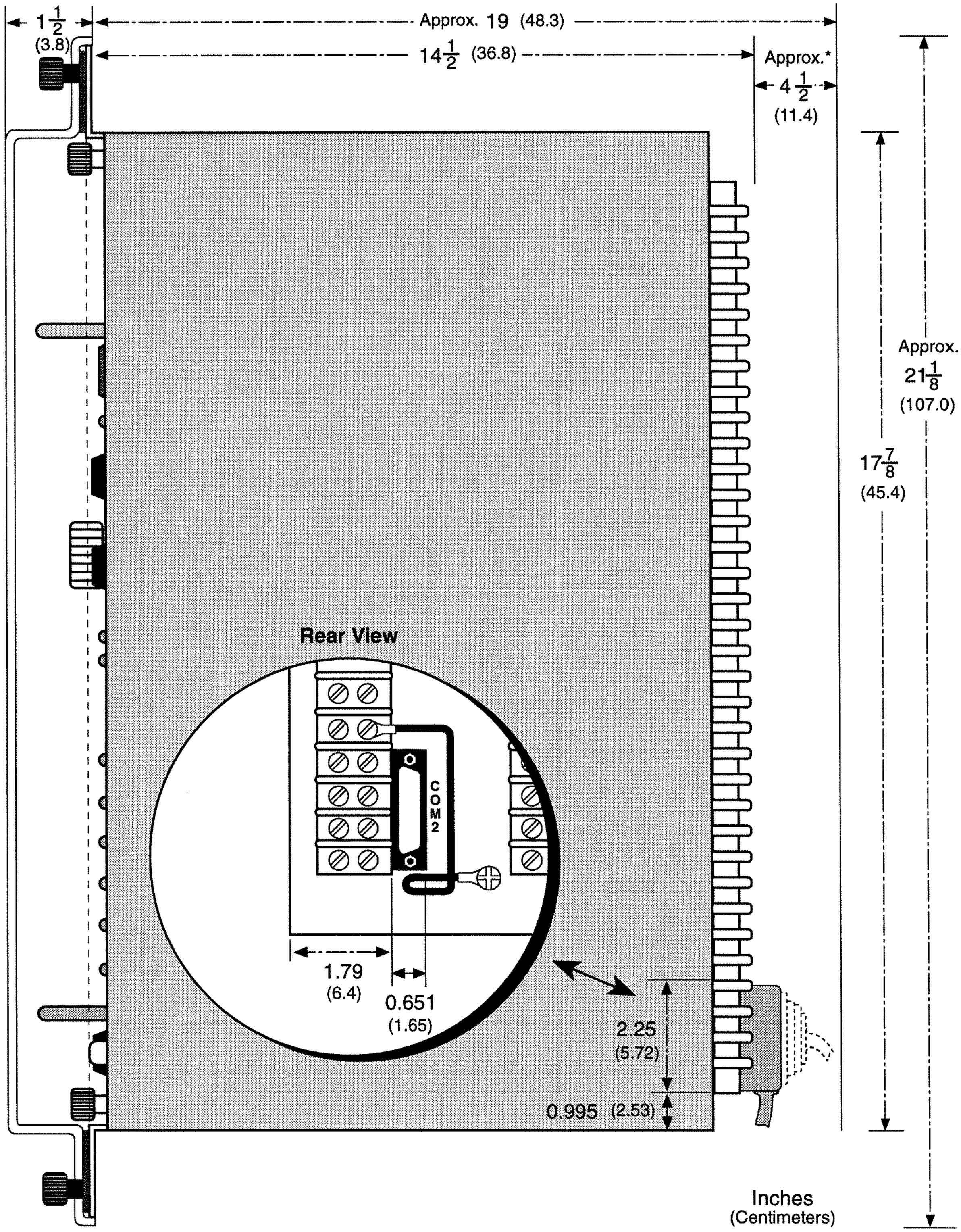
FIGURE 6-2 Mounting Dimensions for GE L-2 Cabinet



Front View

FIGURE 6-3 Mounting Dimensions for Westinghouse FT-41 Cabinet

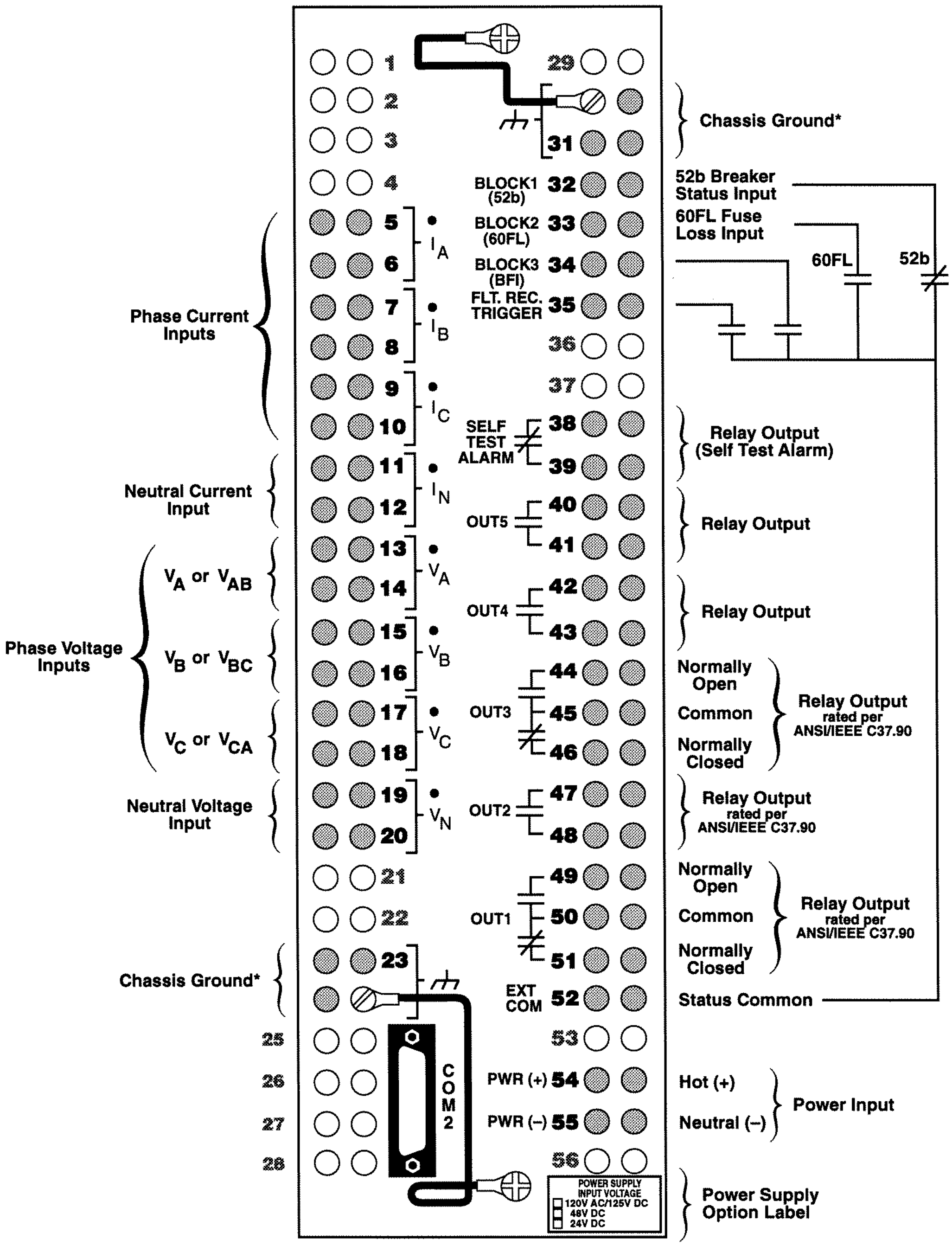
SIDE VIEW



■ **NOTE:** Approximately 2.5" clearance is required when a right-angle connector is used for the rear RS-232C port.

FIGURE 6-4 M-0430 Side View

EXTERNAL CONNECTIONS



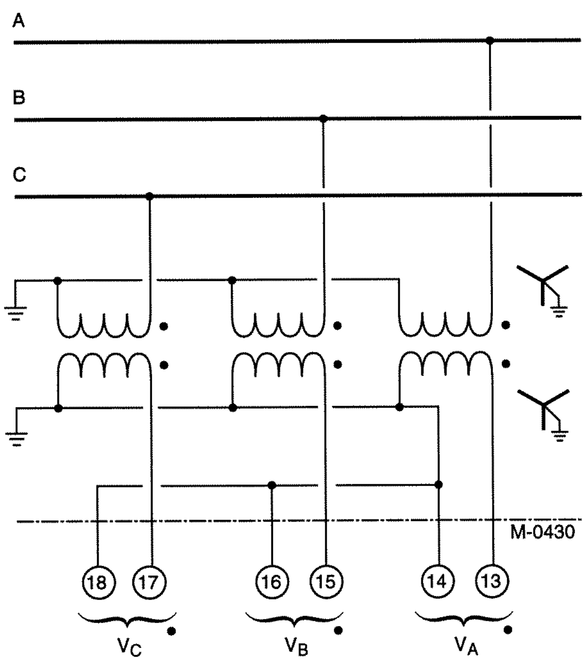
*▲ **CAUTION**: Always connect both locations (terminals 23 and 31) to external chassis ground.

■ **NOTES:**

1. Normally-closed contacts will open when the M-0430 is removed from its pull-out case.
2. Unmarked terminals reserved for future expansion.

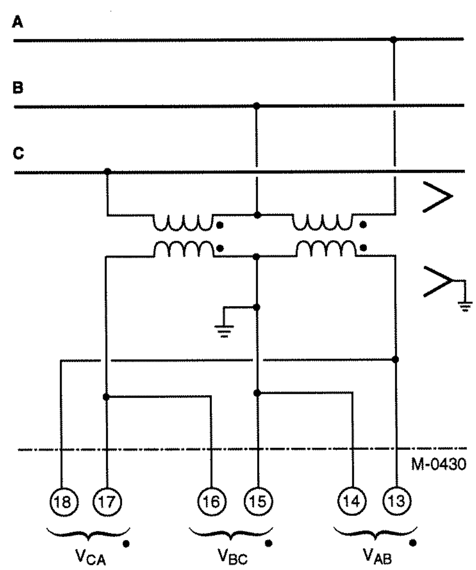
FIGURE 6-5 External Connections

SUGGESTED VT CONNECTIONS



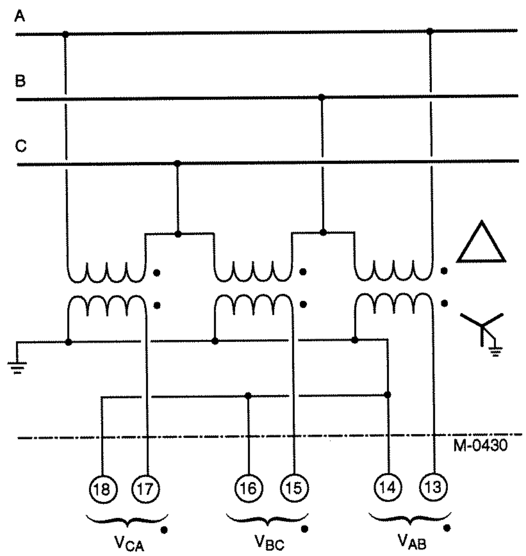
■ NOTE: On the internal configuration DIP switch, select line-to-ground for basic VT input and either 69.3 V ac or 120 V ac for VT secondary voltage.

FIGURE 6-6 Connections for Wye-Wye-Connected VTs



■ NOTE: On the internal configuration DIP switch, select line-to-line for basic VT input and either 69.3 V ac or 120 V ac for VT secondary voltage.

FIGURE 6-7 Connections for Open-Delta-Connected VTs

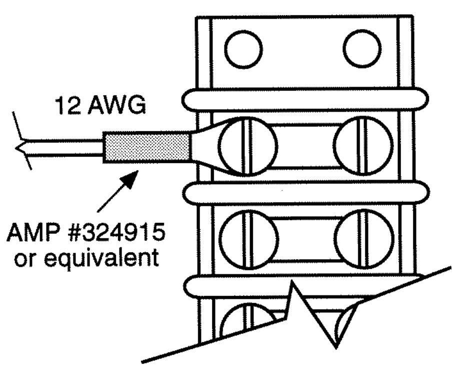


■ NOTE: On the internal configuration DIP switch, select line-to-line for basic VT input and either 69.3 V ac or 120 V ac for VT secondary voltage.

FIGURE 6-8 Connections for Delta-Wye-Connected VTs

UL-APPROVED TERMINAL BLOCK CONNECTIONS

The M-0430 is listed to UL Standards for Safety by Underwriters Laboratories Inc. (UL). To fulfill the UL requirements, terminal block connections must be made as illustrated in Figure 6-9: the wire should be No. 12 AWG inserted in an AMP #324915 (or equivalent) connector, and both screws tightened to 20 inch-pounds torque.



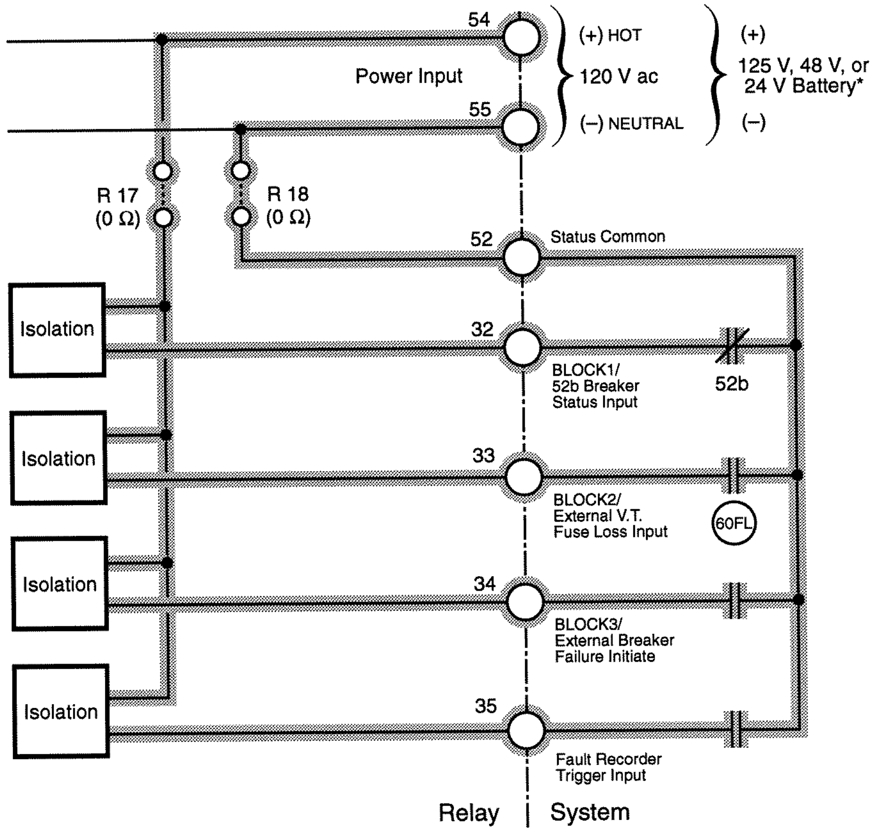
Recommended Wire Terminations

Tighten to 20 inch-pounds

FIGURE 6-9 Wire Terminations for External Connections as Required for UL Listing

CONTACT WETTING

As illustrated in Figure 6-10, the M-0430 provides power to the external contacts via the M-0430 internal power source.



*■ **NOTE:** Input voltage depends on power supply ordered with unit. Shading shows circuit path.

FIGURE 6–10 External Wiring and Relay Circuit for Status Input Contact Wetting

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7
TEST PROCEDURES

This chapter provides step-by-step test procedures for each M-0430 function as well as the diagnostic mode procedures and the self-calibration procedure. (The diagnostic mode procedures provide a means to check the basic functionality of the relay, including inputs, outputs, the alphanumeric display, LEDs, pushbuttons, and the COM ports.) Refer to Figure 6-5 for the external connections diagram. These tests are based on the three-phase line-to-neutral configuration, with DIP switches 4 and 5 OFF (up).

UNIT SETUP

No calibration is needed since the unit is calibrated and fully tested at the factory. If calibration is necessary because of a component replacement, follow the self-calibration procedure detailed at the end of this chapter. These test procedures are based on the prerequisite that the functions are enabled and have initial settings as shown in Chapter 2, Application, and in the Specifications at the front of this book. (Functions with two available setpoints have only setpoint #1 enabled.)

Before beginning these test procedures, examine the DIP switch settings by going to the **SETUP UNIT** menu and selecting **DIP SWITCH SETTINGS**. If switches 4 and 5 are shown to be **ON** (down), remove the unit from its case and reset them to **OFF**. The applied test voltages and the M-0430 responses defined below are valid only for the three-phase line-to-neutral configuration. If the unit is intended for line-to-line service, reset the DIP switches after completing the tests.

EQUIPMENT REQUIRED

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

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

   * Three Doble F2200 Test Systems or equivalent can be used.
   ** Doble F2200 or FT-2, or equivalent timer.Test and Equipment Setup

TEST AND EQUIPMENT SETUP

1. Make sure that the internal configuration DIP switches are set as shown in Figure 7–1.

2. Connect system power to the power input terminals 54 (hot) and 55 (neutral). The relay can be ordered with a nominal input power supply of 120 V ac/125 V dc, 48 V dc, or 24 V dc.

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

3. For each test procedure, connect the voltage and current inputs according to the configuration listed at the beginning of the test procedure. For example, for the Function 59 RMS Overvoltage, 3-Phase test procedure, connect the voltage inputs as shown in Voltage Configuration V1 (Figure 7-2), and connect the current inputs as shown in Current Configuration C1 (Figure 7-4).

4. Before you begin each test, enter the setpoints listed at the beginning of the test procedure. For example, for the Function 59 test procedure, the magnitude of the first setpoint should be set to 126 V and the time delay to 1 cycle. Additionally, the volts-per-hertz and breaker failure functions should be disabled. The programmed output should be OUT1.

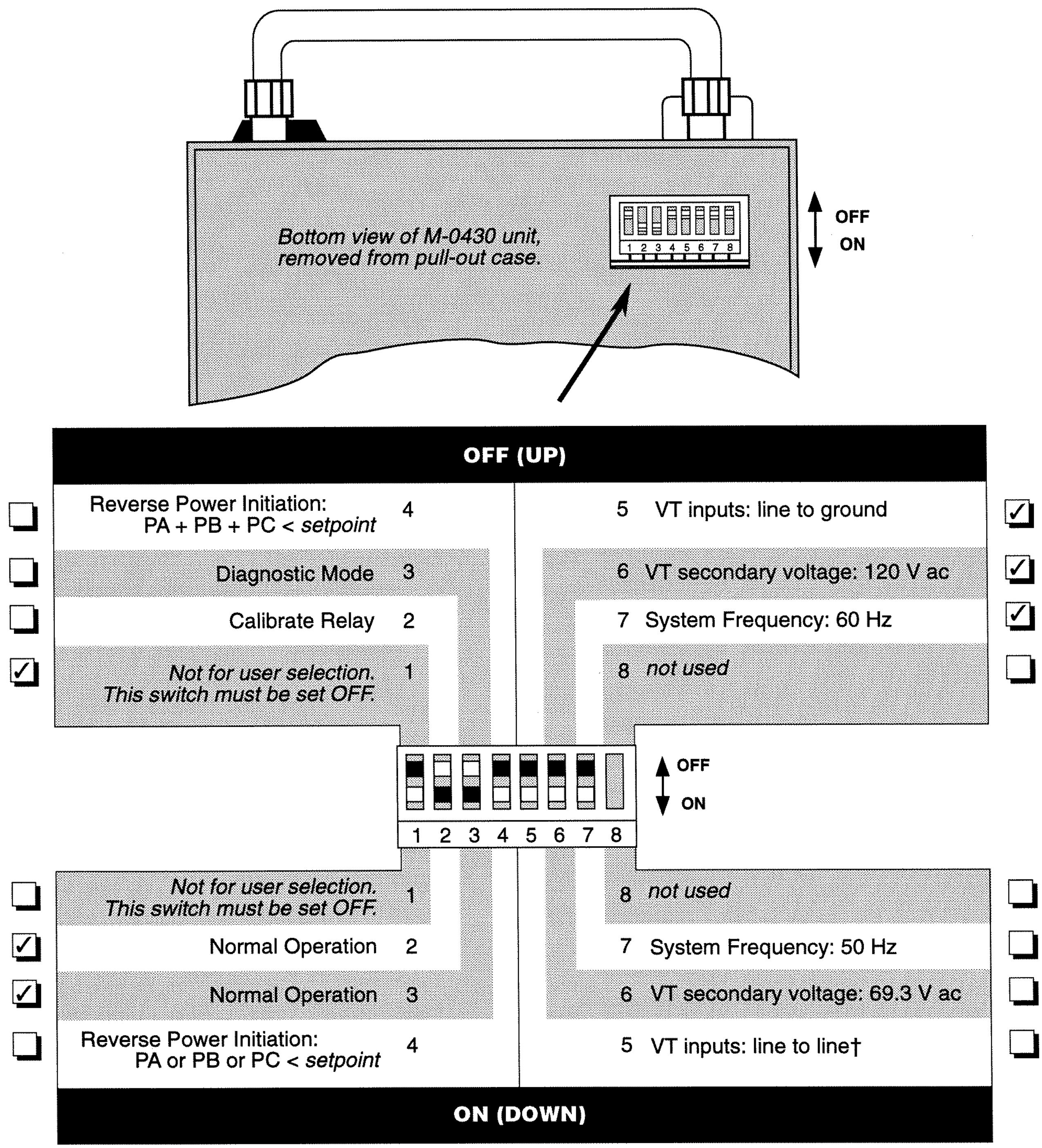

FIGURE 7–1 Test Procedure DIP Switch Settings

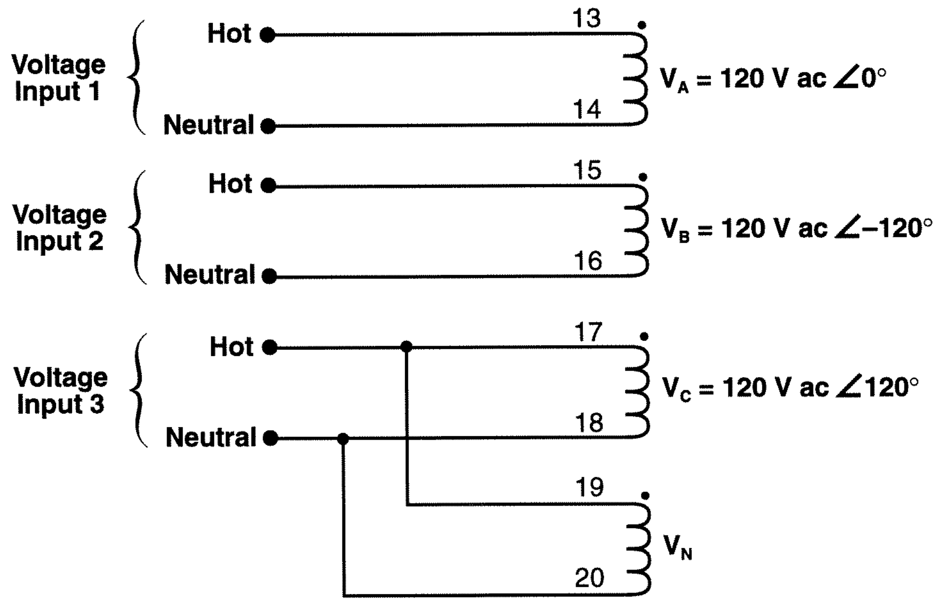

FIGURE 7–2 Voltage Inputs—Configuration V1

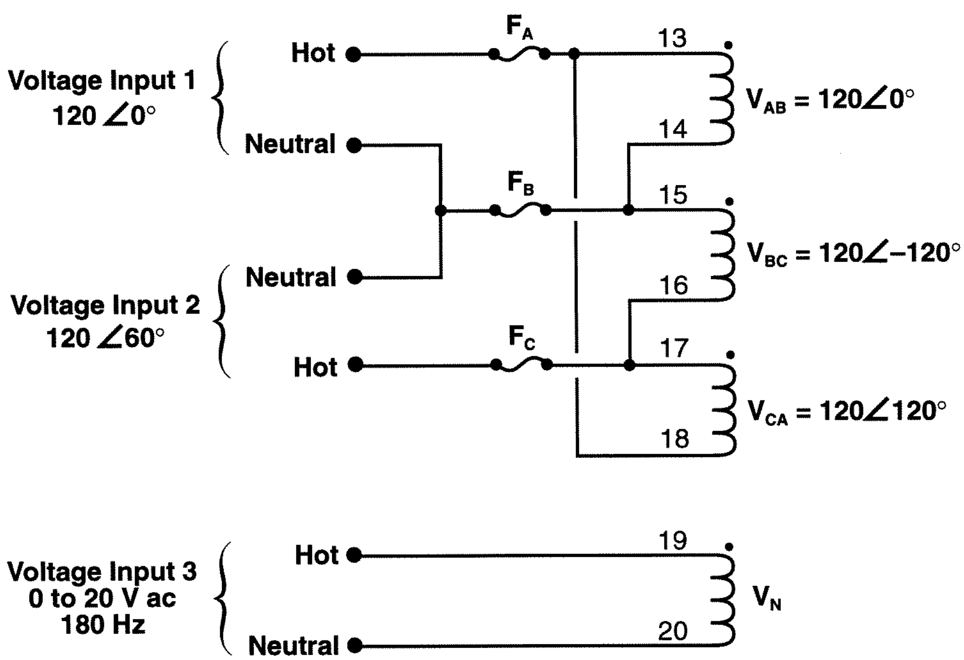

FIGURE 7–3 Voltage Inputs—Configuration V2

■ **NOTE:** The phase angles shown here use leading angles as positive and lagging angles as negative. Some manufacturers of test equipment have used lagging angles as positive, in which case V_B=120 Vac∠120° and V_C=120 Vac∠240°.

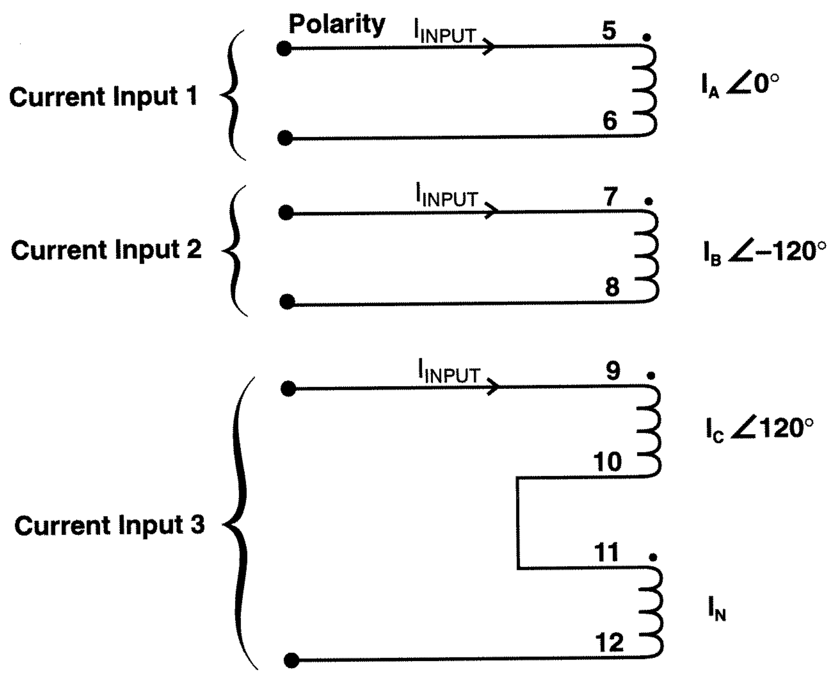

FIGURE 7–4 Current Inputs—Configuration C1

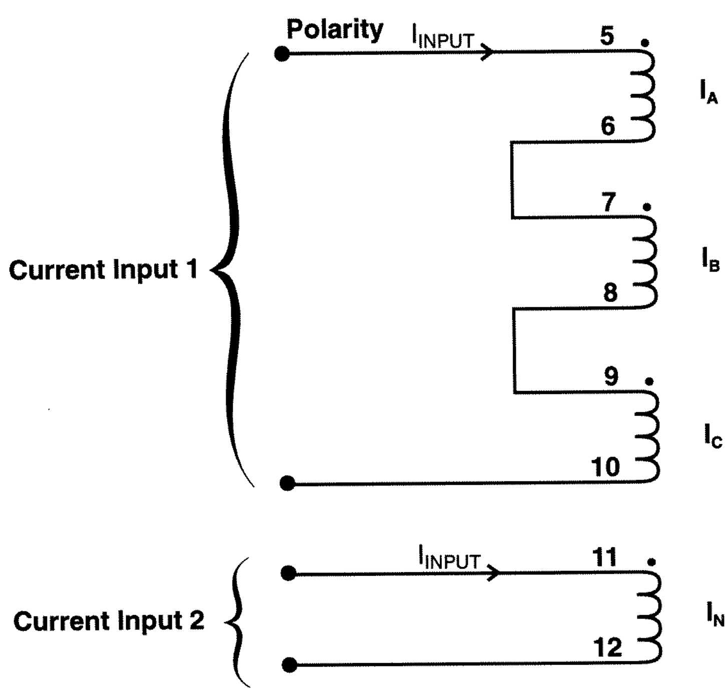

FIGURE 7–5 Current Inputs—Configuration C2

■ **NOTE:** The phase angles shown here use leading angles as positive and lagging angles as negative. Some manufacturers of test equipment have used lagging angles as positive, in which case V_B=120 Vac∠120° and V_C=120 Vac∠240°.

DIAGNOSTIC TEST PROCEDURES

The diagnostic procedures perform basic functional tests to verify the operation of the M-0430 front-panel controls, inputs and outputs, and communication ports. These tests are performed in diagnostic mode, which is entered by setting switch 3 of the internal configuration DIP switch to the **OFF** (up) position.

To enter diagnostic mode:

1. Power down the unit and remove it from the pull-out case.

2. Set switch 3 of the internal configuration DIP switch to **OFF** (up).

3. Return the unit to the case and power up the unit. The **DIAGNOSTIC MODE** menu will be displayed.

```
DIAGNOSTIC MODE
```

```
OUTPUT TEST (RELAY)
OUTPUT input led button→
```

Diagnostic mode selections work in a similar manner to the operational mode, with the exception that after each test is completed and the **EXIT** pushbutton pressed, the word **DONE** is displayed. **EXIT** must be pressed one additional time to return to the **DIAGNOSTIC MODE** main menu.

If you press **EXIT** from the **DIAGNOSTIC MODE** main menu, the following screen will be displayed:

```
RETURN DIAG MODE DIP SW
PRESS ANY KEY TO RESET
```

To return the unit to normal operation, power down the unit, reset switch 3 of the internal configuration DIP switch to **ON** (down), and power up the unit.

To return to the **DIAGNOSTIC MODE** main menu, press any pushbutton except the **TARGET RESET/LAMP TEST** pushbutton.

OUTPUT TEST

The **OUTPUT TEST** menu selection enables the user to check the individual relay outputs. Individual relay outputs can be selected by number by using the rotary knob. The selected output can then be turned on or off using the left- and right-arrow pushbuttons.

RELAY NUMBER	RELAY NAME	NORMALLY OPEN CONTACT*	NORMALLY CLOSED CONTACT*
1	OUT3	44–45	45–46
2	OUT2	47–48	—
3	OUT4	42–43	—
4	OUT5	40–41	—
5	SELF-TEST ALARM	—	38–39
6	OUT1	49–50	50–51
7	N/A	—	—
8	N/A	—	—

** "Normal" position of the contact corresponds to the OFF (de-energized) state of the relay.*

TABLE 7–1 Output Test Terminal Contacts

1. Turn the rotary knob (if necessary) until the unit displays

```
OUTPUT TEST (RELAY)
OUTPUT input led button→
```

2. Press **ENTER**.

   The unit should display

```
RELAY NUMBER
    1
```

3. Press **ENTER**.

   The unit should display

```
RELAY NUMBER
OFF on
```

4. Referring to Table 7–1, connect a DMM between the normally open contacts for relay 1 (terminals 44 and 45 of the **OUT3** relay). The output contacts should be open; the DMM should read ∞ Ω.

   Connect the DMM between the normally closed contacts for relay 1 (terminals 45 and 46 of the **OUT3** relay). The output contacts should be closed; the DMM should read 0 Ω.

5. Use the right-arrow pushbutton to highlight the word **ON**. The unit should display

```
RELAY NUMBER
off ON
```

6. Press **ENTER**. The unit should display

```
RELAY NUMBER
    1
```

   The normally open output contacts should close: the DMM should read 0 Ω between terminals 44 and 45.

   The normally closed output contacts should open: the DMM should read ∞ Ω between terminals 45 and 46.

7. Press **ENTER**.

   The unit should display

```
RELAY NUMBER
off ON
```

8. Use the left-arrow pushbutton to highlight the word **OFF**. The unit should display

```
RELAY NUMBER
OFF on
```

9. Press **ENTER**. The unit should display

```
RELAY NUMBER
      1
```

   The normally open output contacts should open: the DMM should read ∞ Ω between terminals 44 and 45.

   The normally closed output contacts should close: the DMM should read 0 Ω between terminals 45 and 46.

10. Turn the rotary knob clockwise to select relay number 2. The unit should display

```
RELAY NUMBER
      2
```

11. Repeat steps 3 through 9 for relay 2 and the remainder of the relays. When finished, press **EXIT** twice to return to the **DIAGNOSTIC MODE** main menu.

– END –

INPUT TEST

The **INPUT TEST** menu selection enables the user to determine the status of the individual status inputs. Individual inputs can be selected by number by using the rotary knob. The status of the input will then be displayed.

INPUT NUMBER	DESIGNATION	TERMINAL
1	BLOCK1	32
2	BLOCK2	33
3	BLOCK3 (BFI)	34
4	Fault Recorder Trigger	35
5	*not used*	—
6	*not used*	—

TABLE 7–2 Input Test Terminals

1. Turn the rotary knob until the unit displays

```
INPUT TEST
output INPUT led button→
```

2. Press **ENTER**.

   The unit should display

```
INPUT NUMBER
    1
```

3. Press **ENTER**.

   The unit should display

```
INPUT NUMBER
CIRCUIT OPEN
```

4. Connect **External Status Common** (**EXT COM**—terminal 52) to input 1 (**BLOCK1**—terminal 32).

   The unit should display

```
INPUT NUMBER
CIRCUIT CLOSED
```

5. Press **ENTER**.

   The unit should display.

```
INPUT NUMBER
    1
```

   Disconnect **External Status Common** (**EXT COM**—terminal 52) to input 1 (**BLOCK1**—terminal 32).

6. Turn the rotary knob clockwise until the unit displays

```
INPUT NUMBER
    2
```

7. Referring to Table 7–2, repeat steps 2 through 5 for inputs 2 to 4. When finished, press **EXIT** three times to return to the **DIAGNOSITIC MODE** main menu.

■ **NOTE**: Inputs 5 through 8 are not currently used.

— END—

LED TEST

The **LED TEST** menu selection enables the user to check the front-panel LEDs individually.

LED	DESIGNATION	LED	DESIGNATION
1	OUT2	8	OUT4
2	59 OVERVOLTAGE	9	40 LOSS OF FIELD
3	24 VOLTS PER HERTZ	10	21 PHASE DISTANCE
4	59 N NEUTRAL OVERVOLTAGE	11	81O/U FREQUENCY
5	27TN NEUTRAL UNDERVOLTAGE (3RD HARMONIC)	12	50BF/FL BREAKER FAILURE/ VT FUSE LOSS
6	87 GD GROUND DIFFERENTIAL	13	32 DIRECTONAL OVERPOWER
7	FAULT RECORDED	14	BREAKER CLOSED
16	OUT1	15	OUT3
17	SELECT FUNCTION	19	ENTER SETPOINT

NOTE: LEDs 18 (POWER) and 20 (RELAY OK) are not tested with this function. The POWER LED should be on continuously when power is applied to the unit. The RELAY OK LED should flash or remain on, as programmed by the user, when power is applied to the unit.

TABLE 7–3 LED Designations

1. Turn the rotary knob until the unit displays

```
LED TEST
output input LED button→
```

2. Press **ENTER**.

   The unit should display

```
LED TEST
LED Number 1=ON
```

   and LED 1, **OUT2**, should turn on.

3. Press **ENTER**.

```
LED TEST
LED Number 2=ON
```

   and LED 2, **59 OVERVOLTAGE**, should turn on.

4. Referring to Table 7–3, repeat step 2 for each LED. When all LEDs have been tested, press **EXIT** twice to return to the **DIAGNOSTIC MODE** main menu.

■ **NOTE**: LEDs 18 (**POWER**) and 20 (**RELAY OK**) are not tested with this function. The **POWER** LED should be on continuously when power is applied to the unit. The **RELAY OK** LED should either be on continuously or blink when power is applied to the unit.

—END—

BUTTON TEST

The **BUTTON TEST** menu selection enables the user to check the front-panel pushbuttons. As each pushbutton is pressed, its name is displayed. The rotary knob should cause the displayed number to increment.

1. Turn the rotary knob until the unit displays

```
BUTTON TEST
output input led BUTTON→
```

2. Press **ENTER**.

   The unit should display

```
BUTTON TEST
  0
```

3. Rotate the rotary knob clockwise. The number should increment.

4. Rotate the rotary knob counterclockwise. The number should decrement.

5. Press and hold **ENTER**.

   The unit should display

```
BUTTON TEST
  0  ENTER
```

6. Release **ENTER**.

   The unit should display

```
BUTTON TEST
  0
```

5. Repeat steps 5 and 6 for each front-panel button (left- and right-arrow, **TARGET RESET/LAMP TEST**, and **EXIT**. The name of the button should be displayed while it is held down. When finished, press **EXIT** twice to return to the **DIAGNOSTIC MODE** main menu.

   ■ **NOTE**: Since pressing the **EXIT** pushbutton will exit from this test, it should be checked last.

—END—

DISPLAY TEST

The **DISPLAY TEST** menu selection enables the user to check the Liquid Crystal Display. This test cycles through varying test patterns until **EXIT** is pressed.

1. Turn the rotary knob until the unit displays

```
DISPLAY TEST
←DISP backlit com1 com2→
```

2. Press **ENTER**.

   The unit should display a sequence of test characters.

3. After the test has cycled through completely, press **EXIT** twice to return to the **DIAGNOSTIC MODE** main menu.

—END—

BACKLIGHT TEST

The **BACKLIGHT TEST** menu selection enables the user to check the Liquid Crystal Display backlight by turning it on and off under manual control. The backlight will be turned on for normal operation regardless of whether it is turned on or off when the **DIAGNOSTIC MODE** is exited.

1. Turn the rotary knob until the unit displays

```
BACKLITE TEST
←disp BACKLIT com1 com2→
```

2. Press **ENTER**.

   The unit should display

```
BACKLITE TEST
OFF on
```

3. Press **ENTER**.

   The unit should display

```
BACKLITE TEST
BACKLIGHT OFF
```

   and the backlight should turn off.

3. Press **ENTER**.

   The unit should display

```
BACKLITE TEST
OFF on
```

3. Press the right-arrow pushbutton to highlight **ON**. The unit should display

```
BACKLITE TEST
off ON
```

4. Press **ENTER**.

   The unit should display

```
BACKLITE TEST
BACKLIGHT ON
```

   and the backlight should turn on.

5. Press **EXIT** twice to return to the **DIAGNOSTIC MODE** main menu.

—END—

COM1 TEST

The **COM1 TEST** menu selection enables the user to check the front-panel RS-232C port. A loop-back plug is required for this test.

■ **NOTE**: The loopback plug required for COM1 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.

1. Turn the rotary knob until the unit displays

```
COM1 TEST
←disp backlit COM1 com2→
```

2. Press **ENTER**.

   The unit should display

```
COM1 TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loop-back plug to **COM1**, the front-panel RS-232C connector.

4. Press **ENTER**.

   The test will run; when complete the unit should display

```
COM1 TEST
PASS
```

5. Press **ENTER** to return to the **DIAGNOSTIC MODE** main menu.

—END—

COM2 TEST

The **COM2 TEST** menu selection enables the user to check the rear-panel RS-232C port. A loop-back plug is required for this test.

> ■ **NOTE**: The loopback plug required for COM2 consists of a DB25P connector (male) with pin 2 (**TX**) connected to pin 3 (**RX**) and pin 4 (**RTS**) connected to pin 5 (**CTS**). No other connections are necessary.

1. Turn the rotary knob until the unit displays

```
COM2 TEST
←disp backlit com1 COM2→
```

2. Press **ENTER**.

   The unit should display

```
COM2 TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loop-back plug to COM2, the rear-panel RS-232C port.

4. Press **ENTER**.

   The test will run; when complete the unit should display

```
COM2 TEST
PASS
```

5. Press **ENTER** to return to the **DIAGNOSTIC MODE** main menu.

—END—

OTHER DIAGNOSTIC MODE COMMANDS

The following diagnostic mode commands are not part of the diagnostic procedures, but are included here for completeness.

CLEAR BATTERY BACKED RAM

The **CLEAR BATTERY BACKED RAM** menu selection enables the user to clear the internal battery-backed RAM. This will clear all currently stored trip data, along with the counters and other internal data.

1. Turn the rotary knob until the unit displays

```
CLEAR BATTERY RAM
←BBRAM clock init     →
```

2. Press **ENTER**. The unit will display the following screens:

```
CLEAR BATTERY RAM
–WAIT–
```

```
CLEAR BATTERY RAM
–DONE–
```

3. Press **EXIT** to return to the **DIAGNOSTIC MODE** main menu.

—END—

CLEAR DATE AND TIME

The **CLEAR DATE AND TIME** menu selection enables the user to reset the unit's internal clock to 01/01/01 01:01:00.

1. Turn the rotary knob until the unit displays

```
CLEAR DATE & TIME
←bbram CLOCK init     →
```

2. Press **ENTER**. The unit will display the following screens:

```
CLEAR DATE & TIME
–WAIT–
```

```
CLEAR DATE & TIME
–DONE–
```

3. Press **EXIT** to return to the **DIAGNOSTIC MODE** main menu.

—END—

INITIALIZE SETPOINTS

The **INITIALIZE SETPOINTS** menu selection enables the user to reset all setpoints to their initial settings as defined in Chapter 2, **Application**.

■ **NOTE**: This selection will also reset all access codes.

1. Turn the rotary knob until the unit displays

```
INITIALIZE SETPOINTS
←bbram clock INIT    →
```

2. Press **ENTER**. The unit will display

```
INIT SETPOINTS & ACCESS
CODE TO DEFAULT VALUES?
```

■ **NOTE**: If you do not wish to initialize the setpoints at this time, press **EXIT** to return to the **DIAGNOSTIC MODE** main menu.

3. Press **ENTER** to initialize the setpoints. The unit will display

```
INITIALIZING SETPOINTS
-WAIT-
```

```
INITIALIZING SETPOINTS
CSUM S=10 EE=E7 IN=01
```

The **CSUM** (checksum) values are for information only and will vary from unit to unit.

4. Press **EXIT** to return to the **DIAGNOSTIC MODE** main menu.

—END—

FACTORY USE ONLY

The **FACTORY USE ONLY** menu selection provides access to diagnostic information and routines of use only to factory personnel. A factory access code is required to proceed beyond this selection.

```
FACTORY USE ONLY
←FACTORY
```

POWER-ON SELF-TEST

VOLTAGE INPUTS: none

CURRENT INPUTS: none

1. Apply proper power to the power input terminals: 54 (HOT) and 55 (NEUTRAL).

2. The unit should display

```
POWER ON SELFTESTS
XXXXXXXX
```

3. All LEDs should turn on for about 1 sec. The **POWER** and **RELAY OK** LEDs should remain on; the rest of the LEDs should turn off.

   The unit should display

```
POWER ON SELFTESTS
PASS                  →
```

4. The unit should display the model number

```
 Beckwith Electric Co.
        M-0430
```

5. The unit should display

```
Beckwith Electric Co.
D-0024xx.xx-x
```

   where "xx.xx-x" signifies the software revision;

```
Beckwith Electric Co.
SERIAL NUMBER xxx
```

   and where "xxx" signifies the unit serial number.

   The **POWER** LED should turn on. The **RELAY OK** LED should flash (or stay on as programmed in the setup menu) and the **BREAKER CLOSED** LED should remain on. The power-on self-tests ends with the system date and time and the default logo, and then presents the default screens. These are the target history screens when a trip has occurred, which will have occurred if the voltage and frequency relays are enabled, but there is no input voltage.

—END—

59 RMS OVERVOLTAGE, THREE-PHASE

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: Configuration C1

MAGNITUDE ACCURACY TEST

TEST SETTINGS:	Magnitude #1	126 V (1.05 P.U.)
	Time Delay #1	1 cycles
	Function 50BF, Breaker Failure	Disable
	Function 24, Volts/Hz	Disable
	Programmed Output	OUT1
	Function 59N, Rms Overvoltage	Disable

1. Apply 120 V ac to the voltage input terminals: 13 (HOT) and 14 (NEUTRAL).
2. Connect a digital timer to the trip contacts: terminals 49 and 50.
3. Press **ENTER**.
4. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

5. Press **ENTER**. The unit should display

```
OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over  →
```

6. Press **ENTER**. The unit should display

```
PHASE OVERVOLTAGE      #1
   132 Volts
```

7. Change the setpoint by turning the rotary knob counterclockwise to 126 V. The unit should display

```
PHASE OVERVOLTAGE      #1
  126 Volts
```

8. Press **ENTER** once. Change the setpoint by turning the rotary knob clockwise to 1 cycles. The unit should display

```
DELAY PHASE OVERVOLT  #1
     1 Cycles
```

9. Press **ENTER**. The unit should display

```
OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over  →
```

10. Press **EXIT** once. The unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

11. Rotate the rotary knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

12. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

13. Press **ENTER** and then rotate the rotary knob clockwise until the unit displays

```
NEUTRAL OVERVOLTAGE   #1
disable ENABLE
```

.

14. Rotate the rotary knob counterclockwise. The unit should show **DISABLE** highlighted instead of **enable**.

15. Press **ENTER** and then **EXIT** once.

16. Rotate the rotary knob clockwise until the unit displays

```
CONFIGURE RELAYS
←VOLTS_PER_HERTZ_RELAY →
```

17. Press **ENTER** and then rotate the rotary knob counterclockwise. The unit should show **DISABLE** highlighted instead of **enable**.

    Repeat steps 16 and17 for Inverse Time V/Hz.

18. Press **ENTER** and then **EXIT** once.

19. Rotate the front-panel clockwise knob until the unit displays

```
CONFIGURE RELAY
←BREAKER_FAILURE_RELAY →
```

20. Press **ENTER** once. The unit should display

```
BREAKER FAILURE
disable ENABLE
```

21. Rotate the rotary knob counterclockwise. The unit should show **DISABLE** highlighted instead of **enable.**

22. Press **ENTER** once and then **EXIT** three times. The unit should display

```
 Beckwith Electric Co.
        M-0430
```

23. Slowly increase the input voltage on phase A until the **OVERVOLTAGE 59** LED lights and OUT1 closes. The voltage level at which the LED lights should be 126 V ac ± 0.5 V ac. Decrease the input voltage until the **OVERVOLTAGE 59** and OUT1 LEDs go out.

24. Press the **TARGET RESET/LAMP TEST** button to remove the target.

25. Press **ENTER.**

26. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

27. Press **ENTER**. The unit should display

```
OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over  →
```

28. Press **ENTER**. The unit should display

```
PHASE OVERVOLTAGE      #1
  126 Volts
```

29. Change the setpoint by turning the rotary knob clockwise to 132 V. The unit should display

```
PHASE OVERVOLTAGE      #1
   132 Volts
```

30. Press **ENTER** once. Change the setpoint by turning the rotary knob clockwise to 300 cycles. The unit should display

```
DELAY PHASE OVERVOLT   #1
   300 Cycles
```

31. Press **ENTER**. The unit should display

```
OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over  →
```

32. Press **EXIT** once. The unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

33. Press **EXIT** once. The unit should display

```
 Beckwith Electric Co.
        M-0430
```

34. Increase the input voltage on phase A to 133 V ac and start timing.

35. The unit should trip after 300 cycles (+20 cycles) time delay.

36. **OVERVOLTAGE 59** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
 PHASE OVERVOLTAGE #1
```

```
-TRGT- 01/15/93 16:44:20
 PHASE A=X B=0 C=0
```

37. Set the input voltage to 120 V ac.

38. Press **TARGET RESET/LAMP TEST** button. The **OVERVOLTAGE 59** LED should turn off. The unit should display

```
 Beckwith Electric Co.
        M-0430
```

—END—

59N RMS OVERVOLTAGE, NEUTRAL CIRCUIT OR ZERO SEQUENCE

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C1**	
TEST SETTINGS:	**Magnitude #1**	**126 V (1.25 P.U.)**
	Time Delay #1	**30 cycles**
	Function 50BF, Breaker Failure	**Disable**
	Function 24, Volts/Hz	**Disable**
	Function 27TN, Third-Harmonic Undervoltage	**Disable**
	Programmed Ouput	**OUT1**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Press **ENTER**. Rotate the rotary knob clockwise until **NUTRL_OVER** is highlighted.

```
OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over  →
```

3. Press **ENTER** once. Change the setpoint by turning the knob clockwise to 126 V ac. The unit should display

```
NEUTRAL OVERVOLTAGE    #1
  126 Volts
```

4. Press **ENTER** once and then **EXIT** three times.
5. Increase the input voltage on phase C and the neutral input (V_N) to 155 V ac and start timing.
6. The unit should trip after 30 cycles (–1 to +3 cycles) time delay.
7. The **OVERVOLTAGE 59N** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
 NEUTRAL OVERVOLTAGE  #1
```

8. Set the input voltage on phase C and the neutral input (V_N) to 120 V ac.

—END—

81O OVERFREQUENCY

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C1**	
TEST SETTINGS:	**Magnitude #1**	**60.50 Hz**
	Time Delay #1	**30 cycles**
	Function 50BF, Breaker Failure	**Disable**
	Programmed Output	**OUT1**

1. Set the input voltages (V_A, V_B, V_C, and V_N) to 120 V ac.
2. Depress and hold down the **TARGET RESET/LAMP TEST** button.
3. Slowly increase the frequency on the voltage inputs (V_A, V_B, V_C, and V_N) until the over **OVERFREQUENCY 81** and OUT1 LEDs come on.
4. Set the frequency back to 60.00 Hz.
5. Increase the frequency on the voltage inputs (V_A, V_B, V_C, and V_N) to 61.00 Hz and start timing.
6. The unit should trip after 30 cycles (–1 to +3 cycles) time delay.
7. The **OVERFREQUENCY 81** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/16/93 16:44:20
OVERFREQUENCY         #1
```

8. Set the frequency to 60.00 Hz.
9. Press the **TARGET RESET/LAMP TEST** button. The **OVERFREQUENCY 81** LED should turn off. The unit should display

```
  Beckwith Electric Co.
         M-0430
```

—END—

81U UNDERFREQUENCY

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C1**	
TEST SETTINGS:	**Magnitude #1**	**59.50 Hz**
	Time Delay #1	**30 cycles**
	Function 50BF, Breaker Failure	**Disable**
	Programmed Output	**OUT1**

1. Depress and hold down the **TARGET RESET/LAMP TEST** button.

2. Slowly decrease the frequency on the voltage inputs (V_A, V_B, V_C, and V_N) until the **UNDERFREQUENCY 81** and OUT1 LEDs come on. The measured frequency should be 59.50 ±0.2 Hz.

3. Set the frequency back to 60.00 Hz.

4. Decrease the frequency on the voltage inputs to 59.00 Hz and start timing.

5. The unit should trip after 30 cycles (–1 to +3 cycles) time delay.

6. The **UNDER FREQUENCY 81** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
UNDERFREQUENCY        #1
```

7. Set the frequency to 60.00 Hz.

8. Press the **TARGET RESET/LAMP TEST** button. The **UNDERFREQUENCY 81** LED should turn off and the unit should display

```
  Beckwith Electric Co.
         M-0430
```

—END—

32 DIRECTIONAL POWER, THREE-PHASE

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:

Forward Overpower	3.0 pu
Time Delay	30 cycles
Reverse Overpower	–3.0 pu
Time Delay	30 cycles
Function 50BF, Breaker Failure	Disable
Programmed Output	OUT1

1. Set the three-phase input voltages to 120 V ac.
2. Increase the three-phase input currents to 16 A and start timing.
3. The unit should trip after 30 cycles (–1 to +3 cycles) time delay.
4. The **DIRECTIONAL OVERPOWER 32** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
FORWARD OVERPOWER
```

5. Set input current to 0 A.
6. Press the **TARGET RESET/LAMP TEST** button. The **DIRECTIONAL OVERPOWER 32** LED should turn off and the unit should display

```
  Beckwith Electric Co.
         M-0430
```

7. Set the phase angle on the current source to 180°.
8. Increase the input currents (I_A, I_B, I_C, and I_N) to 16 A and start timing.
9. The unit should trip after 30 cycles (–1 to +3 cycles) time delay.

10. The **DIRECTIONAL OVERPOWER 32** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
 REVERSE OVERPOWER
```

11. Set the three-phase input current to 0 A. Set the phase angle between three-phase voltage and current to zero.

12. Press the **TARGET RESET/LAMP TEST** button. The **DIRECTIONAL OVERPOWER 32** LED should turn off and the unit should display

```
  Beckwith Electric Co.
         M-0430
```

—END—

21 PHASE DISTANCE

Voltage Inputs:	**Configuration V1 @ 120 V ac**	
Current Inputs:	**Configuration C1 @ 0 Amps**	
Setpoints	**Function40, Loss of field**	**Disabled**
	Function 59N, Neutral Overvoltage	**Disabled**
	Function 87GD, Ground Differential	**Disabled**
	Function 50BF, Breaker Fail	**Disabled**
	Offset	**0 ohms**
	Diameter	**100 ohms**
	Angle	**45°**
	Timer	**30 cycles**
	Programmed Output	**OUT1**

1. Press **ENTER**. The select function LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the rotary knob clockwise until the unit displays

```
PHASE DISTANCE RELAY
←lof DIST brkfail fuse →
```

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

```
PHASE DISTANCE SETPOINTS
DIST
```

4. Press **ENTER**. The unit should display

```
DIAMETER PHASE DISTANCE
   50.0 Ohms
```

   Rotate the rotary knob until the unit displays 100.0 ohms. Press **ENTER**.

```
OFFSET PHASE DISTANCE
  0.0 Ohms
```

Rotate the rotary knob until the unit displays 0.0 ohms. Press **ENTER**.

```
Z ANGLE PHASE DISTANCE
   85 Degrees
```

Rotate the rotary knob until the unit displays 45°. Press **ENTER**.

```
DELAY PHASE DISTANCE
  30 Cycles
```

Rotate the rotary knob until the unit displays 30.0 cycles. Press **ENTER**.

5. Press the **EXIT** button once. The unit should display

```
PHASE DISTANCE RELAY
←lof DIST brkfail fuse →
```

6. Rotate the rotary knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG     →
```

7. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY         →
```

8. Press the **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE   #1
disable ENABLE
```

9. Rotate the rotary knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

10. Press **ENTER** and then **EXIT** once.

11. Rotate the rotary knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

12. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL   #1
disable ENABLE
```

13. Rotate the rotary knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

14. Press **ENTER** and then **EXIT** once.

15. Repeat the same method in 11, 12, 13, and 14 to disable the Loss of Field (40) and Breaker Failure (50BF) functions, making sure that **ENTER** is pressed after each entry.

16. Set the three-phase input voltage to 120 V ac.

17. Set the three-phase current to 0.0 A.

18. Set the phase angle between the three-phase input voltage and the three-phase input current to –45.00°.

19. Depress and hold down the **TARGET RESET/LAMP TEST** button.

20. Slowly increase the current until the **21 PHASE DISTANCE** and **OUT1** LEDs come on. The current level where the LED comes on should be approximately 1.20 A.

21. Decrease the current until the **21 PHASE DISTANCE** and **OUT1** LEDs go off. Release the **TARGET RESET/ LAMP TEST** button.

22. Press the **EXIT** button until the unit displays

```
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       M-0430
```

23. Increase the current to 1.50 A and start timing.

24. The OUT1 output should trip after 30 cycles (–1 to +3 cycles).

25. The **21 PHASE DISTANCE** LED should turn on and the unit should rotate displays as follows:

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
PHASE DISTANCE
```

```
-TRGT- 01/15/93 16:44:20
AB=X BC=X CA=X
```

26. Set the input voltages and currents to zero.

27. Press the **TARGET RESET/LAMP TEST** button. The **21 PHASE DISTANCE** LED should turn off and the unit should display

```
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```

— END —

40 LOSS OF FIELD

VOLTAGE INPUTS:	**Configuration V1 @ 120 V ac**	
CURRENT INPUTS:	**Configuration C1 @ 0 Amps**	
TEST SETTINGS:	**Function 21, Phase Distance**	**Disable**
	Function 59N, Neutral Overvoltage	**Disable**
	Function 87GD, Ground Differential	**Disable**
	Function 50BF, Breaker Fail	**Disable**
	Offset	**–50 ohms**
	Diameter	**100 ohms**
	Timer	**300 cycles**
	Programmed Output	**OUT1**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the front-panel knob clockwise until the unit displays

```
LOSS OF FIELD RELAY
←LOF dist brkfail fuse →
```

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

```
LOSS OF FIELD SETPOINTS
LOF
```

4. Press **ENTER**. The unit should display

```
DIAMETER LOSS OF FIELD#1
    50.0 Ohms
```

Rotate the front-panel knob until the unit displays 100.0 ohms. Press **ENTER**. Repeat this step for Offset Loss of Field #1 and Delay Loss of Field #1:

```
OFFSET LOSS OF FIELD  #1
  10.0 Ohms
```

Rotate the front-panel knob until the unit displays –50.0 ohms. Press **ENTER**.

```
DELAY LOSS OF FIELD     #1
     30 Cycles
```

Rotate the front-panel knob until the unit displays 1cycle. Press **ENTER**.

5. Press the **EXIT** button once. The unit should display

```
LOSS OF FIELD RELAY
←LOF dist brkfail fuse →
```

6. Rotate the front-panel knob clockwise until unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

7. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

8. Press the **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE    #1
disable ENABLE
```

9. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

10. Press **ENTER** and then **EXIT** once.

11. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

12. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL    #1
disable ENABLE
```

13. Rotate the front-panel knob counterclockwise. **DISABLE** should now be highlighted rather than **enable**.

14. Press **ENTER** and then **EXIT** once.

15. Repeat the same method in steps 11, 12, 13, and 14 to disable the Phase Distance (21) and Breaker Failure (50BF) functions, and to enable the Loss of Field (40) function, making sure that **ENTER** is pressed after each entry.

16. Set the three-phase input voltage to 120 V ac.

17. Set the three-phase current to 3.0 A.

18. Set the phase angle between the three-phase input voltage and the three-phase input current to 90°.

19. Slowly decrease the current until the **LOSS OF FIELD** and OUT 1 LEDs come on. The current level where the LED lights should be approximately 2.40 A.

20. Increase the current until the **LOSS OF FIELD** LED goes off. Release the **TARGET RESET/LAMP TEST** button.

21. Press the **TARGET RESET/LAMP TEST** button to remove the target.

22. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

23. Rotate the front-panel knob clockwise until the unit displays

```
LOSS OF FIELD RELAY
←LOF dist brkfail fuse →
```

24. Press **ENTER**. The unit should display

```
LOSS OF FIELD SETPOINTS
LOF
```

25. Press **ENTER** three times. The unit should display

```
DELAY LOSS OF FIELD    #1
      30 Cycles
```

Rotate the front-panel knob until the unit displays 300 cycles. Press **ENTER**.

26. Press the **EXIT** button once. The unit should display

```
LOSS OF FIELD RELAY
←LOF dist brkfail fuse →
```

27. Press the **EXIT** button until the unit displays

```
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```

28. Decrease current to 2.25 A and start timing.

29. The unit should trip on OUT 1 output after 300 cycles (–1 to +3 cycles).

30. The **40 LOSS OF FIELD** LED should turn on and the unit should rotate displays as follows

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
Loss of Field #1
```

31. Set the input voltage and current to zero.

32. Press the **TARGET RESET/LAMP TEST** button. The **40 LOSS OF FIELD** LED should turn off and the unit should display

```
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```

—END—

24 VOLTS/HZ INVERSE TIME

VOLTAGE INPUTS:	**V1**	
CURRENT INPUTS:	**none**	
TEST SETTINGS:	**Function 24, Volts/Hz, Definite Time**	**Disable**
	Function 59, RMS Overvoltage	**Disable**
	Function 59N, Neutral Overvoltage	**Disable**
	Function 87GD, Ground Differential	**Disable**
	Function 50BF, Breaker Failure	**Disable**
	Function 24, Volts/Hz, Inverse Time #1	**101%**
	Programmed Output	**OUT1**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the front-panel knob clockwise until the unit displays

```
VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→
```

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

```
DEFTIME V/HZ SETPOINTS
DEF_V/HZ inv_v/hz
```

   Rotate the front-panel knob clockwise until INV_V/HZ is highlighted.

4. Press **ENTER**. The unit should display

```
PICKUP INVERSE TIME V/HZ
   105%
```

   Rotate the front-panel knob counterclockwise until the unit displays 101%.

5. Press **ENTER** twice. The unit should display

```
TIME DIAL INV TIME V/HZ
  9
```

Rotate the front-panel knob counterclockwise until the unit displays 1. Press **ENTER**.

6. Press **ENTER**. The unit should display

```
RESET RATE INV TIME V/HZ
   200 Sec.
```

Rotate the front-panel knob counterclockwise until the unit displays 1 sec. Press **ENTER**.

7. Press the **EXIT** button once. The unit should display

```
VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→
```

8. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG     →
```

9. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
   VOLTAGE_RELAY        →
```

10. Press **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE    #1
disable ENABLE
```

11. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted rather than **enable**.

12. Press **ENTER** and then **EXIT** once.

13. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

14. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL    #1
disable ENABLE
```

15. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted rather then **enable**.

16. Press **ENTER** and then **EXIT** once.

17. Repeat the same method in 13, 14, 15 and 16 to disable the Breaker Failure (50BF), Volts per Hertz (24), Definite Time, and RMS Overvoltage (59) functions, making sure that **ENTER** is pressed after each entry.

18. Press **EXIT** until the unit displays

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

19. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR STATUS
←setpts STAT config    →
```

20. Press **ENTER**. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR V/HZ STATUS
volt curr freq V/HZ    →
```

21. Press **ENTER**. The unit should display

```
VOLTS PER HERTZ
        0%
```

22. Set the three-phase input voltage to 120 V ac.

23. Depress and hold down the **TARGET RESET/LAMP TEST** button.

24. Slowly increase the voltage on phase A until the **VOLTS/HZ** LED comes on. The LED should come on at 101% Volts per Hertz or 120 X 1.01 = 121.2 V ac.

25. Decrease the voltage until the **VOLTS/HZ** LED goes off. Release the **TARGET RESET/LAMP TEST** button.

26. Press the **EXIT** button until the unit displays

```
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```

27. Increase voltage to 105% and start timing.

28. The OUT1 output should trip after 3400 cycles (+20 cycles).

29. The **24 VOLTS/HZ** LED should turn on and the unit should rotate displays as follows:

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
Definite Time V/Hz #1
```

30. Set the input voltage to zero.

31. Repeat step 27 for each of the input values below.

Limit	Setpoint	Input	Measured Input	Measured Time	Cal
K=1	101%	105%	_____ V ac	_____ Sec.	
	101%	110%	_____ V ac	_____ Sec.	
	101%	120%	_____ V ac	_____ Sec.	
	101%	130%	_____ V ac	_____ Sec.	
	101%	140%	_____ V ac	_____ Sec.	
	101%	150%	_____ V ac	_____ Sec.	

Record the measured time in the graph provided to show the inverse curve.

32. Press the **TARGET RESET/LAMP TEST** button. The **24 VOLTS/HZ** LED should turn off and the unit should display

```
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```

—END—

24 VOLTS/HZ DEFINITE TIME

VOLTAGE INPUTS: V1

CURRENT INPUTS: none

TEST SETTINGS:

Function 24, Volts/Hz, Inverse Time	Disable
Function 59, RMS Overvoltage	Disable
Function 59N, Neutral Overvoltage	Disable
Function 87GD, Ground Differential	Disable
Function 50BF, Breaker Fail	Disable
Function 24, Volts/Hz, Definite Time #1	110%
Time Dealy Def Time v/hz #1	300 cycles
Programmed Output	OUT1

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the front-panel knob clockwise until the unit displays

```
VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→
```

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

```
DEFTIME V/HZ SETPOINTS
DEF_V/HZ inv_v/hz
```

4. Press **ENTER**. The unit should display

```
DEFINITE TIME V/HZ    #1
  110%
```

5. Press **ENTER**. The unit should display

```
DELAY DEFTIME V/HZ    #1
  360 Cycles
```

Rotate the front-panel knob counterclockwise until the unit displays 300 cycles. Press **ENTER**.

6. Press the **EXIT** button once. The unit should display

```
VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→
```

7. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

8. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

9. Press **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE    #1
disable ENABLE
```

10. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted rather than **enable**.

11. Press **ENTER** and then **EXIT** once.

12. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

13. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL    #1
disable ENABLE
```

14. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted rather then **enable**.

15. Press **ENTER** and then **EXIT** once.

16. Repeat the same method in 12, 13, 14 and 15 to disable the Breaker Failure (50BF), Volts-per-Hertz Inverse Time (24), and RMS Overvoltage (59) functions, making sure that **ENTER** is pressed after each entry.

17. Press **EXIT** until the unit displays

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

18. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR STATUS
←setpts STAT config  →
```

19. Press **ENTER**. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR V/HZ STATUS
volt curr freq V/HZ  →
```

20. Press **ENTER**. The unit should display

```
VOLTS PER HERTZ
      0%
```

21. Set the three-phase input voltage to 120 V ac.

22. Depress and hold down the **TARGET RESET/LAMP TEST** button.

23. Slowly increase the voltage on phase A until the **VOLTS/HZ** LED comes on. The LED should come on at 110% Volts per Hertz or 120 X 1.10 = 132 V ac.

24. Decrease the voltage on phase A until the **VOLTS/HZ** LED goes off. Release the **TARGET RESET/LAMP TEST** button.

25. Press the **EXIT** button until the unit displays

```
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```

26. Increase voltage on phase to 115% and start timing.

27. The OUT1 output should trip after 300 cycles (+20 cycles).

28. The **24 VOLTS/HZ** LED should turn on and the unit should rotate displays as follows:

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
Definite Time V/Hz #1
```

29. Set the input voltage to zero.

30. Press the **TARGET RESET/LAMP TEST** button. The **24 VOLTS/HZ** LED should turn off and the unit should display

```
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```

—END—

87GD GROUND DIFFERENTIAL

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C2**	
TEST SETTINGS:	**Function 59N, Neutral Overvoltage**	**Disable**
	Function 50BF, Breaker Fail	**Disable**
	Function 87GD, Ground Differential #1	**0.5 Amp**
	Function 87GD, Time Delay	**300 cycles**
	Programmed Output	**OUT1**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the front-panel knob clockwise until the unit displays

```
GND DIFFERENTIAL RELAY
volt freq v/hz powr GND→
```

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

```
GND DIFFERENTIAL SETPNTS
GND
```

4. Press **ENTER**. The unit should display

```
GND DIFFERENTIAL      #1
 .5 Amps
```

Repeat the step for the Delay GND Differential.

```
DELAY GND DIFFERENTIAL
   30 Cycles
```

Rotate the front-panel knob until the unit displays 300 cycles. Press **ENTER**.

5. Press the **EXIT** button once. The unit should display

```
GND DIFFERENTIAL RELAY
volt freq v/hz powr GND→
```

6. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG   →
```

7. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY       →
```

8. Press **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE  #1
disable ENABLE
```

9. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

10. Press **ENTER** and then **EXIT** once.

11. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAY
←BREAKER_FAILURE_RELAY →
```

12. Press **ENTER** once. The unit should display

```
BREAKER FAILURE
disable ENABLE
```

13. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

14. Press **ENTER** and then **EXIT** once.

15. Set the three-phase input voltage to 120 V ac, 60 Hz.

16. Set the I_A, I_B, I_C current to 3 A.

17. Set the I_N current to 9 A.

18. Depress and hold down the **TARGET RESET/LAMP TEST** button.

19. Slowly decrease the I_N current until the **87GD GROUND DIFFERENTIAL** LED comes on. The current level where the LED comes on should be approximately 8.50 A.

20. Increase the current until the **GROUND DIFFERENTIAL** LED goes off. Release the **TARGET RESET/LAMP TEST** button.

21. Press the **EXIT** button until the unit displays

```
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```

22. Decrease current to 8.00 A and start timing.

23. The unit OUT1 output should trip after 300 cycles (–1 to +3 cycles).

24. The **87GD GND DIFFERENTIAL** LED should turn on and the unit should rotate displays

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
–TRGT– 01/15/93 16:44:20
Gnd Differential #1
```

25. Press the **TARGET RESET/LAMP TEST** button and the **ENTER** button. The unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

26. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

27. Press **ENTER** and then rotate the front-panel knob clockwise until the unit displays:

```
SETUP FUNCTION
←SETUP
```

28. Press **ENTER** once. Rotate the front-panel knob until the unit displays

```
DIRECTIONAL CNTRL GNDIF
v/hz GND gnd lof1 lof2 →
```

29. Press **ENTER** and rotate the front-panel knob clockwise. The unit should now show **DIRECTIONAL** highlighted instead of **non-directional**.

30. Press **ENTER** and then **EXIT** twice.

31. Verify that the unit is no longer tripped.

32. Reverse the polarity of I_N by creating a 180° phase difference between I_A, I_B, I_C and I_N. Verify that the unit is tripped (not blocking).

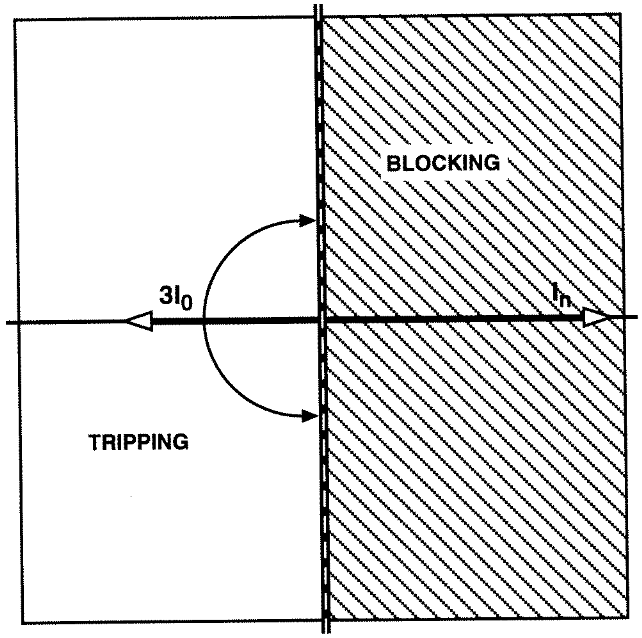

FIGURE 7–7 87GD Directional Element Characteristic

33. Set the input voltages and currents to zero.

34. Press the **TARGET RESET/LAMP TEST** button. The unit should display

```
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```

—END—

50BF BREAKER FAILURE

Refer to Breaker Failure Logic diagram in Chapter 2

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C2**	
TEST SETTINGS:	**Function 87GD, Ground Differential**	**Disable**
	Pick-up Phase Breaker Fail	**1.0 Amps**
	Pick-up Neutral Breaker Fail	**1.0 Amps**
	Delay Breaker Failure	**10 cycles**
	Breaker Failure Initiate	**OUT1**
	Programmed Output	**OUT4**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Rotate the front-panel knob clockwise until the unit displays

```
BREAKER FAILURE RELAY
←lof dist BRKFAIL fuse →
```

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

```
BREAKER FAILURE SETPNTS
BRKFAIL
```

4. Press **ENTER**. The unit should display

```
PICKUP PHASE BRKER FAIL
   1.0 Amps
```

5. Press **ENTER**. The unit should display

```
PICKUP NUTRL BRKER FAIL
   1.0 Amps
```

6. Press **ENTER**. The unit should display

```
DELAY BREAKER FAILURE
   30 Cycles
```

7. Rotate the front-panel knob until the unit displays 10 cycles. Press **ENTER** and then **EXIT** button twice.

8. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

9. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

10. Press the **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE   #1
disable ENABLE
```

11. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

12. Press **ENTER** and then **EXIT** once.

13. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

14. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL   #1
disable ENABLE
```

15. Rotate the front-panel knob counterclockwise. The unit should now show **DISABLE** highlighted instead of **enable**.

16. Press **ENTER** and then **EXIT** once.

17. Rotate front-panel knob clockwise until the unit displays

```
SETUP FUNCTION
←SETUP
```

18. Press **ENTER**. The unit should display

```
NOMINAL VOLTAGE V/HZ
V/HZ gnd gnd lof1 lof1 →
```

19. Rotate the front-panel knob clockwise until the unit displays

```
EXTERNAL BFI  BRKR FAIL
←brkfail brkfail BRKFAIL
```

20. Press **ENTER**. The unit should display

```
EXTERNAL BFI BRKRFAIL
DISABLE enable
```

21. Rotate the front-panel knob clockwise. The unit should now show **ENABLE** highlighted instead of **disable**.

22. Press **ENTER** and then **EXIT** four times.

23. Connect an external open contact from TB32 (BLOCK1 52B) to TB52 (Ext. Com.)

24. Connect an external open contact from TB34 (BLOCK3 BFI) to TB52 (Ext. Com.)

25. Set the three-phase input voltage to 120 V ac, 60 Hz.

26. Set I_A, I_B, I_C and I_N to 0.50 A.

27. Close the contact from BLOCK3 (BFI) to Ext. Com. and start timing.

28. The unit should close the OUT4 output after 10 cycles (–1 to +3 cycles).

29. The **50BF** LED should turn on and the unit should rotate displays as follows:

```
-TRGT- 01/15/93 16:44:20
   OUT4
```

```
-TRGT- 01/15/93 16:44:20
BREAKER FAILURE
```

30. Close the contact from BLOCK1 (52B) to Ext. Com. Verify that the unit is no longer tripped on out 4 and that the **BREAKER CLOSED** LED is off. Return both contacts to the open position.

31. Press the **TARGET RESET/LAMP TEST** button.

32. Close the contact from BLOCK1 (52B) to Ext. Com. Verify that the **BREAKER CLOSED** LED is off.

33. Increase I_A, I_B, I_C and I_N to 1.50 A and verify that the OUT4 output closes after 10 cycles. The **50BF** LED should turn on.

34. Decrease I_N I_A, I_B, I_C current below 1.00 A and verify that the OUT4 output is not longer closed.

35. Open the contact from BLOCK1 (52B) to Ext. Com.

36. Increase the phase A voltage to 133 V ac. Verify that the unit trips on 59 overvoltage, and 50BF breaker failure. (This tests the unit's ability to initiate the BF Timer whenever any of the programmed outputs is activated.)

—END—

27TN NEUTRAL UNDERVOLTAGE (3RD HARMONIC)

VOLTAGE INPUTS:	**Configuration V2**	
CURRENT INPUTS:	**Configuration C1**	
TEST SETTINGS:	**Function 87GD, Ground Differential**	**Disable**
	Function 50BF, Breaker Failure	**Disable**
	Function 27TN, Neutral Undervoltage #1	**15 Volts**
	Delay Neutral Undervoltage #1	**300 cycles**
	Inhibit Neutral Undervoltage #1	**100 Volts**
	Programmed Output	**OUT 1**

1. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

2. Press **ENTER**.

3. Rotate the front-panel knob clockwise until the unit displays

```
UNDERVOLTAGE SETPOINTS
←NUTRL_UNDER
```

4. Press **ENTER**. The unit should display

```
NEUTRAL UNDERVOLTAGE  #1
   1.2 Volts
```

Rotate the front-panel knob until the unit displays 15 volts. Press **ENTER**. Repeat the step for **Delay Neutral Undervoltage #1** and **Inhibit Neutral Undervoltage #1**:

```
DELAY NUTRL UNDERVOLT #1
   30 Cycles
```

Rotate the front-panel knob until the unit displays 300 cycles. Press **ENTER**.

```
INHIBIT NUTRL UNDERVOLT
   12 Volts
```

Rotate the front-panel knob until the unit displays 100 V. Press **ENTER**.

5. Press the **EXIT** button once. The unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

6. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

7. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

8. Rotate the front-panel knob until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

9. Press the **ENTER** button once. The unit should display

```
GROUND DIFFERENTIAL   #1
disable ENABLE
```

10. Rotate the front-panel knob counterclockwise. **DISABLE** should now be highlighted rather than **enable**.

11. Press **ENTER** and then **EXIT** once.

12. Repeat the same method in steps 8, 9, 10, and 11 to disable the Breaker Failure (50 BF) function and to enable the Neutral Undervoltage (27TN) function.

13. Set the three-phase input voltage for V_A, V_B, V_C to 120 V ac, 60 Hz.

14. Set V_N to 10 V ac, 180 Hz.

15. Depress and hold down the **TARGET RESET/LAMP TEST**.

16. Slowly increase the V_N voltage until the **27TN** LED goes off. The LED should go off at 15 V ac, ±.15 volts.

17. Press the **EXIT** button until the unit displays

```
  Beckwith Electric Co.
         M-0430
```

18. Decrease V_N voltage to 10 V ac and start timing.

19. The OUT1 output should trip after 300 cycles (–1 to +3 cycles).

20. The **27TN** LED should turn on and the unit should rotate displays as follows

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
 NEUTRAL UNDERVOLTAGE #1
```

21. Increase V_N voltage to 20 V ac.

22. Press the **TARGET RESET/LAMP TEST** button. The **27TN** LED should turn off and the unit should display

```
  Beckwith Electric Co.
         M-0430
```

23. Press **ENTER**. The **SELECT FUNCTION** LED should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

24. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR STATUS
←setpts STAT config    →
```

25. Press **ENTER**. The unit should display

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

26. Press **ENTER**. Rotate the front-panel knob clockwise until the unit displays

```
POS SEQUENCE VOLTAGE
    XXX.X Volts
```

27. Lower the phase A voltage until POS Sequence voltage displays 99.0 Volts.

28. Depress and hold down the **TARGET RESET/LAMP TEST** button.

29. Decrease the V_N voltage to 10 V ac and verify that 27TN function is inhibited.

30. Set the input voltages back to zero.

–END–

60 FL VT FUSE LOSS DETECTION

VOLTAGE INPUTS:	**Configuration V1**	
CURRENT INPUTS:	**Configuration C1**	
TEST SETTINGS::	**Function 50, Breaker Failure**	**Disable**
	Function 59N, Neutral Overvoltage	**Disable**
	Function 87GD Ground Differential	**Disable**
	Function 60FL, Internal VT Fuse Loss	**Enable**
	Time Delay	**30 Cycles**
	Programmed Output	**OUT1**

1. Turn on proper power to the unit
2. Adjust the three-phase voltage source to 120 V ac.
3. Adjust the three-phase current source to 5.0 A.
4. Press **ENTER**. The **SELECT FUNCTION LED** should turn on and the unit should display

```
VOLTAGE RELAY
VOLT freq v/hz powr gnd→
```

5. Turn the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←setpts stat CONFIG    →
```

6. Press **ENTER** once. The unit should display

```
CONFIGURE RELAYS
  VOLTAGE_RELAY        →
```

7. Press the **ENTER** button five times. The unit should display

```
NEUTRAL OVERVOLTAGE   #1
disable ENABLE
```

8. Rotate the front-panel knob counterclockwise. **DISABLE** should now be highlighted rather than **enable**.
9. Press **ENTER** and then **EXIT** once.

10. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAYS
←GND_DIFFERENTIAL RELAY→
```

11. Press **ENTER** once. The unit should display

```
GROUND DIFFERENTIAL    #1
disable ENABLE
```

12. Rotate the front-panel knob counterclockwise. **DISABLE** should now be highlighted rather than enable.

13. Press **ENTER** and the **EXIT** once.

14. Rotate the front-panel knob clockwise until the unit displays

```
CONFIGURE RELAY
←BREAKER_FAILURE_RELAY →
```

15. Press **ENTER** once. The unit should display

```
BREAKER FAILURE
disable ENABLE
```

16. Rotate the front-panel knob counter clockwise. **DISABLE** should now be highlighted rather than enable.

17. Press **ENTER**.

18. Rotate the front-panel knob clockwise until the unit displays

```
SETUP FUNCTION
←SETUP
```

19. Press **ENTER**. Rotate the front-panel knob clockwise until the unit displays

```
INTERNAL V.T. FUSE LOSS
←FUSE sealin
```

20. Press **ENTER** once. The unit should display

```
INTERNAL V.T. FUSE LOSS
DISABLE enable
```

21. Rotate the front-panel knob clockwise. **ENABLE** should now be highlighted rather than disable.

22. Press **ENTER**. Use the arrow keys to move the cursor to **out1**. Rotate the front-panel knob to highlight **OUT1**.

23. Press **ENTER** once and then **EXIT** twice. The unit should display

```
CONFIGURE RELAYS
←setpts stat CONFIG   →
```

24. Rotate the front-panel knob counterclockwise. The unit should display

```
MONITOR STATUS
←setpts STAT config   →
```

25. Press **ENTER**. Rotate the front-panel knob clockwise until the unit displays

```
MONITOR FUSE STATUS
←recon temp FUSE      →
```

26. Press **ENTER**. The unit should display

```
V.T. FUSE STATUS
--OK--
```

27. Remove the phase A voltage.

28. The unit should trip on the OUT1 output after 30 cycles. The unit should display

```
V.T. FUSE STATUS
--BLOWN--
```

29. Reconnect the phase A voltage.

30. Press the **EXIT** button until the unit displays.

```
  Beckwith Electric Co.
         M-0430
```

31. Remove the phase B voltage.

32. The **50BF/FL BREAKER FAILURE/VT FUSE LOSS** LED should turn on and the unit should rotate displays as follows

```
-TRGT- 01/15/93 16:44:20
                    OUT1
```

```
-TRGT- 01/15/93 16:44:20
V.T. FUSE LOSS
```

33. Reconnect the phase B voltage.

34. Press the **TARGET RESET / LAMP TEST** button. The **50BF/FL BREAKER FAILURE/VT FUSE LOSS** LED should turn off and the unit should display

```
Beckwith Electric Co.
       M-0430
```

35. Remove the phase C voltage.

36. The unit should trip as before on VT fuse loss.

37. Set the input voltage and current to zero.

—END—

SELF-CALIBRATION PROCEDURE

■ **NOTE:** The M-0430 has been fully calibrated at the factory. There is no need to recalibrate the unit prior to initial installation. Further calibration is only necessary if a component was changed during a repair procedure or if a unit originally ordered as 60 Hz will be operated at 50 Hz.

1. Pull the unit out of the housing and set DIP switch 2 to "OFF" (up).
2. Place the unit back in the housing and power up. The LCD should display "**CALIBRATION**" and then "**CONNECT INPUTS AND PRESS ENTER TO RECAL.**"
3. Connect $V_A = V_B = V_C = V_N = 120.0$ V at 0° phase and $I_A = I_B = I_C = I_N = 5.00$ A at 0° phase. Connections are indicated in Figures 7–8 and 7–9.

■ **NOTE:** The phase angle difference between all signals should be 0°, and an accurate low-distortion source should be used.

4. Press **ENTER**. While the unit is calibrating, the LCD should display "**WAIT**." When the calibration is complete, the LCD should display "**DONE**."
5. Remove the relay from the housing and set the dip switch to the Normal Operation position (down).
6. Place the unit back in the housing and power up. Verify the calibration by reading the status:

$V_A = V_B = V_C = V_N = 120$ V

$V_1 = V_2 = 0$

$V_0 = 120$V

$I_A = I_B = I_C = I_N = 5$A

$I_1 = I_2 = 0$

$I_0 = 5$ A

$P = 1$ pu

$Q = 0.0$ pu

Power Factor = 1.0

where subscript 0, 1, and 2 represent zero, positive, and negative sequence quantities respectively.

7. Remove the calibration source inputs.

—END—

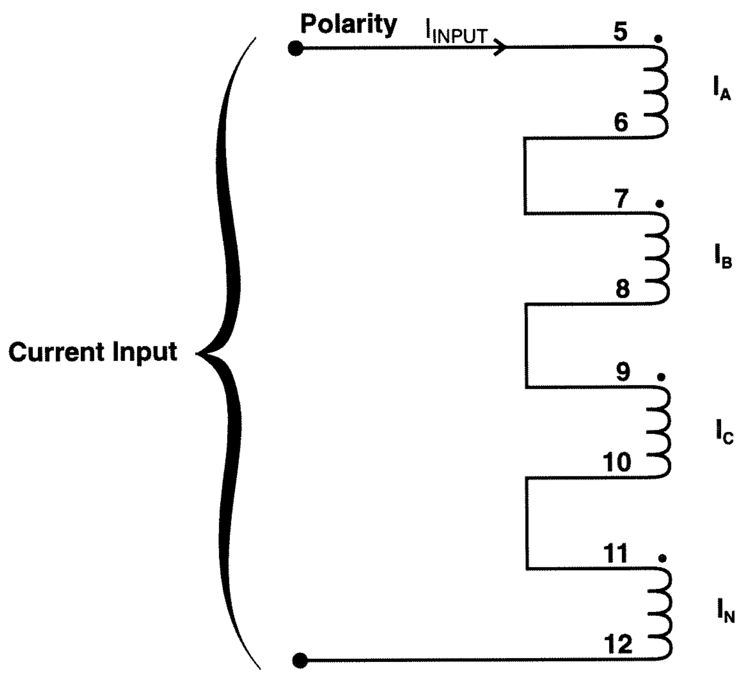

FIGURE 7–8 Current Input Configuration—Self-Calibration

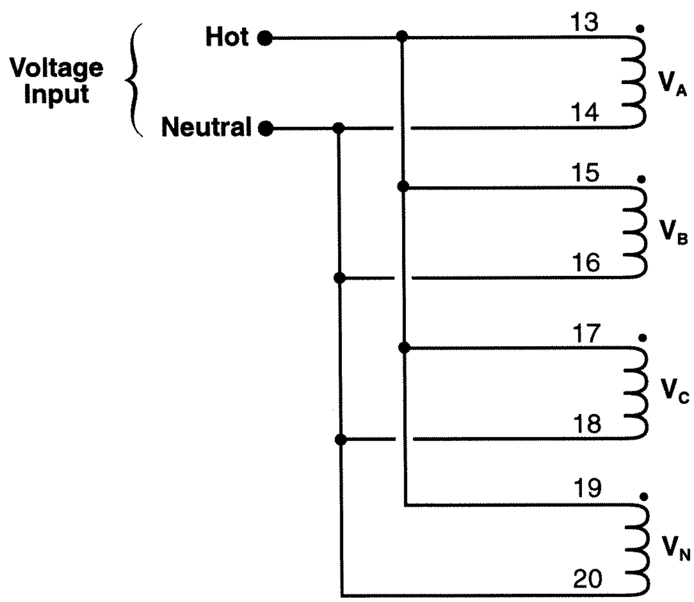

FIGURE 7–9 Voltage Input Configuration—Self-Calibration

APPENDIX A
SELF-TEST ERROR CODES

Error Code	Description
1	Host to DSP sync fail (int1)
2	DSP aux register fail
3	DSP RAM fail
4	DSP Program fail
5	DSP ALU fail
6	DSP status register fail
7	DSP shifter fail
8	DSP multiplier fail
9	DSP miscellaneous fail
10	(reserved for DSP)
11	(reserved for DSP)
12	high-speed interrupt fail (int2)
13	dual-ported RAM fail, DSP side
14	A/D timing fail
15	Incompatible DSP Software Version
16	Uncalibratable Inputs
17	(reserved for DSP)
18	(reserved for DSP)
19	(reserved for DSP)
20	uninitialized EEPROM 0
21	uninitialized EEPROM 1
22	uninitialized EEPROM 2 (not used at present)
23	checksum error EEPROM 0
24	checksum error EEPROM 1
25	checksum error EEPROM 2 (not used at present)

TABLE A-1 Self-Test Error Codes

Error Code	Description
26	read/write error EEPROM 0
27	read/write error EEPROM 1
28	read/write error EEPROM 2 (not used at present)
29	DPRAM calibration values checksum error
30	fault recorder buffer fail
31	watchdog for values update faulure
32	values update out-of-sequence failure
33	unimplemented host interrupt (NMI)
34	unrecognized DSP interrupt code failure
35	unimplemented host interrupt
36	unimplemented host restart
37	unimplemented host opcode trap
38	main routing return error
39	math error (square root or divide by zero)
40	WARNING: low clock battery
41	read/write clock RAM fail
42	dual-ported RAM fail, host side
43	dual-ported RAM fail-to-read-clear, host side
44	WARNING: unitialized clock RAM
45	(unused)
46	EEPROM write verify error
47	Communication Buffer Error
48	unrecognized failure code
49	failure of DSP to enter run mode
50	failure of DSP to enter self-test mode

TABLE A-2 Self-Test Error Codes (continued)

Error Code	Description
51	phase ground reference gain 1 fail
52	neutral ground reference gain 1 fail
53	phase ground reference gain 8 fail
54	neutral ground reference gain 8 fail
55	positive supply reference fail
56	negative supply reference gain 1 fail
57	negative supply reference gain 2 fail
58	negative supply reference gain 4 fail
59	negative supply reference gain 8 fail

TABLE A-3 Self-Test Error Codes (continued)

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APPENDIX B
COMMUNICATIONS

The M-0430 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. Generally, all data available to the operator through the front panel of the M-0430 is accessible remotely through the communication software interface and the data exchange protocol.

■ **NOTE**: For detailed information on communications, refer to the M-0429A BECOCOM®/M-0428A BECOPLOT® User's Guide.

THE BECOCOM® PROTOCOL

The M-0430 and the M-0429 communications software use the BECOCOM protocol. The protocol implements full-duplex, serial, byte-oriented, asynchronous communication and can be used to fulfill the following communication functions:

- Real-time monitoring of line status.
- Interrogation and modification of setpoints.
- Downloading of recorded fault data.
- Reconfiguration of relay functions.

COMMUNICATION PORTS

The M-0430 has both front- and rear-panel RS-232 ports. The front-panel connector is a 9-pin (DB9S) connector configured as DTE (Data Terminal Equipment) per the RS-232C standard. The rear-panel connector is a 25-pin (DB25S) connector also configured as DTE. Signals are defined as shown in Table B-1.

■ **NOTE**: The RS-232C standard specifies a combined cable length between the modem, relays and communication-line splitter not to exceed 50 feet. Successful operation cannot be guaranteed for cable exceeding this recommendation. Every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended for long runs.

All control signals are electrically compatible with RS-232 levels and are actively driven, with the exception of the front panel DTR signal which is permanently wired TRUE. All RS-232 signals are optically isolated to withstand 1414 V dc and incorporate MOV protection. Each communication port can be configured for any of the standard baud rates (300, 600, 1200, 2400, 4800, and 9600).

■ **NOTE**: The RS-232 communication ports are excluded by Beckwith Electric from passing ANSI/IEEE C37.90.1-1989. We suggest the use of fiber optic communication lines to avoid any question of surge-withstand capability.

	Signal	COM1	COM2
RX	Receive Data	Pin 2	Pin 3
TX	Transmit Data	Pin 3	Pin 2
RTS	Request-to-Send	Pin 7	Pin 4
CTS	Clear-to-Send	Pin 8	Pin 5
DTR	Data Terminal Ready	Pin 4	—
SGND	Signal Ground	Pin 5	Pin 7
CGND	Chassis Ground	—	Pin 1

TABLE B-1 Communication Port Signals

DIRECT TERMINAL COMMUNICATIONS VIA COM1

The M-0430 provides a limited communications ability via the front panel **COM1** port: a subset of the status parameters and control functions can be executed via a standard "dumb" terminal. This function can be used in testing or while the unit is on-line.

■ **NOTE**: The M-0430 must not be in local mode.

Any terminal which supports ANSI emulation (sometimes called an ANSI BBS terminal) can be used. Additionally, a compatible PC running any standard terminal emulator software (such as Procomm or Smarterm) set to the ANSI terminal type can be used.

Because most terminals and PCs are also configured as DTE (Data Terminal Equipment) some form of null modem cable is usually required. Pin-outs for these cables are provided in Figures C-1 and C-2. These cables are available from Beckwith Electric, or can be fabricated or purchased from most computer supply houses.

The baud rate and parity of the terminal must match the settings of the M-0430. The M-0430 always communicates with 8 data bits, 1 stop bit, and either even or no parity.

The commands available in this mode are listed in Table B-2. They can be issued by pressing the appropriate key.

■ **NOTE**: Do not use other keys. They are reserved for factory uses and may result in unpredictable operation.

Procedure: M-0430 Terminal Communications via COM1

1. Set the baud rate and parity on the **CONFIGURE BOM1** menu on the M-0430.
2. Exit local mode.
3. Connect properly wired cable between the front-panel **COM1** port and the terminal or PC.
4. Set the terminal baud rate, number of bits, number of stop bits, etc.
5. Press any of the key codes defined in Table B-2.

Key*	Function
M	Metering and Status
A	Arm Fault Recorder
D	Disarm Fault Recorder
F	Trigger Fault Recorder
R	Reset Local LED Targets
Z	Clear Trip History Records

**Note: Letters must be upper case.*

TABLE B-2 Terminal Commands

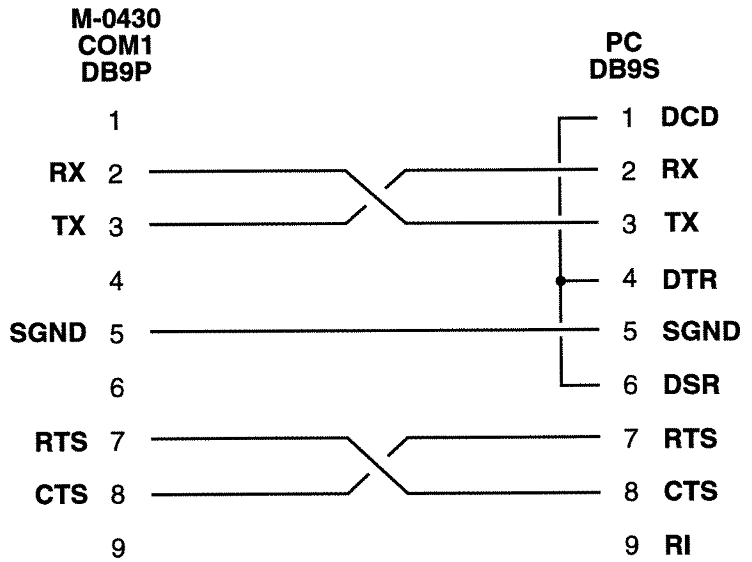

FIGURE B-1 Null Modem Cable: M-0430 COM1 to PC (9-pin)

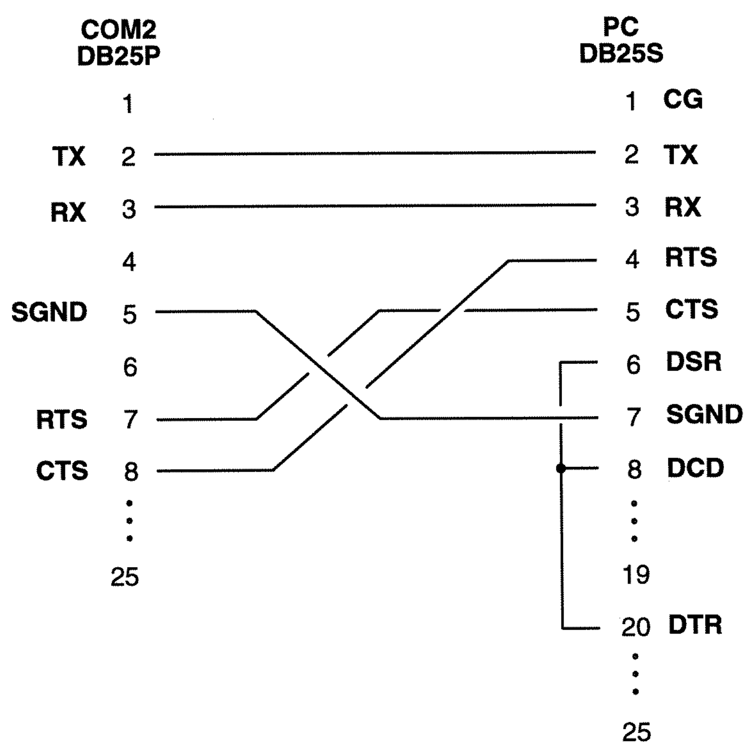

FIGURE B-2 Null Modem Cable: M-0430 COM2 to PC (25-pin)

APPENDIX C
PRINTED CIRCUIT BOARD INTERCONNECTIONS

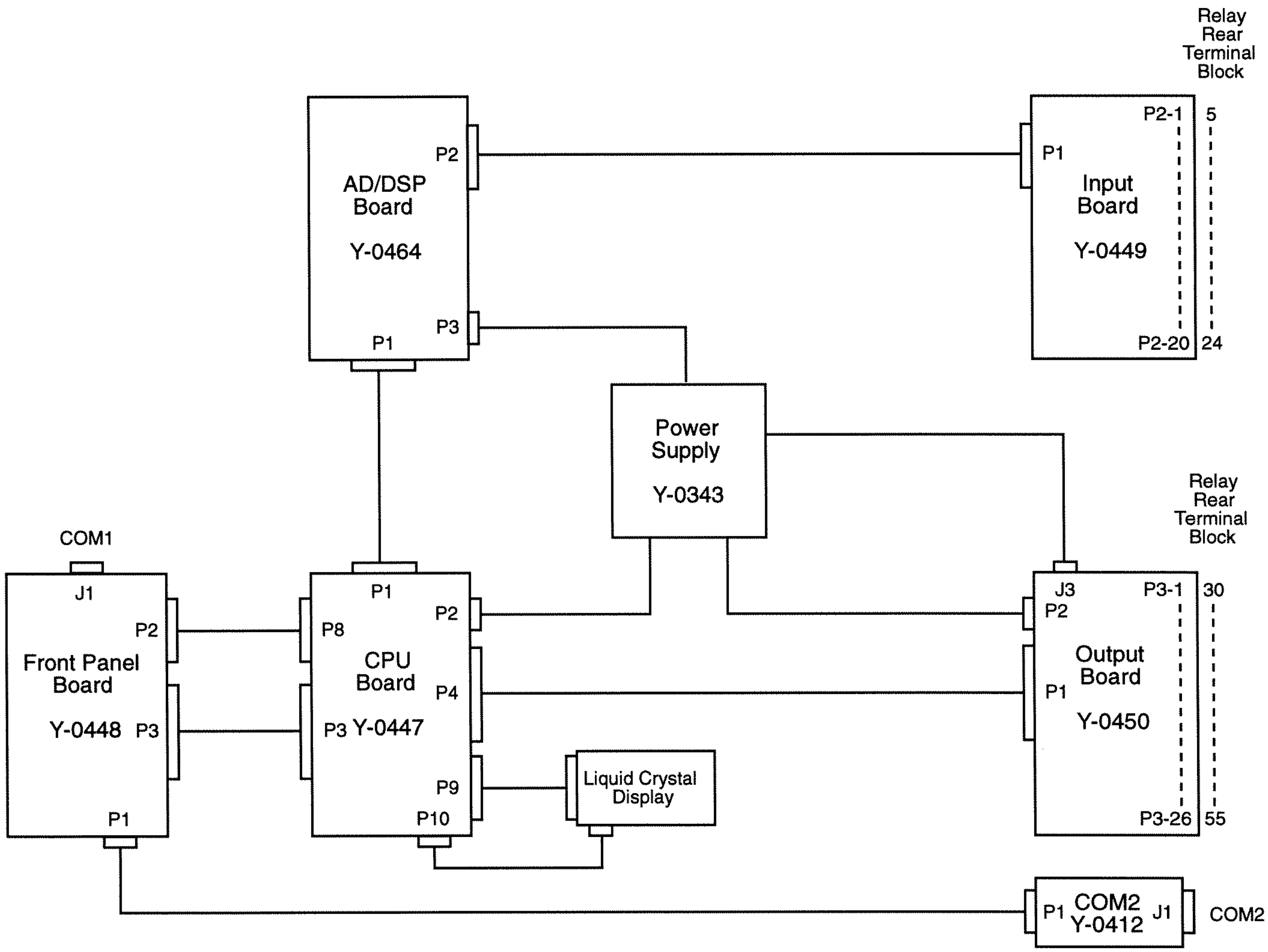

FIGURE C-1 M-0430 Board Interconnections

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APPENDIX D
CONFIGURATION RECORD FORMS

This appendix contains forms that you can photocopy for recording and keeping on file the configuration of your M-0430(s).

The first form is the Functional Configuration Record. This form reproduces the **CONFIGURE RELAYS** series of menus accessible from the M-0430 front panel. For each function or setpoint, circle whether it is enabled or disabled.

The following Setpoint Configuration Record forms allow you to record the specific values entered for each enabled setpoint or function. (The provided check boxes allow you to mark the enabled setpoints and functions.)

Examples of the suggested use of these forms are provided below.

Finally, an Internal DIP Switch Configuration Record form is provided for noting the settings of the internal configuration DIP switches.

59

PHASE OVERVOLTAGE #1
disable ENABLE

PHASE OVERVOLTAGE #2
DISABLE enable

Functional Configuration

59

☑ PHASE OVERVOLTAGE #1
122.5 Volts (1.02 PU)

DELAY PHASE OVERVOLT #1
300 Cycles

❑ PHASE OVERVOLTAGE #2
— Volts (— PU)

DELAY PHASE OVERVOLT #2
— Cycles

Setpoint Configuration

Relay Function		OUT1①	OUT2	OUT3	OUT4	OUT5	BLOCK1② (52b)	BLOCK2③ (60FL)	BLOCK3/④ BFI
59	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
59N	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
81O	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
81U	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
32	F	O	O	O	O	O	O	O	O
	R	O	O	O	O	O	O	O	O
40	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
21		O	O	O	O	O	O	O	O
24	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
	INV	O	O	O	O	O	O	O	O
27TN	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
87GD	#1	O	O	O	O	O	O	O	O
	#2	O	O	O	O	O	O	O	O
60FL		O	O	O	O	O			
50BF		O	O	O	O	O			Configure BLOCK3/BFI
Breaker Failure Initiate		O	O	O	O	O			O*

■ NOTES:

① **OUT1**, **OUT2**, and **OUT3** are rated for tripping per ANSI/IEEE C37.90-1989. **OUT4** and **OUT5** are provided primarily for alarm purposes; they are not rated for tripping.

② **BLOCK1** is usually used for the 52b status input; it illuminates the **BREAKER CLOSED** front-panel LED.

③ **BLOCK2** is usually used for external fuse-loss input; this input is logically OR'd with the internal fuse loss logic (when enabled).

√ **BLOCK3/BFI** can be assigned either to block some combination of functions 59 through 87GD in a manner identical to **BLOCK1** and **BLOCK2**, *or* as **Breaker Failure Initiate** input. To signify this on the chart above, if the circle marked * (**Configure BLOCK3/BFI**) is left undarkened, **BLOCK3/BFI** is assigned as **BLOCK3** and the functions it will block are darkened in the **BLOCK3/BFI** *column* above. If the circle marked * is darkened, **BLOCK3/BFI** is assigned as **Breaker Failure Initiate** input. *In this case, no circle in the* **BLOCK3/BFI** *column above may be darkened.* For either case, however, *outputs* that are to initiate the breaker failure timer are darkened in the **Breaker Failure Initiate** row to the left.

By: ____________________

Date: ____________________

Serial Number: ____________

Relay Configuration Record

Located at: ______________

CONFIGURE RELAY
setpts stat CONFIG

CONFIGURE RELAY
VOLTAGE_RELAY

(59)
PHASE OVERVOLTAGE #1
disable enable

PHASE OVERVOLTAGE #1
out5 out4 out3 out2 out1

PHASE OVERVOLTAGE #1
blk3 blk2 blk1

PHASE OVERVOLTAGE #2
disable enable

PHASE OVERVOLTAGE #2
out5 out4 out3 out2 out1

PHASE OVERVOLTAGE #2
blk3 blk2 blk1

(59N)
NEUTRAL OVERVOLTAGE #1
disable enable

NEUTRAL OVERVOLTAGE #1
out5 out4 out3 out2 out1

NEUTRAL OVERVOLTAGE #1
blk3 blk2 blk1

NEUTRAL OVERVOLTAGE #2
disable enable

NEUTRAL OVERVOLTAGE #2
out5 out4 out3 out2 out1

NEUTRAL OVERVOLTAGE #2
blk3 blk2 blk1

(27TN)
NEUTRAL UNDERVOLTAGE #1
disable enable

NEUTRAL UNDERVOLTAGE #1
out5 out4 out3 out2 out1

NEUTRAL UNDERVOLTAGE #1
blk3 blk2 blk1

NEUTRAL UNDERVOLTAGE #2
disable enable

NEUTRAL UNDERVOLTAGE #2
out5 out4 out3 out2 out1

NEUTRAL UNDERVOLTAGE #2
blk3 blk2 blk1

CONFIGURE RELAY
FREQUENCY_RELAY

(81O)
OVER FREQUENCY #1
disable enable

OVER FREQUENCY #1
out5 out4 out3 out2 out1

OVER FREQUENCY #1
blk3 blk2 blk1

OVER FREQUENCY #2
disable enable

OVER FREQENCY #2
out5 out4 out3 out2 out1

OVER FREQUENCY #2
blk3 blk2 blk1

(81U)
UNDER FREQUENCY #1
disable enable

UNDER FREQUENCY #1
out5 out4 out3 out2 out1

UNDER FREQUENCY #1
blk3 blk2 blk1

UNDER FREQUENCY #2
disable enable

UNDER FREQUENCY #2
out5 out4 out3 out2 out1

UNDER FREQUENCY #2
blk3 blk2 blk1

CONFIGURE RELAY
VOLTS_PER_HERTZ_RELAY

(24)
DEFINITE TIME V/HZ #1
disable enable

DEFINITE TIME V/HZ #1
out5 out4 out3 out2 out1

DEFINITE TIME V/HZ #1
blk3 blk2 blk1

DEFINITE TIME V/HZ #2
disable enable

DEFINITE TIME V/HZ #2
out5 out4 out3 out2 out1

DEFINITE TIME V/HZ #2
blk3 blk2 blk1

INVERSE TIME V/HZ
disable enable

INVERSE TIME V/HZ
out5 out4 out3 out2 out1

INVERSE TIME V/HZ
blk3 blk2 blk1

By: ____________________

Date: ____________________

Serial Number: ____________

Located at: ______________

M-0430 Functional Configuration Record (1)

CONFIGURE RELAY
setpts stat CONFIG

CONFIGURE RELAY
POWER_RELAY

(32)
FORWARD OVERPOWER
disable enable

FORWARD OVERPOWER
out5 out4 out3 out2 out1

FORWARD OVERPOWER
blk3 blk2 blk1

REVERSE OVERPOWER
disable enable

REVERSE OVERPOWER
out5 out4 out3 out2 out1

REVERSE OVERPOWER
blk3 blk2 blk1

CONFIGURE RELAY
GND_DIFFERENTIAL_RELAY

(87GD)
GROUND DIFFERENTIAL #1
disable enable

GROUND DIFFERENTIAL #1
out5 out4 out3 out2 out1

GROUND DIFFERENTIAL #1
blk3 blk2 blk1

GROUND DIFFERENTIAL #2
disable enable

GROUND DIFFERENTIAL #2
out5 out4 out3 out2 out1

GROUND DIFFERENTIAL #2
blk3 blk2 blk1

CONFIGURE RELAY
LOSS_OF_FIELD_RELAY

(24)
LOSS OF FIELD #1
disable enable

LOSS OF FIELD #1
out5 out4 out3 out2 out1

LOSS OF FIELD #1
blk3 blk2 blk1

LOSS OF FIELD #2
disable enable

LOSS OF FIELD #2
out5 out4 out3 out2 out1

LOSS OF FIELD #2
blk3 blk2 blk1

CONFIGURE RELAY
PHASE_DISTANCE_RELAY

(21)
PHASE DISTANCE #1
disable enable

PHASE DISTANCE #1
out5 out4 out3 out2 out1

PHASE DISTANCE #1
blk3 blk2 blk1

CONFIGURE RELAY
BREAKER_FAILURE_RELAY

(50BF)
BREAKER FAILURE
disable enable

BREAKER FAILURE
out5 out4 out3 out2 out1

CONFIGURE RELAY
V.T.FUSE_LOSS_RELAY

(60FL)
V.T. FUSE LOSS
disable enable

V.T. FUSE LOSS
out5 out4 out3 out2 out1

By: ____________________

Date: ____________________

Serial Number: ____________

Located at: ______________

M-0430 Functional Configuration Record (2)

CONFIGURE RELAYS
setpts stat CONFIG

SETUP FUNCTION
SETUP

(24)

NOMINAL VOLTAGE V/HZ
V/HZ gnd gnd lof1 lof1

NOMINAL VOLTAGE V/HZ
_____ Volts

(87GD)

DIRECTIONAL CNTRL GNDIF
v/hz GND gnd lof1 lof1

DIRECTIONAL CNTRL GNDIF
nondirectnl directional

C.T. CORRECTION GNDIF
v/hz gnd GND lof1 lof1

C.T. CORRECTION GNDIF
_____

(40)

VOLTAGE CONTROL LOF#1
v/hz gnd gnd LOF1 lof1

VOLTAGE CONTROL LOF#1
disable enable

FREQUENCY CONTROL LOF#1
v/hz gnd gnd lof1 LOF1

FREQUENCY CONTROL LOF#1
disable enable

VOLTAGE CONTROL LOF#2
LOF2 lof2 dist

VOLTAGE CONTROL LOF#2
disable enable

FREQUENCY CONTROL LOF#2
lof2 LOF2 dist

FREQUENCY CONTROL LOF#2
disable enable

(21)

DELTA-Y XFORM PHASE DIST
lof2 lof2 DIST

DELTA-Y XFORM PHASE DIST
disable enable

(50BF)

PHASE OVR CURR BRKR FAIL
brkfail BRKFAIL brkfail

PHASE OVR CURR BRKFAIL
disable enable

NUTRL INITIATE BRKR FAIL
brkfail BRKFAIL brkfail

NUTRL INITIATE BRKFAIL
disable enable

EXTERNAL BFI BRKR FAIL
brkfail BRKFAIL brkfail

EXTERNAL BFI BRKFAIL
disable enable

INTERNAL V.T. FUSE LOSS
FUSE sealin

INTERNAL V.T. FUSE LOSS
disable enable

RELAY SEAL-IN TIME
fuse SEALIN

RELAY SEAL-IN TIME
disable enable

By: ____________________

Date: ____________________

Serial Number: ____________

Located at: ________________

M-0430 Functional Configuration Record (3)

SETUP UNIT
count comm SETUP exit

ALTER ACCESS CODES
vers ACCESS time dipsw

LEVEL#1
______

LEVEL#2
______

LEVEL#3
______

USER LOGO LINE 1
LOGO1 logo2 disp okled

USER LOGO LINE 1
______

USER LOGO LINE 2
logo1 LOGO2 disp okled

USER LOGO LINE 2
______

LCD DISPLAY BLANKING
logo1 logo2 DISP okled

LCD DISPLAY BLANKING
disable enable

RELAY OK LED FLASH
logo1 logo2 disp OKLED

RELAY OK LED FLASH
disable enable

V.T. & C.T. RATIOS
RATIO

V.T. PHASE RATIO
______ :1

V.T. NEUTRAL RATIO
______ :1

C.T. PHASE RATIO
______ :1

C.T. NEUTRAL RATIO
______ :1

COMMUNICATION
count COMM setup exit

CONFIGURE COM1
COM1 com2 com_adr accss

BAUD RATE COM1
______

ENABLE COM1 PARITY(EVEN)
disable enable

CONFIGURE COM12
com1 COM2 com_adr accss

BAUD RATE COM2
______

ENABLE COM2 PARITY(EVEN)
disable enable

COMMUNICATION ADDRESS
com1 com2 COM_ADR accss

COMMUNICATION ADDRESS
______

COMM ACCESS CODE
com1 com2 com_adr ACCSS

COMM ACCESS CODE
______

ENTER COM2 MODEM LOG ON
issue ENTER

ENTER COM2 MODEM LOG ON
______

By: ______

Date: ______

Serial Number: ______

Located at: ______

M-0430 Communciation and Setup Unit Configuration Record

M-0430 Setpoint Configuration Record (1)

VOLTAGE RELAY
VOLT freq v/hz powr gnd→

(59) OVERVOLTAGE SETPOINTS
PHASE_OVER nutrl_over →

- ❑ PHASE OVERVOLTAGE #1 — _____ Volts
- DELAY PHASE OVERVOLT #1 — _____ Cycles
- ❑ PHASE OVERVOLTAGE #2 — _____ Volts
- DELAY PHASE OVERVOLT #2 — _____ Cycles

(59N) OVERVOLTAGE SETPOINTS
phase_over NUTRL_OVER →

- ❑ NEUTRAL OVERVOLTAGE #1 — _____ Volts
- DELAY NUTRL OVERVOLT #1 — _____ Cycles
- ❑ NEUTRAL OVERVOLTAGE #2 — _____ Volts
- DELAY NUTRL OVERVOLT #2 — _____ Cycles

(27TN) UNDERVOLTAGE SETPOINTS
← NUTRL_UNDER

- ❑ NEUTRAL UNDERVOLTAGE #1 — _____ Volts
- DELAY NUTRL UNDERVOLT #1 — _____ Cycles
- ❑ NEUTRAL UNDERVOLTAGE #2 — _____ Volts
- DELAY NUTRL UNDERVOLT #2 — _____ Cycles
- ❑ INHIBIT NUTRL UNDERVOLT — _____ VOLTS

FREQUENCY RELAY
volt FREQ v/hz powr gnd→

(81O) OVERFREQUENCY SETPOINTS
OVER under

- ❑ OVERFREQUENCY #1 — _____ Hz
- DELAY OVERFREQUENCY #1 — _____ Cycles
- ❑ OVERFREQUENCY #2 — _____ Hz
- DELAY OVERFREQUENCY #2 — _____ Cycles

(81U) OVERFREQUENCY SETPOINTS
over UNDER

- ❑ UNDERFREQUENCY #1 — _____ Hz
- DELAY UNDERFREQUENCY #1 — _____ Cycles
- ❑ UNDERFREQUENCY #2 — _____ Hz
- DELAY UNDERFREQUENCY #2 — _____ Cycles

(59) VOLTS PER HERTZ RELAY
volt freq V/HZ powr gnd→

DEF TIME V/HZ SETPOINTS
DEF_V/HZ inv_v/hz

- ❑ DEFINITE TIME V/HZ #1 — _____ %
- DELAY DEF TIME V/HZ #1 — _____ Cycles
- ❑ DEFINITE TIME V/HZ #2 — _____ %
- DELAY DEF TIME V/HZ #2 — _____ Cycles

INV TIME V/HZ SETPOINTS
def_v/hz INV_V/HZ

- ❑ PICKUP INVERSE TIME V/HZ — _____ %
- TIMING INVERSE TIME V/HZ — CRV#1 crv#2 crv#3 crv#4
- TIME DIAL INV TIME V/HZ — _____
- RESET RATE INV TIME V/HZ — _____ Sec

POWER RELAY
volt freq v/hz POWR gnd→

(32F) FORWARD POWER SETPOINTS
FORWARD reverse

- ❑ FORWARD OVERPOWER — _____ PU
- DELAY FORWARD POWER — _____ Cycles

(32R) REVERSE POWER SETPOINTS
forward REVERSE

- ❑ REVERSE OVERPOWER — _____ PU
- DELAY REVERSE POWER — _____ Cycles

By: ____________

Date: ____________

Serial Number: ____________

Located at: ____________

M-0430 Setpoint Configuration Record (2)

87GD

GND DIFFERENTIAL RELAY
volt freq v/hz powr GND→

GND DIFFERENTIAL SETPNTS
GND

❑ GROUND DIFFERENTIAL #1
______ Amps

DELAY GND DIFFERENTIAL#1
______ Cycles

❑ GROUND DIFFERENTIAL #2
______ Amps

DELAY GND DIFFERENTIAL#2
______ Cycles

DIRECTIONAL CNTRL GNDDIF
nondirectnal DIRECTIONAL

40

LOSS OF FIELD RELAY
←LOF dist brkfail fuse →

LOSS OF FIELD RELAY
LOF

❑ DIAMETER LOSS OF FIELD#1
______ Ohms

OFFSET LOSS OF FIELD #1
______ Ohms

DELAY LOSS OF FIELD #1
______ Cycles

❑ DIAMETER LOSS OF FIELD#2
______ Ohms

OFFSET LOSS OF FIELD #2
______ Ohms

DELAY LOSS OF FIELD #2
______ Cycles

❑ VOLT CNTR1 LOSS OF FIELD
______ Volts

❑ FREQ CNTRL LOSS OF FIELD
______ Hz

21

PHASE DISTANCE RELAY
←lof DIST brkfail fuse →

PHASE DISTANCE SETPOINTS
DIST

❑ DIAMETER PHASE DISTANCE
______ Ohms

OFFSET PHASE DISTANCE
______ Ohms

Z-ANGLE PHASE DISTANCE
______ Degrees

DELAY PHASE DISTANCE
______ Cycles

50BF

BREAKER FAILURE RELAY
←lof dist BRKFAIL fuse →

BREAKER FAILURE SETPNTS
BRKFAIL

❑ PICKUP PHASE BRKER FAIL
______ Amps

PICKUP NUTRL BRKER FAIL
______ Amps

DELAY BREAKER FAILURE
______ Cycles

BREAKER FAILURE INITIATE
out5 out4 out3 out2 OUT1

60FL

V.T. FUSE LOSS RELAY
←lof dist brkfail FUSE →

V.T. FUSE LOSS SETPOINTS
FUSE

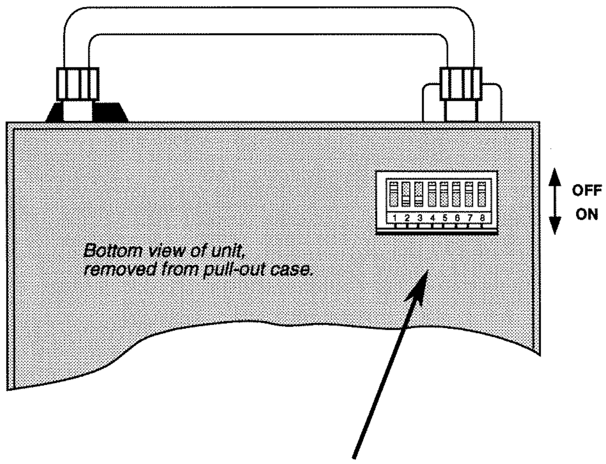
❑ DELAY V.T. FUSE LOSS
______ Cycles

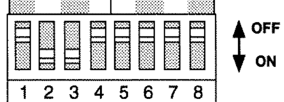
By: ____________________

Date: ____________________

Serial Number: ____________

Located at: ______________





Switch	OFF (UP)	ON (DOWN)
1	*Not for user selection. This switch must be set OFF.*	*Not for user selection. This switch must be set OFF.*
2	Calibrate Relay	Normal Operation
3	Diagnostic Mode	Normal Operation
4	Reverse Power Initiation: PA + PB + PC < *setpoint*	Reverse Power Initiation: PA or PB or PC < *setpoint*
5	VT inputs: line to ground	VT inputs: line to line †
6	VT secondary voltage: 120 V ac	VT secondary voltage: 69.3 V ac *
7	System Frequency: 60 Hz	System Frequency: 50 Hz ††
8	*Not Used*	*Not Used*

■ **NOTES:**

* When 69.3 V is chosen for the VT secondary voltage, 69.3 V is internally converted to 120 V (1 pu) for all calculations and for setting and display purposes.

† If line-to-line is chosen for the basic VT inputs (DIP switch 5 is ON), reverse power sensing will respond to total three-phase power regardless of the setting of DIP switch 4.

†† If the system frequency selection (DIP switch 7) is changed from the original factory calibration, the unit must be recalibrated (see the self-calibration procedure in Chapter 7, **Test Procedures**).

Check the box adjacent to the switch settings you have chosen.
For additional reference, shade in the corresponding DIP switch positions.

By: ____________________

Date: ____________________

Serial Number: ____________

Located at: ______________

Internal DIP Switch Configuration Record

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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 therein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of two years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to perform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided however that Buyer shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to the replacement value of the equipment furnished under this contract. The foregoing shall constitute the exclusive remedy of the Buyer and the sole liability of the seller and is in lieu of all other warranties, whether written, oral, implied or statutory, except as to the title of the Seller to the equipment furnished. No implied statutory warranty of merchantability or of fitness for a particular purpose shall apply. Seller does not warrant any product or services of others which Buyer has designated.

SELLER MAKES NO WARRANTIES EXPRESSED OR IMPLIED OTHER THAN THOSE SET OUT ABOVE. SELLER SPECIFICALLY EXCLUDES THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION CONTAINED HEREIN. IN NO EVENT SHALL SELLER BE LIABLE FOR CONSEQUENTIAL, EXEMPLARY, OR PUNITIVE DAMAGES OF WHATEVER NATURE.

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

INDEMNIFICATION

The Seller shall not be liable for any property damages whatsoever or claims of any kind whether based on contract, warranty, tort including negligence or otherwise, 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 or any services 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. It is the intention of the parties that this is a complete indemnification and hold harmless agreement in regard to all claims arising from nuclear operations of Buyer.

ISO 9001:1994 Registered

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