B Appendix B–Communications

The M-3425 Generator Protection Relay incorporates three 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 relay with the optional M-3931 Human-Machine Interface module is accessible remotely through the BECO 2200 or MODBUS data exchange protocol. These protocol documents and the database-specific protocol document are available from the factory or from our website at www.beckwithelectric.com.

The M-3820A IPSCom® Communication Software package has been supplied for communication to any IBM compatible computer running under Microsoft® Windows 95 or higher.

The communcation protocols implement serial, byte oriented, asynchronous communication and can be used to fulfill the following communications functions:

- Real time monitoring of line status.
- Interrogation and modification of setpoints.
- Downloading of recorded oscillograph data.
- Reconfiguration of relay functions.

■ **NOTE**: The following restrictions apply for MODBUS protocol use:

1. MODBUS protocol is not supported on COM1.
2. Parity is supported on COM2 and COM3; valid selections are 8,N,2; 8,O,1 or 8,E,1.
3. ASCII mode is not supported (RTU only).
4. Standard baud rates from 300 to 9600 are supported.
5. Only the following MODBUS commands are supported:
   a. read holding register (function 03)
   b. read input register (function 04)
   c. force single coil (function 05)
   d. preset single register (function 06)

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

Communication Ports

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

The 2-wire RS-485 port is assigned to the rear panel terminal block pins 3 (–) and 4 (+).

Each communication port may be configured to operate at any of the standard baud rates (300, 600, 1200, 2400, 4800, and 9600). The RS-485 port shares the same baud rate with COM 2 (for COM1 see Section 5.4, Circuit Board Switches and Jumpers).

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

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

Circuit		Signal	COM1	COM2
BB	RX	Receive Data	Pin 2	Pin 2
BA	TX	Transmit Data	Pin 3	Pin 3
CA	RTS	Request to Send	Pin 7	Pin 7
CB	CTS	Clear to Send		Pin 8
CD	DTR	Data Terminal Ready	Pin 4	Pin 4
CF	DCD	Data Carrier Detect		Pin 1*
AB	GND	Signal Ground	Pin 5	Pin 5
	+15 V			Pin 1*
	-15 V			Pin 9*
		TTL IRIG-B (+)		Pin 6*

** Optional: See Section 5.4, Circuit Board Switches and Jumpers ±15V (±15%) @100 mA maximum.*

Table B-1 Communication Port Signals

■ **NOTE:** Also see Tables 5-1, 5-2 and Figure 5-7.

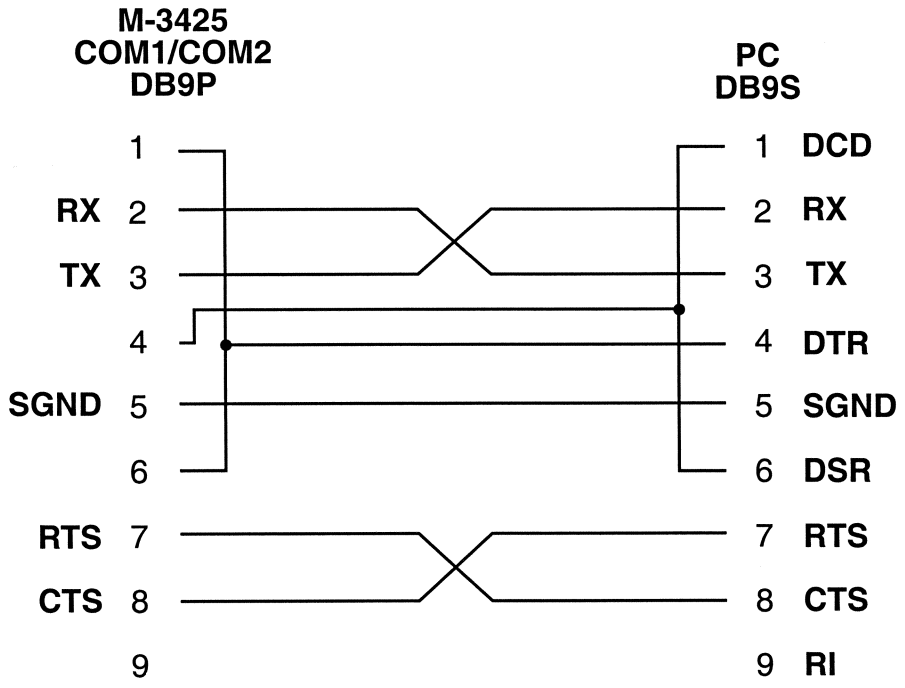


Figure B-1 Null Modem Cable: M-0423

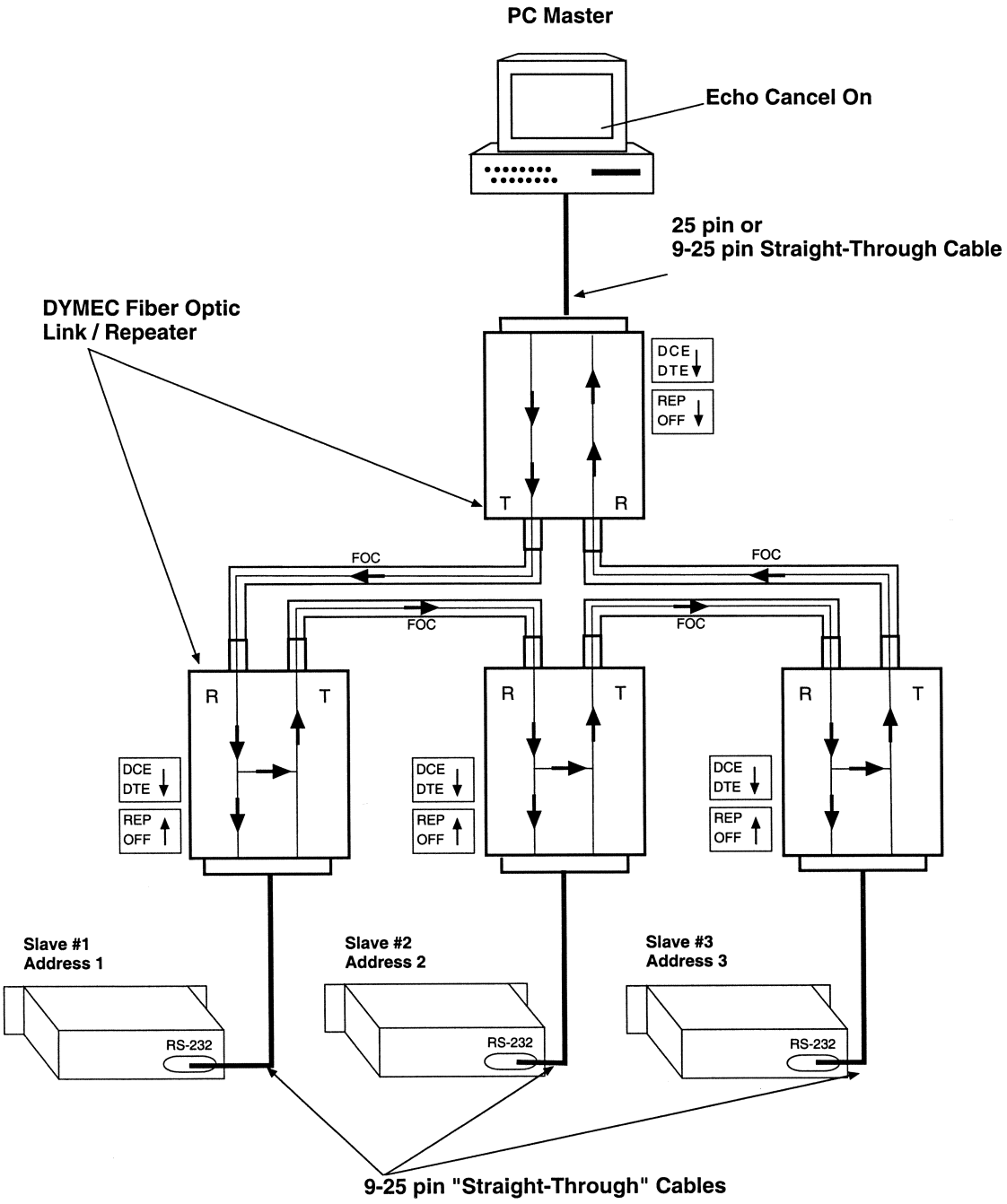
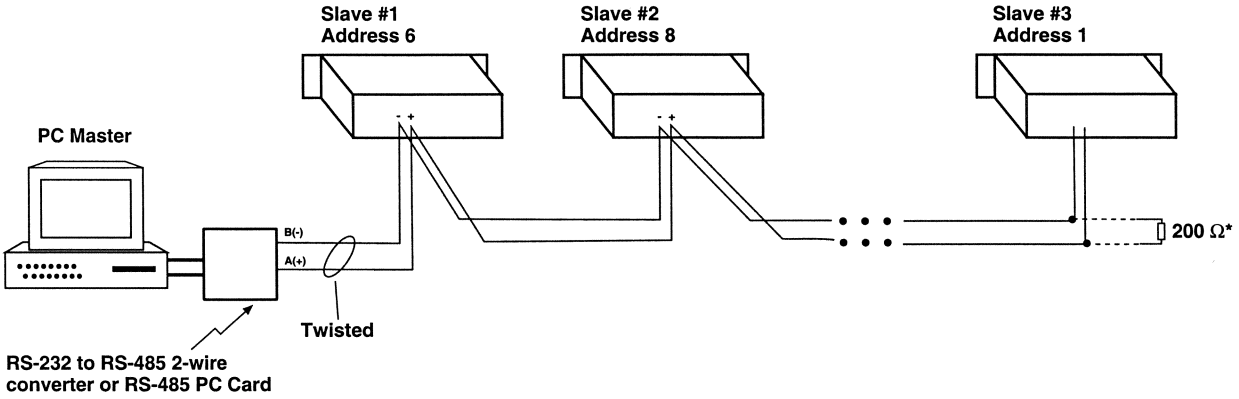


Figure B-2 RS-232 Fiber Optic Network

RS-485 2-Wire Network



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

■ **NOTE**: Each address on the network must be unique. Only the last physical slave on the network should have the termination resistor installed. This may be completed externally or via a dip jumper internal to the unit. See Section 5.4, Circuit Board Switches and Jumpers.

Figure B-3 RS-485 Network

B Communicaciones

El Relevador de Protección de Generador M-3425 incorpora tres puertos seriales para tener comunicación con dispositivos externos. Equipos tales como RTU's, concentradores de datos, modems o computadoras pueden ser puestos en interfase para adquisición de datos y control directo, en línea y tiempo real. Generalmente, todos los datos disponibles al operador a través del panel frontal del relevador con el módulo de interfase hombre-máquina M-3931 son accesibles remotamente a través de BECO 2200 o protocolo de intercambio de datos MODBUS. Los documentos de estos protocolos y el documento de la base de datos específica están disponibles en fábrica o desde nuestro sitio Web en www.beckwithelectric.com.

El software de comunicación IPSCom (r) M-3820A ha sido suministrado para la comunicación con cualquier computadora compatible con IBM corriendo bajo Microsoft (r) Windows 95 o superior.

Los protocolos de comunicación implementan comunicación serial, orientada a byte, asíncrona y puede ser usada para cumplir las siguientes funciones de comunicaciones:

- Monitoreo en tiempo real del estado del generador.
- Interrogación y modificación de puntos de ajustes.
- Descarga de datos de oscilografía registrados.
- Reconfiguración de funciones del relevador.

■ **NOTA**: Las siguientes restricciones aplican para el uso del protocolo MODBUS:

1. Protocolo MODBUS no es soportado por el COM1.
2. Paridad es soportada sobre COM2 y COM3; selecciones válidas son 8,N,2; 8,O,1 ó 8,E,1.
3. Modo ASCII no es soportado (Únicamente RTU).
4. Tasas de Baud estándar de 300 a 9600 son soportadas.
5. Únicamente los siguientes comandos MODBUS soportados:
   a. Lectura de registros almacenados (función 03)
   b. Lecturas de registros de entrada (función 04)
   c. Forzar salidas sencillas (función 05)
   d. Preajustar registros sencillos (función 06)

Para información detallada sobre comunicaciones IPScom Refiérase al **Capítulo 4 Operación Remota**.

Puertos de Comunicación

El relevador tiene dos puertos RS-232, uno en el frente y uno trasero, y un puerto RS-485 trasero. Los puertos RS-232 son conectores de 9 pines (DB9S) configurado como DTE (Data Terminal Equipment) de acuerdo al estándar EIA-232D. Las señales están definidas en la Tabla B-1.

El puerto RS-485 de 2-hilos está asignado al bloque de terminales en la parte trasera del panel, pines 3 (-) y 4 (+).

Cada puerto de comunicación puede ser configurado para operar en cualquiera de las tasas de baud estándar (300, 600, 1200, 2400, 4800, and 9600). El puerto RS-485 comparte la misma tasa de baud con el COM 2 (para COM1 vea la Sección 5.4, Switches y Puentes de tarjetas.)

Aunque los puertos de comunicación digital incluyen algún circuito de protección ESD (Descarga Electrostática), ellos están excluidos de pasar el estándar ANSI/IEEE C37.90.1-1989. Beckwith Electric recomienda el uso de RS-232/485 a convertidores de fibra óptica para evitar cualquier problema de sobretensión o de elevación de potencial de tierra.

Un cable null modem es también mostrado en la Figura B-1 si desea tener una conexión directa a la PC (computadora personal).

Circuito		Señal	COM1	COM2
BB	RX	Recepción de Datos	Pin 2	Pin 2
BA	TX	Transmisión de Datos	Pin 3	Pin 3
CA	RTS	Requerimiento de Envío	Pin 7	Pin 7
CB	CTS	Limpio para Envío		Pin 8
CD	DTR	Listo para Terminal de Datos	Pin 4	Pin 4
CF	DCD	Detección de Portador de Datos		Pin 1*
AB	GND	Señal de Tierra	Pin 5	Pin 5
	+15 V			Pin 1*
	-15 V			Pin 9*
		TTL IRIG-B (+)		Pin 6*

** Opcional: Ver la Sección 5.4, Puentes Interruptores de Circuito de la Targeta ±15V (±15%) a un maximo de 100 mA.*

Tabla B-1 Señales del Puerto de Comunicación

■ **NOTA**: Ver también Tablas 5-1, 5-2 y la Figura 5-7.

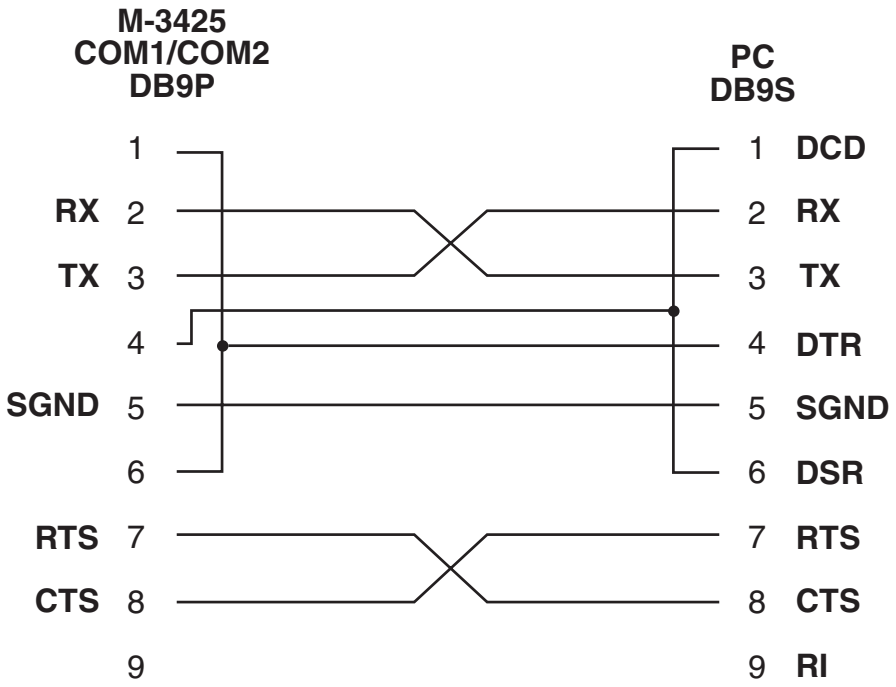


Figure B-1 Cable Null Modem: M-0423

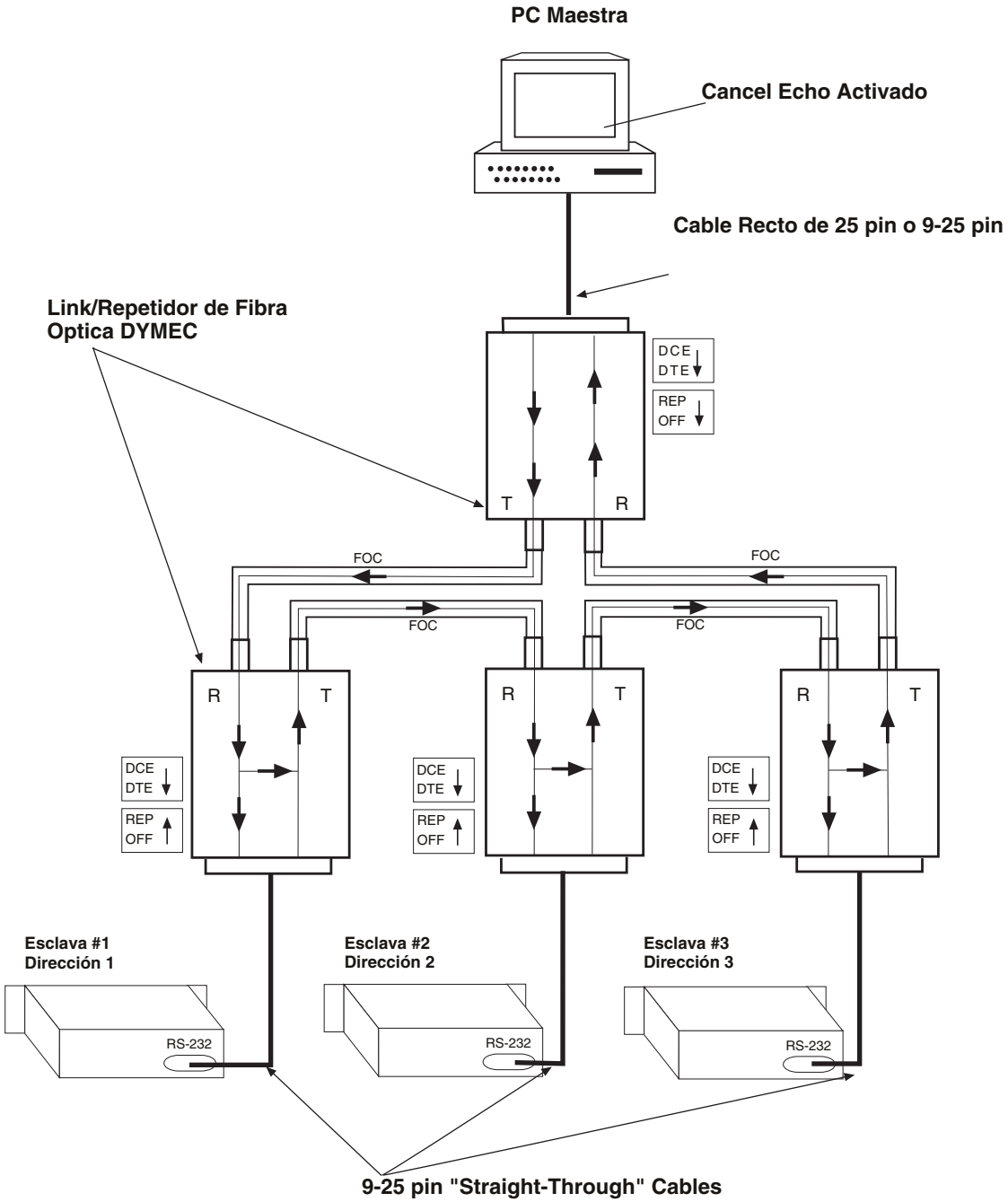
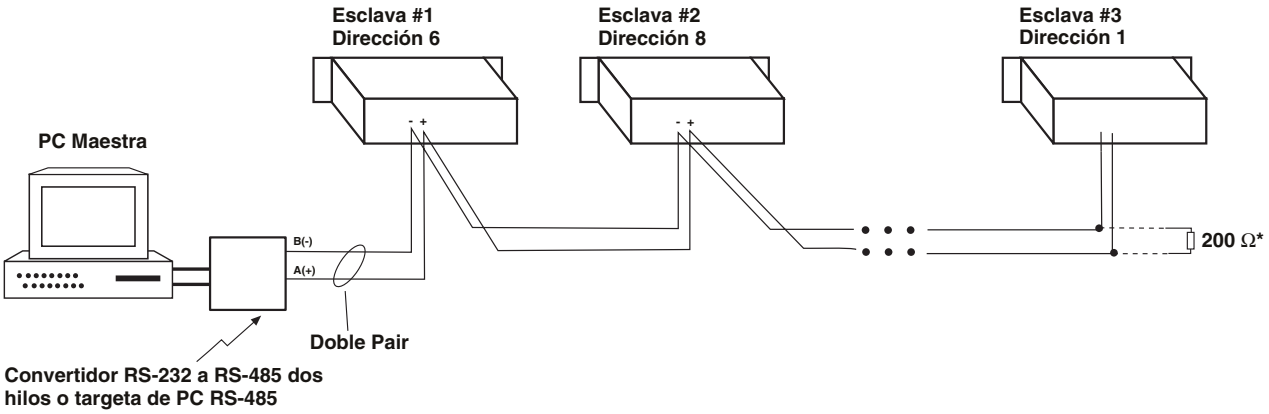


Figura B-2 Red de Fibra Optica RS-232

RS-485 Red de 2-Hilos



▲ **PRECAUCIÓN:** Debido a la posibilidad de la diferencia de potencial a tierra entre las unidades, todas las unidades deberán ser montadas en el mismo gabinete. Si esto no es posible, se debe usar fibra óptica con convertidores apropiados para asegurar el aislamiento.

■ **NOTA**: Cada dirección de la red debe ser única. Únicamente la última “esclava” física sobre la red debe tener el resistor de terminación instalado (200 W). Esto puede ser completado externamente o vía un puente interno a la unidad. Vea la Sección 5.4, Switches y Puentes de Tarjetas.

Figura B-3 Red RS-485

C Appendix C–Self-test Error Codes

Error Code	Description
1	
2	Battery backed RAM test fail
3	EEPROM write power-up fail
4	EEPROM read back power-up fail
5	Dual port RAM test fail
6	EEPROM write calibration checksum fail
7	EEPROM write setpoint checksum fail loss of power
8	EEPROM write setpoint checksum fail loss of battery backed RAM
9	DMA checksum/physical block fail
10	Oscillograph Memory Test fail
11	DSP external program RAM fail
12	DSP A/D convert fail
13	DSP ground channel fail
14	DSP reference channel fail
15	DSP PGA gain fail
16	DSP DSP<-> HOST interrupt 1 fail
17	DSP DSP -> HOST interrupt 2 set fail
18	DSP DSP -> HOST interrupt 2 reset fail
19	DSP program load fail
20	DSP not running run mode code
21	DSP not running secondary boot code
22	DSP DPRAM pattern test fail
23	EEPROM write verify error
24	BBRAM test error
25	Uninitialized EEPROM

Table C-1 Self-Test Error Codes

Error Code	Description
26	WARNING calibration checksum mismatch warning
27	WARNING setpoint checksum mismatch warning
28	WARNING low battery (BBRAM) warning
29	Supply/mux PGA running test fail
30	External DSP RAM test fail
31	Unrecognized INT1 code
32	Values update watchdog fail
33	Abort Error
34	Restart Error
35	Interrupt Error
36	Trap Error
37	Calibration running check fail
38	
39	
40	Interrupt noise INT2
41	Interrupt noise INT1
42	
43	
44	Oscillograph buffer overflow
45	Oscillograph buffer underflow
46	Failure of DSP to calculate calibration phasors
47	Unable to calibrate input (gain)
48	Unable to calibrate input (phase)
49	
50	Stack Overflow
51	Setpoint Write Overflow
52	Field Ground Error

Table C-1 Self-Test Error Codes (continued)

Error Code	Description
Comm Channel Lock	An incorrect pass word supplied to the control will result in this message.
Control in Local Mode	This message indicates that the control is being operated locally and serial communication is suspended.
Echo Timeout	This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.
Invalid Data	This error results if incorrect or out-of-range data is entered.
Invalid ID	This message is displayed when attempting to communicate with a device other than the M-3425.
Invalid Number of Points	This error results if an incompatible version of IPScom software is used. This is a communication protocol error. Contact a Beckwith Electric Co. factory representative.
Invalid Point Number	This error results if an incompatible version of IPScom software is used. This is a communication protocol error. Contact a Beckwith Electric Co. factory representative.
Read Invalid Checksum	This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.
Read Packet Timeout	This error results when communication with the control is lost while attempting to read data to the control.
Response Timeout	This error results when communication with the control is lost while attempting to read data from the control.
Unknown System Error	This error could be caused by a malfunction of the control.
User Cancel	This message displays when the escape (ESC) key is pressed.
Write Invalid Checksum	This error results if there are problems with the communication link or if the echo cancel function is used incorrectly.
Write Packet Timeout	This error results when communication with the control is lost while attempting to write data to the control.

Table C-2 IPScom® Error Messages

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D Appendix D – Inverse Time Curves

This Appendix contains two sets of Inverse Time Curve Families. The first set is used for Volts per Hertz functions (Figures D-1 through D-4), and the second set is for the M-3425 functions which utilize the Inverse Time Overcurrent curves (Figures D-5 through D-12).

■ **NOTE:** Table D-1A and D-1B on pages D–6 and D–7 contains a list of the data that characterizes Definite Time, Inverse Time, Very Inverse Time, and Extremely Inverse Time Overcurrent Curves.

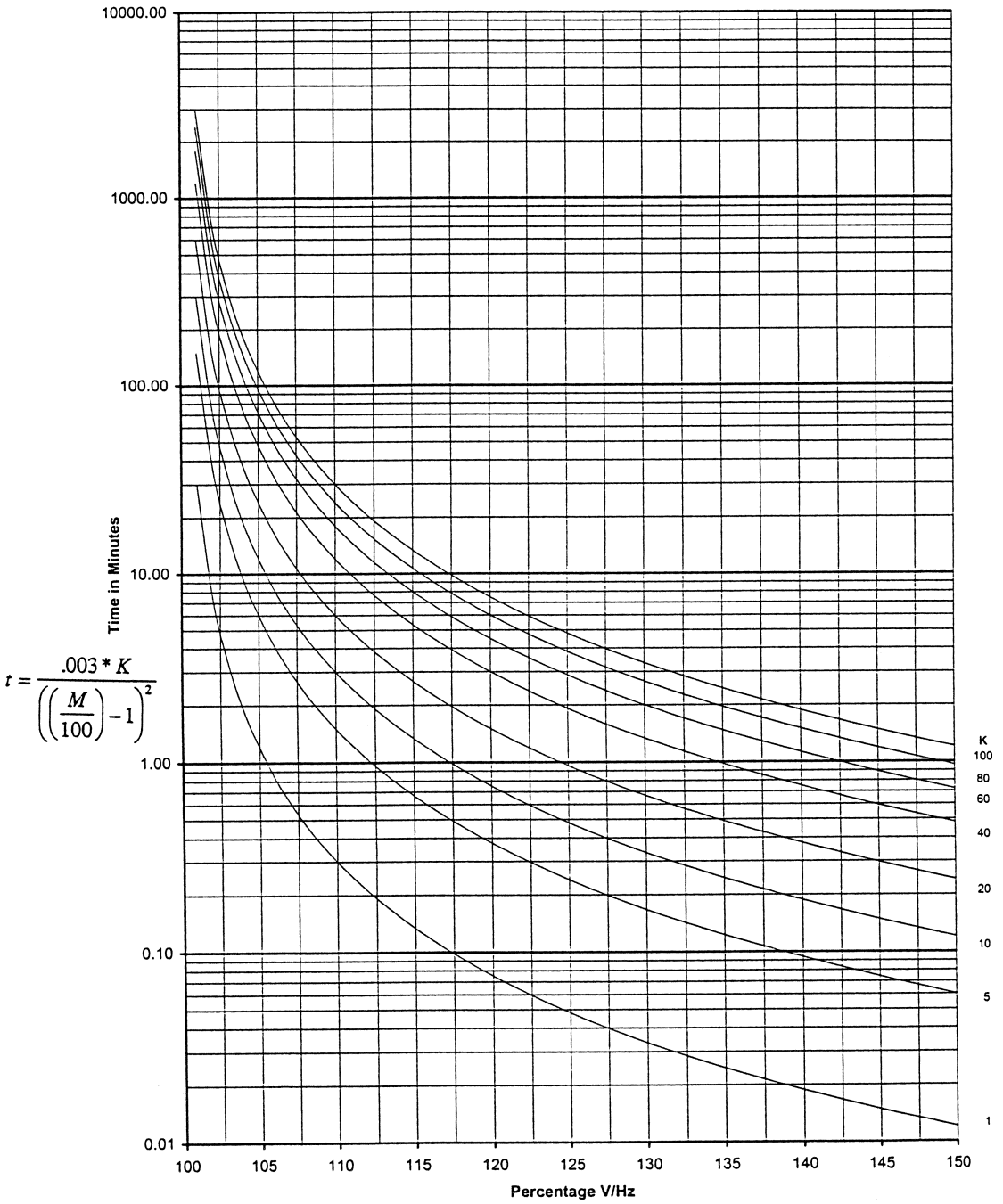


Figure D-1 Volts/Hz (24) Inverse Curve Family #1 (Inverse Square)

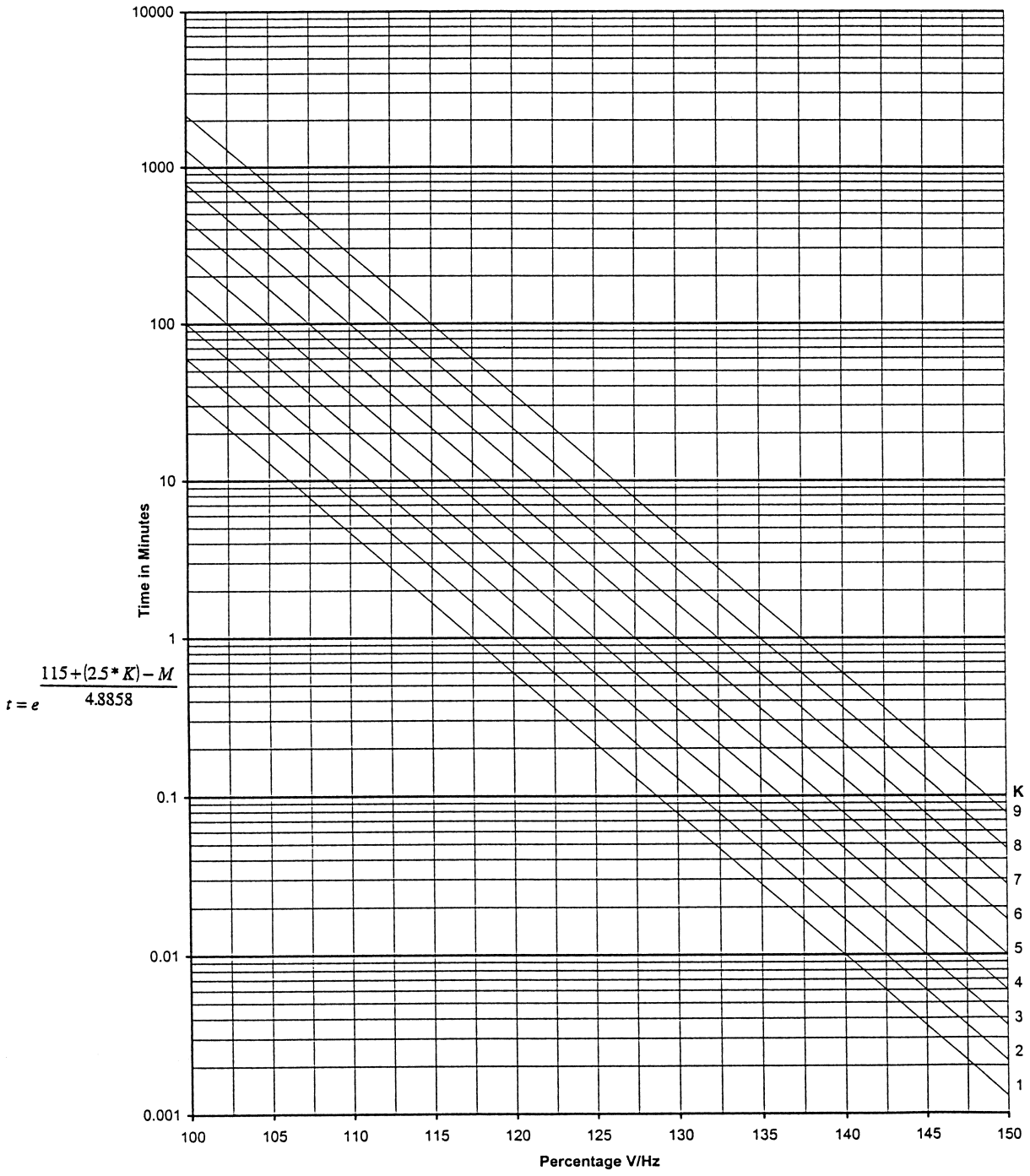


Figure D-2 Volts/Hz (24) Inverse Family Curve #2

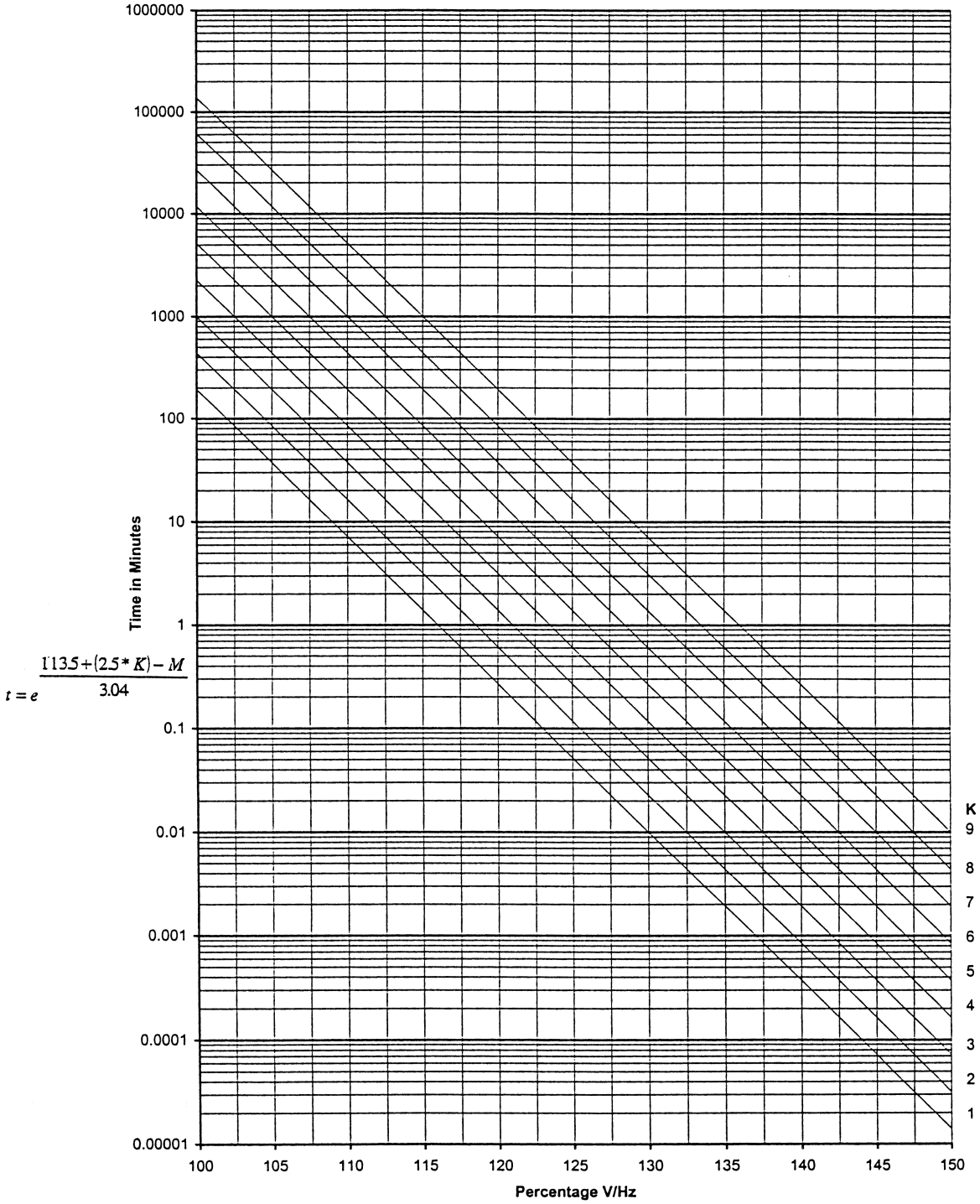


Figure D-3 Volts/Hz (24IT) Inverse Curve Family #3

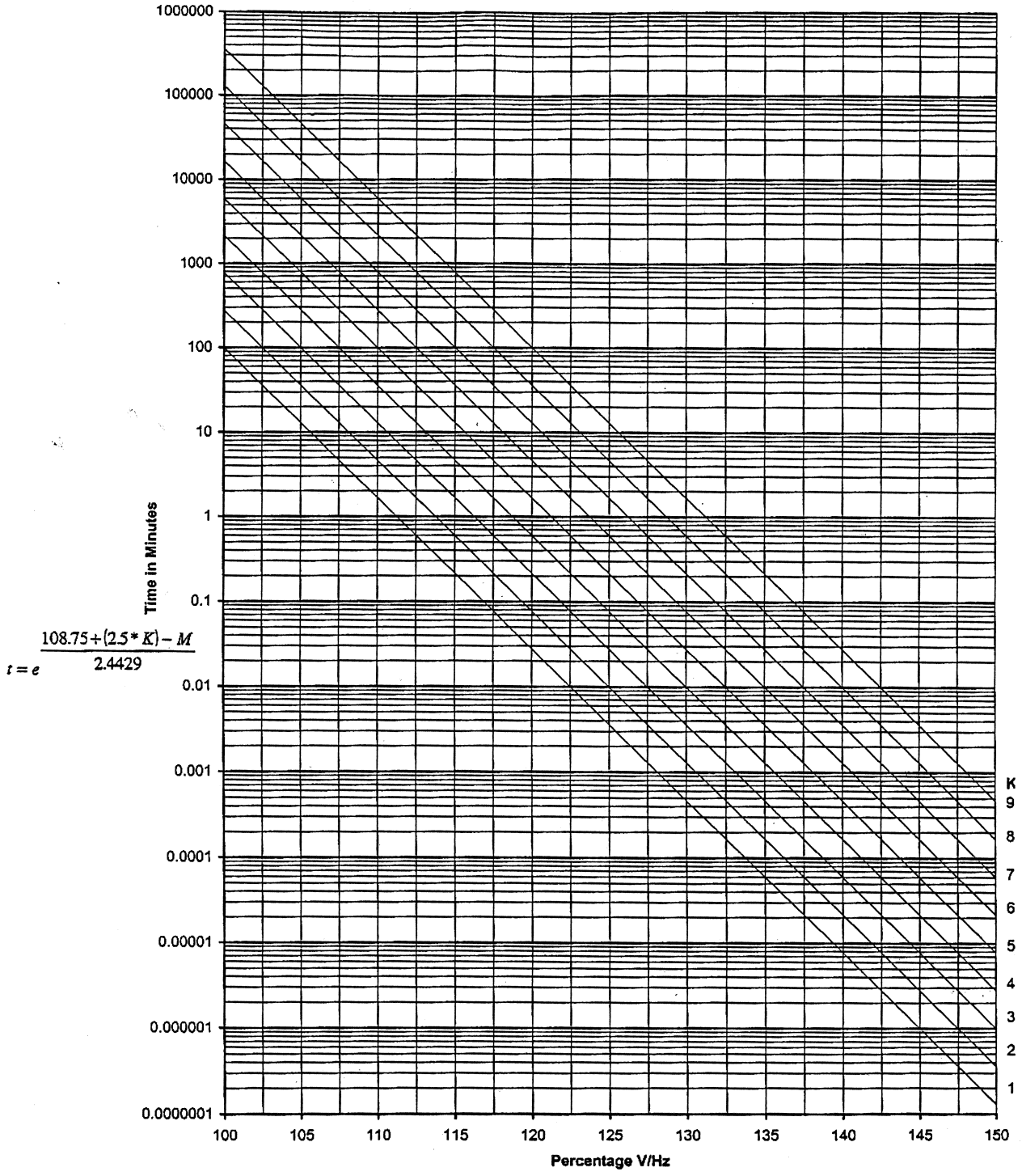


Figure D-4 Volts/Hz (24IT) Inverse Curve Family #4

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
1.50	0.69899	4.53954	3.46578	4.83520
1.55	0.64862	4.15533	3.11203	4.28747
1.60	0.60539	3.81903	2.81228	3.83562
1.65	0.56803	3.52265	2.55654	3.45706
1.70	0.53558	3.25987	2.33607	3.13573
1.75	0.50725	3.02558	2.14431	2.85994
1.80	0.48245	2.81566	1.97620	2.62094
1.85	0.46068	2.62673	1.82779	2.41208
1.90	0.44156	2.45599	1.69597	2.22822
1.95	0.42477	2.30111	1.57823	2.06529
2.00	0.41006	2.16013	1.47254	1.92006
2.05	0.39721	2.03139	1.37723	1.78994
2.10	0.38606	1.91348	1.29093	1.67278
2.15	0.37648	1.80519	1.21249	1.56686
2.20	0.36554	1.72257	1.12812	1.47820
2.30	0.35293	1.54094	1.01626	1.32268
2.40	0.34115	1.39104	0.92207	1.19250
2.50	0.33018	1.26561	0.84190	1.08221
2.60	0.31999	1.15945	0.77301	0.98780
2.70	0.31057	1.06871	0.71334	0.90626
2.80	0.30189	0.99049	0.66127	0.83527
2.90	0.29392	0.92258	0.61554	0.77303
3.00	0.28666	0.86325	0.57515	0.71811
3.10	0.28007	0.81113	0.53930	0.66939
3.20	0.27415	0.76514	0.50733	0.62593
3.30	0.26889	0.72439	0.47870	0.58700
3.40	0.26427	0.68818	0.45297	0.55196
3.50	0.26030	0.65591	0.42977	0.52032
3.60	0.25697	0.62710	0.40879	0.49163
3.70	0.25429	0.60135	0.38977	0.46554
3.80	0.25229	0.57832	0.37248	0.44175
4.00	0.24975	0.53904	0.34102	0.40129
4.20	0.24572	0.50641	0.31528	0.36564
4.40	0.24197	0.47746	0.29332	0.33460
4.60	0.23852	0.45176	0.27453	0.30741
4.80	0.23541	0.42894	0.25841	0.28346

■ **NOTE:** The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1A M-3425 Inverse Time Overcurrent Relay Characteristic Curves (1 of 2)

Multiple of Tap Setting	Definite Time	Inverse Time	Very Inverse Time	Extremely Inverse Time
5.00	0.23266	0.40871	0.24456	0.26227
5.20	0.23029	0.39078	0.23269	0.24343
5.40	0.22834	0.37495	0.22254	0.22660
5.60	0.22684	0.36102	0.21394	0.21151
5.80	0.22583	0.34884	0.20673	0.19793
6.00	0.22534	0.33828	0.20081	0.18567
6.20	0.22526	0.32771	0.19511	0.17531
6.40	0.22492	0.31939	0.19044	0.16586
6.60	0.22360	0.31150	0.18602	0.15731
6.80	0.22230	0.30402	0.18187	0.14957
7.00	0.22102	0.29695	0.17797	0.14253
7.20	0.21977	0.29027	0.17431	0.13611
7.40	0.21855	0.28398	0.17090	0.13027
7.60	0.21736	0.27807	0.16773	0.12492
7.80	0.21621	0.27253	0.16479	0.12003
8.00	0.21510	0.26734	0.16209	0.11555
8.20	0.21403	0.26251	0.15961	0.11144
8.40	0.21300	0.25803	0.15736	0.10768
8.60	0.21203	0.25388	0.15534	0.10422
8.80	0.21111	0.25007	0.15354	0.10105
9.00	0.21025	0.24660	0.15197	0.09814
9.50	0.20813	0.23935	0.14770	0.09070
10.00	0.20740	0.23422	0.14473	0.08474
10.50	0.20667	0.22923	0.14180	0.07943
11.00	0.20594	0.22442	0.13894	0.07469
11.50	0.20521	0.21979	0.13615	0.07046
12.00	0.20449	0.21536	0.13345	0.06667
12.50	0.20378	0.21115	0.13084	0.06329
13.00	0.20310	0.20716	0.12833	0.06026
13.50	0.20243	0.20341	0.12593	0.05755
14.00	0.20179	0.19991	0.12364	0.05513
14.50	0.20119	0.19666	0.12146	0.05297
15.00	0.20062	0.19367	0.11941	0.05104
15.50	0.20009	0.19095	0.11747	0.04934
16.00	0.19961	0.18851	0.11566	0.04784
16.50	0.19918	0.18635	0.11398	0.04652
17.00	0.19881	0.18449	0.11243	0.04539
17.50	0.19851	0.18294	0.11102	0.04442
18.00	0.19827	0.18171	0.10974	0.04362
18.50	0.19811	0.18082	0.10861	0.04298
19.00	0.19803	0.18029	0.10762	0.04250
19.50	0.19803	0.18014	0.10679	0.04219
20.00	0.19803	0.18014	0.10611	0.04205

■ **NOTE**: The above times are in seconds and are given for a time dial of 1.0. For other time dial values, multiply the above by the time dial value.

Table D-1B M-3425 Inverse Time Overcurrent Relay Characteristic Curves (2 of 2)

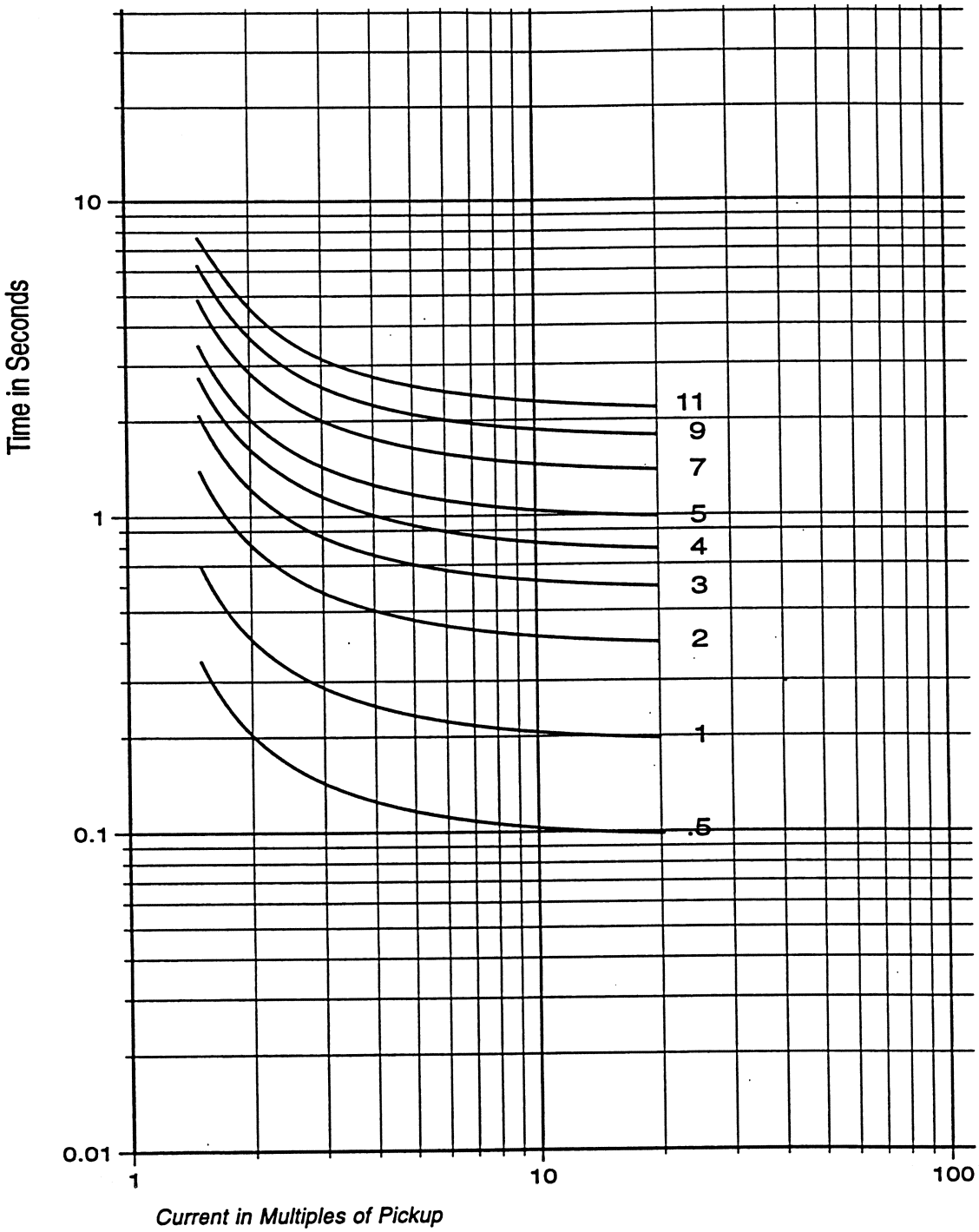


Figure D-5 Definite Time Overcurrent Curve

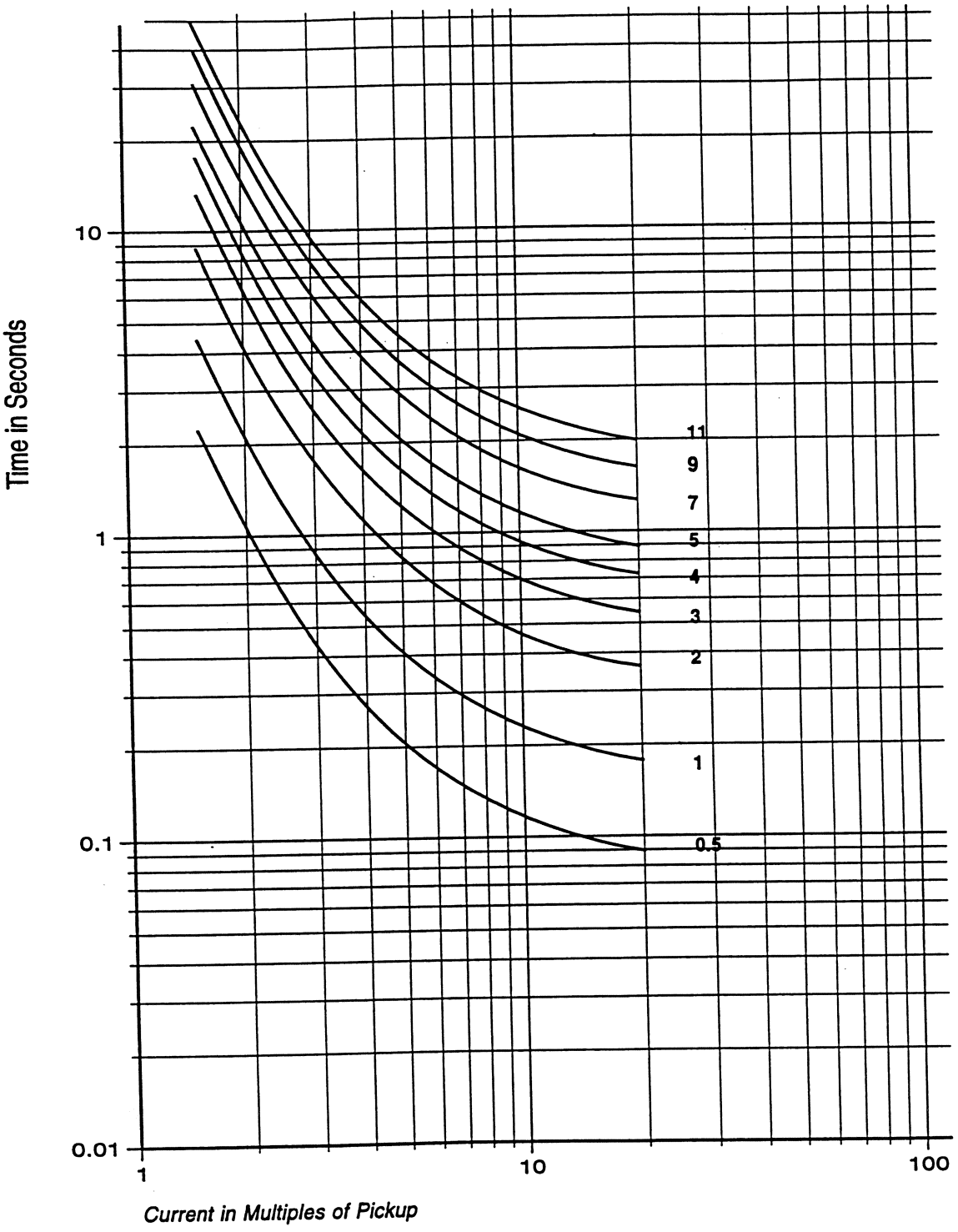


Figure D-6 Inverse Time Overcurrent Curve

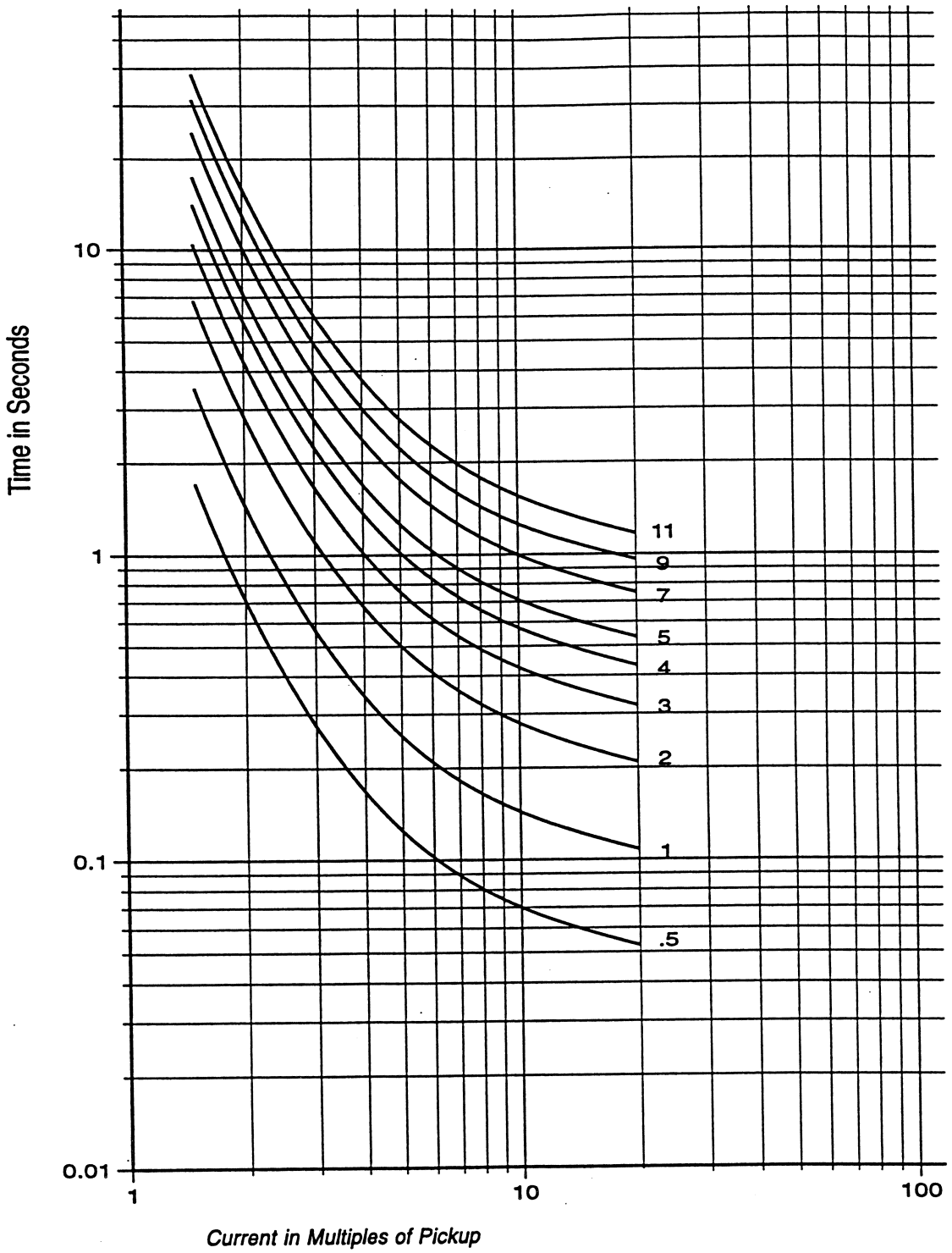


Figure D-7 Very Inverse Time Overcurrent Curve

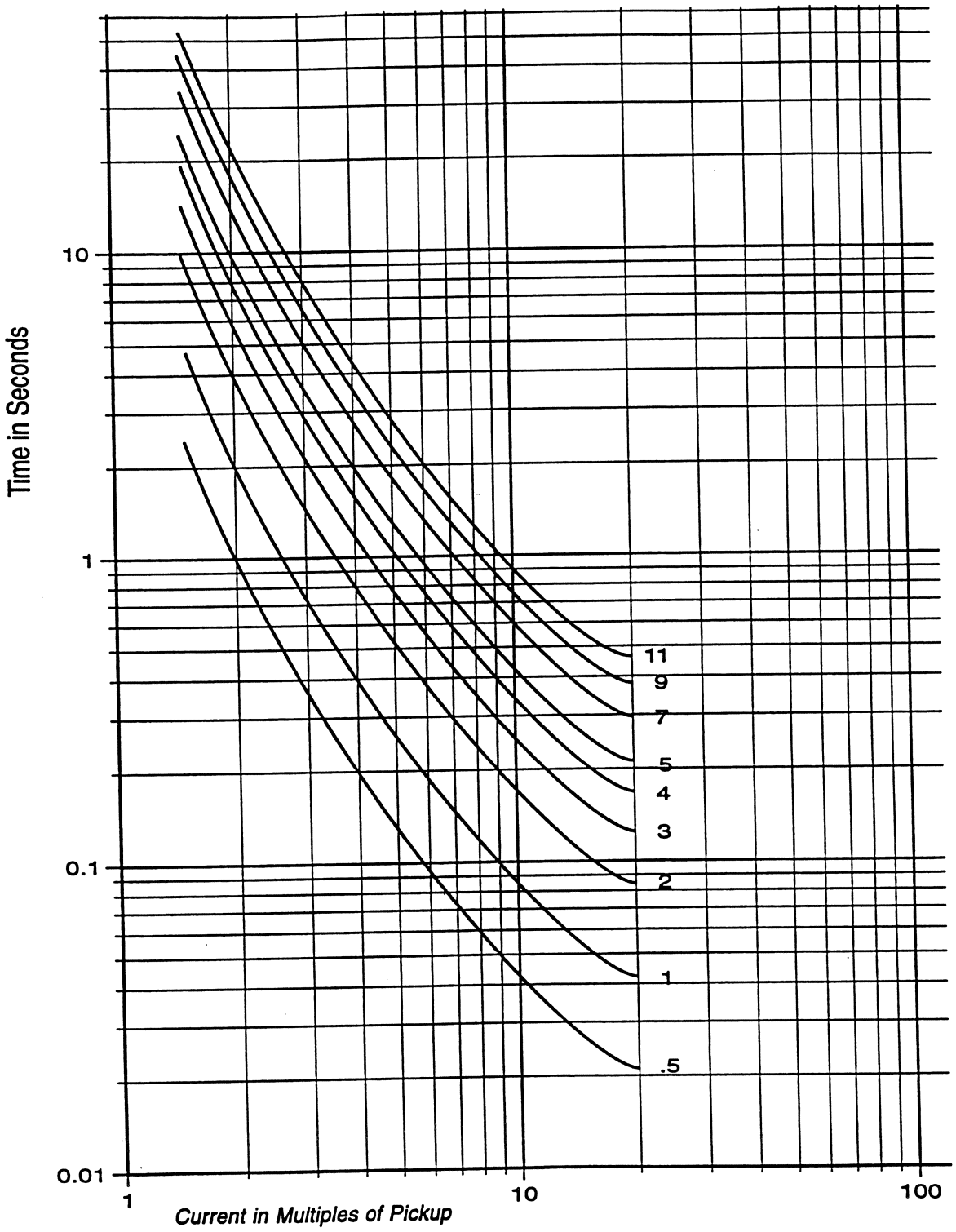
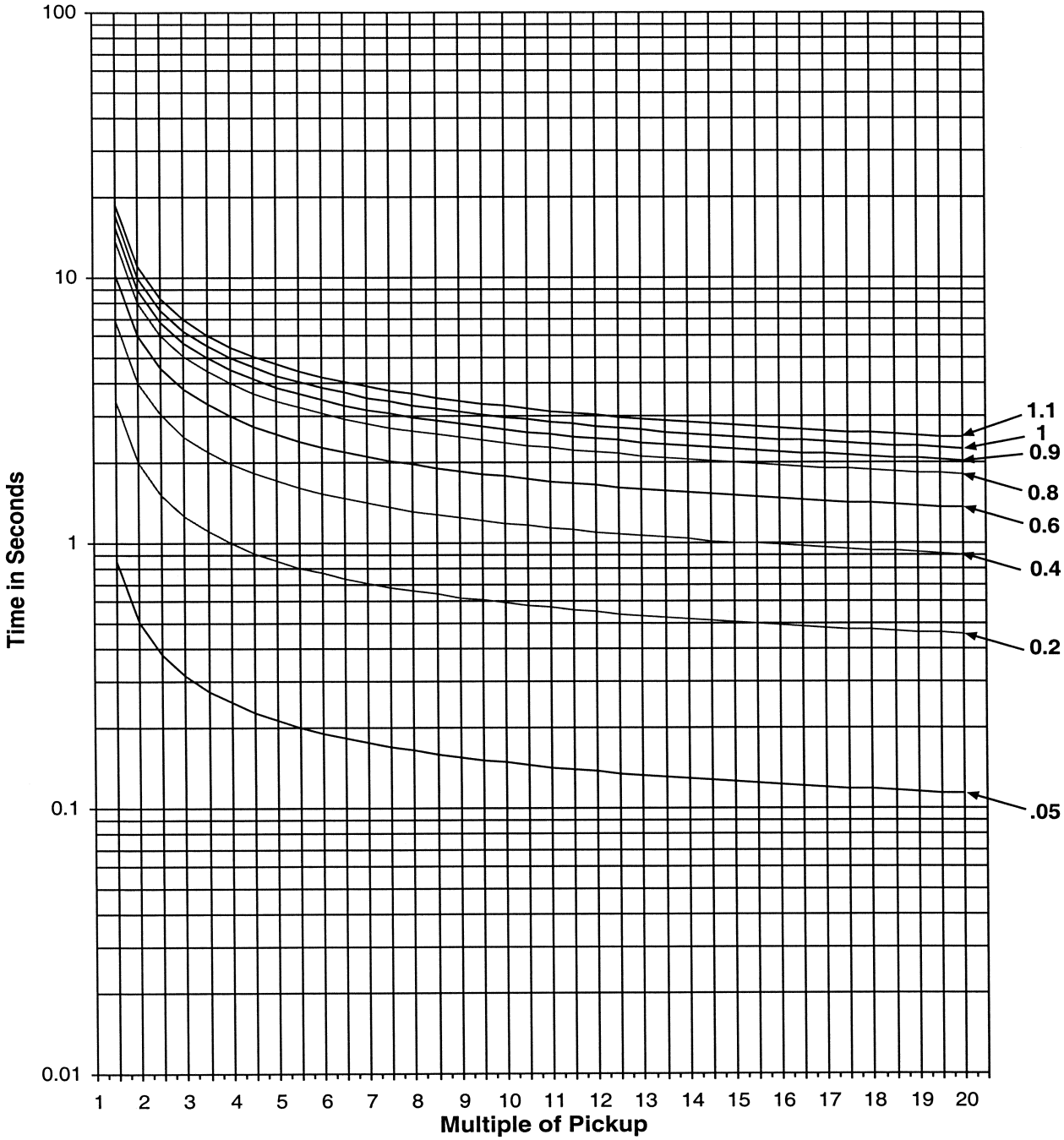
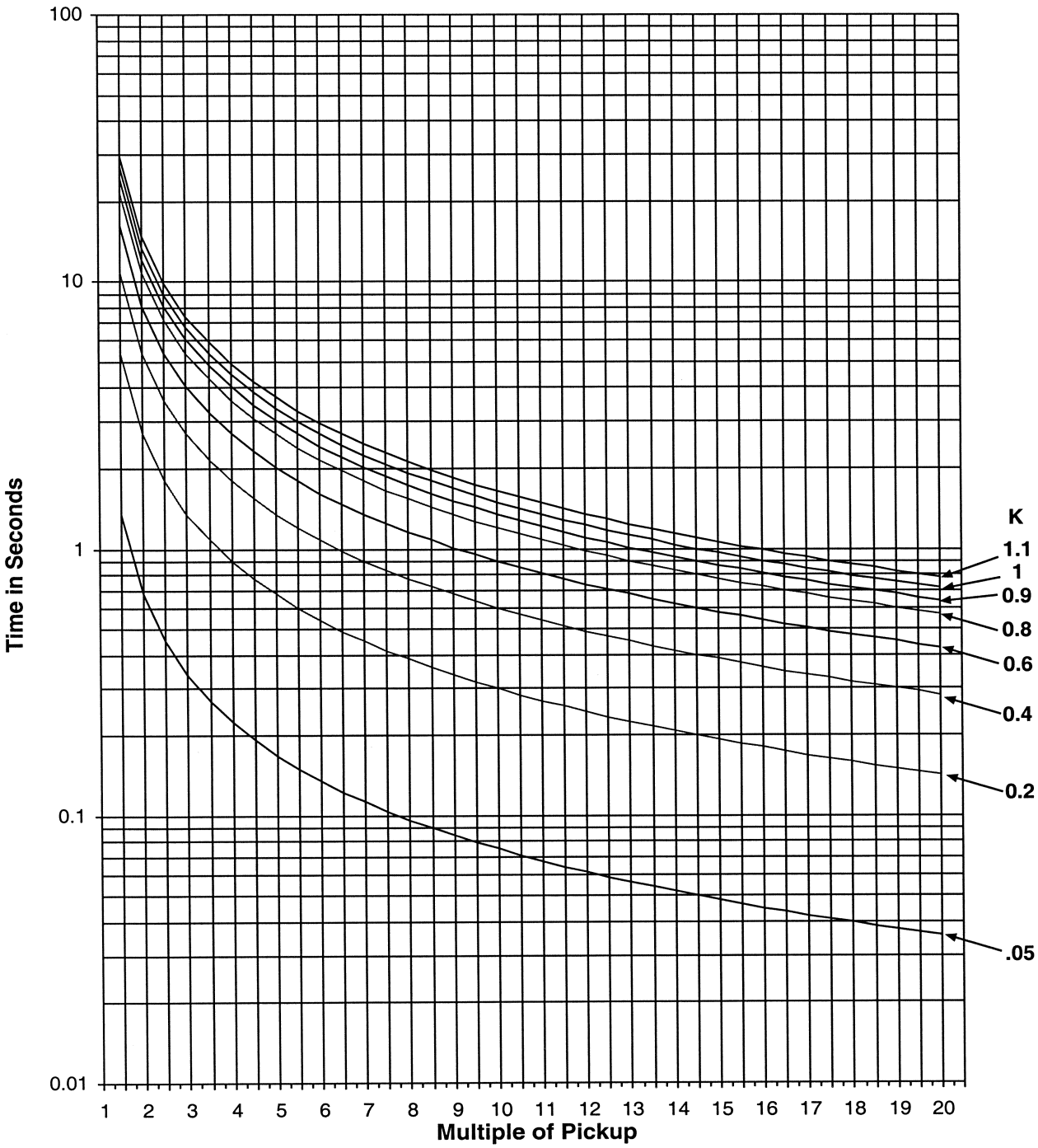


Figure D-8 Extremely Inverse Time Overcurrent Curve



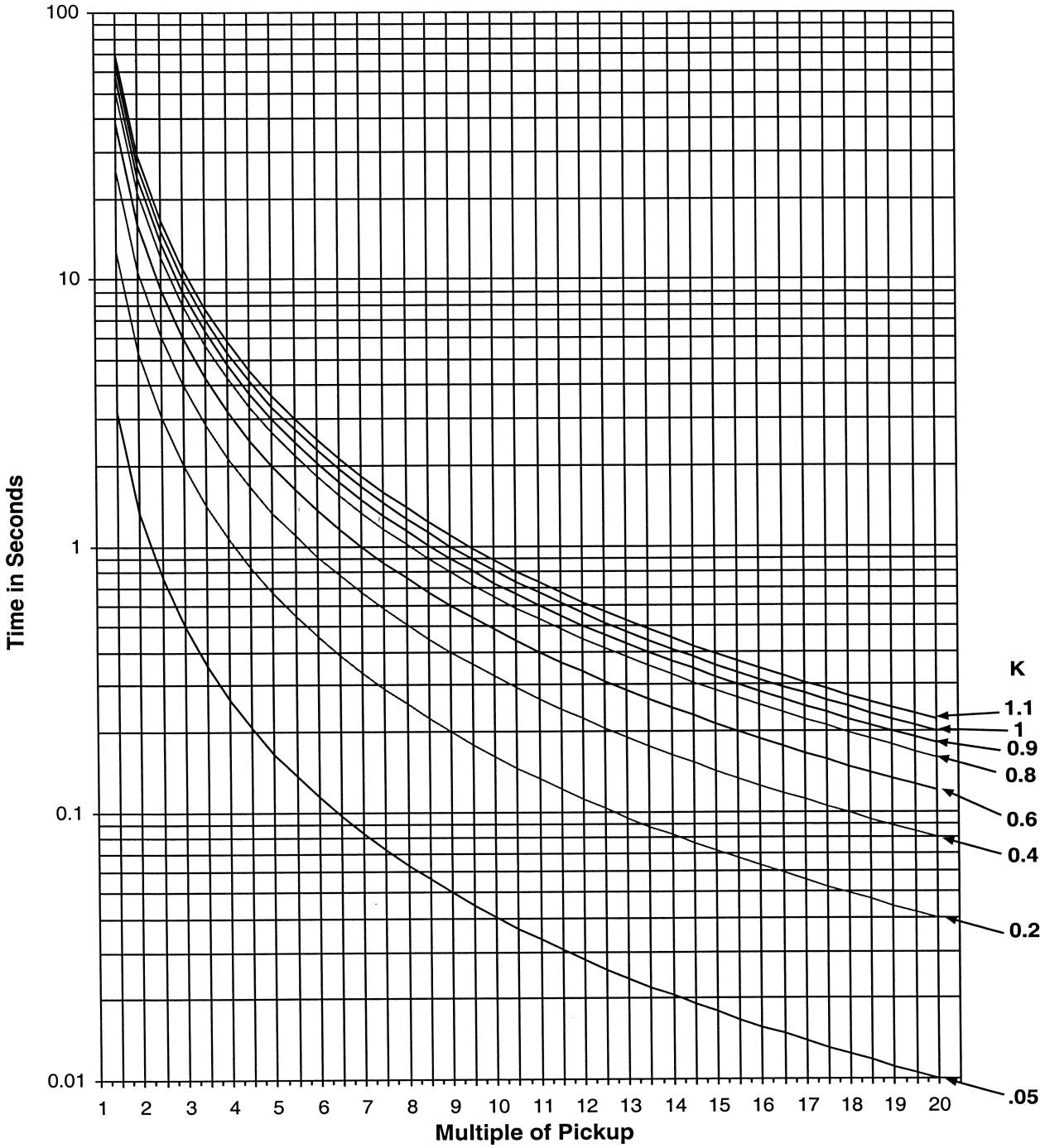
$$t=TD \times \left[\frac{0.14}{M^{0.02} - 1}\right]$$

Figure D-9 IEC Curve #1 Inverse



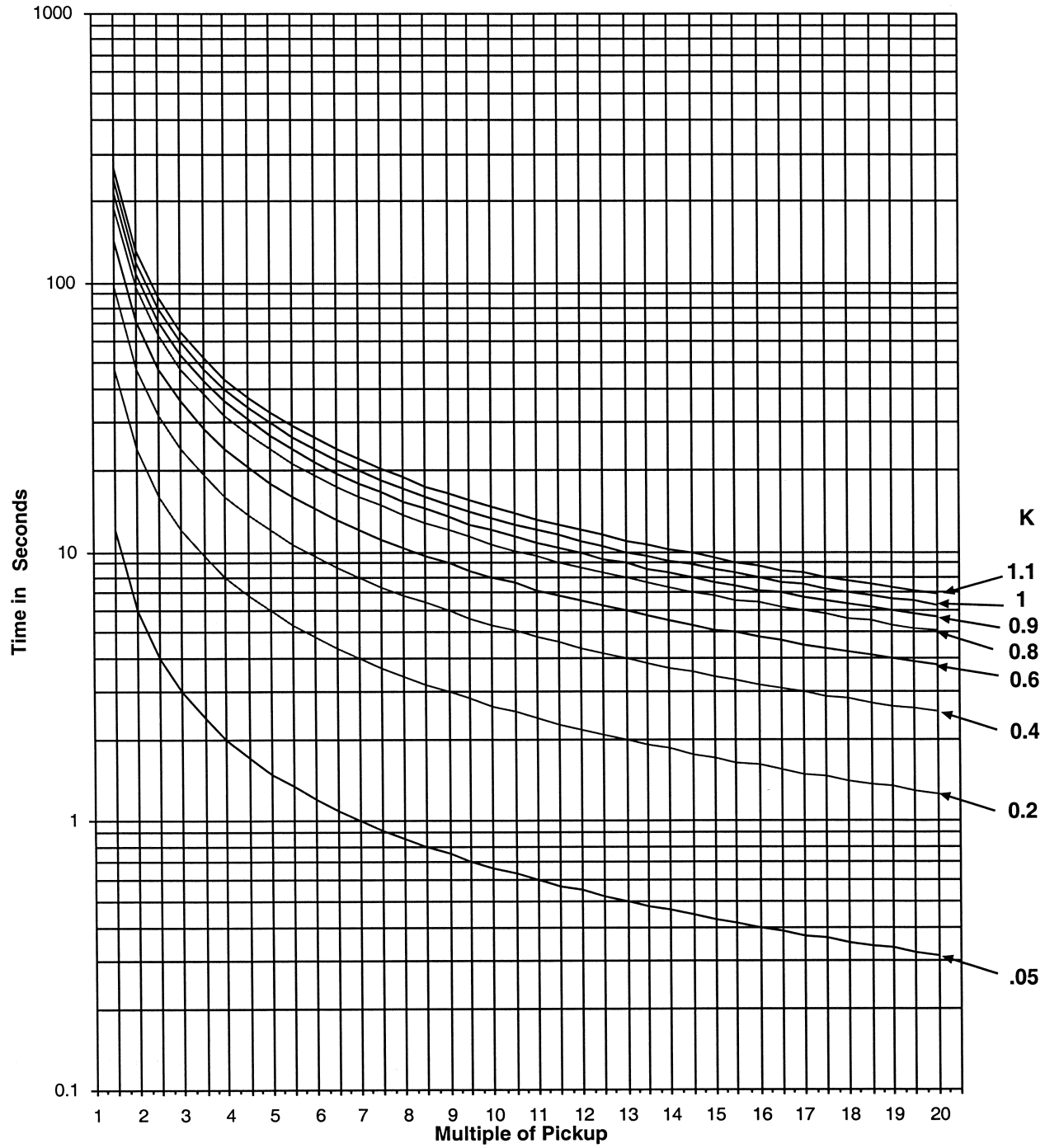
$$t=TD \times \left[\frac{13.5}{M-1}\right]$$

Figure D-10 IEC Curve #2 Very Inverse



$$t=TD \times \left[\frac{80}{M^2 - 1}\right]$$

Figure D-11 IEC Curve #3 Extremely Inverse



$$t=TD \times \left[\frac{120}{M - 1}\right]$$

Figure D-12 IEC Curve #4 Long-Time Inverse

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1 Introduction

1.1 Instruction Book Contents

This instruction book has six chapters and four Appendices.

Chapter 1: Introduction

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

Chapter 2: Application

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

Chapter 3: Operation

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

Chapter 4: Remote Operation

This chapter is designed for the person or group responsible for the remote operation and setting of the relay using the M-3820A IPScom® Communications Software package or other means.

Chapter 5: Installation

The person or group responsible for the installation of the relay will find herein all mechanical information required for physical installation, equipment ratings, and all external connections in this chapter. For reference, the Three-Line Connection Diagram is repeated from Chapter 2, **Application**. Further, a commissioning checkout procedure is outlined using the HMI option to check the external CT and VT connections. Additional tests which may be desirable at the time of installation are described in Chapter 6, **Testing**.

Chapter 6: Testing

This chapter provides step-by-step test procedures for each function, as well as diagnostic mode and autocalibration procedures for HMI-equipped units.

Appendix A: Configuration Record Forms

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

Appendix B: Communications

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

Appendix C: Self-Test Error Codes

This Appendix lists all the error codes and their definitions.

Appendix D: Inverse Time Curves

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

1.2 M-3425 Generator Protection Relay

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

The available internal functions of the relay are listed in Table 1-1. The nomenclature follows the standards of ANSI/IEEE Std. C37.2-1991, Standard Electric Power Systems Device Function Numbers.

Six input contacts can be programmed to block any relay function and/or to trigger the oscillograph recorder. Any of the functions or the input contacts can be individually programmed to activate any one or more of the eight programmable output contacts.

With the optional M-3931 HMI (Human-Machine Interface) Module, all functions can be set or examined via a local, menu-driven, 2 line by 24 character alphanumeric display. The module allows local metering of various quantities, including phase, neutral, and sequence voltages and currents, real and reactive power, power factor, and positive sequence impedance measurements.

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

The unit retains up to 170 cycles of oscillograph waveform data. This data can be downloaded and analyzed using the M-3801A IPSplot® Oscillograph Analysis Software package.

The unit is powered from a wide input range switch mode power supply. An optional redundant power supply is available.

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

FUNCTION	DESCRIPTION
Standard Protective Functions	
21	Phase Distance
24	Volts/Hz (Inverse & Definite Time)
27	RMS Undervoltage
27TN	Third Harmonic Undervoltage, Neutral
32	Directional Power
40	Loss-of-Field
46	Negative Sequence Overcurrent
50	Instantaneous Overcurrent
50BF	Breaker Failure
50DT	Definite Time Overcurrent
50N	Instantaneous Overcurrent, Neutral
50/27	Inadvertant Energizing
51N	Inverse Time Neutral Overcurrent
51V	Inverse Time Overcurrent, with Voltage Control/Restraint
59	RMS Overvoltage
59N	RMS Overvoltage, Neutral
60FL	VT Fuse-Loss Detection
78	Out-of-Step
81	Frequency
81R	Rate of Change of Frequency
87	Phase Differential
87GD	Ground (zero sequence) Differential
Ext	External Functions
Optional Protective Functions	
51T	Inverse Time Positive Sequence Overcurrent for Stator Thermal Protection
64F/64B	Field Ground Protection/ Brush Lift-Off Detection

Table 1-1 M-3425 Device Functions

Three communication ports are provided. COM1 and COM2 are standard 9-pin RS-232 DTE-configured communications ports. The front-panel port, COM1, is used to locally set and interrogate the relay via a portable computer. The second RS-232 port, COM2, is provided at the rear of the unit. An RS-485 communications port, COM3, is also available at the rear terminal block of the relay. Either rear-panel port, COM2 or COM3, can be used to remotely set and interrogate the relay via hard-wired serial connection or modem.

M-3820A IPScom Communications Software

IPScom® is shipped standard with every relay. This software runs on a PC-compatible computer operating under Microsoft Windows® 95/98 or later. When properly connected via either direct serial connection or modem, IPScom can provide the following functions:

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

1.3 Accessories

M-3925 Target Module

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

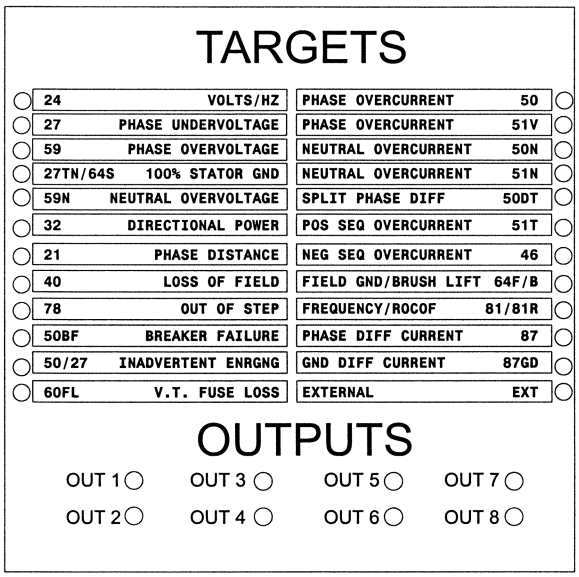


Figure 1-1 M-3925 Target Module

M-3933/M-0423 Serial Communication Cables

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

The M-0423 cable is a 10-foot null-modem RS-232 cable for direct connection between a PC and the relay's front panel COM1 port, or the rear COM2 port. This cable has a DB9 (9-pin) connector at each end.

M-3931 HMI (Human-Machine Interface) Module

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

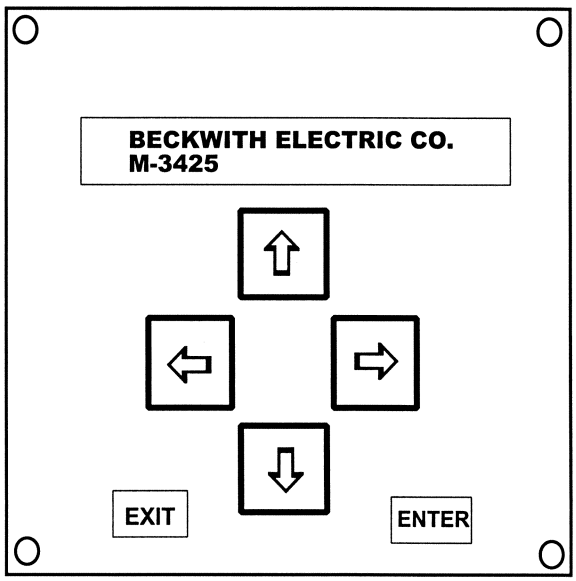


Figure 1-2 M-3931 Human-Machine Interface (HMI) Module

M-3801A IPSplot® Oscillograph Analysis Software Package

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

2 Application

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

Screens shown in the following examples are as they would appear on units equipped with the M-3931 HMI Module. The same setting may be entered remotely via M-3820A IPScom® Communications Software (see Chapter 4, **Remote Operation**).

2.1 Configuration

Functions

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

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

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

("•" denotes standard protective functions and "+" denotes optional protective functions.)

- 21 Phase Distance, #1, #2
- 24 Volts/Hz: Def Time #1, #2, Inv Time
- 27 RMS Undervoltage, 3-Phase #1, #2
- 27TN Third-Harmonic Undervoltage, Neutral, #1, #2
- 32 Directional Power, 3-Phase #1, #2
- 40 Loss of Field #1, #2
- 46 Negative Sequence Overcurrent: Def Time, Inv Time
- 50 Instantaneous Phase Overcurrent
- 50BF Breaker Failure
- 50DT Definite Time Overcurrent, #1, #2
- 50N Instantaneous Neutral Overcurrent
- 50/27 Inadvertent Energization
- 51N Inverse Time Neutral Overcurrent

+ 51T Inverse Time Positive Sequence Overcurrent for Stator Thermal Protection

- 51V Inverse Time Phase Overcurrent with Voltage Control/ Restraint
- 59 RMS Overvoltage, 3-Phase #1, #2
- 59N RMS Overvoltage, Neutral #1, #2
- 60FL Fuse Loss Detection

+ 64B Brush Lift-Off Detection
+ 64F Field Ground Protection, #1, #2

- 78 Out-of-Step
- 81 Frequency #1, #2, #3, #4
- 81R Rate of Change of Frequency, #1,#2
- 87 Phase Differential
- 87GD Ground Differential
- External #1, #2

The relay allows the user to designate up to two external functions which perform similarly to internal relay functions. These external functions may be enabled or disabled, and output contacts and blocking inputs are chosen the same as for the internal functions. The external functions are described in further detail in Section 2.3, Setpoint and Time Settings, External Functions subsection.

```
60FL V.T. FUSE LOSS
disable  ENABLE
```

```
60FL BLOCK INPUT
fl i6 i5 i4 i3 i2 I1
```

```
60FL RELAY OUTPUT
o8 o7 o6 o5 o4 o3 o2 O1
```

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

This assigns the blocking designations (up to six) for the enabled function. "OR" logic is used if more than one input is selected.

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

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

Relay System Setup

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

```
NOMINAL VOLTAGE
_________ Volts
```

The secondary VT voltage when primary voltage is equal to the rated *generator* voltage. (**V** gen rated ÷ VT ratio)

```
NOMINAL CURRENT
_________ Amps
```

The secondary CT current of the phase CT's with rated *generator* current. (**I** gen rated ÷ CT ratio)

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

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

```
DELTA-Y TRANSFORM
disable enable
```

By enabling the Delta-Y Transform, the relay will internally consider the 30° phase shift through the delta-wye unit transformer for 51V and 21 functions.

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

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

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

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

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

If the 50DT function is to be used for split-phase differential protection, this selection should be enabled. If the 50DT function is to be used as a definite time overcurrent function, this selection should be disabled.

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

If pulse relay operation is selected, output will dropout after the seal-in delay expires, even if the condition which caused the relay to pick up is still out of band.

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

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

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

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

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

Ratio of the phase VTs.

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

Ratio of the neutral VT.

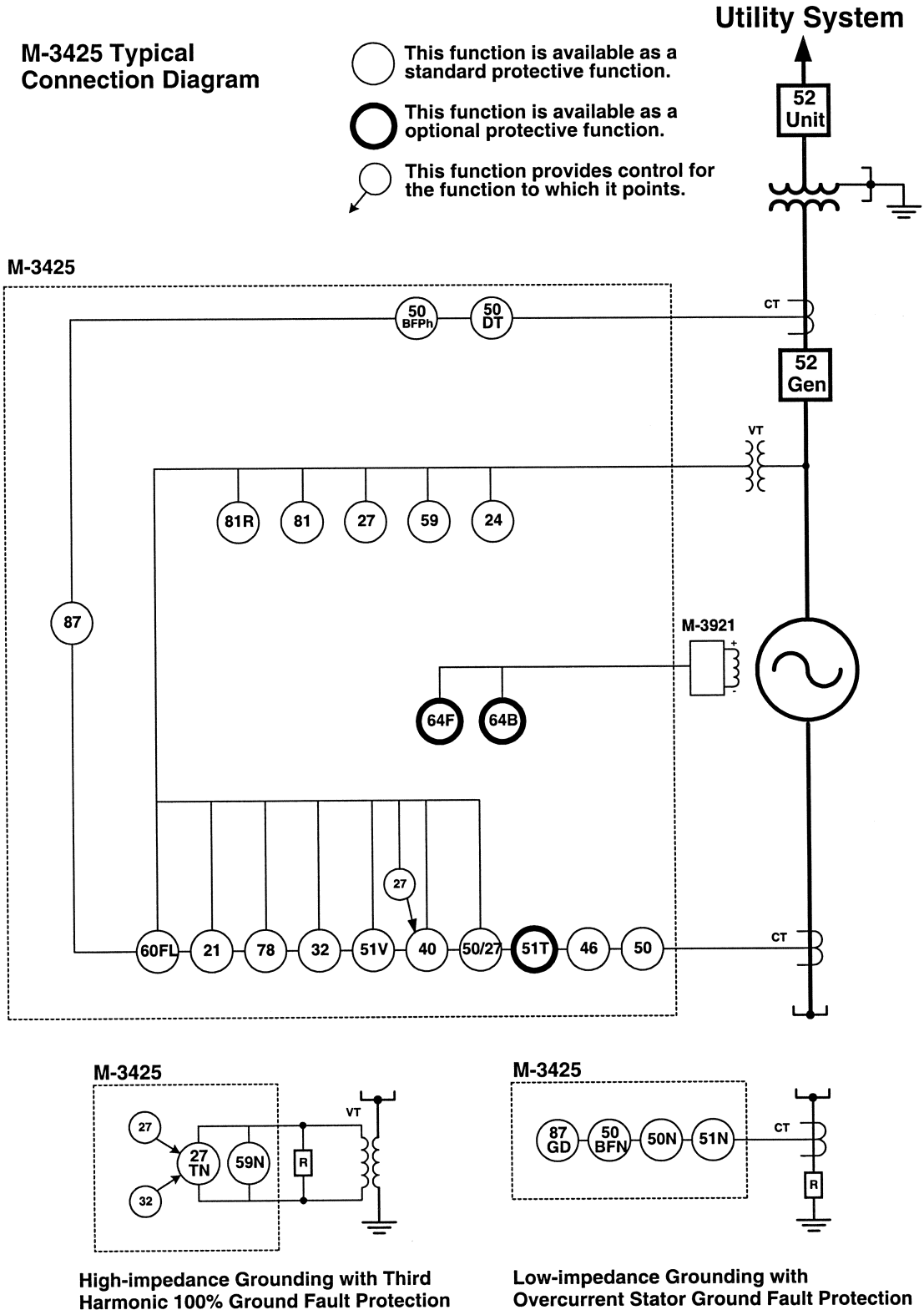
```
C.T. PHASE RATIO
 _______ : 1
```

Ratio of phase CTs.

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

Ratio of transformer neutral CT.

2.2 System Diagrams



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

Low-impedance Grounding with Overcurrent Stator Ground Fault Protection

Figure 2-1 One-Line Functional Diagram

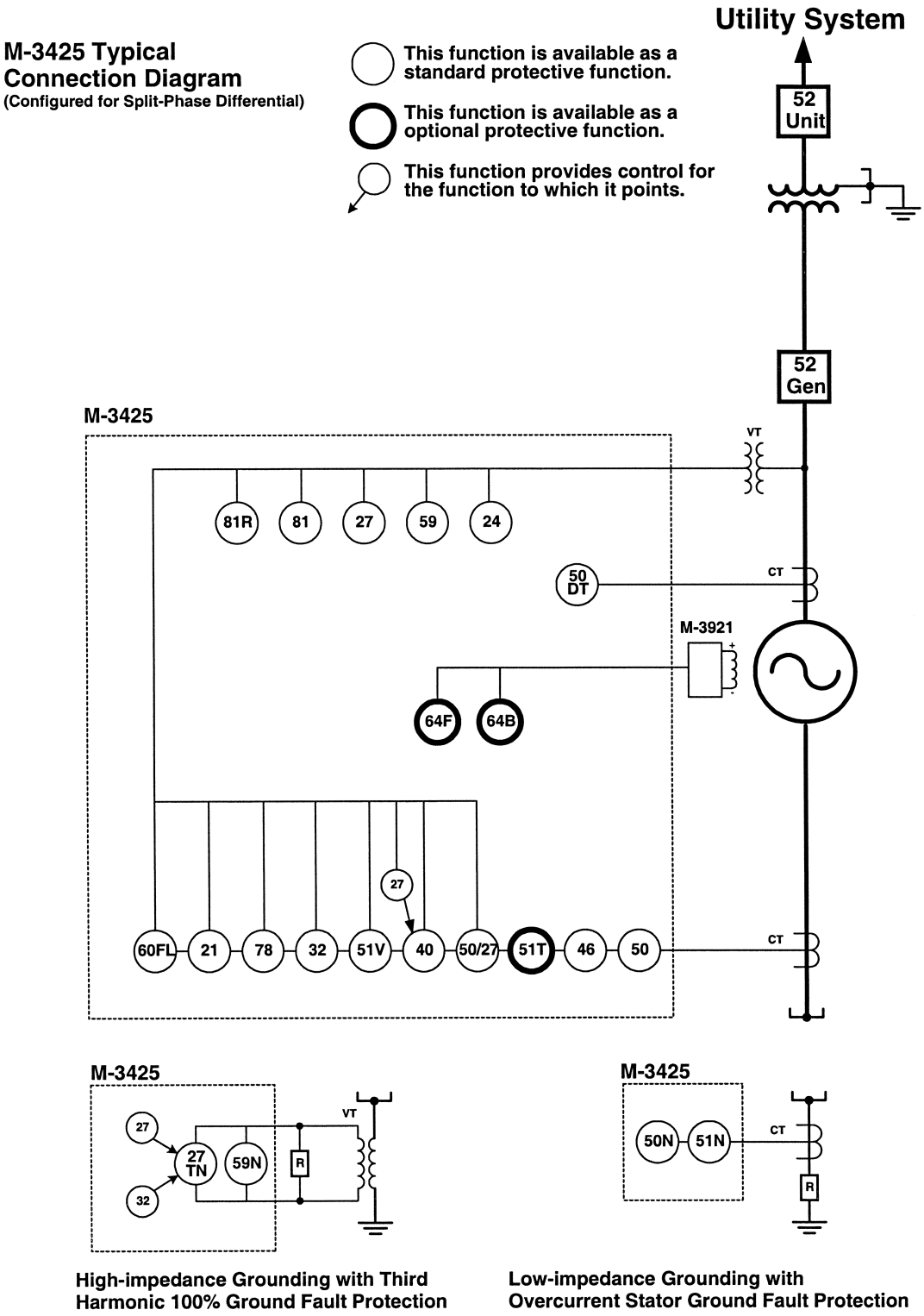


Figure 2-2 Alternative One-Line Functional Diagram

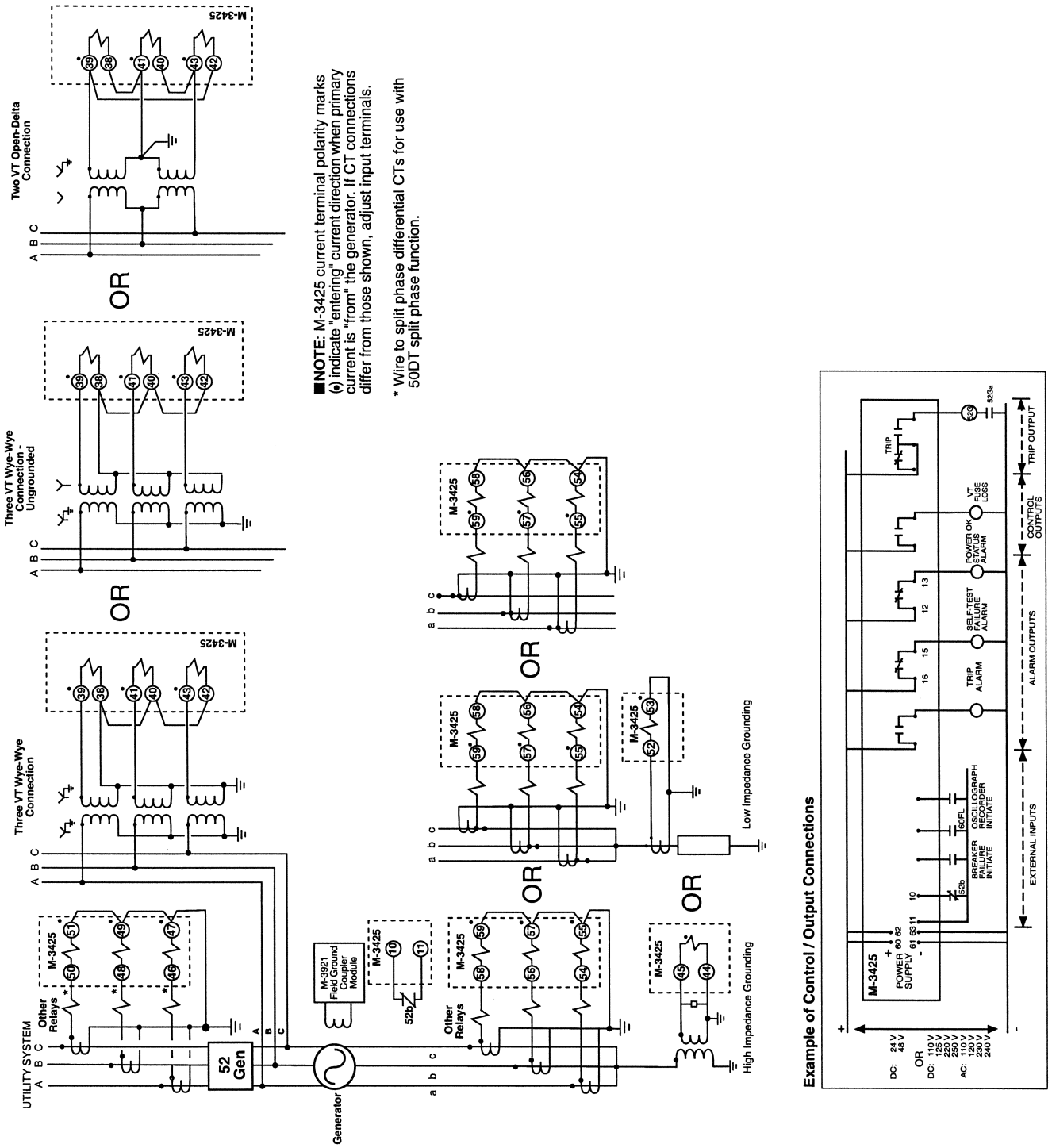


Figure 2-3 Three-Line Connection Diagram

2.3 Setpoints and Time Settings

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

21 Phase Distance

The phase distance function (21) is designed for system phase fault backup protection and is implemented as a two-zone mho characteristic. Three separate distance elements are used to detect AB, BC, and CA fault types. The ranges and increments are shown in Table 2-1. The diameter, offset, system impedance angle (relay characteristic angle), and definite time delay need to be selected for each zone for coordination with the system relaying in the specific application.

When the generator is connected to the system through a delta/wye transformer, proper voltages and currents (equivalent to the high side of the transformer) must be used in order for the relay to see correct impedances for system faults. By enabling the Delta-Y Transform feature (see Section 2.1, Configuration, Relay System Setup), the relay can internally consider the 30° phase shift through the delta/wye transformer, saving auxiliary VTs.

Impedance calculations for various VT connections are shown in Table 2-2. All impedance settings are secondary relay quantities and can be derived from the following formula:

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

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

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

FUNCTION	SETPOINT RANGE	INCREMENT
Phase Distance (21)		
Circle Diameter #1, #2	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω
Offset #1, #2	-100.0 to 100.0 Ω (-500.0 to 500.0 Ω)	0.1 Ω
Impedance Angle #1, #2	0° to 90°	1°
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

Table 2-1 Phase Distance (21) Setpoint Ranges

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

Table 2-2 Impedance Calculation

21 #1 DIAMETER
_____ Ohms

Typically the first zone of protection is set to an impedance value enough in excess of the first external protective section (typically the unit transformer) to assure operation for faults within that protective zone. (See Figure 2-4, Phase Distance (21) Coverage.)

21 #1 OFFSET
_____ Ohms

A negative or positive offset can be specified to offset the mho circle from the origin. This offset is usually set at zero. (See Figure 2-5, Phase Distance (21) Function Applied For System Backup.)

21 #1 IMPEDANCE ANGLE
_____ Degrees

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

21 #1 DELAY
_____ Cycles

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

21 #2 DIAMETER
_____ Ohms

The 21 #2 zone settings can be set for the second external section of protection on the system (typically transmission Zone 1 distance relays) plus adequate overreach.

21 #2 OFFSET
_____ Ohms

21 #2 IMPEDANCE ANGLE
_____ Degrees

21 #2 DELAY
_____ Cycles

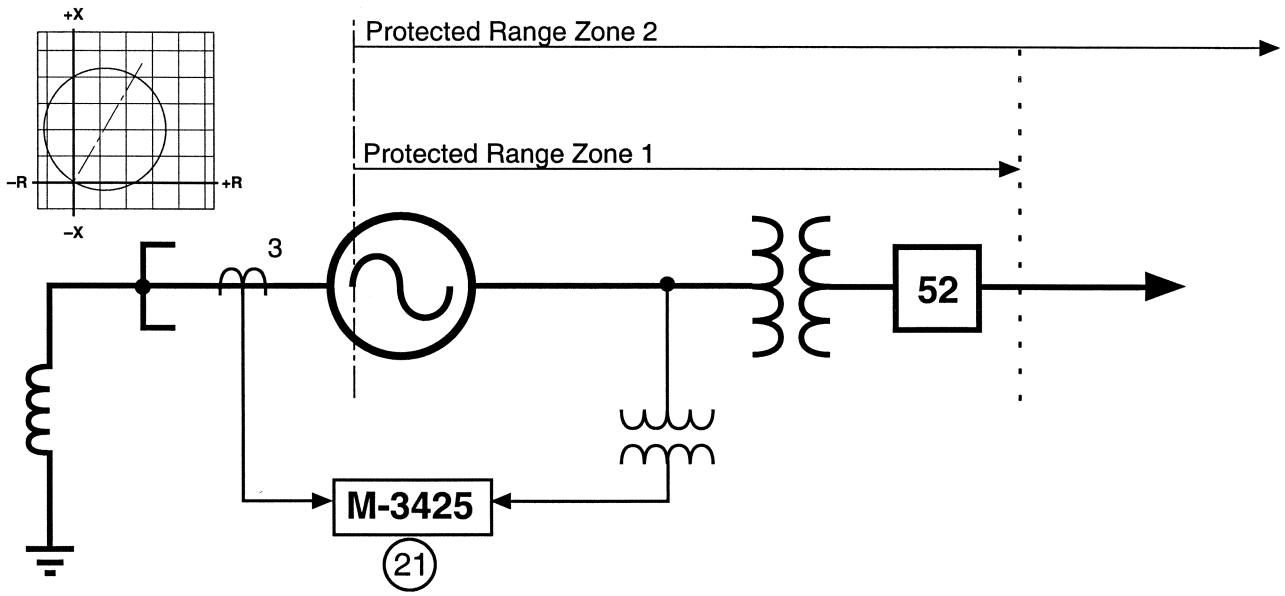


Figure 2-4 Phase Distance (21) Coverage

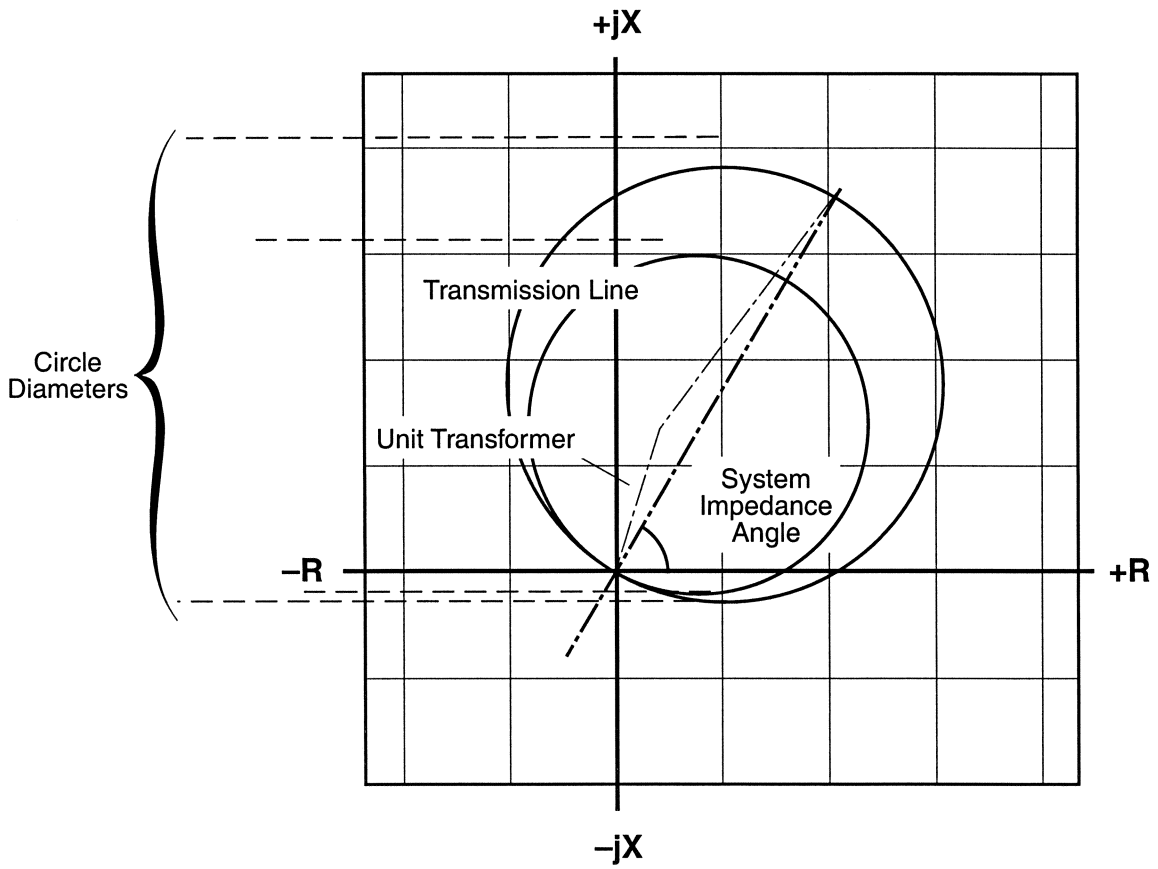


Figure 2-5 Phase Distance (21) Function Applied for System Backup

24 Volts/Hz

The Volts-Per-Hertz function (24) provides overexcitation protection for the generator and unit-connected transformers. This function incorporates two definite time elements which can be used to realize traditional two-step overexcitation protection. In addition, the relay includes an inverse time element that provides superior protection by closely approximating the combined generator/unit transformer overexcitation curve. Industry standard inverse curves may be selected along with a linear reset rate which may be programmed to match specific machine cooling characteristics. The percent pickup is based on the Nominal Voltage setting and the based frequency. The V/Hz function provides reliable measurements of V/Hz up to 200% for a frequency range of 2–80 Hz. The ranges and increments are presented in Table 2-3.

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

FUNCTION	SETPOINT RANGE	INCREMENT
Volts-Per-Hertz (24)		
Definite Time		
Pickup #1, #2	100 to 180%	1%
Time Delay #1, #2	30 to 8160 Cycles	1 Cycle
Inverse Time		
Pickup	100 to 200%	1%
Characteristic Curves	Inverse Time #1 – #4	-
Time Dial Setting:		
Curve 1	1-100	1
Curves 2 to 4	0-9	0.1
Reset Rate	1 to 999 Sec (from threshold of trip)	1 Sec
The percent pickup is based on nominal VT secondary voltage and nominal system frequency settings.		

Table 2-3 Volts-per-Hertz (24) Setpoint Ranges

Figure 2-6 illustrates a composite graph of generator and transformer limits, a chosen inverse time curve and pickup, and a definite time pickup and delay.

Be aware that all V/Hz inverse timing curves saturate at 150%, above which timing will be constant. If definite time element #1 or #2 is to be used for fixed time trip operation in conjunction with the inverse time element, definite time pickup must be programmed above the inverse time pickup. Also, the time delay at this pickup should be less than the inverse operating time at that same level to be effective.

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

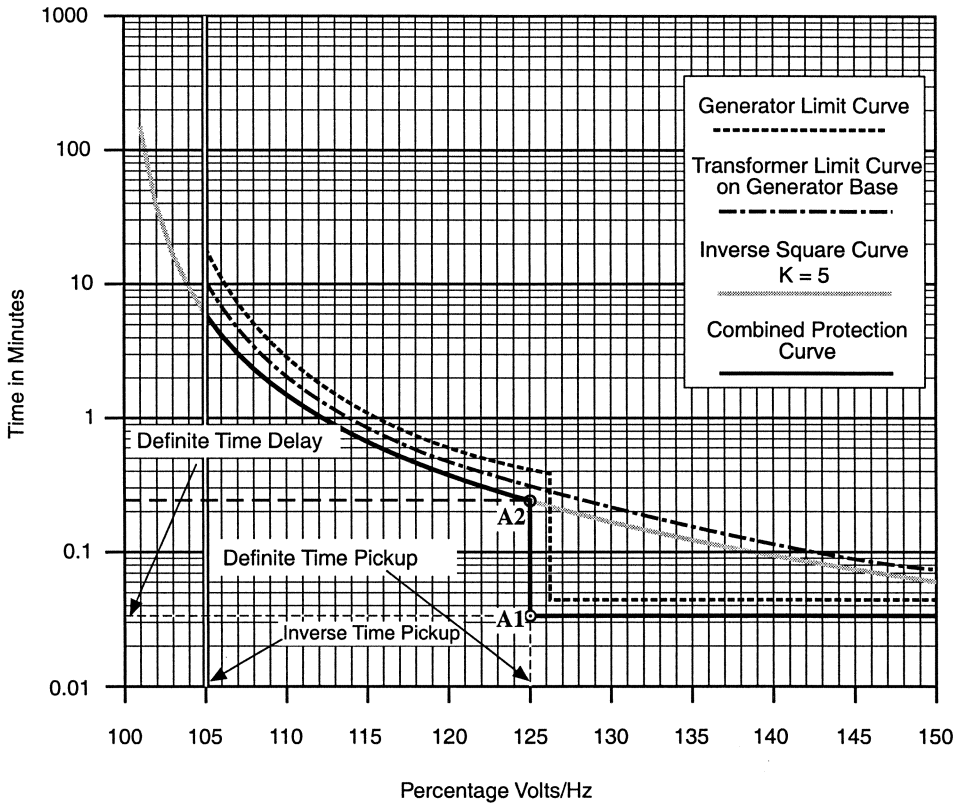
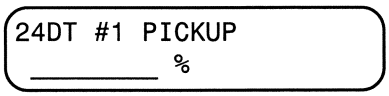
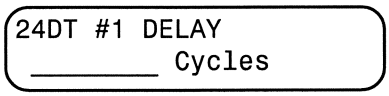


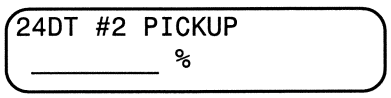
Figure 2-6 Example of Capability and Protection Curves (24)



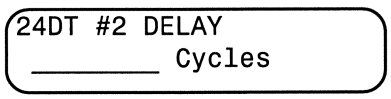
Definite time setpoint #1 establishes the V/Hz level above which the protection operating time will be fixed at the definite time delay #1.



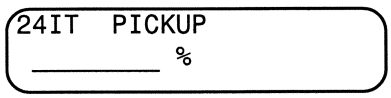
Delay time #1 establishes the operation time of the protection for all V/Hz values above the level set by definite time setpoint #1.



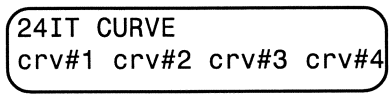
Definite time setpoint #2 could be programmed to alarm, alerting the operator to take proper control action to possibly avoid tripping.



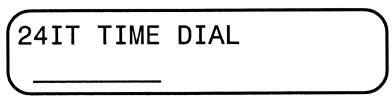
Time to operation at any V/Hz value exceeding Definite time setting #2.



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



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



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

The value entered here should be the time needed for the unit to cool to normal operating temperature if the V/Hz excursion time was just under the trip time.

27 RMS Undervoltage, 3 Phase

The Undervoltage function (27) may be used to detect any condition causing long- or short-term undervoltage. This is a true three-phase function in that each phase has an independent timing element. The ranges and increments are presented in Table 2-4.

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

FUNCTION	SETPOINT RANGE	INCREMENT
RMS Undervoltage (27)		
Pickup #1, #2	5 to 180 V	1 V
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

Table 2-4 RMS Undervoltage, 3-Phase (27) Setpoint Range

```
27 #1 PICKUP
_______ Volts
```

```
27 #1 DELAY
_______ Cycles
```

```
27 #2 PICKUP
_______ Volts
```

```
27 #2 DELAY
_______ Cycles
```

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 (See Figure 2-7). When used in conjunction with the fundamental neutral overvoltage (60/50Hz) function (59N), 100% stator ground-fault protection can be provided. This is illustrated in Figure 2-7.

The 27TN function supervision can be configured by the user to be either independent positive-sequence undervoltage element or forward power flow element, or both. Supervision can prevent tripping when the generator field is not energized or the unit is not yet synchronized.

The 27TN setting depends on the actual third-harmonic neutral voltage level seen during normal operation of the generator. The setting should be about 50% of the minimum third-harmonic voltage observed during various loading conditions. This can be most conveniently measured during commissioning of the relay. Since the relay measures the 3rd harmonic voltage levels and will display those values directly, no additional equipment is required. The undervoltage inhibit setting should be about 80% to 90% of the nominal voltage. The ranges and increments are presented in Table 2-5.

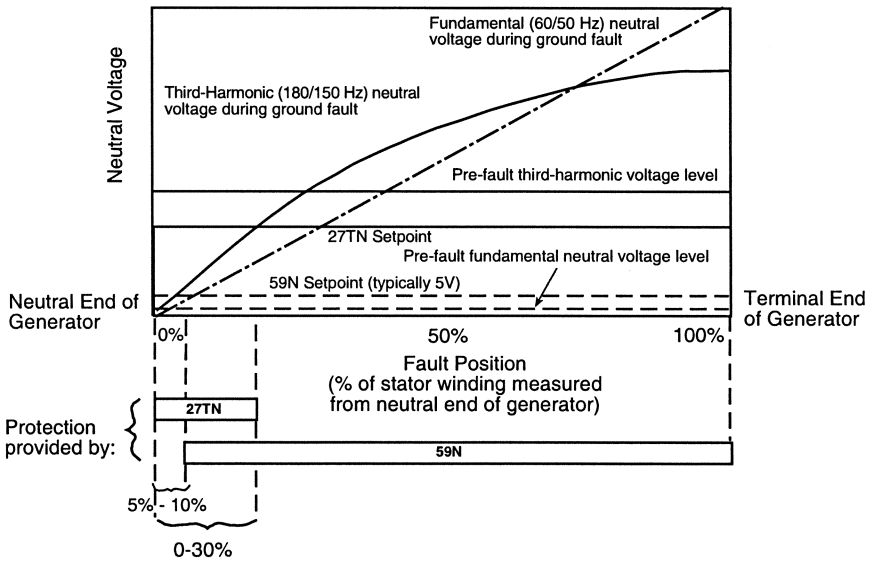


Figure 2-7 Third Harmonic Undervoltage (27TN) Protection Characteristics

FUNCTION	SETPOINT RANGE	INCREMENT
Third-Harmonic Undervoltage, Neutral Circuit (27TN)		
Pickup #1, #2	0.3 to 20.0 V	0.1 V
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle
Undervoltage Inhibit #1, #2 (positive sequence)	5 to 180 V	1 V
Underpower Inhibit #1, #2	0.002 to 3.000 pu	0.001 pu

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

```
27TN #1 PICKUP
_______ Volts
```

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

```
27TN #1  DELAY
_______ Cycles
```

```
27TN #1 VOLT INHIBIT
_______ Volts
```

An inhibit voltage setting is required if 27TN #1 is enabled. Generally set equal to 80–90% of nominal voltage.

```
27TN #1 POWER INHIBIT
disable  enable
```

In some generation applications, it is desirable to supervise the operation of the 27TN with power flow from the generator. In those applications, enable the 27TN Under Power Inhibit and set at the desired per unit power level.

```
27TN #1 POWER INHIBIT
_______ PU
```

The per unit value is based on the Nominal Current and Nominal Voltage values input to the relay and may be set from 0.002 to 3.000 PU.

```
27TN #2 PICKUP
_______ Volts
```

```
27TN #2  DELAY
_______ Cycles
```

```
27TN #2 VOLT INHIBIT
_______ Volts
```

```
27TN #2 POWER INHIBIT
disable ENABLE
```

```
27TN #2 POWER INHIBIT
_______ PU
```

32 Directional Power, 3-Phase

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

When the Low Forward Power setting is disabled, the relay will trip in the forward direction (positive programmed Pickup setting). This configuration can be used for overload protection, providing either alarm or tripping. Again, when the Low Forward Power setting is disabled, the relay will trip in the reverse direction (negative programmed Pickup setting), when the measured real power is less than (more negative) or equal to the Pickup setting. This configuration can be used for sequential tripping when power is below the setting. The ranges and increments are presented in Table 2-6.

When tripping is desired for reverse power flow or very small forward power values, the Low Forward Power setting can be enabled. In this case, tripping occurs when the power is in the reverse direction or below the pickup value in the forward direction (see Figure 2-8 for settings in the positive direction, and Figure 2-9 for settings in the negative direction). When the Low Forward Power feature is used, it may be necessary to block the 32 function during startup in order to avoid nuisance trips.

FUNCTION	SETPOINT RANGES	INCREMENT
Directional Power (32)		
Pickup #1, #2	-3.000 to +3.000 PU	0.001 PU
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

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

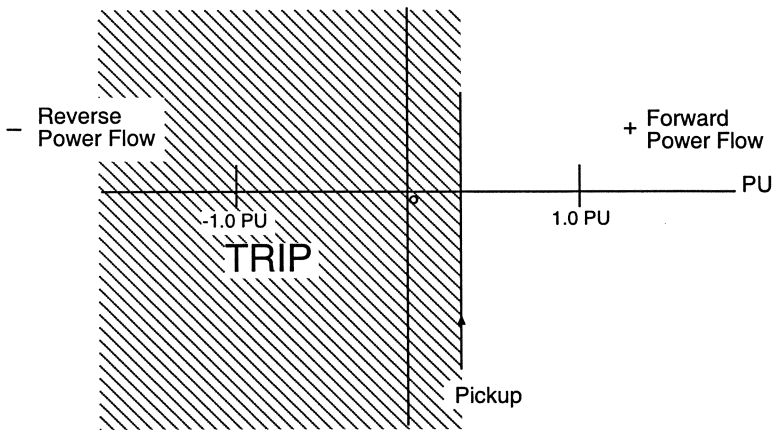


Figure 2-8 Tripping on Low Forward Power in Positive Direction (Toward System)

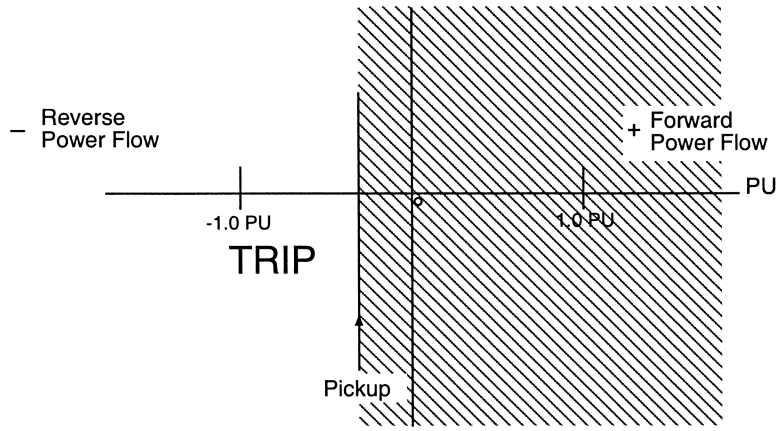


Figure 2-9 Tripping on Low Forward Power in Negative Direction (Toward Generator)

```
32 #1 PICKUP
_____ PU
```

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

```
32 #1 DELAY
_____ Cycles
```

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

```
32#1 LOW FORWARD POWER
disable enable
```

When Low Forward Power is enabled, regardless of the direction of power, the relay will trip when the real power measurement is *less than or equal to* the pickup setpoint.

```
32 #2 PICKUP
_____ PU
```

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

```
32 #2 DELAY
_____ Cycles
```

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

```
32#2 LOW FORWARD POWER
disable enable
```

40 Loss of Field

The Loss-of-Field function (40) provides protection for a partial or complete loss of field. A variety of possible settings make the M-3425 Generator Protection Relay very flexible when applied to loss-of-field generation. Ranges and increments are presented in Table 2-7.

The loss-of-field function is implemented with two offset mho elements, an undervoltage element, and a directional element. The setting for each mho element, diameter, offset, and time delay, are adjusted individually. Voltage control may be enabled on each element but the voltage level setting is common. When voltage control is enabled, the measured positive sequence voltage must be less than the voltage control setting for the loss-of-field function to operate. The common directional unit is provided to block the relay operation during slightly underexcited conditions (since approach #1 with negative offset is inherently directional, the directional element is not required). The directional unit's zero sensitivity (torque) line is placed at –13° from the R axis.

The settings of the offset mho elements should be such that the relay detects the loss-of-field condition for any loading while not mis-operating during power swings and fault conditions. Two approaches are widely used in the industry, both of which are supported by the M-3425 relay. Both approaches require knowledge of the reactances and other parameters of the generator. They are described in Figure 2-10, Loss of Field (40) — Protective Approach I and Figure 2-11, Loss of Field (40) — Protective Approach II.

Impedance calculations for various VT connections are shown in Table 2-2. All impedance settings are secondary relay quantities and can be derived from the following formula:

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

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

FUNCTION	SETPOINT RANGE	INCREMENT
Loss of Field (40)		
Circle Diameter #1, #2	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω
Offset #1, #2	–50.0 to 50.0 Ω (–250.0 to 250.0 Ω)	0.1 Ω
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle
Voltage Control (positive sequence)	5 to 180 V	1 V
Directional Element	Fixed at –13°	–

Table 2-7 Loss-of-Field (40) Setpoint Ranges

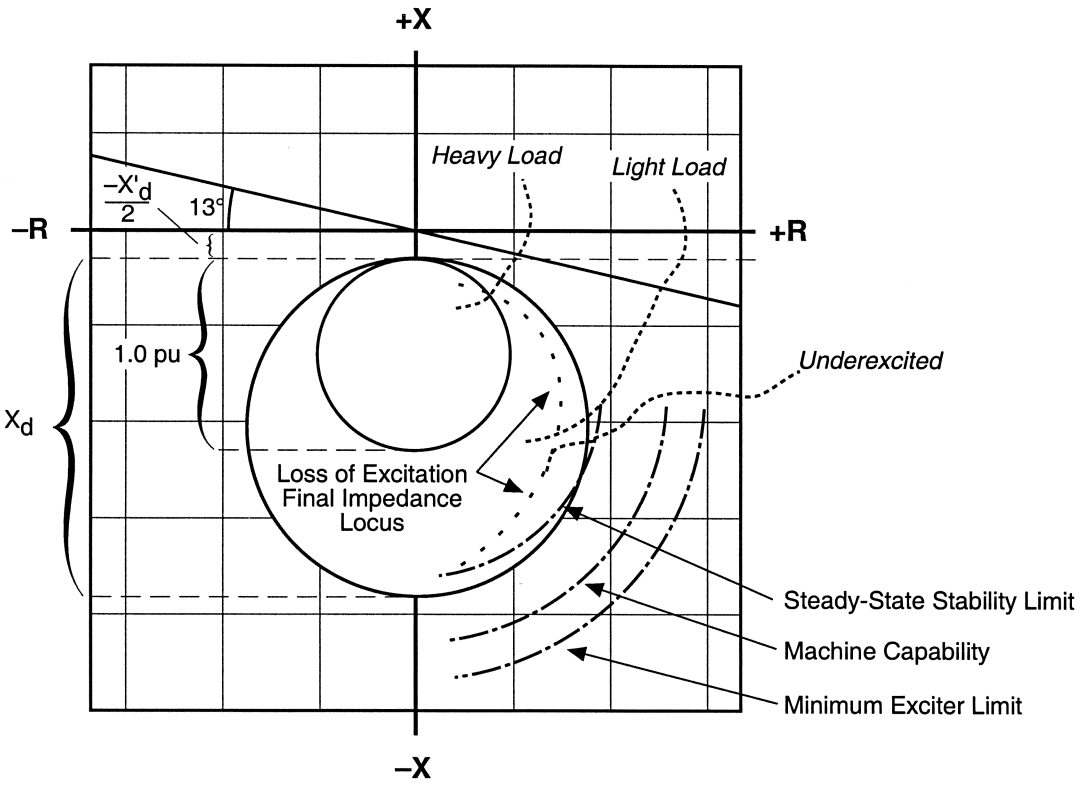


Figure 2-10 Loss of Field (40)—Protective Approach 1

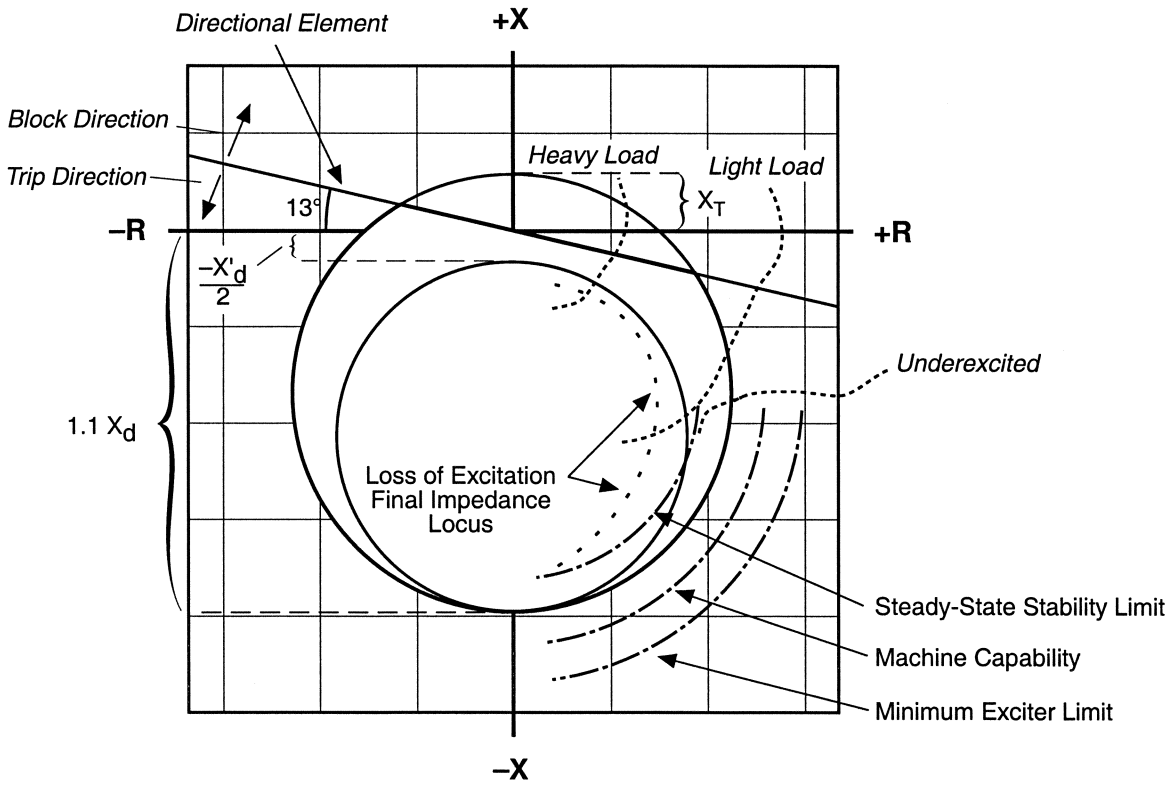


Figure 2-11 Loss of Field (40)—Protective Approach 2

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

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

```
40 #1 VOLTAGE CONTROL
disable  enable
```

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

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

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

```
40 #2 VOLTAGE CONTROL
disable     enable
```

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

```
40 VOLTAGE CONTROL
_________ Volts
```

The first approach is shown in Figure 2-10, Loss of Field (40) — Protective Approach I. Here, both of the offset mho elements (#1 and #2) are set with an offset of $-X'_d \div 2$, where X'_d is the direct axis transient reactance of the generator. The diameter of the smaller circle (#1) is set at 1.0 pu impedance on the machine base. This mho element detects loss-of-field from full load to about 30% load. A small time delay provides fast protection.

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

The second approach is shown in Figure 2-11, Loss of Field (40) – Protective Approach II. In this approach, one of the mho elements is set with an offset of $-X'_d \div 2$, a diameter of $1.1\ X_d - (X'_d \div 2)$, and a time delay of 10 to 30 cycles. The second element is set to coordinate with the generator minimum excitation limit and steady-state stability limit.

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

Although the voltage control is common to both zones, either one can be enabled or disabled and is typically set at 80% to 90% of the nominal voltage. 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.

46 Negative Sequence Overcurrent

The Negative Sequence Overcurrent function provides protection against possible rotor overheating and damage due to unbalanced faults or other system conditions which can cause unbalanced three phase currents in the generator. Ranges and increments are presented in Table 2-8.

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

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

Operating times are lower than that is shown in Figure 2-12 when measured current values are greater than 15 A (3 A for 1 A rated circuit).

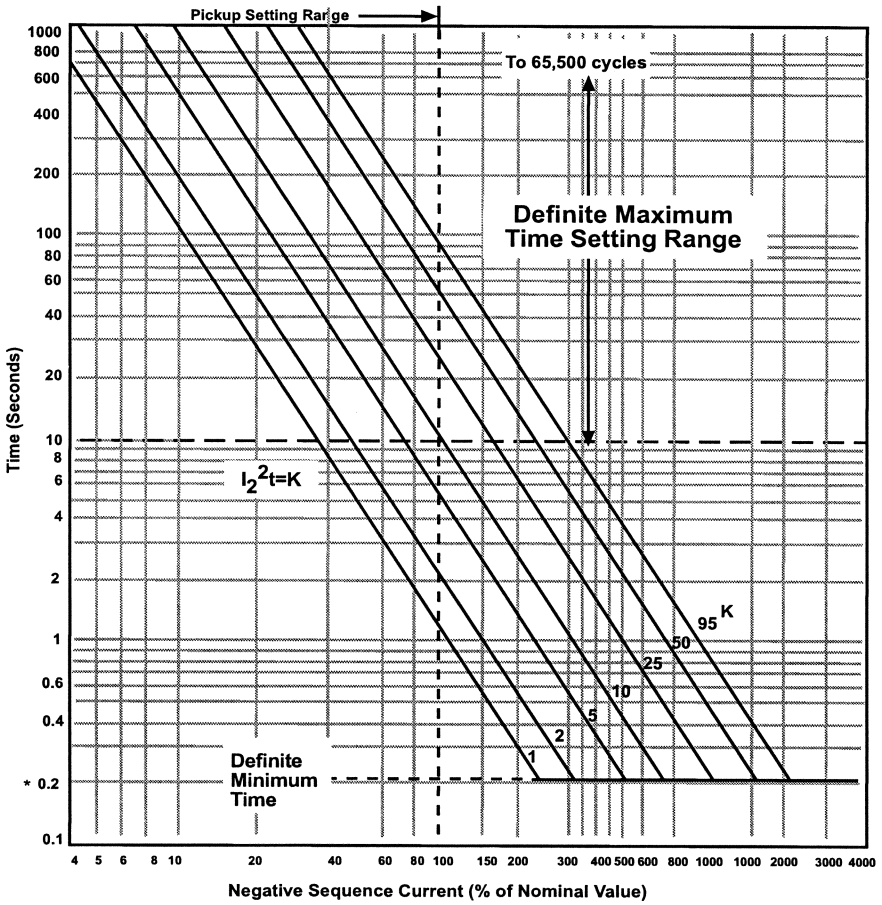
The first task of setting this function is to determine the capabilities of the associated machine. As established by ANSI standards, the machine limits are expressed as $(I_2)^2t = K$. The value of K is established by the machine design and is generally provided on test sheets of the machine. The relay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

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

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

FUNCTION	SETPOINT RANGE	INCREMENT
Negative Sequence Overcurrent (46)		
Definite Time		
Pickup	3 to 100%	1%
Time Delay	1 to 8160 Cycles	1 Cycle
Inverse Time		
Pickup	3 to 100%	1%
Time Dial Setting ($K=I_2^2t$)	1 to 95	1
Definite Maximum		
Time to Trip	600 to 65,500 Cycles	1 Cycle
Definite Minimum Time	12 Cycles	Fixed
Reset Time (linear)	4 minutes (from threshold of trip)	–

Table 2-8 Negative Sequence Overcurrent (46) Setpoint Ranges



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

* 0.24 seconds for 50 Hz units.

Figure 2-12 Negative Sequence Overcurrent Inverse Time Curves

```
46DT PICKUP
_________ %
```

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

```
46DT DELAY
_________ Cycles
```

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

```
46IT PICKUP
_________ %
```

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

```
46IT TIME DIAL
_________
```

The time dial setting corresponds to the K provided by the generator manufacturer for the specific unit being protected. See Figure 2-12 for the negative sequence overcurrent inverse time curves.

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

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

50/50N Instantaneous Overcurrent, Phase and Neutral Circuits

The Instantaneous Phase (50) and Instantaneous Neutral (50N) overcurrent functions provide fast tripping for high fault currents. The settings of both functions must be set such that they will not pickup for fault or conditions outside the immediate protective zone. If the neutral current input is connected to step-up transformer's neutral CT, the 50N function can be used as a breaker flashover protection when used in conjunction with external breaker failure protection. Ranges and Increments are presented in Table 2-9.

FUNCTION	SETPOINT RANGE	INCREMENT
Instantaneous Overcurrent (50)		
Pickup	0.1 to 240.0 A (0.1 to 48.0 A)	0.1 A
Trip Time Response	< 2 Cycles	–
Instantaneous Overcurrent, Neutral (50N)		
Pickup	0.1 to 240.0 A (0.1 to 48.0 A)	0.1 A
Trip Time Response	< 2 Cycles	—

Table 2-9 Instantaneous Overcurrent (50/50N) Setpoint Ranges

```
50 PICKUP
_________ Amps
```

```
50N PICKUP
_________ Amps
```

The relay current (I_R) is equal to the primary current (I_p) divided by the appropriate CT ratio.

50BF Generator Breaker Failure/HV Breaker Flashover

The 50BF function is applicable when a generator breaker is present and line side generator CTs are being used. The 50BF-Ph phase detector element (if enabled) is used for breaker failure and the 50BF-N (if enabled) provides breaker flashover protection by providing an additional breaker failure initiate which is only active when the breaker is open. For high impedance grounded applications, the 50BF-N function is inapplicable and must be disabled. Ranges and increments are presented in Table 2-10, Breaker Failure (50BF) Setpoint Ranges.

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

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

Implementation of the generator breaker failure function is illustrated in Figure 2-13. The breaker failure timer will be started whenever any one of the designated output contacts or the external programmed breaker failure initiate status input are operated. The timer continues to time if any one of the phase currents are above the 50BF-Ph pickup setting or if the 52b contact indicates the breaker is still closed; otherwise, the timer is reset.

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

50BF-Neutral Element: This instantaneous overcurrent relay is energized from the generator neutral CT (See Figure 2-1, One-Line Functional Diagram). This function is internally in series with a breaker "b" contact (IN1) to provide logic for the breaker flashover protection (see Figure 2-13).

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

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

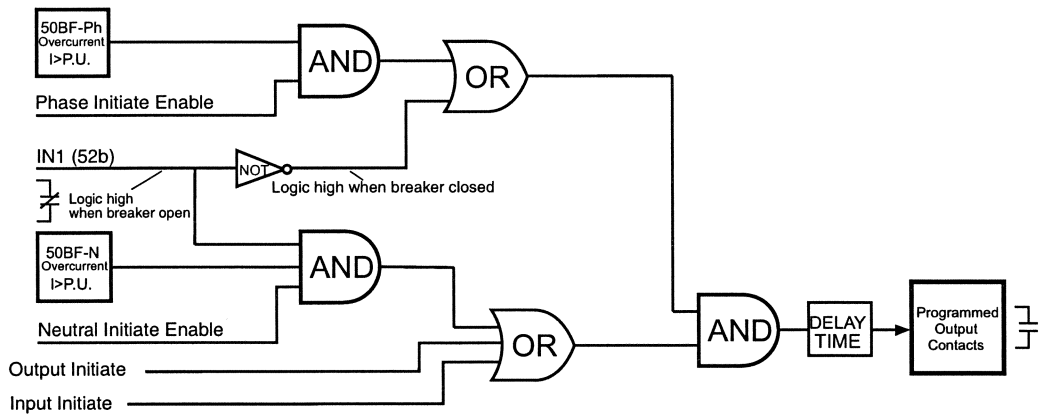


Figure 2-12 Breaker Failure Logic Diagram

FUNCTION	SETPOINT RANGE	INCREMENT
Breaker Failure (50BF)		
Pickup		
Phase Current (50 BF-Ph)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A
Neutral Current (50 BF-N)	0.10 to 10.00 A (0.02 to 2.00 A)	0.01 A
Time Delay	1 to 8160 Cycles	1 Cycle

Table 2-10 Breaker Failure (50BF) Setpoint Ranges

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

If the breaker flashover protection is to be used with the generator breaker failure function of the relay, set **ENABLE**, set the neutral pickup amps, and enable and set the phase element.

```
50BF PICKUP NEUTRAL
 _______ Amps
```

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

If generator breaker failure function is used in this application, **ENABLE** here and set phase pickup amps.

```
50BF PICKUP PHASE
 _______ Amps
```

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

Designate the status inputs which will initiate the breaker failure timer.

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

Designate the outputs that will initiate the breaker failure timer.

```
50BF DELAY
 _______ Cycles
```

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

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

This function can be applied in two different configurations based on the CT connections. When CT configuration shown in Figure 2-1, One Line Functional Diagram is used, the 50DT function is used as a definite time phase overcurrent function to provide protection for external and internal faults in the generator. When the CTs are connected to measure the split phase differential current (shown in Figure 2-2, Alternative One Line Functional Diagram), the 50DT function can be used as a split-phase differential relay.

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

In some cases, the generators may be run with a faulted turn shorted until the generator winding is repaired. To prevent mis-operation under these conditions, the pickup setting of the faulted phase should be set higher than the other phases. To accommodate this function, individual pickup settings are available for each phase. Ranges and increments are presented in Table 2-11.

FUNCTION	SETPOINT RANGE	INCREMENT
Definite Time Overcurrent (for split-phase differential) (50DT)		
Pickup Phase A #1, #2	0.2 A to 240.0 A (0.2 to 48.0 A)	0.1
Pickup Phase B #1, #2	0.2 A to 240.0 A (0.2 to 48.0 A)	0.1
Pickup Phase C #1, #2	0.2 A to 240.0 A (0.2 to 48.0 A)	0.1
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle
When 50DT function is used for split-phase differential, 50BF, 87, and 87GD functions must be disabled.		

Table 2-11 Definite Time Overcurrent (50DT) Setpoint Ranges

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

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

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

```
50DT #1 DELAY
_______ Cycles
```

51N Inverse Time Neutral Overcurrent

The Inverse Time Neutral Overcurrent function (51N) provides protection against ground faults. Since no zero sequence or ground current is usually present during normal operation, this function can be set for greater sensitivity than the phase overcurrent protection. If the 51N and 50N functions are not used at the generator neutral, they can be used to detect system ground faults by being energized by the step-up transformer neutral CTs. Ranges and increments are presented in Table 2-12.

FUNCTION	SETPOINT RANGE	INCREMENT
Inverse Time Neutral Overcurrent (51N)		
Pickup	0.25 to 12.00 A (0.05 to 2.40 A)	0.01A
Characteristic Curve	Definite Time/Inverse/Very Inverse /Extremely Inverse/IEC Curves	
Tap Setting	0.5 to 12.00 A (0.10 to 2.40 A)	0.01 A
Time Dial Setting	0.5 to 11.0 0.05 to 1.10 (IEC Curves)	0.1 0.01

Table 2-12 Inverse Time Neutral Overcurrent (51N) Setpoint Range

```
51N PICKUP
 _______ Amps
```

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

```
51N CURVE
def  inv  vinv  einv →
←ieci iecvi iecei ieclt
```

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

```
51N TIME DIAL
 _______
```

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

51T Inverse Time Positive Sequence Overcurrent ($I^2t=K$) for Stator Thermal Protection

The 51T function is designed to provide overload protection. The function has a pickup setting and an operating time at a current value of six (6) times pickup as shown on Figure 2-14, Inverse Time Curve — 51T. The inverse time curve is $I^2t=K$, where I is the positive sequence current. This curve is applicable for coordination with the generator overheating characteristics. In order to handle recurring overload conditions, the function is provided with linear reset rate of 4 minutes from its 100% trip level. Ranges and increments are presented in Table 2-13.

FUNCTION	SETPOINT RANGE	INCREMENT
Inverse Time Positive Sequence Overcurrent for Stator Thermal Protection (51T)		
Pickup	0.50 to 15.00 A (0.10 to 3.00 A)	0.01 A
Time Delay*	0.10 to 10.00 Sec	1 Cycle
Reset Characteristics (Linear)	4 minutes from threshold of trip	-
**This time delay is at six times the pickup current.*		

Table 2-13 Inverse Time Positive Sequence Overcurrent (51T) Setpoint Ranges

```
51T PICKUP
_____ Amps
```

```
51T DELAY @600% PICKUP
_____ Sec
```

This setting is the operating time of the function at six (6) times pickup value. This is illustrated in Figure 2-14, Inverse Time Curve 51T on the following page, where the operating time for all other current values may be derived for coordination with other protections.

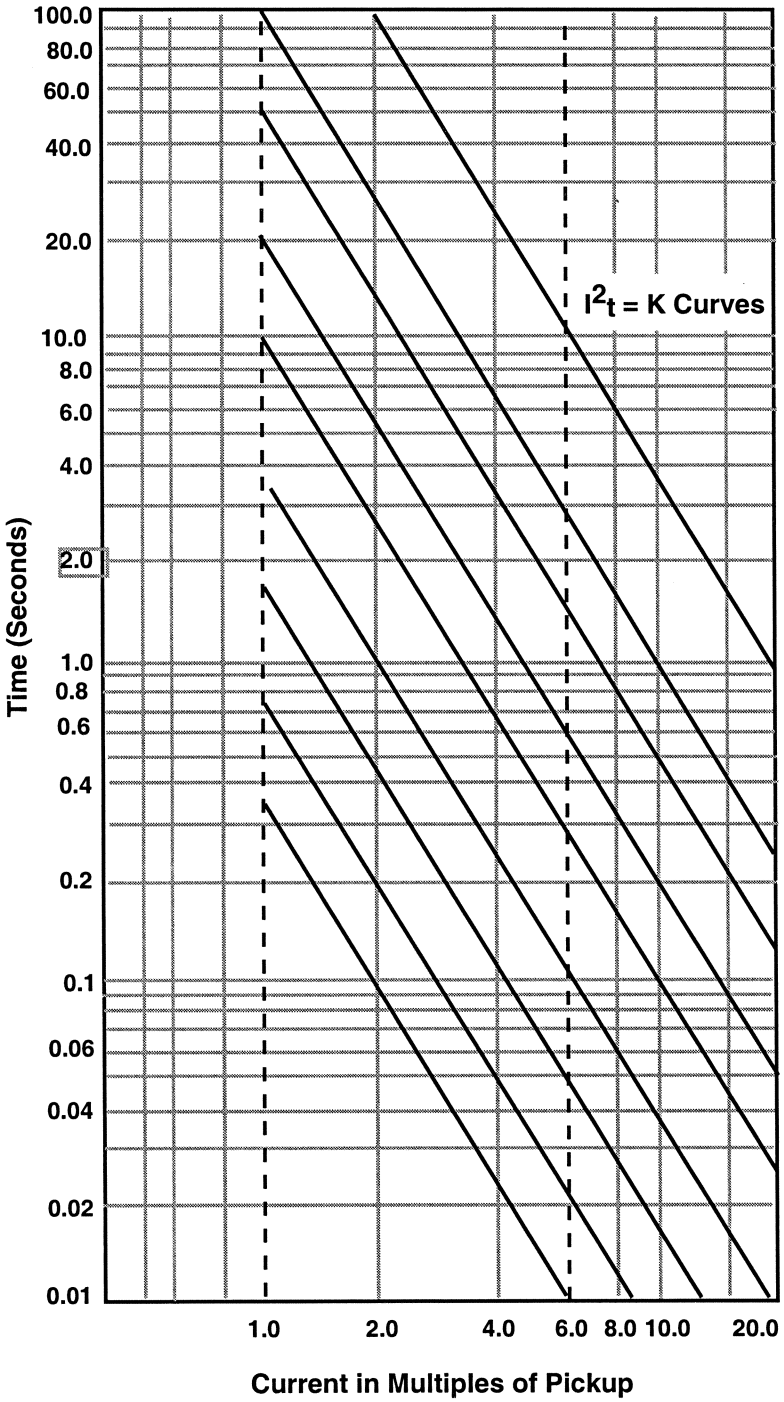


Figure 2-13 Inverse Time Curve – 51T

51V Inverse Time Phase Overcurrent with Voltage Control/Restraint

Time-overcurrent relays, one per phase, are used to trip circuits selectively and to time-coordinate with other up- or downstream relays. For this function, eight complete series of inverse time tripping characteristics are included. The same descriptions and nomenclature which are traditionally used with electromechanical relays are used in the relay. Thus, the curve families to be chosen are definite time, inverse, very inverse, extremely inverse and four IEC curves. In the menu, these are abbreviated as DEF, INV, VINV, EINV, IECI, IECVI, IECEI, and IECLT. Within each family, the operator selects time dial setting and pickup (tap) setting, just as with electromechanical relays. Ranges and increments are presented in Table 2-14.

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

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

The inverse time overcurrent function can be voltage controlled (VC), voltage restrained (VR), or neither. For voltage-controlled operation, the function is not active unless the voltage is below the voltage control setpoint. This philosophy is used to confirm that the overcurrent is due to system fault. When applied, most users will set voltage control limits in the range of 0.7 to 0.01 per unit RMS voltage. When voltage restraint is selected (See Figure 2-15, Voltage Restraint (51VR) Characteristic), the pickup setting is continuously modified in proportion to the collapsing terminal voltage. The voltage restraint function is well-suited to small generators with relatively short time constants.

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

The internally derived voltage used to realize the voltage control or restraint feature depends on the configured VT configuration and the Delta-Y Transform setting (see Section 2.1, Configuration, Relay System Setup). Table 2-15, Delta/Wye Transformer Voltage-Current Pairs describes the calculation for the various system VT configurations.

FUNCTION	SETPOINT RANGE	INCREMENT
Inverse Time Overcurrent, with Voltage Control or Voltage Restraint (51V)		
Pickup	0.50 to 12.00 A (0.10 to 2.40 A)	0.01 A
Characteristic Curve	Definite Time/Inverse/Very Inverse /Extremely Inverse/IEC Curves	
Time Dial	0.5 to 11.0 0.05 to 1.10 (IEC Curves)	0.1 0.01
Voltage Control (VC)	5 to 180 V	1 V
or		
Voltage Restraint (VR)	Linear Restraint	—

Table 2-14 Inverse Time Overcurrent with Voltage Control/Voltage Restraint (51VC/VR) Setpoint Ranges

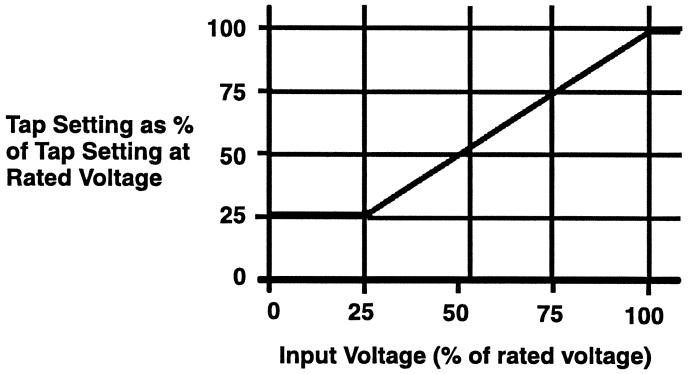


Figure 2-14 Voltage Restraint (51VR) Characteristic

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

Table 2-15 Delta/Wye Transformer Voltage-Current Pairs

```
51V PICKUP
_______ Amps
```

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

```
51V CURVE
def _ inv _ vinv _ einv→ _
←ieci iecvi iecei ieclt
```

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

```
51V TIME DIAL
_______
```

```
51V VOLTAGE CONTROL
disable v_cntl v_rstrnt
```

Disable if neither voltage control nor voltage restraint is desired. If voltage restraint is designated, the tap setting is modified as shown in Figure 2-15. If voltage control is designated, the 51V will only operate when the voltage is less than the 51V voltage control setting specified below. When applied, the voltage control is usually set in the range of 70% to 90% of the nominal voltage.

```
51V VOLTAGE CONTROL
_______ Volts
```

50/27 Inadvertent Energizing

The inadvertent energizing protection function (50/27) of the relay is an overcurrent function supervised by generator terminal bus voltage. Inadvertent or accidental energizing of off-line generators has occurred frequently enough to warrant the use of dedicated protection logic to detect this condition. Operating errors, breaker flashovers, control circuit malfunctions or a combination of these causes have resulted in generators being accidentally energized while off-line. The problem is particularly prevalent on large generators connected through a high voltage disconnect switch to either a ring bus or breaker-and-a-half bus configuration. When a generator is accidentally energized from the power system, it will accelerate like an induction motor. While the machine is accelerating, high currents induced into the rotor can cause significant damage in a matter of seconds. Voltage supervised overcurrent logic is designed to provide this protection. (See Figure 2-16, Inadvertent Energizing Function Logic Diagram)

An undervoltage element (all three phase voltages must be below pickup) with adjustable pickup and dropout time delay supervises instantaneous overcurrent tripping. The undervoltage detectors automatically arm the overcurrent tripping when the generator is taken off-line. This undervoltage detector will disable or disarm the overcurrent operation when the machine is put back in service. Ranges and increments are presented in Table 2-16.

FUNCTION	SETPOINT RANGE	INCREMENT
Inadvertent Energizing (50/27)		
Overcurrent (50)		
Pickup	0.50 to 15.00 A (0.10 to 3.00 A)	0.01 A
Undervoltage(27)		
Pickup	40 to 130 V	1 V
Pickup Time Delay	1 to 8160 Cycles	1 Cycle
Drop-out Time Delay	1 to 8160 Cycles	1 Cycle

Table 2-16 Inadvertent Energizing (50/27) Setpoint Ranges

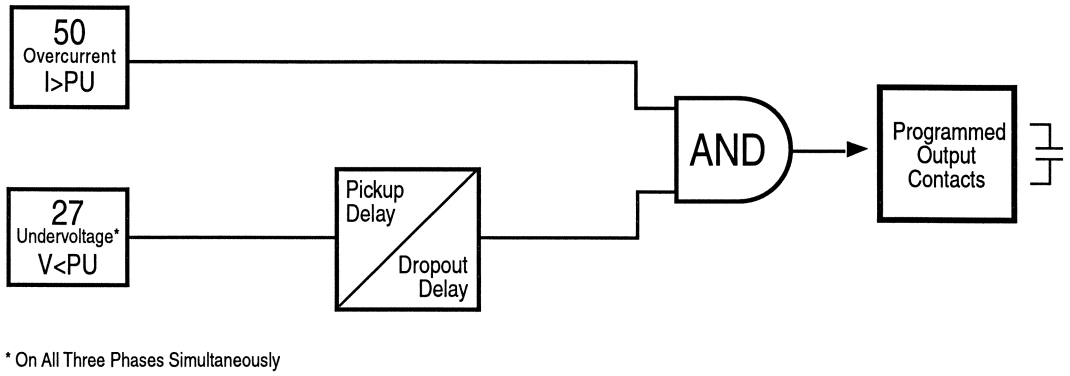


Figure 2-15 Inadvertent Energizing Function Logic Diagram

50/27 PICKUP
_____ Amps

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

50/27 VOLTAGE CONTROL
_____ Volts

The purpose of the undervoltage detector is to determine whether the unit is connected to the system. The voltage level during this accidental energization depends on the system strength. Typical setting is 50%–70% of rated voltage.

50/27 PICKUP DELAY
_____ Cycles

The pickup time delay is the time for the unit to operate to *arm* the protection. It must coordinate with other protection for conditions which cause low voltages.

50/27 DROPOUT DELAY
_____ Cycles

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

59 RMS Overvoltage, 3-Phase

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

Magnitude measurement depends on the 59/27 Magnitude Select setting (See Section 2.1, Configuration, Relay System Setup). When the RMS option is selected, the magnitude calculation is accurate over a wide frequency range (10 to 80 Hz) and the accuracy of the time delay is +20 cycles. If DFT option is selected, the magnitude calculation is accurate near 50 or 60 Hz, and the timer accuracy is ± 1 cycle. Ranges and increments are presented in Table 2-17.

FUNCTION	SETPOINT RANGE	INCREMENT
RMS Overvoltage (59)		
Pickup #1, #2	5 to 180 V	1 V
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

Table 2-17 RMS Overvoltage, 3-Phase (59) Setpoint Ranges

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

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

```
59 #2 PICKUP
_______ Volts
```

```
59 #2 DELAY
_______ Cycles
```

Generator capability is generally 105% of rated voltage.

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 90–95% of the stator winding (measured from the terminal end).

The 59N function provides two setpoints, and responds only to the fundamental frequency component, rejecting all other harmonic components. Ranges and increments are presented in Table 2-18.

FUNCTION	SETPOINT RANGE	INCREMENT
RMS Overvoltage, Neutral (59N)		
Pickup #1, #2	5.0 to 180.0 V	0.1 V
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

Table 2-18 RMS Overvoltage, Neutral Circuit or Zero Sequence (59N) Setpoint Ranges

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

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

```
59N #2 PICKUP
_______ Volts
```

```
59N #2 DELAY
_______ Cycles
```

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

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

Since system ground faults can induce zero sequence voltages at the generator due to transformer capacitance coupling, this relay must coordinate with the system ground fault relaying.

60FL Fuse Loss

Since some functions may inadvertently operate when a VT fuse is blown, provisions are incorporated for both internal and external fuse loss detection.

For internal detection of a fuse-loss condition, positive and negative sequence quantities are compared. The presence of negative sequence voltage in the absence of negative sequence current is considered to be a fuse loss condition. An additional supervising condition includes a minimum positive sequence voltage to assure VT inputs are being applied to the relay.

For the specific application where the above logic cannot be considered reliable (such as when current inputs to the relay are not connected, sustained positive sequence current during fault conditions is minimal, or negative sequence currents are not present during fault conditions), provision is made for ignoring the fuse-loss internal logic by not highlighting "FL" from among the 60FL Input Initiate Inputs. Other functions in the relay may be programmed to be blocked by the fuse-loss detection logic. Again, in cases where the internal logic is not considered to be reliable, the FL blocking selection should not be chosen.

The 60FL function can also be initiated via the external status inputs, thus accommodating other fuse loss detection schemes. Any combination ("OR" logic) of status input (IN1 through IN6) may be used to initiate operation.

A timer associated with the fuse loss logic is available. This timer is to assure proper coordination for conditions which may appear as a fuse loss, such as secondary VT circuit faults which will be cleared by local low voltage circuit action. Ranges and increments are presented in Table 2-19.

FUNCTION	SETPOINT RANGE	INCREMENT
VT Fuse–Loss Detection (60FL)		
Time Delay	1 to 8160 Cycles	1 Cycle

Table 2-19 Fuse Loss (60FL) Setpoint Ranges

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

The initiating inputs are user-designated. The closing of any of the externally-connected contacts (across these inputs) will start the associated time delay to the 60FL function operation. Designating FL will initiate this function with the internal logic. Externally initiated fuse loss detection may be input to other status inputs.

```
60FL DELAY
_____ Cycles
```

The time delay is set to coordinate for conditions which may appear as a fuse loss but will be corrected by other protection (such as a secondary VT circuit fault which will be cleared by local low voltage circuit action).

64B Brush Lift-Off Detection

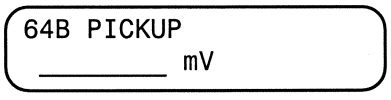
The Brush Lift-Off Detection (64B) provides detection of open brushes of the rotor shaft. This function works in conjunction with the 64F Field Ground Detection function, and requires the M-3921 Field Ground Coupler. To improve accuracy and minimize the effects of stray capacitance, the M-3921 Field Ground Coupler should be mounted close to the exciter. Connections from the coupler to the relay should use low capacitance shielded cable, and be as short as possible. Cable shield should be terminated at the relay end to terminal 36 (See Figure 5-5, External Connections). If cabling between the coupler and relay exceeds 100 feet, provisions are made for in circuit calibration to nullify the effects of cabling capacitance. See Section 6.3, Auto Calibration, for calibration procedure.

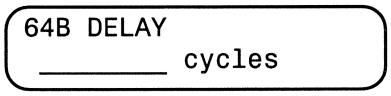
When 64B operates, indicating open brush conditions, the 64F function cannot detect field ground. For most generators, when the brushes of the rotor shaft are lifted, the capacitance across the field winding and the ground significantly reduces to less than 0.15 μF. The 64B function analyzes this capacitance-related signal, and initiates an output contact when it detects an open brush condition. Typically, this output is used to alert the operating personnel of an open brush condition. Ranges and increments are presented in Table 2-20. The typical pickup settings for different open brush capacitances are listed in Table 2-21, Typical Brush Lift-Off Settings.

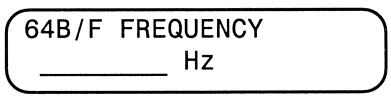
In order to assure correct setting, it is recommended that the actual operating value be predetermined during the final stage of the relay installation. By introducing the brush-open condition, the actual value can be easily obtained from the relay. The following procedure can be used to obtain the actual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

1. After installation has been completed, determine the rotor capacitance, as outlined for the 64F function on page 2-41.
2. With the machine still off-line, apply power to the relay and set the 64B/F operating frequency in accordance with the value listed in Table 2-23, Typical Frequency Settings.
3. Introduce the brush-open condition by disconnecting the rotor brushes or lifting the brushes from their ground. Observe the 64B voltage value displayed by IPScom or the relay. The displayed value is the actual measured operating value of the 64B function.
4. To ensure correct operation and prevent erroneous trips, the Pickup Setting for the 64B Lift-off condition should be set at 80–90% of the actual operating value (or 10–20%).

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







FUNCTION	SETPOINT RANGE	INCREMENT
Brush Lift-Off Detection (64B)		
Pickup	0 to 5000 mV	1 mV
Time Delay	1 to 8160 Cycles	1 Cycle

Table 2-20 Brush Lift-Off Detection (64B) Setpoint Ranges

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

Table 2-21 Typical Brush Lift-Off Settings

64F Field Ground Protection

The Field Ground function provides detection of insulation breakdown between the excitation field winding and the ground. There are two pickup and time delay settings, and one adjustable injection frequency setting for the 64F function. The adjustable frequency is provided to compensate for the amount of capacitance across the field winding and the ground so that the function accuracy is improved. Ranges and increments are presented in Table 2-22.

FUNCTION	SETPOINT RANGE	INCREMENT
Field Ground Protection (64F)		
Pickup #1, #2	5 to 100 KΩ	1 KΩ
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle
Injection Frequency	0.10 to 1.00 Hz	0.01 Hz
Requires external coupler module (M-3921) to provide isolation from dc field voltages.		

Table 2-22 Field Ground Protection (64F) Setpoint Ranges

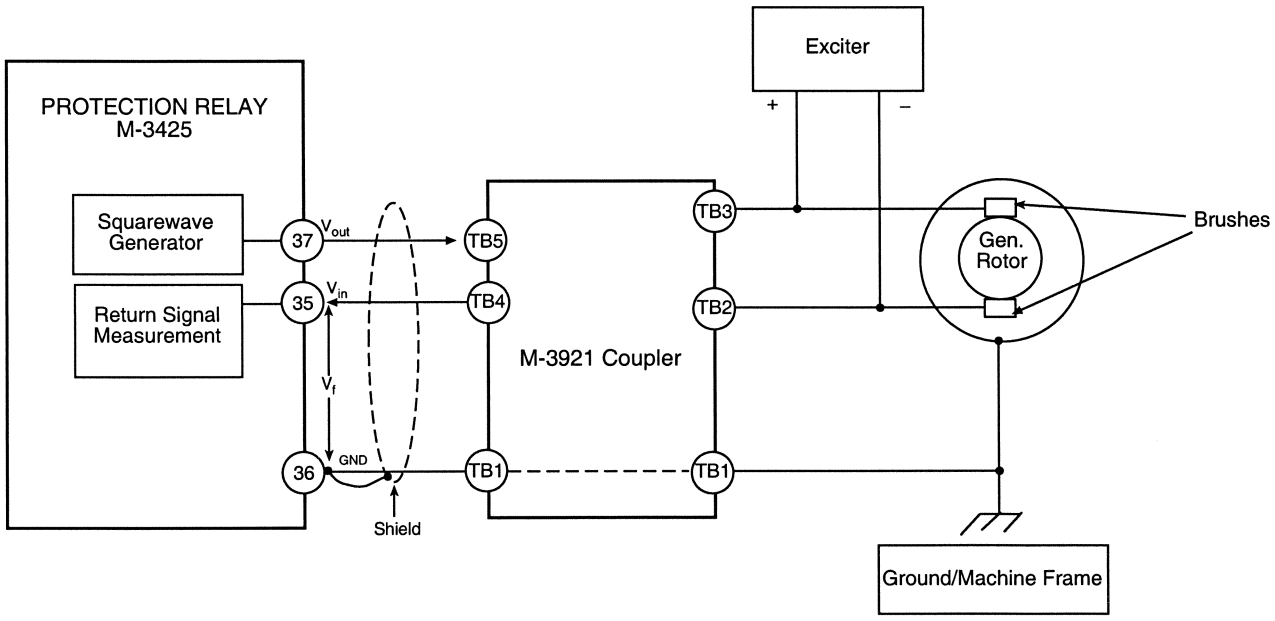


Figure 2-16 M-3921 Field Ground Coupler

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

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

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

Table 2-23 Typical Frequency Settings

64F #1 PICKUP
_____ kOhm

64F #1 DELAY
_____ Cycles

64F #2 PICKUP
_____ kOhm

64F #2 DELAY
_____ Cycles

64B/F FREQUENCY
_____ Hz

To minimize measurement errors, the 64B/F frequency should be set according to the amount of capacitance across the field winding and the ground. Table 2-23, above, has typical settings of the frequency for capacitance, ranging from 1 μF to 10 μF.

78 Out-of-Step

The Out-of-Step function (78) is used to protect the generator from out-of-step or pole slip conditions. This function uses one set of blinders, along with a supervisory MHO element. Ranges and increments are presented in Table 2-24.

The pickup area is restricted to the shaded area in Figure 2-18, Out-of-Step Relay Characteristics, defined by the inner region of the MHO circle, the region to the right of the blinder A and the region to the left of blinder B. For operation of the blinder scheme, the operating point (positive sequence impedance) must originate outside either blinder A or B, and swing through the pickup area for a time greater than or equal to the time delay setting and progress to the opposite blinder from where the swing had originated. When this scenario happens, the tripping circuit is complete. The contact will remain closed for the amount of time set by the seal-in timer delay.

Consider, for example, Figure 2-18. If the out-of-step swing progresses to impedance $Z_0(t_0)$, the MHO element and the blinder A element will both pick up. As the swing proceeds and crosses blinder B at $Z_1(t_1)$, blinder B will pick up. When the swing reaches $Z_2(t_2)$, blinder A will drop out. If TRIP ON MHO EXIT option is disabled and the timer has expired (t_2–t_1>time delay), then the trip circuit is complete. If the TRIP ON MHO EXIT option is enabled and the timer has expired, then for the trip to occur the swing must progress and cross the MHO circle at $Z_3(t_3)$ where the MHO element drops out. Note the timer is active only in the pickup region (shaded area). If the TRIP ON MHO EXIT option is enabled, a more favorable tripping angle is achieved, which reduces the breaker tripping duty. The relay can also be set with a Pole Slip Counter. The relay will operate when the number of pole slips are greater than the setting, provided the Pole Slip Reset Time was not expired. Typically, the Pole Slip Counter is set to 1, in which case the Pole Slip Reset Time is not applicable.

FUNCTION	SETPOINT RANGE	INCREMENT
Out-of-Step (78)		
Circle Diameter	0.1 to 100.0 Ω (0.5 to 500.0 Ω)	0.1 Ω
Offset	–100.0 to 100.0 Ω (–500.0 to 500.0 Ω)	0.1 Ω
Impedance Angle	0° to 90°	1°
Blinder	0.1 to 50.0 Ω (0.5 to 250.0 Ω)	0.1 Ω
Time Delay	1 to 8160 Cycles	1 Cycle
Pole Slip Counter	1 to 20	1
Pole Slip Reset	1 to 8160 Cycles	1 Cycle

Table 2-24 Out-of-Step (78) Setpoint Ranges

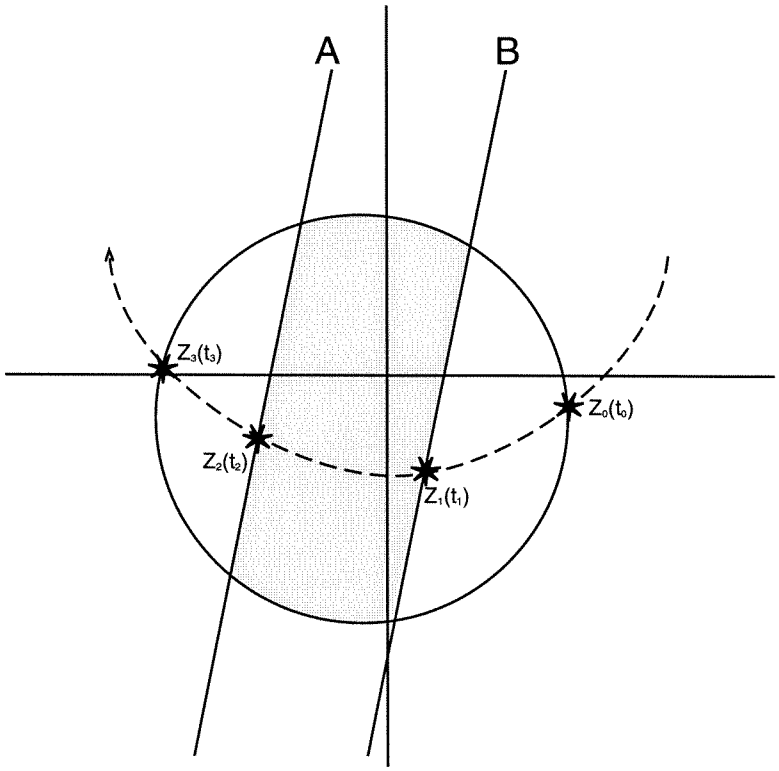


Figure 2-18 Out-of-Step Relay Characteristics

78 DIAMETER
_____ Ohms

78 OFFSET
_____ Ohms

A negative or positive offset can be specified to offset the mho circle from the origin.

78 BLINDER IMPEDANCE
_____ Ohms

The blinder impedance should be programmed less than the set diameter.

78 IMPEDANCE ANGLE
_____ Degrees

78 DELAY
_____ Cycles

78 TRIP ON MHO EXIT
disable enable

78 POLE SLIP COUNT
_____ slips

78 POLE SLIP RESET TIME
_____ Cycles

81 Frequency

The Frequency function (81) provides either overfrequency or underfrequency protection of the generator. It has four independent pickup and time delay settings. The overfrequency mode is automatically selected when the frequency setpoint is programmed higher than the base frequency (50 or 60 Hz), and the underfrequency mode selected when the setpoint is programmed below the base frequency. Ranges and increments are presented in Table 2-25.

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

Sample settings of the 81 function are shown in Figure 2-19. The frequency functions are automatically disabled when the input voltage (positive sequence) is less than about 5 V.

FUNCTION	SETPOINT RANGE	INCREMENT
Frequency (81)		
Pickup #1, #2, #3, #4	50.00 to 67.00 Hz 40.00 to 57.00 Hz*	0.01 Hz
Time Delay #1,#2, #3, #4	2 to 65,500 Cycles	1 Cycle
**This range applies to 50 Hz nominal frequency models.*		

Table 2-25 Frequency (81) Setpoint Ranges

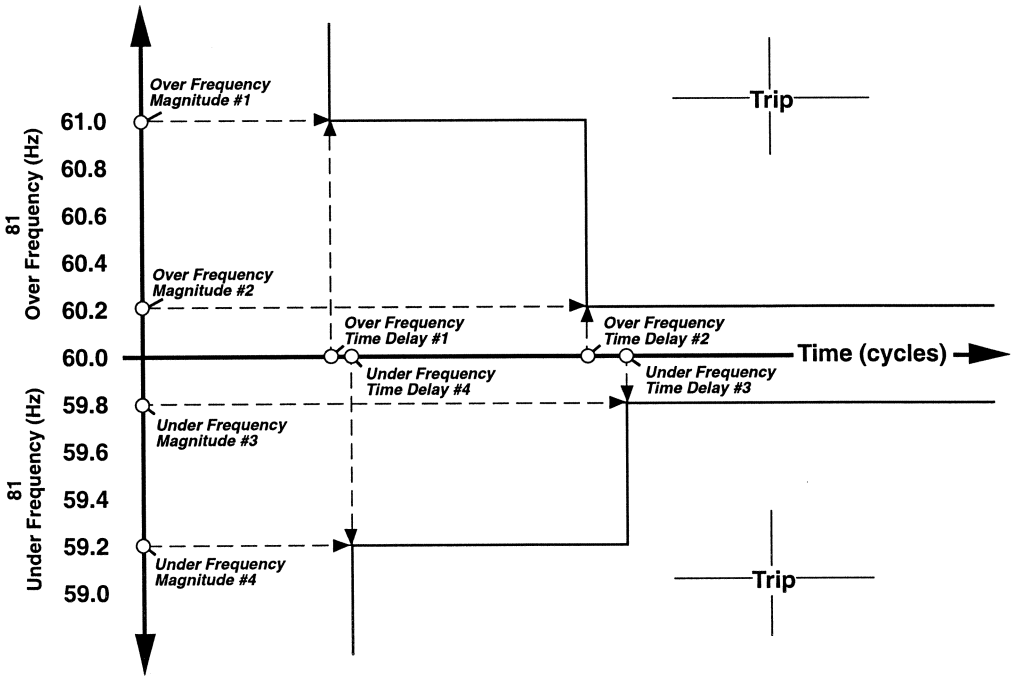


Figure 2-19 Example of Frequency (81) Trip Characteristics

81 #1 PICKUP
_____ Hz

81 #1 DELAY
_____ Cycles

81 #2 PICKUP
_____ Hz

81 #2 DELAY
_____ Cycles

81 #3 PICKUP
_____ Hz

81 #3 DELAY
_____ Cycles

81 #4 PICKUP
_____ Hz

81 #4 DELAY
_____ Cycles

These magnitude and time settings describe a curve (as shown in Figure 2-19, Example of Frequency (81) Trip Characteristics) which is to be coordinated with the capability curves of the turbine and generator as well as the system underfrequency load-shedding program. These capabilities are given by a description of areas of prohibited operation, restricted time operation, and continuous allowable operation.

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

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

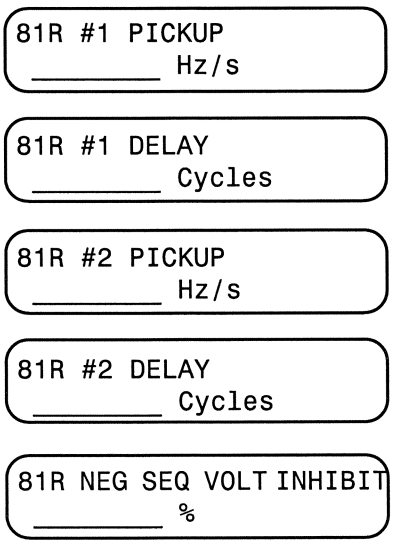
81R Rate of Change of Frequency

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

The function also has an automatic disable feature, to disable 81R function during unbalanced faults and other system disturbances. This feature uses negative sequence voltage to block 81R function. When the measured negative sequence voltage exceeds the inhibit setting, the function 81R is blocked. The time delay and magnitude settings of 81R should be based on simulation studies. The ranges and increments are presented in Table 2-26, below.

FUNCTION	SETPOINT RANGE	INCREMENT
Rate of Change of Frequency (81R)		
Pickup #1, #2	0.10 to 20.00 Hz/Sec	0.01 Hz/Sec
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle
Negative Sequence Voltage Inhibit	0 to 99 %	1%

Table 2-26 Rate of Change of Frequency (81R) Setpoint Ranges



87GD Ground (Zero Sequence) Differential

The Zero Sequence Differential function (87GD) provides ground fault protection for low impedance grounded generator applications. High sensitivity and fast operation can be obtained using this function. Ranges and increments are presented in Table 2-27.

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

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

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

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

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

FUNCTION	SETPOINT RANGE	INCREMENT
Ground Differential (87GD)		
Pickup	0.20 to 10.00 A (0.04 to 2.00 A)	0.01
Time Delay	1 to 8160 Cycles	1 Cycle
CT Ratio Correction (R_C)	0.10 to 7.99	0.01

Table 2-27 Ground Differential (87GD) Setpoint Ranges

```
87GD  PICKUP
_______ Amps
```

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

```
87GD  DELAY
_______ Cycles
```

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

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

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

87 Phase Differential

The phase differential function (87) is a percentage differential with an adjustable slope of 1–100%. Although this protection is used to protect the machine from all internal winding faults, single-phase to ground faults in machines with high impedance grounding may have currents less than the sensitivity of the differential relay (typically between 3 and 30 primary amps). Ranges and increments are presented in Table 2-28.

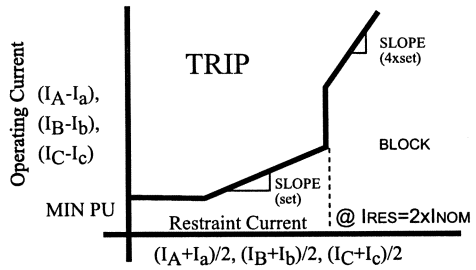
Turn-to-turn faults are not detected by differential relays because the current into the generator equals the current out. Even though the percentage differential relay is more tolerant of CT errors, all CTs should have the same characteristics and accuracies.

To provide restraint for CT saturation at high offset currents, the slope is automatically adjusted (at a restraining current equal to two times nominal current) to four times the slope setting, see Figure 2-19 below.

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

FUNCTION	SETPOINT RANGE	INCREMENT
Phase Differential Current (87)		
Minimum Pickup	0.20 A to 3.00 A (0.04 to 0.60 A)	0.01 A
Percent Slope	1 to 100%	1%
Time Delay	1 to 8160 Cycles	1 Cycle
When a time delay of 1 cycle is selected, the response time is less than 1-1/2 cycles.		

Table 2-28 Differential (87) Setpoint Ranges



Where I_A and I_a are generator high side and neutral side currents respectively.

Figure 2-20 Differential Relay (87) Operating Characteristics

```
87  PICKUP
_________ Amps
```

A typical setting is 0.2 to 0.3 amps.

```
87 SLOPE
_________ %
```

A typical setting is 10%.

```
87 DELAY
_________ Cycles
```

A typical setting is 3 to 5 cycles. Typical settings given above assume matched current transformer performance, and that transformer inrush of the unit transformer does not cause dc saturation of the generator CTs. If there is a significant difference in current transformer ratings (C800 vs C200, for example), or if saturation of the generator CTs is expected during energizing of the step up transformer, more appropriate settings might be 0.5 A pick up, 20% slope, and a delay of 5 to 8 cycles.

External Functions

The M-3425 Generator Protection Relay provides two "external functions" to allow external device contacts to trip through the relay. These functions expand the relay's capability by providing additional operating logic and target information for external devices. The *initiating inputs* are designated to provide external stimulus to start the function. The designated *blocking inputs* and *output contacts,* as specified in Section 2.1, Configuration, can be used to provide additional logic.

FUNCTION	SETPOINT RANGE	INCREMENT
External Functions		
Two functions are provided for externally connected devices to trip through the M-3425 to provide additional logic and target information. Any one or more of the input contacts (INPUT1 through INPUT6) can be programmed to activate designated output contacts after a selected time delay.		
Time Delay #1, #2	1 to 8160 Cycles	1 Cycle

Table 2-29 External Functions Setpoint Range

```
EXT #1 INPUT INITIATE
i6 i5 i4 i3 i2 i1
```

The *initiating inputs* are user-designated for each enabled external function. The operation of any externally connected contact (across these M-3425 inputs) will start the external function timer operation.

```
EXT #1 DELAY
_______ Cycles
```

Each enabled external function requires a time delay setting.

```
EXT #2 INPUT INITIATE
i6 i5 i4 i3 i2 i1
```

For the following example of the setup of an external function (see Figure 2-21, External Function Example), the function is **ENABLED**. The designated initiating contacts as described here are IN2 and IN5. The designated blocking status input is IN3, and the designated output contact for the function is OUT6.

```
EXT #2 DELAY
_______ Cycles
```

A time delay setting is also required. The only logical limitation is that the same status input cannot be both a designated initiating input and a designated blocking input.

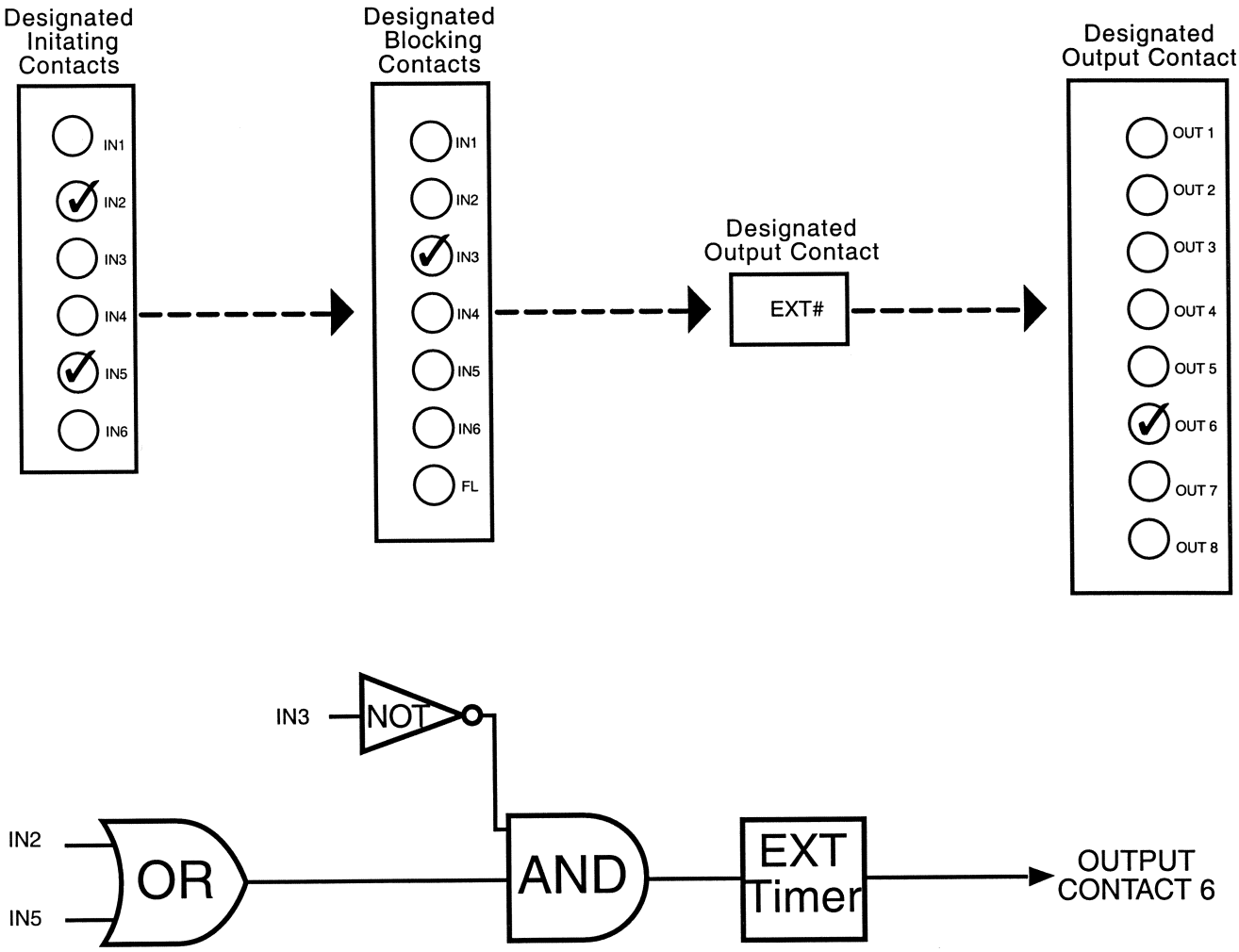


Figure 2-21 External Function Example

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3 Operation

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

3.1 Front Panel Controls

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

Alphanumeric Display

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

Arrow Push-buttons

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

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

EXIT Button

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

ENTER Button

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

Target & Status Indicators and Controls

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

Power Supply #1 (#2) LED

The green **PS** LED indicator will remain lit for the appropriate power supply whenever power is applied to the unit and the power supply is operating correctly. A second power supply is available as an option.

Relay OK LED

The green **RELAY OK** LED is under control of the relay's microprocessor. A flashing **RELAY OK** LED indicates proper program cycling. The LED can also be programmed to be continuously lit.

Oscillograph Recorded LED

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

Breaker Closed LED

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

Target Indicators and Target Reset

Upon any condition which causes the operation of outputs 1 through 8, the **TARGET** LED will light, indicating a relay operation. The **TARGET** LED will remain lit until the condition causing the trip is cleared, and the operator presses the **TARGET RESET** button. For units equipped with the optional M-3925 Target module, additional targeting information is available. The Target module includes an additional 24 target LEDs, and 8 output status LEDs. LEDs corresponding to the particular operated function as well as the present state of the outputs are available. Pressing and holding the **TARGET RESET** button will display the present pickup status for all functions available on the Target module. This is a valuable diagnostic tool which may be used during commissioning and testing.

Time Sync LED

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

Diagnostic LED

The diagnostic **DIAG** LED flashes upon detection of a self-test error. The LED will flash the Error Code number; for example, for Error Code 32, the LED will flash 3 times, followed by a short pause, and then 2 flashes, followed by a long pause, and then repeat. For units equipped with the HMI, the Error Code number is also displayed on the screen.

Accessing Screens

To prevent unauthorized access to relay functions, the unit has the provision for assigning access codes. If access codes have been assigned, the access code entry screen will be displayed after **ENTER** is pressed from the default message screen.

Default Message Screens

When powered up, the relay performs a number of self-tests to ensure its correct operation. During the self-tests, the display shows an "**x**" for each test successfully executed. If all tests are executed successfully, it will briefly display the word PASS and then a series of status screens, including the model number, the software version number, the serial number, the date and time as set in the system clock, and the user logo screen. If any test should fail, an error code will be displayed and the relay will not allow operation to proceed. In such a case, the error code should be noted and the factory contacted. A list of error codes and their descriptions are provided in Appendix C, **Error Codes**.

When the relay is powered and unattended, user logo lines are displayed. The display automatically returns to the logo screens after exiting from the menu and most other screens after five minutes of unattended operation.

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

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

3.2 Initial Setup Procedure/ Settings

The M-3425 Generator Protection Relay is shipped from the factory with all functions disabled (user will only be able to enable purchased functions). The following is a suggested setup procedure for initially entering settings into the relay. While written for HMI-equipped units, the same procedure applies when setting the relay through remote communication. Following the steps outlined below are several sections which give additional detail concerning the settings required for proper commissioning.

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

1. Enter the Setup Unit data. This is general information required including altering access codes, setting date and time, defining user logos, and other adjustments. See Section 3.2, Setup Unit Data subsection.
2. Configure the Setup System data. This is the general system and equipment information required for operation, including such items as CT and VT ratios, VT configuration, and Nominal values. See Section 3.2, Setup System Data subsection.
3. Enable the desired functions and elements. See Section 3.2, Configure Relay Data subsection.
4. Enter the desired setpoints for the enabled functions. See Section 3.2, Setpoints and Time Settings subsection.
5. Enter configuration information for the oscillograph recorder. See Section 3.2, Oscillograph Recorder Data subsection.
6. If remote communication is used, set the parameters as needed. See Section 3.2, Communications Data subsection, or in Chapter 4, **Remote Operation**.

Setup Unit Data

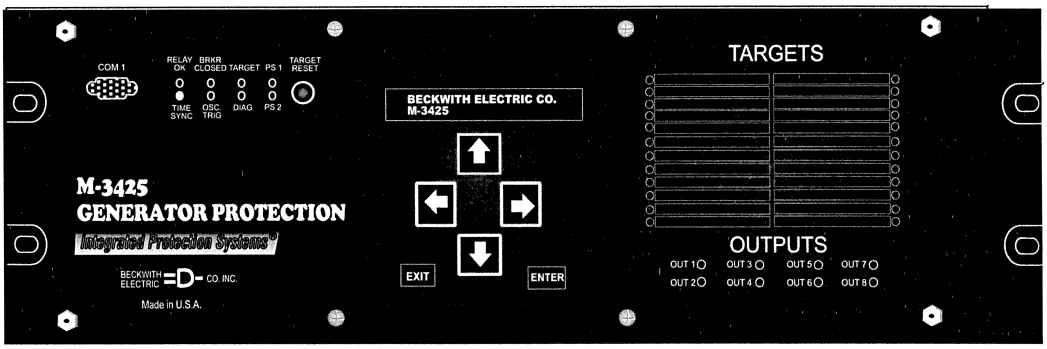
To input the data, access the **SETUP UNIT** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **SETUP UNIT** appears on the top line of the display.
3. Press **ENTER** to access the **SETUP UNIT** menu and begin the data input.

The general information required to complete the input data in this section includes:

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

1. Level 1 access = Read setpoints, monitor status, view target history.



M-3931
Human-Machine Interface
Module
–Optional–

M-3925
Target Module
–Optional–

Figure 3-1 M-3425 Front Panel

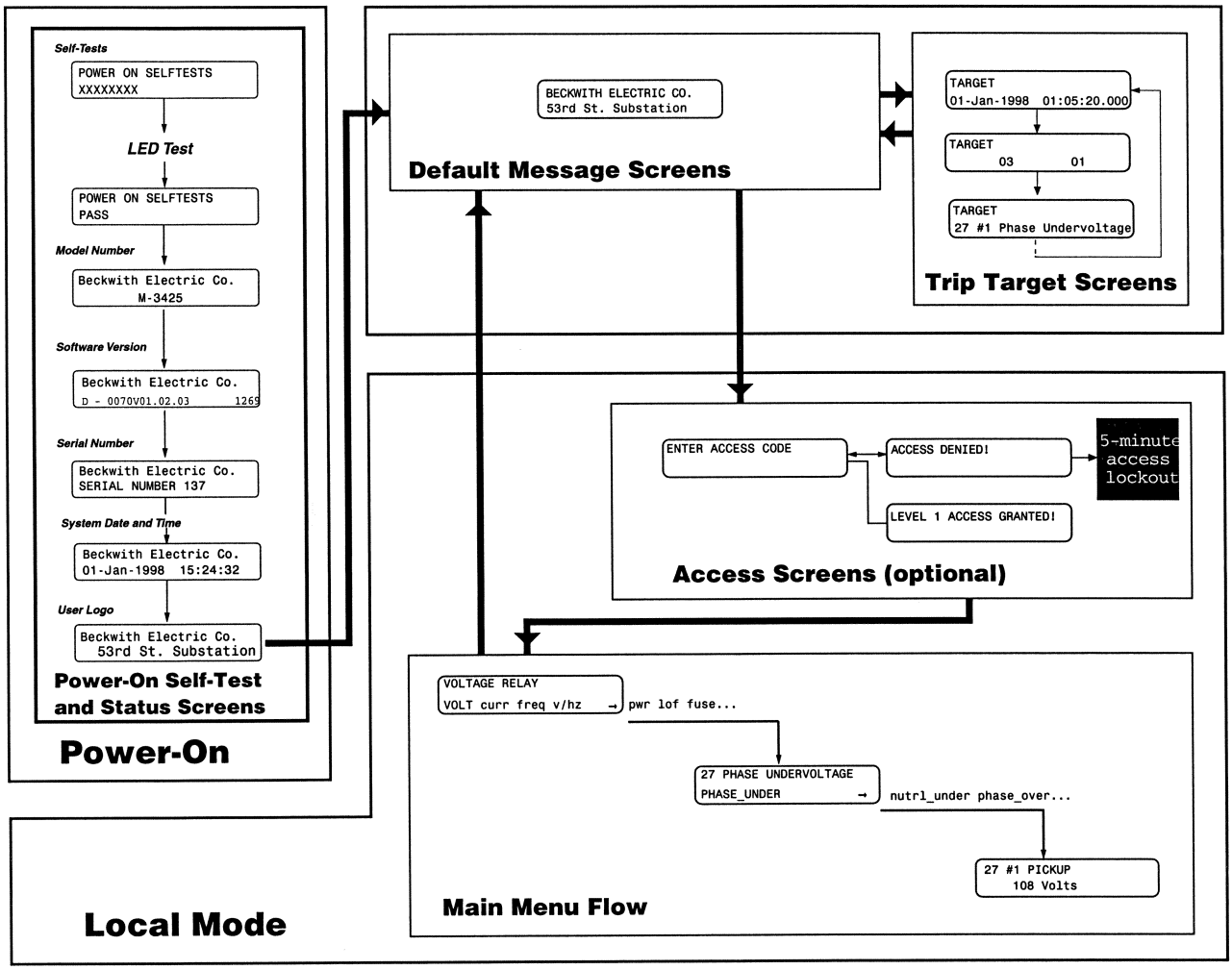


Figure 3-2 Screen Message Menu Flow

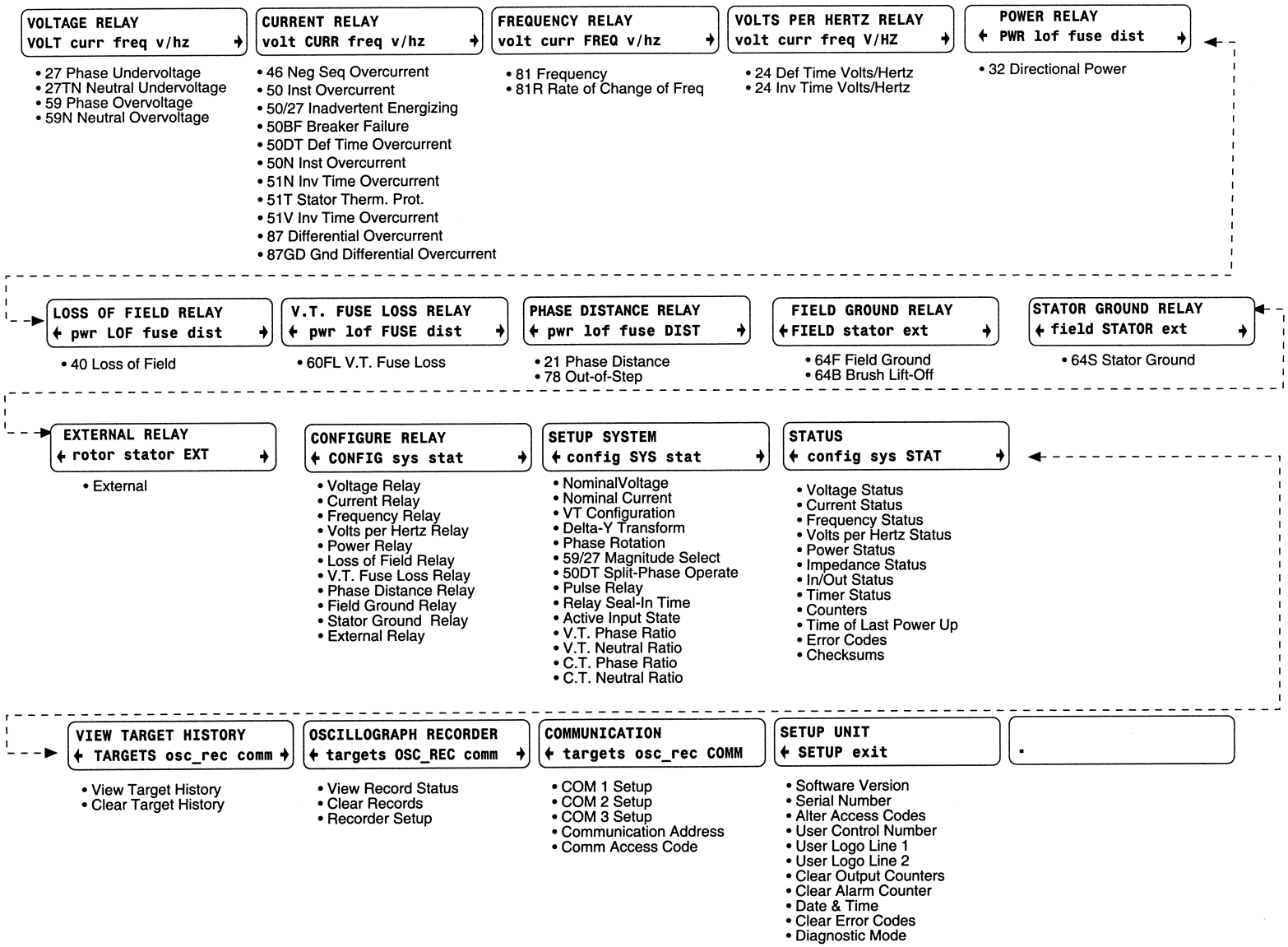


Figure 3-3 Main Menu Flow

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

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

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

If the level 3 access code is set to 9999, the access code feature is disabled. When access codes are disabled, the access screens are bypassed, and all users have full access to all the relay menus. The relay is shipped from the factory with the access code feature disabled.

- **User Control Number**: This is a user-defined value which can be used for inventory or identification. The relay does not use this value, but it is exposed via the communications interface, and can be read remotely.
- **User Logo**: The user logo is a programmable, two-line by 24-character string, which can be used to identify the relay, and which is displayed locally when the relay is idle. This information is also available remotely.
- **Date and Time**: This screen is used to view and set the relay's internal time of day clock. The clock is used to time stamp system events such as trip and oscillograph operations. The clock is disabled when shipped from the factory (indicated by "80" seconds appearing on the clock) to preserve battery life. If the relay is to be unpowered for an extended length of time, the clock should be stopped (see Diagnostic Mode). If the IRIG-B interface is used, the hours, minutes, and seconds information in the clock will be synchronized with IRIG-B time information every hour. The IRIG-B signal will provide the relay with an additional 3 digits of time information. With IRIG-B, events are tagged to the nearest millisecond, but without IRIG-B, events are tagged to the nearest second, and rely on the accuracy of the internal real time clock. The relay can accept a modulated IRIG-B signal via the rear panel BNC connector, or a demodulated TTL level signal via extra pins on the rear panel COM2 RS-232 interface connector.
- **Clear Output, Alarm Counters, and Error Codes**: These codes are self-explanatory. Also available under this submenu is the ability to read the software version and serial number as well as enter the Diagnostic Mode. Note that while the relay is in Diagnostic Mode, all protective functions are inoperative.

Setup System Data

To input the data, access the **SETUP SYSTEM** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **SETUP SYSTEM** appears on the top line of the display.
3. Press **ENTER** to access the **SETUP SYSTEM** menu and begin the data input.

System setup data is required for proper operation of the relay. Information needed to complete this section includes: Nominal Voltage, Nominal Current, VT Configuration, and other system-related information. See Chapter 2, Configuration, Relay System Setup for a more detailed description of the settings required.

Configure Relay Data

To input the data, access the **CONFIGURE RELAY** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **CONFIGURE RELAY** appears on the top line of the display.
3. Press **ENTER** to access the **CONFIGURE RELAY** menu and begin the data input.

The general information required to complete the input data in this section includes:

- enable/disable
- output choices (OUT1–OUT8)
- input blocking choices (IN1–IN6), plus fuse loss blocking

Each of the purchased functions within the relay may be individually enabled or disabled. In addition, many functions have more than one element which may also be enabled or disabled. Unused functions and elements should be disabled to avoid nuisance tripping and speed up HMI response time. After enabling a function/element, the user is presented with two additional screens for selection of input blocking and output contact designations. Any combination of the six status inputs or the internally generated V.T. fuse loss logic can be selected to dynamically block the enabled function. "OR" logic is used if more than one input is selected. Outputs are designated in a similar manner. Outputs 1–6 are form "a" contacts (normally open) and outputs 7 and 8 are form "c" contacts (center tapped "a" and "b" contacts). Output contacts 1–4 contain special circuitry for high-speed operation and pick up about 4 μsec faster than other contacts.

See Section 2.1, Configuration, for more information.

Setpoints and Time Settings

To input the data, access these menus as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **VOLTAGE RELAY**, the first of the setpoint and time setting menus, appears on the top line of the display.

■ **NOTE**: Some menus are dynamic, and do not appear if the function is not purchased or is unavailable.

3. Press **ENTER** to begin the data input for this menu, or continue pressing the right arrow button until the desired setpoint and time setting menu appears, and then press **ENTER** to begin the data input.

The general information required to complete the input data in this section includes individual relay function:

- pickup settings (converted to relay quantities)
- time delay settings
- frequency settings
- time dials
- power level settings (in percent rated)
- impedance diameter in relay ohms for distance and offset settings

Settings should be programmed based on system analysis as described in Chapter 2, **Application**. A complete description of the individual function as well as guidelines for settings are explained therein.

Oscillograph Recorder Data

To input the data, access the **OSCILLOGRAPH RECORDER** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **OSCILLOGRAPH RECORDER** appears on the top line of the display.
3. Press **ENTER** to access the **OSCILLOGRAPH RECORDER** menu and begin the data input.

The Oscillograph Recorder provides comprehensive data recording (voltage, current, and status input/output signals) for all monitored waveforms (at 16 samples per cycle). Oscillograph data can be downloaded via the communications ports to any IBM compatible personal computer running the M-3820A IPScom® Communications software package. Once downloaded, the waveform data can be examined and printed using the optional M-3801A IPSplot® Oscillograph Data Analysis Software package.

The general information required to complete the input data of this section includes:

- **Recorder Partitions**: When untriggered, the recorder continuously records waveform data, keeping the data in a buffer memory. The recorder's memory may be partitioned into 1 record of 170 cycles, 2 records of 112 cycles, 3 records of 84 cycles, or 4 records of 68 cycles each. When triggered, the time stamp is recorded, and the recorder continues recording for a user-defined period. The snapshot of the waveform is stored in memory for later retrieval using IPScom Communications Software. The **OSC TRIG** LED on the front panel will indicate a recorder operation (data is available for downloading).
- **Trigger Inputs and Outputs**: The recorder can be triggered remotely through serial communications via IPScom, or automatically via programmed status inputs (IN1–6) or outputs (OUT1–8).

- **Post-Trigger Delay**: A post-trigger delay of 5% to 95% must be specified. After triggering, the recorder will continue to store data for the programmed portion of the total record before rearming for the next record. For example, a setting of 80% will result in a record with 20% pretrigger data, and 80% post-trigger data.

Communications Data

To input the data, access the **COMMUNICATION** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **COMMUNICATION** appears on the top line of the display.
3. Press ENTER to access the **COMMUNICATION** menu and begin the data input.

The general information required to complete the input data of this section includes:

- Baud rate for COM1 and COM2 communication ports. The COM3 port does not have a separate baud rate setting but uses the setting of COM2 (or COM1: see Section 5.4 Circuit Board Switches & Jumpers).
- Communications address is used to access multiple relays via a multidrop communication line.
- Communications access code is used for communication system security (entering an access code of 9999 disables the communication security).
- Communication protocol and dead sync time for COM2 and COM3.
- Parity for COM2 or COM3 if MODBUS protocol used.

Detailed information concerning setup and operation of the communication ports is covered in Chapter 4, **Remote Operation**.

3.3 Status/Metering

Monitor Status/Metering

Access the **STATUS** menu as follows:

1. Press **ENTER** to bring up the main menu.
2. Press the right arrow button until **STATUS** appears on the top line of the display.
3. Press **ENTER** to access the **STATUS** menu and begin the monitoring.

Each category listed below is a menu item. Pressing the **ENTER** button moves down within that menu, allowing you to monitor values within that menu category. To exit a specific category and continue to the next menu category, press the **EXIT** button.

Some menus are dynamic and do not appear if certain functions are not purchased, or are unavailable.

The menu categories for monitored values are:

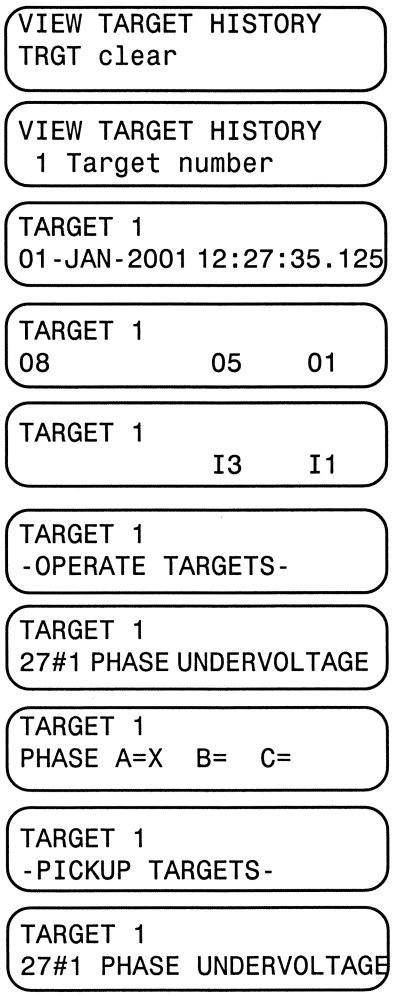
- **Voltage Status**: phase voltages, neutral voltage, positive sequence voltage, negative sequence voltage, zero sequence voltage, 3rd harmonic neutral voltage, field ground measurement circuit, stator low frequency injection voltage
- **Current Status:** phase currents (A–B–C/ a-b-c), differential current, neutral current, ground differential current, positive sequence current, negative sequence current, zero sequence current, stator low frequency injection current
- **Frequency Status**: frequency, rate of change of frequency
- **Volts/Hz Status:** volts per hertz
- **Power Status**: real power, reactive power, apparent power, power factor
- **Impedance Status**: impedance (Zab, Zbc, Zca), positive sequence impedance, field ground resistance
- **IN/OUT Status**: Status of input and output contacts
- **Timer:** 51V Delay Timer, 51N Delay Timer, 46IT Delay Timer, 51T Delay Timer, 24IT Delay Timer
- **Counters**: output, alarm counter
- **Time of Last Powerup**
- **Error Codes**
- **Checksums:** setpoints, calibration, ROM

3.4 Target History

The M-3425 Generator Protection Relay has the ability to store the last twenty-four target conditions in a nonvolatile manner. A target is triggered whenever an output is operated (OUT1–OUT8). A second function attempting to operate an output (which is already operated) will not trigger a new target, since no new output has been operated or closed. If the second function operation closes a different, unoperated output, a new target will be triggered. A target includes:

- an indication which function(s) have operated, and timers expired (operated),
- status information which indicates any function that is timing (picked up),
- individual phase element information at the time of the trigger, if the operating function was a three phase function,
- phase currents at the time of operation
- neutral current at the time of operation,
- input and output status, and
- a date/time tag.

When a target is triggered, the front panel **TARGET** LED will light, indicating a recent event. If the optional M-3925 Target Module is present, the corresponding function LED will be lit. If the optional M-3931 HMI module is available, a series of screens will be presented, describing the most recent operation. This information is also available remotely by using the IPScom® communication package.



This screen gives access to the target history, and also allows the user to clear the target history record from memory.

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

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

This screen displays operated outputs.

This screen displays operated inputs at time of trip.

The following screens display the timed out or "operate" functions.

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

This gives the phase information for the displayed function at time out.

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

```
TARGET 1
PHASE A=X B=X C=X
```

This gives the phase pickup information for the specific function.

```
TARGET 1
-CURRENT STATUS-
```

```
TARGET 1
a=0.02 b=0.03 c=0.04
```

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

```
TARGET 1
N=0.50 AMPS
```

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

4 Remote Operation

This chapter is designed for the person or group responsible for the remote operation and setting of the relay using the M-3820A IPScom Communications Software package or other means.

4.1 Remote Operation

The M-3425 Generator Protection Relay provides three serial communication ports. Two serial interface ports, COM1 and COM2, are standard 9-pin, RS-232, DTE-configured ports. The front-panel port, COM1, can be used to locally set and interrogate the relay via a temporary connection to a PC or laptop computer. The second RS-232 port, COM2, is provided at the rear of the unit. Either port COM2 or COM3 may be used to remotely set and interrogate the relay via a modem or other direct serial connection. Equipment such as RTU's, data concentrators, modems, or computers can be interfaced for direct, on-line, real time data acquisition and control. Generally, all data available to the operator through the front panel of the relay with the optional M-3931 HMI module is accessible remotely through the BECO 2200 or MODBUS data exchange protocol. These protocol documents and the database specific protocol document are available from the factory or our website at www.beckwithelectric.com.

The communication protocols implement serial, byte oriented, asynchronous communication and can be used to fulfill the following communications functions:

- Real-time monitoring of line status
- Interrogation and modification of setpoints
- Downloading of recorded oscillograph data
- Reconfiguration of all relay functions

Direct Connection

In order for IPScom to communicate with the relay via direct serial connection, a serial "null modem" cable is required, with a 9-pin connector (DB9P) for the system, and an applicable connector for the computer (usually DB9S or DB25S). Pin-outs for a null modem adapter are provided in Appendix B, **Communications**.

An optional 10 foot null modem cable (M-0423) is available from the factory, for direct connection between a PC and the relay's front panel COM port, or the rear COM2 port.

When fabricating communication cables, every effort should be made to keep cabling as short as possible. Low capacitance cable is recommended. The RS-232 standard specifies a maximum cable length of 50 feet for RS-232 connections. If over 50 feet of cable length is required, other technologies should be investigated.

Multiple Systems Setup

The individual addressing capability of IPScom® and the relay allows multiple systems to share a direct or modem connection when connected via a communications-line splitter (see Figure 4-1, below). One such device enables 2 to 6 units to share one communications line.

Serial Multidrop Network Setup

Individual remote addressing also allows for communications through a serial multidrop network. Up to 32 relays can be connected using the same 2-wire RS-485 communications line.

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

Other communication topologies are possible using the M-3425 Generator Protection Relay. An Application Note, "*Serial Communication with Beckwith Electric's Integrated Protection System Relays*" is available from the factory.

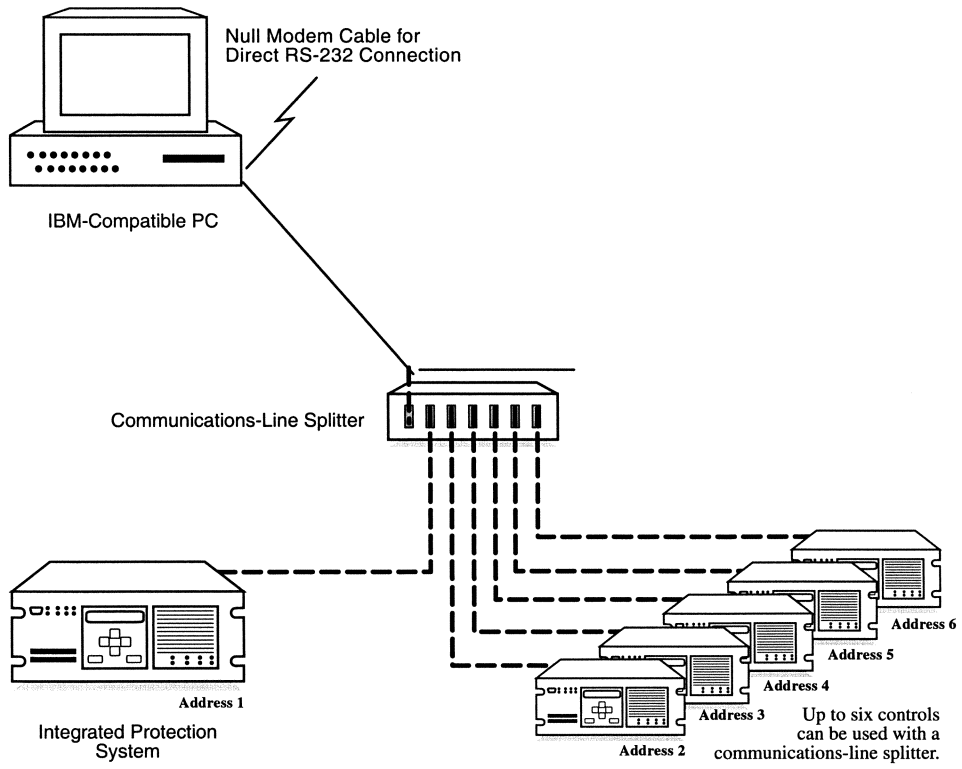


Figure 4-1 Multiple Systems Addressing Using Communications-Line Splitter

Setting Up the M-3425 Generator Protection Relay for Communication

The initial setup of the relay for communication must be completed by the optional M-3931 HMI Module or via direct serial connection.

For units shipped without the optional HMI Module, the communication parameters may be altered by first establishing communication using the default parameters and the IPSutil™ program.

IPSutil is an auxiliary program shipped on the same disk with the IPScom® program. It is used exclusively for altering communication and setup parameters on units shipped without the M-3931 HMI Module.

The following communication parameters must be set for proper operation:

COM1 Baud Rate: Standard baud rates from 300 to 9600 are available.

COM2 Baud Rate: Standard baud rates from 300 to 9600 are available. COM2 and COM3 share the same baud rate (see Table 5.1, Jumpers).

COM2 Dead Sync Time: This delay establishes the line idle time to re-sync packet communication. Dead sync time should be programmed based on the channel's baud rate.

COM2 Protocol: BECO 2200 or MODBUS protocol is supported on COM2.

COM2 Parity: None, odd or even parity is available if MODBUS protocol is selected.

COM3 Dead Sync Time: This delay establishes the line idle time to re-sync packet communication. Dead sync time should be programmed based on the channel's baud rate.

COM3 Protocol: BECO 2200 or MODBUS protocol is supported on COM3.

COM3 Parity: None, odd or even parity is available if MODBUS protocol is selected.

Communications Address: For multidrop networks, each device must have a unique address.

Communication Access Code: If additional link security is desired, a communication access code can be programmed. Like the user access codes, if the communication access code is set to 9999 (default), communication security is disabled.

Individual relay communication addresses should be between 1 and 200. The dead sync time, while not critical for most communication networks, should be programmed to match the communications channels baud rate (see Table 4-1, below).

Baud Rate	Dead-Sync Time
9600	4 ms
4800	8 ms
2400	16 ms
1200	32 ms
600	64 ms
300	128 ms

Table 4-1 Dead-Sync Time

Installing the Modems

Using IPScom to interrogate, set or monitor the relay via a modem requires both a remote modem connected at the relay location and a local modem connected to the computer with IPScom installed.

In order to use IPScom to communicate with the relay via a modem, the following must be provided with the unit:

- An external modem (300 baud or higher), capable of understanding standard AT commands.
- Serial modem cable with 9-pin connector for the unit and the applicable connector for the modem.

■ **NOTE**: Any compatible modem may be used; however, the unit only communicates at 300 to 9600 baud.

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

The local modem can be initialized, using IPScom, by connecting the modem to the computer, and selecting the **COMM** menu in IPScom. Select **MODEM**, enter the required information, and finally select **INITIALIZE** from the expanded Communications dialog box. The following steps outline the initialized modem setup procedure.

1. Connecting the modem to the computer:
   a. If the computer has an external modem, use a standard straight-through RS-232 modem cable to connect the computer and modem (M-3933). If the computer has an internal modem, refer to the modem's instruction book to determine which communications port should be selected.
   b. The modem must be attached to (if external) or assigned to (if internal) the same serial port as assigned in IPScom®. While IPScom can use any of the four serial ports (COM1 through COM4), most computers support only COM1 and COM2.
   c. Connect the modem to the telephone line and power up.

2. Connecting the Modem to the Relay:

   Setup of the modem attached to the relay may be slightly complicated. It involves programming the parameters (via the AT command set), and storing this profile in the modem's nonvolatile memory.

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

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

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

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

E0	No Echo
Q1	Don't return result code
&D3	On to OFF DTR, hang-up and reset
&S0	DSR always on
&C1	DCD ON when detected
S0=2	Answer on second ring

The following commands may also be required at the modem:

&Q6	Constant DTE to DCE
N0	Answer only at specified speed
W	Disable serial data rate adjust
\Q3	Bi-directional RTS/CTS relay
&B1	Fixed serial port rate
S37	Desired line connection speed

There are some variations in the AT commands supported by modem manufacturers. Refer to the hardware user documentation for a list of supported AT commands and direction on issuing these commands.

4.2 Installation and Setup (IPScom)

IPScom runs with the Microsoft Windows® 95 operating system or later. IPScom only supports communication via the BECO 2200 protocol.

IPScom is available via the following (IBM PC-compatible format):

- two 3.5" double-sided, high-density (DS/HD 1.44 Mb) disk
- available for download from our website at www.beckwithelectric.com

The M-3820A IPScom Communications Software package is not copy-protected and can be copied to a hard disk. For more information on your specific rights and responsibilities, see the licensing agreement enclosed with your software or contact Beckwith Electric.

Hardware Requirements

IPScom® will run on any IBM PC-compatible computer that provides at least the following:

- 8 Mb of RAM
- Microsoft Windows 95 or later
- one 3.5" double-sided, high-density (DS/HD 1.44 Mb) disk drive
- one serial (RS-232) communication port
- VGA monitor
- Mouse or pointing device

Recommended, but not required, are the following:

- Windows-compatible printer

Installation

Before installing the IPScom program, make a copy of the software disks for archival purposes.

Figure 4-2 IPScom Program Icon

IPScom can be run from a hard disk. An installation utility (setup.exe) has been provided to make the process easier.

Installing IPScom

1. Insert software disk 1 in your drive.
2. Select Run from the Start Menu.
3. In the Run dialog box, specify the file to be installed by typing either A:\Setup or B:\Setup, depending on the drive in which the software diskette is inserted.
4. The installation utility establishes a program folder (Becoware) and subdirectory (IPScom). After installation, the IPScom program item icon (see Figure 4-2) is located in Becoware. The default location for the application files is on drive C:, in the new subdirectory "IPScom" (C:\Becoware\Ipscom).

Installing IPSutil™

IPSutil is utility software used to program system-level parameters for units shipped without the M-3931 HMI Module. The IPSutil.exe file is automatically installed in the Becoware folder, along with the IPScom files, and does not require separate installation.

4.3 Operation

Activating Communications

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

1. Choose the IPScom icon from the Becoware folder.
2. The IPScom splash screen is displayed briefly, providing the software version number and copyright information. This information is also available by choosing the **About**... command from the **Help** menu.
3. Choose the **COMM** menu selection. Complete the appropriate information on the window for the relay to be addressed.
   a. If communication is through a modem, choose the **Modem** command button to expand the communications dialog box. Choose the desired relay location and choose **Dial** button. This action establishes contact and automatically opens communication to the relay.
   b. If computer is connected through the front port, choose the **Open COM** button. This action establishes communications.
4. Enter any valid IPScom command(s) as desired.
5. To end communication when communicating by modem, choose the **Hang Up** command button from the expanded Communication dialog box. To close the communication channel when connected locally, choose the **Close COM** command button.

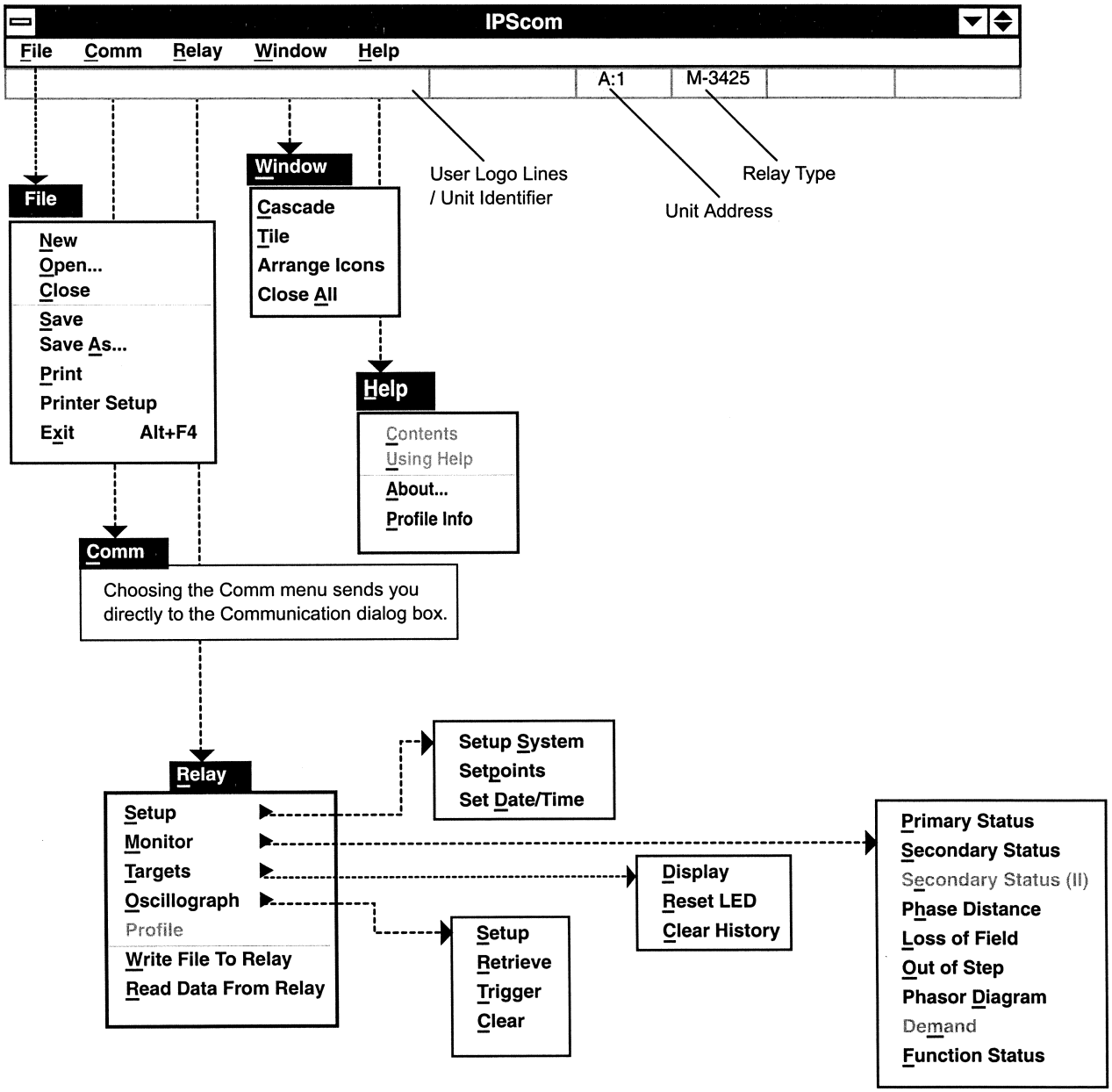


Figure 4-3 IPScom® Menu Selections

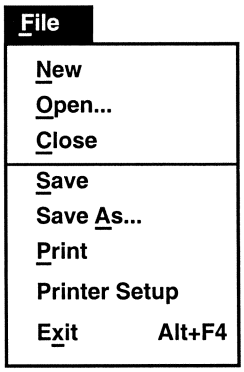
■ **NOTE**: Greyed-out menu items are for future release, and are not currently available.

Overview

When IPScom® is run, a menu and status bar is displayed, as shown in Figure 4-3. This section describes each IPScom menu selection and explains each IPScom command in the same order as they are displayed in the software program. For detailed information on each dialog box field (function), refer to Chapter 2, **Application**.

When starting IPScom, the initial menu choices are the **File** menu or the **Comm** menu. The choice specifies whether the operator desires to write to a data file or to communicate directly with the relay.

File Menu



The **File** menu enables the user to create a new data file, open a previously created data file, close, print, and save the file. The IPScom program can also be exited through the **File** menu.

Since IPScom can be used with several Beckwith protection systems in addition to the M-3425 Generator Protection Relay, the format and contents of a file must be established depending on which protective system is being addressed. When not connected to one of the protection systems, using the **New** command, a new file is established with the New Device Profile dialog box (see Figure 4-4). Choosing the **OK** command button allows the new data file to be named by using the **Save** or **Save As**...commands.

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

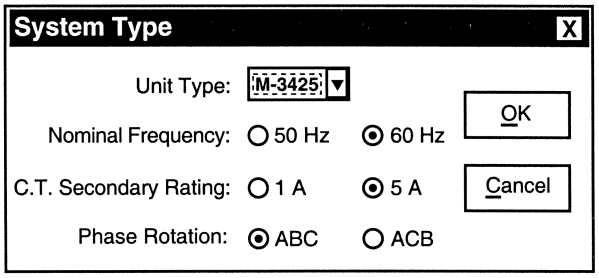


Figure 4-4 New Device Profile Dialog Box

Path: File menu / New command

COMMAND BUTTONS

OK Saves the currently displayed information.

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

The **Save** and **Save As**... commands allow re-saving a file or renaming a file, respectively. The **Open** command allows opening a previously created data file. With an opened data file, use the **Relay... Setup...** menu items to access the setpoint windows.

If communication can be established with a relay, it is always safer to use the **Read Data From Relay** command to update the PC's data file with the relay data. This file now contains the proper system type information, eliminating the need to set the information manually.

The **Print** and **Printer Setup** commands allow user to select printer options and print out all setpoint data from the data file or directly from the relay, if a relay is communicating with the PC.

The **Exit** command quits the IPScom program.

Comm Menu

File | Comm | Relay | Window | Help

The Communication dialog box (see Figure 4-5) allows setup of the IPScom communication data to coordinate with the relay and by choosing the **Modem** button, to establish contact for remote locations. When communicating by way of a fiber optic loop network, echo cancelling is available by checking the Echo Cancel box. This command masks the sender's returned echo.

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

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

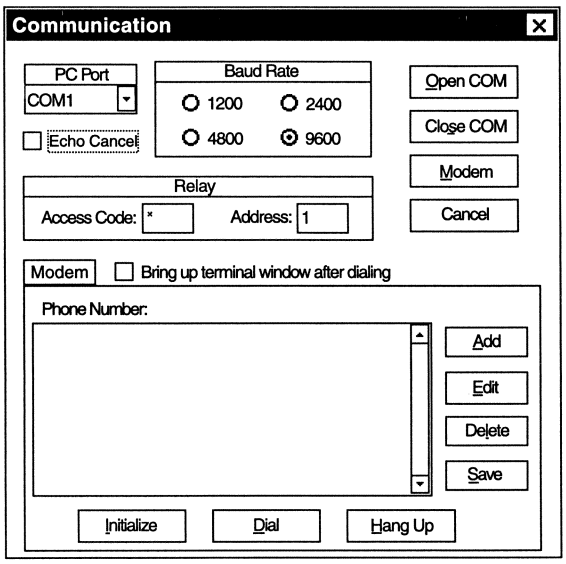


Figure 4-5 Communication Dialog Box

Path: Comm menu

COMMAND BUTTONS

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

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

Modem Displays the expanded Communication dialog box.

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

Add Displays the Add/Edit dialog box, allowing you to type a protective system's unit identifier, phone number, and communication address.

Edit Displays the Add/Edit dialog box, allowing you to review and change the user lines (unit identifier), phone number, and communication address of a selected entry.

Delete Deletes a selected entry.

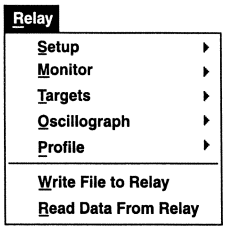
Initialize Allows you to send special setup or other AT commands directly to the modem.

Dial Dials the entry selected from the directory.

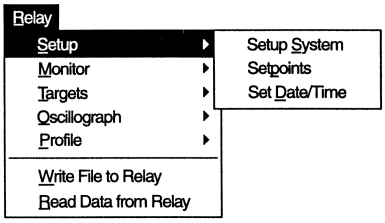
Hang Up Ends modem communication, allowing you to dial again.

Bring Up Terminal Window After Dialing Built-in terminal window allows interactive communication between modem and relay

Relay Menu



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



The **Setup** submenu provides three commands: **Setup System**, **Setpoints**, and **Set Date/Time**. The **Setup System** command displays the Setup System dialog box (Figure 4-6) allowing the input of the pertinent information regarding the system on which the protective relay is applied (see Section 2.1, **Configuration**, Relay System Setup).

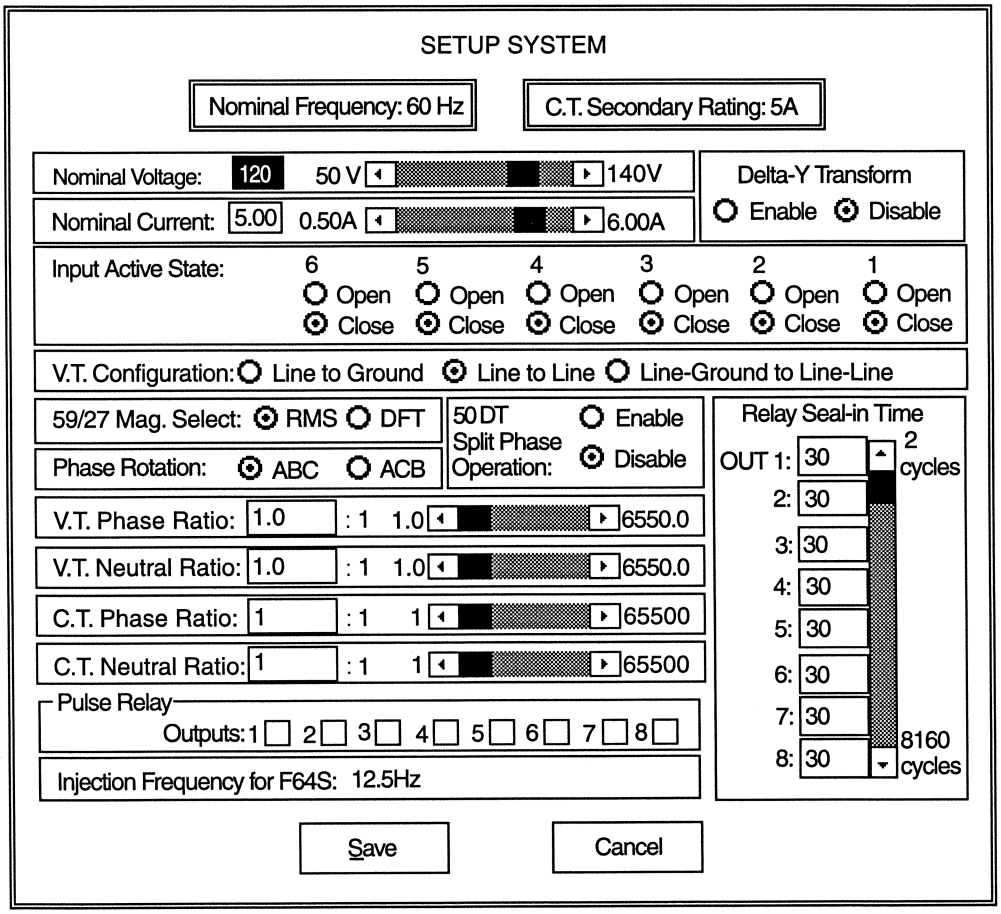


Figure 4-6 Setup System Dialog Box

Path: Relay menu / Setup submenu / Setup System command

COMMAND BUTTONS

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

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

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

The **Setpoints** command displays the Relay Setpoints dialog box (see Figure 4-7) from which the individual relay function dialog boxes can be accessed. Choosing a Relay function button will display the corresponding function dialog box (see Figure 4-8 for example).

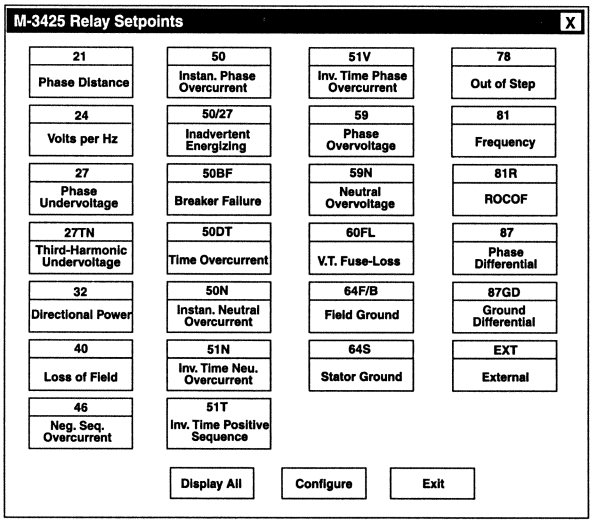


Figure 4-7 Relay Setpoints Dialog Box

Path: Relay menu / Setup submenu / Setpoints window

COMMAND BUTTONS

Display All Opens the All Setpoints Table dialog box.

Configure Opens the Configure dialog box.

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

The Relay Setpoints dialog box gives access to two additional dialog boxes: Display All and Configure.

Choosing the **Display All** command button displays the All Setpoints Table dialog box (see Fig. 4-9). This dialog contains a list of settings for each relay within a single window to allow scrolling through all relay setpoint configuration values. Choosing the **Configure** command button displays the Configure dialog box (see Fig. 4-10), which contains a chart of programmed input and output contacts, in order to allow scrolling through all relay output and blocking input configurations. Both dialog boxes (All Setpoint Table and Configure), feature hotspots which allows the user to jump from a scrolling dialog box to an individual relay function dialog box and return to the scrolling dialog box again. All available parameters can be reviewed or changed when jumping to a relay configuration dialog box from either scrolling dialog box.

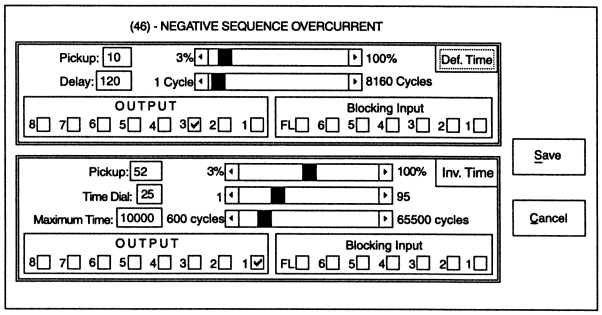


Figure 4-8 Negative Sequence Overcurrent Setpoint Dialog Box

Path: Relay menu / Setup submenu / Setpoints window/ 46 command button OR 46 jump hotspot within All Setpoints Table or Configure dialog box

COMMAND BUTTONS

Save When connected to a protection system, sends the currently displayed information to the unit. Otherwise, saves the currently displayed information and returns you to the Relay Setpoints, All Setpoints Table, or Configure dialog box.

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

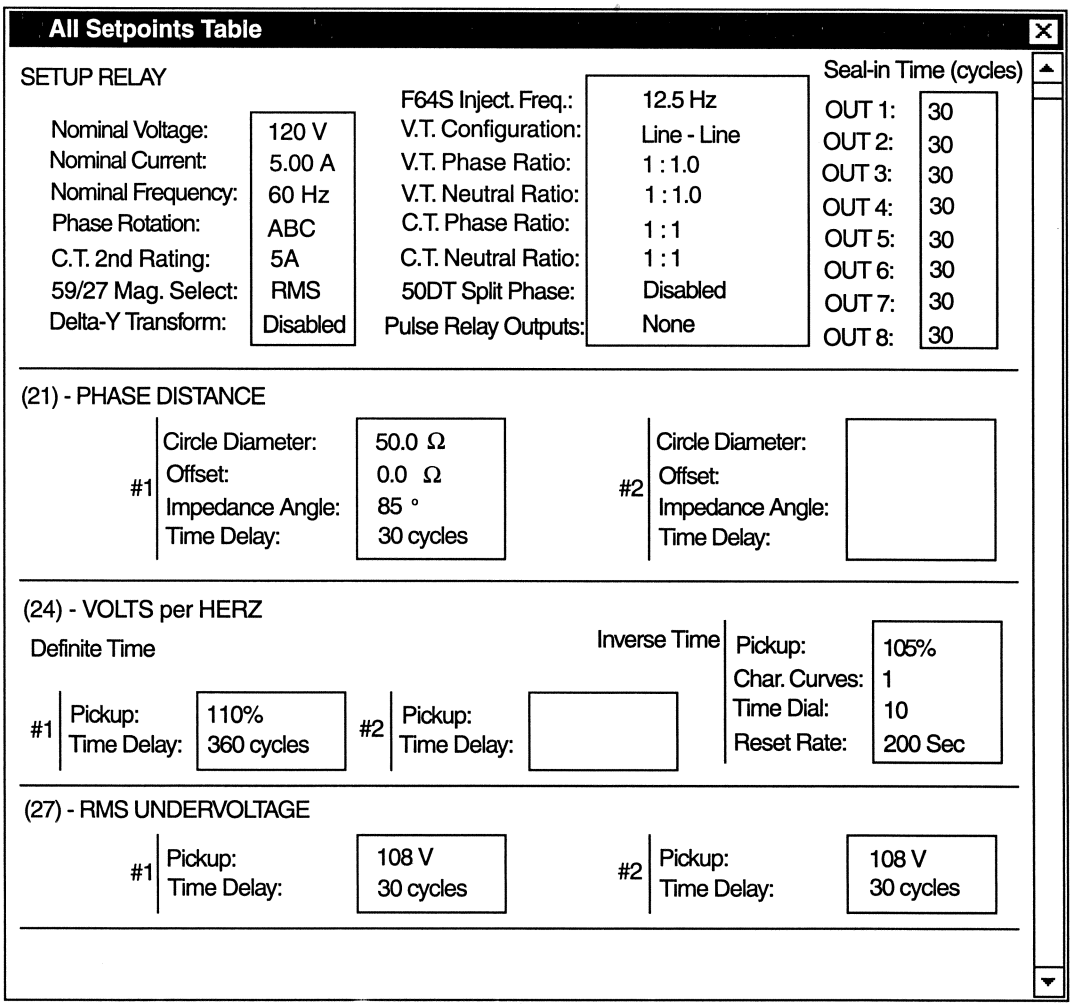


Figure 4-9 All Setpoints Table Dialog Box

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

JUMP HOTSPOTS

This window provides you with jump hotspots, identified by the hand icon, that take you to each relay dialog box and the Setup Relay dialog box. Exiting any of these dialog boxes will return you to the All Setpoints Table dialog box.

CONTROL MENU

Close Returns you to the Relay Setpoints dialog box.

Move Allows you to reposition the dialog box.

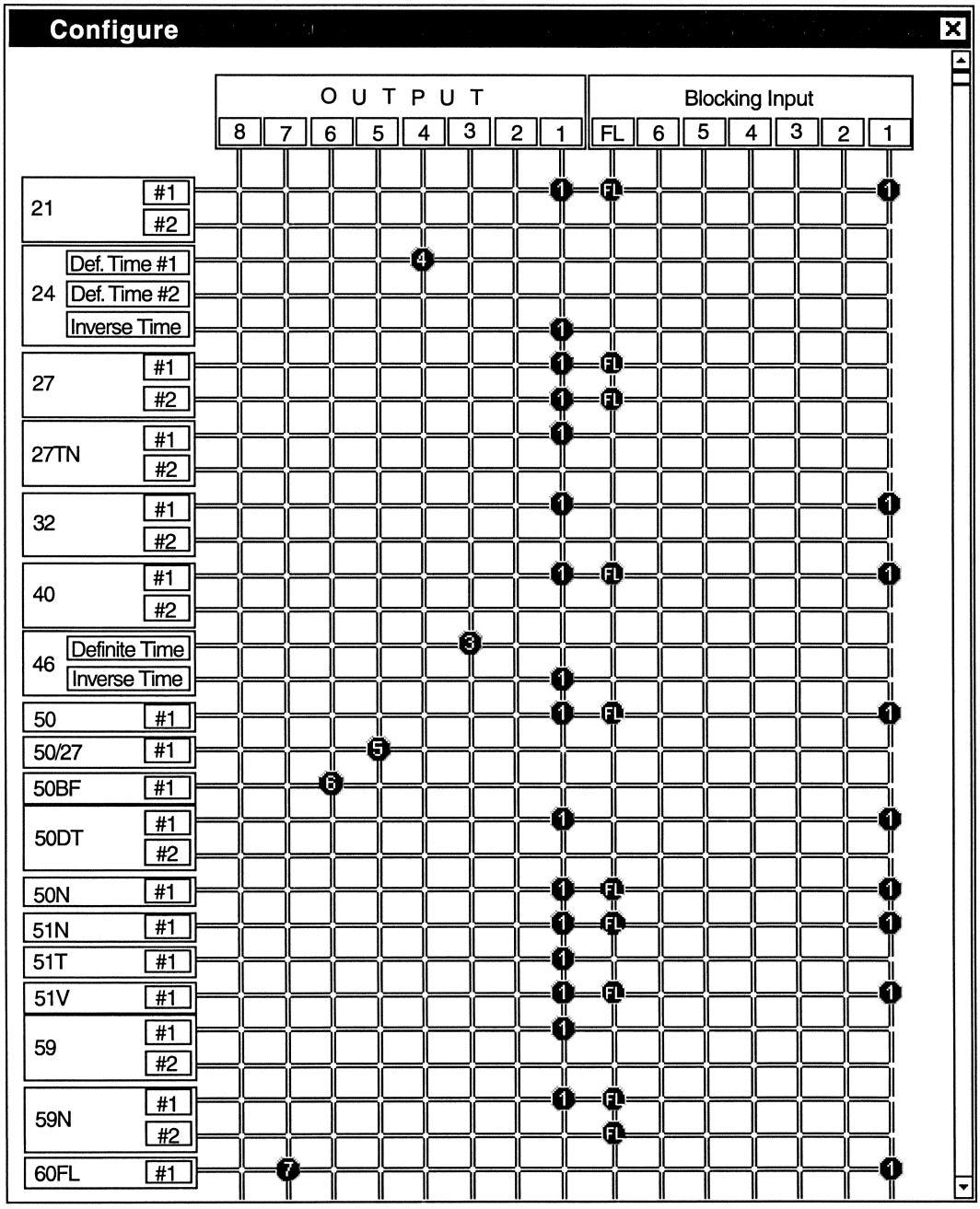


Figure 4-10 Configure Dialog Box

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

JUMP HOTSPOTS

This window provides you with jump hotspots, identified by the hand icon, that take you to each relay dialog box. Exiting any of these dialog boxes will return you to the Configure dialog box.

CONTROL MENU

Close Returns you to the Relay Setpoints dialog box.

Move Allows you to reposition the dialog box.

The **Set Date/Time** command (see Figure 4-11) allows the system date and time to be set, or system clock to be stopped. This dialog box also displays an LED mimic to identify when the Time Sync is in use (preventing date/time from being changed by user).

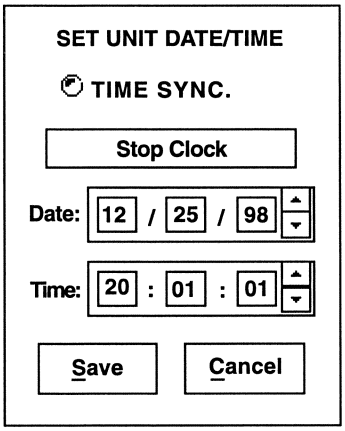


Figure 4-11 Unit Date/Time Dialog Box

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

There is a blue Time Sync LED mimic on this dialog box (the LED is displayed as different shading on a monochrome monitor). When this LED is blue, the relay is synchronized with the IRIG-B signal and the Time field is grayed out, indicating that this field can't be changed. But the Date field can be changed (by editing and pressing **Save**).

When the LED is *not* blue, the relay is not time-synchronized and therefore, both the Date and Time fields can be changed.

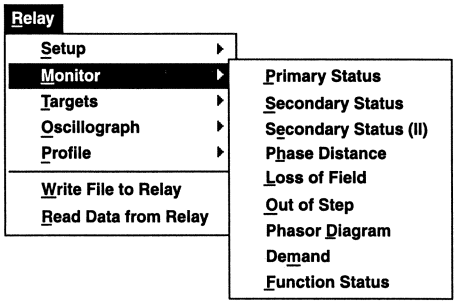
The time field in the dialog box is not updated continuously. The time at which the dialog box was opened is the time that is displayed and remains as such. This is true whether the relay is synchronized with the IRIG-B signal or not.

COMMAND BUTTONS

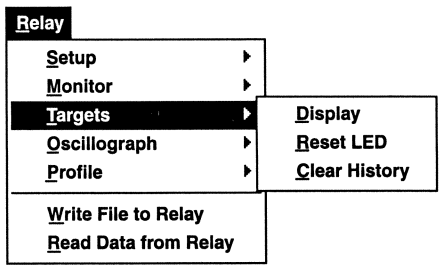
Stop Clock This toggles between start/stop, the relay clock. 'Stop' pauses, 'Start' resumes.

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

The **Monitor** submenu provides access for reviewing the present status of the relay's measured and calculated values, other real-time parameters and conditions as well as examining real-time and historical demand metering information (see Section 4.4 Checkout Status/Metering). A cascading menu appears, providing several command options as shown below.



The **Targets** submenu provides three command options: **Display**, **Reset LED**, and **Clear History**. The **Display** command displays the **Target** Dialog. This dialog box (see Figure 4-12) provides detailed data on target events, including time, date, function status, phase current values, and IN/OUT contact status at the time of trip. Individually recorded events may be selected within the dialog box and saved into a text file, or be printed out with optional added comments. The **Reset LED** is similar to pushing the **Target Reset** button on the relay's front panel, resetting current target(s) displayed on the relay. This command does not reset any target history.



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

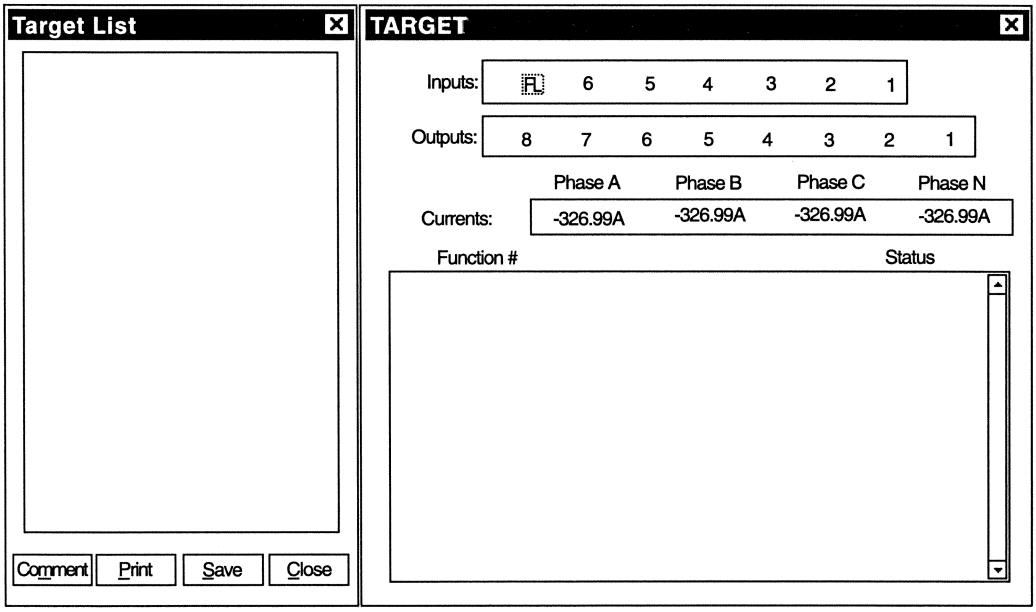


Figure 4-12 Target Dialog Box

Path: Relay menu / Targets submenu / Display window

Time is displayed in milliseconds when the IRIG-B time synchronization is used. When the IRIG-B is not used, the millisecond part of the time stamp reads 000.

COMMAND BUTTONS

Comment Opens comment dialog box for annotation.

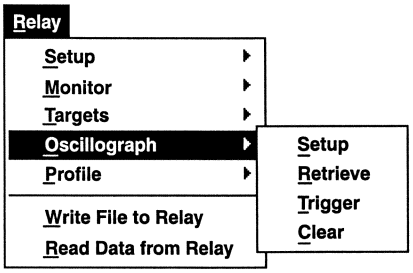
Print Prints out selected target information, with comment.

Save Saves selected target information, with comment, as a text file.

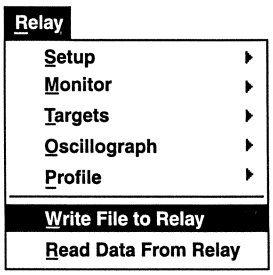
Close Exits the currently displayed dialog box.

The **Oscillograph** submenu allows storing data on selected parameters for review and plotting at a later time. The **Setup** command allows the user to set the number of partitions and triggering designations to be made. The **Retrieve** command downloads and stores collected data to a file; **Trigger** allows the manual triggering of the recorder; **Clear** erases the existing records. Run the optional M-3801A IPSplot® Oscillograph Analysis Software program to view the downloaded oscillograph files.

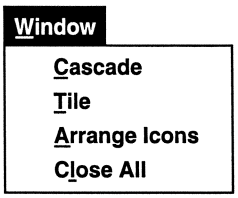
Profile is currently unavailable, and will be greyed-out in display.



The **Write File To Relay** command is used to write the data to the relay. The **Read Data From Relay** command is used to retrieve the data from the relay to the computer for display.



Window Menu/Help Menu



The **Window** menu enables the positioning and arrangement of all IPScom® windows so that there is better access to available functions. This feature allows the display of several windows at the same time. Clicking on an inactive window activates that window.

Currently in revision, the **Help** menu will enable the user to look up information about any IPScom menus or commands. Though displaying (greyed-out) **Help** commands, this menu item is currently unavailable.

The **About** IPScom Dialog Box (see Figure 4-13) displays IPScom version and development information.

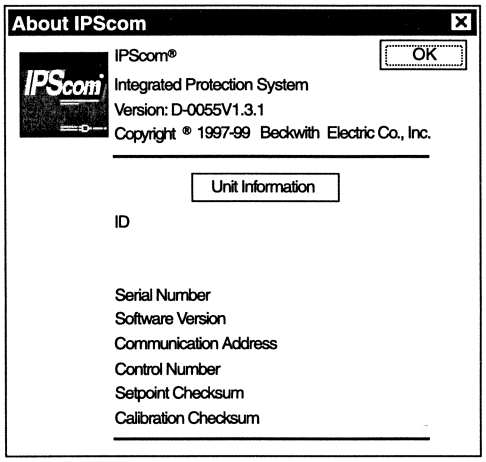


Figure 4-13 About IPScom Dialog Box

Path: Help menu / About... command

COMMAND BUTTONS

OK Exits the currently displayed dialog box.

The **Profile Info** will allow the user to view or make notations for the relay setpoint data files. This command is currently unavailable, and will be greyed-out in the display.

4.4 Checkout Status/Metering

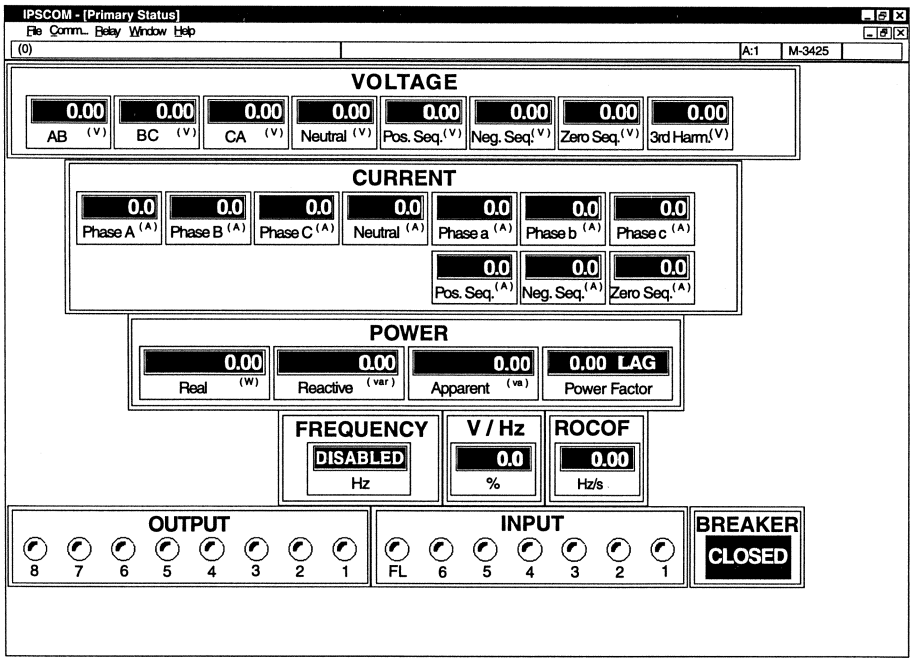


Figure 4-14 Primary Status Dialog Box

Path: Relay menu/ Monitor submenu/ Primary Status window

These are calculated values based on the VT and CT inputs.

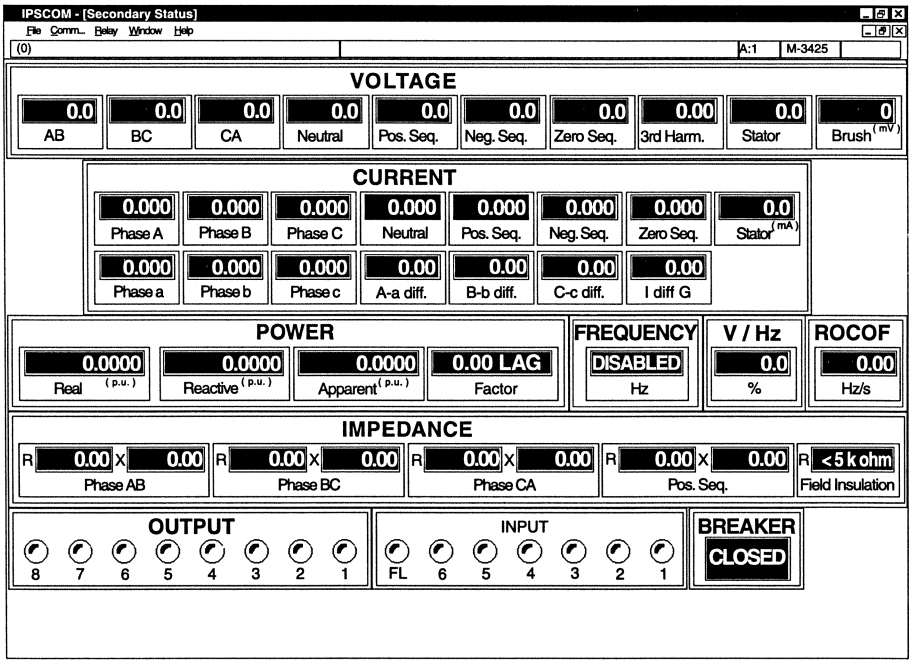


Figure 4-15 Secondary Status Dialog Box

Path: Relay menu/ Monitor submenu/ Secondary Status window

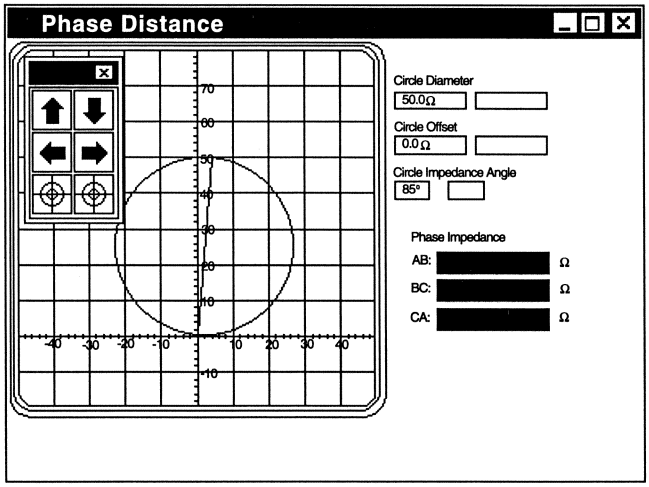


Figure 4-16 Phase Distance Dialog Box

Path: Relay menu / Monitor submenu / Phase Distance window

Phase Distance window shows a graphic representation of phase distance settings.

CONTROL BUTTONS

- Move up the scope window
- Move down the scope window
- Move the scope window to the left
- Move the scope window to the right
- Zoom In
- Zoom Out

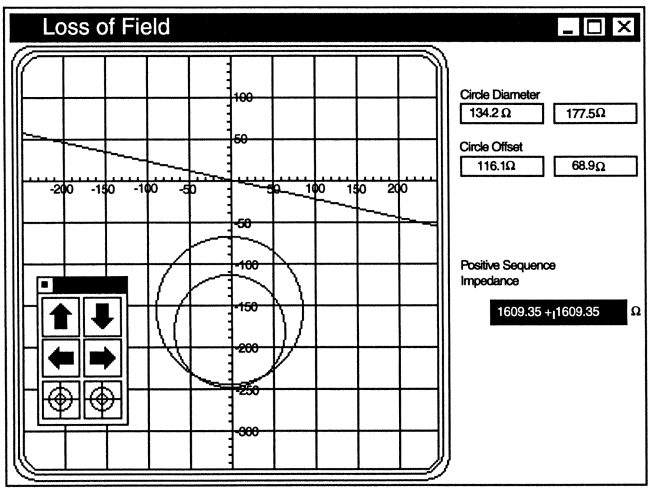


Figure 4-17 Loss of Field Dialog Box

Path: Relay menu / Monitor submenu / Loss of Field window

Loss-of-Field window shows a graphic representation of loss-of-field settings, and also displays the positive sequence impedance.

CONTROL BUTTONS

- Move up the scope window
- Move down the scope window
- Move the scope window to the left
- Move the scope window to the right
- Zoom In
- Zoom Out

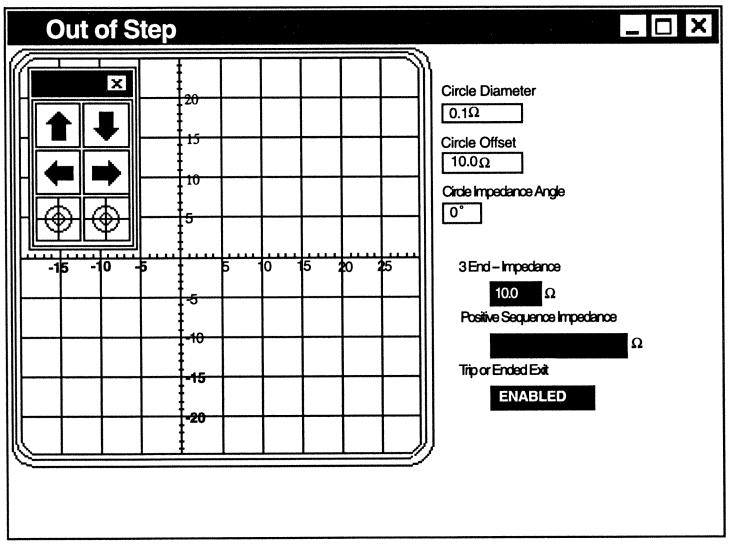


Figure 4-18 Out-of-Step Dialog Box

Path: Relay menu / Monitor submenu / Out-of-Step window

CONTROL BUTTONS

⬆	Move up the scope window	➡	Move the scope window to the right
⬇	Move down the scope window	⊕	Zoom In
⬅	Move the scope window to the left	⊖	Zoom Out

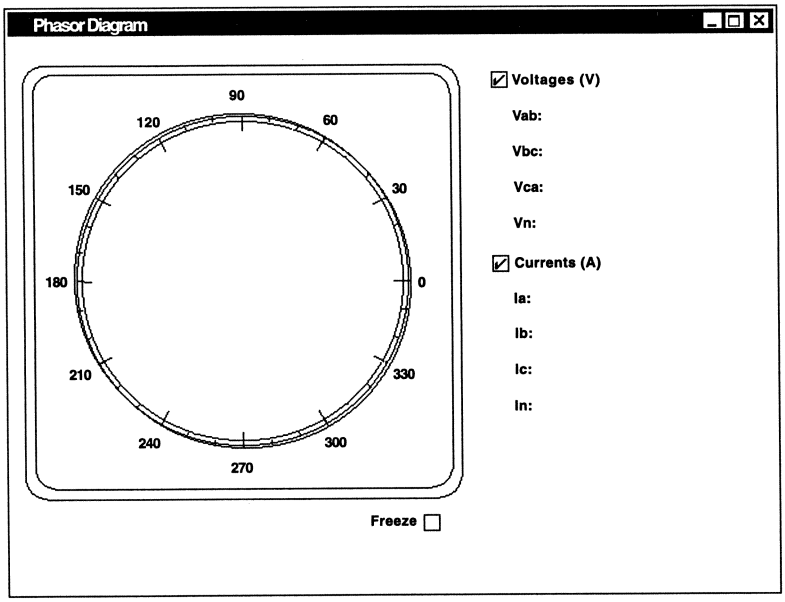


Figure 4-19 Phasor Dialog Box

Path: Relay menu / Monitor submenu / Phasor Diagram window

CONTROL BUTTONS

❒ Voltage Toggle & display voltage channel information

❒ Currents (A) Toggle & display current channel information.

❒ Freeze Toggle & update information

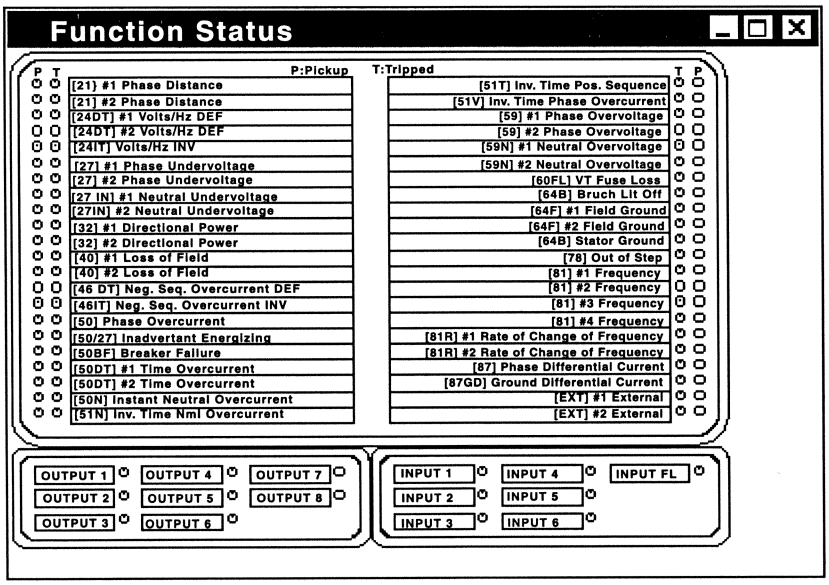


Figure 4-20 Function Status Dialog Box

Path: Relay menu / Monitor submenu / Function Status window

Function Status window shows the status of various functions, with "T" representing the function which has tripped, and "P" representing the function which has picked up and is timing.

COMMAND BUTTONS

Close Exits the currently displayed dialog box.

4.5 Cautions

System and IPScom® Compatibility

Every attempt has been made to maintain compatibility with previous software versions. In some cases (most notably with older protection systems), compatibility cannot be maintained. If there is any question about compatibility, contact the factory.

System Priority

System conflicts will not occur, as local commands initiated from the front panel receive priority recognition. When the unit is in local mode, communication via the serial ports is suspended. IPScom displays an error message to indicate this fact.

Time and Date Stamping

Time and date stamping of events is only as useful as the validity of the unit's internal clock. Under the **Relay** menu, the **Set Date/TIme** command allows you to manually set the unit's clock.

Echo Cancel

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

Serial Port Connections

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

4.6 Keyboard Shortcuts

Keyboard Shortcuts

SYSTEM KEYS

These keys can be used within Microsoft Windows® and IPScom®.

Alt-Tab	To switch between applications.
Ctrl-Esc	To open Task List dialog box. Opens Start Menu (Win 95/98).
Ctrl-Tab	To switch between windows within an application.
Arrow Keys	To select an application or group icon.
First Character of Name	To select application or group icon.
Enter	To open selected group or run selected application.

MENU KEYS

These keys enable you to select menus and choose commands.

Alt or F10	To select or cancel selection of the Setup menu on the menu bar.
Left Arrow, Right Arrow	To move between menus.
Up Arrow, Down Arrow	To move between commands.
A character key	To choose the menu or command. The underlined character matches the one you type.
Enter	To choose the selected menu name or command.
Esc	To cancel the selected menu name, or to close the open menu.

DIALOG BOX KEYS

These keys are useful when working in a dialog box.

Alt-a character key	To move to the option or group whose underlined letter or number matches the one you type.
Arrow Keys	To move highlighted selections within list boxes.
Alt-Down Arrow	To open a list.
Spacebar	To select an item or cancel a selection in a list. Also to select or clear a check box.
Enter	To carry out a command.
Esc or Alt-F4	To close a dialog box without completing the command.

Table 4-2 Microsoft Windows Keyboard Shortcuts

4.7 IPSutil™ Communications Software

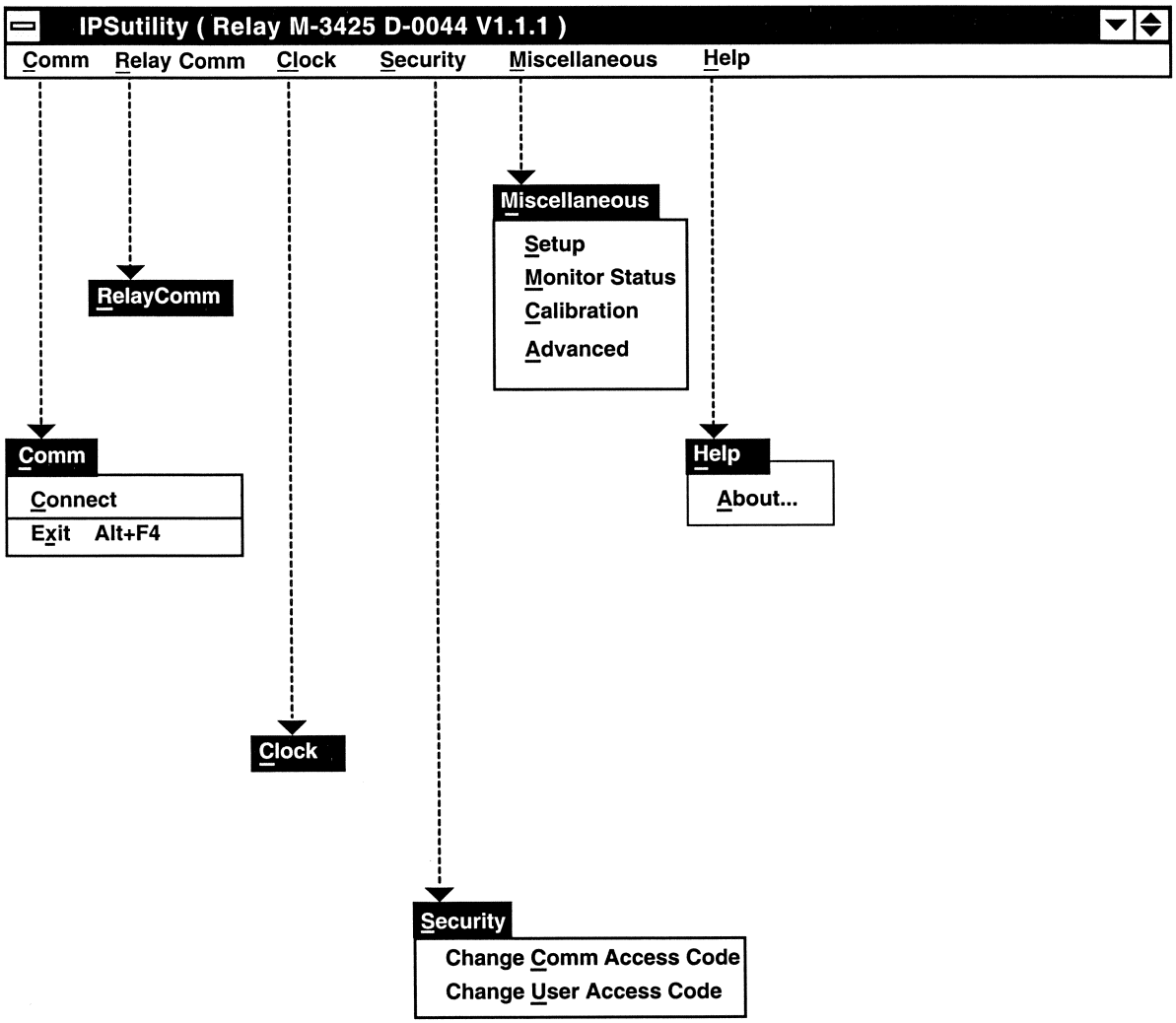


Figure 4-21 Main Menu Flow

M-3890 IPSutil

The M-3890 IPSutil Communication software package provides communication with the Beckwith Integrated Protection System® (IPS) for setting up the relays. Its main purpose is to aid in setting up IPS relays that are ordered without the optional front panel HMI interface.

WARNING: For convenience, Beckwith Electric distributes both the IPScom® and IPSutil programs on the same disk. The user should be aware, however, that the IPSutil program has the capability of overriding the security parameters set in the relay. It is recommended that you remove the IPSutil program from the IPScom disk and file it separately in a safe place, to be used by authorized people.

Installation and Setup

IPSutil™ runs with the Microsoft® Windows 95 operating system or above. Hardware requirements are the same as those stated for IPScom®.

Installation

An installation utility has been provided as a part of IPScom and IPSutil programs. After installation, IPSutil can be run from the hard drive by choosing IPSUTIL.EXE.

System Setup

Connect a null modem cable from COM1 of the relay to the PC serial port. IPSutil supports COM1 port direct connection only. Modem connection is not supported. IPSutil is not supported through COM2 or COM3 ports of the relay.

Overview

IPSutil helps in setting up IPS relays which were ordered without the optional front panel HMI interface. Units delivered without HMI's are shipped with a set of factory default settings for various parameters that the end user may wish to change. While the utility program is directed to users that do not have HMI, users of HMI-provided relays can also use IPSutil to set various parameters. When IPSutil is started, a warning window appears:

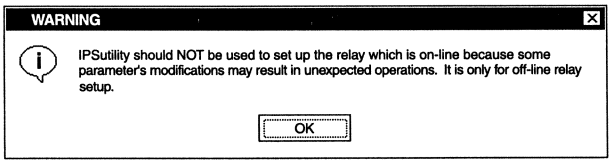
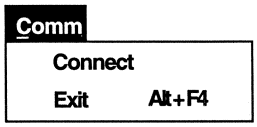


Figure 4-22 Warning Message

After you accept the warning, you can access the IPSutil main menu. The following sections describe each IPSutil menu items.

Comm Menu

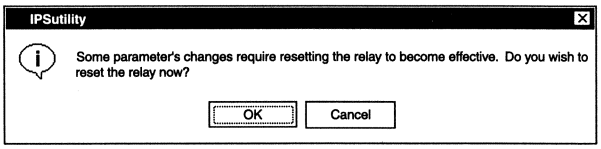


The **Comm** menu allows you to make connections to the relay. This is the first command you must use to access the unit. After you click the **Connect** submenu item, the Communications dialog box appears (See Figure 4-24).

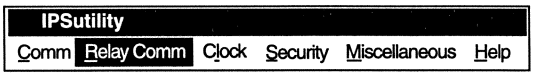
- Select the correct PC communication port where the null modem cable is connected for the relay.
- Select the baud rate of the relay. Factory default is 9600 baud.
- Select the access code resident in the relay. Factory default is 9999.
- Click "Open com" button.

The following message window will appear showing COM opened. Now, the title bar will display the relay model and the software version.

The **Exit** submenu allows you to quit IPSutil. If the relay was connected, this submenu disconnects the relay. When the relay was connected, if you have made any changes for some parameters (for example, baud rate, phase rotation) the following message window appears.



Relay Comm Command



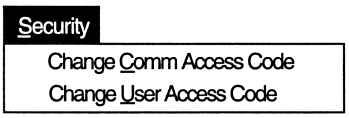
When **Relay Comm** command is selected, the Relay Comm Port Settings dialog box appears (see Figure 4-24). It allows you to set the relay communication ports COM1 or COM2/COM3 baud rate. For COM2/COM3, it allows you to set the protocol and dead sync time. Additionally, for COM2 and COM3, if you select MODBUS protocol, the dialog box allows you to enable the parity option.

■ **NOTE:** If COM1 baud rate is changed and the relay is reset, the new baud rate must be used to communicate with COM1.

Clock Command

When the **Clock** command is selected, the "Set Unit Date/Time" dialog box appears (See Figure 4-26). Date and Time can be changed and sent to the relay. This dialog box allows you to start or stop the clock in the relay.

Security Menu



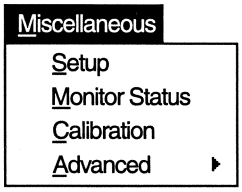
The **Security** Menu allows you to set the communication access code and the level access codes for the relay.

The **Change Comm Access Code** allows you to assign new communication access code to the relay. The range of the access code is 1 to 9999. Note that the access code 9999 is a factory default (See Figure 4-27).

■ **NOTE:** Setting the access code to 9999 disables security.

The **Change User Access Code** allows you to assign three different levels of access code for the relay functions accessibility. The range of the level access code is 1 to 9999 (See Figure 4-28).

Miscellaneous Menu



The **Miscellaneous** menu allows you to set and monitor some of the relay parameters.

The **Setup** command allows you to change the users Logo information, test outputs, assign communication address and user control number, phase rotation, **OK** LED flash mode in the relay. Note that the highest number used for the communication address is 255 and the highest control number allowed is 9999 (See Figure 4-29).

The **Monitor Status** command allows you to monitor and clear the error code counters, monitor the check sums, and to view inputs test status. Note that the powerloss counter cannot be cleared.

The **Calibration** command allows easy access to the relay's Autocalibration features (see also Section 6.3, Autocalibration), including Auto Calibrate, Nominal Frequency, Third Harmonic, and, if purchased, the 64F Field Ground function. See Figure 4-23, below.

The **Advanced** command is reserved for factory use only.

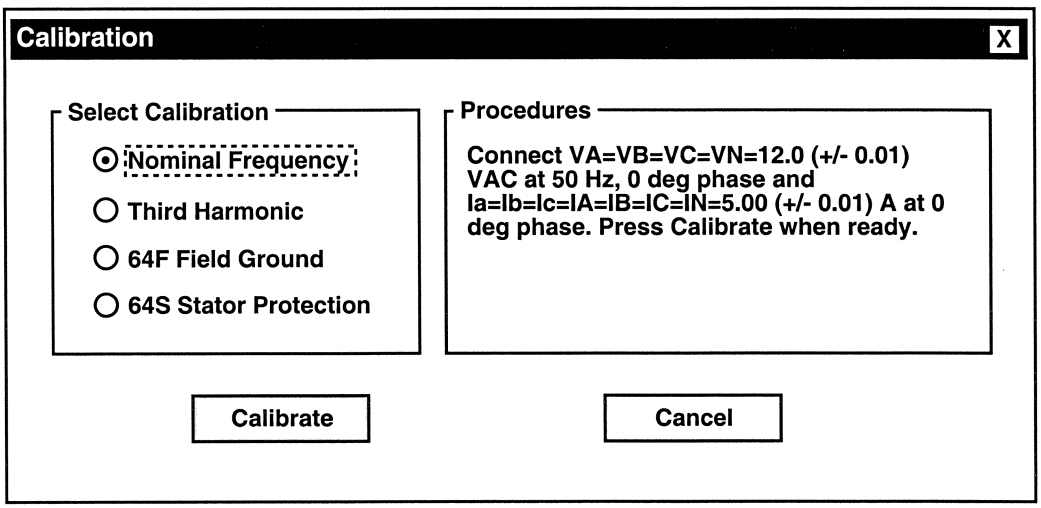
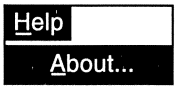


Figure 4-23 Calibration Dialog Box

Help Menu



Under **Help**, the **About...** submenu provides you the information on the IPSUtil™ version numbers.

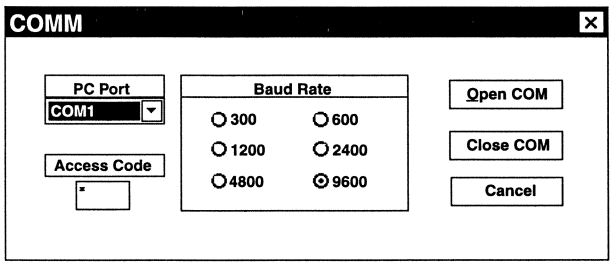


Figure 4-24 Communication Dialog

COMMAND BUTTONS

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

Close COM Discontinues communication with the protective system.

Cancel Returns you to the IPSutil™ main window. Any changes to the displayed information are lost.

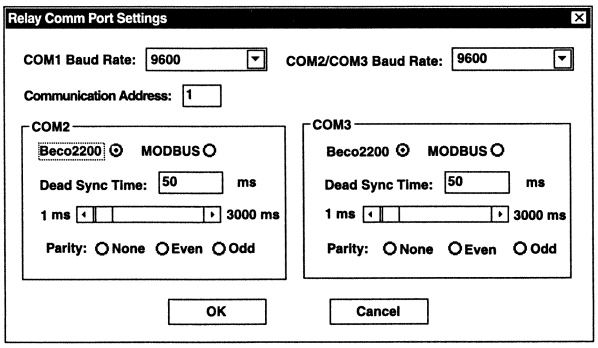


Figure 4-25 Relay Comm Port Settings

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

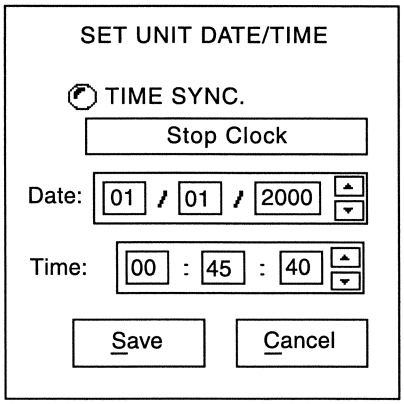


Figure 4-26 Unit Date/Time Dialog Box

COMMAND BUTTONS

Stop Clock This toggles between start/stop the clock of the relay. The 'Stop' stops the clock in the relay. The 'Start' resumes the clock in the relay.

Save When connected to the protection system, the date and time information on the display is sent to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

There is a blue Time Sync LED mimic on this dialog box (the LED is displayed as different shading on a monochrome monitor). When this LED is blue, the relay is synchronized with the IRIG-B signal and the Time field is grayed out, indicating that this field can't be changed. But the Date field can be changed (by editing and pressing **Save**). When the LED is *not* blue, the relay is not time-synchronized and therefore, both the Date and Time fields can be changed. The time field in the dialog box is not updated continuously. The time at which the dialog box was opened is the time that is displayed and remains as such. This is true whether the relay is synchronized with the IRIG-B signal or not.

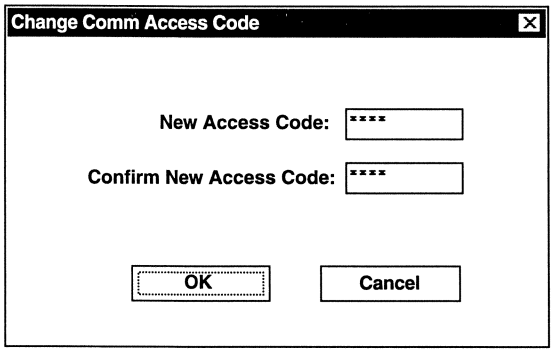


Figure 4-27 Change Communication Access Code Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil™ main window. Any changes to the displayed information are lost.

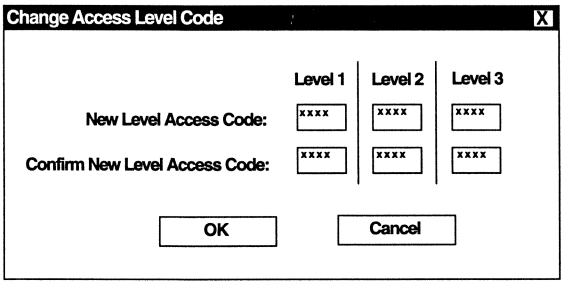


Figure 4-28 Change User Access Code Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

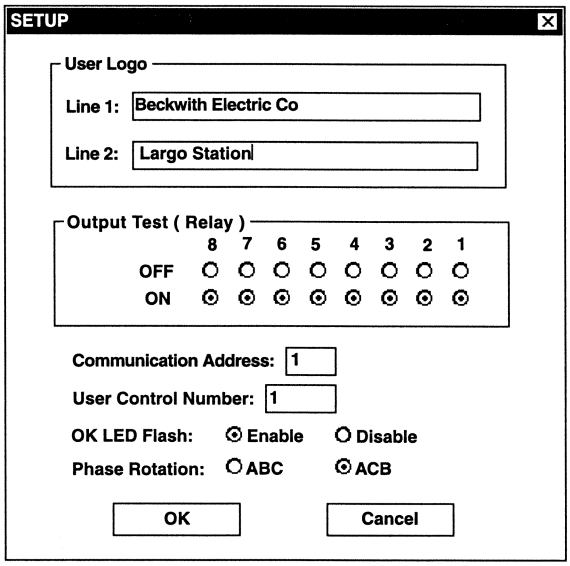


Figure 4-29 Setup Dialog Box

COMMAND BUTTONS

OK Sends the currently displayed information to the relay.

Cancel Returns you to the IPSutil main window. Any changes to the displayed information are lost.

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5 Installation

5.1 General Information

The person or group responsible for the installation of the relay will find herein all mechanical information required for physical installation, equipment ratings, and all external connections in this chapter. For reference, the Three-Line Connection Diagram is repeated from Chapter 2, **Application**. Further, a commissioning checkout procedure is outlined using the HMI option to check the external CT and VT connections. Additional tests which may be desirable at the time of installation are described in Chapter 6, **Testing**.

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

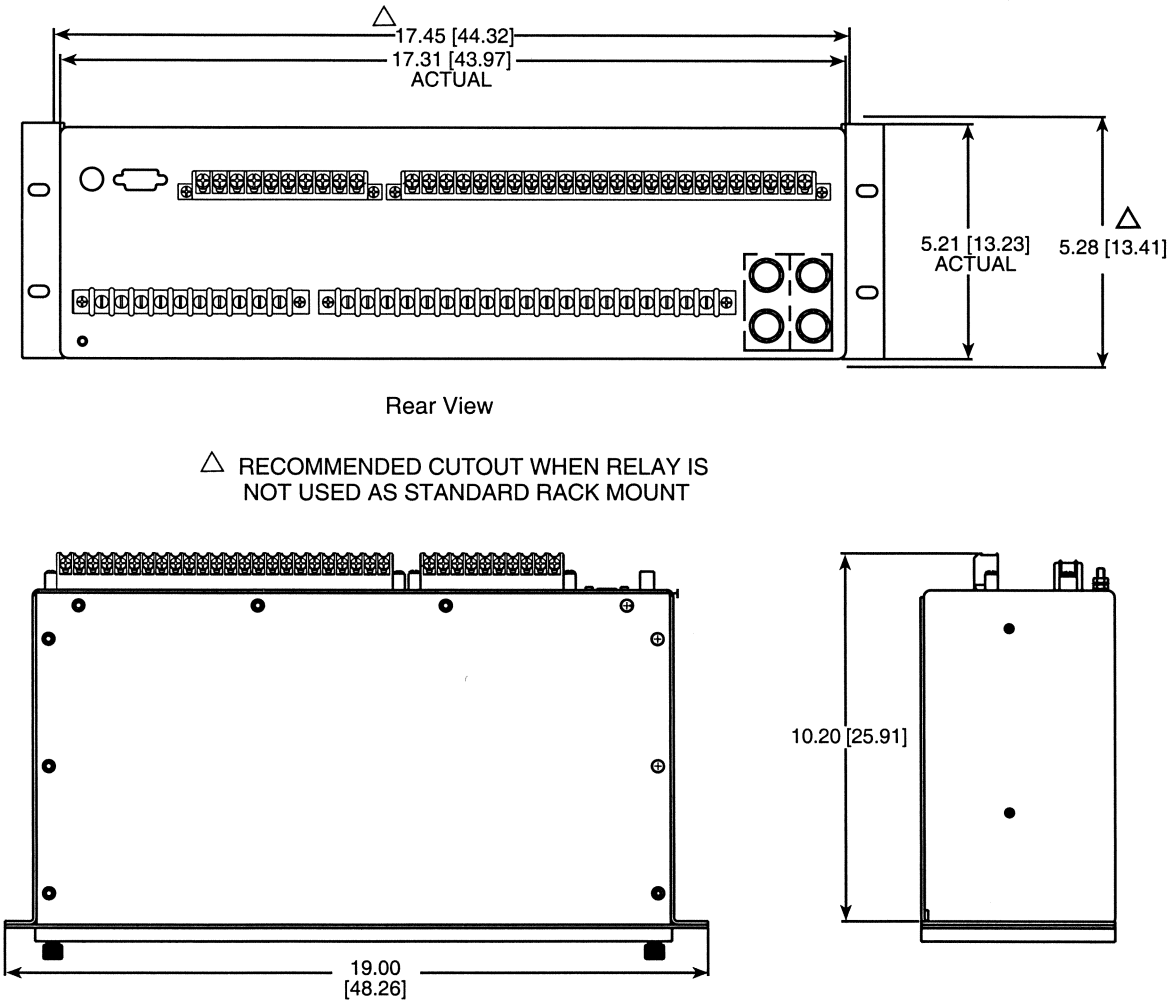
It is suggested the terminal connections illustrated here be transferred to *station* one-line wiring and three-line connection diagrams, *station* panel drawings and *station* DC wiring schematics.

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

The operation of the relay, including the initial setup procedure, is described in Chapter 3, **Operation**, for HMI front panel users and in Chapter 4, **Remote Operation**, when using a personal computer. Section 3.1, Front Panel Controls, details the front panel controls. Section 3.2, Initial Setup Procedure/Settings, details the HMI setup procedure. This includes details necessary for input of the communications data, unit setup data, configure relays data, the individual setpoints and time settings for each function, and oscillograph recorder setup information. Section 3.3, Status/Metering, guides the operator through the checkout status procedures, including monitoring the status and viewing the target history.

5.2 Mechanical/Physical Dimensions

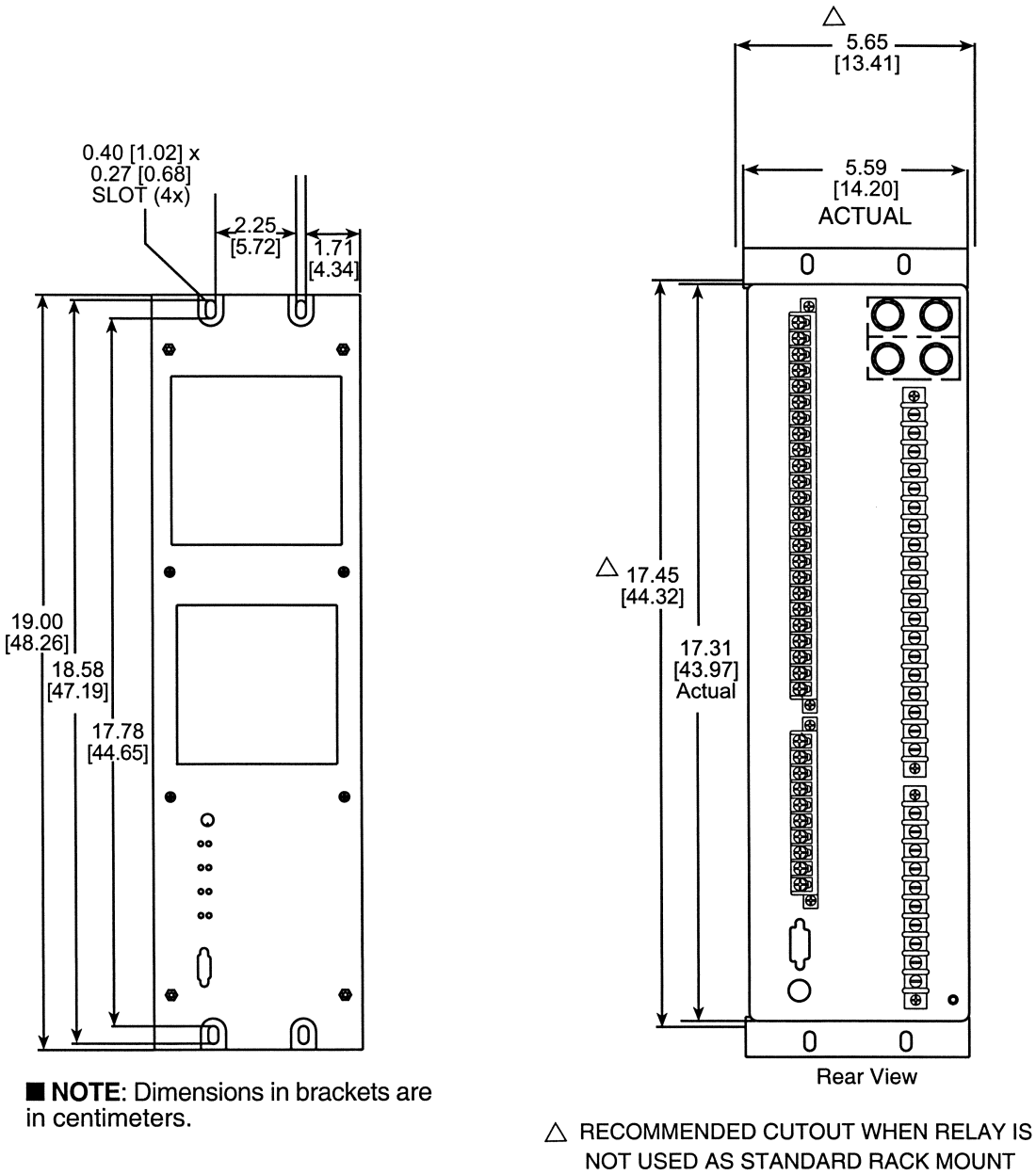
Figures 5-1, 5-2, 5-3, and 5-4 contain physical dimensions of the relay that may be required for mounting the unit on a rack.



Standard 19" Horizontal Mount Chassis

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

Figure 5-1 M-3425 Mounting Dimensions – Horizontal Chassis



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

△ RECOMMENDED CUTOUT WHEN RELAY IS NOT USED AS STANDARD RACK MOUNT

Optional Vertical Mount Chassis

Figure 5-2 M-3425 Mounting Dimensions – Vertical Chassis

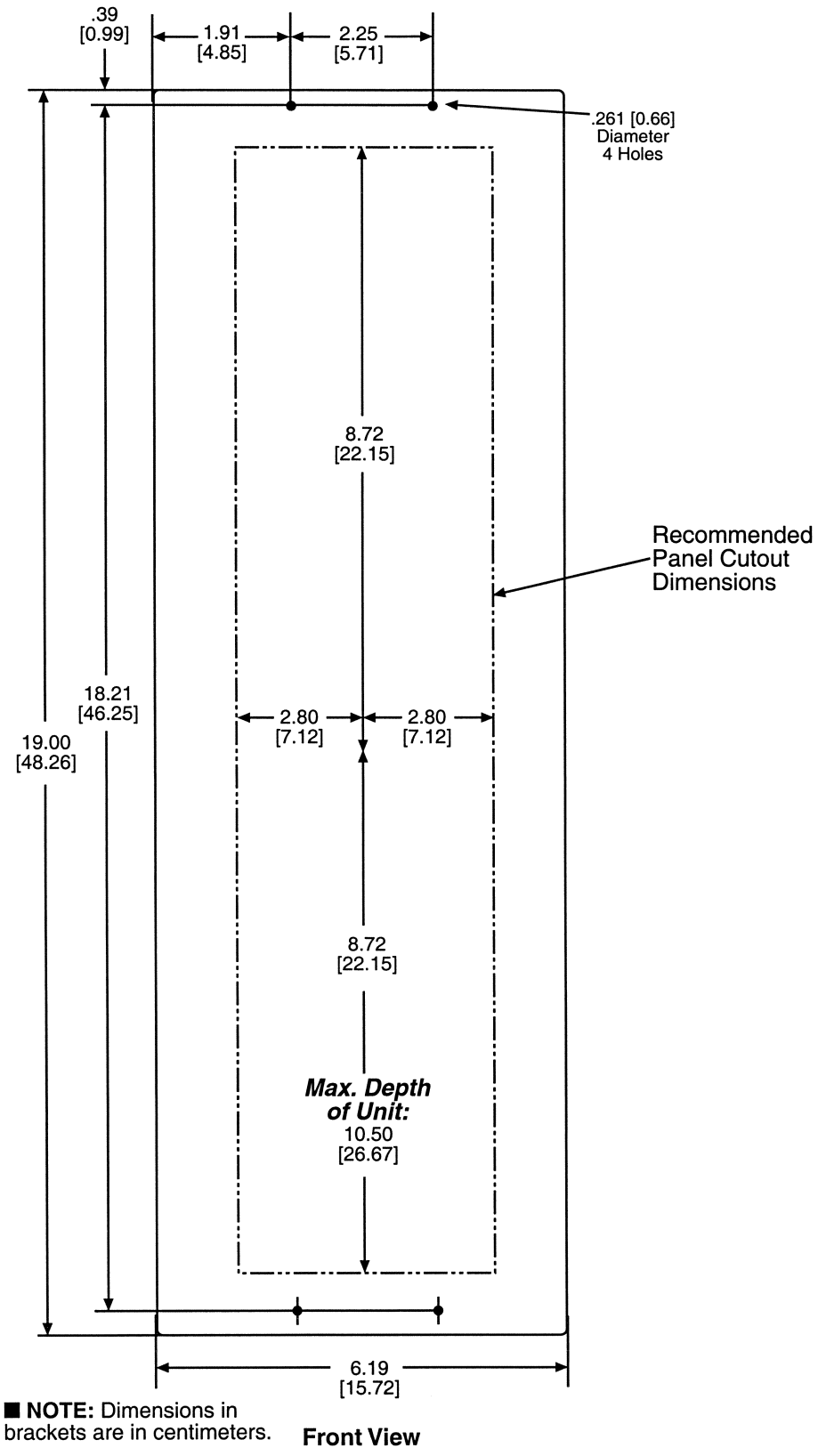


Figure 5-3 (H2) Mounting Dimensions

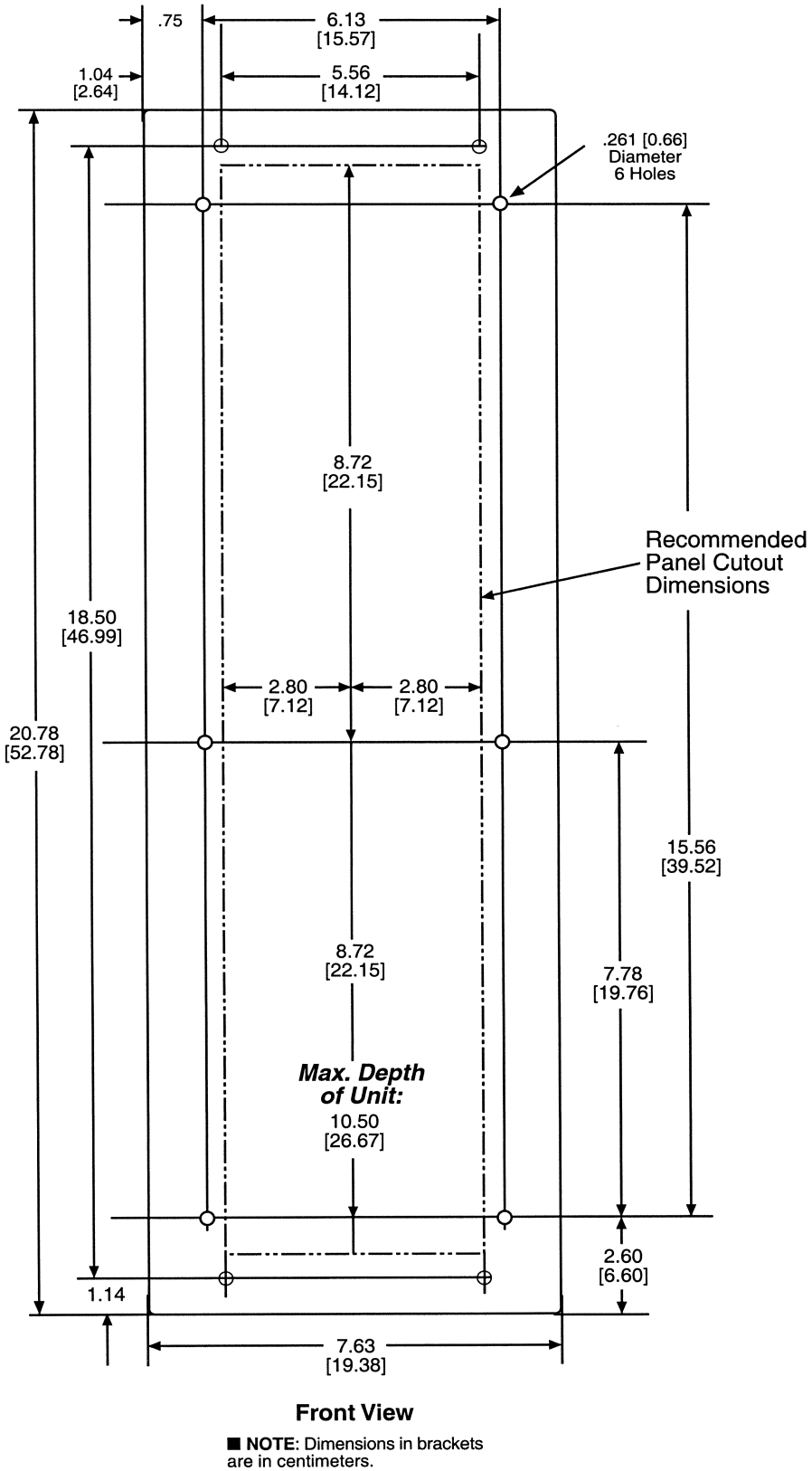


Figure 5-4 (H3) Mounting Dimensions for GE L-2 Cabinet

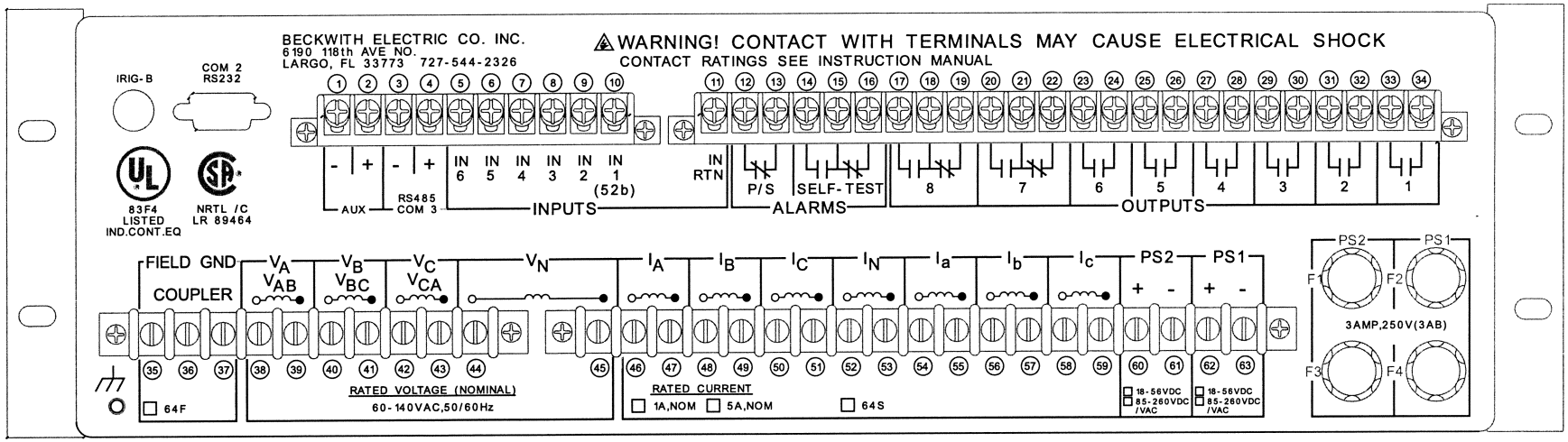


Figure 5-5 External Connections

■ **NOTES**:
All relays are shown in the de-energized state.

Output contacts #1 through #4 are high speed operation contacts.

The power supply relay (P/S) is energized when the power supply is OK.

The self-test relay is energized when the relay has performed all self-tests successfully.

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

Torque Requirements:

- **Terminals 1–34**: 7.5 in-lbs, minimum, and 8.0 in-lbs, maximum.
- **Terminals 35–63**: 8.5 in-lbs, minimum, and 9.0 in-lbs, maximum.

● **WARNING: ONLY DRY CONTACTS must be connected to inputs (terminals 5 through 10 with 11 common) because these contact inputs are internally wetted. Application of external voltage on these inputs may result in damage to the units.**

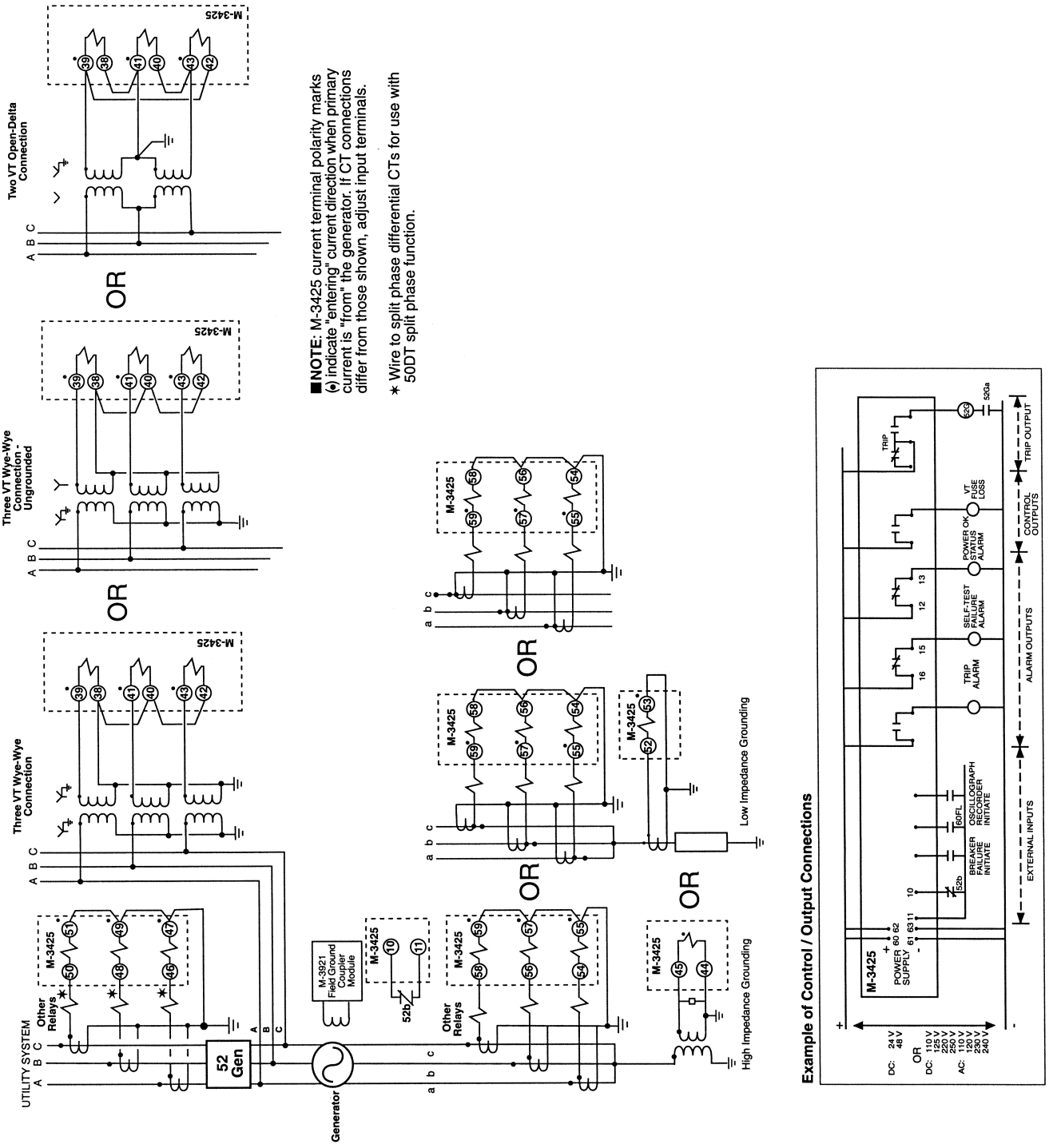


Figure 5-6 Three-Line Connection Diagram

5.3 Commissioning Checkout

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

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

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

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

```
STATUS
← config sys STAT →
```

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

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

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

```
PHASE VOLTAGE (VOLTS)
A=      B=     C=
```

Compare these voltages with actual measurements using a voltmeter. If there is a discrepancy, check for loose connections to the rear terminal block of the unit. If line-ground to line-line voltage selection is used, the voltages displayed are S3 times of the line-ground voltages applied.

5. Press **ENTER** to display the Neutral Voltage:

```
NEUTRAL VOLTAGE
_____ Volts
```

The neutral voltage should be near zero volts.

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

```
POS SEQUENCE VOLTAGE
_____ Volts
```

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

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

```
NEG SEQUENCE VOLTAGE
0.0 Volts
```

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

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

```
ZERO SEQUENCE VOLTAGE
0.0 Volts
```

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

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

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

```
3RD HARMONIC NTRL VOLT
0.00 Volts
```

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

```
FIELD GND MEAS. CIRCUIT
220.82 mV
```

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

```
STATOR LOW FREQ. INJECT.
0.0 Volts
```

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

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

13. Press the right arrow to display:

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

14. Press **ENTER** to display line currents (I_A, I_B, I_C). The unit should display:

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

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

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

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

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

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

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

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

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

```
NEUTRAL CURRENT
_____ Amps
```

The Neutral Current IN should be near zero Amps.

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

```
GND DIFFERENTIAL CURRENT
_____ Amps
```

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

```
POS SEQUENCE CURRENT
_____ Amps
```

The positive sequence current should be I_{POS} y I_a y I_b y I_c.

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

```
NEG SEQUENCE CURRENT
0.0 Amps
```

Negative sequence current should near zero amperes.

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

```
ZERO SEQUENCE CURRENT
0.0 Amps
```

The zero sequence current should be I_{ZERO}y0 A. If a significant amount of negative or zero sequence current (greater than 25% of I_A, I_B, I_C,) then either the phase sequence or the polarities are incorrect. Modify connections to obtain proper phase sequence and polarities.

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

```
STATOR LOW FREQ. INJECT.
I = 0.0 mAmps
```

23. Press **EXIT, then** the Right arrow to display:

```
POWER STATUS
← POWER imped i/o timer →
```

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

```
REAL POWER
__________    pu ____W
```

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

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

```
REACTIVE POWER
_________ PU  ____VAr
```

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

```
APPARENT POWER
_________ pu   _____va
```

27. Press **ENTER** to display:

```
POWER FACTOR
__ Lag/Lead
```

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

5.4 Circuit Board Switches and Jumpers

JUMPER	POSITION	DESCRIPTION
J60	A to B	Connects CD signal to pin 1 of COM2 (Default)
	B to C	Connects +15V to pin 1 of COM2
J61	A to B	Connects -15V to pin 9 of COM2
	B to C	COM2 pin 9 float (Default)
	B to C	Receiver disabled while transmitting (Default)
J18	A to B	COM3 200 ohm termination resistor inserted
	B to C	COM3 no termination (Default)
J46	A to B	COM3 shares Baud rate with COM1
	B to C	COM3 shares Baud rate with COM2 (Default)
J5	AB	Demodulated IRIG-B TTL signal on pin 6 COM2
	BC	Modulated IRIG-B signal BNC (Default)

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

Table 5-1 Jumpers

Dipswitch SW1				
1	**2**	**3**	**4**	
	X	X	X	Open (up)
X				Closed (down)

Switches should not be changed while unit is energized.

3 up	4 up	Run Mode
3 up	4 down	Initialize EEPROM to default*
3 down	4 up	Initialize Access Codes and Communication*
3 down	4 down	Factory Use
2 up		Flash Update Disable (Factory Default)
2 down		Flash Update Enable
1 up		Dual Power Supply Unit
1 down		Single Power Supply Unit

**After power up, the OK LED light remains off and the Diagnostic LED will light when operation has been satisfactorily completed.*

Table 5-2 Dip Switch SW-1

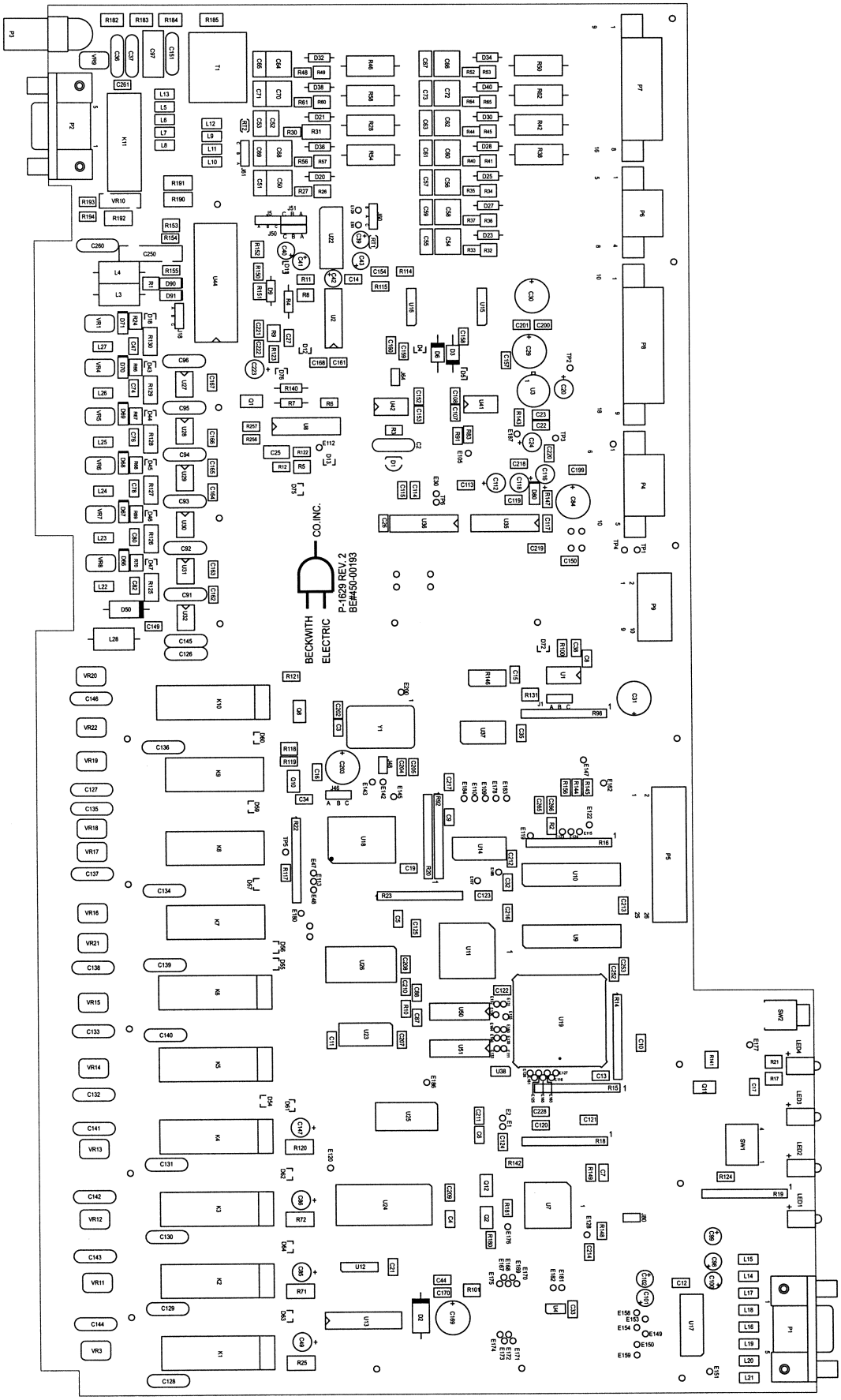


Figure 5-7 M-3425 Circuit Board

6 Testing

6.1 Equipment/Test Setup

No calibration is necessary, as the M-3425 Generator Protection Relay is calibrated and fully tested at the factory. If calibration is necessary because of a component replacement, follow the auto calibration procedure detailed in Section 6.3, Auto Calibration (or see Section 5.4 for units without an HMI). These test procedures are based on the prerequisite that the functions are enabled and have settings as described in Chapter 2, **Application**, and that the unit is fitted with the optional HMI module.

Equipment Required

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

1. Two Digital Multimeters (DMM) with 10 A current range.
2. 120 V ac or 0 to 125 V dc variable supply for system power.
3. Three-phase independent voltage sources (0 to 250 V) variable phase to simulate VT inputs.
4. Three-phase independent current sources (0 to 25 A) variable phase to simulate CT inputs.
5. Electronic timer accurate to at least 8 ms.
6. For relays with the 64F/B option:

    a. Resistor decade box capable of 500 ohms to 150 kOhms, able to step in 100 ohm increments.

    b. Capacitors ranging from 0.15 mf to 10 μf.

Setup

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

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

2. For each test procedure, connect the voltage and current sources according to the configuration listed in the test procedure and follow the steps outlined. When the testing of one function may cause another function to operate depending on the particular settings, it is recommended the untested function be disabled. (See Table 6-1.)

Function Being Tested	Function to Disable																								
	21	24DT	24IT	27	27TN	32	40	46	50	50/27	50BF	50DT	50N	51N	51T	51V	59	59N	60FL	64B	64F	78	81	81R	87	87GD
21																			✓			✓			✓	
24DT			✓														✓		✓							
24IT		✓															✓		✓							
27																			✓							
27TN																										
32																			✓						✓	
40	✓					✓													✓						✓	
46									✓						✓	✓									✓	
50															✓	✓									✓	✓
50/27				✓							✓														✓	
50BF																			✓						✓	
50DT																										
50N														✓												✓
51N													✓													✓
51T																										
51V							✓																		✓	✓
59																										
59N					✓																					
60FL				✓		✓																			✓	
64B																					✓					
64F																				✓						
78	✓						✓																✓		✓	
81		✓	✓																					✓		
81R		✓	✓																							
87								✓			✓															
87GD								✓																	✓	

Table 6-1 Functions to Disable When Testing

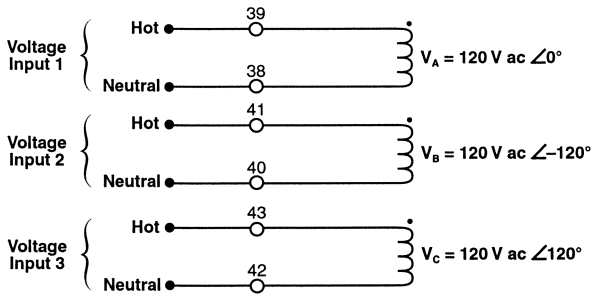


Figure 6-1 Voltage Inputs: Configuration V1

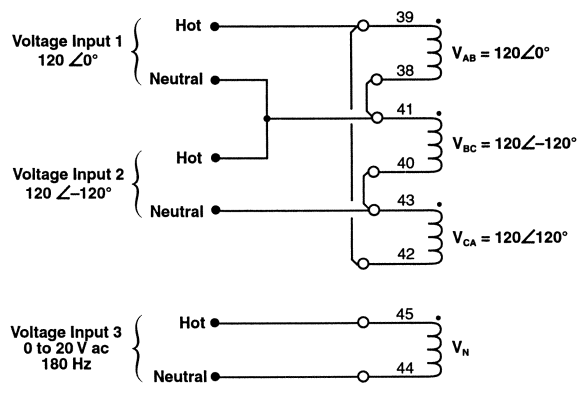


Figure 6-2 Voltage Inputs: Configuration V2

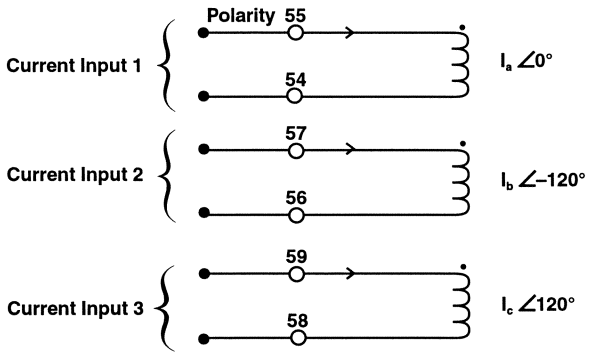


Figure 6-3 Current Inputs: Configuration C1

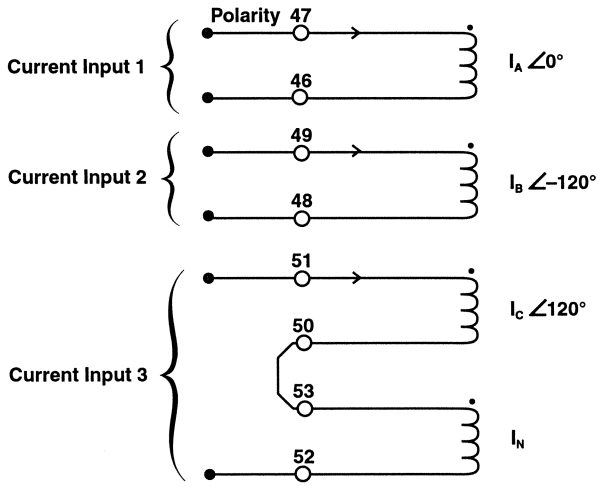


Figure 6-4 Current Inputs: Configuration C2

■ **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 V ∠120° and V_C=120 V ∠240°. Similarly other voltages and currents phase angles should be adjusted. These test configurations are for ABC phase rotation. They must be adjusted appropriately for ACB phase rotation.

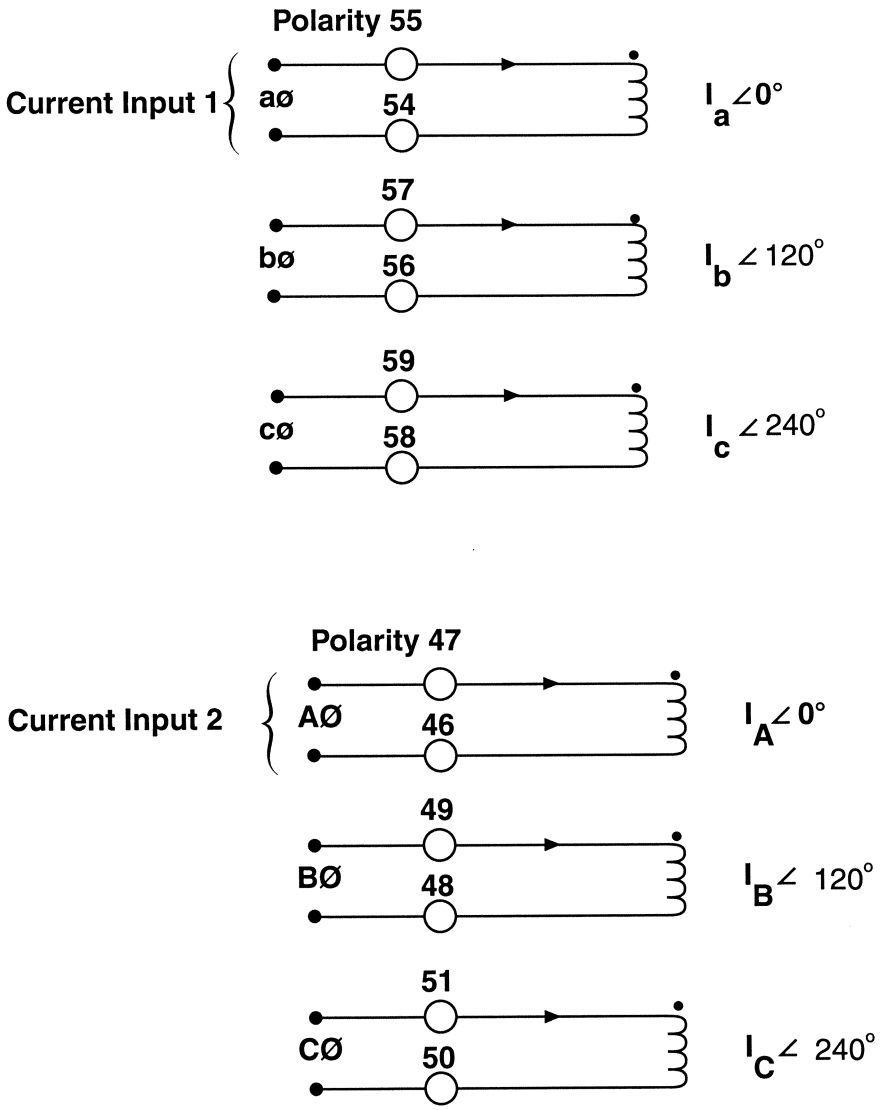


Figure 6-5 Current Configuration C3

6.2 Diagnostic Test Procedures

The diagnostic procedures perform basic functional tests to verify the operation of the front-panel controls, inputs and outputs, and communication ports. These tests are performed in diagnostic mode, which is entered in the following manner:

1. Press **ENTER** to begin main menu.
2. Press the right arrow button until **SETUP UNIT** appears on the top line of the display.
3. Press **ENTER** to access the **SETUP UNIT** menu.
4. Press the right arrow button until **DIAGNOSTIC MODE** appears in the display.
5. Press **ENTER**. A reset warning appears: **PROCESSOR WILL RESET!** (Relay functions are inoperative in Diagnostic Mode.)
6. Press **ENTER**. Unit will reset and **DIAGNOSTIC MODE** will be temporarily displayed, followed by **OUTPUT TEST (RELAY)**. This is the beginning of the diagnostic menu.

The diagnostic menu includes the following tests: Output, Input, Status LED, Target LED, Button, Display, COM1/COM2/COM3 Loopback, COM3 2-Wire, Clock, Flash Relay OK, and Auto Calibration. Each is described individually in this chapter (Auto Calibration is described in detail in Section 6.3, Auto Calibration). The left arrow and right arrow buttons are used to move within the diagnostic menu.

After **EXIT** is pushed, **PRESS EXIT TO EXIT DIAGNOSTIC MODE** is displayed.

Output Test (Relay)

The first step in testing the operation of the function outputs is to confirm the positions of the outputs in the unoperated or **OFF** position. This can be accomplished by connecting a DMM (Digital Multimeter) across the appropriate contacts and confirming open or closed. The de-energized or **OFF** positions for each output is listed in Table 6-2.

RELAY OUTPUT NUMBER	NORMALLY OPEN CONTACT	NORMALLY CLOSED CONTACT*
1	33-34	--
2	31-32	--
3	29-30	--
4	27-28	--
5	25-26	--
6	23-24	--
7	21-20	21-22
8	18-17	18-19
9 (Self-Test)	15-14	15-16
10 (Power Supply)	--	13-12

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

Table 6-2 Output Contacts

Following completion of output contact positions in the de-energized or **OFF** position, the output status can be turned **ON** in the following manner:

1. Press **ENTER**. The following is displayed:

```
RELAY NUMBER
      1
```

2. Press **ENTER**. The following is displayed:

```
RELAY NUMBER 1
OFF on
```

3. Use the right arrow button to change **ON** to upper case letters, which signifies selection.

4. Press **ENTER**. The following is displayed:

```
RELAY NUMBER
      1
```

Choose outputs 2 through 8 by using the up arrow and down arrow buttons to turn all relays or outputs to the energized or **ON** position. Note that when each output is turned on, the appropriate red **OUTPUT** LED turns on and stays on.

The DMM can now be used to verify the position of the output contacts in the operated or **ON** position. The readings should be the opposite of the initial reading above. All outputs should be returned to their initial de-energized or **OFF** positions (**OUTPUT** LEDs will go out when each output is turned off) before pushing **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Input Test (Status)

The **INPUT TEST** menu enables the user to determine the status of the individual status inputs. Individual inputs can be selected by number using the up and down arrow buttons. The status of the input will then be displayed.

INPUT NUMBER	COMMON TERMINAL	TERMINAL
1 (52b)	11	10
2	11	9
3	11	8
4	11	7
5	11	6
6	11	5

Table 6-3 Input Contacts

1. When **OUTPUT TEST (RELAY)** is displayed, press the right arrow button until the following is displayed:

```
INPUT TEST (STATUS)
output INPUT led target →
```

2. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
      1
```

3. Press **ENTER**. The following is displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

4. Connect **IN COM** terminal (terminal #11) to **IN1** terminal (terminal #10). See Table 6-3.

   Alternatively, if this specific input is being used in this application and the external wiring is complete, the actual external status input contact can be manually closed. This will test the input contact operation *and* the external wiring to the input contacts. The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT CLOSED
```

5. Disconnect **IN COM** terminal (terminal #11) from **IN1** terminal (terminal #10). The following is immediately displayed:

```
INPUT NUMBER 1
CIRCUIT OPEN
```

6. Press **ENTER**. The following is displayed:

```
INPUT NUMBER
      1
```

7. Use the up arrow button to go to the next input. Repeat the procedure using the contacts as shown in Table 6-3. When finished, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

Status LED Test

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

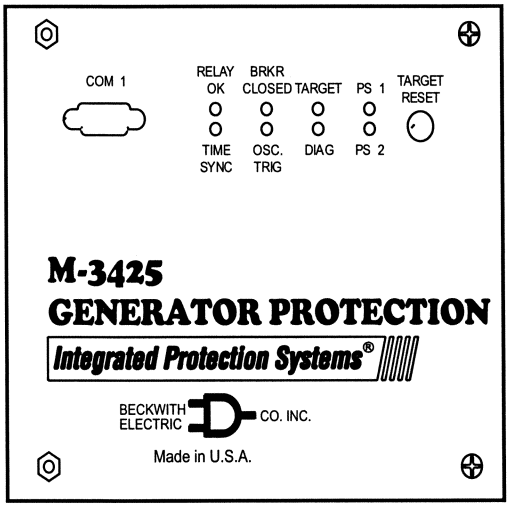


Figure 6-6 Status LED Panel

1. When **INPUT TESTS (STATUS)** is displayed, press the right arrow button until the following is displayed:

```
STATUS LED TEST
output input LED target →
```

2. Press **ENTER**. LED #1 (**RELAY OK**) lights and the following is displayed:

```
STATUS LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for the LEDs shown in Figure 6-6, with the exception of **PS1** & **PS2** LEDs.

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

Target LED Test

The **TARGET LED TEST** menu allows the user to check the M-3925 Target Module LEDs individually.

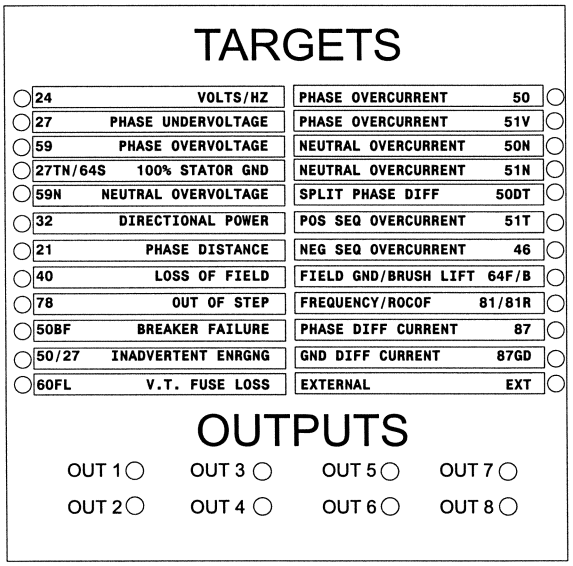


Figure 6-7 M-3925 Target Module Panel

1. When **STATUS LED TEST** is displayed, press the right arrow button until the following is displayed:

```
TARGET LED TEST
output input led TARGET →
```

2. Press **ENTER**. Target LED #1 lights and the following is displayed:

```
TARGET LED TEST
LED NUMBER 1 = ON
```

3. Repeat step 2 for each LED shown in Figure 6-7. When all LEDs have been tested, press **EXIT** to return to the **DIAGNOSTIC MODE** menu. Pressing the **TARGET RESET** button on the front panel also provides a simultaneous test for all **TARGET** LEDs.

Expanded Input/Output Test

Not implemented at this time.

Button Test

The **BUTTON TEST** menu selection allows the user to check the M-3931 HMI Module buttons. As each button is pressed, its name is displayed.

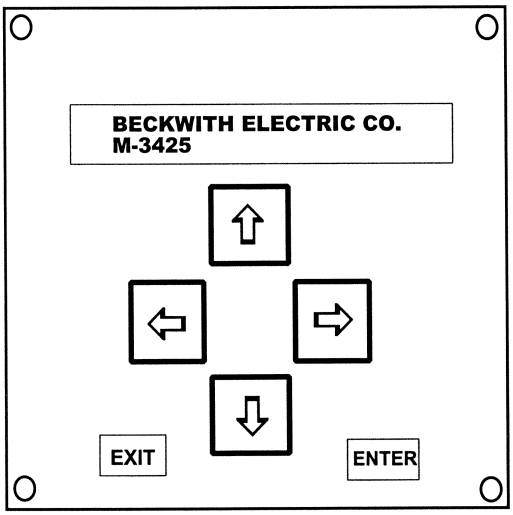


Figure 6-8 M-3931 Human-Machine Interface Module

1. When the **TARGET LED TEST** is displayed, press the right arrow button until the following is displayed:

```
BUTTON TEST
←ex_io BUTTON disp →
```

2. Press **ENTER**. The following is displayed:

```
BUTTON TEST
     0
```

3. Press each button for test. As each button is pressed, the display will briefly show the name for each key ("RIGHT ARROW", "UP ARROW", etc).

■ **NOTE:** Pressing the **EXIT** button will exit from this test, so it should be tested last. If it is pushed before this test sequence is completed, the test may be restarted by pushing **ENTER**. Notice that the word **EXIT** is displayed temporarily before the test sequence is exited.

Display Test

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

1. When **BUTTON TEST** is displayed, press the right arrow button until the following is displayed:

```
DISPLAY TEST
←ex_io button DISP→
```

2. Press **ENTER**. The unit will display a sequence of test characters until **EXIT** is pushed.
3. After the test has cycled through completely, press **EXIT** to return to the **DIAGNOSTIC MODE** menu.

COM1/COM2/COM3 Loopback Test

The **COM1 LOOPBACK TEST** menu allows the user to check the front-panel RS-232C port. A loopback plug is required for this test. **COM2 LOOPBACK TEST** menu checks the rear panel RS-232C port.

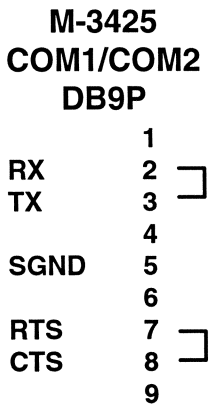


Figure 6-9 COM1/COM2 Loopback Plug

■ **NOTE:** The loopback plug required consists of a DB9P connector (male) with pin 2 (RX) connected to pin 3 (TX) and pin 7 (RTS) connected to pin 8 (CTS). No other connections are necessary.

1. When **DISPLAY TEST** is displayed, press the right arrow button until the following is displayed:

```
COM1 LOOPBACK TEST
←COM1 com2 com3 clock→
```

2. Press **ENTER**. The following is displayed:

```
COM1 LOOPBACK TEST
CONNECT LOOPBACK PLUG
```

3. Connect the loop-back plug to **COM1**, the front-panel RS-232C connector.
4. Press **ENTER**. After the test, the following is displayed:

```
COM1 LOOPBACK TEST
-DONE-
```

5. Press **EXIT** to return to the **DIAGNOSTIC MODE** menu.
6. When **COM1 TEST** is displayed, press the right arrow button until **COM2 TEST** appears and repeat steps 1 through 5 for **COM2**. Continue to **COM3 TEST**.

COM3 Test (2-Wire)

The COM3 Echo Test 2-Wire allows the user to test the RS-485 rear terminal connections for proper operation.

■ **NOTE**: This test requires a PC with an RS-485 converter and terminal emulator software installed.

1. When **COM2 LOOPBACK TEST** is displayed, press the right arrow button until the following is displayed:

```
COM3 ECHO TEST 2 WIRE
← com1 com2 COM3 clock→
```

2. Press **ENTER**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
IDLING...9600, N, 8, 1
```

3. On the rear of the unit, connect a PC to the relay at terminals 3(-) and 4(+) via RS-485 converter set for 2-wire operation. See Figure 6-10 for diagram.

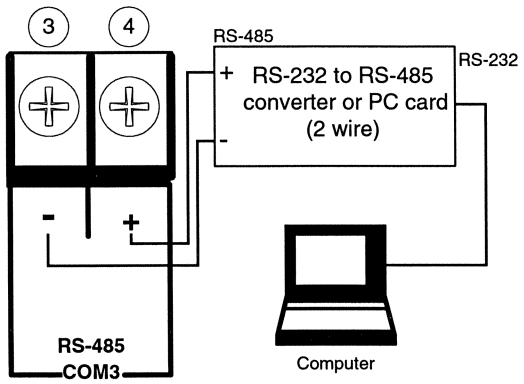


Figure 6-10 RS-485 2-Wire Testing

4. Set the following PC communications parameters:

Baud Rate	9600
Parity	None
Data Bits	8
Stop Bits	1
Duplex	Half

5. Open the terminal emulator program on the PC and open the COM port for the RS-485 converter.
6. Press a key on the PC keyboard. Verify that the character pressed shows temporarily on the relay's display, and appears on the PC monitor.
7. When communication has been verified, press **EXIT**. The following is displayed:

```
COM3 ECHO TEST 2WIRE
-DONE-
```

8. Close the COM port on the PC, and exit the terminal program.

Clock Test

```
CLOCK TEST
←com1 com2 com3 CLOCK→
```

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

```
CLOCK TEST
01-Jan-2001 01:01:80
```

2. Pressing **ENTER** will start the clock for testing, and unit will display:

```
CLOCK TEST
CLOCK START
```

3. Repeat number 2 above to stop clock.
4. When finished, press **EXIT** twice. After initial press of **EXIT**, unit will display:

```
CLOCK TEST
-DONE-
```

■ **NOTE**: '80' will be displayed in the seconds place when the clock is stopped. To preserve battery life, the clock should be stopped if the unit is to be powered down for long periods of time.

Flash Relay OK LED Test

1. Press the right arrow until the unit displays:

```
FLASH RELAY OK LED
← clock LED cal factory
```

2. Press ENTER. Unit will display:

```
FLASH RELAY OK LED
OFF on
```

3. Use the right arrow key to select "ON", and press Enter. The unit will display

```
FLASH RELAY OK LED
-DONE-
```

4. Press Exit to return to the former menu.

Auto Calibration

Refer to the following Section 6.3, Auto Calibration, for more information on that function.

```
AUTO CALIBRATION
← clock led CAL factory
```

Factory Use Only

This function is provided to allow access by factory personnel.

```
FACTORY USE ONLY
← clock led cal FACTORY
```

6.3 Auto Calibration

■ **NOTE:** The M-3425 Generator Protection Relay has been fully calibrated at the factory. There is no need to recalibrate the unit prior to initial installation (In-system calibration of the 64F function may be needed for units purchased with the 64F Field Ground option). Calibration can be initiated via the HMI or IPSutil™ program.

Phase and Neutral Fundamental Calibration

1. Enter Diagnostic Mode and press the right arrow button until the following is displayed:

```
AUTO CALIBRATION
← CAL factory
```

2. Press **ENTER**. The following is displayed:

```
CONNECT REFERENCE INPUTS
PRESS ENTER TO CALIBRATE
```

3. Connect $V_A = V_B = V_C = V_N$ = 120.0(±0.01)V at 0° phase. (See Figure 6-12.)
4. Connect $I_a=I_b=I_c=I_A=I_B=I_C=I_N$=5.00** Amps at 0° (see Figure 6-11).

   ** *For a 1 A CT rating, use 1 A.*

The calibration can be verified by reading status:

$V_A=V_B=V_C=V_N$=120V $V_1=V_2$=0 V_0=120V

$I_A=I_B=I_C$=5 A** $I_1=I_2$=0 I_0=5 A*

$I_a=I_b=I_c$=5 A*

Real=1 pu Reactive=0.0 pu

Power Factor = 1.0

$I_{diffa} = I_{diffb} = I_{diffc} = 0$

Where subscript 0, 1, and 2 represent zero, positive, and negative sequence quantities, respectively.

** *For a 1 A CT rating, use 1 A.*

■ **NOTE:** The phase angle difference between voltage and current input source should be 0°, K0.05°, and an accurate low-distortion source should be used. (THD less than 1%).

5. Press **ENTER**. The display will show **WAIT** while the relay is being calibrated. When calibration is complete, the display will read **CONNECT 180 Hz INPUTS** (150 Hz for 50 Hz models).
6. Remove the calibration source inputs. If you wish to calibrate the third harmonic, continue to Third Harmonic Calibration. If not, press **EXIT** to exit calibration mode.

Third Harmonic Calibration

1. If the user wishes to calibrate the third harmonic only, follow the Step #1 and #2 procedures for calibration (above), and press the down arrow when the display reads **CONNECT 60 Hz INPUTS**. The display will then read **CONNECT 180 Hz INPUTS** (150 Hz for 50 Hz models).
2. Connect V_N=10 V, 180 Hz (150 Hz for 50 Hz units). See Figure 6-12.
3. Press **ENTER**. The display will show **WAIT** while the third harmonic is calibrated. When calibration is complete, it will show **DONE**.
4. Remove the voltage from V_N.

Field Ground Calibration

Field Ground Calibration only applies to units purchased with the 64F Field Ground option. Calibration is necessary for long cable lengths (greater than 100 feet) to compensate for cabling losses from the M-3425 and the M-3921 Coupler module, and therefore should be accomplished in system, after all wiring is complete.

1. Connect the M-3921 Field Ground Coupler box as shown in Figure 6-13, Field Ground Coupler Calibration.
2. Enter the Calibration menu in Diagnostic mode and select the FIELD_GND item and press **ENTER**. The display will show **CONNECT 1KOHM REF. PRESS ENTER TO CALIBRATE**.
3. Set the decade box for 1kΩ resistance and press **ENTER**. When the display shows DONE press **ENTER**.
4. Set the decade box to the resistance specified by the HMI, and press **ENTER**. When the display shows DONE press **ENTER**.
5. Continue step 4 until the calibration is complete for 100 kΩ.
6. Press **EXIT** twice to exit Diagnostic Mode.

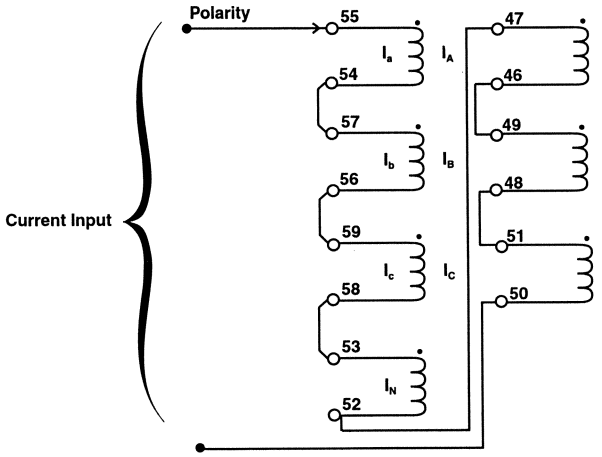


Figure 6-11 Current Input Configuration

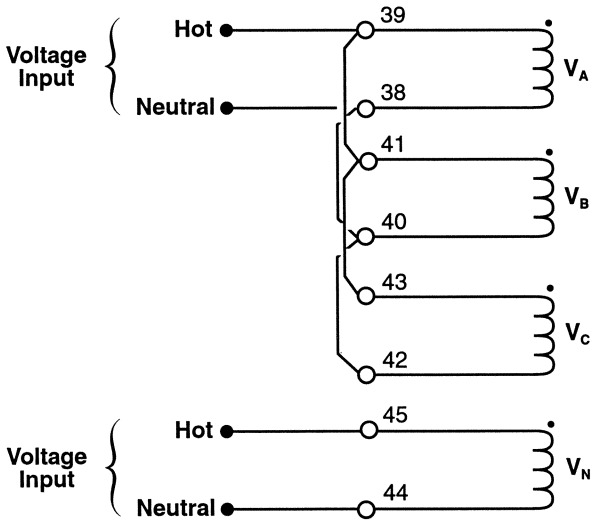
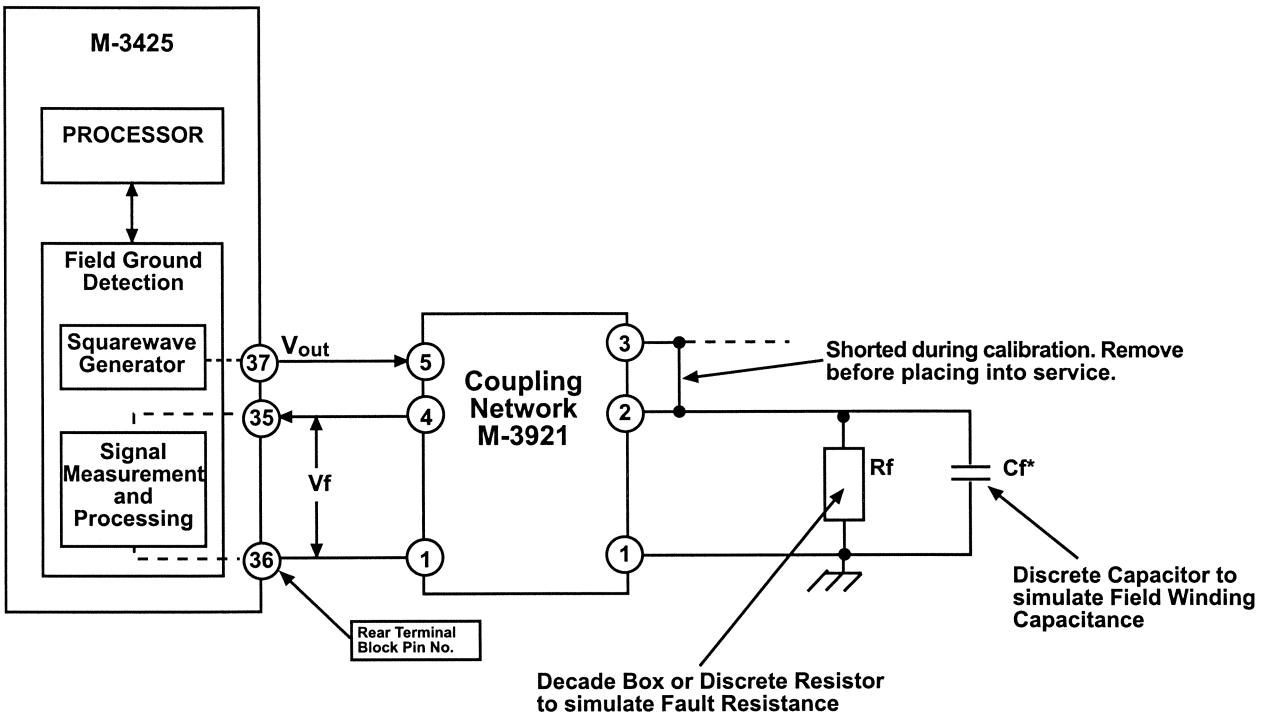


Figure 6-12 Voltage Input Configuration



*** If the rotor is NOT connected, the value of Cf should approximate the rotor capacitance. If the rotor is connected Cf is NOT required.**

Figure 6-13 Field Ground Coupler Calibration

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

6.4 Functional Test Procedures

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

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

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

It may be desirable to program all test settings in an alternate profile, or to save the relay settings in IPScom to preserve desired setup.

The tests are described in this section in ascending function number order as used in Chapter 2, **Application**. Depending on which functions are to be tested at a given time, an order may be determined with the aid of Table 6-1, Functions to Disable When Testing. This may result in the fewer changes in connections and disable/enable operations.

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

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

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

If timer quantities are to be checked, the timer must be activated by the appropriate output contacts. The contact pin numbers are enumerated in Table 6-2, Output Contacts.

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

Input Configurations – pg 6–4
Output Contact Numbers – pg 6–6
Relay Configuration Table – pg A–2
Setpoint & Timing Record Form – pg A–9

Power On Self Tests

VOLTAGE INPUTS: **none**

CURRENT INPUTS: **none**

1. Apply proper power to the power input terminals: 60 (HOT) and 61 (NEUTRAL).

2. The unit will display:

```
POWER ON SELFTESTS
XXXXXXxxxxxxxxxx
```

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

   The unit will display:

```
POWER ON SELFTESTS
PASS
```

   The model number:

```
BECKWITH ELECTRIC CO.
M-3425
```

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

```
BECKWITH ELECTRIC
D-0024xx.xx.x
```

   where "xxx" signifies the unit serial number:

```
BECKWITH ELECTRIC CO.
SERIAL NUMBER xxx
```

The **POWER** LED(s) will turn on. The **RELAY OK** LED will flash (or stay on as programmed in the setup menu) and the **BREAKER CLOSED** LED will remain on. The power-on self-tests ends with the system date and time and default logo. Any recorded targets are then displayed.

21 Phase Distance (#1 or #2) Line to Line

VOLTAGE INPUTS:Configuration V1

CURRENT INPUTS:Configuration C1

TEST SETTINGS:	**Diameter**	**P**	**ohms**	**(0.1 to 100)**
	1 Amp CT Rating			**(0.5 to 500.0)**
	Offset	**O**	**ohms**	**(–100 to 100)**
	1 Amp CT Rating			**(–500.0 to 500.0)**
	Impedance Angle	**A**	**degrees**	**(0 to 90)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**output**	**(1 to 8)**

Functions 27, 27TN, 32, 40	**Disable**
Functions 50/27, 51V	**Disable**
Functions 60FL, 21 (1 or 2)	**Disable**
Functions 78, 87	**Disable**
Delta-Y Transform	**Disable**

■ **NOTE:** It would be efficient to disable the function with the higher "reach" (Diameter plus Offset) setting first (*lower current*), and test the lower reach setting operation, since the higher reach setting operation can be tested without disabling the lower setting.

1. Disable functions as shown. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data subsection, for procedure.
2. Confirm settings to be tested.
3. Connect input in Configuration V1 and C1 as designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.
4. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as **R** ohms = (**P** ohms + **O** ohms) [**O**, usually set at zero ohms].
   b. Define "current" as **I** = ((Selected Voltage/S3)**I R** ohms). The voltage level may be selected based on the desired test current level.
5. ***Pickup Test***: Set the three-phase voltages to the Selected Voltage value from step 4b. Set the phase angle between the voltage and current inputs at (**A** – 30°) degrees from settings above. Hold the **TARGET RESET** button in and slowly increase the three-phase currents until the appropriate **21 PHASE DISTANCE** LED light goes on, or the pickup indicator operates on the computer target screen. The level should be equal to **I** calculated in step 4 with the resulting impedance ±0.1 ohms or 5%. Release the **TARGET RESET** button and decrease the **INPUT CURRENTS**, and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
6. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately 110% of the current (**I**) found in step 4, and start timing. The contacts will close after **D** cycles within ±1 cycle or ±1%.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

21 Phase Distance (#1 or #2) Line to Ground

VOLTAGE INPUTS:Configuration V1

CURRENT INPUTS:Configuration C1

TEST SETTINGS:	**Diameter**	**P**	**ohms**	**(0.1 to 100)**
	1 Amp CT Rating			**(0.5 to 500.0)**
	Offset	**O**	**ohms**	**(–100 to 100)**
	1 Amp CT Rating			**(–500.0 to 500.0)**
	Impedance Angle	**A**	**Degrees**	**(0 to 90)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**output**	**(1 to 8)**

VT Configuration	**Line-Ground**
Functions 27, 27TN, 32, 40	**Disable**
Functions 50/27, 51V	**Disable**
Functions 60FL, 21 (1 or 2)	**Disable**
Functions 78, 87	**Disable**
Delta-Y Transform	**Disable**

■ **NOTE:** It would be efficient to disable the function with the higher "reach" (Diameter plus Offset) setting first (lower current), and test the lower reach setting operation, since the higher reach setting operation can be tested without disabling the lower setting.

1. Disable functions as shown. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect input in Configuration V1 and C1 as designated above. Refer to Section 6.1, Equipment/Test Setup for configurations.
4. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as **R** ohms = (**P** ohms + **O** ohms),[**O**, usually set at zero ohms].
   b. Define "current" as **I** = ((Selected Voltage)I**R** ohms). The voltage level may be selected based on the desired test current level
5. ***Pickup Test***: Set the three-phase voltages to the Selected Voltage value from step 4b. Set the phase angle between the voltage and current inputs at (**A**) degrees from setting above. Hold the **TARGET RESET** button in and slowly increase the three-phase currents on the input until the appropriate **21 PHASE DISTANCE** LED light goes on, or the pickup indicator operates on the computer target screen. The level should be equal to **I** calculated in step 4 with the resulting impedance ±0.1 ohms or 5%. Release the **TARGET RESET** button and decrease the **INPUT CURRENTS**, and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
6. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately 110% of the current (**I**) found in step 4, and start timing. The contacts will close after **D** cycles within ±1 cycle or ±1%.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

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

VOLTAGE INPUTS: V1

CURRENT INPUTS: none

TEST SETTINGS:	**Definite Time Pickup**	**P**	**%**	**(100 to 200)**
	Time Delay	**D**	**cycles**	**(30 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 24IT, 27, 27TN	**Disable**		
	Function 24 DT (#1 or #2)	**Disable**		
	Functions 32, 59, 81, 81R	**Disable**		

■ **NOTE**: It would be efficient to disable the 24 Definite Time function with the lower pickup setting first and test the higher setting operation. Since the lower setting operation can be tested without disabling the higher setting, the 24 Definite Time functions will be enabled when the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect input in Configuration V1 as designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. The Volts per Hertz pickup level at a percentage setting at nominal frequency (50 or 60 Hz) is: Pickup voltage = (**P**% ÷ 100) x (**Nominal Voltage**) where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and are recorded on the **COMMUNICATION & UNIT SETUP RECORD FORM**.
5. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase the voltage on A phase until the **24 VOLTS/HZ** LED light goes on or the pickup indicator operates on the computer target screen. The voltage level of operation will equal **P** volts ±1%. Release the **TARGET RESET** button and decrease the voltage and the output LEDs will go out. Press **TARGET RESET** button to remove targets.
6. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately (**P** + 10 volts) volts and start timing. The contacts will close after **D** cycles within 25 cycles.
7. Test phases B and C by repeating steps 4 and 5.
8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

24 Volts/Hz Inverse Time

VOLTAGE INPUTS: V1
CURRENT INPUTS: none

TEST SETTINGS:	**Inverse Time Pickup**	**P**	**%**	**(100 to 200)**
	Inverse Time Curve	**C**		**(1 to 4)**
	Time Dial (curve 1)	**K**		**(1 to 100)**
	Time Dial (Curves 2-4)			**(0.0 to 9.0)**
	Reset Rate	**R**	**seconds**	**(1 to 999)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 24DT, 27, 27TN	**Disable**		
	Functions 32, 59, 81, 81R	**Disable**		

1. Set 24DT #1 Pickup to 200%, and Delay to 30 cycles.
2. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
3. Confirm settings to be tested.
4. Connect voltage input in Configuration V1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
5. The Volts per Hertz pickup level of a percentage setting at nominal frequency (50 or 60 Hz) is: Pickup voltage = (**P**% ÷ 100) x (**Nominal Voltage**) where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and are recorded on the Figure A-2, Communication Data & Unit Setup Record Form.
6. Test levels may be chosen at any percentages of Nominal Voltage which are a minimum of 5% higher than the pickup percentage, **P%**. (Suggest 4 or 5 test levels chosen and calculated in Step 5.)
7. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase the voltage on A phase until the **VOLTS/HZ** LED light goes on or the pickup indicator operates on the computer target screen. The voltage level of operation will equal **P** volts ±1%. Release the **TARGET RESET** button and decrease the voltage and the output LEDs will go out. Press **TARGET RESET** button to remove targets.
8. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply voltage equal to the chosen test level calculated in step 5 on A phase and start timing. The operating time will be as read from the appropriate Inverse Curve Family and **K** (Time Dial) setting (refer to Appendix D, **Inverse Time Curves**). The measured time should be within the time corresponding to ± 1% of the pickup value.
9. Repeat step 6 for all test levels chosen. The curve portion extending to lower than **P**% V/Hz values are inactive and can be ignored. The tested points verify the operating times of the function.
10. To test the reset time, begin timing immediately when the input voltage is reduced below pickup value.
11. Holding the **TARGET RESET** Button in, stop timing when the **TARGET** LED goes out. The time should be the reset time within ±1 cycle or ±1%, whichever is greater.
12. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

■ **NOTE**: If retesting is required, the unit should be powered down or wait for the programmed reset time period before the next test to assure resetting of the timer.

27 RMS Undervoltage, 3 Phase (#1 or #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:	**Pickup**	**P**	**Volts**	**(5 to 180)**
	Time Delay	**Y**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**

Functions 21, 27 (#1 or #2)	**Disable**
Functions 27TN, 32, 40	**Disable**
Functions 60FL, 78	**Disable**

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 6.1, Equipment/Test Setup for configuration. Set at Nominal Voltage.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly decrease the input voltage on phase A until **27 PHASE UNDERVOLTAGE** LED light goes on (or the pickup indicator operates on the computer target screen). The voltage level should be equal to **P** volts ±0.5 V*. Release the **TARGET RESET** button and increase the input to the nominal voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately (**P** – 1) volts and start timing. The contacts will close after **D** cycles within 20 cycles or ± 1%(RMS), or ± 1 cycle or ± 0.5% (DFT), whichever is greater.
6. Test phases B and C by repeating steps 4 and 5.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

* When both RMS and Line-Ground to Line-Line is selected, the accuracy is ± 0.8V or ± 0.75%

27TN Third-Harmonic Undervoltage, Neutral (#1 or #2)

VOLTAGE INPUTS: Configuration V2

CURRENT INPUTS: None

TEST SETTINGS:	**Pickup**	**P**	**Volts**	**(0.3 to 20.0)**
	Time Delay	**Y**	**cycles**	**(1 to 8160)**
	Undervoltage Inhibit		**Volts**	**(5 to 180)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 27TN (#1 or #2)	**Disable**		
	Functions 27, 32	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V2 designated above. See Section 6.1, Equipment/Test Setup for configuration. Set at Nominal Voltage.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly decrease the neutral voltage until **27TN/64S 100% STATOR GND** LED light goes on (or the pickup indicator operates on the computer target screen). The voltage level should be equal to **P** volts ±0.15 V or ±1%. Release the **TARGET RESET** button and increase the input to the nominal voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately (**P** – 1) volts and start timing. The contacts will close after **D** cycles within ±1 cycle or ± 1%.
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

32 Directional Power, Line to Ground, 3 Phase (#1, #2)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:	**Pickup**	**P**	**PU**	**(-3.000 to +3.000)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 32 (#1 or #2)	**Disable**		
	Functions 27TN, 40, 50/27	**Disable**		
	Functions 60FL, 78, 87	**Disable**		
	VT Configuration	**Line-Ground**		

■ **NOTE**: It would be efficient to disable the function with the lower pickup setting first and test the higher setting operation. Since the lower setting operation can be tested without disabling the higher setting, the 32 functions will be enabled when the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. The level of current at which operation is to be expected for an individual power setting is as follows: Multiply the PU pickup value (**P** above) by the **Nominal Current** previously input to the relay. This value is described in Section 2.1, Configuration and should be recorded on Figure A-2, Communication Data and Unit Setup Record Form.
5. Set the three phase voltages to the **Nominal Voltage**.
6. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the three phase currents (*for negative or reverse power flow direction, the phase angle of the phase currents are set at 180 degrees from the respective phase voltages*). Increase the currents until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the computer target screen. The level of operation will be equal to that calculated in step 4, ±2% or ±0.002 PU, whichever is greater.
7. Release the **TARGET RESET** button and decrease the currents. The **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
8. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately 110% of the pickup current and start timing. The contacts will close after **D** cycles within +16 cycles.
9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

32 Directional Power, 3 Phase Line to Line (#1, #2)

VOLTAGE INPUTS: Configuration V2

CURRENT INPUTS: Configuration C1

TEST SETTINGS:	**Pickup**	**P**	**PU**	**(-3.000 to +3.000)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Low Forward Power	**Disable**		
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 32 (#1 or #2)	**Disable**		
	Functions 27TN, 40, 50/27	**Disable**		
	Functions 60FL, 78, 87	**Disable**		
	VT Configuration	**Line-Line**		

■ **NOTE:** It would be efficient to disable the function with the lower pickup setting first and test the higher setting operation. Since the lower setting operation can be tested without disabling the higher setting, the 32 functions will be enabled when the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. The level of current at which operation is to be expected for an individual power setting is as follows: Multiply the PU pickup value (**P** above) by the **Nominal Current** previously input to the M-3425. This value is described in Section 2.1, Configuration and should be recorded on Figure A-2, Communication Data and Unit Setup Record Form.
5. Set the three phase voltages to the **Nominal Voltage**.
6. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the three phase currents (–30° angle for each phase). (■ **NOTE:** *For negative or reverse power flow direction, the phase angle of these currents are set to 180 degrees*). Increase the current until the **32 DIRECTIONAL POWER** LED light goes on or the pickup indicator operates on the computer target screen. The level of operation will be equal to that calculated in step 4, ± 2% or ± 0.002 PU.
7. Release the **TARGET RESET** button and decrease the currents. The **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
8. ***Time Test***: With output contacts **(Z)** connected to stop the timer, apply approximately 110% of the pickup current and start timing. The contacts will close after **D** cycles within +16 cycles.
9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

40 Loss of Field (#1 or #2)

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**Configuration C1**			
TEST SETTINGS:	**Diameter**	**P**	**ohms**	**(0.1 to 100)**
	Offset	**O**	**ohms**	**(–50 to 50)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Voltage Control	**V**	**Volts**	**(5 to 180)**
	Directional Element	**E**	**degrees**	**(–13)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 27, 27TN	**Disable**		
	Functions 32, 50/27, 60FL	**Disable**		
	Functions 78, 87			
	Function 40 Volt Control	**Disable**		
	Function 40 (#1 or #2)	**Disable**		
	VT Configuration	**Line-Ground**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. The level of current at which operation is to be expected for an individual setting is as follows:
   a. Define "reach" as **R ohms = (P - O ohms)** where **O** is usually negative.
   b. Define "trip current" as **I = (Selected Voltage ÷ R ohms)**. The voltage level may be selected based on the desired test current level.
   c. Define "offset current" as **IO = (Selected Voltage ÷ O ohms).**
5. Set the three-phase voltages V_A, V_B, and V_C to the **Selected Voltage** value from step 4, and set the phase angle between the voltage and current inputs to 90° (current leading voltage).
6. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the three-phase currents until the appropriate **40 LOSS OF FIELD** LED light goes on or the pickup indicator operates on the computer target screen. The level will be equal to **"I"** calculated in step 4 with the resulting impedance within ± 0.1 ohms or ± 5%. *If the offset is negative, continue to increase the current until the LED light goes out. The level will be equal to **"IO"** calculated in step 4 with the resulting offset impedance within ±0.1 ohms or ±5%.*
7. Release **TARGET RESET** button and decrease the currents and **OUTPUT LED**s will go out. Press **TARGET RESET** button to reset targets.
8. ***Time Test***: Set the three-phase voltages V_A, V_B, and V_C to the **Selected Voltage** value from step 4, and set the phase angle between the voltage and current inputs to 90° (current leading voltage). With output contacts (**Z**) connected to stop the timer, apply I + 10% Amps and start timing. Contacts will close within ± 1 cycle or ± 1%.
9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

   (For proper testing, use I ≤ 3 x CT rating)

46 Negative Sequence Overcurrent Definite Time

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**Configuration C1 (MODIFIED)**			
TEST SETTINGS:	**Pickup Def Time**	**P**	**%**	**(3 to 100)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 27TN, 32, 50	**Disable**		
	Functions 51T, 51V, 87	**Disable**		
	Function 46 Inv Time	**Disable**		

■ **NOTE:** Although no voltage input is required for the testing of the 46 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they should also be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 (MODIFIED) designated above. The modification to C1 (See Section 6.1, Equipment/Test Setup for configuration) is to exchange Current input 2 and 3 (phase B current = input 3 and phase C current = input 2). Set Voltages = Nominal voltage.
4. The level of current at which operation is to be expected for an individual setting is: Pickup current = (**P**% ÷ 100) x (**Nominal Current**) where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and should be recorded on Figure A-2, Communication Data and Unit Setup Record Form.
5. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the three-phase currents until the appropriate **NEG SEQ OVERCURRENT 46** LED light goes on or the pickup indicator operates on the computer target screen. The level will be equal to pickup current calculated in step 4 ±0.5% of 5 A.
6. Release **TARGET RESET** button and decrease the currents and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
7. ***Time Test***: With output contacts (Z) connected to stop the timer, apply current of at least (**1.1 x pickup**) amps and start timing. The contacts will close after **D** cycles within ± 1 cycle or ± 1%.
8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

(For proper testing, use $I \leq 3 \times$ CT rating)

46 Negative Sequence Overcurrent Inverse Time

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**Configuration C1 (MODIFIED)**			
TEST SETTINGS:	**Pickup Inv Time**	**P**	**%**	**(3 to 100)**
	Time Dial Setting	**K**		**(1 to 95)**
	Maximum Trip Time	**D**	**cycles**	**(600 to 65,500)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 27TN, 32, 50	**Disable**		
	Functions 51T, 51V, 87	**Disable**		
	Function 46 Definite Time	**Disable**		

■ **NOTE:** Although no voltage input is required for the testing of the 46 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they will need to also be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 (MODIFIED) designated above. The modification to C1 (See Section 6.1, Equipment/Test Setup for configuration) is to exchange Current input 2 and 3 (phase B current = input 3 and phase C current = input 2.)
4. The current pickup level at a percentage setting is: Pickup current = (**P**% ÷ 100) x (**Nominal Current**) where the Nominal Values have been programmed in the system setup data described in Section 2.1, Configuration and should be recorded on Figure A-2, Communication Data and Unit Setup Record Form.
5. Test levels may be chosen at any percentages of Nominal Current which are a minimum of 5% higher than the pickup percentage, **P%**. (Suggest 4 or 5 test levels chosen and calculated in amps.)
6. Set the three-phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value from step 4.
7. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply currents equal to the chosen test levels calculated in step 5 and start timing. The operating time will be as read from Figure 2-11, Negative Sequence Inverse Time Curves, negative sequence current in % of Nominal Current and appropriate **K** (Time Dial) setting, or the maximum trip time (whichever is faster). Repeat this step for all test levels chosen.
8. ***Reset Time Test***: If it is desired to test the reset time, begin timing immediately when the input current is reduced below the pickup value. Holding the **TARGET RESET** button in, stop timing when the **TARGET** LED goes out. The time should be approximately 4 minutes.
9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

■ **NOTE**: If retesting is required, the unit should be powered down or wait 4 minutes before the next test to assure resetting of the timer.

(For proper testing, use $I \leq 3 \times CT$ rating)

50 Instantaneous Phase Overcurrent

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**Configuration C1**			
TEST SETTINGS:	**Pickup**	**P**	**Amps**	**(1.0 to 240)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 27TN, 32, 51T	**Disable**		
	Functions 51V, 87, 87GD	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup. Set the three-phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase current input 3 (C phase) until the **PHASE OVERCURRENT 50** LED light goes on or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) amps ±0.1 amps or ±3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply approximately 110% of **P** amps and start timing. The operating time will be O2 cycles. Reduce input 3 current to 0 amps.
6. Test may be repeated using inputs 1 (A phase) and 2 (B phase) individually.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

50BF/50BF-N Breaker Failure

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C2

TEST SETTINGS:	**50BF-Ph Pickup**	**P**	**Amps**	**(0.1 to 10)**
	50BF-N Pickup	**N**	**Amps**	**(0.1 to 10)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Breaker Failure Initiate	**B** **I**	**OUT** **IN**	**(1 to 8)** **(1 to 6)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 32, 50DT, 60FL **Function 87**	**Disable** **Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C2 designated above. See Section 6.1, Equipment/Test Setup.
4. ***Testing 50BF-Ph Generator Breaker Failure Operation***: 50BF-N DISABLED, 50BF-Ph ENABLED, 50BF Pickup Setting = **P** amps, Time delay setting = **D** cycles.
5. Initiate operation by externally shorting any ONE set of contacts (I) IN shown above. Short IN1 (connect contacts 10 & 11) to simulate 52b contact closure (breaker open). Alternatively, the external contact may be operated if all connections are made.
6. Press and hold the **TARGET RESET** button and slowly increase current input 3 until the **50BF BREAKER FAILURE** LED light goes on (or the pickup indicator operates on the computer target screen). The current level of operation will be (**P**) amps ±0.1 amps or ±2%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
7. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply approximately 110% of **P** amps and start timing. The operating time will be **D** cycles within ± 1 cycle or ± 1%. Reduce input 3 current to 0 amps.
8. ***Testing 50BF-Ph/50BF-N Generator Breaker Failure Operation***: **50BF-N ENABLED, 50BF-Ph ENABLED**, 50BF-N Pickup Setting = N amps, 50BF-Ph Pickup Setting < **P** amps, Time delay setting = **D** cycles. (Note: 50BF-Ph setting (**P**) must be equal to or less than 50BF-N setting (N).]
9. Short IN1 (connect contacts 10 & 11) to simulate 52b contact closure (breaker open).
10. Press and hold the **TARGET RESET** button and slowly increase current input 3 until the **50BF BREAKER FAILURE** LED light goes on (or the pickup indicator operates on the computer target screen). The current level of operation will be (**N**) amps ±0.1 amps or ±2%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
11. ***BFN Time Test***: With output contacts (**Z**) connected to stop the timer, input approximately 110% of **N** amps and start timing. The operating time will be **D** cycles within ± 1 cycle or 1%. Reduce input 3 current to 0 amps.

12. ***Testing HV Breaker Failure Operation***: 50BF-N DISABLED, 50BF-Ph DISABLED, Time delay set = **D** cycles, Input 1 in breaker closed state.

13. With output contacts (**Z**) connected to the timer, initiate operation by externally shorting any ONE set of contacts (**I**) IN except Input 1 above. The operating time will be **D** cycles within ±1 cycle or ±1%.

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

50/27 Inadvertent Energizing

VOLTAGE INPUTS:Configuration V1

CURRENT INPUTS:Configuration C2

TEST SETTINGS:	**50 Pickup**	**P**	**Amps**	**(0.5 to 15)**
	27 Pickup	**V**	**Volts**	**(40 to 130)**
	Pickup Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Dropout Time Delay	**T**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 27, 27TN	**Disable**		
	Functions 32, 40, 50BF	**Disable**		
	Functions 51T, 51V, 87	**Disable**		

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C2 designated above. See Section 6.1, Equipment/Test Setup.
4. ***50 Overcurrent Test***: Set Voltage inputs at Zero volts (after a minimum time of **D** cycles). Press and hold the **TARGET RESET** button and slowly increase the Phase A current (Input 1) until the **50/27 INADVERTENT ENRGNG** LED light goes on (or the pickup indicator operates on the computer target screen). The level of operation will be (**P**) amps ±0.1 A or ±2%.
5. ***27 Undervoltage Test***: If desired, the dropout time delay (**T**) can be set to minimum setting for this test. Hold the **TARGET RESET** button in and slowly increase the voltage input (continuing current input in step 4.). Wait at least **T** cycles between each voltage change. The 50/27 LED will go out at **V** volts ±0.5 Volts.
6. ***27 Pickup Delay Test***: Reduce voltage to Zero volts and start timing. The operating time to close will be **D** cycles within ± 1 cycle or 1%.
7. ***27 Dropout Delay Test***: Increase current by one (1) amp and then with output contacts (**Z**) connected to the timer, input approximately 110% of **V** volts (pickup setting) and start timing. The operating time to open will be **T** cycles within ± 1 cycle or ± 1%.
8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

50DT Definite Time Overcurrent (for split-phase differential), #1 or #2

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**Configuration C1**			
TEST SETTINGS:	**Pickup A Phase**	**A**	**Amps**	**(0.2 to 240)**
	Pickup B Phase	**B**	**Amps**	**(0.2 to 240.0)**
	Pickup C Phase	**C**	**Amps**	**(0.2 to 240.0)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 50DT (#1 or #2)	**Disable**		
	Function 50BF	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup. Set the three-phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase current input 1 (A phase) until the **PHASE OVERCURRENT 50** LED light goes on or the pickup indicator operates on the computer target screen. The current level of operation will be (**A**) amps ±0.1 amps or ±3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply approximately 110% of **P** amps and start timing. The operating time will be ± 1 cycle or ± 1%, whichever is greater. Reduce input 3 current to 0 amps.
6. Test may be repeated for phases B & C by repeating Steps 4 and 5.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

50N Instantaneous Neutral Overcurrent

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**As described**			
TEST SETTINGS:	**Pickup**	**P**	**Amps**	**(1.0 to 240)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 51N, 87GD	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. Set the three-phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value. See Section 6.1, Equipment/Test Setup.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase current input I_N (terminals 53 and 52) until the **NEUTRAL OVERCURRENT 50N** LED light goes on or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) amps ±0.1 amps or ±3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply approximately 110% of **P** amps and start timing. The operating time will be $\leqq$ 2 cycles. Reduce input 3 current to 0 amps.
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

51N Inverse Time Neutral Overcurrent

VOLTAGE INPUTS:	**Configuration V1**			
CURRENT INPUTS:	**As described**			
TEST SETTINGS:	**Pickup Inv Time**	**P**	**Amps**	**(0.25 to 12.0)**
	Curve Characteristic	**C**		**(1, 2, 3 or 4)**
	Time Dial Setting	**K**		**(0.5 to 11.0)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 50N, 87GD	**Disable**		

■ **NOTE:** Although no voltage input is required for the testing of the 51N function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they will need to also be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. Set the three–phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value.
4. Refer to Appendix D, Figures D5–D12, or Tables D-1A and D-1B. Test levels may be chosen in terms of multiples of pickup value and associated time in seconds. (Suggest 4 or 5 test levels chosen and calculated in amps.)
5. ***Time Test***: With output contacts (**Z**) connected to the timer, apply current (I_N) to terminals 53 and 52 equal to the chosen test level calculated in step 4 and start timing. Operating time will be within ±3% or K3 cycles whichever is greater. Repeat this step for all test levels chosen. The tested points verify the operating times of the function.
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

51T Inverse Time Positive Sequence Overcurrent for Stator Thermal Protection

VOLTAGE INPUTS: **Configuration V1**

CURRENT INPUTS: **Configuration C1**

TEST SETTINGS:	**Pickup**	**P**	**Amps**	**(0.5 to 15.0)**
	Time Delay	**T_6**	**Sec**	**(0.1 to 10.0)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 27, 32, 40	**Disable**		
	Functions 50, 50/27, 51V	**Disable**		
	Functions 87, 87GD	**Disable**		

■ **NOTE**: Although no voltage input is required for the testing of the 51T function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they will need to also be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup. Set the three-phase voltages V_A, V_B, and V_C to the **Nominal Voltage** value.
4. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly increase positive sequence current input 3 until the **POS SEQ OVERCURRENT 51T** LED light goes on or the pickup indicator operates on the computer target screen. The current level of operation will be (**P**) amps ±0.1 amps or ±3%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: Calculate trip time using:

$$\frac{36 \times T_6}{\left(\frac{I_{app}}{P}\right)^2}$$

where $\mathbf{T_6}$ is the time delay at 6x Pickup (**P**) and I_{app} = applied current.

With output contacts (**Z**) connected to stop the timer, apply approximately 110% of **P** amps and start timing. The operating time will be as calculated above, ±3% or 3 cycles. Reduce input 3 current to 0 amps.

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

51V Inverse Time Phase Overcurrent with Voltage Control/Restraint

VOLTAGE INPUTS: V1

CURRENT INPUTS: C1

TEST SETTINGS:	**Pickup**	**P**	**Amps**	**(0.5 to 12.00)**
	Inverse Time Curve	**C**		**(1 to 4)**
	Time Dial	**K**		**(0.5 to 11)**
	Voltage Control Setting	**V**	**Volts**	**(5 to 180)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 27, 27TN	**Disable**		
	Functions 32, 40, 46	**Disable**		
	Functions 50, 50/27, 51T	**Disable**		
	Functions 87, 87GD	**Disable**		

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect voltage input in Configuration V1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. Test levels may be chosen at any ampere values which are a minimum of 50% higher than the pickup amps, **P Amps**. It is suggested that the user select 4 or 5 test levels to verify curve.
5. ***For VC or Voltage Controlled Units***: Set the input voltages at least 5% under the Voltage Control setting **V**.
6. ***Time Test***: With output contacts (**Z**) connected to stop the timer, input current equal to the chosen test level calculated in step 4 on A phase and start timing. The operating time will be as read from the appropriate Inverse Curve Family and **K** (Time Dial) setting in Appendix D, Figures D-5 through D-8, or Tables D-1A through D-1B. Repeat this step for all test levels chosen. The accuracy specified is valid for currents above 1.5 times the pickup current.
7. ***Voltage Control Test***: The input voltage may be increased over the Voltage Control setting by at least 0.5 Volts and the function will dropout.
8. ***For VR or Voltage Restrained Units:*** Input Nominal Voltages and test as in steps 4, 5, and 6 above (same current input values). Repeat steps 4, 5, and 6 with reduced input voltage values and current reduced by the same percentage as value (see Figure 2-14).
9. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

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

VOLTAGE INPUTS:Configuration V1

CURRENT INPUTS:None

TEST SETTINGS:	**Pickup**	**P**	**Volts**	**(5 to 180)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 27TN, 32	**Disable**		
	Function 59 (#1 or #2)	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 6.1, Equipment /Test Setup for configuration. Set Voltages = Nominal voltage
4. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the input voltage on phase A until **59 PHASE OVERVOLTAGE** LED light goes on or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5 V or ±0.5%*. Release the **TARGET RESET** button and decrease the input voltage to nominal voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply (**P**+1) Volts on phase A and start timing. The contacts will close after **D** cycles within 20 cycles (RMS) or ±1 cycle or ±1% (DFT).
6. Test phases B and C by repeating steps 4 and 5.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

* When both RMS and Line-Ground to Line-Line is selected, the accuracy is ±0.8V or ±0.75%.

59N RMS Overvoltage, Neutral Circuit or Zero Sequence (#1 or #2)

VOLTAGE INPUTS: See Below

CURRENT INPUTS: None

TEST SETTINGS:	**Pickup**	**P**	**Volts**	**(5 to 180)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 27TN	**Disable**		
	Function 59N (#1 or #2)	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect voltage input to terminal numbers 44 and 45.
4. ***Pickup Test***: Press and hold the **TARGET RESET** button and slowly increase the input voltage V_N until **59N NEUTRAL OVERVOLTAGE** LED light goes on or the pickup indicator operates on the computer target screen. The level should be equal to **P** volts ±0.5 V or ±0.5%. Release the **TARGET RESET** button and decrease the input voltage and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply (**P**+1) Volts and start timing. The contacts will close after **D** cycles within ± 1 cycle or ± 1%.
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

60FL VT Fuse Loss Detection

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: Configuration C1

TEST SETTINGS:	**Time Delay**	**D**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 27, 27TN, 32, 87	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations.
4. Adjust the three-phase voltage source to Nominal volts, and the three-phase current source to Nominal amps.
5. ***Time Test***: With output contacts connected to the timer, remove the A phase voltage input and start timing, and the **60FL V.T. FUSE LOSS** LED and output **Z** LEDs will light or the pickup indicator operates on the computer target screen. The operating time will be **D** cycles within ±1 cycle or ±1%.
6. Reconnect the phase A voltage and press **TARGET RESET** button to remove targets.
7. Repeat steps 5 and 6 for phases B and C.
8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

64F Field Ground Protection (#1, #2)

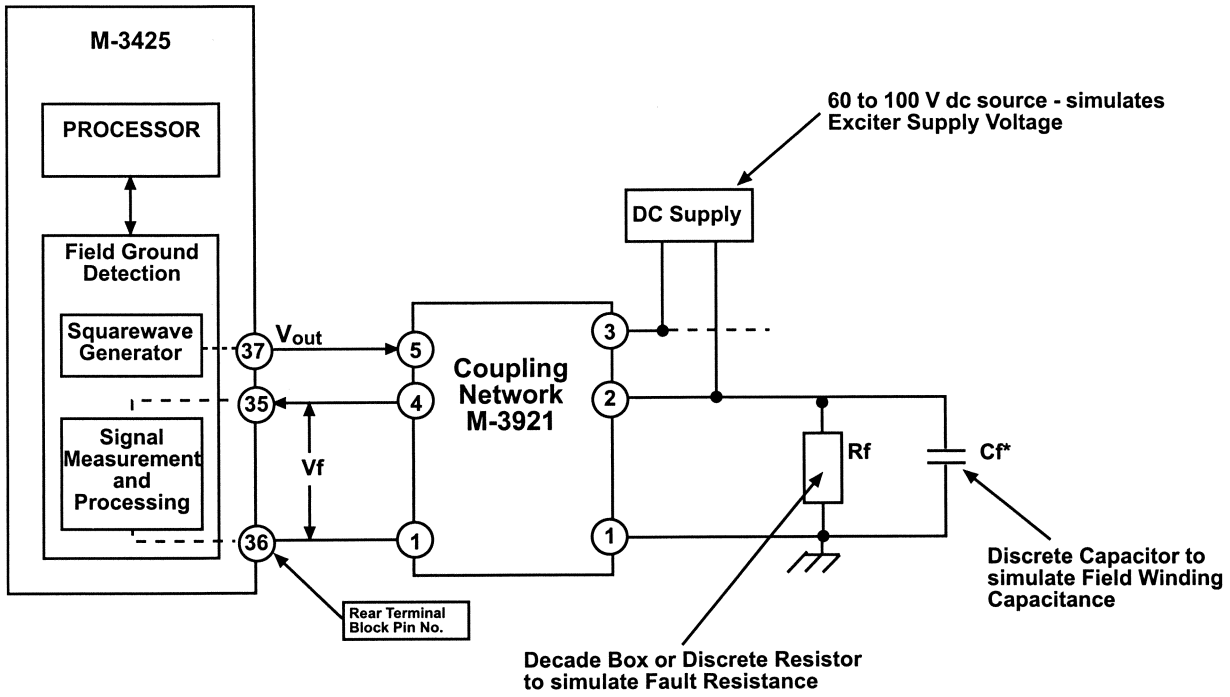
VOLTAGE INPUTS:None

CURRENT INPUTS:None

TEST SETTINGS:	**Pickup**	**P**	**KOhms**	**(5 to 100)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Injection Frequency	**F**	**Hz**	**(0.10 to 1.00)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 64B	**Disable**		

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect M-3921 Field Ground Coupler and decade box as shown in Figure 6-14.
4. Set resistance on decade box 10% more than pickup **P**.
5. ***Pickup Test***: Hold the **TARGET RESET** button in and slowly decrease the resistance on the decade box until the **FIELD GND/BRUSH LIFT 64F/B** LED or the pickup indicator on the IPScom® Function Status screen illuminates. The level of operation will be **P** kW ±1kW or ±10%. Release the **TARGET RESET** button and increase the resistance and the **OUTPUT** LED(s) will extinguish. Press the **TARGET RESET** button again to remove targets.
6. ***Time Test***: With output contact **(Z)** connected to stop the timer, change the resistance on the decade box to 90% of **P** and start timing. The operating time will be after **D** cycles, within ±(2/**IF + 1**).
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

Once the capacitance value and the operating frequency have been determined, the actual insulation resistance can be verified by installing a variable resistor (5 to 100 KW) and discrete capacitor to the coupler module (M-3921).



*** If the rotor is NOT connected, the value of Cf should approximate the rotor capacitance. If the rotor is connected Cf is NOT required.**

Figure 6-14 Field Ground Coupler

64B Brush Lift-Off Detection

VOLTAGE INPUTS:None

CURRENT INPUTS:None

TEST SETTINGS:	**Pickup**	**P**	**mV**	**(0 to 5000)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Injection Frequency	**IF**	**Hz**	**(0.10 to 1.00)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 64F	**Disable**		

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect M-3921 Field Ground Coupler and decade box as shown in Figure 6-14, set Rf to open (infinity) and Cf to 1μf.
4. Monitor the **FIELD GND MEAS. CIRCUIT** display under the **VOLTAGE** menu in **MONITOR STATUS**. Set the pickup (**P**) to 110% of the displayed value.
5. ***Pickup Test***: Hold the **TARGET RESET** button in and open Cf and the **FIELD GND/BRUSH LIFT 64F/B** LED or the pickup indicator on the IPScom® Function Status screen will illuminate. Connect the capacitor Cf before starting the timing test. Press the **TARGET RESET** button again to remove targets.
6. ***Time Test***: With output contact **(Z)** connected to stop the timer, remove the capacitance connected to the decade box and start timing. The operating time will be after **D** cycles, within ±(2/**IF + 1**) sec.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

78 Out of Step

VOLTAGE INPUTS:Configuration V1

CURRENT INPUTS:Configuration C1

TEST SETTINGS:	**Diameter**	**P**	**ohms**	**(0.1 to 100)**
	Offset	**O**	**ohms**	**(–100 to +100)**
	Impedance Angle	**A**	**Degrees**	**(0 to 90)**
	Time Delay	**D**	**cycles**	**(1 to 8160)**
	Blinder Impedance	**B**	**ohms**	**(0.1 to 50.0)**
	Trip on MHO Exit	**See Below**		
	Programmed Output	**Z**		
	Delta-Y Transform	**Disable**		
	Functions 21, 27, 27TN	**Disable**		
	Functions 32, 40, 51V	**Disable**		
	Functions 81, 87	**Disable**		

■ **NOTE:** Use Figure 2-16 for reference. A stopwatch is required for this test.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C1 designated above. See Section 6.1, Equipment/Test Setup for configurations. Adjust voltage and currents while monitoring the positive sequence impedance to a point similar to point $\mathbf{Z_0}$ in Figure 2-17.
4. ***Pickup Test:*** Disable the **TRIP ON MHO EXIT** setting and set the delay, **D**, to a minimal setting. Press and hold the **TARGET RESET** button and sweep the current angle towards point $\mathbf{Z_1}$. When the impedance passes through point $\mathbf{Z_1}$, verify that the **78 OUT OF STEP** LED comes on or the function status indicator shows the function picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Continue to sweep the current angle to point $\mathbf{Z_2}$, and verify output **Z** operates as point $\mathbf{Z_2}$ is crossed, and resets after the seal-in time delay.

   Blocking on Stable Swing Test: Reset impedance to a point outside of the mho circle. Adjust voltages and currents to point $\mathbf{Z_0}$. Press and hold the **TARGET RESET** button and sweep past point $\mathbf{Z_1}$. Verify the **78 OUT OF STEP** LED comes on or the function status indicator shows the function picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Reverse sweep direction and sweep the current angle to point $\mathbf{Z_1}$, and verify output **Z** does not operate and the **78 OUT OF STEP** LED goes out or the function status indicator shows the function reset on the **Monitor Function Status** screen as point $\mathbf{Z_1}$ is crossed.
5. ***Pickup Test (Trip on mho Exit):*** Enable the **TRIP ON MHO EXIT** setting. Adjust voltages and currents to point $\mathbf{Z_0}$. Press and hold the **TARGET RESET** button, and sweep the current angle towards point $\mathbf{Z_1}$. When the impedance passes through point $\mathbf{Z_1}$, verify that the **78 OUT OF STEP** LED comes on or the function status indicator shows that the function has picked up on the **Monitor Function Status** screen. Pause testing until the delay timer has time to expire. Continue to sweep the current angle to point $\mathbf{Z_2}$, and verify that output **Z** does not operate as point $\mathbf{Z_2}$ is crossed. Sweep the impedance further towards point $\mathbf{Z_3}$, and verify output **Z** operates as point $\mathbf{Z_3}$ is crossed, and resets after the seal-in time delay.

81 Frequency (#1, #2, #3, #4)

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: None

TEST SETTINGS:	**Pickup**	**P**	**Hz**	**(50 to 67)**
	Time Delay	**D**	**cycles**	**(2 to 65,500)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Function 24, 27TN, 81R	**Disable**		

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

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated above. See Section 6.1, Equipment/Test Setup for configuration.
4. ***Pickup Test***: Set the voltages V_A, V_B, and V_C to nominal voltage (nominal frequency). For overfrequency testing, hold the **TARGET RESET** button in and slowly increase the frequency on the input voltage(s) until the appropriate **FREQUENCY/ROCOF 81/81R** LED light goes on or the pickup indicator operates on the computer target screen. The level will be equal to **P** Hz ±0.02 Hz only if **P** is within 3 Hz of $F_{nom,}$ otherwise, ±0.1 Hz. Return to nominal input frequency and **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets. For underfrequency testing, decrease the input frequency and return to nominal after operation.
5. ***Time Test***: With output contacts (**Z**) connected to stop the timer, apply (**P**+ or – 0.5) Hz and start timing. The contacts will close after **D** cycles within ±2 cycles or ±1%, whichever is greater.
6. Complete the testing for all 81 functions by repeating the appropriate steps for each one.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this point.

81R Rate of Change of Frequency (#1, #2)

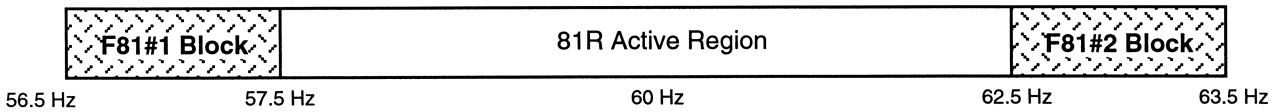
VOLTAGE INPUTS:V1

CURRENT INPUTS:None

TEST SETTINGS:	**Pickup**	**P**	**Hz/Sec**	**(0.10 to 20)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Negative Sequence Voltage Inhibit	**N**	**%**	**(0 to 99)**
	Programmed Outputs	**Z**	**Output**	**(1 to 8)**
	Functions 24, 27TN	**Disable**		
	Function 81	**See Below**		

■ **NOTE**: Testing of the 81R function requires a 3-phase voltage source capable of smoothly sweeping the frequency of all voltages at a variable rate, continuously.

1. Disable functions as shown. Refer to Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 designated previously. Refer to Section 6.1, Equipment/Test Setup for configuration.
4. It is recommended that the 81 function be used to establish a window of operation for the 81R function which is smaller than the actual sweep range of the frequency applied. This is accomplished by enabling 81#1 to pickup at a frequency 1 Hz higher than the minimum frequency of the ramp, and assign a unique output. Set 81#2 to pickup 1 Hz lower than the maximum frequency of the ramp, and assign a unique output (see figure below). The frequencies given are suggested for testing rates below 10 Hz/Sec. Higher rates will require consideration of the capabilities of the test equipment involved. Connect both of these outputs to an input with jumpers, and set the 81R function to block on this input. Set the time delays and seal-in times of the 81 functions to minimum. This will result in an operational window that is free of erroneous Hz/Sec measurements when the voltage source begins or ends the sweep.



Using this setup, it is important to remember that the 81 elements being used will be operating in the 81R blocking regions, and the 81R contact operation must be distinguished from the 81 contacts.

5. ***Pickup Test***: Apply Nominal Voltage to all three phases. Calculate the time for the pickup setting and apply a sweep rate 25% less than the pickup (**P**) to all three phases.

   Hold the **TARGET RESET** button in and slowly decrease the sweep time until the **FREQUENCY/ ROCOF 81/81R** LED lights, or the pickup indicator operates on the computer target screen. The level should be equal to **P** ±0.05 Hz/S or ±5 %. Release the **TARGET RESET** button, and increase the sweep time, and the **OUTPUT** LED will go out.

6. ***Negative Sequence Voltage Inhibit Test***: Reset targets and apply Nominal Voltage to all three phases at a sweep rate 25% above **P**. Verify that the **FREQUENCY/ROCOF 81/81R** LED lights, or the pickup indicator operates on the computer target screen. Swing the phase angle of a phase voltage and monitor the positive and negative sequence voltage levels. The **81R OUTPUT** should reset when the negative sequence voltage is **N**%, ±0.5% of the positive sequence voltage.
7. ***Timer Test***: Reset targets and apply Nominal Voltage to all three phases at a sweep rate 25% below **P**. With output contacts (**Z**) connected to stop the timer, apply a sweep rate 25% above **P** and start timing. The contacts will close after **D** cycles within 20 cycles, or K3 %.
8. If testing is complete, enable any functions disabled for this test. If further testing is desired, check the proper functions to disable for the next test and continue from this point.

87 Phase Differential

VOLTAGE INPUTS: Configuration V1
CURRENT INPUTS: Configuration C3

TEST SETTINGS:	**Minimum Pickup**	**P**	**Amps**	**(0.2 to 3.0)**
	Percent Slope	**S**	**%**	**(1 to 100)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**

Functions 21, 32, 40	**Disable**
Functions 46, 50, 50/27	**Disable**
Functions 50DT, 50N	**Disable**
Functions 51T, 51V, 87GD	**Disable**

■ **NOTE**: Although no voltage input is required for the testing of the 87 function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests, they will need to also be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect inputs in Configuration V1 and C3 as designated above. See Section 6.1, Equipment/Test Setup for configuration. Set Voltages = Nominal voltage.
4. ***Minimum Pickup Test***: Set I_a = 0 Amps (input 1); press and hold the **TARGET RESET** button and slowly increase I_A (input 2) until the **PHASE DIFF CURRENT 87** LED light goes on (or the pickup indicator operates on the computer target screen). The current level of operation will be equal to **P** amps ±0.1 A or ±5%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets. Each phase may be tested individually or I_A and I_a may be exchanged.
5. ***Timer Test***: With output contacts (**Z**) connected to stop the timer, apply at least 10% higher I_A (input 2) current than the minimum pickup level and start timing. The contacts will close after **D** cycles within ± 1 cycle or 1%. When the Time Delay is set to 1 cycle, the relay operation is less than 1-1/2 cycles.
6. ***Slope Test:*** Define any number of testing points desirable to verify the trip curve. Choosing any values for I_a (input 1), calculate the expected operating current I_A (input 2) according to the following:

(I_A-I_a)	>	(I_A+I_a)	x	Slope/100	÷2
Difference in currents	is greater than	sum of the currents	times	the per unit slope	÷2

or $I_A = [(1+K) \div (1-K)] \times I_a$ where **K** = **S**/200 and where **S** is % slope input above.

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

7. With I_a (input 1) and I_A (Input 2) set at the chosen value, hold the **TARGET RESET** button in and slowly increase either current until the **PHASE DIFF CURRENT 87** LED light goes on or the pickup indicator operates on the computer target screen. The current level of operation will equal to I_A within ±0.1 A or ±2% slope calculation. Release the **TARGET RESET** button and decrease the larger **CURRENT** and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets. Note that the difference in current must be greater than minimum pickup current for proper operation.
8. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

87GD Ground Differential

VOLTAGE INPUTS: Configuration V1

CURRENT INPUTS: As described

TEST SETTINGS:	**Pickup**	**P**	**Amps**	**(0.2 to 10)**
	Time Delay	**D**	**Cycles**	**(1 to 8160)**
	CT Ratio Correction			**(0.10 to 7.99)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Functions 21, 46, 50/27	**Disable**		
	Functions 50N, 51N, 51T	**Disable**		
	Functions 51V, 87	**Disable**		

■ **NOTE**: Although no voltage input is required for the testing of the 87GD function, it is suggested that Nominal Volts be applied to restrain the functions which use both voltage and current inputs for operation. If other functions operate during these tests they need to be disabled for the test and enabled after the tests are complete.

1. Disable functions as shown. See Section 3.2, Initial Setup Procedure/Settings, Configure Relay Data, for procedure.
2. Confirm settings to be tested.
3. Connect voltage input in Configuration V1 as designated above. See Section 6.1, Equipment/Test Setup for configuration V1. Set Voltages = Nominal voltage
4. ***Non–Directional Pickup Test***: With I_A=I_B=I_C= 0 Amps; press and hold the **TARGET RESET** button and slowly increase I_N (terminals 53 and 52) until the **GND DIFF CURRENT 87GD** LED light goes on (or the pickup indicator operates on the computer target screen). The current level of operation will be equal to **P** amps ±0.1 A or ±5%. Release the **TARGET RESET** button and decrease the current and the **OUTPUT** LEDs will go out. Press **TARGET RESET** button to remove targets.
5. ***Timer Test***: With output contacts (**Z**) connected to stop the timer, apply at least 10% higher I_N (terminals 53 and 52) current than the minimum pickup level and start timing. The contacts will close after **D** cycles within –1 to +3 cycles.
6. ***Directional Time Test***: With output contacts (**Z**) connected to the timer, apply I_N=1.0 A @ Zero degrees and I_A or I_B or I_C @ P–0.9 A @180 degrees and start timing. The contacts will close after **D** cycles within ±1 cycle or ±1%. Remove currents and reset targets. Reverse either current input (current inputs now in phase) and retest. The relay will not operate. If the I_A or I_B or I_C current input value is reduced to 140 ma or less and the difference current exceeds the pickup value, the relay will operate regardless of polarities of the currents.
7. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

External Functions (#1 OR #2)

VOLTAGE INPUTS: None

CURRENT INPUTS: None

TEST SETTINGS:	**Time Delay**	**D**	**Cycles**	**(1 to 8160)**
	Programmed Outputs	**Z**	**OUT**	**(1 to 8)**
	Initiating Inputs	**I**	**IN**	

1. Confirm initiating input numbers.
2. ***Time Test***: With output contacts (**Z**) connected to stop the timer, either short out input terminals designated or actually close external initiating contacts (one at a time) and start timing. The operating time will be **D** cycles within ± 1 cycle or ± 1% and the **EXTERNAL EXT** LED and output **Z** LEDs will light or the pickup indicator operates on the computer target screen.
3. ***Blocking Input Test***: To test the designated blocking inputs, press and hold the **TARGET RESET** button, and short (see step 2) input terminals (one at a time) designated as blocking inputs. The **EXTERNAL EXT** LED will go out.
4. Open initiating contact and press **TARGET RESET** button between contact closures to remove targets.
5. Repeat for each designated external triggering contact.
6. If testing is complete, enable any functions disabled for this test. If other tests are to be completed, check the proper functions to disable for the next test and proceed from this configuration.

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A Appendix A – Configuration Record Forms

This Appendix contains photocopy–ready forms for recording the configuration and setting of the M-3425 Generator Protection Relay. The forms can be supplied to field service personnel for configuring the relay, and kept on file for future reference.

A copy of the **Relay Configuration Table** (Table A-1) is provided to define and record the blocking inputs and output configuration. For each function; check the **D** (disabled) column or check the output contacts *to* be operated by the function, and check the inputs designated to block the function operation.

Figure A-2, Communication Data & Unit Setup Record Form reproduces the Communication and Setup unit menus. This form records definition of the parameters necessary for communication with the relay, as well as access codes, user logo lines, date & time setting, and front panel display operation.

Figure A-3, Functional Configuration Record Form reproduces the Configure Relay menus. For each function or setpoint, refer to the configuration you have defined using the Relay Configuration Table, and circle whether it should be enabled or disabled, the output contacts it will activate, and the inputs that will block its operation.

Figure A-4, Setpoint & Timing Record Form allows recording of the specific values entered for each enabled setpoint or function. The form follows the main menu selections of the relay.

Unpurchased or unavailable functions will not be visible within the menus. If a function is DISABLED, the input/output screens for that function will not be displayed.

FUNCTION	D	OUTPUTS									INPUTS					
		8	7	6	5	4	3	2	1	FL	6	5	4	3	2	1
27 1																
27 2																
27TN 1																
27TN 2																
59 1																
59 2																
59N 1																
59N 2																
46 DEF																
46 INV																
50																
50/27																
50BF																
50DT 1																
50DT 2																
50N																
51N																
51T																
51V																
87																
87GD																
81 1																
81 2																
81 3																
81 4																
81R 1																
81R 2																
24 1																
24 2																
24																
32 1																
32 2																
40 1																
40 2																
60FL																
21 1																
21 2																
78																
64B																
64F																
EXT 1																
EXT 2																

Check each box applicable : ✓
(See page A-1 for information on using this table.)
D Column = Function Disabled.
OUTPUTS Columns =Designated function output(s)
fl Column = Function blocked by fuse loss.
INPUTS Columns =Designated function blocking input(s)

Table A-1 Relay Configuration Table

KEY TO INPUT DATA RECORD FORMS

A. All unshaded [ ] screens shown on forms require data inputs. Whatever is in that screen when **ENTER** button is pushed (see Figure A-1) will be installed in the relay.

B. All heavy bordered [ ] screens are either MENU screens which have horizontal choices (made with right - left arrows) or screens displaying a result of a choice previously made.

C. Dotted boxes [ ] enclose screens which bound areas that pushbutton **ENTER** will move in. In order to move out of one of the dotted boxes it is necessary to either push **EXIT** or make a menu choice change using the Right - Left arrow.

D. The Up/Down arrows only adjust value or letter (lower/upper case) inputs; they do not move within the menus or between menu displays.

E. The Right/Left arrows are used only to make horizontally displayed choices. These can be either menu choices or input value digit choices. The previous choice or location in a menu is highlighted immediately.

F. The **ENTER** pushbutton records the setting change and moves down *within* a menu. The operator will notice that after the last menu item, **ENTER** moves to the top of the same menu but does not change menu positions.

G. Pushing **EXIT** at any time will exit the display screen to the last screen containing a horizontal choice. (Return to the preceding menu).

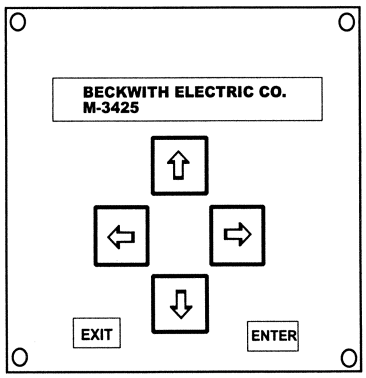

Figure A-1 Human-Machine Interface Module

H. The symbol → or ← in a screen indicates additional horizontal menu choices are available in the indicated direction. As previously described, the Right and Left arrows will move the operator to those additional choices.

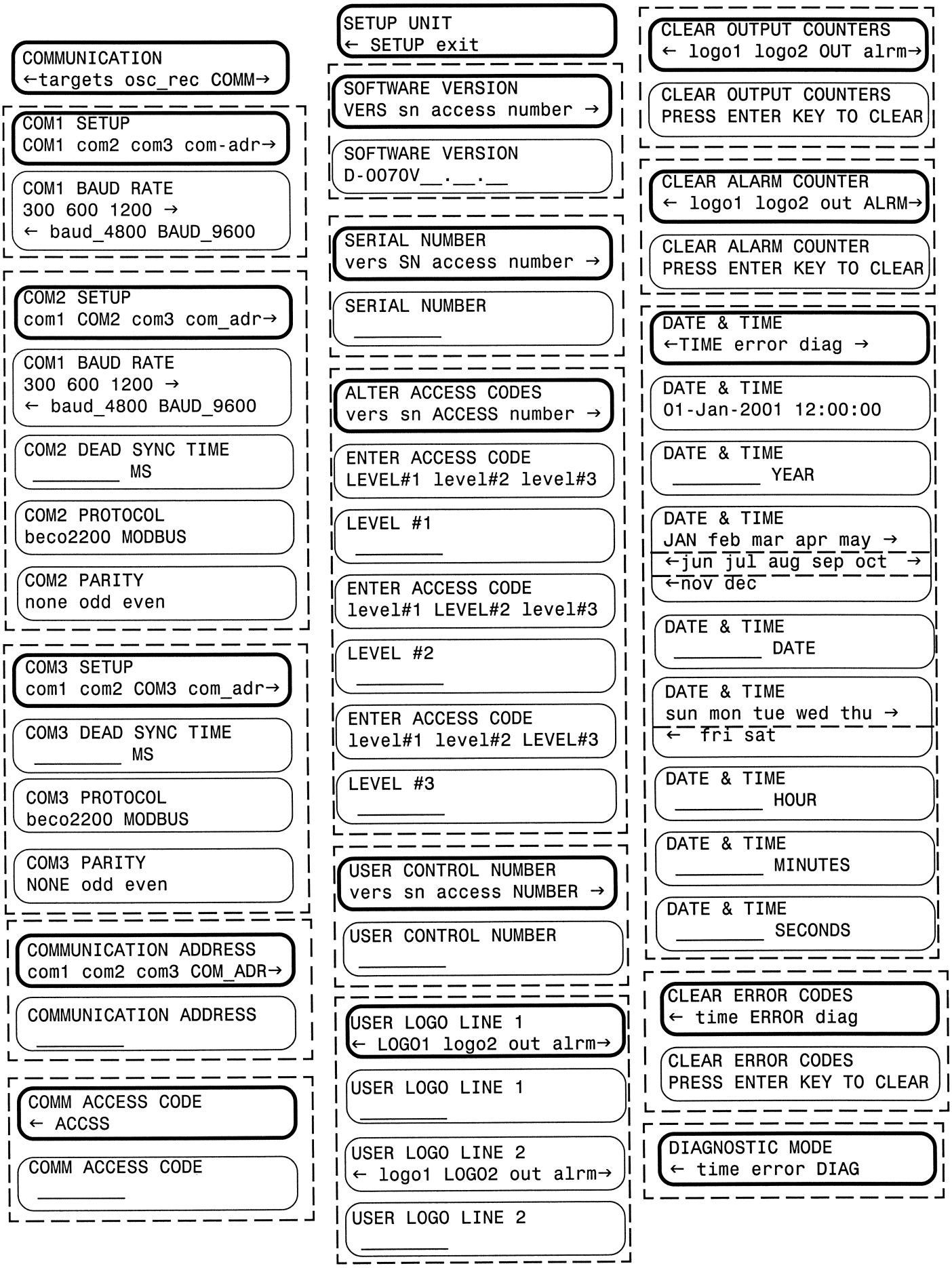

Figure A-2 Communication Data & Unit Setup Record Form

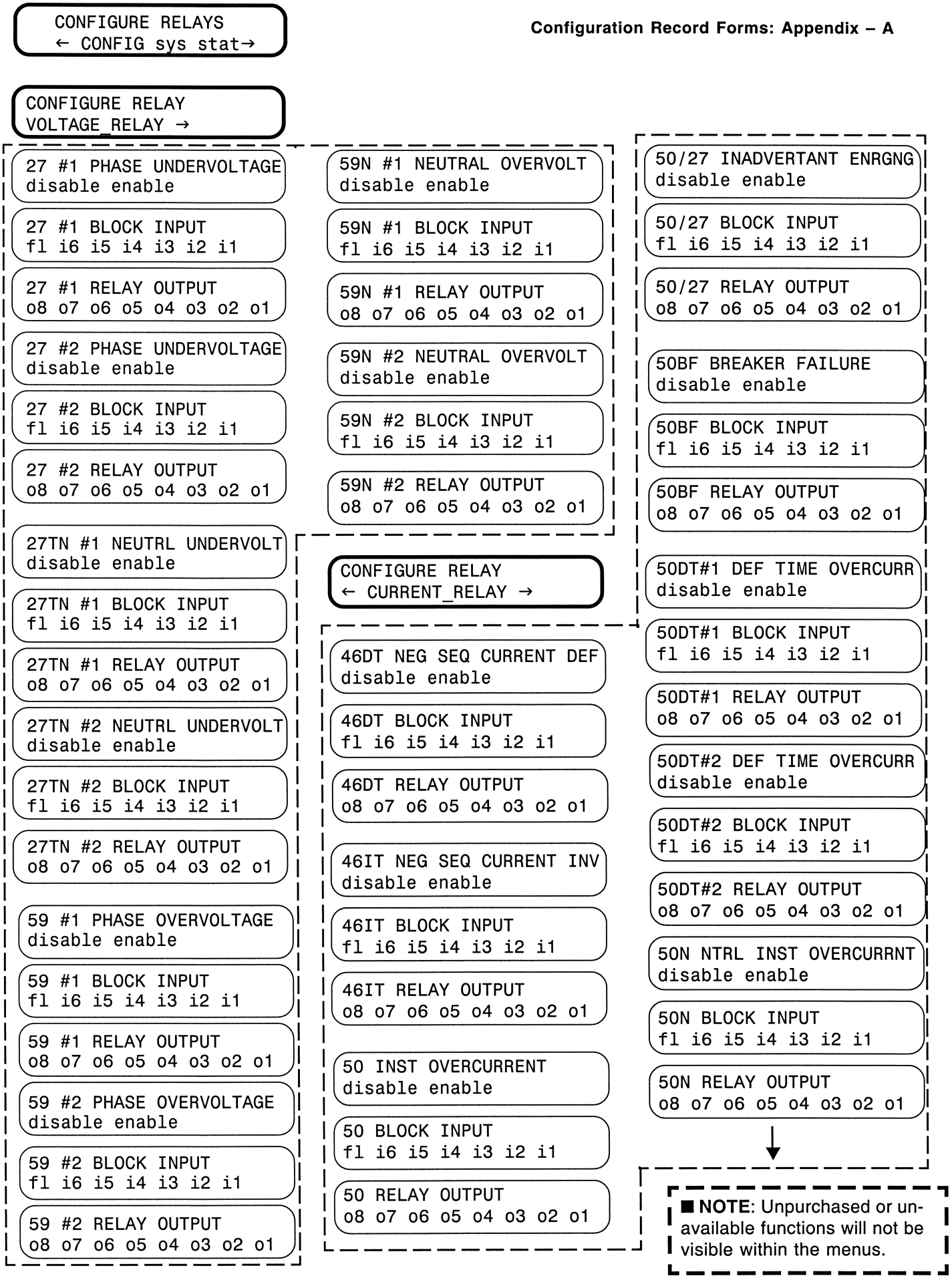

Figure A-3 Functional Configuration Record Form (1 of 4)

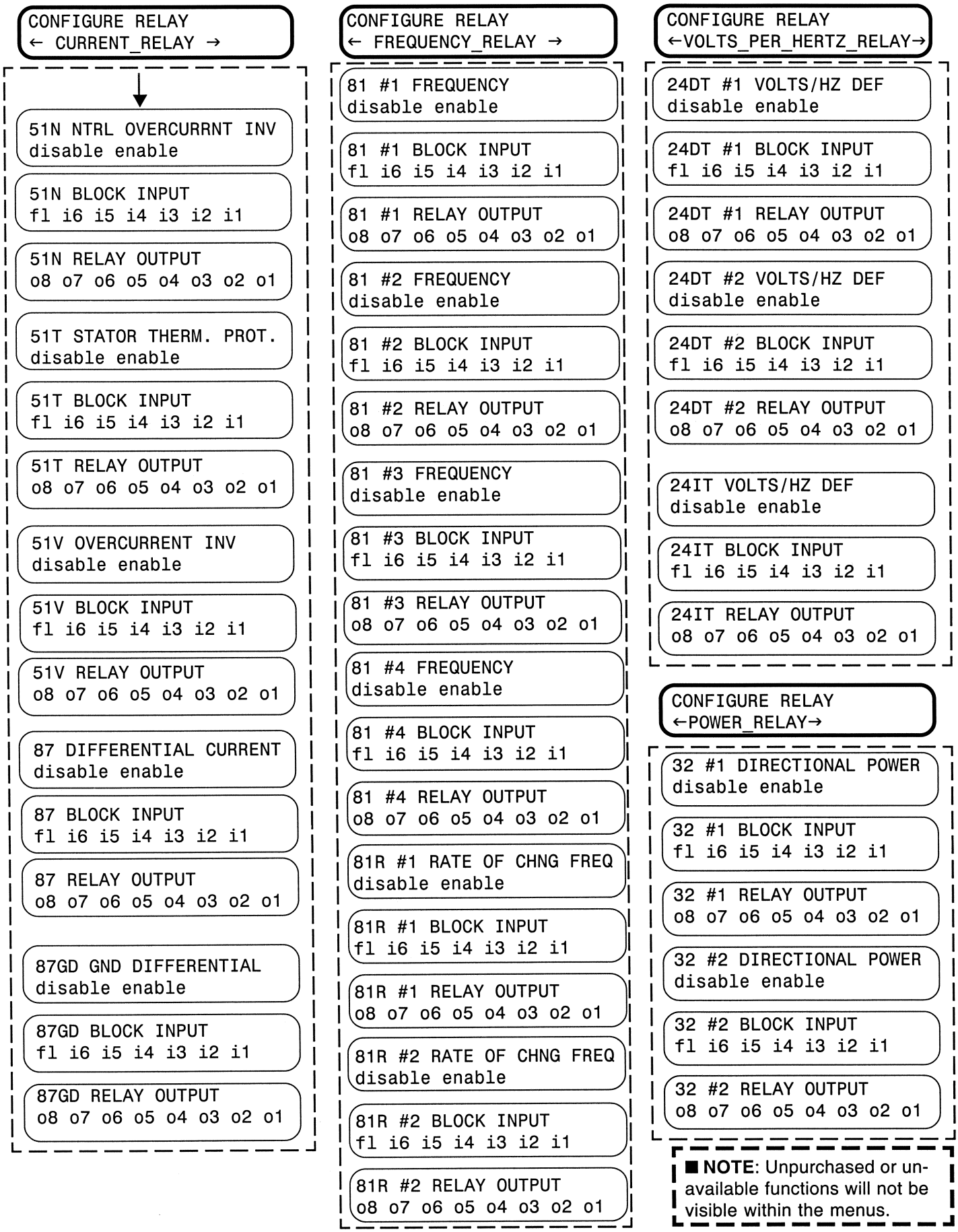

Figure A-3 Functional Configuration Record Form (2 of 4)

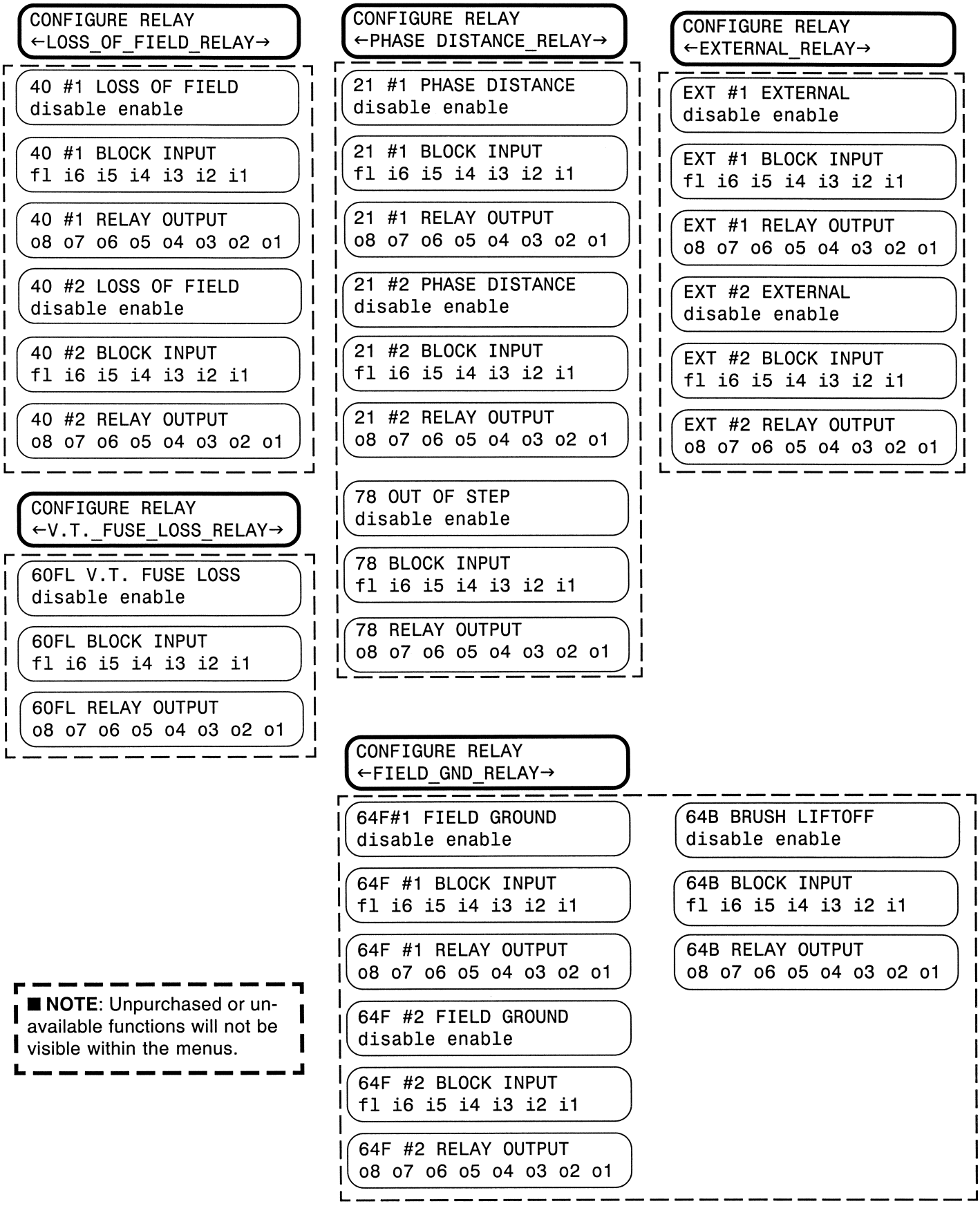

Figure A-3 Functional Configuration Record Form (3 of 4)

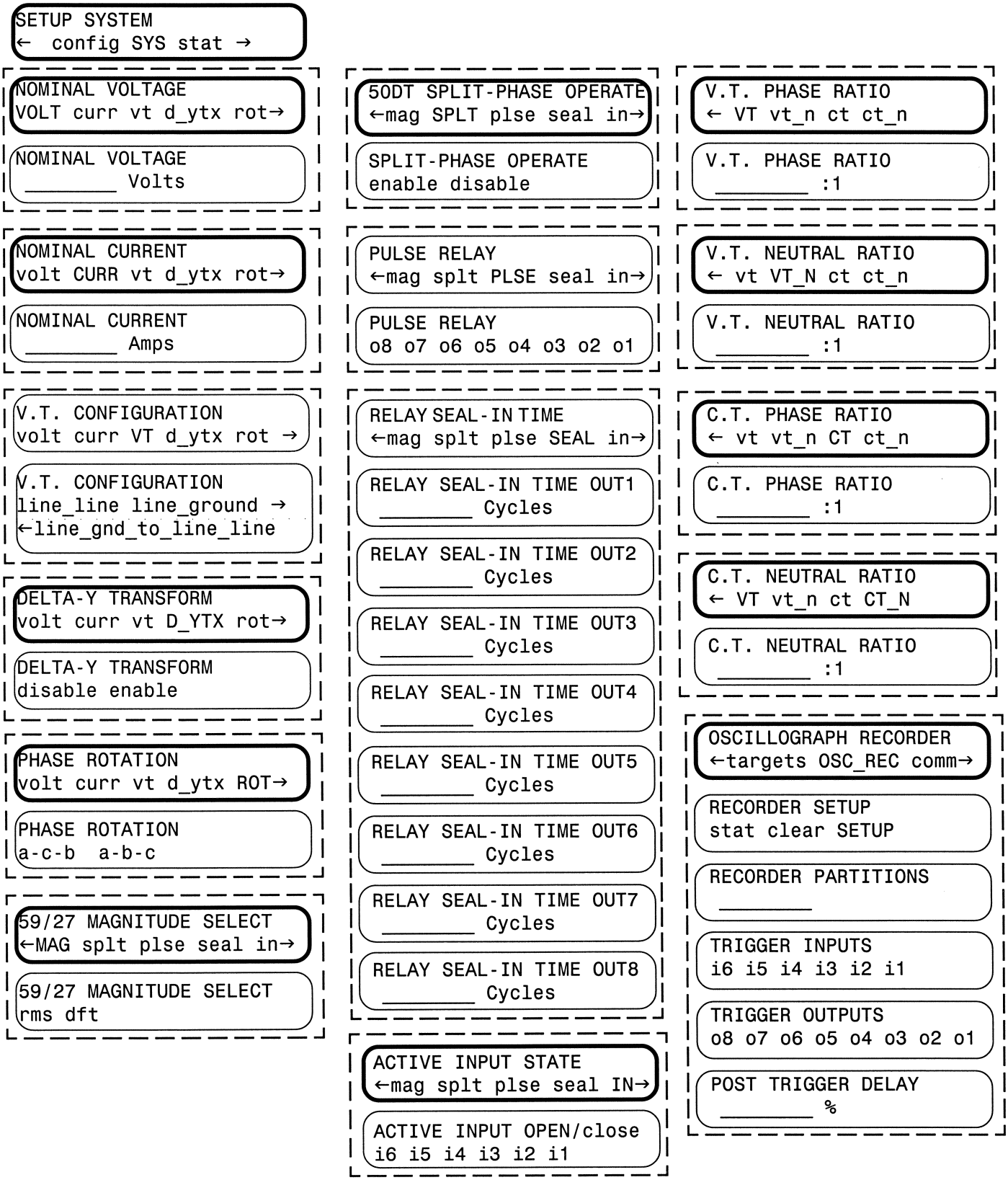

Figure A-3 Functional Configuration Record Form (4 of 4)

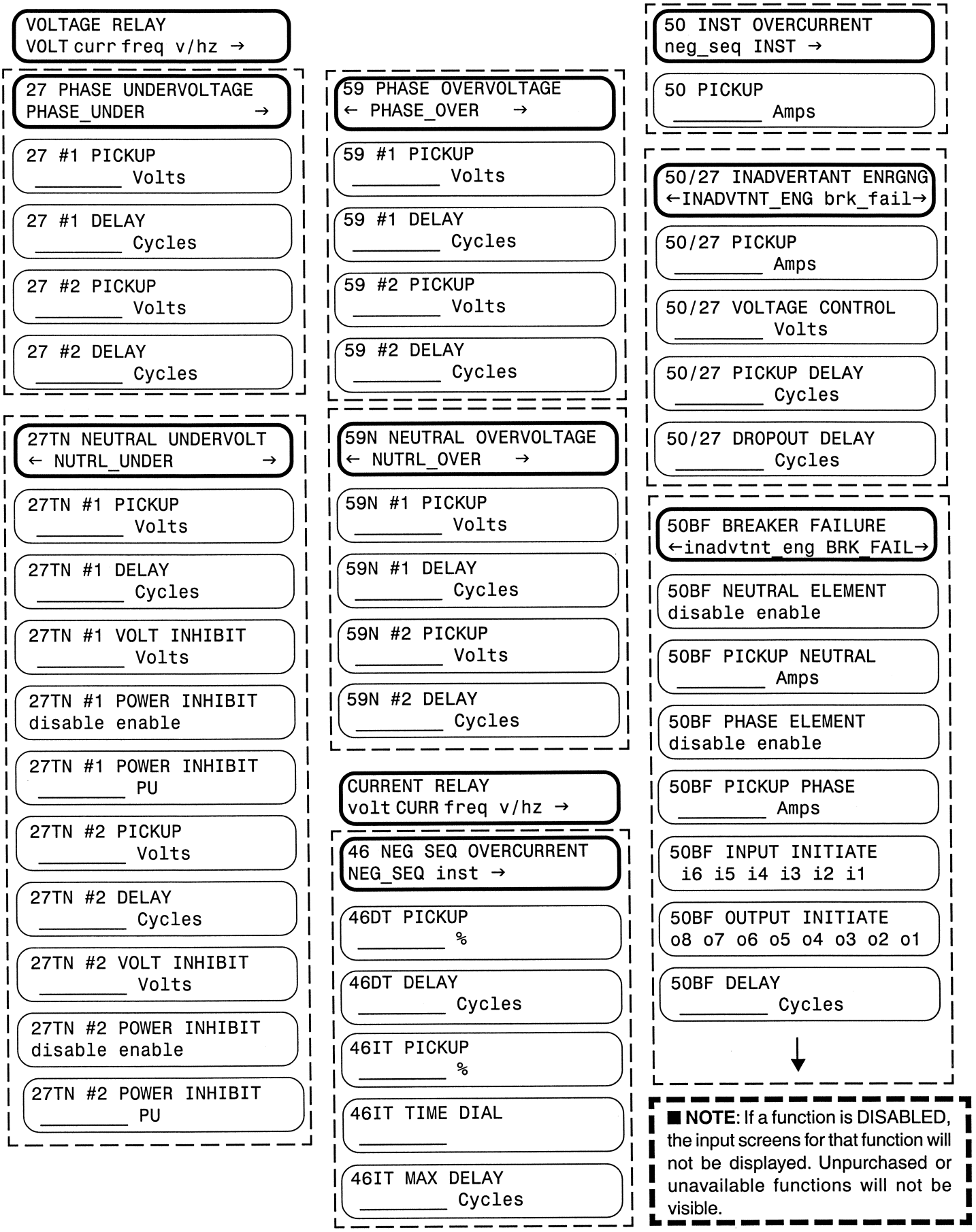

Figure A-4 Setpoint & Timing Record Form (1 of 4)

CURRENT RELAY
volt CURR freq v/hz →

50DT DEF TIME OVERCURR
← P_INST n_inst n_inv →

50DT #1 PICKUP PHASE A
_____ Amps

50DT #1 PICKUP PHASE B
_____ Amps

50DT #1 PICKUP PHASE C
_____ Amps

50DT #1 DELAY
_____ Cycles

50DT #2 PICKUP PHASE A
_____ Amps

50DT #2 PICKUP PHASE B
_____ Amps

50DT #2 PICKUP PHASE C
_____ Amps

50DT #2 DELAY
_____ Cycles

50N INST OVERCURRENT
← p_inst N_INST n_inv→

50N PICKUP
_____ Amps

51N INV TIME OVERCURRENT
← p_inst n_inst N_INV→

51N PICKUP
_____ Amps

51N CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51N TIME DIAL
_____

51T STATOR THERM. PROT.
← T_INV v_inv diff →

51T PICKUP
_____ Amps

51T DELAY @600% PICKUP
_____ Sec

51V INV TIME OVERCURRENT
← t_inv V_INV diff →

51V PICKUP
_____ Amps

51V CURVE
def inv vinv einv →
←ieci iecvi iecei ieclti

51V TIME DIAL
_____

51V VOLTAGE CONTROL
disable v_cntrl v_rstrnt

51V VOLTAGE CONTROL
_____ Volts

87 DIFFERENTIAL OVERCURR
← t_inv v_inv DIFF →

87 PICKUP
_____ Amps

87 SLOPE
_____ %

87 DELAY
_____ Cycles

87GD GND DIFF OVERCURR
← G_DIFF

87GD PICKUP
_____ Amps

87GD DELAY
_____ Cycles

87GD C.T. RATIO CORRECT
_____

FREQUENCY RELAY
volt curr FREQ v/hz →

81 FREQUENCY
FREQ rcfreq

81 #1 PICKUP
_____ Hz

81 #1 DELAY
_____ Cycles

81 #2 PICKUP
_____ Hz

81 #2 DELAY
_____ Cycles

81 #3 PICKUP
_____ Hz

81 #3 DELAY
_____ Cycles

81 #4 PICKUP
_____ Hz

81 #4 DELAY
_____ Cycles

81R RATE OF CHNG FREQ
freq RCFREQ

81R #1 PICKUP
_____ Hz/s

81R #1 DELAY
_____ Cycles

81R #2 PICKUP
_____ Hz/s

81R #2 DELAY
_____ Cycles

81R NEG SEG VOLT INHIBIT
_____ %

■ **NOTE**: If a function is DISABLED, the input screens for that function will not be displayed. Unpurchased or unavailable functions will not be visible.

A-4 Setpoint & Timing Record Form (2 of 4)

VOLTS PER HERTZ RELAY
volt curr freq V/HZ →

24 DEF TIME VOLTS/HERTZ
DEF_V/HZ inv_v/hz

24DT #1 PICKUP
_____ %

24DT #1 DELAY
_____ Cycles

24DT #2 PICKUP
_____ %

24DT #2 DELAY
_____ Cycles

24 INV TIME VOLTS/HERTZ
def_v/hz INV_V/HZ

24IT #1 PICKUP
_____ %

24IT CURVE
crv1 crv2 crv3 crv4

24IT TIME DIAL
_____

24IT RESET RATE
_____ Seconds

■ **NOTE**: If a function is DISABLED, the input screens for that function will not be displayed. Unpurchased or unavailable functions will not be visible.

POWER RELAY
← PWR lof fuse dist→

32 DIRECTIONAL POWER
PWR

32 #1 PICKUP
_____ PU

32 #1 DELAY
_____ Cycles

32 #1 LOW FORWARD POWER
disable enable

32 #2 PICKUP
_____ PU

32 #2 DELAY
_____ Cycles

32 #2 LOW FORWARD POWER
disable enable

LOSS OF FIELD RELAY
← pwr LOF fuse dist→

40 LOSS OF FIELD
LOF

40 #1 DIAMETER
_____ Ohms

40 #1 OFFSET
_____ Ohms

40 #1 VOLTAGE CONTROL
disable enable

40 #1 DELAY
_____ Cycles

40 #2 DIAMETER
_____ Ohms

40 #2 OFFSET
_____ Ohms

40 #2 VOLTAGE CONTROL
disable enable

40 #2 DELAY
_____ Cycles

40 VOLTAGE CONTROL
_____ Volts

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

60FL V.T. FUSE LOSS
FUSE

60FL INPUT INITIATE
FL i6 i5 i4 i3 i2 i1

60FL DELAY
_____ Cycles

PHASE DISTANCE RELAY
← pwr lof fuse DIST→

21 PHASE DISTANCE
DIST ostp

21#1 DIAMETER
_____ Ohms

21#1 OFFSET
_____ Ohms

21#1 IMPEDANCE ANGLE
_____ Degrees

21#1 DELAY
_____ Cycles

21#2 DIAMETER
_____ Ohms

21#2 OFFSET
_____ Ohms

21#2 IMPEDANCE ANGLE
_____ Degrees

21#2 DELAY
_____ Cycles

↓

Figure A-4 Setpoint & Timing Record Form (3 of 4)

PHASE DISTANCE RELAY
← pwr lof fuse DIST→

78 OUT OF STEP
dist OSTP

78 DIAMETER
_____ Ohms

78 OFFSET
_____ Ohms

78 BLINDER IMPEDANCE
_____ Ohms

78 IMPEDANCE ANGLE
_____ Degrees

78 DELAY
_____ CYCLES

78 TRIP ON MHO EXIT
disable enable

78 POLE SLIP COUNT
_____ Slips

78 POLE SLIP RESET TIME
_____ Cycles

FIELD GROUND RELAY
← FIELD stator ext →

64B/F FIELD GROUND
FIELD

64F #1 PICKUP
_____ kOhm

64F #1 DELAY
_____ Cycles

64F # 2 PICKUP
_____ kOhm

64F # 2 DELAY
_____ Cycles

64B PICKUP
_____ mV

64B DELAY
_____ Cycles

64B/F FREQUENCY
_____ Hz

EXTERNAL RELAY
← rotor stator EXT →

EXTERNAL
EXT

EXT #1 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT #1 DELAY
_____ Cycles

EXT #2 INPUT INITIATE
i6 i5 i4 i3 i2 i1

EXT #2 DELAY
_____ Cycles

■ **NOTE**: If a function is DISABLED, the input screens for that function will not be displayed. Unpurchased or unavailable functions will not be visible.

Figure A-4 Setpoint & Timing Record Form (4 of 4)