489

GENERATOR MANAGEMENT RELAY®

Instruction Manual

489 Firmware Revision: 32G140A8.000
489 PC Software Revision: 1.40
Manual P/N: 1601-0071-E7
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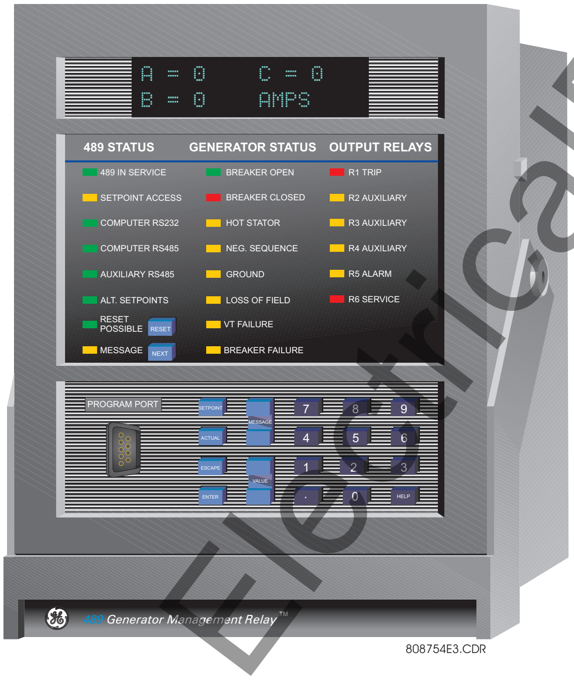

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APPENDIX A

APPENDIX B

APPENDIX C

APPENDIX D

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The 489 Generator Management Relay is a microprocessor based relay designed for the protection and management of synchronous and induction generators. The 489 is equipped with 6 output relays for trips and alarms. Generator protection, fault diagnostics, power metering, and RTU functions are integrated into one economical drawout package. The single line diagram of Figure 1-1 illustrates the 489 functionality using the ANSI (American National Standards Institute) device numbers.

ANSI	PROTECTION	Synchronous	Induction
12	overspeed	●	●
21	distance	●	●
24	volts/hertz	●	
27	undervoltage	●	●
50/27	inadvertent generator energization	●	●
32	reverse power/low forward power	●	●
38	bearing overtemperature (RTD)	●	●
39	bearing vibration (analog inputs)	●	●
40	loss of excitation (impedance)	●	
40Q	loss of field (reactive power)	●	
46	negative sequence overcurrent ($I_2 t$)	●	●
47	voltage phase reversal	●	●
49	stator thermal (RTD/thermal model)	●	●
50	high-set phase overcurrent	●	●
50BF	breaker failure detection	●	●
50	offline overcurrent	●	●
50/51GN	ground overcurrent	●	●
51V	voltage restrained phase overcurrent	●	●
59	overvoltage	●	●
59GN/27TN	100% stator ground	●	●
60FL	VT fuse failure	●	●
67	ground directional	●	●
76	overexcitation (analog input)	●	
81	overfrequency/underfrequency	●	●
86	electrical lockout	●	●
87G	percentage differential	●	●
	sequential tripping logic	●	●
	trip coil supervision	●	●
	generator running hours alarm	●	●

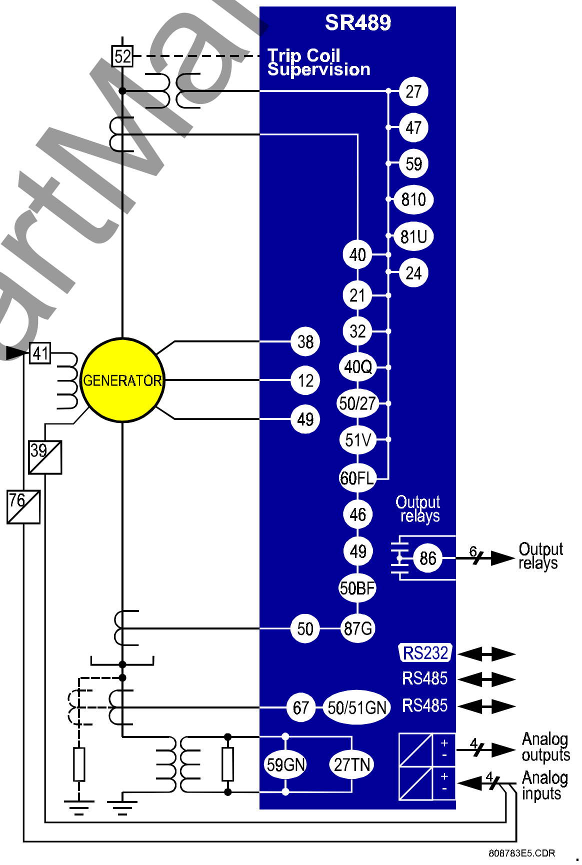

Figure 1-1 SINGLE LINE DIAGRAM

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A complete list protection features may be found below in the following tables: Table 1-1 and Table 1-2.

Table 1-1 TRIP PROTECTION

- 7 assignable digital inputs: general input, sequential trip (low forward power or reverse power) , field-breaker discrepancy, and tachometer
- offline overcurrent (protection during startup)
- inadvertent energization
- phase overcurrent with voltage restraint
- negative sequence overcurrent
- ground overcurrent
- percentage phase differential
- ground directional
- high-set phase overcurrent
- undervoltage
- overvoltage
- volts/hertz
- voltage phase reversal
- underfrequency (two step)
- overfrequency (two step)
- neutral overvoltage (fundamental)
- neutral undervoltage (3rd harmonic)
- loss of excitation (2 impedance circles)
- distance element (2 zones of protection)
- reactive power (kvar) for loss of field
- reverse power for anti-motoring
- low forward power
- RTDs: stator, bearing, ambient, other
- thermal overload
- analog Inputs 1-4
- electrical lockout

Table 1-2 ALARM PROTECTION

- 7 assignable digital inputs: general input and tachometer
- overload
- negative sequence
- ground overcurrent
- ground directional
- undervoltage
- overvoltage
- volts/hertz
- underfrequency
- overfrequency
- neutral overvoltage (fundamental)
- neutral undervoltage (3rd harmonic)
- reactive power (kvar)
- reverse power
- low forward power
- RTD: stator, bearing, ambient, other
- short/low RTD
- open RTD
- thermal overload
- trip counter
- breaker failure
- trip coil monitor
- VT fuse failure
- demand: current, MW, Mvar, MVA
- generator running hours
- analog inputs 1-4
- service (self-test failures)

Fault diagnostics are provided through pretrip data, event record, waveform capture, and statistics. Prior to issuing a trip, the 489 will take a snapshot of the measured parameters and store them in a record with the cause of the trip. This pre-trip data may be viewed using the [NEXT] key before the trip is reset, or by accessing the last trip data of Actual Values page 1. The 489 event recorder will store up to 40 time and date stamped events including the pre-trip data. Each time a trip occurs, the 489 will store a trace of 16 cycles for all measured AC quantities. Trip counters record the number of occurrences of each type of trip. Minimum and maximum values for RTDs and analog inputs are also recorded. These features will enable the operator to pinpoint a problem quickly and with certainty.

Power metering is built into the 489 as a standard feature. Table 1-3 outlines the metered parameters that are available to the operator or plant engineer either through the front panel or through the communications ports. The 489 is equipped with 3 fully functional and independent communications ports. The front panel RS232 port may be used for 489 setpoint programming, local interrogation or control, and upgrading of 489 firmware. The Computer RS485 port may be connected to a PLC, DCS, or PC based man-machine interface program. The Auxiliary RS485 port may be used for redundancy or simultaneous interrogation and/or control from a second PLC, DCS, or PC program. There are also four 4-20 mA transducer outputs that may be assigned to any measured parameter. The range of these outputs is scaleable.

Additional features are outlined in Table 1-4.

Table 1-3 METERING

- voltage (phasors)
- current (phasors) and amps demand
- real power, MW demand, MWh
- apparent power and MVA demand
- reactive power, Mvar demand, Mvarh positive/negative
- frequency
- power factor
- RTD
- speed in RPM with a key phasor Input
- user programmable analog inputs

Table 1-4 ADDITIONAL FEATURES

- drawout case (for ease of maintenance and testing)
- breaker failure
- trip coil supervision
- VT fuse failure
- simulation
- flash memory for easy firmware updates

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ORDERING

489 * * *

489				Base unit generator management relay
	P1			Current Transformer Inputs: 1 A CT secondaries
	P5			Current Transformer Inputs: 5 A CT secondaries
		LO		Control Power: DC: 20-60V; AC: 20-48V @ 48-62 Hz
		HI		Control Power: DC: 90-300V; AC: 70-265V @ 48-62 Hz
			A1	0-1 mA Analog Outputs
			A20	4-20 mA Analog Outputs

ACCESSORIES

489PC Software:........... Shipped free with 489
DEMO:.......................... Metal carry case in which 489 unit may be mounted
SR 19-1 PANEL: .... Single cutout for 19” panel
SR 19-2 PANEL: .... Double cutout for 19” panel
SCI MODULE: .... RS232 to RS485 converter box, designed for harsh industrial environments
PCT:.............................. 50, 75, 100, 150, 200, 250, 300, 350, 400, 500, 600, 750, 1000 Phase CT primaries
HGF3, HGF5, HGF8:.... For sensitive ground detection on high resistance grounded systems
489 1 3/8” Collar: .... For shallow switchgear, reduces the depth of the relay by 1 3/8”
489 3” Collar: .... For shallow switchgear, reduces the depth of the relay by 3”

All features of the 489 are standard, there are no options. The phase CT secondaries must be specified at the time of order. The control power and analog output range must also be specified at the time of order. There are two ground CT inputs, one for the GE Power Management HGF core balance CT and one for a ground CT with a 1A secondary (may also be used to accommodate 5A secondary). The VT inputs will accommodate VTs in either a delta or wye configuration. The output relays are always non-failsafe with the exception of the service relay. The 489PC program is provided with each unit. A metal demo case may be ordered for demonstration or testing purposes. Other accessories are listed below.

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POWER SUPPLY

Options: LO / HI (must be specified when ordering)
Range: LO: DC: 20 to 60 Vdc
AC: 20 to 48 Vac @ 48 to 62 Hz
HI: DC: 90 to 300 Vdc
AC: 70 to 265 Vac @ 48 to 62 Hz
Power: 45 VA (max), 25 VA typical
Proper operation time without supply voltage: 30 ms

AC ANALOG INPUTS FREQUENCY TRACKING

Frequency Tracking: Va for wye, Vab for open delta
6 V minimum, 10 Hz / sec.

OUTPUT AND NEUTRAL END CURRENT INPUTS

CT Primary: 10 - 50000A
CT Secondary: 1A or 5A (must be specified with order)
Conversion Range: 0.02 - 20 x CT
Accuracy: @ < 2 x CT: ± 0.5% of 2 x CT
@ ≥ 2 x CT: ± 1% of 20 x CT
Burden: Less than 0.2 VA at rated load
CT Withstand: 1 second @ 80 times rated current
2 seconds @ 40 times rated current
continuous @ 3 times rated current

GROUND CURRENT INPUT

CT Primary: 10 – 10000A (1A/5A)
CT Secondary: 1A/5A or 50:0.025 (HGF)
Conversion Range: 0.02 – 20 x CT for 1A/5A
0.0 – 100A primary for 50:0.025 CT (HGF)
Accuracy: HGF: ± 0.1A @ < 10A
± 1.0A @ ≥ 10 – 100A
1A/5A: @ < 2 x CT: ± 0.5% of 2 x CT
@ ≥ 2 x CT: ± 1% of 20 x CT

GROUND CT BURDEN			
Ground CT	**INPUT (A)**	**BURDEN**	
		VA	**Ω**
1A/5A	1	0.024	0.024
	5	0.605	0.024
	20	9.809	0.024
50:0.025 HGF	0.025	0.057	90.7
	0.1	0.634	90.7
	0.5	18.9	75.6

GROUND CT CURRENT WITHSTAND (Secondary)			
Ground CT	**WITHSTAND TIME**		
	1s	**2s**	**continuous**
1A/5A	80 x CT	40 x CT	3 x CT
50:0.025 HGF	N/A	N/A	150 mA

PHASE VOLTAGE INPUTS

VT Ratio: 1.00 – 240.00:1 in steps of 0.01
VT Secondary: 200Vac (Full Scale)
Conversion Range: 0.02 - 1.00 x Full Scale
Accuracy: ± 0.5% of Full Scale
Max. Continuous: 280Vac
Burden: > 500 KΩ

NEUTRAL VOLTAGE INPUT

VT Ratio: 1.00 – 240.00:1 in steps of 0.01
VT Secondary: 100Vac (Full Scale)
Conversion Range: 0.005 - 1.00 x Full Scale
Accuracy: ± 0.5% of Full Scale
Max. Continuous: 280Vac

DIGITAL INPUTS

Inputs: 9 opto-isolated inputs
External Switch: dry contact < 800Ω, or
open collector NPN transistor from sensor
6mA sinking from internal 4K pullup @ 24Vdc
with Vce < 4Vdc
489 Sensor Supply: +24Vdc @ 20mA Max.

RTD INPUTS

RTDs: 3 wire type 100Ω Platinum (DIN.43760)
100Ω Nickel
120Ω Nickel
10Ω Copper
} field programmable
RTD Sensing Current: 5mA
Isolation: 36Vpk (Isolated with Analog Inputs and Outputs)
Range: -50 to +250 °C
Accuracy: ± 2°C for Platinum and Nickel
± 5°C for Copper
Lead Resistance: 25Ω Max per lead
No Sensor: >1kΩ
Short/Low Alarm: < -50°C

TRIP COIL SUPERVISION

Applicable Voltage: 20-300 Vdc/Vac
Trickle Current: 2-5mA

ANALOG CURRENT INPUTS

Current Inputs: 0-1mA, 0-20mA or 4-20mA (setpoint)
Input Impedance: 226Ω+/-10%
Conversion Range: 0-2mA
Accuracy: ± 1% of full scale
Type: Passive
Analog Input Supply: +24VDC @ 100mA max.
Sampling Interval: 50 ms

COMMUNICATIONS PORTS

RS232 Port: 1, Front Panel, non-isolated
RS485 Ports: 2, Isolated together @ 36Vpk
Baud Rates: RS485: 300,1200,2400,4800,9600,19200
RS232: 9600
Parity: None, Odd, Even
Protocol: Modbus® RTU / half duplex, DNP 3.0

ANALOG CURRENT OUTPUT

Type: Active
Range: 4-20mA, 0-1 mA (must be specified with order)
Accuracy: ± 1% of full scale
4 20 mA max. load: 1.2kΩ
0-1mA max. load: 10kΩ
Isolation: 36Vpk (Isolated with RTDs and analog inputs)
4 Assignable Outputs: Phase A,B,C output current
3 phase average current
negative sequence current
generator load
hottest stator RTD
hottest bearing RTD
RTD # 1-12
AB voltage
BC voltage
CA voltage
average phase-phase voltage
volts/hertz
frequency
3rd harmonic neutral voltage
power factor
3 phase reactive power (Mvar)
3 phase real power (MW)
3 phase apparent power (MVA)
analog inputs 1-4
tachometer
thermal capacity used
I, Mvar, MW, MVA demands
Torque

OUTPUT RELAYS

Configuration: 6 Electo-Mechanical Form C
Contact Material: silver alloy
Operate Time: 10ms
Max Ratings for 100000 operations

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VOLTAGE		MAKE/CARRY CONTINUOUS	MAKE/CARRY 0.2 s	BREAK	MAX LOAD
DC Resistive	30 Vdc	10 A	30 A	10 A	300 W
	125 Vdc	10 A	30 A	0.5 A	62.5 W
	250 Vdc	10 A	30 A	0.3 A	75 W
DC Inductive L/R = 40 ms	30 Vdc	10 A	30 A	5 A	150 W
	125 Vdc	10 A	30 A	0.25 A	31.3 W
	250 Vdc	10 A	30 A	0.15 A	37.5 W
AC Resistive	120 Vac	10 A	30 A	10 A	2770 VA
	250 Vac	10 A	30 A	10 A	2770 VA
AC Inductive PF = 0.4	120 Vac	10 A	30 A	4 A	480 VA
	250 Vac	10 A	30 A	3 A	750 VA

TERMINALS

Low Voltage (A, B, C, D terminals):
12 AWG max
High Voltage (E, F, G, H terminals):
#8 ring lug, 10 AWG wire standard

POWER METERING

Range:	0.000 - 2000.000 +/-Mw, +/-Mvar, MVA
Accuracy:	±1% of √3x2xCTxVTxVT full scale @ Iavg < 2xCT ±1.5% of √3x20xCTxVTxVT full scale @ Iavg > 2xCT

WATTHOUR and VARHOUR METERING

Description:	Continuous total of +Watthours and +/- varhours
Range:	0.000 - 4000000.000 Mvar-Hours
Timing Accuracy:	±0.5%
Update Rate:	50ms

DEMAND METERING

Metered Values:	Maximum Phase Current 3 Phase Real Power 3 Phase Apparent Power 3 Phase Reactive Power
Measurement Type:	Rolling Demand
Demand Interval:	5 - 90 minutes in steps of 1
Update Rate:	1 minute
Elements:	Alarm

GENERAL INPUT A - G (Digital Input)

Configurable:	Assignable Digital Inputs1- 7
Time Delay:	0.1 - 5000.0 s in steps of 0.1
Block From Online:	0 - 5000 s in steps of 1
Timing Accuracy:	±100 ms or ± 0.5 % of total time
Elements:	Trip , Alarm, and Control

SEQUENTIAL TRIP (Digital Input)

Configurable:	Assignable to Digital Inputs1- 7
Pickup Level:	0.02 - 0.99 x Rated MW in steps of 0.01 Low Forward Power / Reverse Power
Time Delay:	0.2 - 120.0 s in steps of 0.1
Pickup Accuracy:	see power metering
Timing Accuracy:	±100ms or ± 0.5 % of total time
Elements:	Trip

FIELD BREAKER DISCREPANCY (Digital Input)

Configurable:	Assignable to Digital Inputs1- 7
Time Delay:	0.1 - 500.0 s in steps of 0.1
Timing Accuracy:	±100ms or ± 0.5 % of total time
Elements:	Trip

TACHOMETER (Digital Input)

Configurable:	Assignable to Digital Inputs 4- 7
RPM Measurement:	100 - 7200 RPM
Duty Cycle of Pulse:	> 10 %
Pickup Level:	101 - 175 x Rated Speed in steps of 1
Time Delay:	1 - 250 s in steps of 1
Timing Accuracy:	±0.5 s or ± 0.5 % of total time
Elements:	Trip and Alarm

OVERCURRENT ALARM

Pick-up Level:	0.10 - 1.50 x FLA in steps of 0.01 average phase current
Time Delay:	0.1 - 250.0 s in steps of 0.1
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	±100ms or ± 0.5 % of total time
Elements:	Alarm

OFFLINE OVERCURRENT

Pick-up Level:	0.05 - 1.00 x CT in steps of 0.01 of any one phase
Time Delay:	3 - 99 cycles in steps of 1
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	+50ms @ 50/60 Hz
Elements:	Trip

INADVERTENT ENERGIZATION

Arming Signal:	undervoltage and/or Offline from breaker status
Pick-up Level:	0.05 - 3.00 x CT in steps of 0.01 of any one phase
Time Delay:	no intentional delay
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	+50ms @ 50/60 Hz
Elements:	Trip

PHASE OVERCURRENT

Voltage Restraint:	Programmable fixed characteristic
Pick-up Level:	0.15 - 20.00 x CT in steps of 0.01 of any one phase
Curve Shapes:	ANSI, IEC, IAC, Flexcurve, Definite Time
Time Delay:	0.000 - 100.000 s in steps of 0.001
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	+50ms @ 50/60 Hz or ± 0.5 % of total time
Elements:	Trip

NEGATIVE SEQUENCE OVERCURRENT

Pick-up Level:	3 - 100 % FLA in steps of 1
Curve Shapes:	I_2^2t trip as defined by k, definite time alarm
Time Delay:	0.1 - 100.0 s in steps of 0.1
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	±100ms or ± 0.5 % of total time
Elements:	Trip and Alarm

GROUND OVERCURRENT

Pick-up Level:	0.05- 20.00 x CT in steps of 0.01
Curve Shapes:	ANSI, IEC, IAC, Flexcurve, Definite Time
Time Delay:	0.00 - 100.00 s in steps of 0.01
Pickup Accuracy:	as per Ground Current Input
Timing Accuracy:	+50ms @ 50/60 Hz or ± 0.5 % of total time
Elements:	Trip

PHASE DIFFERENTIAL

Pick-up Level:	0.05-1.00 x CT in steps of 0.01
Curve Shape:	Dual Slope
Time Delay:	0 - 100 cycles in steps of 1
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	+50ms @ 50/60 Hz or ± 0.5 % of total time
Elements:	Trip

GROUND DIRECTIONAL

Pickup Level:	0.05 - 20.00 x CT in steps of 0.01
Time Delay:	0.1 - 120.0 s in steps of 0.1
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	±100 ms or ±0.5 % of total time
Elements:	Trip and Alarm

HIGH-SET PHASE OVERCURRENT

Pickup Level:	0.15 - 20.00 x CT in steps of 0.01
Time Delay:	0.00 - 100.00 s in steps of 0.01
Pickup Accuracy:	as per Phase Current Inputs
Timing Accuracy:	±50 ms @ 50/60 Hz or ±0.5 % of total time
Elements:	Trip

UNDERVOLTAGE

Pick-up Level:	0.50 - 0.99 x rated Voltage in steps of 0.01
Curve Shapes:	Inverse Time, definite time alarm
Time Delay:	0.2 - 120.0 s in steps of 0.1
Pickup Accuracy:	as per Voltage Inputs
Timing Accuracy:	±100ms or ± 0.5 % of total time
Elements:	Trip and Alarm

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OVERVOLTAGE

Pick-up Level: 1.01 - 1.50 x rated Voltage in steps of 0.01
Curve Shapes: Inverse Time, definite time alarm
Time Delay: 0.2 - 120.0 s in steps of 0.1
Pickup Accuracy: as per Voltage Inputs
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

VOLTS/HERTZ

Pick-up Level: 1.00 - 1.99 x nominal in steps of 0.01
Curve Shapes: Inverse Time, definite time alarm
Time Delay: 0.1 - 120.0 s in steps of 0.1
Pickup Accuracy: as per Voltage Inputs
Timing Accuracy: ±100ms @ ≥ 1.2 x Pickup
±300ms @ < 1.2 x Pickup
Elements: Trip and Alarm

VOLTAGE PHASE REVERSAL

Configuration: ABC or ACB phase rotation
Timing Accuracy: 200 -400 ms
Elements: Trip

UNDERFREQUENCY

Required Voltage: 0.50 - 0.99 x rated voltage in Phase A
Block From Online: 0 - 5 s in steps of 1
Pick- up Level: 20.00 - 60.00 in steps of 0.01
Curve Shapes: 1 level alarm, two level trip definite time
Time Delay: 0.1 - 5000.0 s in steps of 0.1
Pickup Accuracy: ± 0.02 Hz
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

OVERFREQUENCY

Required Voltage: 0.50 - 0.99 x rated voltage in Phase A
Block From Online: 0 - 5 s in steps of 1
Pick- up Level: 25.01 - 70.00 in steps of 0.01
Curve Shapes: 1 level alarm, two level trip definite time
Time Delay: 0.1 - 5000.0 s in steps of 0.1
Pickup Accuracy: ± 0.02 Hz
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

NEUTRAL OVERVOLTAGE (Fundamental)

Pick-up Level: 2.0 - 100.0 Vsecondary in steps of 0.01
Time Delay: 0.1 - 120.0 s in steps of 0.1
Pickup Accuracy: as per Neutral Voltage Input
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

NEUTRAL UNDERVOLTAGE (3rd Harmonic)

Blocking Signals: Low power and Low Voltage if Open Delta
Pick-up Level: 0.5 - 20.0 Vsecondary in steps of 0.01 if open delta
adaptive if wye VT connection
Time Delay: 5 - 120 s in steps of 1
Pickup Accuracy: at ≤20.0 V secondary: as per Neutral Voltage Input
at >20.0 V secondary: ±5% of pickup
Timing Accuracy: ±3.0 s
Elements: Trip and Alarm

LOSS OF EXCITATION (Impedance)

Pickup Level: 2.5 - 300.0 Ω secondary in steps of 0.1 with adjustable
impedance offset 1.0 - 300.0 Ω secondary in steps of 0.1
Time Delay: 0.1 - 10.0 s in steps of 0.1
Pickup Accuracy: as per Voltage Input and Phase Current Input
Timing Accuracy: ±100 ms or ±0.5 % of total time
Elements: Trip - two trip zones using impedance circles

DISTANCE (Impedance)

Pickup Levels: 0.1 - 500.0 Ω secondary in steps of 0.1
50 - 85° reach in steps of 1°
Time Delay: 0.0 - 150.0 s in steps of 0.1
Pickup Accuracy: as per Voltage Input and Phase Current Input
Timing Accuracy: 150 ms ±50 ms or ±0.5 % of total time
Elements: Trip - two trip zones

REACTIVE POWER

Block From Online: 0 - 5000 s in steps of 1
Pick- up Level: 0.02 - 1.50 x rated Mvar Positive and negative
Time Delay: 0.2- 120.0 s in steps of 0.1
Pickup Accuracy: see power metering
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

REVERSE POWER

Block From Online: 0 - 5000 s in steps of 1
Pick- up Level: 0.02 - 0.99 x rated MW
Time Delay: 0.2- 120.0 s in steps of 0.1
Pickup Accuracy: see power metering
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

LOW FORWARD POWER

Block From Online: 0 - 15000 s in steps of 1
Pick- up Level: 0.02 - 0.99 x rated MW
Time Delay: 0.2- 120.0 s in steps of 0.1
Pickup Accuracy: see power metering
Timing Accuracy: ±100ms or ± 0.5 % of total time
Elements: Trip and Alarm

PULSE OUTPUT

Parameters: + kwh, +kvarh, -kvarh
Interval: 1-50000 in steps of 1
Pulse Width: 200-1000 ms in steps of 1 ms

RTDs 1-12

Pickup: 1 - 250 °C in steps of 1
Pickup Hysteresis: 2°C
Time Delay: 3 s
Elements: Trip and Alarm

OVERLOAD / STALL PROTECTION / THERMAL MODEL

Overload Curves: 15 Standard Overload Curves
Custom Curve
Voltage Dependent Custom Curve
(all curves time out against average phase current)
Curve Biasing: Phase Unbalance
Hot/Cold Curve Ratio
Stator RTD
Online Cooling Rate
Offline Cooling Rate
Line Voltage
Overload Pickup: 1.01 - 1.25
Pickup Accuracy: as per Phase Current Inputs
Timing Accuracy: ±100ms or ± 2 % of total time
Elements: Trip and Alarm

OTHER FEATURES

- Serial Start/Stop Initiation
- Remote Reset (Configurable Digital Input)
- Test Input (Configurable Digital Input)
- Thermal Reset (Configurable Digital Input)
- Dual Setpoints
- Pre-Trip Data
- Event Recorder
- Waveform Memory
- Fault Simulation
- VT Failure
- Trip Counter
- Breaker Failure
- Trip Coil Monitor
- Generator Running Hours Alarm

ENVIRONMENT

Ambient Operating Temperature: -40 °C – +60 °C
Ambient Storage Temperature: 40 °C – +80 °C.
Humidity: Up to 90%, noncondensing.
Altitude: Up to 2000m
Pollution Degree: 2

NOTE: It is recommended that the 489 be powered up at least once per year to prevent deterioration of electrolytic capacitors in the power supply.

CASE

Fully drawout (Automatic CT shorts)
Seal provision
Dust tight door
Panel or 19" rack mount

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IP Class: IP20-X

PRODUCTION TESTS

Thermal Cycling:	Operational test at ambient, reducing to -40°C and then increasing to 60°C
Dielectric Strength:	2.0 kV for 1 minute from relays, CTs, VTs, power supply to Safety Ground

DO NOT CONNECT FILTER GROUND TO SAFETY GROUND DURING TEST

FUSE

Current Rating:	3.15A
Type:	5x20mm Slo-Blo Littelfuse, High Breaking Capacity
Model#:	215.315

NOTE: External fuse must be used if supply voltage exceeds 250V

TYPE TESTS

Dielectric Strength:	Per IEC 255-5 and ANSI/IEEE C37.90 2.0 kV for 1 minute from relays, CTs, VTs, power supply to Safety Ground

DO NOT CONNECT FILTER GROUND TO SAFETY GROUND DURING TEST

Insulation Resistance:	IEC255-5 500Vdc, from relays, CTs, VTs, power supply to Safety Ground

DO NOT CONNECT FILTER GROUND TO SAFETY GROUND DURING TEST

Transients:	ANSI C37.90.1 Oscillatory (2.5kV/1MHz) ANSI C37.90.1 Fast Rise (5kV/10ns) Ontario Hydro A-28M-82 IEC255-4 Impulse/High Frequency Disturbance Class III Level
Impulse Test:	IEC 255-5 0.5 Joule 5kV
RFI:	50 MHz/15W Transmitter
EMI:	C37.90.2 Electromagnetic Interference @ 150 MHz and 450 MHz, 10V/m
Static:	IEC 801-2 Static Discharge
Humidity:	90% non-condensing
Temperature:	-40 °C to +60 °C ambient
Environment:	IEC 68-2-38 Temperature/Humidity Cycle
Vibration:	Sinusoidal Vibration 8.0g for 72 hrs

PACKAGING

Shipping Box:	12"x11"x10" (WxHxD) 30.5cm x 27.9cm x 25.4cm
Shipping Weight:	17 lbs Max / 7.7 kg

CERTIFICATION

ISO:	Manufactured under an ISO9001 registered system.
UL:	UL
CSA:	CSA
CE:	Conforms to IEC 947-1,IEC 1010-1

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2.1.1 DESCRIPTION

The 489 is packaged in the standard GE Power Management SR series arrangement, which consists of a drawout unit and a companion fixed case. The case provides mechanical protection to the unit, and is used to make permanent connections to all external equipment. The only electrical components mounted in the case are those required to connect the unit to the external wiring. Connections in the case are fitted with mechanisms required to allow the safe removal of the relay unit from an energized panel, such as automatic CT shorting. The unit is mechanically held in the case by pins on the locking handle, which cannot be fully lowered to the locked position until the electrical connections are completely mated. Any 489 can be installed in any 489 case, except for custom manufactured units that are clearly identified as such on both case and unit, and are equipped with an index pin keying mechanism to prevent incorrect pairings.

No special ventilation requirements need to be observed during the installation of the unit, but the unit should be wiped clean with a damp cloth.

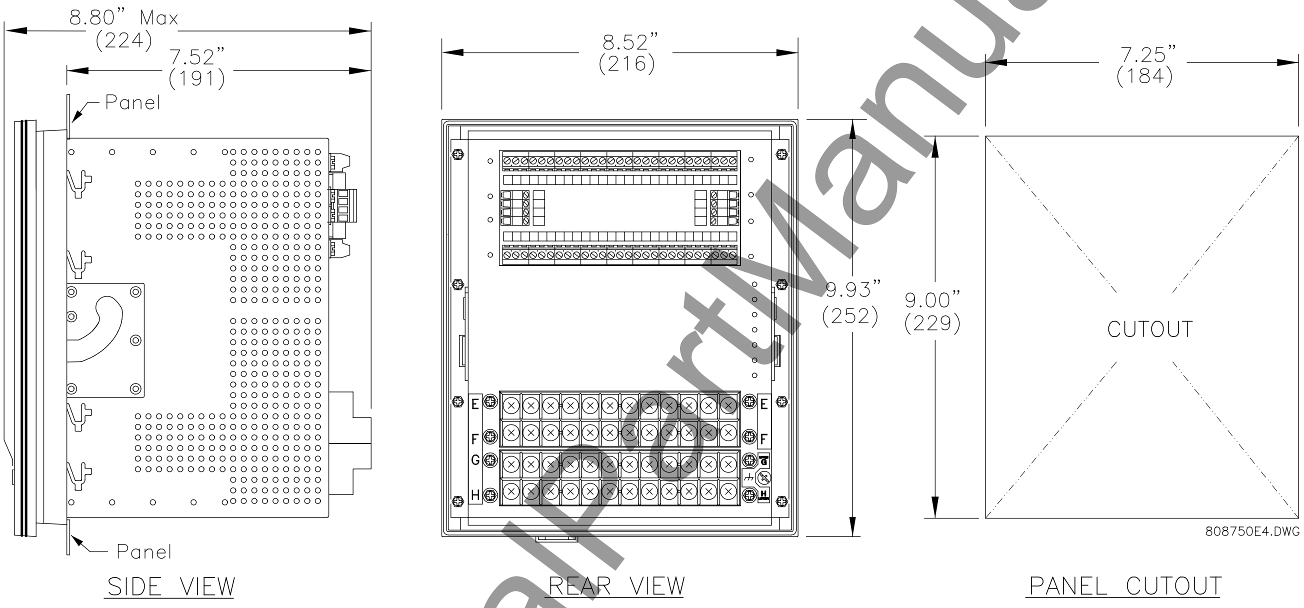
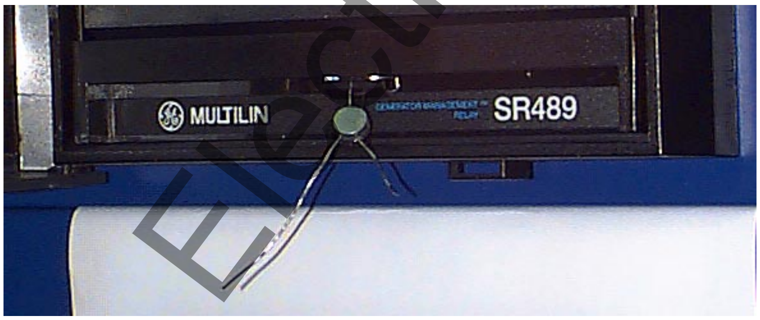


Figure 2-1 489 DIMENSIONS



To prevent unauthorized removal of the drawout unit, a wire lead seal can be installed in the slot provided on the handle as shown in Figure 2-2. With this seal in place, the drawout unit cannot be removed. A passcode or setpoint access jumper can be used to prevent entry of setpoints but still allow monitoring of actual values. If access to the front panel controls must be restricted, a separate seal can be installed on the outside of the cover to prevent it from being opened.

Figure 2-2 SEAL ON DRAWOUT UNIT

**** WARNING ** Hazard may result if the product is not used for its intended purpose.**

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2.1.2 PRODUCT IDENTIFICATION

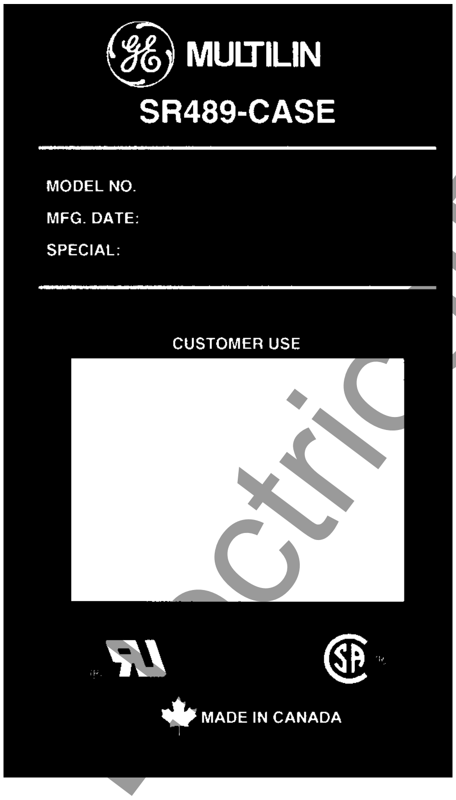
Each 489 unit and case are equipped with a permanent label. This label is installed on the left side (when facing the front of the relay) of both unit and case. The case label details which units can be installed.

The case label details the following information:

- MODEL NUMBER
- MANUFACTURE DATE
- SPECIAL NOTES

The unit label details the following information:

- MODEL NUMBER
- TYPE
- SERIAL NUMBER
- FILE NUMBER
- MANUFACTURE DATE
- PHASE CURRENT INPUTS
- SPECIAL NOTES
- OVERVOLTAGE CATEGORY
- INSULATION VOLTAGE
- POLLUTION DEGREE
- CONTROL POWER
- OUTPUT CONTACT RATING



MULTILIN

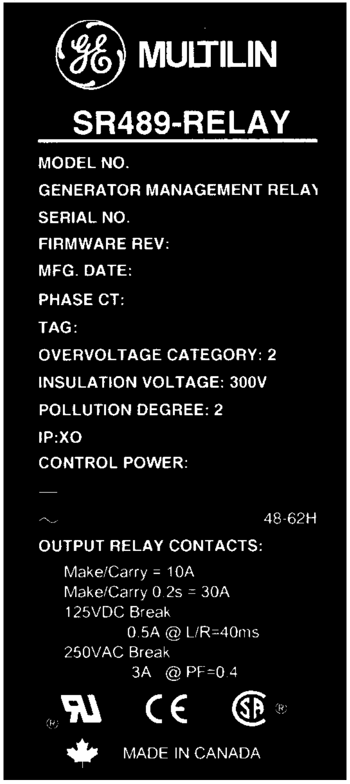
SR489-CASE

MODEL NO.
MFG. DATE:
SPECIAL:

CUSTOMER USE

MADE IN CANADA

Figure 2-3 CASE IDENTIFICATION LABEL



MULTILIN

SR489-RELAY

MODEL NO.
GENERATOR MANAGEMENT RELAY
SERIAL NO.
FIRMWARE REV:
MFG. DATE:
PHASE CT:
TAG:
OVERVOLTAGE CATEGORY: 2
INSULATION VOLTAGE: 300V
POLLUTION DEGREE: 2
IP:XO
CONTROL POWER:
—
~ 48-62H
OUTPUT RELAY CONTACTS:
Make/Carry = 10A
Make/Carry 0.2s = 30A
125VDC Break
0.5A @ L/R=40ms
250VAC Break
3A @ PF=0.4

MADE IN CANADA

Figure 2-4 UNIT IDENTIFICATION LABEL

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2.1.3 INSTALLATION

The 489 case, alone or adjacent to another SR-series unit, can be installed in the panel of a standard 19 inch rack. (See Figure 2-1 489 DIMENSIONS for panel cutout dimensions.) When mounting, provision must be made for the front door to swing open without interference to, or from, adjacent equipment. Normally the 489 unit is mounted in its case when shipped from the factory, and should be removed before mounting the case in the supporting panel. Unit withdrawal is described in section 2.1.4 .

After the mounting hole in the panel has been prepared, slide the 489 case into the panel from the front. Applying firm pressure on the front to ensure the front bezel fits snugly against the front of the panel, bend out the pair of retaining tabs (to a horizontal position) from each side of the case, as shown in Figure 2-5. The case is now securely mounted, ready for panel wiring.

Figure 2-5 BEND UP MOUNTING TABS

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2.1.4 UNIT WITHDRAWAL AND INSERTION

Figure 2-6 PRESS LATCH TO DISENGAGE HANDLE

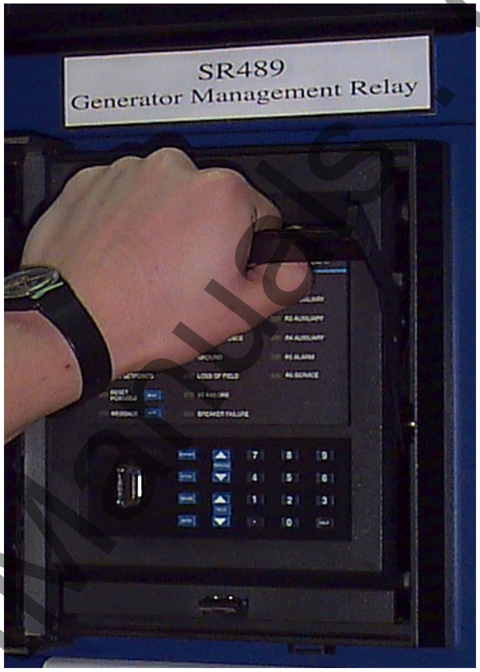

Figure 2-7 ROTATE HANDLE TO STOP POSITION

Figure 2-8 SLIDE UNIT OUT OF THE CASE

To remove the unit from the case:
(1) Open the cover by pulling the upper or lower corner of the right side of the cover, which will rotate about the hinges on the left.
(2) Release the locking latch, located below the locking handle, by pressing upward on the latch with the tip of a screwdriver (see Figure 2-6).
(3) Grasp the locking handle in the center and pull firmly, rotating the handle up from the bottom of the unit until movement ceases (see Figure 2-7).
(4) Once the handle is released from the locking mechanism, the unit can freely slide out of the case when pulled by the handle. It may sometimes be necessary to adjust the handle position slightly to free the unit (Figure 2-8).

To insert the unit into the case:
(1) Raise the locking handle to the highest position.
(2) Hold the unit immediately in front of the case and align the rolling guide pins (near the hinges of the locking handle) to the guide slots on either side of the case.
(3) Slide the unit into the case until the guide pins on the unit have engaged the guide slots on either side of the case.

⚠ **CAUTION: If an attempt is made to install a unit into a non-matching case, the mechanical key will prevent full insertion of the unit. Do not apply strong force in the following step or damage may result.**

(4) Grasp the locking handle from the center and press down firmly, rotating the handle from the raised position toward the bottom of the unit.
(5) When the unit is fully inserted, the latch will be heard to click, locking the handle in the final position.

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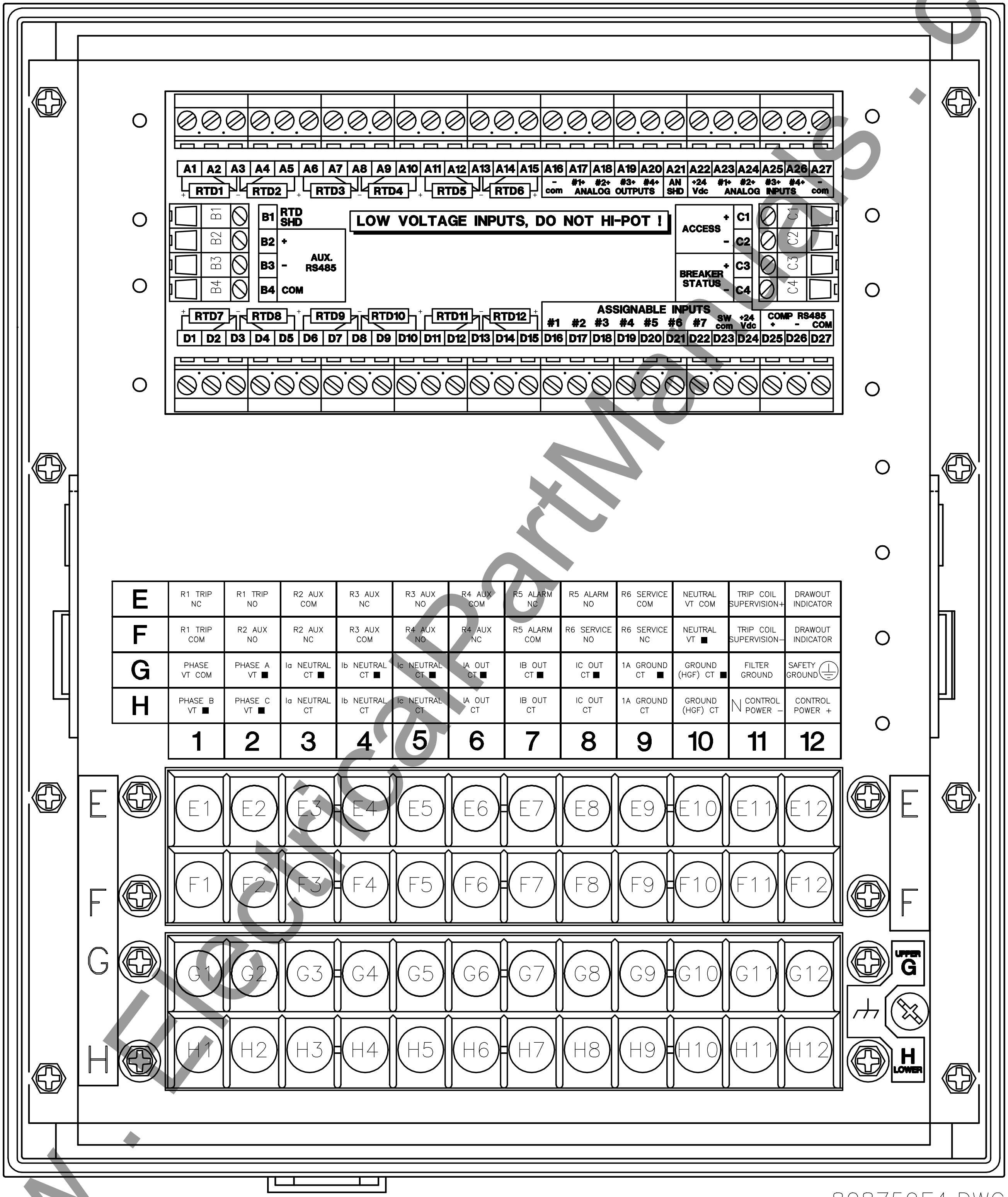
2.1.5 TERMINAL LOCATIONS



E	R1 TRIP NC	R1 TRIP NO	R2 AUX COM	R3 AUX NC	R3 AUX NO	R4 AUX COM	R5 ALARM NC	R5 ALARM NO	R6 SERVICE COM	NEUTRAL VT COM	TRIP COIL SUPERVISION+	DRAWOUT INDICATOR
F	R1 TRIP COM	R2 AUX NO	R2 AUX NC	R3 AUX COM	R4 AUX NO	R4 AUX NC	R5 ALARM COM	R6 SERVICE NO	R6 SERVICE NC	NEUTRAL VT ■	TRIP COIL SUPERVISION–	DRAWOUT INDICATOR
G	PHASE VT COM	PHASE A VT ■	Ia NEUTRAL CT ■	Ib NEUTRAL CT ■	Ic NEUTRAL CT ■	IA OUT CT ■	IB OUT CT ■	IC OUT CT ■	1A GROUND CT ■	GROUND (HGF) CT ■	FILTER GROUND	SAFETY GROUND ⏚
H	PHASE B VT ■	PHASE C VT ■	Ia NEUTRAL CT	Ib NEUTRAL CT	Ic NEUTRAL CT	IA OUT CT	IB OUT CT	IC OUT CT	1A GROUND CT	GROUND (HGF) CT	N CONTROL POWER –	CONTROL POWER +
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**

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Figure 2-9 TERMINAL LAYOUT

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Table 2-1 489 TERMINAL LIST

TERMINAL	WIRING CONNECTION
A01	RTD#1 HOT
A02	RTD#1 COMPENSATION
A03	RTD RETURN
A04	RTD#2 COMPENSATION
A05	RTD#2 HOT
A06	RTD#3 HOT
A07	RTD#3 COMPENSATION
A08	RTD RETURN
A09	RTD#4 COMPENSATION
A10	RTD#4 HOT
A11	RTD#5 HOT
A12	RTD#5 COMPENSATION
A13	RTD RETURN
A14	RTD#6 COMPENSATION
A15	RTD#6 HOT
A16	ANALOG OUT COMMON -
A17	ANALOG OUT1 +
A18	ANALOG OUT2 +
A19	ANALOG OUT3 +
A20	ANALOG OUT4 +
A21	ANALOG SHIELD
A22	ANALOG INPUT 24Vdc SUPPLY +
A23	ANALOG INPUT1+
A24	ANALOG INPUT2 +
A25	ANALOG INPUT3 +
A26	ANALOG INPUT4 +
A27	ANALOG INPUT COMMON -
B01	RTD SHIELD
B02	AUXILIARY RS485 +
B03	AUXILIARY RS485 –
B04	AUXILIARY RS485 COMMON
C01	ACCESS +
C02	ACCESS -
C03	BREAKER STATUS+
C04	BREAKER STATUS-
D01	RTD#7 HOT
D02	RTD#7 COMPENSATION
D03	RTD RETURN
D04	RTD#8 COMPENSATION
D05	RTD#8 HOT
D06	RTD#9 HOT
D07	RTD#9 COMPENSATION
D08	RTD RETURN
D09	RTD#10 COMPENSATION
D10	RTD#10 HOT
D11	RTD#11 HOT
D12	RTD#11 COMPENSATION
D13	RTD RETURN
D14	RTD#12 COMPENSATION
D15	RTD#12 HOT
D16	ASSIGNABLE SW.01
D17	ASSIGNABLE SW.02
D18	ASSIGNABLE SW.03
D19	ASSIGNABLE SW.04
D20	ASSIGNABLE SW.05
D21	ASSIGNABLE SW.06
D22	ASSIGNABLE SW.07
D23	SWITCH COMMON
D24	SWITCH +24Vdc
D25	COMPUTER 485 +
D26	COMPUTER 485 –
D27	COMPUTER RS485 COMMON

TERMINAL	WIRING CONNECTION
E01	R1 TRIP NC
E02	R1 TRIP NO
E03	R2 AUXILIARY COMMON
E04	R3 AUXILIARY NC
E05	R3 AUXILIARY NO
E06	R4 AUXILIARY COMMON
E07	R5 ALARM NC
E08	R5 ALARM NO
E09	R6 SERVICE COMMON
E10	NEUTRAL VT COM
E11	COIL SUPERVISION+
E12	IRIG-B +
F01	R1 TRIP COMMON
F02	R2 AUXILIARY NO
F03	R2 AUXILIARY NC
F04	R3 AUXILIARY COMMON
F05	R4 AUXILIARY NO
F06	R4 AUXILIARY NC
F07	R5 ALARM COMMON
F08	R6 SERVICE NO
F09	R6 SERVICE NC
F10	NEUTRAL VT •
F11	COIL SUPERVISION-
F12	IRIB-B –
G01	PHASE VT COM
G02	PHASE A VT•
G03	NEUTRAL PHASE a CT•
G04	NEUTRAL PHASE b CT•
G05	NEUTRAL PHASE c CT•
G06	OUTPUT PHASE A CT•
G07	OUTPUT PHASE B CT•
G08	OUTPUT PHASE C CT•
G09	1A GROUND CT•
G10	HGF GROUND CT•
G11	FILTER GROUND
G12	SAFETY GROUND
H01	PHASE B VT•
H02	PHASE C VT•
H03	NEUTRAL PHASE a CT
H04	NEUTRAL PHASE b CT
H05	NEUTRAL PHASE c CT
H06	OUTPUT PHASE A CT
H07	OUTPUT PHASE B CT
H08	OUTPUT PHASE C CT
H09	1A GROUND CT
H10	HGF GROUND CT
H11	CONTROL POWER -
H12	CONTROL POWER +

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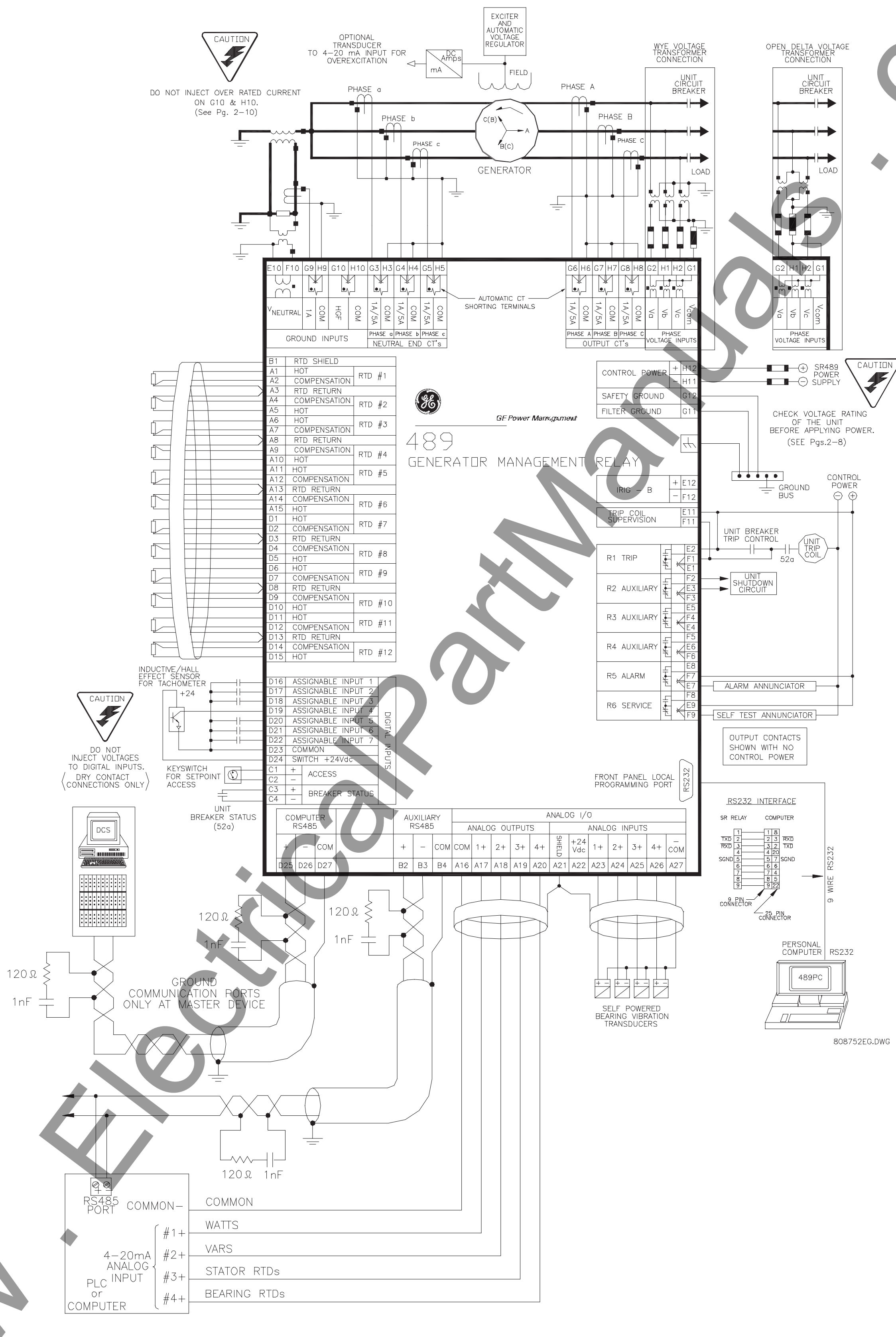

Figure 2-10 TYPICAL WIRING DIAGRAM

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2.2.1 TYPICAL WIRING

A broad range of applications are available to the user and it is not possible to present typical connections for all possible schemes. The information in this section will cover the important aspects of interconnections, in the general areas of instrument transformer inputs, other inputs, outputs, communications and grounding. See Figure 2-9 and Table 2-1 for terminal arrangement, and Figure 2-10 for typical connections.

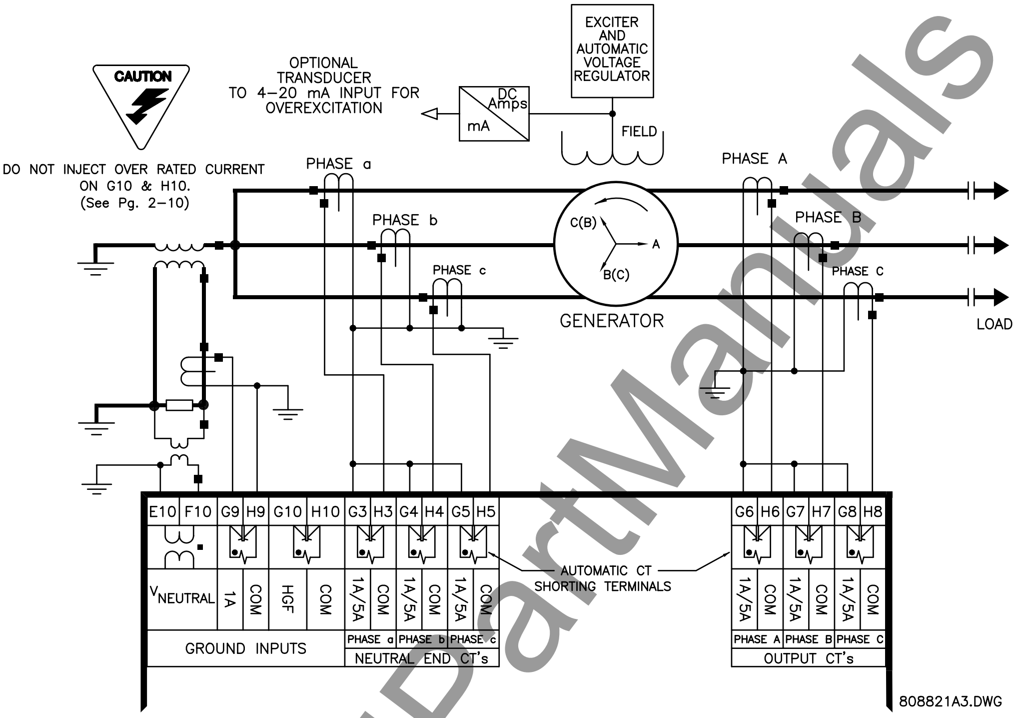

Figure 2-11 TYPICAL WIRING 2

2.2.2 CONTROL POWER

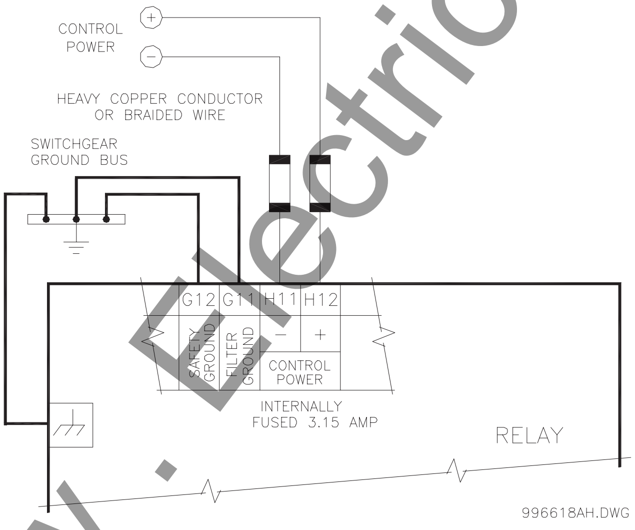

Figure 2-12 CONTROL POWER CONNECTION

CAUTION: Control power supplied to the 489 must match the installed switching power supply. If the applied voltage does not match, damage to the unit may occur.

The order code from the terminal label on the side of the drawout unit specifies the nominal control voltage as one of the following:

LO:	20-60 Vdc
	20-48 Vac
HI:	90-300 Vdc
	70-265 Vac

Ensure applied control voltage and rated voltage on drawout case terminal label match. For example, the HI power supply will work with any DC voltage from 90 to 300 V, or AC voltage from 70 to 265 V. The internal fuse may blow if the applied voltage exceeds this range.

Extensive filtering and transient protection are built into the 489 to ensure proper operation in harsh industrial environments. Transient energy must be conducted back to the source through the filter ground terminal. A separate safety ground terminal is provided for hi-pot testing.

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2.2.3 PHASE CURRENT INPUTS

The 489 has six phase current transformer inputs (three output side and three neutral end), each with an isolating transformer. There are no internal ground connections on the CT inputs. Each phase CT circuit is shorted by automatic mechanisms on the 489 case if the unit is withdrawn. The phase CTs should be chosen such that the FLA is no less than 50 % of the rated phase CT primary. Ideally, the phase CT primary should be chosen such that the FLA is 100 % of the phase CT primary or slightly less. This will ensure maximum accuracy for the current measurements. The maximum phase CT primary current is 50000 A.

The 489 will measure correctly up to 20 times the phase current nominal rating. Since the conversion range is large, 1 A or 5 A CT secondaries must be specified at the time of order such that the appropriate interposing CT may be installed in the unit. CTs chosen must be capable of driving the 489 phase CT burden (see Specifications for ratings).

CAUTION: Verify that the 489 nominal phase current of 1 A or 5 A matches the secondary rating and connections of the connected CTs. Unmatched CTs may result in equipment damage or inadequate protection. Polarity of the phase CTs is critical for phase differential, negative sequence, power measurement, and residual ground current detection (if used).

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2.2.4 GROUND CURRENT INPUT

The 489 has a dual primary isolating transformer for ground CT connection. There are no internal ground connections on the ground current inputs. The ground CT circuits are shorted by automatic mechanisms on the 489 case if the unit is withdrawn.

The 1A tap is used for 1A or 5A secondary CTs in either core balance (see Figure 2-10) or residual ground configurations (see Figure 2-13). If the 1A tap is used, the 489 will measure up to 20 A secondary current with a maximum ground CT ratio is 10000:1. The ground CT chosen must be capable of driving the 489 ground CT burden (see Specifications for ratings).

The HGF ground CT input has been designed for sensitive ground current detection on high resistance grounded systems where the GE Power Management HGF core balance CT (50:0.025) is to be used. In applications such as mines, where earth leakage current must be measured for personnel safety, primary ground current as low as 0.25A may be detected with the GE Power Management HGF CT. Only one ground CT input tap should be used on a given unit.

NOTE: Only one ground input should be wired and the other input should be unconnected.

⚠ **CAUTION: DO NOT INJECT OVER THE RATED CURRENT TO HGF TERMINAL (0.25 to 25 A PRIMARY)**

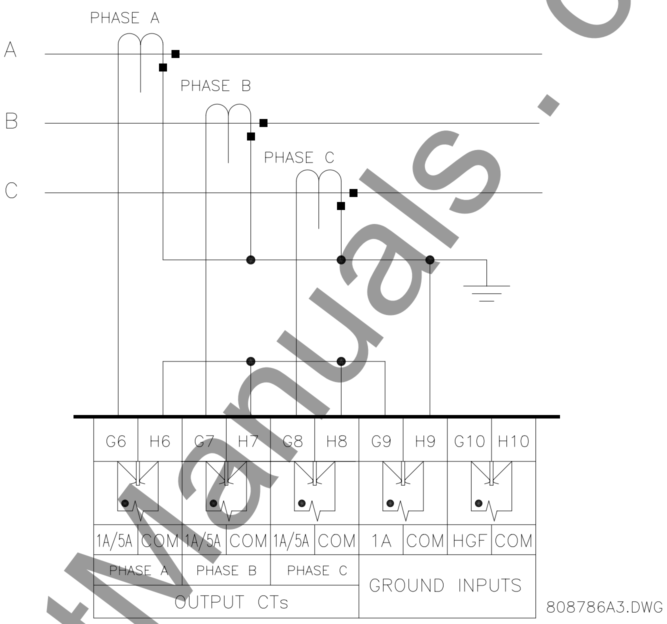

Figure 2-13 RESIDUAL GROUND CT CONNECTION

The exact placement of a zero sequence CT, so that only ground fault current will be detected, is shown in Figure 2-14. If the core balance CT is placed over shielded cable, capacitive coupling of phase current into the cable shield may be detected as ground current unless the shield wire is also passed through the CT window. Twisted pair cabling on the zero sequence CT is recommended.

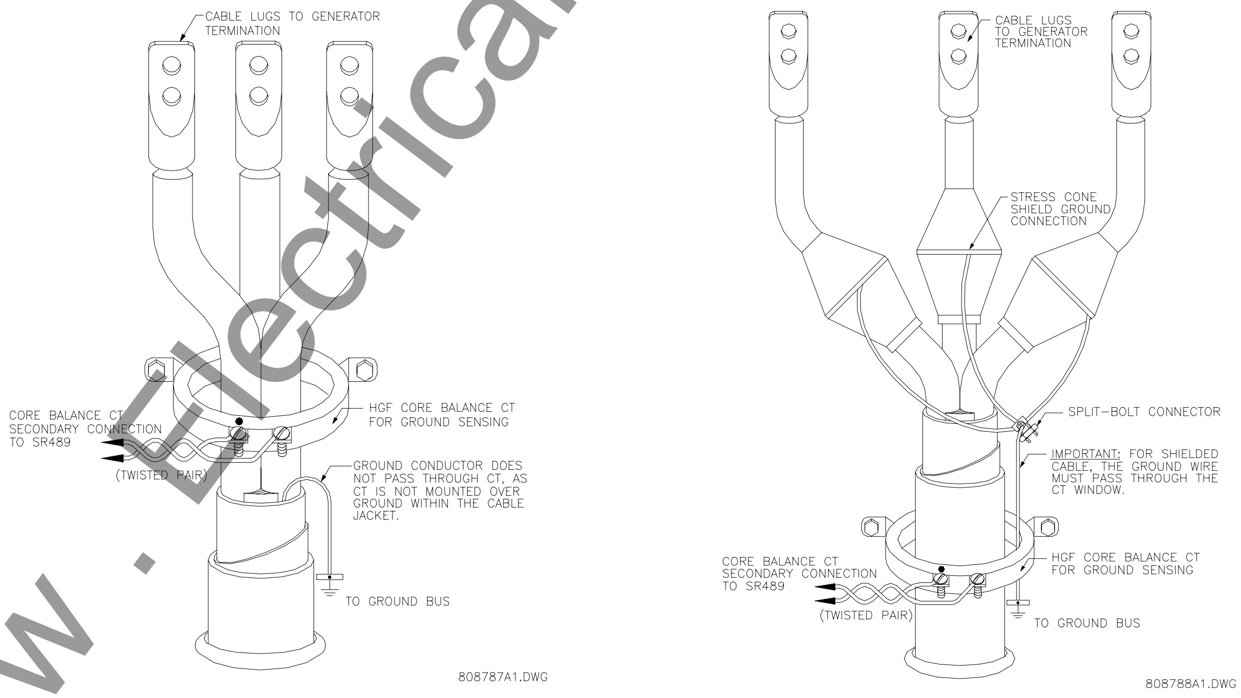

Figure 2-14 CORE BALANCE GROUND CT INSTALLATION

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2.2.5 VOLTAGE INPUTS

The 489 has four voltage transformer inputs, three for generator terminal voltage and one for neutral voltage. There are no internal fuses or ground connections on the voltage inputs. The maximum VT ratio is 240.00:1. The two possible VT connections for generator terminal voltage measurement are open delta or wye (see Figure 2-10). The voltage channels are connected in wye internally, which means that the jumper shown on the delta-source connection of Figure 2-10, between the phase B input and the 489 neutral terminal, must be installed for open delta VTs.

Caution: Polarity of the generator terminal VTs is critical for correct power measurement and voltage phase reversal operation.

2.2.6 DIGITAL INPUTS

There are 9 digital inputs that are designed for dry contact connections only. Two of the digital inputs, Access and Breaker Status have their own common terminal, the balance of the digital inputs share one common terminal (see Figure 2-10).

In addition, the +24Vdc switch supply is brought out for control power of an inductive or capacitive proximity probe. The NPN transistor output could be taken to one of the assignable digital inputs configured as a counter or tachometer. Refer to the Specifications section of this manual for maximum current draw from the +24Vdc switch supply.

CAUTION: DO NOT INJECT VOLTAGES TO DIGITAL INPUTS. DRY CONTACT CONNECTIONS ONLY.

2.2.7 ANALOG INPUTS

Terminals are provided on the 489 for the input of four 0-1mA, 0-20mA, or 4-20mA current signals (field programmable). This current signal can be used to monitor any external quantity such as: vibration, pressure, field current, etc. The four inputs share one common return. Polarity of these inputs must be observed for proper operation The analog input circuitry is isolated as a group with the Analog Output circuitry and the RTD circuitry. Only one ground reference should be used for the three circuits. Transorbs limit this isolation to ±36 volts with respect to the 489 safety ground.

In addition, the +24Vdc analog input supply is brought out for control power of loop powered transducers (see Figure 2-15). Refer to the Specifications section of this manual for maximum current draw from this supply.

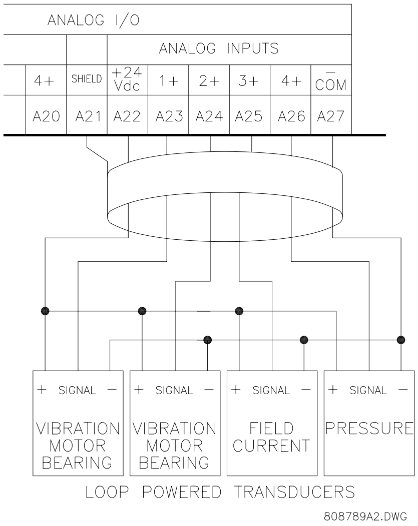

Figure 2-15 LOOP POWERED TRANSDUCER CONNECTION

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2.2.8 ANALOG OUTPUTS

The 489 provides 4 analog output channels, which when ordering, are selected to provide a full-scale range of either 0-1 mA (into a maximum 10 kΩ impedance), or 4-20 mA (into a maximum 600 Ω impedance). Each channel can be configured to provide full-scale output sensitivity for any range of any measured parameter.

As shown in the wiring diagram of Figure 2-10, these outputs share one common return. Polarity of these outputs must be observed for proper operation. Shielded cable should be used, with only one end of the shield grounded, to minimize noise effects.

The analog output circuitry is isolated as a group with the Analog Input circuitry and the RTD circuitry. Only one ground reference should be used for the three circuits. Transorbs limit this isolation to ±36 volts with respect to the 489 safety ground.

If a voltage output is required, a burden resistor must be connected at the input of the SCADA measuring device. Ignoring the input impedance of the input, $R_{LOAD} = V_{FULL\ SCALE} / I_{MAX}$. For 0-1 mA, for example, if 5 V full scale is required to correspond to 1 mA, R_{LOAD} = 5 / 0.001 = 5000 ohms. For 4-20 mA, this resistor would be R_{LOAD} = 5 V / 0.020 = 250 ohms.

2.2.9 RTD SENSOR CONNECTIONS

The 489 can monitor up to 12 RTD inputs for Stator, Bearing, Ambient, or Other temperature monitoring. The type of each RTD is field programmable as: 100Ω Platinum (DIN.43760), 100Ω Nickel, 120Ω Nickel, or 10 Ω Copper. RTDs must be three wire type. Every two RTDs shares a common return.

The 489 RTD circuitry compensates for lead resistance, provided that each of the three leads is the same length. Lead resistance should not exceed 25Ω per lead. Shielded cable should be used to prevent noise pickup in the industrial environment. RTD cables should be kept close to grounded metal casings and avoid areas of high electromagnetic or radio interference. RTD leads should not be run adjacent to or in the same conduit as high current carrying wires.

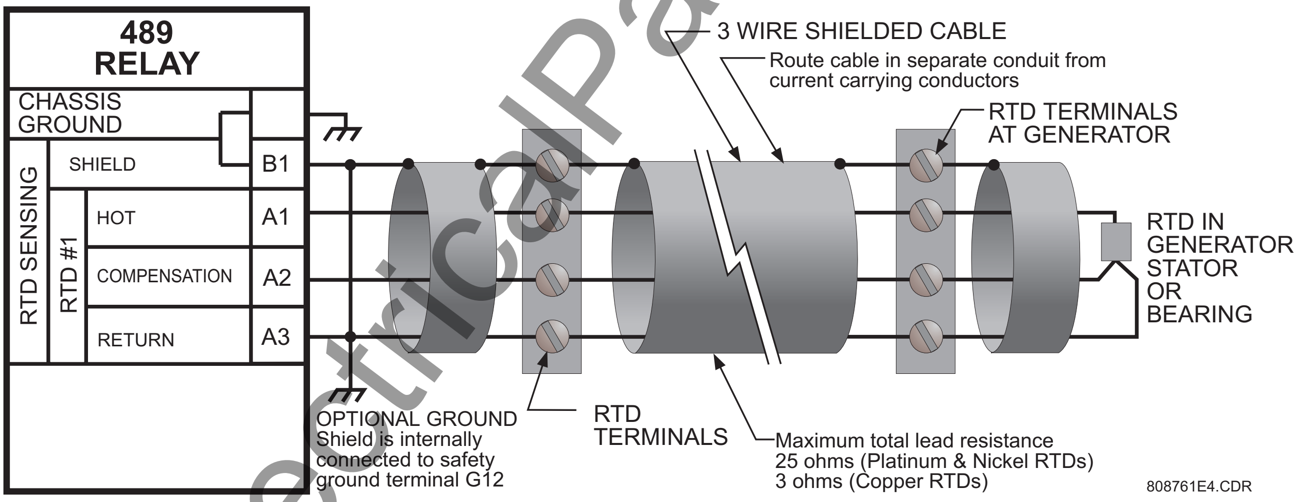

Figure 2-16 RTD WIRING

IMPORTANT: The RTD circuitry is isolated as a group with the Analog Input circuitry and the Analog Output circuitry. Only one ground reference should be used for the three circuits. Transorbs limit this isolation to ±36 volts with respect to the 489 safety ground. If code requires that the RTDs be grounded locally at the generator terminal box, that will also be the ground reference for the analog inputs and outputs.

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2.2.10 OUTPUT RELAYS

There are six Form C output relays. (See specifications for ratings). Five of the six relays are always non-failsafe, R6 Service is always failsafe. As failsafe, R6 relay will be energized normally and de-energize when called upon to operate. It will also de-energize when control power to the 489 is lost and therefore, be in its operated state. All other relays, being non-failsafe, will be de-energized normally and energize when called upon to operate. Obviously, when control power is lost to the 489, these relays must be de-energized and therefore, they will be in their non-operated state. Shorting bars in the drawout case ensure that when the 489 is drawn out, no trip or alarm occurs. The R6 Service output will however indicate that the 489 has been drawn out. Each output relay has an LED indicator on the 489 front panel that comes on while the associated relay is in the operated state.

R1 TRIP: The trip relay should be wired such that the generator is taken offline when conditions warrant. For a breaker application, the NO R1 Trip contact should be wired in series with the Breaker trip coil.

Supervision of a breaker trip coil requires that the supervision circuit be paralleled with the R1 TRIP relay output contacts, as shown in Figure 2-10. With this connection made, the supervision input circuits will place an impedance across the contacts that will draw a current of 2 - 5 mA (for an external supply voltage from 30-250 Vdc) through the breaker trip coil. The supervision circuits respond to a loss of this trickle current as a failure condition. Circuit breakers equipped with standard control circuits have a breaker auxiliary contact permitting the trip coil to be energized only when the breaker is closed. When these contacts are open, as detected by the Breaker Status digital input, trip coil supervision circuit is automatically disabled. This logic provides that the trip circuit is monitored only when the breaker is closed.

R2 AUXILIARY, R3 AUXILIARY, R4 AUXILIARY: The auxiliary relays may be programmed for numerous functions such as, trip echo, alarm echo, trip backup, alarm or trip differentiation, control circuitry, etc. They should be wired as configuration warrants.

R5 ALARM: The alarm relay should connect to the appropriate annunciator or monitoring device.

R6 SERVICE: The service relay will operate if any of the 489 diagnostics detect an internal failure or on loss of control power. This output may be monitored with an annunciator, PLC or DCS.

The service relay NC contact may also be wired in parallel with the trip relay on a breaker application. This will provide failsafe operation of the generator; that is, the generator will be tripped offline in the event that the 489 is not protecting it. Simple annunciation of such a failure will allow the operator or the operation computer to either continue, or do a sequenced shutdown.

2.2.11 IRIG-B

IRIG-B is a standard time-code format that allows stamping of events to be synchronized among connected devices within 1 millisecond. The IRIG-B time codes are serial, width-modulated formats which are either DC level shifted or amplitude modulated (AM). Third party equipment is available for generating the IRIG-B signal. This equipment may use a GPS satellite system to obtain the time reference enabling devices at different geographic locations to be synchronized.

Terminals E12 and F12 on the 489 unit are provided for the connection of an IRIG-B signal.

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2.2.12 RS485 COMMUNICATIONS PORTS

Two totally independent two-wire RS485 ports are provided. Up to 32 489's can be daisy-chained together on a communication channel without exceeding the driver capability. For larger systems, additional serial channels must be added. It is also possible to use commercially available repeaters to increase the number of relays on a single channel to more than 32. Suitable cable should have a characteristic impedance of 120 ohms (eg. Belden #9841) and total wire length should not exceed 4000 ft. Commercially available repeaters will allow for transmission distances greater than 4000 ft.

Voltage differences between remote ends of the communication link are not uncommon. For this reason, surge protection devices are internally installed across all RS485 terminals. Internally, an isolated power supply with an optocoupled data interface is used to prevent noise coupling. **To ensure that all devices in a daisy-chain are at the same potential, it is imperative that the common terminals of each RS485 port are tied together and grounded only once, at the master. Failure to do so may result in intermittent or failed communications.** The source computer/PLC/SCADA system should have similar transient protection devices installed, either internally or externally, to ensure maximum reliability. Ground the shield at one point only, as shown in Figure 2-17, to avoid ground loops.

Correct polarity is also essential. 489's must be wired with all '+' terminals connected together, and all '–' terminals connected together. Each relay must be daisy-chained to the next one. Avoid star or stub connected configurations. The last device at each end of the daisy chain should be terminated with a 120 ohm 1/4 watt resistor in series with a 1nF capacitor across the '+' and '–' terminals. Observing these guidelines will result in a reliable communication system that is immune to system transients.

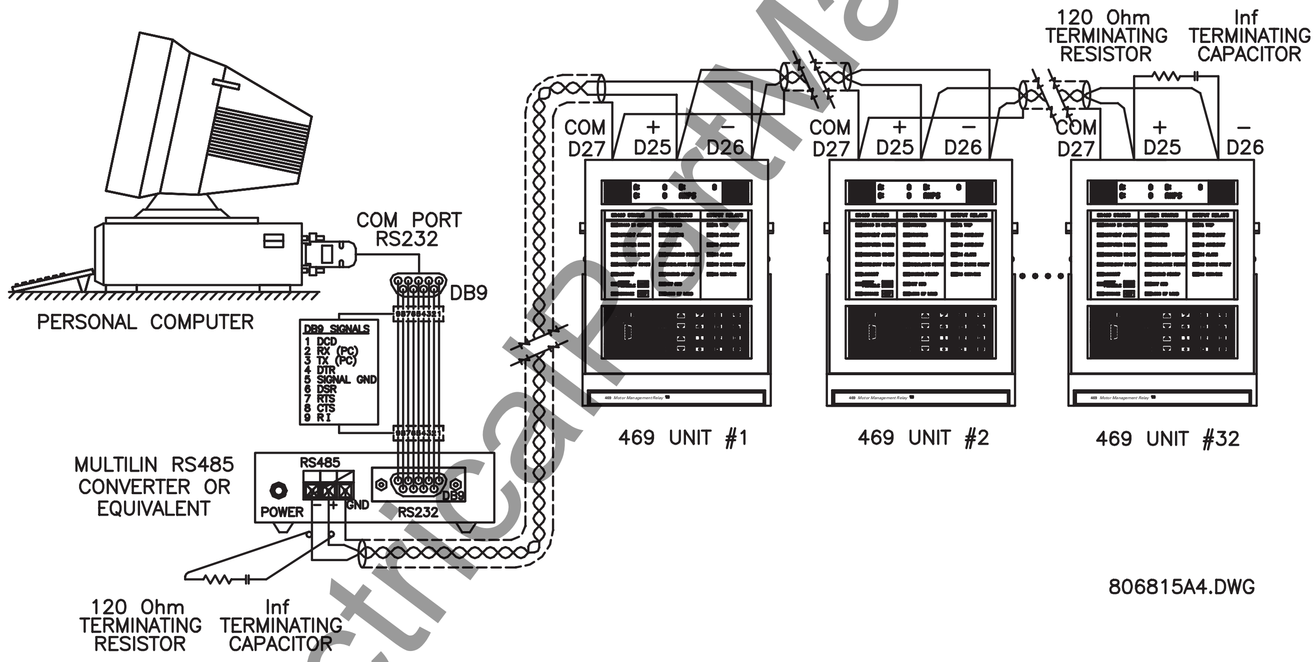

Figure 2-17 RS485 COMMUNICATIONS INTERFACE

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2.2.13 DIELECTRIC STRENGTH TESTING

It may be required to test for dielectric strength ("flash" or hipot") with the 489 installed. The 489 is rated for 2000Vdc isolation between relay contacts, CT inputs, VT inputs, trip coil supervision, and the safety ground terminal G12. Some precautions are required to prevent 489 damage during these tests.

Filter networks and transient protection clamps are used between control power, trip coil supervision, and the filter ground terminal G11. This filtering is intended to filter out high voltage transients, radio frequency interference (RFI), and electomagnetic interference (EMI). The filter capacitors and transient suppressors could be damaged by application continuous high voltage. Disconnect filter ground terminal G11 during testing of control power and trip coil supervision. CT inputs, VT inputs, and output relays do not require any special precautions. Low voltage inputs (< 30V), RTDs, analog inputs, analog outputs, digital inputs, and RS485 communication ports are not to be tested for dielectric strength under any circumstance (see Figure 2-18).

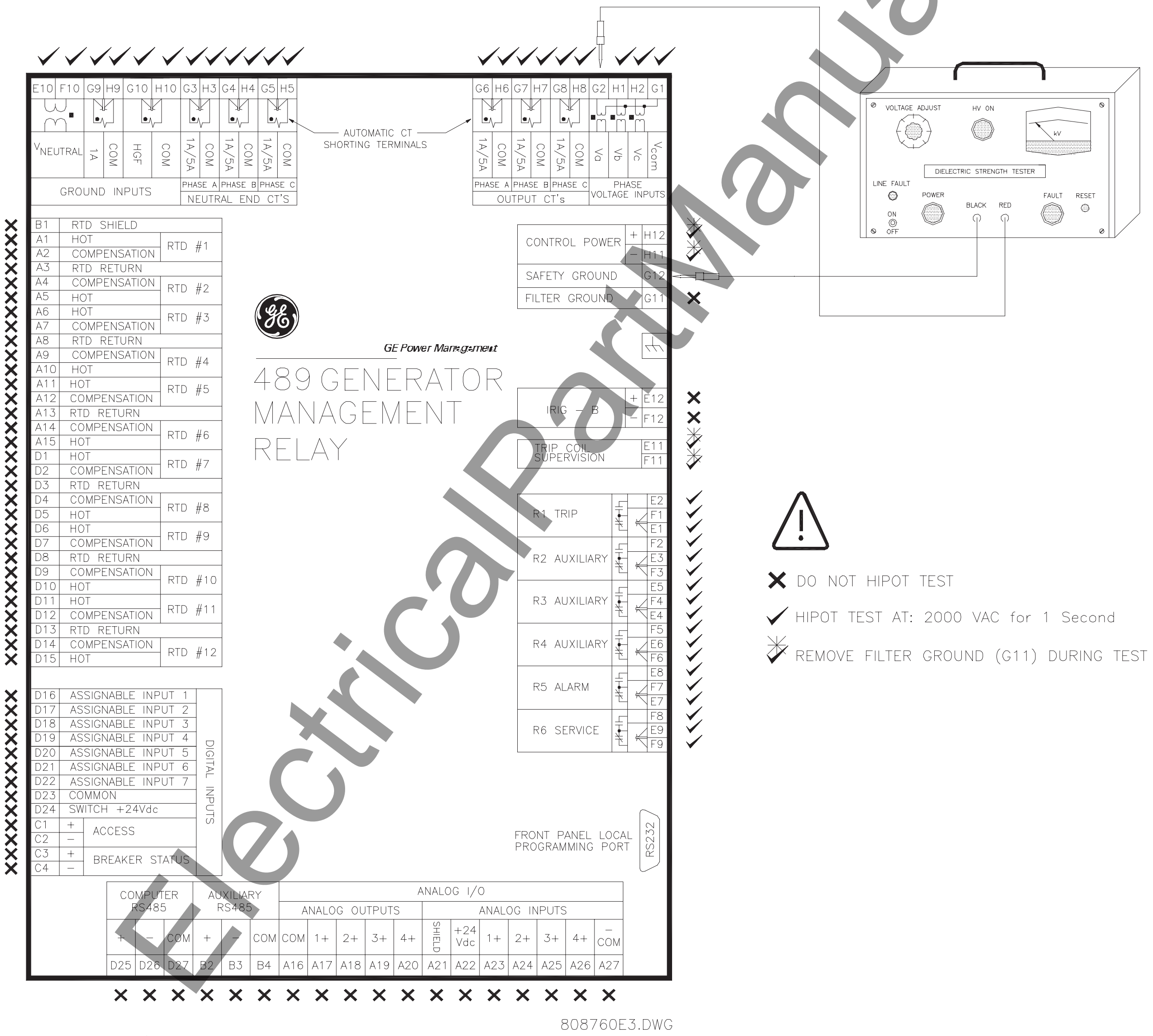

Figure 2-18 TESTING THE 489 FOR DIELECTRIC STRENGTH

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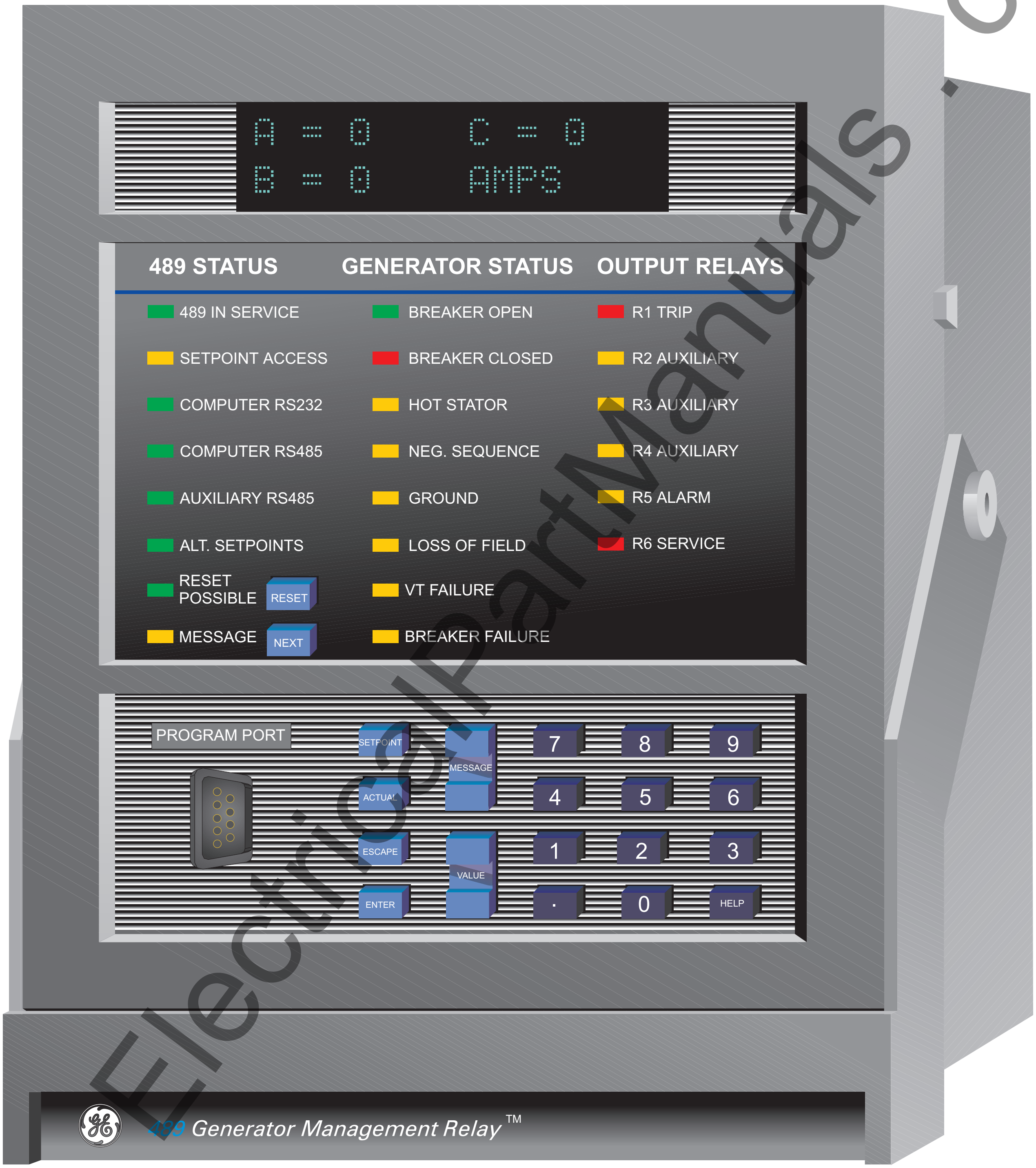
3.1.1. 489 FACEPLATE



808754E3.CDR

Figure 3-1 489 FACEPLATE

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3.1.2. DISPLAY

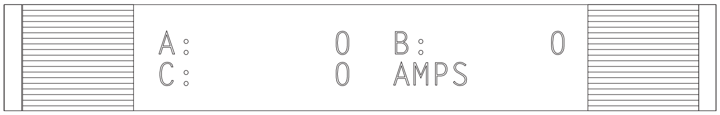

Figure 3-2 489 DISPLAY

All messages are displayed on a 40 character vacuum fluorescent display to make them visible under poor lighting conditions. Messages are displayed in plain English and do not require the aid of an instruction manual for deciphering. While the keypad and display are not actively being used, the display will default to user defined status messages. Any trip or alarm will automatically override the default messages and appear on the display.

LAMP TEST: Press **Help** button for 2 seconds to initiate lamp test.

3.1.3. LED INDICATORS

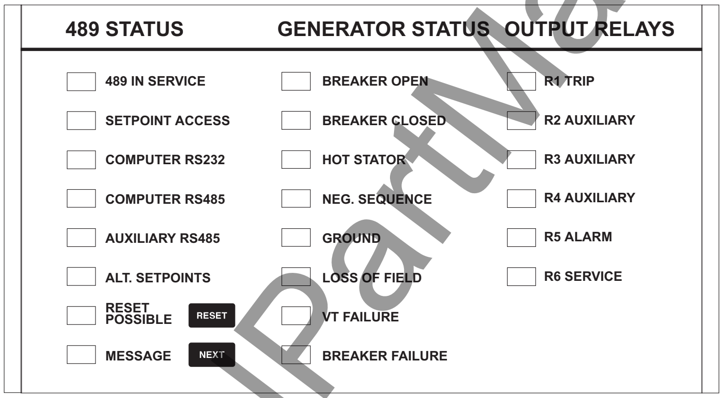

Figure 3-3 489 LED INDICATORS

There are three groups of LED indicators. They are 489 Status, Generator Status, and Output Relays.

<u>489 STATUS LED INDICATORS</u>

- **489 IN SERVICE:** Control power is applied & all monitored I/O and internal systems are OK & the 489 has been programmed & the 489 is in protection mode, not simulation mode. When in simulation or testing mode, the LED indicator will flash.
- **SETPOINT ACCESS:** Access jumper is installed and passcode protection has been satisfied; setpoints may be altered and stored.
- **COMPUTER RS232:** Flashes when there is any activity on the comm. port. Remains on solid if incoming data is valid.
- **COMPUTER RS485:** Flashes when there is any activity on the comm. port. Remains on solid if incoming data is valid and intended for the slave address programmed in the relay.
- **AUXILIARY RS485:** Flashes when there is any activity on the comm. port. Remains on solid if incoming data is valid and intended for the slave address programmed in the relay.
- **ALT. SETPOINTS:** Flashes when the alternate setpoint group is being edited, but the primary setpoint group is active. Remains on solid if the alternate setpoint group is active. The alternate setpoint group feature is enabled as one of the assignable digital inputs. The alternate setpoints group can be selected manually through the DUAL SETPOINTS digital input page.
- **RESET POSSIBLE:** A trip or latched alarm may be reset. Pressing the [RESET] key will clear said trip or alarm.
- **MESSAGE:** Flashes when a trip or alarm occurs. Pressing the next key will scroll through diagnostic messages. Remains solid when setpoint and actual value messages are being viewed. Pressing the [NEXT] key will return the display to the default messages.

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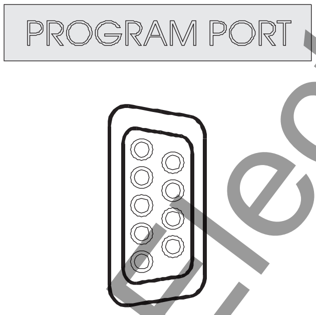
GENERATOR STATUS LED INDICATORS

- **BREAKER OPEN:** Uses the breaker status input signal to indicate that the breaker is open and the generator is offline.
- **BREAKER CLOSED:** Uses the breaker status input signal to indicate that the breaker is closed and the generator is online.
- **HOT STATOR:** Indicates that the generator stator is above normal temperature when one of the stator RTD alarm or trip elements is picked up or the thermal capacity alarm element is picked up.
- **NEG. SEQUENCE:** Indicates that the negative sequence current alarm or trip element is picked up.
- **GROUND:** Indicates that at least one of the ground overcurrent, neutral overvoltage (fundamental), or neutral undervoltage (3rd harmonic) alarm/trip elements is picked up.
- **LOSS OF FIELD:** Indicates that at least one of the reactive power (kvar) or field-breaker discrepancy alarm/trip elements is picked up.
- **VT FAILURE:** Indicates that the VT fuse failure alarm is picked up.
- **BREAKER FAILURE:** Indicates that the breaker failure or trip coil monitor alarm is picked up.

OUTPUT RELAY LED INDICATORS

- **R1 TRIP:** R1 Trip relay has operated (energized).
- **R2 AUXILIARY:** R2 Auxiliary relay has operated (energized).
- **R3 AUXILIARY:** R3 Auxiliary relay has operated (energized).
- **R4 AUXILIARY:** R4 Auxiliary relay has operated (energized).
- **R5 ALARM:** R5 Alarm relay has operated (energized).
- **R6 SERVICE:** R6 Service relay has operated (de-energized, R6 is failsafe, normally energized).

3.1.4. RS232 PROGRAM PORT



This port is intended for connection to a portable PC. Setpoint files may be created at any location and downloaded through this port using the 489PC program. Local interrogation of Setpoints and Actual Values is also possible. New firmware may be downloaded to the 489 flash memory through this port. Upgrading of the relay firmware does not require a hardware EPROM change.

Figure 3-4 RS232 PROGRAM PORT

3.1.5. KEYPAD

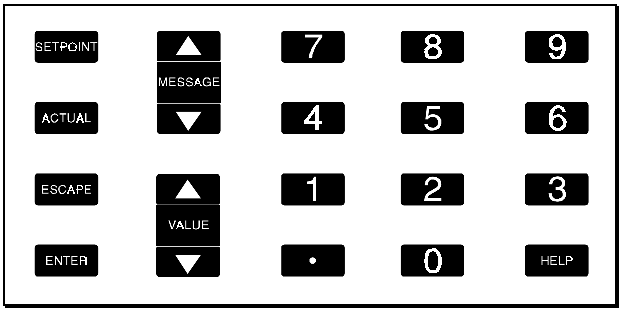


Figure 3-5 489 KEYPAD

The 489 messages are organized into pages under the main headings, Setpoints and Actual Values. The [SETPOINT] key is used to navigate through the headers of pages of programmable parameters. The [ACTUAL] key is used to navigate through the headers of pages of measured parameters.

Each page is broken down further into logical subgroups of messages. The [MESSAGE] up and down keys may be used to navigate through the subgroups.

The [ENTER] key is dual purpose. It is used to enter the subgroups or store altered setpoint values.

The [ESCAPE] key is also dual purpose. It may be used to exit the subgroups or to return an altered setpoint to its original value before it has been stored.

The [VALUE] up and down key is used to scroll through variables in the setpoint programming mode. It will increment and decrement numerical setpoint values. Alternatively, these values may be entered with the numeric keypad.

The [HELP] key may be pressed at any time for context sensitive help messages.

3.1.6. ENTERING ALPHANUMERIC TEXT

In order to allow the 489 to be customized for specific applications, there are several places where text messages may be programmed. One example is the MESSAGE SCRATCHPAD. To enter alphanumeric text messages, the following procedure should be followed:

Example: to enter the text, "Generator #1"

- press [.] to enter text edit mode,
- press the [VALUE ▲] or [VALUE ▼] key until 'G' appears, press [.] to advance the cursor to the next position,
- repeat step 2 for the remaining characters: e,n,e,r,a,t,o,r, ,#,1
- press [ENTER] to store

3.1.7. ENTERING +/- SIGNS

The 489 does not have a ‘+’ or ‘-’ key. Negative numbers may be entered in one of two manners. First, immediately pressing the [VALUE UP] or [VALUE DOWN] key will cause the setpoint to scroll through its range including any negative numbers. Alternately, once a setpoint message is entered, after pressing at least one numeric key, pressing the [VALUE UP] or [VALUE DOWN] key will cause the sign to change if applicable.

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3.1.8. SETPOINT ENTRY

In order to store any setpoints from the front panel keypad, terminals C1 and C2 (access terminals) must be shorted. (A key switch may be used for security). There is also a Setpoint Passcode feature that may be enabled to restrict access to setpoints from the keypad and communication ports. The passcode must be entered to allow the changing of setpoint values. A passcode of 0 effectively turns off the passcode feature and only the access jumper is required for changing setpoints. If no setpoint changes are made for 30 minutes, access to setpoint values will be restricted until the passcode is entered again. To prevent setpoint access before the 30 minutes expires, the unit may be turned off and back on, the access jumper may be removed, or the SETPOINT ACCESS: Permitted setpoint may be changed to Restricted. The passcode for the front panel keypad cannot be entered until terminals C1 and C2 (access terminals) are shorted. When setpoint access is allowed for the front panel keypad, the 'SETPOINT ACCESS' indicator on the front of the 489 unit will be lit.

The following procedure may be used to access and alter any setpoint message. This specific example will refer to entering a valid passcode in order to allow access to setpoints if the passcode was '489'.

1. The 489 programming is broken down into pages by logical groups. Press [SETPOINTS] to cycle through the setpoint pages until the desired page appears on the screen. Press [MESSAGE t] to enter a page.

```
▌▌ SETPOINTS
▌▌ S1 489 SETUP
```

2. Each page is broken further into subgroups. Press [MESSAGE ▼] and [MESSAGE ▲] to cycle through subgroups until the desired subgroup appears on the screen. Press [ENTER] to enter a subgroup.

```
▌ PASSCODE
▌ [ENTER] for more
```

3. Each sub-group has one or more associated setpoint messages. Press [MESSAGE ▼] and [MESSAGE ▲] to cycle through setpoint messages until the desired setpoint message appears on the screen.

```
ENTER PASSCODE FOR
ACCESS:
```

4. The majority of setpoint messages may be may be altered in a simple fashion by pressing [VALUE ▲] and [VALUE ▼] until the desired value appears and pressing [ENTER]. Setpoints that are strictly numeric may also be entered by pressing the numeric keys (including decimals) and pressing [ENTER]. If a setpoint is entered that is out of range, the original setpoint value will reappear. If a setpoint is entered that is out of step, an adjusted value will be stored (e.g. 101 for a setpoint that steps 95,100,105 will store as 100). If a mistake is made entering the new value, pressing [ESCAPE] will cause the value to revert to its original value. Text editing is a special case described in detail in 3.1.6 ENTERING ALPHANUMERIC TEXT. Each time a new setpoint is successfully stored, a message will flash on the display stating 'NEW SETPOINT HAS BEEN STORED'.

```
ENTER PASSCODE FOR
ACCESS: ***
```

Press [4], [8], [9],[ENTER]
FLASH:

```
NEW SETPOINT HAS
BEEN STORED
```

RETURNS:

```
SETPOINT ACCESS:
PERMITTED
```

5. Press [ESCAPE] to exit a subgroup.

```
▌ PASSCODE
▌ [ENTER] for more
```

6. Pressing [ESCAPE] numerous times will always bring the cursor to the top of the page.

```
▌▌ SETPOINTS
▌▌ S1 489 SETUP
```

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4.1.1 TRIPS / ALARMS / CONTROL FEATURES DEFINED

The 489 Generator Management Relay has three basic categories of functions; TRIPS, ALARMS, and CONTROL.

TRIPS

A 489 trip feature may be assigned to any combination of the four output relays: R1 Trip Relay, R2 Auxiliary, R3 Auxiliary, and R4 Auxiliary. If a Trip becomes active, the appropriate LED (indicator) on the 489 faceplate will illuminate to show which of the output relays has operated. Each trip feature may be programmed as latched or unlatched. Once a latched trip feature becomes active, the reset key must be pressed to reset that trip. If the condition that caused the trip is still present (e.g. hot RTD) the trip relay(s) will not reset until the condition is no longer present. If on the other hand, an unlatched trip feature becomes active, that trip will reset itself (and associated output relay(s)) after the condition that caused the trip ceases and the Breaker Status input indicates that the breaker is open. If there is a lockout time, the trip relay(s) will not reset until the lockout time has expired. Immediately prior to issuing a trip, the 489 takes a snapshot of generator parameters and stores them as pre-trip values which will allow for troubleshooting after the trip occurs. The cause of last trip message is updated with the current trip and the 489 display defaults to that message. All trip features are automatically logged and date and time stamped as they occur. In addition, all trips are counted and logged as statistics such that any long term trends may be identified.
Note: Lockout time will occur due to overload trip. (See Section 4.10.2)

ALARMS

A 489 alarm feature may be assigned to operate any combination of four output relays: R5 Alarm, R4 Auxiliary, R3 Auxiliary, and R2 Auxiliary. When an Alarm becomes active, the appropriate LED (indicator) on the 489 faceplate will illuminate when an output relay(s) has operated. Each alarm feature may be programmed as latched or unlatched. Once a latched alarm feature becomes active, the reset key must be pressed to reset that alarm. If the condition that has caused the alarm is still present (e.g. hot RTD) the Alarm relay(s) will not reset until the condition is no longer present. If on the other hand, an unlatched alarm feature becomes active, that alarm will reset itself (and associated output relay(s)) as soon as the condition that caused the alarm ceases. As soon as an alarm occurs, the alarms messages are updated to reflect the alarm and the 489 display defaults to that message. Since it may not be desirable to log all alarms as events, each alarm feature may be programmed to log as an event or not. If an alarm is programmed to log as an event, when it becomes active, it is automatically logged as a date and time stamped event.

CONTROL

A 489 control feature may be assigned to operate any combination of five output relays: R5 Alarm, R4 Auxiliary, R3 Auxiliary, and R2 Auxiliary, and R1 Trip. The combination of relays available for each function is determined by the suitability of each relay for that particular function. The appropriate LED (indicator) on the 489 faceplate will illuminate when an output relay(s) has been operated by a control function. Since it may not be desirable to log all control function as events, each control feature may be programmed to log as an event or not. If a control feature is programmed to log as an event, each control relay event is automatically logged with a date and time stamp.

4.1.2 RELAY ASSIGNMENT PRACTICES

There are six output relays. Five of the relays are always non-failsafe, the other (Service) is failsafe and dedicated to annunciate internal 489 faults (these faults include Setpoint Corruption, failed hardware components, loss of control power, etc.). The five remaining relays may be programmed for different types of features depending on what is required. One of the relays, R1 TRIP, is intended to be used as a trip relay wired to the unit trip breaker. Another relay, R5 ALARM, is intended to be used as the main alarm relay. The three remaining relays, R2 Auxiliary, R3 Auxiliary, and R4 Auxiliary, are intended for special requirements.

When assigning features to R2, R3, and R4 it is a good idea to decide early on what is required since features that may be assigned may conflict. For example, if R2 is to be dedicated as a relay for sequential tripping, it cannot also be used to annunciate a specific alarm condition.

In order to ensure that conflicts in relay assignments do not occur, several precautions have been taken. All trips default to the R1 TRIP output relay and all alarms default to the R5 ALARM relay. It is recommended that relay assignments be reviewed once all the setpoints have been programmed.

4.1.3 DUAL SETPOINTS

The 489 has dual settings for the current, voltage, power, RTD, and thermal model protection elements (S5 - S9). These settings are organized in two setpoint groups: the main default group (Group 1) and the alternate group (Group 2). Only one group of settings is active in the protection scheme at a time. The active group can be selected using the ‘ACTIVATE SETPOINT GROUP’ setpoint or an assigned digital input in S3 Digital Inputs. The LED indicator on the faceplate of the 489 will indicate when the alternate setpoints are active in the protection scheme. Independently, the setpoints in either group can be viewed and/or edited using the EDIT SETPOINT GROUP setpoint. Headers for each setpoint message subgroup that has dual settings will be denoted by a superscript number indicating which setpoint group is being viewed or edited. Also, when a setpoint that has dual settings is stored, the flash message that appears will indicate which setpoint group setting has been changed.

It is suggested that if only one setting group is required, edit and activate only Group 1. (i.e. do not assign a digital input to Dual Setpoints, and do not alter the ‘ACTIVATE SETPOINT GROUP’ setpoint or EDIT SETPOINT GROUP setpoint in S3 Digital Inputs).

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4.1.4 SETPOINT MESSAGE MAP

Table 4-1 SETPOINT MESSAGE MAP

⇨ SETPOINT

▌▌ S1 SETPOINTS
▌▌ 489 SETUP

- ▌ PASSCODE
- ▌ PREFERENCES
- ▌ SERIAL PORTS
- ▌ REAL TIME CLOCK
- ▌ DEFAULT MESSAGES
- ▌ MESSAGE SCRATCHPAD
- ▌ CLEAR DATA

⇨ SETPOINT

▌▌ S2 SETPOINTS
▌▌ SYSTEM SETUP

- ▌ CURRENT SENSING
- ▌ VOLTAGE SENSING
- ▌ GEN. PARAMETERS
- ▌ SERIAL START/STOP

⇨ SETPOINT

▌▌ S3 SETPOINTS
▌▌ DIGITAL INPUTS

- ▌ BREAKER STATUS
- ▌ GENERAL INPUT A
- through
- ▌ GENERAL INPUT G
- ▌ REMOTE RESET
- ▌ TEST INPUT
- ▌ THERMAL RESET
- ▌ DUAL SETPOINTS
- ▌ SEQUENTIAL TRIP
- ▌ FIELD-BKR DISCREP.
- ▌ TACHOMETER
- ▌ WAVEFORM CAPTURE
- ▌ GND SWITCH STATUS

⇨ SETPOINT

▌▌ S4 SETPOINTS
▌▌ OUTPUT RELAYS

- ▌ RELAY RESET MODE

⇨ SETPOINT

▌▌ S5 SETPOINTS
▌▌ CURRENT ELEMENTS

- ▌ OVERCURRENT ALARM
- ▌ OFFLINE O/C
- ▌ INADVERTENT ENERG.
- ▌ PHASE OVERCURRENT
- ▌ NEGATIVE SEQUENCE
- ▌ GROUND O/C
- ▌ PHASE DIFFERENTIAL
- ▌ GROUND DIRECTIONAL
- ▌ HIGH-SET PHASE O/C

⇨ SETPOINT

▌▌ S6 SETPOINTS
▌▌ VOLTAGE ELEMENTS

- ▌ UNDERVOLTAGE
- ▌ OVERVOLTAGE
- ▌ VOLTS/HERTZ
- ▌ PHASE REVERSAL
- ▌ UNDERFREQUENCY
- ▌ OVERFREQUENCY
- ▌ NEUTRAL O/V (Fund)
- ▌ NEUTRAL U/V (3rd)
- ▌ LOSS OF EXCITATION
- ▌ DISTANCE ELEMENT

⇨ SETPOINT

▌▌ S7 SETPOINTS
▌▌ POWER ELEMENTS

- ▌ REACTIVE POWER
- ▌ REVERSE POWER
- ▌ LOW FORWARD POWER

⇨ SETPOINT

▌▌ S8 SETPOINTS
▌▌ RTD TEMPERATURE

- ▌ RTD TYPES
- ▌ RTD #1
- through
- ▌ RTD #12
- ▌ OPEN RTD SENSOR
- ▌ RTD SHORT/LOW TEMP

⇨ SETPOINT

▌▌ S9 SETPOINTS
▌▌ THERMAL MODEL

- ▌ MODEL SETUP
- ▌ THERMAL ELEMENTS

⇨ SETPOINT

▌▌ S10 SETPOINTS
▌▌ MONITORING

- ▌ TRIP COUNTER
- ▌ BREAKER FAILURE
- ▌ TRIP COIL MONITOR
- ▌ VT FUSE FAILURE
- ▌ CURRENT DEMAND
- ▌ MW DEMAND
- ▌ Mvar DEMAND
- ▌ MVA DEMAND
- ▌ PULSE OUTPUT
- ▌ RUNNING HOUR SETUP

⇨ SETPOINT

▌▌ S11 SETPOINTS
▌▌ ANALOG I/O

- ▌ ANALOG OUTPUT 1
- ▌ ANALOG OUTPUT 2
- ▌ ANALOG OUTPUT 3
- ▌ ANALOG OUTPUT 4
- ▌ ANALOG INPUT 1
- ▌ ANALOG INPUT 2
- ▌ ANALOG INPUT 3
- ▌ ANALOG INPUT 4

⇨ SETPOINT

▌▌ S12 SETPOINTS
▌▌ 489 TESTING

- ▌ SIMULATION MODE
- ▌ PRE-FAULT SETUP
- ▌ FAULT SETUP
- ▌ TEST OUTPUT RELAYS
- ▌ TEST ANALOG OUTPUT
- ▌ COMM PORT MONITOR
- ▌ FACTORY SERVICE

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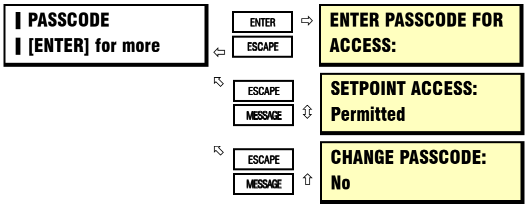
4.2.1 PASSCODE



PASSCODE
[ENTER] for more

ENTER PASSCODE FOR ACCESS:
RANGE: from 1-8 digits, numeric
This message seen only if the passcode is not zero and setpoint access is restricted

SETPOINT ACCESS: Permitted
RANGE: Permitted, Restricted
This message seen only if the passcode is zero or setpoint access is permitted

CHANGE PASSCODE: No
RANGE: No, Yes
This message seen only if the passcode is zero or setpoint access is permitted

FUNCTION:
A passcode access security feature is provided with the 489. When the unit is shipped from the factory, the passcode is defaulted to 0. Passcode protection is ignored when the passcode is 0. In this case, the setpoint access jumper is the only protection when programming setpoints from the front panel keypad and setpoints may be altered using the RS232 and RS485 serial ports without access protection. If however, the passcode is changed to a non-zero value, passcode protection is enabled. The access jumper must be installed and the passcode must be entered, to program setpoints from the front panel keypad. The passcode must also be entered individually from each serial communications port to gain setpoint programming access from that port.

- To enable passcode protection on a new relay, press [ENTER] then [MESSAGE DOWN] until the displayed message is:

CHANGE PASSCODE?
No

- Select "Yes" and follow directions to enter a new passcode from 1-8 digits.

ENTER NEW PASSCODE
FOR ACCESS:

ENTER NEW PASSCODE
AGAIN:

- Once a passcode other than 0 is programmed, this passcode must be entered to gain setpoint access each time setpoint access is restricted.

- Assuming that a non zero passcode has been programmed and setpoint access is restricted, then selecting the passcode subgroup will cause this message to appear:

ENTER PASSCODE FOR
ACCESS:

- Enter the correct passcode that was previously programmed. A flash message will advise if the code is incorrect and allow a retry. If it is correct and the setpoint access jumper is installed this message will appear:

SETPOINT ACCESS:
Permitted

- In this mode, setpoints can now be entered. Exit the passcode message group using the [ESCAPE] key and program the appropriate setpoints. If no new setpoints are stored for 30 minutes, programming access will no longer be allowed and the passcode must be re-entered. Removing the setpoint access jumper or selecting "Restricted" at the SETPOINT ACCESS message will also disable setpoint access immediately for the front panel keypad.

- If a new passcode is required, gain setpoint access by entering the current valid passcode as already described, then press [MESSAGE DOWN] to display the CHANGE PASSCODE message and follow directions.

- If an invalid passcode is entered, an encrypted passcode may be viewed by pressing the [HELP] key. Consult the factory service department with this number if the currently programmed passcode is unknown. Using a deciphering program, the passcode can be determined.

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4.2.2 PREFERENCES

PREFERENCES [ENTER] for more	
DEFAULT MESSAGE CYCLE TIME: 2.0 s	RANGE: 0.5 - 10.0 STEP: 0.5
DEFAULT MESSAGE TIMEOUT: 300s	RANGE: 10-900 STEP: 1
PARAMETER AVERAGES CALC. PERIOD: 15 min	RANGE: 1 - 90 STEP: 1
TEMPERATURE DISPLAY: Celsius	RANGE: Celsius, Fahrenheit
WAVEFORM TRIGGER POSITION: 25%	RANGE: 1 - 100 STEP: 1
WAVEFORM MEM BUFFER 8x14 cycles	RANGE: 1x64, 2x42, 3x32, 4x25, 5x21, 6x18, 7x16, 8x14, 9x12, 10x11, 11x10, 12x9, 13x9, 14x8, 15x8, 16x7 Sets the partitioning of the waveform capture buffer.

FUNCTION:
Some of the 489 characteristics can be modified to suit different situations. Normally "PREFERENCES" will not require any changes.

DEFAULT MESSAGE CYCLE TIME: If multiple default messages are chosen, the 489 display will automatically cycle through those messages. The time these messages remain on the display can be changed to accommodate different user reading rates.

DEFAULT MESSAGE TIMEOUT: If no keys are pressed for a period of time then the relay will automatically scan a programmed set of default messages. This time can be modified to ensure messages remain on the screen long enough during programming or reading of actual values.

PARAMETER AVERAGES CALCULATION PERIOD: The period of time over which the parameter averages are calculated may be adjusted with this setpoint. The calculation is a sliding window.

TEMPERATURE DISPLAY: Measurements of temperature may be displayed in either Celsius or Fahrenheit. Each Actual Value message where a temperature value is displayed will be denoted by either '°C' for Celsius, or '°F' for Fahrenheit. RTD Setpoints are always displayed in Celsius.

WAVEFORM TRIGGER: The trigger setpoint allows the user to adjust how many pre-trip and post-trip cycles are stored in the waveform memory when a trip occurs. A value of 25%, for example, when the WAVEFORM MEMORY BUFFER is 7x16 cycles, would produce a waveform of 4 pre-trip cycles and 12 post-trip cycles.

WAVEFORM MEMORY BUFFER: Selects the partitioning of the waveform memory. The first number indicates the number of events and the second number, the number of cycles. The relay captures 12 samples per cycle. When more waveform captures occur than the available storage, the oldest data will be discarded.

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4.2.3 SERIAL PORTS

SERIAL PORTS
[ENTER] for more

SLAVE ADDRESS: **254**	RANGE: 1-254 STEP:1
COMPUTER RS485 **BAUD RATE: 9600**	RANGE: 300, 1200, 2400, 4800, 9600, 19200
COMPUTER RS485 **PARITY: None**	RANGE: None, Odd, Even
AUXILIARY RS485 **BAUD RATE: 9600**	RANGE: 300, 1200, 2400, 4800, 9600, 19200
AUXILIARY RS485 **PARITY: None**	RANGE: None, Odd, Even
PORT USED FOR DNP: **None**	RANGE: None, Computer RS485, Auxiliary RS485, Front Panel RS232
DNP SLAVE ADDRESS: **255**	RANGE: 0 - 255 STEP: 1
DNP TURNAROUND **TIME: 10 ms**	RANGE: 0 - 100 ms STEP: 10 ms

FUNCTION:

The 489 is equipped with 3 independent serial communications ports supporting a subset of Modbus RTU protocol. The front panel RS232 has a fixed baud rate of 9600 and a fixed data frame of 1 start/8 data/1stop/no parity. The front port is intended for local use only and will respond regardless of the slave address programmed. The front panel RS232 program port may be connected to a personal computer running the 489PC program. This program may be used for downloading and uploading setpoint files, viewing measured parameters, and upgrading the 489 software to the latest revision.

For RS485 communications, each 489 must have a unique address from 1-254. Address 0 is the broadcast address which all relays listen to. Addresses do not have to be sequential but no two units can have the same address or conflicts resulting in errors will occur. Generally each unit added to the link will use the next higher address starting at 1. Baud rates can be selected as 300,1200, 2400, 4800, 9600, or 19200. The data frame is fixed at 1 start, 8 data, and 1 stop bits, while parity is optional. The computer RS485 port is a general purpose port for connection to a DCS, PLC, or PC. The Auxiliary RS485 port may also be used as another general purpose port or it may be used to talk to Auxiliary GE Power Management Devices in the future.

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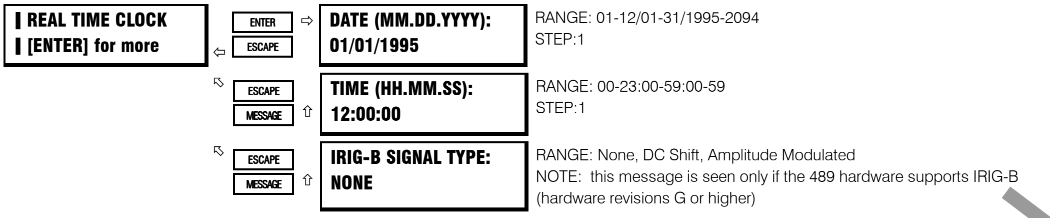
4.2.4 REAL TIME CLOCK



REAL TIME CLOCK [ENTER] for more	
DATE (MM.DD.YYYY): 01/01/1995	RANGE: 01-12/01-31/1995-2094 STEP:1
TIME (HH.MM.SS): 12:00:00	RANGE: 00-23:00-59:00-59 STEP:1
IRIG-B SIGNAL TYPE: NONE	RANGE: None, DC Shift, Amplitude Modulated NOTE: this message is seen only if the 489 hardware supports IRIG-B (hardware revisions G or higher)

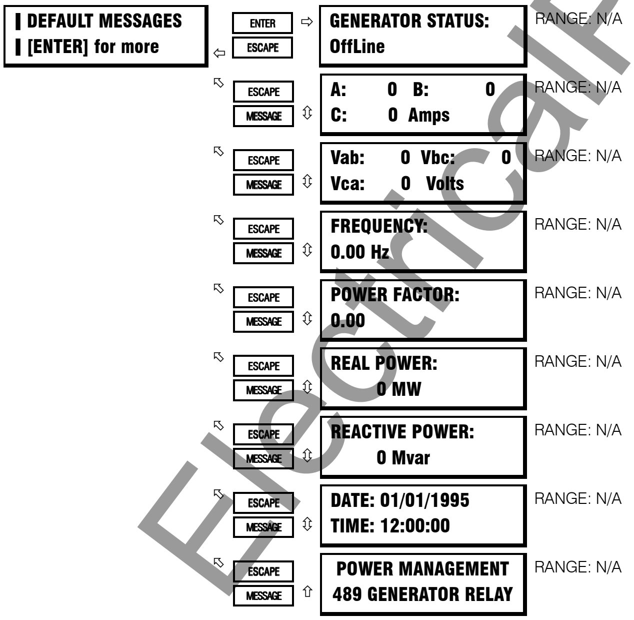
FUNCTION:

For events that are recorded by the event recorder to be correctly time/date stamped, the correct time and date must be entered. A battery backed internal clock runs continuously even when power is off. It has the same accuracy as an electronic watch approximately +/- 1 minute per month. It must be periodically corrected either manually through the front panel or via the clock update command over the RS485 serial link. If the approximate time an event occurred without synchronization to other relays is sufficient, then entry of time/date from the front panel keys is adequate.

If the RS485 serial communication link is used then all the relays can keep time in synchronization with each other. A new clock time is pre-loaded into the memory map via the RS485 communications port by a remote computer to each relay connected on the communications channel. The computer broadcasts (address 0) a "set clock" command to all relays. Then all relays in the system begin timing at the exact same instant. There can be up to 100ms of delay in receiving serial commands so the clock time in each relay is +/- 100ms, +/- absolute clock accuracy in the PLC or PC. See the chapter on Communications for information on programming the time preload and synchronizing commands.

An IRIG-B signal receiver may be connected to 489 units with hardware revision G or higher. The relay will continuously decode the time signal and set its internal time correpsondingly. The “signal type” setpoint must be set to match the signal provided by the receiver.

4.2.5 DEFAULT MESSAGES



DEFAULT MESSAGES [ENTER] for more	
GENERATOR STATUS: OffLine	RANGE: N/A
A: 0 B: 0 C: 0 Amps	RANGE: N/A
Vab: 0 Vbc: 0 Vca: 0 Volts	RANGE: N/A
FREQUENCY: 0.00 Hz	RANGE: N/A
POWER FACTOR: 0.00	RANGE: N/A
REAL POWER: 0 MW	RANGE: N/A
REACTIVE POWER: 0 Mvar	RANGE: N/A
DATE: 01/01/1995 TIME: 12:00:00	RANGE: N/A
POWER MANAGEMENT 489 GENERATOR RELAY	RANGE: N/A

FUNCTION:

After a period of time, the display will change to the default display messages. Between 1-20 default messages can be selected. If more than one message is chosen, default messages will automatically scan in sequence changing at a rate determined by the setpoint S1 489 SETUP /PREFERENCES /DEFAULT MESSAGE CYCLE TIME. Any Actual Value can be selected for default display. In addition, up to 5 user programmable messages can be created and displayed (Message Scratchpad). For example, the relay could be set to alternately scan a generator identification message, the current in each phase and the hottest stator RTD. Default messages that are currently selected can be viewed in DEFAULT MESSAGES subgroup.

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ADDING DEFAULT MESSAGES

Default messages can be added to the end of the default message list, as follows:

- Allow setpoint entry by entering the correct passcode at S1 489 SETUP /PASSCODE /ENTER PASSCODE FOR ACCESS (unless the passcode has already been entered or unless the passcode is 0 defeating the passcode security feature).
- Move to the message that is to be added to the default message list, using the [ENTER], [MESSAGE UP], and [MESSAGE DOWN] keys. The selected message can be any ACTUAL VALUE or MESSAGE SCRATCHPAD message.
- Press [ENTER]. The following message will be displayed for 5 seconds:

```
PRESS [ENTER] TO ADD
DEFAULT MESSAGE
```

- Press [ENTER] again while this message is being displayed to add the current message to the end of the default message list.
- If the procedure was followed correctly, the following flash message will be displayed:

```
DEFAULT MESSAGE
HAS BEEN ADDED
```

- To verify that the message was added, view the last message under the subheading S1 489 SETUP /DEFAULT MESSAGES

REMOVING DEFAULT MESSAGES

Default messages can be removed from the default message list, as follows:

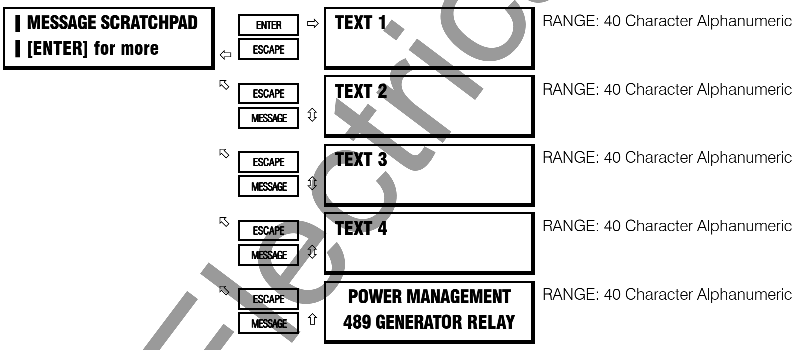
- Allow setpoint entry by entering the correct passcode at S1 489 SETUP /PASSCODE /ENTER PASSCODE FOR ACCESS (unless the passcode has already been entered or unless the passcode is 0 defeating the passcode security feature).
- Move to the message that is to be removed from the default message list under the subheading S1 489 SETUP /DEFAULT MESSAGES.
- When the default message to be removed is displayed, press [ENTER]. The following message will be displayed:

```
PRESS [ENTER] TO
REMOVE MESSAGE
```

- Press [ENTER] while this message is being displayed to remove the current message out of the default message list.
- If the procedure was followed correctly, the following flash message will be displayed:

```
DEFAULT MESSAGE
HAS BEEN REMOVED
```

4.2.6 MESSAGE SCRATCHPAD



```
▌MESSAGE SCRATCHPAD
▌[ENTER] for more
```

```
TEXT 1
```

RANGE: 40 Character Alphanumeric

```
TEXT 2
```

RANGE: 40 Character Alphanumeric

```
TEXT 3
```

RANGE: 40 Character Alphanumeric

```
TEXT 4
```

RANGE: 40 Character Alphanumeric

```
POWER MANAGEMENT
489 GENERATOR RELAY
```

RANGE: 40 Character Alphanumeric

FUNCTION:

Up to 5 message screens can be programmed under the Message Scratchpad area. These messages may be notes that pertain to the installation of the generator. In addition, these notes may be selected for scanning during default message display. This might be useful for reminding operators to perform certain tasks. The messages may be entered from the communications ports or through the keypad. To enter a 40 character message:

- Select the user message to be changed

- Press the [.] key to enter text mode. An underscore cursor will appear under the first character.
- Use the [VALUE UP] / [VALUE DOWN] key to display the desired character. A space is selected like a character.

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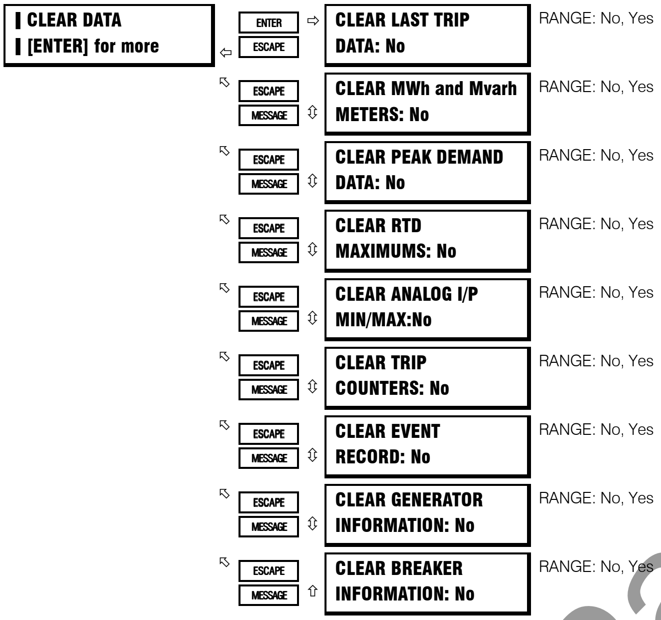
- Press the [.] key to advance to the next character. To skip over a character press the [.] key. If an incorrect character is accidentally stored, press the [.] key enough times to scroll the cursor around to the character.

- When the desired message is displayed press the [ENTER] key to store or the [ESCAPE] key to abort. The message is now permanently stored. Press [ESCAPE] to cancel the altered message.

4.2.7 CLEAR DATA



▌CLEAR DATA ▌[ENTER] for more	
CLEAR LAST TRIP DATA: No	RANGE: No, Yes
CLEAR MWh and Mvarh METERS: No	RANGE: No, Yes
CLEAR PEAK DEMAND DATA: No	RANGE: No, Yes
CLEAR RTD MAXIMUMS: No	RANGE: No, Yes
CLEAR ANALOG I/P MIN/MAX:No	RANGE: No, Yes
CLEAR TRIP COUNTERS: No	RANGE: No, Yes
CLEAR EVENT RECORD: No	RANGE: No, Yes
CLEAR GENERATOR INFORMATION: No	RANGE: No, Yes
CLEAR BREAKER INFORMATION: No	RANGE: No, Yes

FUNCTION:
These commands may be used to clear various historical data.

CLEAR LAST TRIP DATA: The Last Trip Data may be cleared by executing this command.

CLEAR MWh and Mvarh METERS: Executing this command will clear the MWh and Mvarh metering to zero.

CLEAR PEAK DEMAND DATA: Execute this command to clear peak demand values.

CLEAR RTD MAXIMUMS: All maximum RTD temperature measurements are stored and updated each time a new maximum temperature is established. Execute this command to clear the maximum values.

CLEAR ANALOG I/P MIN/MAX: The minimum and maximum Analog Input values are stored for each Analog Input. Those minimum and maximum values may be cleared at any time.

CLEAR TRIP COUNTERS: There are counters for each possible type of trip. Those counters may be cleared by executing this command.

CLEAR EVENT RECORD: The event recorder saves the last 40 events, automatically overwriting the oldest event. If desired, all events can be cleared using this command to prevent confusion with old information.

CLEAR GENERATOR INFORMATION: A counter for the number of thermal resets can be viewed in Actual Values. Total generator running hours may also be viewed in Actual Values. On a new installation or if new equipment is installed, this information can be cleared with this setpoint.

CLEAR BREAKER INFORMATION: The total number of breaker operations can be viewed in Actual Values. On a new installation or if maintenance work is done on the breaker, this accumulator can be cleared with this setpoint.

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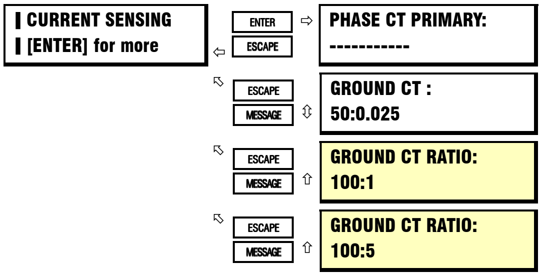
4.3.1 CURRENT SENSING



RANGE: 10-50000 A, or '--------' indicating Not Programmed
STEP: 1

RANGE: None, 1A Secondary, 50:0.025, 5A Secondary

RANGE: 10-10000, STEP: 1
NOTE: this message seen only if the Ground CT Type is 1A

RANGE: 10-10000, STEP: 1
NOTE: this message seen only if the Ground CT Type is 5A

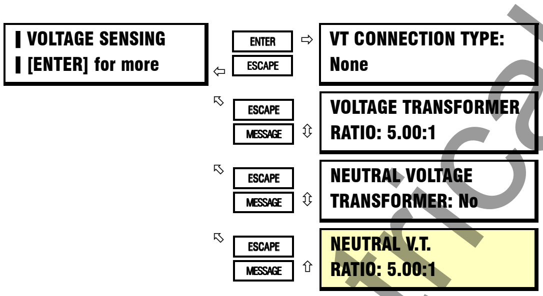
FUNCTION:

As a safeguard, when a unit is received from the factory, the phase CT primary and Generator Parameters setpoints will be defaulted to '--------' indicating Not Programmed. The 489 will indicate that it was never programmed. Once these values are entered, the 489 will be in service. The phase CT should be selected such that the maximum fault current does not exceed 20 times the primary rating. When relaying class CTs are purchased, this precaution will help prevent CT saturation under fault conditions. The secondary value of 1 or 5 amps **must** be specified at the time of order, so that the proper hardware will be installed. The phase CT primary setpoint applies to both the neutral end CTs as well as the output CTs.

For high resistance grounded systems, sensitive ground current detection is possible if the 50:0.025 ground CT is used. To use the 50:0.025 ground CT input, select 50:0.025 for the ground CT setpoint. No additional ground CT messages will appear. On solid or low resistance grounded systems, where fault currents may be quite large, the 489 1A/5A secondary ground CT input should be used. The Ground CT primary should be selected such that potential fault current does not exceed 20 times the primary rating. When relaying class CTs are purchased, this precaution will ensure that the Ground CT does not saturate under fault conditions.

NOTE: The 489 uses a nominal CT primary rating of 5 A for calculation of pickup levels.

4.3.2 VOLTAGE SENSING



RANGE: Open Delta, Wye, None

RANGE: 1.00:1 - 300.00:1
STEP: 0.01

RANGE: No, Yes

RANGE: 1.00:1 - 240.00:1, STEP: 0.01
NOTE: this message seen only if the Neutral Transformer selection is 'Yes'

FUNCTION:

The manner in which the voltage transformers are connected and the turns ratio must be entered. The VT should be selected such that the secondary phase-phase voltage of the VTs is between 70.0 and 135.0 V when the primary is at generator rated voltage.

The Neutral V.T. Ratio must also be entered here for measurement of the voltage across the neutral grounding device. Note, the neutral VT input is not intended to be used at continuos voltages greater than 240V. If the voltage across the neutral input is less than 240V during fault conditions, an auxiliary voltage transformer is not required. If however, this is not the case, use an auxiliary VT to bring the fault voltage below 240V. The neutral VT ratio entered must be the total effective ratio of the grounding transformer and any auxiliary step up or step down VT.

EXAMPLE:

If the distribution transformer ratio is 13200:480,
and the auxiliary VT ratio is 600:120,
enter (13200/480 * 600/120) :1
Neutral VT ratio is 137.50:1

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4.3.3 GENERATOR PARAMETERS

▌GEN. PARAMETERS **▌[ENTER] for more**	ENTER ⇨ ESCAPE ⇦	**GENERATOR RATED** **MVA: ---------------**	RANGE: 0.050 - 2000.000 MVA, '--------' indicating Not Programmed STEP: 0.01
	⇖ ESCAPE MESSAGE ⇳	**GENERATOR RATED** **POWER FACTOR: -----**	RANGE: 0.05 - 0.99, 1.00 indicating Not Programmed STEP: 0.01
	⇖ ESCAPE MESSAGE ⇳	**GENERATOR VOLTAGE** **PHASE-PHASE: ---------**	RANGE: 100-30000 V, '--------' indicating Not Programmed STEP: 1
	⇖ ESCAPE MESSAGE ⇳	**GENERATOR NOMINAL** **FREQUENCY: ------**	RANGE: 25Hz ,50 Hz, 60 Hz, '--------' indicating Not Programmed
	⇖ ESCAPE MESSAGE ⇧	**GENERATOR PHASE** **SEQUENCE: -------**	RANGE: ABC, ACB, '--------' indicating Not Programmed

FUNCTION:
As a safeguard, when a unit is received from the factory, the phase CT primary and Generator Parameters setpoints will be defaulted to '--------' indicating Not Programmed. The 489 will indicate that it was never programmed. Once these values are entered, the 489 will be in service. All elements associated with power quantities will be programmed in per unit values calculated from the rated MVA and rated power factor. The generator full load amps (FLA) will be calculated as: generator rated MVA / (√3 x rated generator phase-phase voltage). All voltage protection features that require a level setpoint are programmed in per unit of the rated generator phase-phase voltage .The nominal system frequency must be entered here. This setpoint allows the 489 to determine the internal sampling rate for maximum accuracy. If the sequence of phase rotation for a given system is ACB rather than the standard ABC, the system phase sequence setpoint may be used to accommodate this rotation. This setpoint allows the 489 to properly calculate phase reversal and negative sequence quantities.

4.3.4 SERIAL START/STOP INITIATION

▌SERIAL START/STOP **▌[ENTER] for more**	ENTER ⇨ ESCAPE ⇦	**SERIAL START/STOP** **INITIATION: Off**	RANGE: On, Off
	⇖ ESCAPE MESSAGE ⇳	**STARTUP INITIATION** **RELAYS (2-5): ----**	RANGE: Any Combination of Relays 2-5
	⇖ ESCAPE MESSAGE ⇳	**SHUTDOWN INITIATION** **RELAYS (1-4): ----**	RANGE: Any Combination of Relays 1-4
	⇖ ESCAPE MESSAGE ⇧	**SERIAL START/STOP** **EVENTS: Off**	RANGE: On, Off

If enabled, this feature will allow the user to initiate a generator startup or shutdown via the RS232/RS485 communication ports. Refer to the Communications chapter for command formats. When a startup command is issued, the auxiliary relay(s) assigned for starting control will be activated for 1 second to initiate startup. When a stop command is issued, the assigned relay(s) will be activated for 1 second to initiate a shutdown.

Page 3 of setpoints has been designated as the 'DIGITAL INPUTS' page. The 489 has nine digital inputs for use with external contacts. Two of the 489 digital inputs have been pre-assigned as inputs having a specific function. The Access Switch does not have any setpoint messages associated with it. The Breaker Status input, may be configured for either an 'a' or 'b' auxiliary contact. The remaining seven digital inputs are assignable; that is to say, each input may be assigned to any of a number of different functions. Some of those functions are very specific, others may be programmed to adapt to user requirements.

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4.4.1 ACCESS SWITCH

Terminals C1 and C2 ***must*** be shorted to allow changing of any setpoint values from the front panel keypad. This safeguard is in addition to the setpoint passcode feature, which functions independently (S1 489 SETUP /PASSCODE). The access switch has no effect on setpoint programming from the RS232 and RS485 serial communications ports.

4.4.2 BREAKER STATUS

▌**BREAKER STATUS** ▌**[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**BREAKER STATUS :** **Breaker Auxiliary b**	RANGE: Breaker Auxiliary a, Breaker Auxiliary b

FUNCTION:

This input is ***necessary*** for all installations. The 489 determines when the generator is online or offline based on the Breaker Status input. Once 'Breaker Auxiliary a' is chosen, terminals C3 and C4 will be monitored to detect the state of the machine main breaker, open signifying the breaker is open and shorted signifying the breaker is closed. Once 'Breaker Auxiliary b' is chosen, terminals C3 and C4 will be monitored to detect the state of the breaker, shorted signifying the breaker is open and open signifying the breaker is closed.

4.4.3 DIGITAL INPUT FUNCTION: GENERAL INPUT A - G

▌**GENERAL INPUT A** ▌**[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**ASSIGN DIGITAL** **INPUT: None**	RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7 * If an input is assigned to the Tachometer function, it may not be used here
	ESCAPE MESSAGE ⇳	**ASSERTED DIGITAL** **INPUT STATE: Closed**	RANGE: Closed, Open
	ESCAPE MESSAGE ⇳	**INPUT NAME:** **Input A**	RANGE: 12 Character Alphanumeric
	ESCAPE MESSAGE ⇳	**BLOCK INPUT** **FROM ONLINE: 0 s**	RANGE: 0 - 5000 (0 indicates feature is active while generator is offline as well as online) STEP: 1
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **CONTROL: Off**	RANGE: Off, On
	ESCAPE MESSAGE ⇳	**PULSED CONTROL RELAY** **DWELL TIME: 0.0 s**	RANGE: 0.0 - 25.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**ASSIGN CONTROL** **RELAYS (1-5): -----**	RANGE: Any Combination of Relays 1-5
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **CONTROL EVENTS: Off**	RANGE: On, Off
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **ALARM:Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **ALARM DELAY: 5.0 s**	RANGE: 0.1 - 5000.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **ALARM EVENTS: Off**	RANGE: On, Off
	ESCAPE MESSAGE ⇳	**GENERAL INPUT A** **TRIP: Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇧	**GENERAL INPUT A** **TRIP DELAY: 5.0 s**	RANGE: 0.1 - 5000.0 STEP: 0.1

FUNCTION:

The seven General Input functions are flexible enough to meet most of the desired digital input requirements. The asserted state and the name of the digital input is programmable.

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To disable the input functions when the generator is offline, and until some period of time after the generator is brought online, a block time should be set. The input functions will be enabled once the block delay has expired. A value of zero for the block time indicates that the input functions are always enabled.

The input may be configured for control, alarm, or trip. If the control feature is enabled, when the input is asserted, the assigned output relay(s) will operate. If the pulsed control relay dwell time is set to zero, the output relay(s) will simply operate only while the input is asserted. If however a dwell time is assigned, the output relay(s) will operate as soon as the input is asserted, for a period of time specified by the setpoint. If an alarm or trip is enabled and the input is asserted, after the specified delay, an alarm or trip will occur.

4.4.4 DIGITAL INPUT FUNCTION: REMOTE RESET

▌REMOTE RESET ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ASSIGN DIGITAL INPUT: None	RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7 * If an input is assigned to the Tachometer function, it may not be used here

FUNCTION:

Once an input is assigned to the Remote Reset function, shorting that input will reset any latched trips or alarms that may be active, provided that any thermal lockout time has expired and the condition that caused the alarm or trip is no longer present.

4.4.5 DIGITAL INPUT FUNCTION: TEST INPUT

▌TEST INPUT ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ASSIGN DIGITAL INPUT: None	RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7 * If an input is assigned to the Tachometer function, it may not be used here

FUNCTION:

Once the 489 is in service, it may be tested from time to time as part of a regular maintenance schedule. The unit will have accumulated statistical information relating historically to generator and breaker operation. This information includes: last trip data, peak demand data, MWh and Mvarh metering, parameter averages, RTD maximums, analog input minimums and maximums, number of trips, number of trips by type, number of breaker operations, the number of thermal resets, total generator running hours, and the event record. When the unit is under test and one of the inputs is assigned to the Test Input function, shorting that input will prevent all of this data from being corrupted or updated.

4.4.6 DIGITAL INPUT FUNCTION: THERMAL RESET

▌THERMAL RESET ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ASSIGN DIGITAL INPUT: None	RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7 * If an input is assigned to the Tachometer function, it may not be used here

FUNCTION:

During testing or in an emergency, it may be desirable to reset the thermal memory used to zero. If an input is assigned to the Thermal Reset function, shorting that input will reset the thermal memory used to zero. All Thermal Resets will be recorded as events.

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4.4.7 DIGITAL INPUT FUNCTION: DUAL SETPOINTS

▌DUAL SETPOINTS
▌[ENTER] for more

ENTER ⇨ / ⇦ ESCAPE

ASSIGN DIGITAL
INPUT: None

RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7
* If an input is assigned to the Tachometer function, it may not be used here

ESCAPE / MESSAGE ⇳

ACTIVATE SETPOINT
GROUP: Group 1

RANGE: Group 1, Group 2

ESCAPE / MESSAGE ⇧

EDIT SETPOINT
GROUP: Group 1

RANGE: Group1, Group 2

FUNCTION:

This feature allows for dual settings for the current, voltage, power, RTD, and thermal model protection elements (S5 - S9). These settings are organized in two setpoint groups the main group (Group 1) and the alternate group (Group 2). Only one group of settings are active in the protection scheme at a time.

⇨ SETPOINT

2 S5 SETPOINTS
▌▌CURRENT ELEMENTS

2 OVERCURRENT ALARM
2 OFFLINE O/C
2 INADVERTENT ENERG.
2 PHASE OVERCURRENT
2 NEGATIVE SEQUENCE
2 GROUND O/C
2 PHASE DIFFERENTIAL
2 GROUND DIFFERENTIAL
2 HIGH-SET PHASE O/C

⇨ SETPOINT

2 S6 SETPOINTS
▌▌VOLTAGE ELEMENTS

2 UNDERVOLTAGE
2 OVERVOLTAGE
2 VOLTS/HERTZ
2 PHASE REVERSAL
2 UNDERFREQUENCY
2 OVERFREQUENCY
2 NEUTRAL O/V (Fund)
2 NEUTRAL U/V (3rd)
2 LOSS OF EXCITATION
2 DISTANCE ELEMENT

⇨ SETPOINT

2 S7 SETPOINTS
▌▌POWER ELEMENTS

2 REACTIVE POWER
2 REVERSE POWER
2 LOW FORWARD POWER

⇨ SETPOINT

2 S8 SETPOINTS
▌▌RTD TEMPERATURE

2 RTD TYPES
2 RTD #1
through
2 RTD #12
2 OPEN RTD SENSOR
2 RTD SHORT/LOW TEMP

⇨ SETPOINT

2 S9 SETPOINTS
▌▌THERMAL MODEL

2 MODEL SETUP
2 THERMAL ELEMENTS

The active group can be selected using the ‘ACTIVATE SETPOINT GROUP’ setpoint or the assigned digital input (shorting that input will activate the alternate set of protection setpoints, Group 2). In the event of a conflict between the ‘ACTIVATE SETPOINT GROUP’ setpoint or the assigned digital input, Group 2 will be activated. The LED indicator on the faceplate of the 489 will indicate when the alternate setpoints are active in the protection scheme. Changing the active setpoint group will be logged as an event. Independently, the setpoints in either group can be viewed and/or edited using the EDIT SETPOINT GROUP setpoint. Headers for each setpoint message subgroup that has dual settings will be denoted by a superscript number indicating which setpoint group is being viewed or edited. Also, when a setpoint that has dual settings is stored, the flash message that appears will indicate which setpoint group setting has been changed.

GROUP 2 SETPOINT
HAS BEEN STORED

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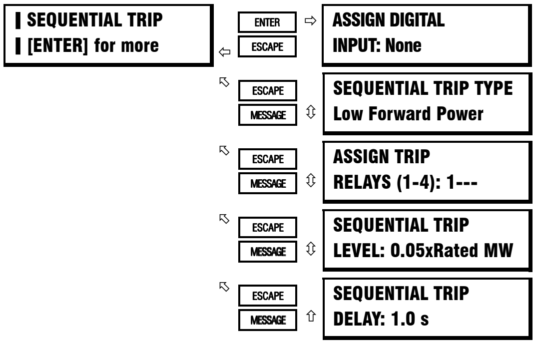
4.4.8 DIGITAL INPUT FUNCTION: SEQUENTIAL TRIP



SEQUENTIAL TRIP [ENTER] for more

ASSIGN DIGITAL INPUT: None
RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7
* If an input is assigned to the Tachometer function, it may not be used here

SEQUENTIAL TRIP TYPE Low Forward Power
RANGE: Low Forward Power, Reverse Power

ASSIGN TRIP RELAYS (1-4): 1---
RANGE: Any Combination of Relays 1-4

SEQUENTIAL TRIP LEVEL: 0.05xRated MW
RANGE: 0.02-0.99
STEP: 0.01

SEQUENTIAL TRIP DELAY: 1.0 s
RANGE: 0.2 - 120.0
STEP: 0.1

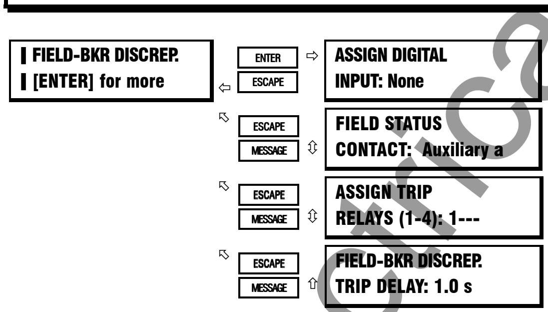
FUNCTION:

During routine shutdown and for some of the less critical trips, it may be desirable to use the sequential trip function to prevent overspeed. If an input is assigned to the sequential trip function, shorting that input will enable either a low forward power or reverse power function. Once the measured 3∅ total power falls below the low forward power level, or exceeds the reverse power level for the period of time specified, a trip will occur. This time delay will typically be shorter than that used for the standard reverse power or low forward power elements. The level is programmed in per unit of generator rated MW calculated from the rated MVA and rated power factor. If the VT type is selected as "None", the sequential trip element will operate as a simple timer. Once the input has been shorted for the period of time specified by the delay, a trip will occur.

NOTE: The minimum magnitude of power measurement is determined by the phase CT minimum of 2 % rated CT primary. If the level for reverse power is set below that level, a trip or alarm will only occur once the phase current exceeds the 2% cutoff.

Users are cautioned that a reverse power element may not provide reliable indication when set to a very low setting, particularly under conditions of large reactive loading on the generator. Under such conditions, low forward power is a more reliable element.

4.4.9 DIGITAL INPUT FUNCTION: FIELD-BREAKER DISCREPANCY



FIELD-BKR DISCREP. [ENTER] for more

ASSIGN DIGITAL INPUT: None
RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7
* If an input is assigned to the Tachometer function, it may not be used here

FIELD STATUS CONTACT: Auxiliary a
RANGE: Auxiliary a, Auxiliary b

ASSIGN TRIP RELAYS (1-4): 1---
RANGE: Any Combination of Relays 1-4

FIELD-BKR DISCREP. TRIP DELAY: 1.0 s
RANGE: 0.1 - 500.0
STEP: 0.1

FUNCTION:

The field-breaker discrepancy function is intended for use with synchronous generators. If a digital input is assigned to the field-breaker discrepancy function, any time that the field status contact indicates that the field is not applied, but the breaker status input indicates that the generator is online, a trip will occur once the time delay has expired. The time delay should be used for coordination to prevent possible nuisance tripping during shutdown. The field status contact may be chosen as Auxiliary a, open signifying the field breaker or contactor is open and shorted signifying the field breaker or contactor is closed. Conversely, the field status contact may be chosen as Auxiliary b, shorted signifying the field breaker or contactor is open and open signifying the field breaker or contactor is closed.

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4.4.10 DIGITAL INPUT FUNCTION: TACHOMETER

TACHOMETER **[ENTER] for more**	ENTER ⇨ ESCAPE ⇦	**ASSIGN DIGITAL** **INPUT: None**	RANGE: None, Input 4, Input 5, Input 6, Input 7 * Only digital inputs 4-7 may be assigned to the Tachometer function
	ESCAPE MESSAGE ⇳	**RATED SPEED:** **3600 RPM**	RANGE: 100- 3600 STEP:1
	ESCAPE MESSAGE ⇳	**TACHOMETER** **ALARM: Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	**TACHOMETER ALARM** **SPEED: 110 % Rated**	RANGE: 101 - 175 STEP: 1
	ESCAPE MESSAGE ⇳	**TACHOMETER ALARM** **DELAY: 1 s**	RANGE: 1-250 STEP: 1
	ESCAPE MESSAGE ⇧	**TACHOMETER ALARM** **EVENTS: Off**	RANGE: On, Off
	ESCAPE MESSAGE ⇳	**TACHOMETER** **TRIP: Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	**TACHOMETER TRIP** **SPEED: 110 % Rated**	RANGE: 101 -175 STEP: 1
	ESCAPE MESSAGE ⇧	**TACHOMETER TRIP** **DELAY: 1 s**	RANGE: 1-250 STEP: 1

FUNCTION:

One of the assignable digital inputs (4-7) may be assigned to the tachometer function to measure mechanical speed. The period of time between each input closure is measured and converted to an RPM value based on one closure per revolution. If an overspeed trip or alarm is enabled, and the RPM measured exceeds the threshold setpoint for the period of time specified by the delay, a trip or alarm will occur. The RPM value may be viewed in the ‘Speed’ sub-group of Actual Values, Page 2, ‘METERING’

EXAMPLE:

> An inductive proximity probe or hall effect gear tooth sensor may be used to sense the key on the generator. The probe could be powered from the +24V from the digital input power supply. The NPN transistor output could be taken to one of the assignable digital inputs assigned to the tachometer function.

4.4.11 WAVEFORM CAPTURE

WAVEFORM CAPTURE **[ENTER] for more**	ENTER ⇨ ESCAPE ⇦	**ASSIGN DIGITAL** **INPUT: None**	RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7 * If an input is assigned to the Tachometer function, it may not be used here

FUNCTION:

This feature may be used to trigger the waveform capture from an external contact. When one of the inputs is assigned to the Waveform Capture function, shorting that input will trigger the waveform.

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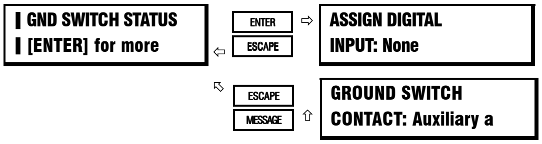
4.4.12 DIGITAL INPUT FUNCTION: GROUND SWITCH STATUS



RANGE: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7
* If an input is assigned to the Tachometer function, it may not be used here

RANGE: Auxiliary a, Auxiliary b

FUNCTION:
This function is used to detect the status of a grounding switch for the generator for which the relay is installed. (Refer to Appendix B for Application Notes.)

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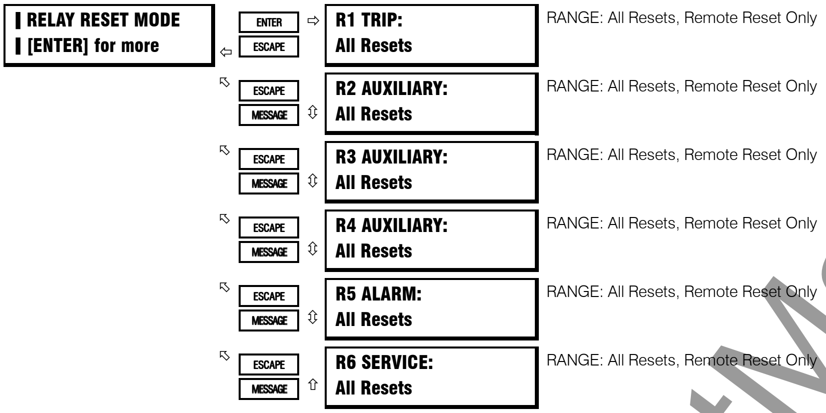
Five of the six output relays are always non-failsafe, R6 Service is always failsafe. As failsafe, R6 relay will be energized normally and de-energize when called upon to operate. It will also de-energize when control power to the 489 is lost and therefore, be in its operated state. All other relays, being non-failsafe, will be de-energized normally and energize when called upon to operate. Obviously, when control power is lost to the 489, the output relays must be de-energized and therefore, they will be in their non-operated state. Shorting bars in the drawout case ensure that when the 489 is drawn out, no trip or alarm occurs. The R6 Service output will however indicate that the 489 has been drawn out.

4.5.1 RELAY RESET MODE



RANGE: All Resets, Remote Reset Only

RANGE: All Resets, Remote Reset Only

RANGE: All Resets, Remote Reset Only

RANGE: All Resets, Remote Reset Only

RANGE: All Resets, Remote Reset Only

RANGE: All Resets, Remote Reset Only

FUNCTION: RESETTING THE 489

Unlatched trips and alarms will reset automatically once the condition is no longer present. Latched trip and alarm features may be reset at any time, providing that the condition that caused the trip or alarm is no longer present and any lockout time has expired. If any condition may be reset, the Reset Possible LED will be lit.

The relays may be programmed to All Resets which allows reset from the front keypad or the remote reset digital input or the communications port. Optionally, they may be programmed to reset by the Remote Reset Only (by the remote reset digital input or the communications port).

EXAMPLE:

Selected trips such as Instantaneous Overcurrent and Ground Fault may be assigned to R2 so that they may only be reset via. the Remote Reset digital input or the Communication Port. The Remote Reset terminals would be connected to a keyswitch so that only authorized personnel could reset such a critical trip.

- Assign only Short Circuit and Ground Fault to R2
- Program R2 to Remote Reset Only

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4.6.1 INVERSE TIME OVERCURRENT CURVE CHARACTERISTICS

The 489 inverse time overcurrent curves may be either ANSI, IEC, or GE Type IAC standard curve shapes. This allows for simplified coordination with downstream devices. If however, none of these curve shapes is adequate, the FlexCurve™ may be used to customize the inverse time curve characteristics. Definite time is also an option that may be appropriate if only simple protection is required.

Table 4-2 489 OVERCURRENT CURVE TYPES

ANSI	IEC	GE Type IAC	Other
ANSI Extremely Inv.	IEC Curve A (BS142)	IAC Extremely Inv.	Flexcurve™
ANSI Very Inverse	IEC Curve B (BS142)	IAC Very Inverse	Definite Time
ANSI Normally Inv.	IEC Curve C (BS142)	IAC Inverse	
ANSI Moderately Inv.	IEC Short Inverse	IAC Short Inverse	

A multiplier setpoint allows selection of a multiple of the base curve shape that is selected with the curve shape setpoint. Unlike the electromechanical time dial equivalent, trip times are directly proportional to the time multiplier setting value. For example, all trip times for a multiplier of 10 are 10 times the multiplier 1 or base curve values. Setting the multiplier to zero results in an instantaneous response to all current levels above pickup.

Note: regardless of the trip time that results from the curve multiplier setpoint, the 489 cannot trip any quicker than one to two cycles plus the operate time of the output relay.

Time overcurrent tripping time calculations are made with an internal "energy capacity" memory variable. When this variable indicates that the energy capacity has reached 100%, a time overcurrent trip is generated. If less than 100% is accumulated in this variable and the current falls below the dropout threshold of 97–98% of the pickup value, the variable must be reduced. Two methods of this resetting operation are available, "Instantaneous" and "Linear". The Instantaneous selection is intended for applications with other relays, such as most static units, which set the energy capacity directly to zero when the current falls below the reset threshold. The Linear selection can be used where the 489 must coordinate with electromechanical units. With this setting, the energy capacity variable is decremented according to the following equation.

$T_{RESET} = E \times M \times C_R$ where,

T_{RESET} = reset time in sec.
E = energy capacity reached (per unit)
M = curve multiplier
C_R = characteristic constant (5 for ANSI, IAC, Definite Time and Flexcurves™, 80 for IEC curves)

ANSI CURVES

The ANSI time overcurrent curve shapes conform to industry standard curves and fit into the ANSI C37.90 curve classifications for extremely, very, normally, and moderately inverse. The 489 ANSI curves are derived from the formula:

$$T = M \times \left[A + \frac{B}{\left(\frac{I}{I_{pickup}} - C\right)} + \frac{D}{\left(\frac{I}{I_{pickup}} - C\right)^2} + \frac{E}{\left(\frac{I}{I_{pickup}} - C\right)^3} \right]$$

where
T = Trip Time (sec)
M = Multiplier Setpoint
I = Input Current
I_{pickup} = Pickup Current Setpoint
A, B, C, D, E = Constants

Table 4-3 ANSI INVERSE TIME CURVE CONSTANTS

ANSI CURVE SHAPE	CONSTANTS				
	A	B	C	D	E
EXTREMELY INVERSE	0.0399	0.2294	0.5000	3.0094	0.7222
VERY INVERSE	0.0615	0.7989	0.3400	-0.2840	4.0505
NORMALLY INVERSE	0.0274	2.2614	0.3000	-4.1899	9.1272
MODERATELY INVERSE	0.1735	0.6791	0.8000	-0.0800	0.1271

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IEC CURVES

For European applications, the relay offers the four standard curves defined in IEC 255-4 and British standard BS142. These are defined as IEC Curve A, IEC Curve B, IEC Curve C, and Short Inverse. The formula for these curves is:

$$T \ = \ M\times\left[\frac{K}{\left(\frac{I}{I_{\text{pickup}}}\right)^{E} \text{-}1}\right]$$

1

where T = Trip Time (sec)
M = Multiplier Setpoint
I = Input Current
I_{pickup} = Pickup Current Setpoint
K, E = Constants

Table 4-4 IEC (BS) INVERSE TIME CURVE CONSTANTS

IEC (BS) CURVE SHAPE	CONSTANTS	
	K	E
IEC CURVE A (BS142)	0.140	0.020
IEC CURVE B (BS142)	13.500	1.000
IEC CURVE C (BS142)	80.000	2.000
SHORT INVERSE	0.050	0.040

IAC CURVES

The curves for the General Electric type IAC relay family are derived from the formula:

$$T = M\times\left[A+\frac{B}{\left(\frac{I}{I_{\text{pickup}}}-C\right)}+\frac{D}{\left(\frac{I}{I_{\text{pickup}}}-C\right)^{2}}+\frac{E}{\left(\frac{I}{I_{\text{pickup}}}-C\right)^{3}}\right]$$

where T = Trip Time (sec)
M = Multiplier Setpoint
I = Input Current
I_{pickup} = Pickup Current Setpoint
A, B, C, D, E = Constants

Table 4-5 GE TYPE IAC INVERSE TIME CURVE CONSTANTS

IAC CURVE SHAPE	CONSTANTS				
	A	B	C	D	E
IAC EXTREME INVERSE	0.0040	0.6379	0.6200	1.7872	0.2461
IAC VERY INVERSE	0.0900	0.7955	0.1000	-1.2885	7.9586
IAC INVERSE	0.2078	0.8630	0.8000	-0.4180	0.1947
IAC SHORT INVERSE	0.0428	0.0609	0.6200	-0.0010	0.0221

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FlexCurve™

The custom FlexCurve™ has setpoints for entering times to trip at the following current levels: 1.03, 1.05, 1.1 to 6.0 in steps of 0.1 and 6.5 to 20.0 in steps of 0.5. The relay then converts these points to a continuous curve by linear interpolation between data points. To enter a custom FlexCurve™, read off each individual point from a time overcurrent coordination drawing and enter it into a table as shown. Then transfer each individual point to the 489 using either the 489 PC program or the front panel keys and display.

Table 4-6 FLEXCURVE™ TABLE

Pickup (I/I_{pickup})	Trip Time (ms)	Pickup (I/I_{pickup})	Trip Time (ms)	Pickup (I/I_{pickup})	Trip Time (ms)	Pickup (I/I_{pickup})	Trip Time (ms)
1.03		2.9		4.9		10.5	
1.05		3.0		5.0		11.0	
1.1		3.1		5.1		11.5	
1.2		3.2		5.2		12.0	
1.3		3.3		5.3		12.5	
1.4		3.4		5.4		13.0	
1.5		3.5		5.5		13.5	
1.6		3.6		5.6		14.0	
1.7		3.7		5.7		14.5	
1.8		3.8		5.8		15.0	
1.9		3.9		5.9		15.5	
2.0		4.0		6.0		16.0	
2.1		4.1		6.5		16.5	
2.2		4.2		7.0		17.0	
2.3		4.3		7.5		17.5	
2.4		4.4		8.0		18.0	
2.5		4.5		8.5		18.5	
2.6		4.6		9.0		19.0	
2.7		4.7		9.5		19.5	
2.8		4.8		10.0		20.0	

DEFINITE TIME CURVE

The definite time curve shape causes a trip as soon as the pickup level is exceeded for a specified period of time. The base definite time curve delay is 100 ms. The curve multiplier of 0.00 - 1000.00 makes this delay adjustable from instantaneous to 100.00 seconds in steps of 1 ms.

$$T = M \times 100\text{ms, when} \qquad I > I\text{pickup}$$

where T = Trip Time (sec)
M = Multiplier Setpoint
I = Input Current
I_{pickup} = Pickup Current Setpoint

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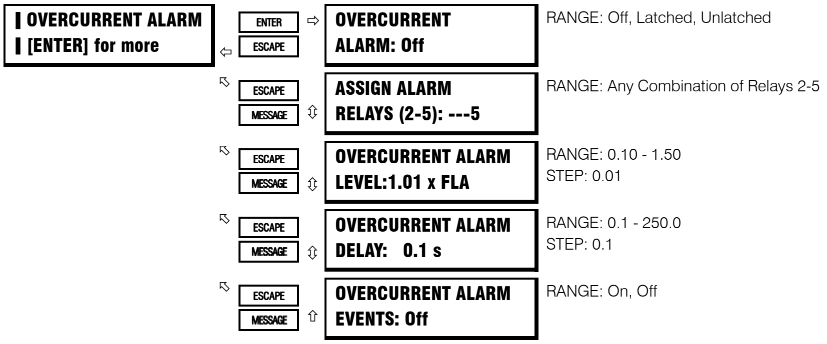
4.6.2 OVERCURRENT ALARM



❙ OVERCURRENT ALARM
❙ [ENTER] for more

OVERCURRENT
ALARM: Off
RANGE: Off, Latched, Unlatched

ASSIGN ALARM
RELAYS (2-5): ---5
RANGE: Any Combination of Relays 2-5

OVERCURRENT ALARM
LEVEL:1.01 x FLA
RANGE: 0.10 - 1.50
STEP: 0.01

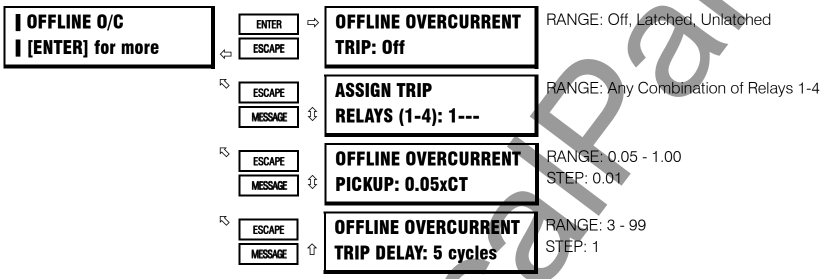
OVERCURRENT ALARM
DELAY: 0.1 s
RANGE: 0.1 - 250.0
STEP: 0.1

OVERCURRENT ALARM
EVENTS: Off
RANGE: On, Off

FUNCTION:

If enabled as Latched or Unlatched, the Overcurrent Alarm will function as follows: If the average generator current (RMS) measured at the output CTs exceeds the level programmed for the period of time specified, an alarm will occur. If programmed as unlatched, the alarm will reset itself when the overcurrent condition is no longer present. If programmed as latched, once the overcurrent condition is gone, the reset key must be pressed to reset the alarm. The generator FLA is calculated as: generator rated MVA / (√3 x rated generator phase-phase voltage).

4.6.3 OFFLINE OVERCURRENT



❙ OFFLINE O/C
❙ [ENTER] for more

OFFLINE OVERCURRENT
TRIP: Off
RANGE: Off, Latched, Unlatched

ASSIGN TRIP
RELAYS (1-4): 1---
RANGE: Any Combination of Relays 1-4

OFFLINE OVERCURRENT
PICKUP: 0.05xCT
RANGE: 0.05 - 1.00
STEP: 0.01

OFFLINE OVERCURRENT
TRIP DELAY: 5 cycles
RANGE: 3 - 99
STEP: 1

FUNCTION:

When a synchronous generator is offline, there should be no measurable current flow in any of the three phases unless the unit is supplying its own station load. Also, since the generator is not yet online, differentiation between system faults and machine faults is easier. The offline overcurrent feature is active only when the generator is offline and uses the neutral end CT measurements (Ia, Ib, Ic). It may be set much more sensitive than the differential element to detect high impedance phase faults. Since the breaker auxiliary contacts wired to the 489 Breaker Status input may not operate at exactly the same time as the main breaker contacts, the time delay should be coordinated with the difference of the operation times. In the event of a low impedance fault, the differential element will still shutdown the generator quickly.

Note: if the unit auxiliary transformer is on the generator side of the breaker, the pickup level must be set greater than the unit auxiliary load.

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4.6.4 INADVERTENT ENERGIZATION

▌INADVERTENT ENERG. ▌[ENTER] for more	ENTER ⇨ / ESCAPE ⇦	
INADVERTENT ENERGIZE TRIP: Off		RANGE: Off, Latched, Unlatched
ASSIGN TRIP RELAYS (1-4): 1---	ESCAPE / MESSAGE ⇳	RANGE: Any Combination of Relays 1-4
ARMING SIGNAL: U/V and Offline	ESCAPE / MESSAGE ⇳	RANGE: U/V and Offline, U/V or Offline
INADVERTENT ENERGIZE O/C PICKUP: 0.05xCT	ESCAPE / MESSAGE ⇳	RANGE: 0.05 - 3.00 STEP: 0.01
INADVERTENT ENERGIZE PICKUP:0.50xRated V	ESCAPE / MESSAGE ⇧	RANGE: 0.50 - 0.99 STEP: 0.01

FUNCTION:

The logic diagram for the inadvertent energization protection feature is shown below. The feature may be armed when all of the phase voltages fall below the undervoltage pickup level 'and' the unit is offline. This would be the case when the VTs are on the generator side of the disconnect device. If however, the VTs are on the power system side of the disconnect device, the feature should be armed if all of the phase voltages fall below the undervoltage pickup level 'or' the unit is offline. When the feature is armed, if any one of the phase currents measured at the output CTs exceeds the overcurrent level programmed, a trip will occur. (Note: 5s to arm, 250ms to disarm.)

Protection can be provided for poor synchronization by using the 'U/V or Offline' arming signal. During normal synchronization, there should be relatively low current measured. If however, synchronization is attempted when conditions are not appropriate, a large current that is measured within 250 ms after the generator is placed online would result in a trip.

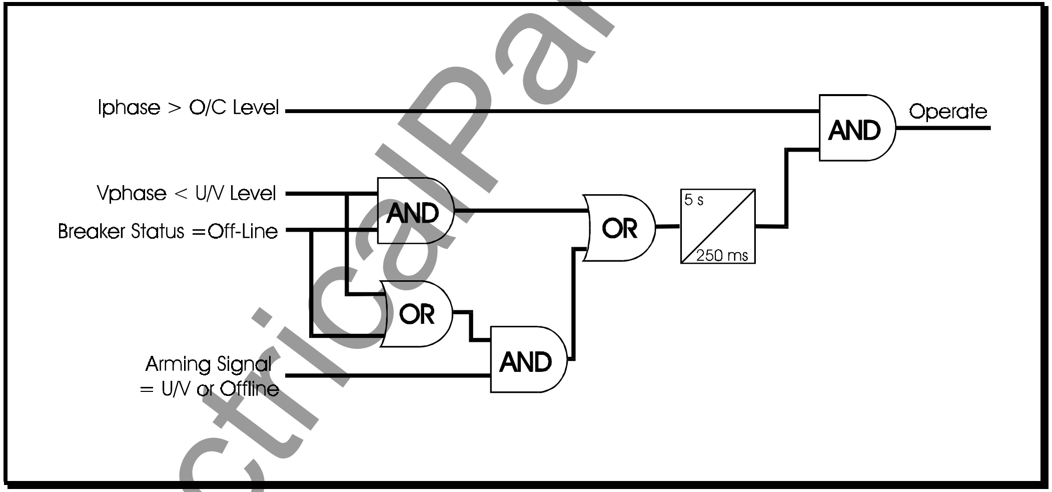

Figure 4-1 INADVERTENT ENERGIZATION

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4.6.5 VOLTAGE RESTRAINED PHASE OVERCURRENT

■ PHASE OVERCURRENT ■ [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	PHASE OVERCURRENT TRIP: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	ENABLE VOLTAGE RESTRAINT: No	RANGE: No, Yes
	ESCAPE MESSAGE ⇳	VOLTAGE LOWER LIMIT: 10%	RANGE: 10 - 60% NOTE: seen only if voltage restraint set to Yes
	ESCAPE MESSAGE ⇳	PHASE OVERCURRENT PICKUP: 10.00xCT	RANGE: 0.15 - 20.00 STEP: 0.01
	ESCAPE MESSAGE ⇳	CURVE SHAPE: ANSI Extremely Inv.	RANGE: See Table 4-2 489 OVERCURRENT CURVE TYPES
	ESCAPE MESSAGE ⇳	FLEXCURVE TRIP TIME AT 1.03xPU: 65535 ms	RANGE: 0 - 65535 NOTE: seen only if curve shape is Flexcurve™
	ESCAPE MESSAGE ⇳	FLEXCURVE TRIP TIME AT 20.0xPU: 65535 ms	RANGE: 0 - 65535 NOTE: seen only if curve shape is Flexcurve™
	ESCAPE MESSAGE ⇳	OVERCURRENT CURVE MULTIPLIER: 1.00	RANGE: 0.00 - 1000.00 STEP: 0.01
	ESCAPE MESSAGE ⇧	OVERCURRENT CURVE RESET: Instantaneous	RANGE: Instantaneous, Linear

FUNCTION:

If the primary system protective relaying fails to properly isolate phase faults, the voltage restrained overcurrent acts as system backup protection. The magnitude of each phase current measured at the output CTs is used to time out against an inverse time curve. The 489 inverse time curve for this element may be either ANSI, IEC, or GE Type IAC standard curve shapes. This allows for simplified coordination with downstream devices. If however, none of these curve shapes is adequate, the FlexCurve™ may be used to customize the inverse time curve characteristics.

When enabled, the voltage restraint feature lowers the pickup value of each individual phase time overcurrent element in a fixed relationship (see Table 4-7 and Figure 4-2) with the corresponding input voltage to a minimum pickup of 0.15 x CT. The voltage lower limit setpoint is intended to prevent very rapid tripping prior to primary protection clearing a fault when voltage restraint is enabled and severe close-in fault has occurred. If voltage restraint is not required, select "No" for this setpoint. If the VT type is selected as "None" or a VT fuse loss is detected, the voltage restraint is ignored and the element operates as simple phase overcurrent.

Note: a fuse failure is detected within 99ms, therefore, any voltage restrained overcurrent trip should have a time delay of 100ms or more or nuisance tripping on fuse loss could occur.

Example:
Determine the voltage restrained phase overcurrent pickup level under the following situation:
Phase Overcurrent Pickup = 2 x CT Enable Voltage Restraint = YES
Phase-Phase Voltage / Rated Phase-Phase Voltage = 0.4pu
Voltage Restrained Phase O/C Pickup = (Phase O/C pickup × Voltage restrained curve pickup multiplier) × CT
= (2 × 0.4) × CT
= 0.8 × CT

Table 4-7 489 PHASE OVERCURRENT RESTRAINT VOLTAGES

CURRENT	VOLTAGE
IA	Vab
IB	Vbc
IC	Vca

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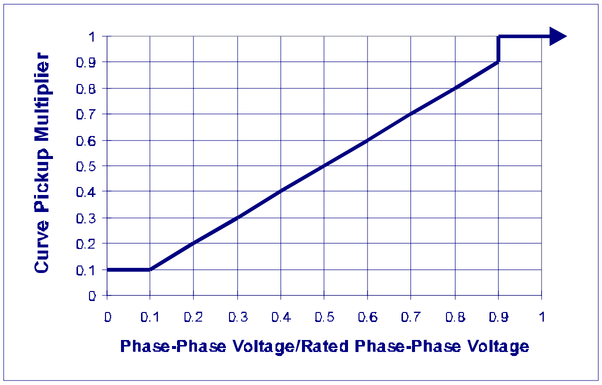

Figure 4-2 VOLTAGE RESTRAINT CHARACTERISTIC

4.6.6 NEGATIVE SEQUENCE OVERCURRENT

▍NEGATIVE SEQUENCE ▍[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	NEGATIVE SEQUENCE ALARM: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	NEG. SEQUENCE ALARM PICKUP: 3 % FLA	RANGE: 3- 100 STEP: 1
	ESCAPE MESSAGE ⇳	NEGATIVE SEQUENCE ALARM DELAY: 5.0 s	RANGE: 0.1 - 100.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	NEGATIVE SEQUENCE ALARM EVENTS: Off	RANGE: On, Off
	ESCAPE MESSAGE ⇳	NEGATIVE SEQUENCE O/C TRIP: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	NEG. SEQUENCE O/C TRIP PICKUP: 8 % FLA	RANGE: 3- 100 STEP: 1
	ESCAPE MESSAGE ⇳	NEG. SEQUENCE O/C CONSTANT K: 1	RANGE: 1 - 100 STEP: 1
	ESCAPE MESSAGE ⇳	NEG. SEQUENCE O/C MAX. TIME: 1000 s	RANGE: 10 - 1000 STEP: 1
	ESCAPE MESSAGE ⇧	NEG. SEQUENCE O/C RESET RATE: 227.0 s	RANGE: 0.0 - 999.9 STEP: 0.1

FUNCTION:

Rotor heating in generators due to negative sequence current is a well known phenomenon. Generators have very specific capability limits where unbalanced current is concerned (see ANSI C50.13). A generator should have a rating for both continuous and also short time operation when negative sequence current components are present.

The formula: $K=I_2^2t$ defines the short time negative sequence capability of the generator
where: K = constant from generator manufacturer depending on generator size and design
I_2 = negative sequence current as a percent of generator rated full load current as measured at the output CTs
t = time in seconds when I_2 > pickup (minimum 250ms, maximum defined by setpoint)

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The 489 has a definite time alarm and inverse time overcurrent curve trip to protect the generator rotor from overheating due to the presence of negative sequence currents. Pickup values are negative sequence current as a percent of generator rated full load current. The generator FLA is calculated as: generator rated MVA / (√3x rated generator phase-phase voltage). Negative sequence overcurrent maximum time defines the maximum time that any value of negative sequence current in excess of the pickup value will be allowed to persist before a trip is issued. The reset rate provides a thermal memory of previous unbalance conditions. It is the linear reset time from the threshold of trip.

NOTE: Unusually high negative sequence current levels may be caused by incorrect phase CT wiring.

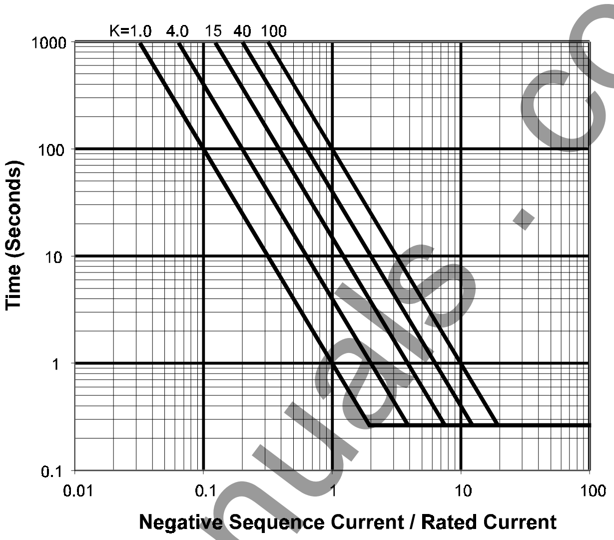

Figure 4-3 NEGATIVE SEQUENCE INVERSE TIME CURVES

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4.6.7 GROUND OVERCURRENT

GROUND O/C
[ENTER] for more

ENTER ESCAPE	**GROUND OVERCURRENT ALARM: Off**	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	**ASSIGN ALARM RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
ESCAPE MESSAGE	**GROUND O/C ALARM PICKUP: 0.20xCT**	RANGE: 0.05 - 20.00 STEP: 0.01
ESCAPE MESSAGE	**GROUND O/C ALARM DELAY: 0 cycles**	RANGE: 0 - 100 STEP: 1
ESCAPE MESSAGE	**GROUND OVERCURRENT ALARM EVENTS: Off**	RANGE: On, Off
ESCAPE MESSAGE	**GROUND OVERCURRENT TRIP: Off**	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	**ASSIGN TRIP RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
ESCAPE MESSAGE	**GROUND O/C TRIP PICKUP: 0.20xCT**	RANGE: 0.05 - 20.00 STEP: 0.01
ESCAPE MESSAGE	**CURVE SHAPE: ANSI Extremely Inv.**	RANGE: See Table 4-2 489 OVERCURRENT CURVE TYPES
ESCAPE MESSAGE	**FLEXCURVE TRIP TIME AT 1.03xPU: 65535 ms**	RANGE: 0 - 65535 NOTE: seen only if curve shape is Flexcurve™
ESCAPE MESSAGE	**FLEXCURVE TRIP TIME AT 20.0xPU: 65535 ms**	RANGE: 0 - 65535 NOTE: seen only if curve shape is Flexcurve™
ESCAPE MESSAGE	**OVERCURRENT CURVE MULTIPLIER: 1.00**	RANGE: 0.00 - 1000.00 STEP: 0.01
ESCAPE MESSAGE	**OVERCURRENT CURVE RESET: Instantaneous**	RANGE: Instantaneous, Linear

FUNCTION:

The 489 ground overcurrent feature consists of both an alarm and a trip element. The magnitude of measured ground current is used to time out against the definite time alarm or inverse time curve trip. The 489 inverse time curve for this element may be either ANSI, IEC, or GE Type IAC standard curve shapes. This allows for simplified coordination with downstream devices. If however, none of these curves shapes is adequate, the FlexCurve™ may be used to customize the inverse time curve characteristics. If the Ground CT is selected as "None", the ground overcurrent protection is disabled.

NOTE: The pickup level for the ground current elements is programmable as a multiple of the CT. The 50:0.025 CT is intended for very sensitive detection of ground faults and its nominal CTrating for the 489 is 50:0.025.

EXAMPLE:

If the ground CT is 50:0.025,
a pickup of 0.20 would be 0.20 x 5 = 1 amp primary

If the ground CT is 50:0.025,
a pickup of 0.05 would be 0.05 x 5 = 0.25 amps primary

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4.6.8 PHASE DIFFERENTIAL

▌PHASE DIFFERENTIAL
▌[ENTER] for more

ENTER ⇨ ESCAPE ⇦

PHASE DIFFERENTIAL
TRIP: Off
RANGE: Off, Latched, Unlatched

ESCAPE MESSAGE ⇳
ASSIGN TRIP
RELAYS (1-4): 1---
RANGE: Any Combination of Relays 1-4

ESCAPE MESSAGE ⇳
DIFFERENTIAL TRIP
MIN. PICKUP: 0.10xCT
RANGE: 0.05 - 1.00
STEP: 0.01

ESCAPE MESSAGE ⇳
DIFFERENTIAL TRIP
SLOPE 1: 10 %
RANGE: 1 - 100
STEP: 1

ESCAPE MESSAGE ⇳
DIFFERENTIAL TRIP
SLOPE 2: 20 %
RANGE: 1 - 100
STEP: 1

ESCAPE MESSAGE ⇧
DIFFERENTIAL TRIP
DELAY: 0 cycles
RANGE: 0 - 100 cycles
STEP: 10

FUNCTION:

The 489 percentage differential element has a dual slope characteristic. This allows for very sensitive settings when fault current is low and less sensitive settings when fault current is high, more that 2 x CT, and CT performance may produce erroneous operate signals. The minimum pickup value sets an absolute minimum pickup in terms of operate current. The delay can be fine tuned to an application such that it still responds very fast, but rides through normal operational disturbances.

The Differential element for phase A will operate when:

$$I_{Operate} > k \times I_{Restraint}$$

$$I_{Operate} = \overline{I_A} - \overline{I_a}$$

$$I_{Restraint} = \frac{|I_A| + |I_a|}{2}$$

where: $I_{Operate}$ = operate current
$I_{Restraint}$ = restraint current
k = characteristic slope of differential element in percent (Slope 1 if I_R< 2 X CT, Slope 2 if I_R>= 2 X CT)
I_A = phase current measured at the output CT
I_a = phase current measured at the neutral end CT

Differential elements for phase B and phase C operate in the same manner.

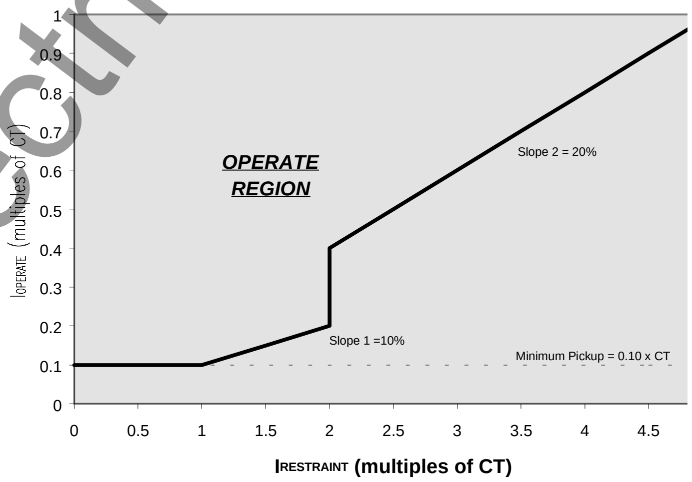

Figure 4-4 DIFFERENTIAL ELEMENTS

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4.6.9 GROUND DIRECTIONAL

▌GROUND DIRECTIONAL ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	SUPERVISE WITH DIGITAL INPUT: Yes	RANGE: Yes, No Note: This message is only seen if a digital input is assigned to Ground Switch Status
	⬁ ESCAPE MESSAGE ⇳	GROUND DIRECTIONAL MTA: 0 °	RANGE: 0°, 90°, 180°, 270° Note: MTA(Maximum Torque angle)
	⬁ ESCAPE MESSAGE ⇳	GROUND DIRECTIONAL ALARM: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⬁ ESCAPE MESSAGE ⇳	GROUND DIR. ALARM PICKUP: 0.05 X CT	RANGE: 0.05 - 20.00 STEP: 0.1
	⬁ ESCAPE MESSAGE ⇳	GROUND DIR. ALARM DELAY: 3.0 sec.	RANGE: 0.1 - 120.0 STEP: 0.1
	⬁ ESCAPE MESSAGE ⇳	GROUND DIR. ALARM EVENTS: Off	RANGE: On, Off
	⬁ ESCAPE MESSAGE ⇳	GROUND DIRECTIONAL TRIP: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	⬁ ESCAPE MESSAGE ⇳	GROUND DIR. TRIP PICKUP: 0.05 X CT	RANGE: 0.05 - 20.00 STEP: 0.1
	⬁ ESCAPE MESSAGE ⇳	GROUND DIR. TRIP DELAY: 3.0 sec.	RANGE: 0.1 - 120.0 STEP: 0.1

FUNCTION:

The 489 can detect ground directional by using two measurement quantities, V_0 and I_0. By comparing the angle between these quantites it can be determined if a ground fault is within the generator or not. This function should be coordinated with the 59GN element (95 % stator ground protection) to ensure proper operation of the element. Particularly, this element should be faster. This element must use a core balance CT to derive the I_0 signal. Polarity is critical in this element. The protection element is blocked for neutral voltages, Vo, below 2.0 V secondary. Refer to the application section for more details.

NOTE: The pickup level for the ground current elements is programmable as a multiple of the CT. The 50:0.025 CT is intended for very sensitive detection of ground faults and its nominal CTrating for the 489 is 50:0.025.

EXAMPLE:

If the ground CT is 50:0.025,
a pickup of 0.20 would be 0.20 x 5 = 1 amp primary

If the ground CT is 50:0.025,
a pickup of 0.05 would be 0.05 x 5 = 0.25 amps primary

(Refer to Appendix B for Application Notes)

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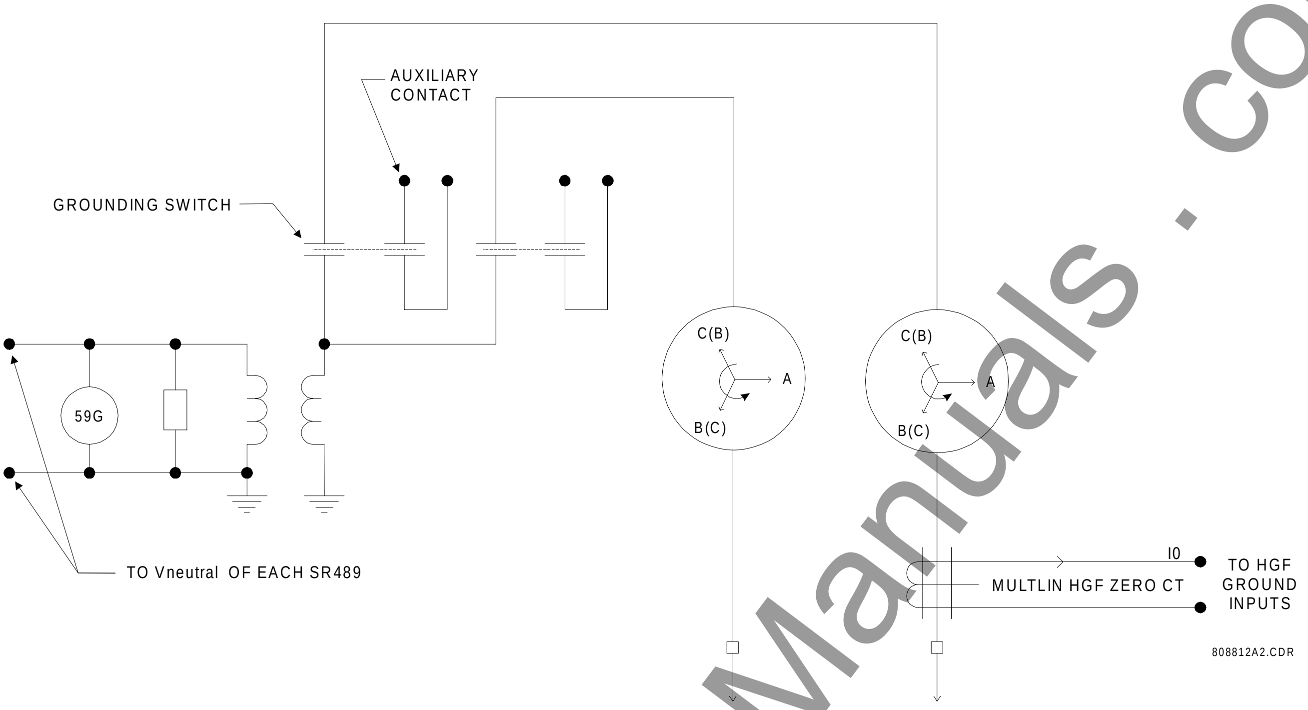

4.6.10 HIGH-SET PHASE OVERCURRENT

▌HIGH-SET PHASE O/C
▌[ENTER] for more

ENTER ⇨ **HIGH-SET PHASE O/C**
ESCAPE ⇩ **TRIP : Off**
RANGE: Off, Latched, Unlatched *MODBUS ADDRESS:0X1830*

ESCAPE / MESSAGE ⇳ **ASSIGN TRIP**
RELAYS (1-4): 1---
RANGE: Any Combination of Relays 1-4 *MODBUS ADDRESS:0X1831*

ESCAPE / MESSAGE ⇳ **HIGH-SET PHASE O/C**
PICKUP: 5.00 X CT
RANGE: 0.15-20.00 *MODBUS ADDRESS:0X1832*
STEP: 0.01

ESCAPE / MESSAGE ⇧ **HIGH-SET PHASE O/C**
DELAY: 1.00 s
RANGE: 0.00 - 100.00 *MODBUS ADDRESS:0X1833*
STEP: 0.01

FUNCTION:

If any individual phase current exceeds the pickup level for the specified trip time a trip will occur if the feature is enabled. The element operates in both online and offline conditions. This element can be used as a backup feature to other protection elements. In situations where generators are connected in parallel this element would be set above the maximum current contribution from the generator on which the protection is installed. With this setting, the element would provide proper selective tripping. The basic operating time of the element with no time delay is 50 ms @ 50/60 Hz.

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4.7.1 UNDERVOLTAGE

▌UNDERVOLTAGE ▌[ENTER] for more	ENTER ⇨ ESCAPE ⇦	
ENTER ⇨ / ESCAPE	UNDERVOLTAGE ALARM: Off	RANGE: Off, Latched, Unlatched
ESCAPE / MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE ALARM PICKUP: 0.85 x Rated	RANGE: 0.50 - 0.99 STEP: 0.01
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE ALARM DELAY: 3.0 s	RANGE: 0.2 - 120.0 STEP: 0.1
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE ALARM EVENTS: Off	RANGE: On, Off
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE TRIP: Off	RANGE: Off, Latched, Unlatched
ESCAPE / MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE TRIP PICKUP: 0.80 x Rated	RANGE: 0.50 - 0.99 STEP: 0.01
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE TRIP DELAY: 1.0 s	RANGE: 0.2- 10.0 STEP: 0.1
ESCAPE / MESSAGE ⇳	UNDERVOLTAGE CURVE RESET RATE: 1.4 s	RANGE: 0.0 - 999.9 STEP: 0.1
ESCAPE / MESSAGE ⇧	UNDERVOLTAGE TRIP ELEMENT: CURVE	RANGE: Curve, DefiniteTime

FUNCTION:

The undervoltage elements may be used for protection of the generator and/or its auxiliary equipment during prolonged undervoltage conditions. They are active only when the generator is online. The alarm element is definite time and the trip element can be either definite time or a curve. When the magnitude of the average phase-phase voltage is less than the pickup x the generator rated phase-phase voltage, the element will begin to time out. If the time expires, a trip or alarm will occur. The curve reset rate is a linear reset time from the threshold of trip. If the VT type is selected as "None" , VT fuse loss is detected, or the magnitude of I_1< 7.5% CT, the undervoltage protection is disabled. The pickup levels are insensitive to frequency over the range of 5 to 90 Hz.

The formula for the curve is:

$$T = \frac{D}{\left(1 - \frac{V}{V_{pickup}}\right)}, \text{when} V < V_{pickup}$$

where T = trip time (sec)
D = delay setpoint
V = actual per unit phase-phase voltage
V_{pickup}= undervoltage pickup setpoint

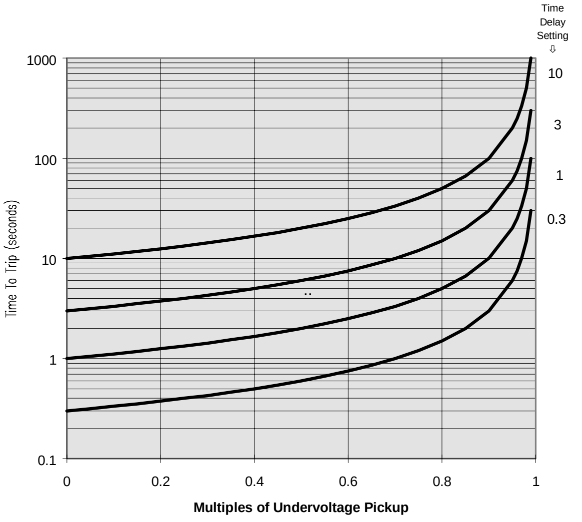

Figure 4-5 UNDERVOLTAGE CURVES

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4.7.2 OVERVOLTAGE

OVERVOLTAGE
[ENTER] for more

ENTER ESCAPE	**OVERVOLTAGE** **ALARM: Off**	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
ESCAPE MESSAGE	**OVERVOLTAGE ALARM** **PICKUP: 1.15 x Rated**	RANGE: 1.01 - 1.50 STEP: 0.01
ESCAPE MESSAGE	**OVERVOLTAGE ALARM** **DELAY: 3.0 s**	RANGE: 0.1 - 120.0 STEP: 0.1
ESCAPE MESSAGE	**OVERVOLTAGE ALARM** **EVENTS: Off**	RANGE: On, Off
ESCAPE MESSAGE	**OVERVOLTAGE** **TRIP: Off**	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	**ASSIGN TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
ESCAPE MESSAGE	**OVERVOLTAGE TRIP** **PICKUP: 1.20 x Rated**	RANGE: 1.01 - 1.50 STEP: 0.01
ESCAPE MESSAGE	**OVERVOLTAGE TRIP** **DELAY: 1.0 s**	RANGE: 0.1 - 10.0 STEP: 0.1
ESCAPE MESSAGE	**OVERVOLTAGE CURVE** **RESET RATE: 1.4 s**	RANGE: 0.0 - 999.9 STEP: 0.1
ESCAPE MESSAGE	**OVERVOLTAGE TRIP** **ELEMENT: CURVE**	RANGE: Curve, DefiniteTime

FUNCTION:

The overvoltage elements may be used for protection of the generator and/or its auxiliary equipment during prolonged overvoltage conditions. They are always active (when the generator is offline or online). The alarm element is definite time and the trip element can be either definite time or an inverse time curve. When the average of the measured phase-phase voltages rises above the pickup level x the generator rated phase-phase voltage, the element will begin to time out. If the time expires, a trip or alarm will occur. The reset rate is a linear reset time from the threshold of trip. The pickup levels are insensitive to frequency over the range of 5 to 90 Hz.

The formula for the curve is:

$$T = \frac{D}{\left(\frac{V}{V_{pickup}} - 1\right)}, \text{when} V > V_{pickup}$$

where T = trip time (sec)
D = delay setpoint
V = actual per unit phase-phase voltage
V_{pickup}= overvoltage pickup setpoint

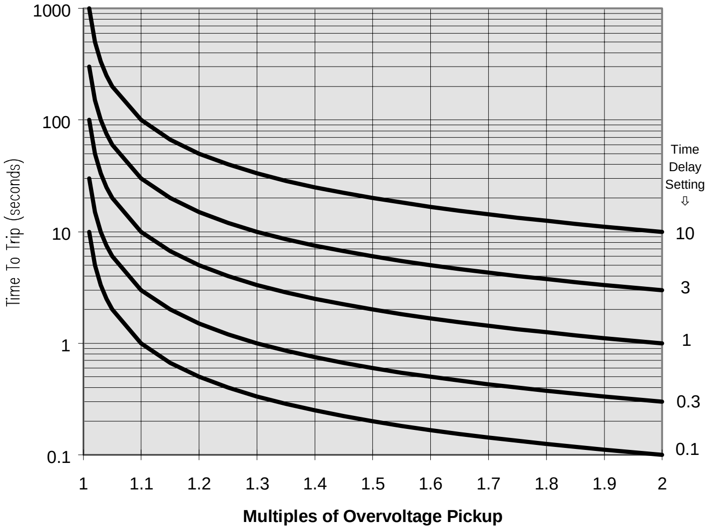

Figure 4-6 OVERVOLTAGE CURVES

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4

4.7.3 VOLTS/HERTZ

VOLTS/HERTZ
[ENTER] for more

ENTER ⇨ / ESCAPE ⇦

VOLTS/HERTZ **ALARM: Off**	RANGE: Off, Latched, Unlatched
ASSIGN ALARM **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
VOLTS/HERTZ ALARM **PICKUP: 1.00xNominal**	RANGE: 0.50 - 1.99 STEP: 0.01
VOLTS/HERTZ ALARM **DELAY: 3.0 s**	RANGE: 0.1 - 150.0 STEP: 0.1
VOLTS/HERTZ ALARM **EVENTS: Off**	RANGE: On, Off
VOLTS/HERTZ **TRIP: Off**	RANGE: Off, Latched, Unlatched
ASSIGN TRIP **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
VOLTS/HERTZ TRIP **PICKUP: 1.00xNominal**	RANGE: 0.50 - 1.99 STEP: 0.01
VOLTS/HERTZ TRIP **DELAY: 1.0 s**	RANGE: 0.1 - 150.0 STEP: 0.1
VOLTS/HERTZ CURVE **RESET RATE: 1.4 s**	RANGE: 0.0 - 999.9 STEP: 0.1
VOLTS/HERTZ TRIP **ELEMENT: CURVE #1**	RANGE: Curve #1, Curve #2, Curve #3, Definite Time

ESCAPE / MESSAGE ⇳

FUNCTION:
The volts/hertz elements may be used for protection of the generator and unit transformer. They are active as soon as the magnitude and frequency of Vab is measurable. The alarm element is definite time and the trip element can be either definite time or a curve. Once the Volts/Hertz measurement Vab exceeds the pickup level, for the period of time specified, a trip or alarm will occur. The reset rate is a linear reset time from the threshold of trip and should be set to match cooling characteristics of the protected equipment. The measurement of Volts/Hertz will be accurate through a frequency range of 5 - 90 Hz. Settings less than 1.00 would only apply for special generators such as short circuit testing machines.

The formula for the curve #1 is:

$$T = \frac{D}{\left[\left(\frac{V}{F}\right) / \left(\frac{V_{NOM}}{F_S} \times \text{Pickup}\right)\right]^2 - 1}, \text{when } \frac{V}{F} > \text{Pickup}$$

where T = trip time (sec)
D = delay setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = volts/hertz pickup setpoint

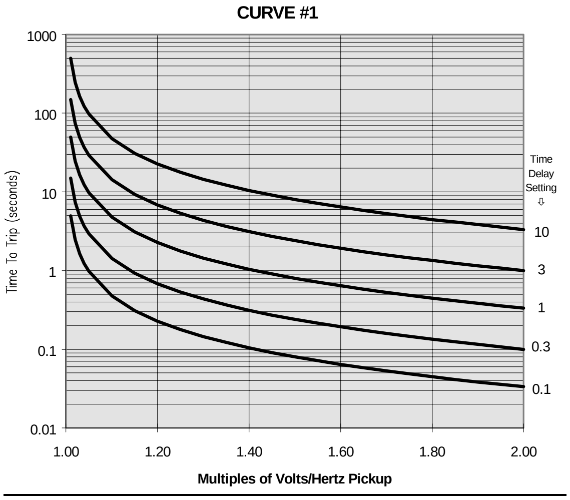

Figure 4-7 VOLTS/HERTZ CURVES #1

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Curve #2:

$$T = \frac{D}{\left[\left(\frac{V}{F}\right)/\left(\frac{V_{NOM}}{F_S}\times \text{Pickup}\right)\right]-1}, \text{when} \frac{V}{F} > \text{Pickup}$$

where T = trip time (sec)
D = delay setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = volts/hertz pickup setpoint

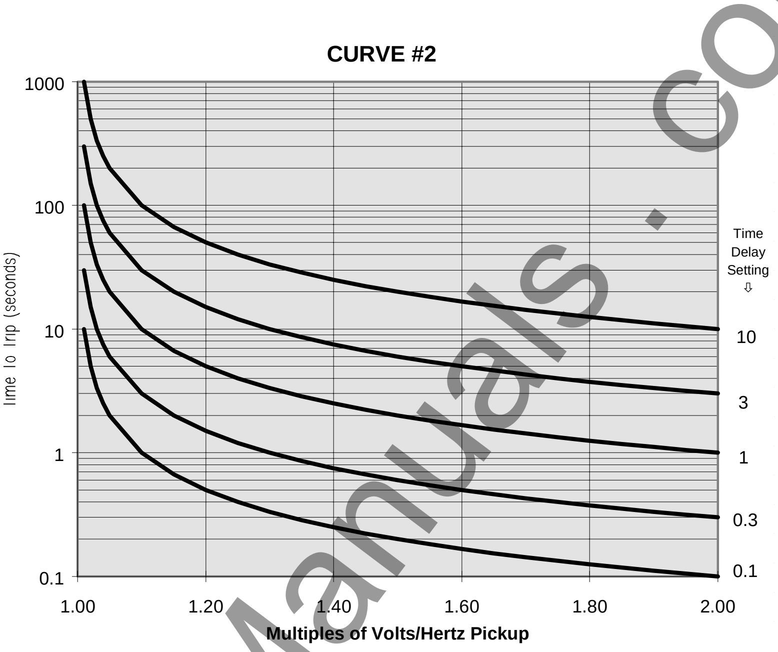

Figure 4-8 VOLTS/HERTZ CURVES #2

Curve #3:

$$T = \frac{D}{\left[\left(\frac{V}{F}\right)/\left(\frac{V_{NOM}}{F_S}\times \text{Pickup}\right)\right]^{0.5}-1}, \text{when} \frac{V}{F} > \text{Pickup}$$

where T = trip time (sec)
D = delay setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = volts/hertz pickup setpoint

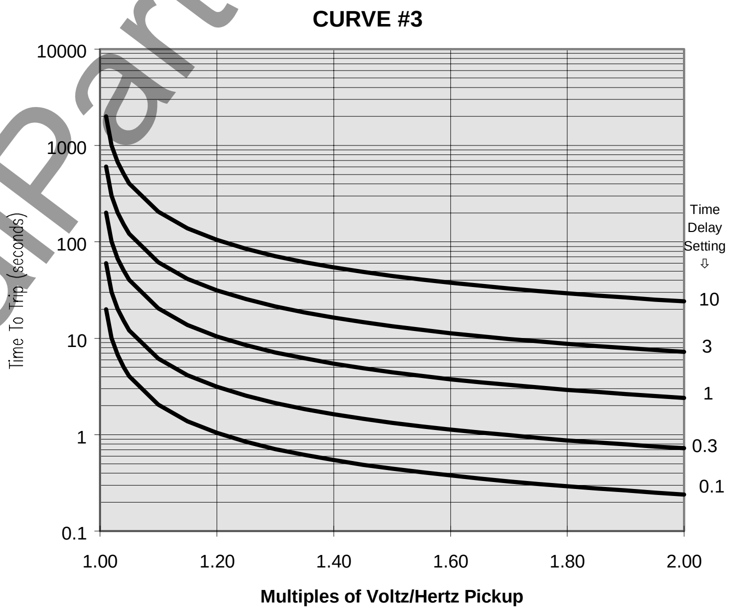

Figure 4-9 VOLTS/HERTZ CURVES #3

Note:
Volts/Hertz is done per unit

$$\text{Volts/Hertz} = \frac{(\text{Phase - phase voltage } / \text{ Rated phase - phase voltage})}{(\text{Frequency } / \text{ Rated frequency})}$$

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4.7.4 PHASE REVERSAL

PHASE REVERSAL [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	PHASE REVERSAL TRIP: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇧	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4

FUNCTION:

The 489 can detect the phase rotation of the three phase voltages. A trip will occur within 200ms if the Phase Reversal feature is turned on, the generator is offline, each of the phase-phase voltages is greater than 50% of the generator rated phase-phase voltage and the phase rotation is not the same as the setpoint. Loss of VT fuses cannot be detected when the generator is offline and could lead to maloperation of this element. If the VT type is selected as "None", the phase reversal protection is disabled.

4.7.5 UNDERFREQUENCY

UNDERFREQUENCY [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	BLOCK UNDERFREQUENCY FROM ONLINE: 1 s	RANGE: 0 - 5 STEP: 1
	ESCAPE MESSAGE ⇳	VOLTAGE LEVEL CUTOFF : 0.50 x Rated	RANGE: 0.50 - 0.99 STEP: 0.01
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY ALARM : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY ALARM LEVEL: 59.50 Hz	RANGE: 20.00 - 60.00 STEP: 0.01
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY ALARM DELAY: 5.0 s	RANGE: 0.1 -5000.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY ALARM EVENTS: Off	RANGE: On, Off
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY TRIP : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY TRIP LEVEL1: 59.50 Hz	RANGE: 20.00 - 60.00 STEP: 0.01
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY TRIP DELAY1: 60.0 s	RANGE: 0.1 -5000.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	UNDERFREQUENCY TRIP LEVEL2: 58.00 Hz	RANGE: 20.00 - 60.00 STEP: 0.01
	ESCAPE MESSAGE ⇧	UNDERFREQUENCY TRIP DELAY2: 30.0 s	RANGE: 0.1 -5000.0 STEP: 0.1

FUNCTION:

It may be undesirable to enable the underfrequency elements until the generator is online. This feature can be blocked until the generator is online and the block time expires. From that point forward, the underfrequency trip and alarm elements will be active. A value of zero for the block time indicates that the underfrequency protection is active as soon as voltage exceeds the cutoff level (programmed as a multiple of the generator rated phase-phase voltage). Frequency is then measured. Once the frequency of Vab is less than the underfrequency setpoints, for the period of time specified, a trip or alarm will occur. There are dual level and time setpoints for the trip element.

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4.7.6 OVERFREQUENCY

▌OVERFREQUENCY
▌[ENTER] for more

ENTER ⇨ / ESCAPE ⇦	**BLOCK OVERFREQUENCY** **FROM ONLINE: 1 s**	RANGE: 0 - 5 STEP: 1
ESCAPE / MESSAGE ⇳	**VOLTAGE LEVEL** **CUTOFF : 0.50 x Rated**	RANGE: 0.50 - 0.99 STEP: 0.01
ESCAPE / MESSAGE ⇳	**OVERFREQUENCY** **ALARM : Off**	RANGE: Off, Latched, Unlatched
ESCAPE / MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
ESCAPE / MESSAGE ⇳	**OVER FREQUENCY** **ALARM LEVEL: 60.50**	RANGE: 25 .01 - 70.00 STEP: 0.01
ESCAPE / MESSAGE ⇳	**OVERFREQUENCY** **ALARM DELAY: 5.0 s**	RANGE: 0.1 -5000.0 STEP: 0.1
ESCAPE / MESSAGE ⇳	**OVERFREQUENCY** **ALARM EVENTS: Off**	RANGE: On, Off
ESCAPE / MESSAGE ⇳	**OVERFREQUENCY** **TRIP : Off**	RANGE: Off, Latched, Unlatched
ESCAPE / MESSAGE ⇳	**ASSIGN TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
ESCAPE / MESSAGE ⇳	**OVER FREQUENCY** **TRIP LEVEL1: 60.50 Hz**	RANGE: 25 .01 - 70.00 STEP: 0.01
ESCAPE / MESSAGE ⇧	**OVERFREQUENCY** **TRIP DELAY1: 60.0 s**	RANGE: 0.1 -5000.0 STEP: 0.1
ESCAPE / MESSAGE ⇳	**OVER FREQUENCY** **TRIP LEVEL2: 62.00 Hz**	RANGE: 25 .01 - 70.00 STEP: 0.01
ESCAPE / MESSAGE ⇧	**OVERFREQUENCY** **TRIP DELAY2: 30.0 s**	RANGE: 0.1 -5000.0 STEP: 0.1

FUNCTION:

It may be undesirable to enable the overfrequency elements until the generator is online. This feature can be blocked until the generator is online and the block time expires. From that point forward, the overfrequency trip and alarm elements will be active. A value of zero for the block time indicates that the overfrequency protection is active as soon as voltage exceeds the cutoff level (programmed as a multiple of the generator rated phase-phase voltage). Frequency is then measured. Once the frequency of Vab exceeds the overfrequency setpoints, for the period of time specified, a trip or alarm will occur. There are dual level and time setpoints for the trip element.

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4.7.7 NEUTRAL OVERVOLTAGE (FUNDAMENTAL)

▌NEUTRAL O/V (FUND) ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	SUPERVISE WITH DIGITAL INPUT: No	RANGE: Yes, No NOTE: This message is only seen if a digital input is assigned to Ground Switch Status
	ESCAPE MESSAGE ⇳	NEUTRAL OVERVOLTAGE ALARM : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	NEUTRAL O/V ALARM LEVEL: 3.0 Vsec	RANGE: 2.0 - 100.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	NEUTRAL OVERVOLTAGE ALARM DELAY: 1.0 s	RANGE: 0.1 -120.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	NEUTRAL OVERVOLTAGE ALARM EVENTS: Off	RANGE: On, Off
	ESCAPE MESSAGE ⇳	NEUTRAL OVERVOLTAGE TRIP : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	NEUTRAL O/V TRIP LEVEL: 5.0 Vsec	RANGE: 2.0 - 100.0 STEP: 0.1
	ESCAPE MESSAGE ⇧	NEUTRAL OVERVOLTAGE TRIP DELAY: 1.0 s	RANGE: 0.1 -120.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	NEUTRAL O/V CURVE RESET RATE: 0.0	RANGE: 0.0 - 999.9 STEP: 0.1
	ESCAPE MESSAGE ⇳	NEUTRAL O/V TRIP ELEMENT: Definite Time	RANGE: Curve, Definite Time

FUNCTION:

The neutral overvoltage function responds to fundamental frequency voltage at the generator neutral. It provides ground fault protection for approximately 95% of the stator windings. 100% protection is provided when this element is used in conjunction with the Neutral Undervoltage (3rd harmonic) function. The alarm element is definite time and the trip element can be either definite time or an inverse time curve. When the neutral voltage rises above the pickup level the element will begin to time out. If the time expires an alarm or trip will occur. The reset rate is a linear reset time from the threshold of trip. The alarm and trip levels are programmable in terms of Neutral VT secondary voltage.

(Refer to Appendix B for Application Notes.)

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The formula for the curve is:

$$T = \frac{D}{\left(\frac{V}{V_{pickup}} - 1\right)}, \text{when} V > V_{pickup}$$

where T = trip time (sec)
D = delay setpoint
V = neutral voltage
V_{pickup} = neutral overvoltage pickup setpoint

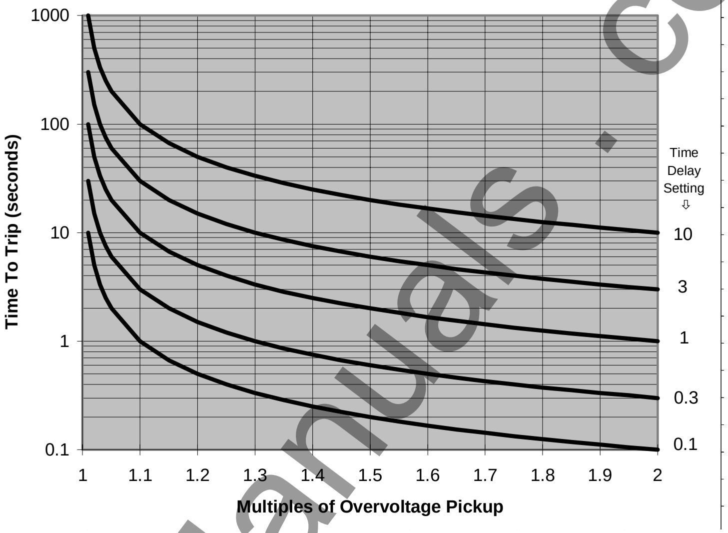
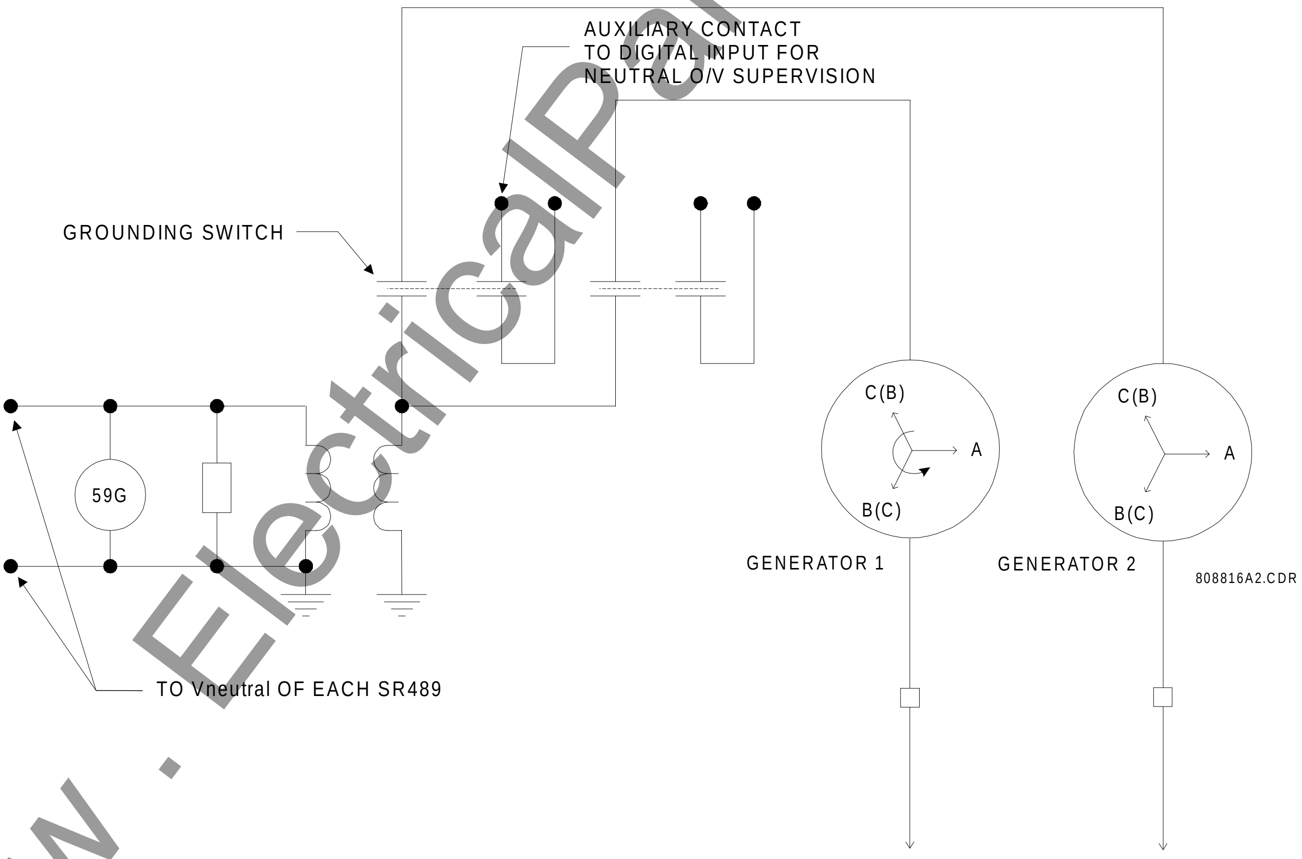


Figure 4-10 OVERVOLTAGE CURVES

Note: If the ground directional element is enabled, the Neutral Overvoltage element should be coordinated with it. In cases of paralleled generator grounds through the same point, with individual ground switches, per sketch below, it is recommended to use a ground switch status function to prevent maloperation of the element.



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4.7.8 NEUTRAL UNDERVOLTAGE (3RD HARMONIC)

▌NEUTRAL U/V (3rd) ▌[ENTER] for more	ENTER ⇨ ESCAPE ⇦	LOW POWER BLOCKING LEVEL: 0.05xRated MW	RANGE: 0.02-0.99 STEP: 0.01 *Note: this message seen only if VT connection is Delta
	ESCAPE MESSAGE ⇳	LOW VOLTAGE BLOCKING LEVEL: 0.75 x Rated	RANGE: 0.50 -1.00 STEP: 0.01 *Note: this message seen only if VT connection is Delta
	ESCAPE MESSAGE ⇳	NEUTRAL UNDERVOLTAGE ALARM : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE ⇳	NEUTRAL U/V ALARM LEVEL: 0.5 Vsec	RANGE: 0.5 - 20.0 STEP: 0.1 *Note: this message seen only if VT connection is Delta
	ESCAPE MESSAGE ⇳	NEUTRAL UNDERVOLTAGE ALARM DELAY: 30 s	RANGE: 5 - 120 STEP: 1
	ESCAPE MESSAGE ⇳	NEUTRAL UNDERVOLTAGE ALARM EVENTS: Off	RANGE: On, Off
	ESCAPE MESSAGE ⇳	NEUTRAL UNDERVOLTAGE TRIP : Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	NEUTRAL U/V TRIP LEVEL: 1.0 Vsec	RANGE: 0.5- 20.0 STEP: 0.1 *Note: this message seen only if VT connection is Delta
	ESCAPE MESSAGE ⇧	NEUTRAL UNDERVOLTAGE TRIP DELAY: 30 s	RANGE: 5 - 120 STEP: 1

FUNCTION:

The neutral undervoltage function responds to 3rd harmonic voltage measured at the generator neutral and output terminals. When used in conjunction with the Neutral Overvoltage (fundamental frequency) function, it provides 100% ground fault protection of the stator windings.

Wye Connected VTs

Since the amount of third harmonic voltage that appears in the neutral is both load and machine dependent, the protection method of choice is an adaptive method. If the phase VT connection is wye, the following formula is used to create an adaptive neutral undervoltage pickup level based on the amount of third harmonic that appears at the generator terminals.

$$\frac{V_{N3}}{\left(\frac{V_{P3}}{3}+V_{N3}\right)} \le 0.15 \quad \text{which simplifies to : } \quad V_{P3} \ge 17V_{N3}$$

The 489 tests the following permissives prior to testing the basic operating equation to ensure that V_{N3}' should be of a measurable magnitude for an unfaulted generator:

$$V_{P3}' > 0.25 \text{ volts} \quad \& \quad V_{P3}' \ge \text{Permissive\_Threshold} \times 17 \times \frac{\text{Neutral VT Ratio}}{\text{Phase VT Ratio}}$$

(Refer to Appendix B for Application Notes.)

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where : V_{N3} is the magnitude of third harmonic voltage at the generator neutral
V_{P3} is the magnitude of third harmonic voltage at the generator terminals
V_{P3}' is the VT secondary magnitude of third harmonic voltage measured at the generator terminals
V_{N3}' is the VT secondary magnitude of third harmonic voltage at the generator neutral
Permissive _Threshold is 0.15 volts for the alarm element and 0.1875 volts for the trip element

Open Delta Connected VTs

If the phase VT connection is open delta, it is not possible to measure the third harmonic voltages at the generator terminals and a simple third harmonic neutral undervoltage element is used. The level is programmable in terms of Neutral VT secondary voltage. In order to prevent nuisance tripping at low load or low generator voltages, two blocking functions are provided. They apply to both the alarm and trip functions. When used as a simple undervoltage element, settings should be based on measured 3rd harmonic neutral voltage of the healthy machine.

NOTE: *This method of using 3rd harmonic voltages to detect stator ground faults near the generator neutral has proved feasible on generators with unit transformers. Its usefulness in other generator applications is unknown.*

4.7.9 LOSS OF EXCITATION

LOSS OF EXCITATION **[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**ENABLE VOLTAGE** **SUPERVISION: YES**	RANGE: Yes, No
	ESCAPE MESSAGE ⇳	**VOLTAGE** **LEVEL: 0.70x Rated**	RANGE: 0.70 - 1.00 STEP: 0.01 *Note: This message only seen if Voltage Supervision is set to Yes
	ESCAPE MESSAGE ⇳	**CIRCLE 1** **TRIP: Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN CIRCLE 1 TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	**CIRCLE 1** **DIAMETER: 25.0 Ω sec.**	RANGE: 2.5- 300.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**CIRCLE 1** **OFFSET: 2.5 Ω sec.**	RANGE: 1.0 - 300.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**CIRCLE 1 TRIP** **DELAY: 5.0 s**	RANGE: 0.1 - 10.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**CIRCLE 2** **TRIP: Off**	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE ⇳	**ASSIGN CIRCLE 2 TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4
	ESCAPE MESSAGE ⇳	**CIRCLE 2** **DIAMETER: 35.0 Ω sec.**	RANGE: 2.5- 300.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**CIRCLE 2** **OFFSET: 2.5 Ω sec.**	RANGE: 1.0 - 300.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	**CIRCLE 2 TRIP** **DELAY: 5.0 s**	RANGE: 0.1 - 10.0 STEP: 0.1

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FUNCTION:

The 489 can detect loss of excitation by using an impedance element. When the impedance falls within the impedance circle for the delay time specified a trip will occur if it is enabled. The user can enable Circle #1 and/or Circle #2 to tune their protection feature to their system. The larger circle diameter should be set to the synchronous reactance of the generator, x_d and the circle offset should be set to the generator transient reactance $x'_d / 2$. Typically the smaller circle, if used will be set to minimum time with a diameter set to 0.7 x_d and an offset of $x'_d / 2$. The feature is blocked if voltage supervision is enabled and the generator voltage is above the VOLTAGE LEVEL setpoint threshold. The trip feature is supervised by minimum current of 0.05 x CT. Note: Element will be blocked if there is a VT fuse failure or if the generator is offline. Also, it uses output CT inputs.

The formula: $Z_{loe} = \frac{V_{AB}}{I_A - I_B} = M_{loe} \angle \theta_{loe}$

where: Z_{loe} = Secondary phase to phase loss of excitation impedance

$M_{loe} \angle \theta_{loe}$ = Secondary impedance phasor (magnitude and angle)

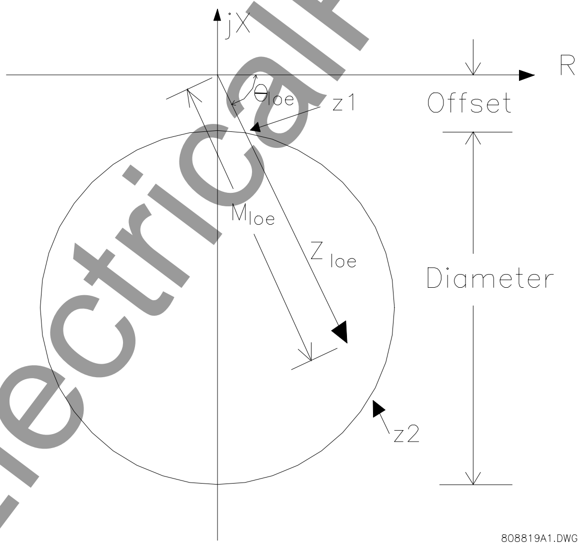
All relay quantities are in terms of secondary impedances. The formula to convert primary impedance quantities to secondary impedance quantities is provided below.

$$Z_{sec} = \frac{Z_{pri} \times CT_{ratio}}{VT_{ratio}}$$

where: Z_{pri} = primary ohms impedance

CT_{ratio} = programmed CT ratio, if CT ratio is 1200 : 5 use a value of 1200 / 5 = 240

VT_{ratio} = programmed VT ratio, if VT ratio is 100 : 1 use a value of 100



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4.7.10 DISTANCE ELEMENTS

▌ DISTANCE ELEMENT
▌ [ENTER] for more

ENTER ESCAPE	STEP UP TRANSFORMER SETUP: None	RANGE: None, Delta/Wye
ENTER ESCAPE	FUSE FAILURE SUPERVISION: On	RANGE: On, Off
ESCAPE MESSAGE	ZONE #1 TRIP: Off	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	ASSIGN ZONE #1 TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
ENTER ESCAPE	ZONE #1 REACH: 10.0 Ω sec.	RANGE: 0.1 - 500.0 STEP: 0.1
ESCAPE MESSAGE	ZONE #1 ANGLE: 75°	RANGE: 50 - 85 STEP: 1
ESCAPE MESSAGE	ZONE #1 TRIP DELAY: 0.4 s	RANGE: 0.0 - 150.0 STEP: 0.1
ESCAPE MESSAGE	ZONE #2 TRIP: Off	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	ASSIGN ZONE #2 TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
ENTER ESCAPE	ZONE #2 REACH: 15.0 Ω sec.	RANGE: 0.1 - 500.0 STEP: 0.1
ESCAPE MESSAGE	ZONE #2 ANGLE: 75°	RANGE: 50 - 85 STEP: 1
ESCAPE MESSAGE	ZONE #2 TRIP DELAY: 2.0 s	RANGE: 0.0 - 150.0 STEP: 0.1

FUNCTION:

The 489 distance protection function (device number 21) implements two zones of mho phase-to-phase distance protection (a total of six elements) using the conventional phase comparator approach, with the polarizing voltage derived from the pre-fault positive sequence voltage of the protected loop. This protection is intended as backup for the primary line protection. The elements make use of the neutral-end current signals and the generator terminal voltage signals, per figure 4-11, thus providing some protection for internal and unit transformer faults. In systems with a delta-wye unit transformer (DY330º), the appropriate transformations of voltage and current signals are implemented internally to allow proper detection of transformer high-side phase-to-phase faults. The reach setting is the positive sequence impedance to be covered, per phase, expressed in secondary ohms. The same transformation shown for the Loss of excitation element can be used to calculate the desired settings as functions of the primary-side impedances.

The elements have a basic operating time of 150 milliseconds. A VT fuse failure could cause a maloperation of a distance element unless the element is supervised by the VT fuse failure element. In order to prevent nuisance tripping the elements require a minimum phase current of .05 x CT.

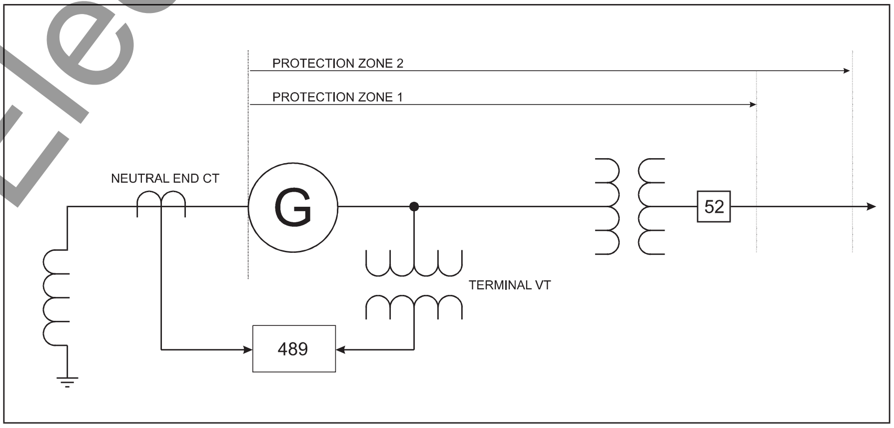

Figure 4-11 DISTANCE ELEMENT SETUP

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4.8.1 POWER MEASUREMENT CONVENTIONS

Generation of power will be displayed on the 489 as positive Watts. By convention, an induction generator normally requires reactive power from the system for excitation. This is displayed on the 489 as negative vars. A synchronous generator on the other hand has its own source of excitation and can be operated with either lagging or leading power factor. This is displayed on the 489 as positive vars and negative vars respectively (see Figure 4-12). All power quantities are measured from the phase-phase voltage and the currents measured at the output CTs.

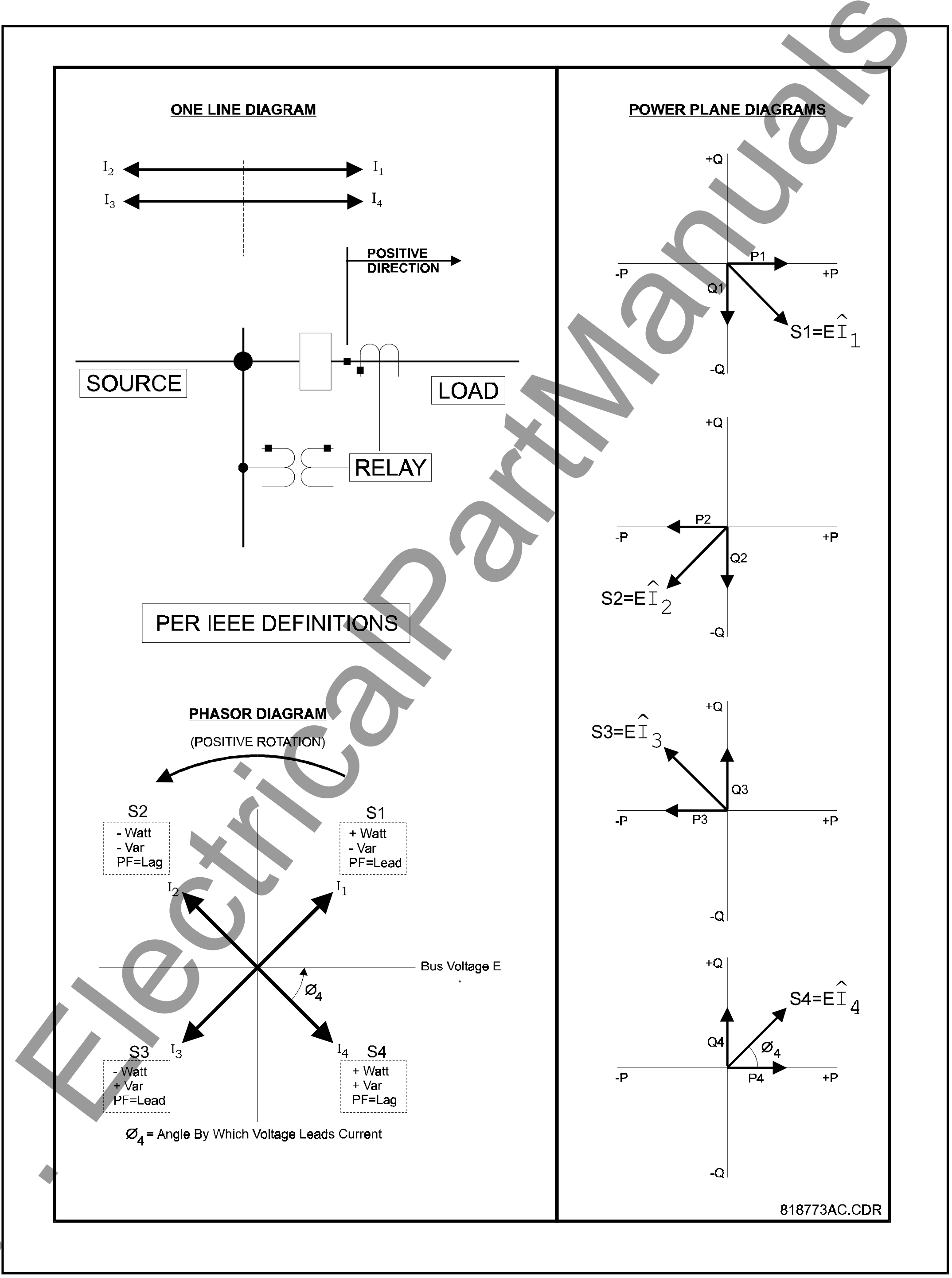

Figure 4-12 POWER MEASUREMENT CONVENTIONS

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4.8.2 REACTIVE POWER

▌REACTIVE POWER
▌[ENTER] for more

ENTER ⇨ ⇦ ESCAPE	**BLOCK Mvar ELEMENT** **FROM ONLINE: 1 s**	RANGE: 0 - 5000 STEP: 1	
ESCAPE MESSAGE ⇳	**REACTIVE POWER** **ALARM : Off**	RANGE: Off, Latched, Unlatched	
ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5	
ESCAPE MESSAGE ⇳	**POSITIVE Mvar ALARM** **LEVEL:0.85xRated**	RANGE: 0.02-1.50 STEP: 0.01	
ESCAPE MESSAGE ⇳	**NEGATIVE Mvar ALARM** **LEVEL:0.85xRated**	RANGE: 0.02-1.50 STEP: 0.01	
ESCAPE MESSAGE ⇳	**POSITIVE Mvar ALARM** **DELAY: 10.0 s**	RANGE: 0.2 - 120.0 s STEP: 0.1	Note: Lagging VARS, overexcited
ESCAPE MESSAGE ⇳	**NEGATIVE Mvar ALARM** **DELAY: 1.0 s**	RANGE: 0.2 - 120.0 s STEP: 0.1	Note: Leading VARS, underexcited
ESCAPE MESSAGE ⇳	**REACTIVE POWER ALARM** **EVENTS: Off**	RANGE: On, Off	
ESCAPE MESSAGE ⇳	**REACTIVE POWER** **TRIP : Off**	RANGE: Off, Latched, Unlatched	
ESCAPE MESSAGE ⇳	**ASSIGN TRIP** **RELAYS (1-4): 1---**	RANGE: Any Combination of Relays 1-4	
ESCAPE MESSAGE ⇳	**POSITIVE Mvar TRIP** **LEVEL:0.80xRated**	RANGE: 0.02-2.00, Off STEP: 0.01	
ESCAPE MESSAGE ⇳	**NEGATIVE Mvar TRIP** **LEVEL:0.80xRated**	RANGE: 0.02-2.00, Off STEP: 0.01	
ESCAPE MESSAGE ⇧	**NEGATIVE Mvar TRIP** **DELAY: 20.0 s**	RANGE: 0.2 - 120.0 STEP: 0.1	Note: Lagging VARS, overexcited
ESCAPE MESSAGE ⇧	**POSITIVE Mvar TRIP** **DELAY: 20.0 s**	RANGE: 0.2 - 120.0 STEP: 0.1	Note: Leading VARS, overexcited

FUNCTION:

In a motor/generator application, it may be desirable not to trip or alarm on reactive power until the machine is online *and* the field has been applied. Therefore, this feature can be blocked until the machine is online and adequate time has expired during which the field had been applied. From that point forward, the reactive power trip and alarm elements will be active. A value of zero for the block time indicates that the reactive power protection is active as soon as both current and voltage are measured regardless of whether the generator is online or offline. Once the 3∅ total reactive power exceeds the positive or negative level, for the specified delay, a trip or alarm will occur indicating a positive or negative Mvar condition. The level is programmed in per unit of generator rated Mvar calculated from the rated MVA and rated power factor. The reactive power elements can be used to detect loss of excitation. If the VT type is selected as "None" or VT fuse loss is detected, the reactive power protection is disabled. Rated Mvars for the system can be calculated as follows:

Example:

Rated MVA = 100 MVA
Rated Power Factor = 0.85
Rated Mvars = (Rated MVA) × sin ($\cos^{-1}$ (Rated Power Factor)) = 100 × sin ($\cos^{-1}$ 0.85) = 52.67 Mvars

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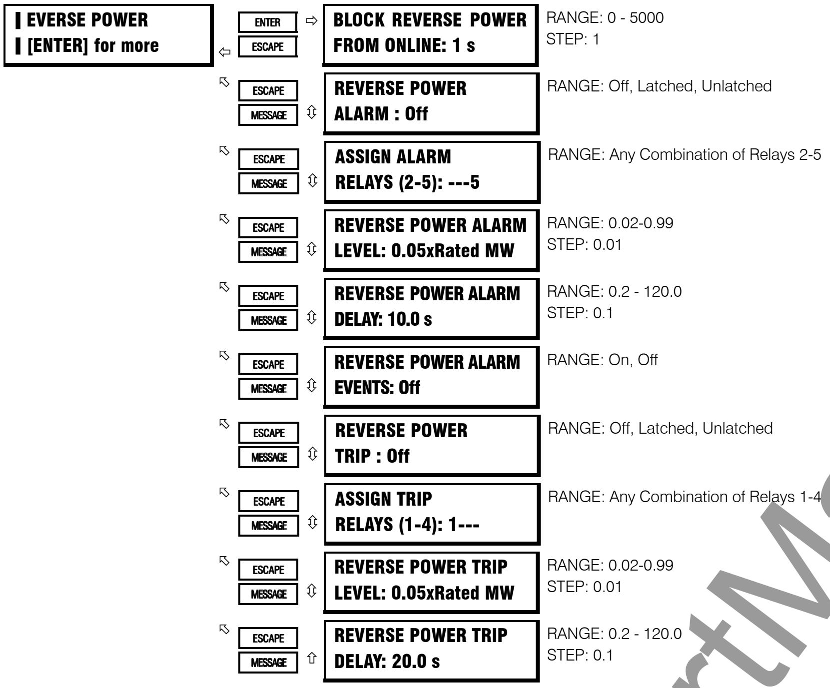
4.8.3 REVERSE POWER



▌EVERSE POWER ▌[ENTER] for more	
BLOCK REVERSE POWER FROM ONLINE: 1 s	RANGE: 0 - 5000 STEP: 1
REVERSE POWER ALARM : Off	RANGE: Off, Latched, Unlatched
ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
REVERSE POWER ALARM LEVEL: 0.05xRated MW	RANGE: 0.02-0.99 STEP: 0.01
REVERSE POWER ALARM DELAY: 10.0 s	RANGE: 0.2 - 120.0 STEP: 0.1
REVERSE POWER ALARM EVENTS: Off	RANGE: On, Off
REVERSE POWER TRIP : Off	RANGE: Off, Latched, Unlatched
ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
REVERSE POWER TRIP LEVEL: 0.05xRated MW	RANGE: 0.02-0.99 STEP: 0.01
REVERSE POWER TRIP DELAY: 20.0 s	RANGE: 0.2 - 120.0 STEP: 0.1

FUNCTION:

If enabled, once the magnitude of 3∅ total power exceeds the Pickup Level in the reverse direction (negative MW) for a period of time specified by the Delay, a trip or alarm will occur. The level is programmed in per unit of generator rated MW calculated from the rated MVA and rated power factor. If the generator is accelerated from the power system rather than the prime mover, the reverse power element may be blocked from start for a specified period of time. A value of zero for the block time indicates that the reverse power protection is active as soon as both current and voltage are measured regardless of whether the generator is online or offline. If the VT type is selected as "None" or VT fuse loss is detected, the reverse power protection is disabled.

NOTE: The minimum magnitude of power measurement is determined by the phase CT minimum of 2 % rated CT primary. If the level for reverse power is set below that level, a trip or alarm will only occur once the phase current exceeds the 2% cutoff.

Users are cautioned that a reverse power element may not provide reliable indication when set to a very low setting, particularly under conditions of large reactive loading on the generator. Under such conditions, low forward power is a more reliable element.

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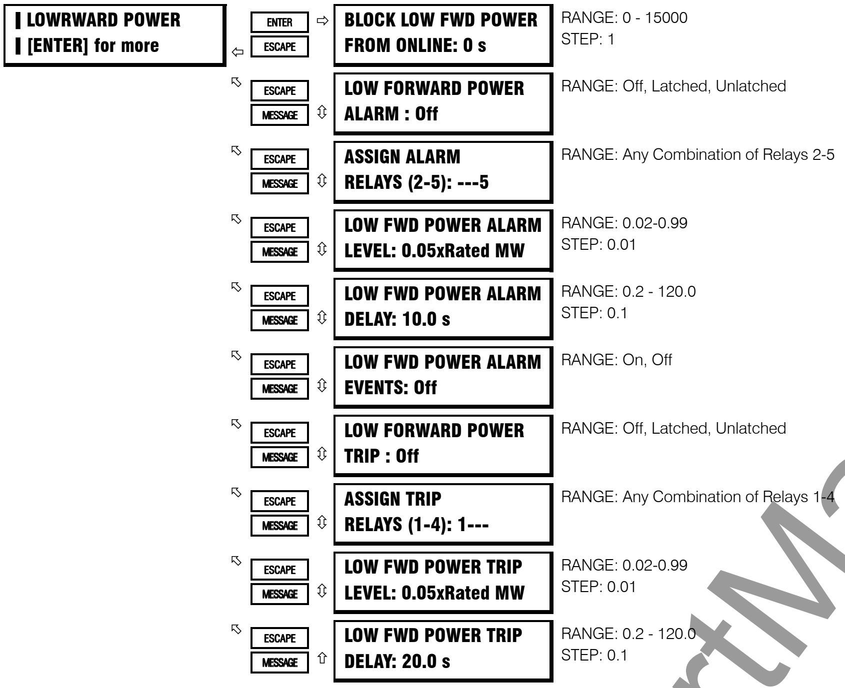
4.8.4 LOW FORWARD POWER



LOWRWARD POWER [ENTER] for more		
	BLOCK LOW FWD POWER FROM ONLINE: 0 s	RANGE: 0 - 15000 STEP: 1
	LOW FORWARD POWER ALARM : Off	RANGE: Off, Latched, Unlatched
	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	LOW FWD POWER ALARM LEVEL: 0.05xRated MW	RANGE: 0.02-0.99 STEP: 0.01
	LOW FWD POWER ALARM DELAY: 10.0 s	RANGE: 0.2 - 120.0 STEP: 0.1
	LOW FWD POWER ALARM EVENTS: Off	RANGE: On, Off
	LOW FORWARD POWER TRIP : Off	RANGE: Off, Latched, Unlatched
	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	LOW FWD POWER TRIP LEVEL: 0.05xRated MW	RANGE: 0.02-0.99 STEP: 0.01
	LOW FWD POWER TRIP DELAY: 20.0 s	RANGE: 0.2 - 120.0 STEP: 0.1

FUNCTION:

If enabled, once the magnitude of 3∅ total power in the forward direction (+MW) falls below the Pickup Level for a period of time specified by the Delay, an alarm will occur. The level is programmed in per unit of generator rated MW calculated from the rated MVA and rated power factor. The low forward power element is active only when the generator is online and will be blocked until the generator is brought online, for a period of time defined by the setpoint Block Low Fwd Power From Online. The pickup level should be set lower than expected generator loading during normal operations. If the VT type is selected as "None" or VT fuse loss is detected, the low forward power protection is disabled.

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4.9.1 RTD TYPES

❙ RTD TYPES
❙ [ENTER] for more

ENTER ⇨ **STATOR RTD TYPE: 100 Ohm Platinum**
RANGE: 100 Ohm Platinum, 120 Ohm Nickel, 100 Ohm Nickel, 10 Ohm Copper

ESCAPE / MESSAGE ⇳ **BEARING RTD TYPE: 100 Ohm Platinum**
RANGE: 100 Ohm Platinum, 120 Ohm Nickel, 100 Ohm Nickel, 10 Ohm Copper

ESCAPE / MESSAGE ⇳ **AMBIENT RTD TYPE: 100 Ohm Platinum**
RANGE: 100 Ohm Platinum, 120 Ohm Nickel, 100 Ohm Nickel, 10 Ohm Copper

ESCAPE / MESSAGE ⇧ **OTHER RTD TYPE: 100 Ohm Platinum**
RANGE: 100 Ohm Platinum, 120 Ohm Nickel, 100 Ohm Nickel, 10 Ohm Copper

FUNCTION:

Each of the twelve RTDs of the 489 may be configured as None or any one of four application types, Stator, Bearing, Ambient, or Other. Each of those types may in turn be any one of four different RTD types: 100 ohm Platinum, 120 ohm Nickel, 100 ohm Nickel, 10 ohm Copper. The table below lists RTD resistance VS Temperature for the different RTD types.

Table 4-8 RTD TEMPERATURE vs. RESISTANCE

TEMP °Celsius	TEMP °Fahrenheit	100 OHM Pt (DIN 43760)	120 OHM Ni	100 OHM Ni	10 OHM Cu
-50	-58	80.31	86.17	71.81	7.10
-40	-40	84.27	92.76	77.30	7.49
-30	-22	88.22	99.41	82.84	7.88
-20	-4	92.16	106.15	88.45	8.26
-10	14	96.09	113.00	94.17	8.65
0	32	100.00	120.00	100.00	9.04
10	50	103.90	127.17	105.97	9.42
20	68	107.79	134.52	112.10	9.81
30	86	111.67	142.06	118.38	10.19
40	104	115.54	149.79	124.82	10.58
50	122	119.39	157.74	131.45	10.97
60	140	123.24	165.90	138.25	11.35
70	158	127.07	174.25	145.20	11.74
80	176	130.89	182.84	152.37	12.12
90	194	134.70	191.64	159.70	12.51
100	212	138.50	200.64	167.20	12.90
110	230	142.29	209.85	174.87	13.28
120	248	146.06	219.29	182.75	13.67
130	266	149.82	228.96	190.80	14.06
140	284	153.58	238.85	199.04	14.44
150	302	157.32	248.95	207.45	14.83
160	320	161.04	259.30	216.08	15.22
170	338	164.76	269.91	224.92	15.61
180	356	168.47	280.77	233.97	16.00
190	374	172.46	291.96	243.30	16.39
200	392	175.84	303.46	252.88	16.78
210	410	179.51	315.31	262.76	17.17
220	428	183.17	327.54	272.94	17.56
230	446	186.82	340.14	283.45	17.95
240	464	190.45	353.14	294.28	18.34
250	482	194.08	366.53	305.44	18.73

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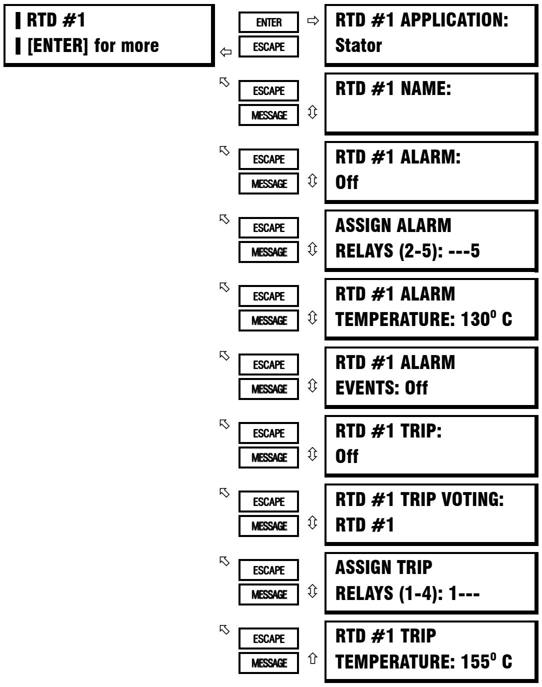
4.9.2 RTDs 1-6

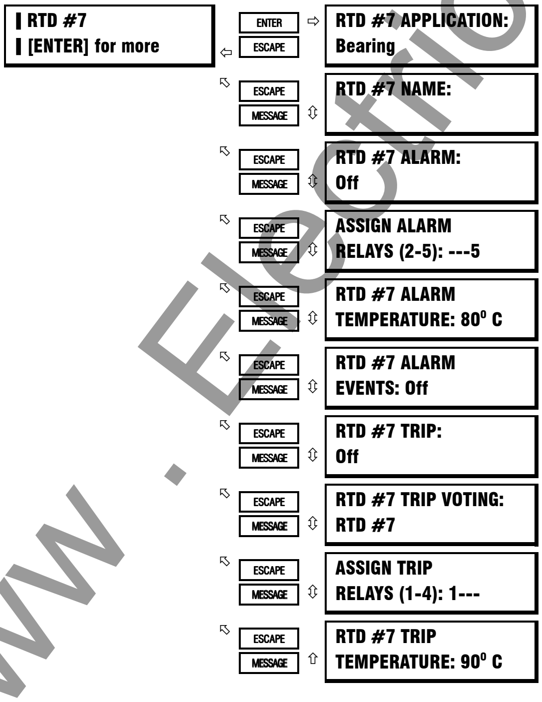


RTD #1 [ENTER] for more	
RTD #1 APPLICATION: Stator	RANGE: Stator, Bearing, Ambient, Other, None
RTD #1 NAME:	RANGE: 8 Character Alphanumeric
RTD #1 ALARM: Off	RANGE: Off, Latched, Unlatched
ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
RTD #1 ALARM TEMPERATURE: 130^0 C	RANGE: 1- 250 STEP: 1
RTD #1 ALARM EVENTS: Off	RANGE: On, Off
RTD #1 TRIP: Off	RANGE: Off, Latched, Unlatched
RTD #1 TRIP VOTING: RTD #1	RANGE: RTD #1, RTD #2, RTD #3, RTD #4, RTD #5, RTD #6, RTD #7, RTD #8, RTD #9, RTD #10, RTD #11, RTD #12
ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
RTD #1 TRIP TEMPERATURE: 155^0 C	RANGE: 1- 250 STEP: 1

FUNCTION:

RTDs 1 through 6 default to Stator RTD type. There are individual alarm and trip configurations for each RTD. This allows one of the RTDs to be turned off if it malfunctions. The alarm level is normally set slightly above the normal running temperature. The trip level is normally set at the insulation rating. Trip voting has been added for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled. Each RTD name may be changed if desired.

4.9.3 RTDs 7 - 10



RTD #7 [ENTER] for more	
RTD #7 APPLICATION: Bearing	RANGE: Stator, Bearing, Ambient, Other, None
RTD #7 NAME:	RANGE: 8 Character Alphanumeric
RTD #7 ALARM: Off	RANGE: Off, Latched, Unlatched
ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
RTD #7 ALARM TEMPERATURE: 80^0 C	RANGE: 1- 250 STEP: 1
RTD #7 ALARM EVENTS: Off	RANGE: On, Off
RTD #7 TRIP: Off	RANGE: Off, Latched, Unlatched
RTD #7 TRIP VOTING: RTD #7	RANGE: RTD #1, RTD #2, RTD #3, RTD #4, RTD #5, RTD #6, RTD #7, RTD #8, RTD #9, RTD #10, RTD #11, RTD #12
ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
RTD #7 TRIP TEMPERATURE: 90^0 C	RANGE: 1- 250 STEP: 1

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FUNCTION:

RTDs 7 through 10 default to Bearing RTD type. There are individual alarm and trip configurations for each RTD. This allows one of the RTDs to be turned off if it malfunctions. The alarm level and the trip level are normally set slightly above the normal running temperature, but below the bearing temperature rating. Trip voting has been added for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled. Each RTD name may be changed if desired.

4.9.4 RTD 11

▌RTD #11 ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	RTD #11 APPLICATION: Other	RANGE: Stator, Bearing, Ambient, Other, None
	⬁ ESCAPE MESSAGE ⇳	RTD #11 NAME:	RANGE: 8 Character Alphanumeric
	⬁ ESCAPE MESSAGE ⇳	RTD #11 ALARM: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⬁ ESCAPE MESSAGE ⇳	RTD #11 ALARM TEMPERATURE: 80° C	RANGE: 1- 250 STEP: 1
	⬁ ESCAPE MESSAGE ⇳	RTD #11 ALARM EVENTS: Off	RANGE: On, Off
	⬁ ESCAPE MESSAGE ⇳	RTD #11 TRIP: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	RTD #11 TRIP VOTING: RTD #11	RANGE: RTD #1, RTD #2, RTD #3, RTD #4, RTD #5, RTD #6, RTD #7, RTD #8, RTD #9, RTD #10, RTD #11, RTD #12
	⬁ ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
	⬁ ESCAPE MESSAGE ⇧	RTD #11 TRIP TEMPERATURE: 90° C	RANGE: 1- 250 STEP: 1

FUNCTION:

RTD 11 defaults to Other RTD type. The Other selection allows the RTD to be used to monitor any temperature that might be required, either for a process or additional bearings or other. There are individual alarm and trip configurations for this RTD. Trip voting has been added for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled. The RTD name may be changed if desired.

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4.9.5 RTD 12

RTD #12 **[ENTER] for more**	ENTER ESCAPE	
RTD #12 APPLICATION: **Ambient**	ESCAPE MESSAGE	RANGE: Stator, Bearing, Ambient, Other, None
RTD #12 NAME:	ESCAPE MESSAGE	RANGE: 8 Character Alphanumeric
RTD #12 ALARM: **Off**	ESCAPE MESSAGE	RANGE: Off, Latched, Unlatched
ASSIGN ALARM **RELAYS (2-5): ---5**	ESCAPE MESSAGE	RANGE: Any Combination of Relays 2-5
RTD #12 ALARM **TEMPERATURE: 60^0 C**	ESCAPE MESSAGE	RANGE: 1- 250 STEP: 1
RTD #12 ALARM **EVENTS: Off**	ESCAPE MESSAGE	RANGE: On, Off
RTD #12 TRIP: **Off**	ESCAPE MESSAGE	RANGE: Off, Latched, Unlatched
RTD #12 TRIP VOTING: **RTD #12**	ESCAPE MESSAGE	RANGE: RTD #1, RTD #2, RTD #3, RTD #4, RTD #5, RTD #6, RTD #7, RTD #8, RTD #9, RTD #10, RTD #11, RTD #12
ASSIGN TRIP **RELAYS (1-4): 1---**	ESCAPE MESSAGE	RANGE: Any Combination of Relays 1-4
RTD #12 TRIP **TEMPERATURE: 80^0 C**	ESCAPE MESSAGE	RANGE: 1- 250 STEP: 1

FUNCTION:

RTDs 12 defaults to Ambient RTD type. The Ambient selection allows the RTD to be used to monitor ambient temperature. There are individual alarm and trip configurations for this RTD. Trip voting has been added for extra reliability in the event of RTD malfunction. If enabled, a second RTD must also exceed the trip temperature of the RTD being checked before a trip will be issued. If the RTD is chosen to vote with itself, the voting feature is disabled. The RTD name may be changed if desired.

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4.9.6 OPEN RTD SENSOR

▌OPEN RTD SENSOR ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	OPEN RTD SENSOR ALARM: Off	RANGE: Off, Latched, Unlatched
	⇖ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⇖ ESCAPE MESSAGE ⇧	OPEN RTD SENSOR ALARM EVENTS: Off	RANGE: On, Off

FUNCTION:

The 489 has an Open RTD Sensor Alarm. This alarm will look at all RTDs that have either an alarm or trip programmed and determine if an RTD connection has been broken. Any RTDs that do not have a trip or alarm associated with them will be ignored for this feature. When a broken sensor is detected, the assigned output relay will operate and a message will appear on the display identifying the RTD that is broken. It is recommended that if this feature is used, the alarm be programmed as latched so that intermittent RTDs are detected and corrective action may be taken.

4.9.7 RTD SHORT/LOW TEMP

▌RTD SHORT/LOW TEMP ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	RTD SHORT/LOW TEMP ALARM: Off	RANGE: Off, Latched, Unlatched
	⇖ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⇖ ESCAPE MESSAGE ⇧	RTD SHORT/LOW TEMP ALARM EVENTS: Off	RANGE: On, Off

FUNCTION:

The 489 has an RTD Short/Low Temperature alarm. This alarm will look at all RTDs that have either an alarm or trip programmed and determine if an RTD has either a short or a very low temperature (less than -50°C). Any RTDs that do not have a trip or alarm associated with them will be ignored for this feature. When a short/low temperature is detected, the assigned output relay will operate and a message will appear on the display identifying the RTD that caused the alarm. It is recommended that if this feature is used, the alarm be programmed as latched so that intermittent RTDs are detected and corrective action may be taken.

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4.10.1 THERMAL MODEL

The thermal model of the 489 is primarily intended for induction generators, especially those that start on the system bus in the same manner as induction motors. However, some of the thermal model features may be used to model the heating that occurs in synchronous generators during overload conditions.

INDUCTION GENERATORS

One of the principle enemies of generator life is heat. Generator thermal limits are dictated by the design of both the stator and the rotor. Induction generators that start on the system bus have three modes of operation: locked rotor or stall (when the rotor is not turning), acceleration (when the rotor is coming up to speed), and generating (when the rotor turns at super-synchronous speed). Heating occurs in the generator during each of these conditions in very distinct ways. Typically, during the generator starting, locked rotor and acceleration conditions, the generator will be rotor limited. That is to say that the rotor will approach its thermal limit before the stator. Under locked rotor conditions, voltage is induced in the rotor at line frequency, 50 or 60 Hz. This voltage causes a current to flow in the rotor, also at line frequency, and the heat generated (I^2R) is a function of the effective rotor resistance. At 50 or 60 Hz, the reactance of the rotor cage causes the current to flow at the outer edges of the rotor bars. The effective resistance of the rotor is therefore at a maximum during a locked rotor condition as is rotor heating. When the generator is running at above rated speed, the voltage induced in the rotor is at a low frequency (approx. 1 Hz) and therefore, the effective resistance of the rotor is reduced quite dramatically. During overloads, the generator thermal limit is typically dictated by stator parameters. Some special generators might be all stator or all rotor limited. During acceleration, the dynamic nature of the generator slip dictates that rotor impedance is also dynamic, and a third thermal limit characteristic is necessary.

Figure 4-13 illustrates typical thermal limit curves for induction motors. The starting characteristic is shown for a high inertia load @ 80% voltage. If the machine started quicker, the distinct characteristics of the thermal limit curves would not be required and the running overload curve would be joined with locked rotor safe stall times to produce a single overload curve.

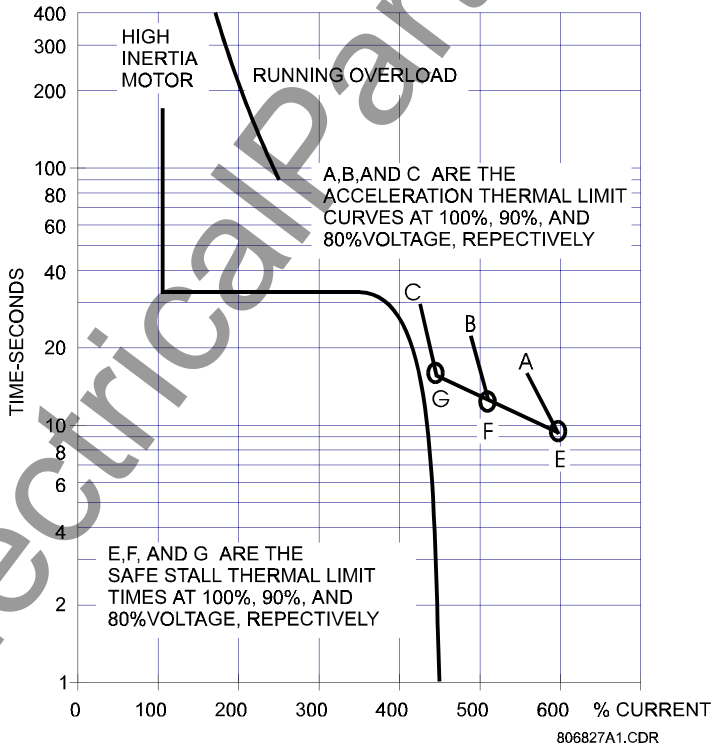

Figure 4-13 TYPICAL TIME-CURRENT AND THERMAL LIMIT CURVES (ANSI/IEEE C37.96)

The generator manufacturer should provide a safe stall time or thermal limit curves for any generator that is started as an induction motor. These thermal limits are intended to be used as guidelines and their definition is not always precise. When operation of the generator exceeds the thermal limit, the generator insulation does not immediately melt, rather, the rate of insulation degradation reaches a point where continued operation will significantly reduce generator life.

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4.10.2 MODEL SETUP

▌MODEL SETUP ▌[ENTER] for more	
ENABLE THERMAL MODEL: No	RANGE: No, Yes
OVERLOAD PICKUP LEVEL:1.01 x FLA	RANGE: 1.01- 1.25 STEP: 0.01
UNBALANCE BIAS K FACTOR: 0	RANGE: 0-12 STEP:1 NOTE: a value of zero effectively defeats this feature
COOL TIME CONSTANT ONLINE: 15 min.	RANGE: 0 - 500 STEP:1
COOL TIME CONSTANT OFFLINE: 30 min.	RANGE: 0 -500 STEP:1
HOT/COLD SAFE STALL RATIO: 1.00	RANGE: 0.01 - 1.00 STEP:0.01
ENABLE RTD BIASING: No	RANGE: No, Yes
RTD BIAS MINIMUM: 40° C	RANGE: 0- 250 STEP:1 Note: this message seen only if RTD Biasing is enabled
RTD BIAS CENTER POINT: 130° C	RANGE:0 - 250 STEP:1 Note: this message seen only if RTD Biasing is enabled
RTD BIAS MAXIMUM: 155° C	RANGE: 0 - 250 STEP:1 Note: this message seen only if RTD Biasing is enabled
SELECT CURVE STYLE: Standard	RANGE: Standard, Custom, Voltage Dependent
STANDARD OVERLOAD CURVE NUMBER: 4	RANGE:1-15 STEP:1 NOTE: This message seen only if Standard Curve Style is selected
TIME TO TRIP AT 1.01x FLA: 17414.5 s	RANGE: 0.5-99999.9 STEP:0.1 NOTE: This message not seen if Standard Curve Style is selected
TIME TO TRIP AT 20.0x FLA: 5.6 s	RANGE: 0.5-99999.9 STEP:0.1 NOTE: This message not seen if Standard Curve Style is selected
MINIMUM ALLOWABLE VOLTAGE:80%	RANGE: 70-95 STEP:1 NOTE: This message seen only if Voltage Dependent Curve Style is selected
STALL CURRENT @ MIN VOLTAGE: 4.80 x FLA	RANGE: 2.00-15.00 STEP:0.01 NOTE: This message seen only if Voltage Dependent Curve Style is selected
SAFE STALL TIME @ MIN VOLTAGE: 20.0 s	RANGE: 0.5-999.9 STEP:0.1 NOTE: This message seen only if Voltage Dependent Curve Style is selected
ACCEL. INTERSECT @ MIN VOLT: 3.80xFLA	RANGE: 2.00-Stall Current @ min Voltage STEP:0.01 NOTE: This message seen only if Voltage Dependent Curve Style is selected
STALL CURRENT @ 100% VOLTAGE: 6.00 x FLA	RANGE: 2.00-15.00 STEP:0.01 NOTE: This message seen only if Voltage Dependent Curve Style is selected
SAFE STALL TIME @ 100% VOLTAGE: 10.0s	RANGE: 0.5-999.9 STEP:0.1 NOTE: This message seen only if Voltage Dependent Curve Style is selected
ACCEL. INTERSECT @ 100% VOLT: 5.00xFLA	RANGE: 2.00- Stall Current @ 100%Voltage STEP:0.01 NOTE: This message seen only if Voltage Dependent Curve Style is selected

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FUNCTION:

The current measured at the output CTs is used for the thermal model. The thermal model consists of five key elements: the overload curve and overload pickup level, the unbalance biasing of the generator current while the machine is running, the cooling time constants, and the biasing of the thermal model based on hot/cold generator information and measured stator temperature. Each of these elements are described in detail in the sections that follow.

NOTE: The generator FLA is calculated as: generator rated MVA / (√3 x rated generator phase-phase voltage).

The 489 integrates both stator and rotor heating into one model. Machine heating is reflected in a register called Thermal Capacity Used. If the machine has been stopped for a long period of time, it will be at ambient temperature and thermal capacity used should be zero. If the machine is in overload, once the thermal capacity used reaches 100%, a trip will occur.

The overload curve accounts for machine heating during stall, acceleration, and running in both the stator and the rotor. The Overload Pickup setpoint defines where the running overload curve begins as the generator enters an overload condition. This is useful to accommodate a service factor. The curve is effectively cut off at current values below this pickup.

Generator thermal limits consist of three distinct parts based on the three conditions of operation, locked rotor or stall, acceleration, and running overload. Each of these curves may be provided for both a hot and cold machine. A hot machine is defined as one that has been running for a period of time at full load such that the stator and rotor temperatures have settled at their rated temperature. A cold machine is defined as a machine that has been stopped for a period of time such that the stator and rotor temperatures have settled at ambient temperature. For most machines, the distinct characteristics of the thermal limits are formed into one smooth homogeneous curve. Sometimes only a safe stall time is provided. This is acceptable if the machine has been designed conservatively and can easily perform its required duty without infringing on the thermal limit. In this case, the protection can be conservative. If the machine has been designed very close to its thermal limits when operated as required, then the distinct characteristics of the thermal limits become important.

The 489 overload curve can take one of three formats, Standard, Custom Curve, or Voltage Dependent. Regardless of which curve style is selected, the 489 will retain thermal memory in the form of a register called Thermal Capacity Used. This register is updated every 50ms using the following equation:

$$\boxed{TC_{used_t} = TC_{used\,t-50ms} + \frac{50ms}{time\_to\_trip} * 100\%}$$

where: time_to_trip = time taken from the overload curve @ Ieq as a function of FLA.

The overload protection curve should always be set slightly lower than the thermal limits provided by the manufacturer. This will ensure that the machine is tripped before the thermal limit is reached. If the starting times are well within the safe stall times, it is recommended that the 489 Standard Overload Curve be used. The standard overload curves are a series of 15 curves with a common curve shape based on typical generator thermal limit curves (see Figure 4-14 and Table 4-9).

When the generator trips offline due to overload the generator will be locked out (i.e. trip relay will stay latched) until generator thermal capacity reaches below 15%.

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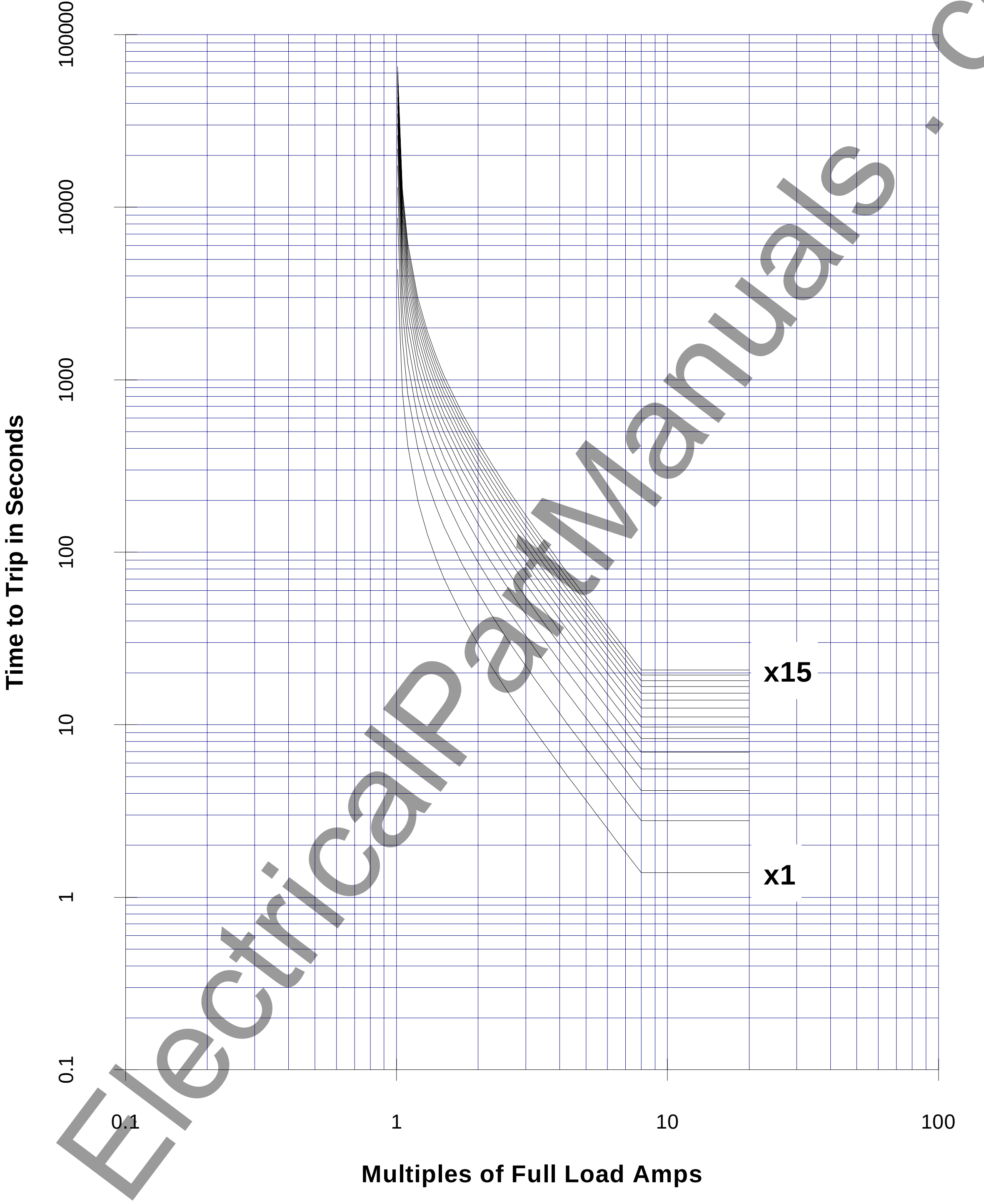

Figure 4-14 489 STANDARD OVERLOAD CURVES

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Table 4-9 489 STANDARD OVERLOAD CURVES

PICKUP LEVEL	STANDARD CURVE MULTIPLIERS														
	x 1	x 2	x 3	x 4	x 5	x 6	x 7	x 8	x 9	x 10	x 11	x 12	x 13	x 14	x 15
1.01	4353.6	8707.2	13061	17414	21768	26122	30475	34829	39183	43536	47890	52243	56597	60951	65304
1.05	853.71	1707.4	2561.1	3414.9	4268.6	5122.3	5976.0	6829.7	7683.4	8537.1	9390.8	10245	11098	11952	12806
1.10	416.68	833.36	1250.0	1666.7	2083.4	2500.1	2916.8	3333.5	3750.1	4166.8	4583.5	5000.2	5416.9	5833.6	6250.2
1.20	198.86	397.72	596.58	795.44	994.30	1193.2	1392.0	1590.9	1789.7	1988.6	2187.5	2386.3	2585.2	2784.1	2982.9
1.30	126.80	253.61	380.41	507.22	634.02	760.82	887.63	1014.4	1141.2	1268.0	1394.8	1521.6	1648.5	1775.3	1902.1
1.40	91.14	182.27	273.41	364.55	455.68	546.82	637.96	729.09	820.23	911.37	1002.5	1093.6	1184.8	1275.9	1367.0
1.50	69.99	139.98	209.97	279.96	349.95	419.94	489.93	559.92	629.91	699.90	769.89	839.88	909.87	979.86	1049.9
1.75	42.41	84.83	127.24	169.66	212.07	254.49	296.90	339.32	381.73	424.15	466.56	508.98	551.39	593.81	636.22
2.00	29.16	58.32	87.47	116.63	145.79	174.95	204.11	233.26	262.42	291.58	320.74	349.90	379.05	408.21	437.37
2.25	21.53	43.06	64.59	86.12	107.65	129.18	150.72	172.25	193.78	215.31	236.84	258.37	279.90	301.43	322.96
2.50	16.66	33.32	49.98	66.64	83.30	99.96	116.62	133.28	149.94	166.60	183.26	199.92	216.58	233.24	249.90
2.75	13.33	26.65	39.98	53.31	66.64	79.96	93.29	106.62	119.95	133.27	146.60	159.93	173.25	186.58	199.91
3.00	10.93	21.86	32.80	43.73	54.66	65.59	76.52	87.46	98.39	109.32	120.25	131.19	142.12	153.05	163.98
3.25	9.15	18.29	27.44	36.58	45.73	54.87	64.02	73.16	82.31	91.46	100.60	109.75	118.89	128.04	137.18
3.50	7.77	15.55	23.32	31.09	38.87	46.64	54.41	62.19	69.96	77.73	85.51	93.28	101.05	108.83	116.60
3.75	6.69	13.39	20.08	26.78	33.47	40.17	46.86	53.56	60.25	66.95	73.64	80.34	87.03	93.73	100.42
4.00	5.83	11.66	17.49	23.32	29.15	34.98	40.81	46.64	52.47	58.30	64.13	69.96	75.79	81.62	87.45
4.25	5.12	10.25	15.37	20.50	25.62	30.75	35.87	41.00	46.12	51.25	56.37	61.50	66.62	71.75	76.87
4.50	4.54	9.08	13.63	18.17	22.71	27.25	31.80	36.34	40.88	45.42	49.97	54.51	59.05	63.59	68.14
4.75	4.06	8.11	12.17	16.22	20.28	24.33	28.39	32.44	36.50	40.55	44.61	48.66	52.72	56.77	60.83
5.00	3.64	7.29	10.93	14.57	18.22	21.86	25.50	29.15	32.79	36.43	40.08	43.72	47.36	51.01	54.65
5.50	2.99	5.98	8.97	11.96	14.95	17.94	20.93	23.91	26.90	29.89	32.88	35.87	38.86	41.85	44.84
6.00	2.50	5.00	7.49	9.99	12.49	14.99	17.49	19.99	22.48	24.98	27.48	29.98	32.48	34.97	37.47
6.50	2.12	4.24	6.36	8.48	10.60	12.72	14.84	16.96	19.08	21.20	23.32	25.44	27.55	29.67	31.79
7.00	1.82	3.64	5.46	7.29	9.11	10.93	12.75	14.57	16.39	18.21	20.04	21.86	23.68	25.50	27.32
7.50	1.58	3.16	4.75	6.33	7.91	9.49	11.08	12.66	14.24	15.82	17.41	18.99	20.57	22.15	23.74
8.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
10.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
15.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82
20.00	1.39	2.78	4.16	5.55	6.94	8.33	9.71	11.10	12.49	13.88	15.27	16.65	18.04	19.43	20.82

NOTE: Above 8.0 x Pickup, the trip time for 8.0 is used.
This prevents the overload curve from acting as an instantaneous element

Standard Overload Curves Equation:

$$\text{Time\_To\_Trip} = \frac{\text{Curve\_Multiplier} \times 2.2116623}{0.025303373 \times (\text{Pickup} - 1)^2 + 0.050547581 \times (\text{Pickup} - 1)}$$

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CUSTOM OVERLOAD CURVE

If the induction generator starting current begins to infringe on the thermal damage curves, it may become necessary to use a custom curve to tailor the protection of the generator so that successful starting may be possible without compromising generator protection. Furthermore, the characteristics of the starting thermal damage curve (locked rotor and acceleration) and the running thermal damage curves may not fit together very smoothly. In this instance, it may become necessary to use a custom curve to tailor the protection to the thermal limits such that the generator may be started successfully and be utilized to its full potential without compromising protection. The distinct parts of the thermal limit curves now become more critical. For these conditions, it is recommended that the 489 custom curve thermal model be used. The custom overload curve of the 489 allows users to program their own curves by entering trip times for 30 pre-determined current levels.

It can be seen in Figure 4-15 that if the running overload thermal limit curve were smoothed into one curve with the locked rotor thermal limit curve, the induction generator could not be started at 80% voltage. A custom curve is required.

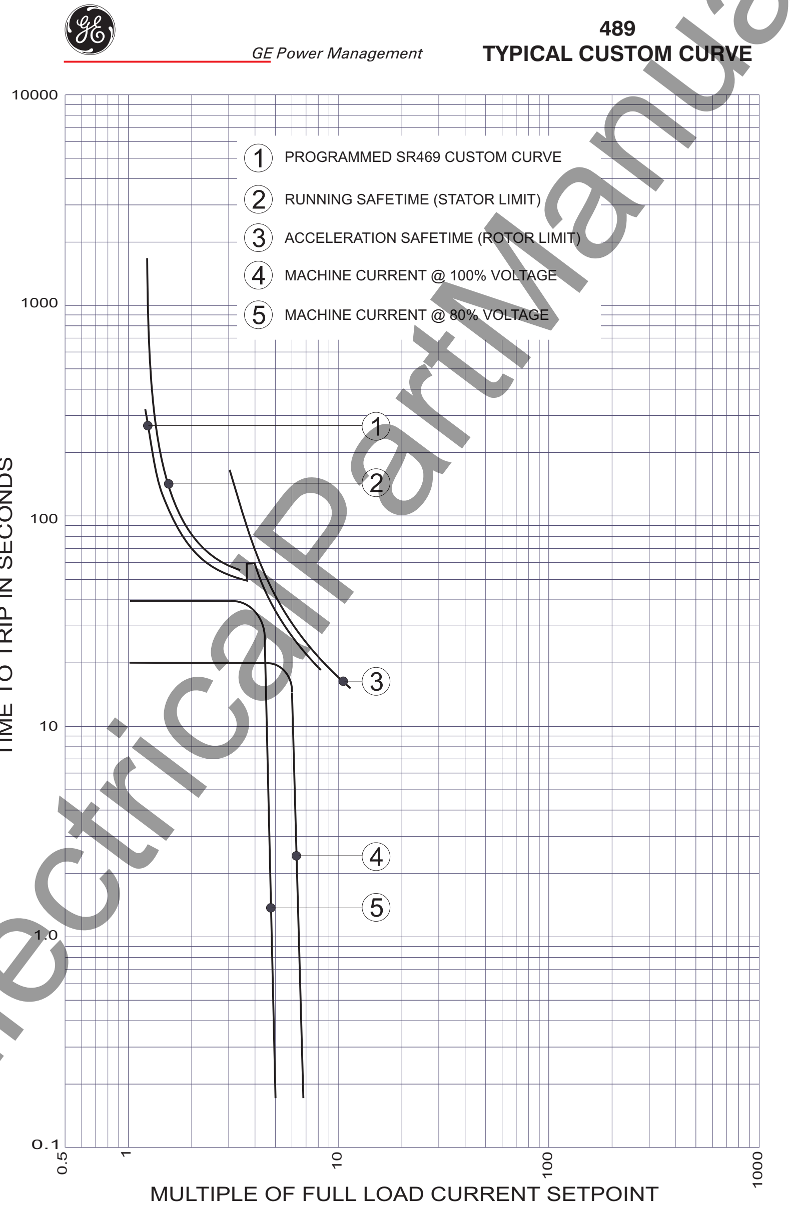

Figure 4-15 CUSTOM CURVE EXAMPLE

Note: During the interval of discontinuity, the longer of the two trip times is used to reduce the chance of nuisance tripping during generator starts.

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VOLTAGE DEPENDENT OVERLOAD CURVE

It is quite possible and acceptable that the acceleration time exceeds the safe stall time. (Bearing in mind that a locked rotor condition is quite different than an acceleration condition). In this instance, each distinct portion of the thermal limit curve must be known and protection must be coordinated against that curve. The relay that is protecting the machine must be able to distinguish between a locked rotor condition, an accelerating condition and a running condition. The 489 Voltage Dependent Overload Curve feature is tailored to protect these types of machines. Voltage is monitored constantly during starting and the acceleration thermal limit curve is adjusted accordingly. If the VT Connection setpoint is set to none or if a VT fuse failure is detected, the acceleration thermal limit curve for the minimum allowable voltage will be used.

The Voltage Dependent Overload Curve is comprised of the three characteristic shapes of thermal limit curves as determined by the stall or locked rotor condition, acceleration, and running overload. The curve is constructed by entering a custom curve shape for the running overload protection curve. Next, a point must be entered for the acceleration protection curve at the point of intersection with the custom curve, based on the minimum allowable starting voltage as defined by the minimum allowable voltage. Locked Rotor Current and safe stall time must also be entered for that voltage. A second point of intersection must be entered for 100% voltage. Once again, the locked rotor current and the safe stall time must be entered, this time for 100% voltage. The protection curve that is created from the safe stall time and intersection point will be dynamic based on the measured voltage between the minimum allowable voltage and the 100% voltage. This method of protection inherently accounts for the change in speed as an impedance relay would. The change in impedance is reflected by machine terminal voltage and line current. For any given speed at any given voltage, there is only one value of line current.

EXAMPLE: To illustrate the Voltage Dependent Overload Curve feature, the thermal limits of Figure 4-16 will be used.

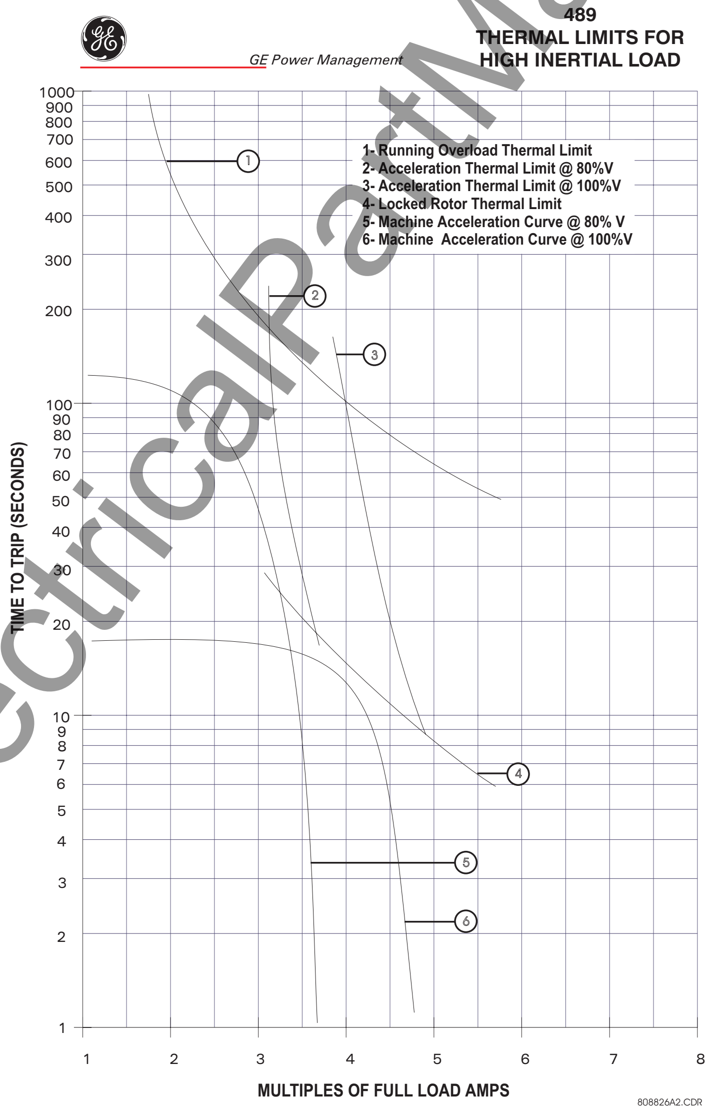

Figure 4-16 THERMAL LIMITS FOR HIGH INERTIAL LOAD

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1. Construct a custom curve for the running overload thermal limit. If the curve does not extend to the acceleration thermal limits, extend it such that the curve intersects the acceleration thermal limit curves. (see Fig 4-17)

2. Enter the per unit current value for the acceleration overload curve intersect with the custom curve for 80% voltage. Also enter the per unit current and safe stall protection time for 80% voltage. (see 4-18)

3. Enter the per unit current value for the acceleration overload curve intersect with the custom curve for 100% voltage. Also enter the per unit current and safe stall protection time for 100% voltage. (see 4-18)

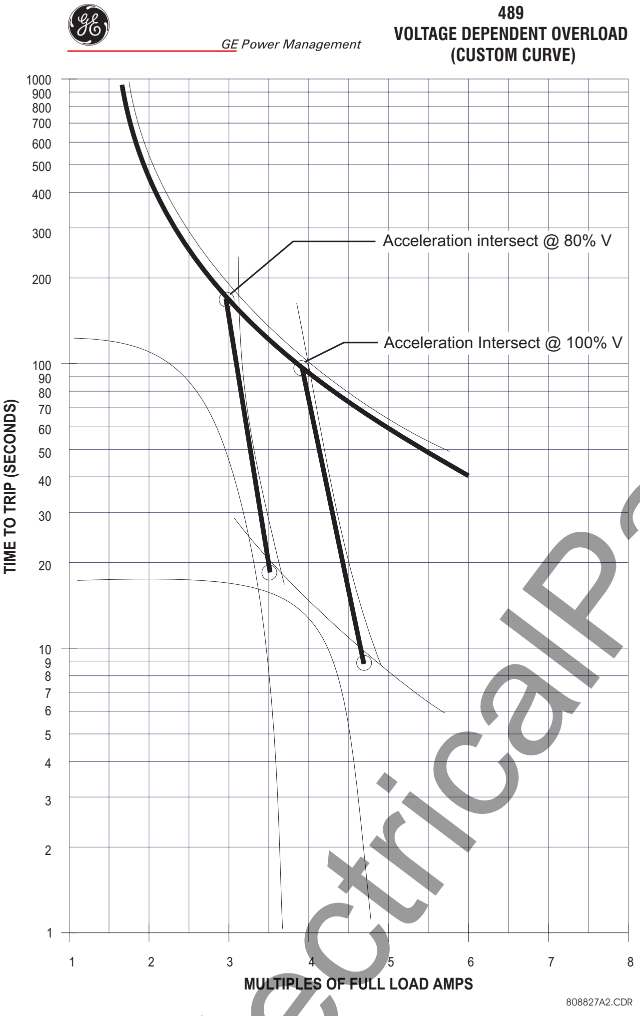

Figure 4-17 VOLTAGE DEPENDENT OVERLOAD (CUSTOM CURVE)

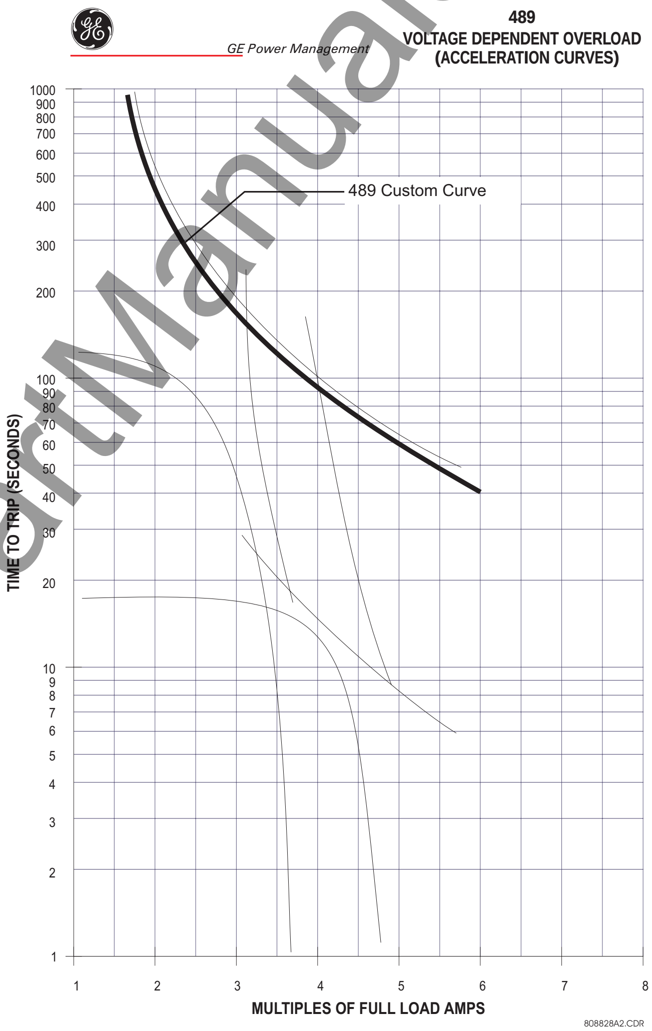

Figure 4-18 VOLTAGE DEPENDENT OVERLOAD (ACCELERATION CURVES)

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The 489 will take the information provided and create protection curves for any voltage between the minimum and 100%. For values above the voltage in question, the 489 will extrapolate the safe stall protection curve to 110% voltage. This current level is calculated by taking the locked rotor current @ 100% voltage and multiplying by 1.10. For trip times above the 110% current level, the trip time of 110% will be used. (see Figure 4-19)

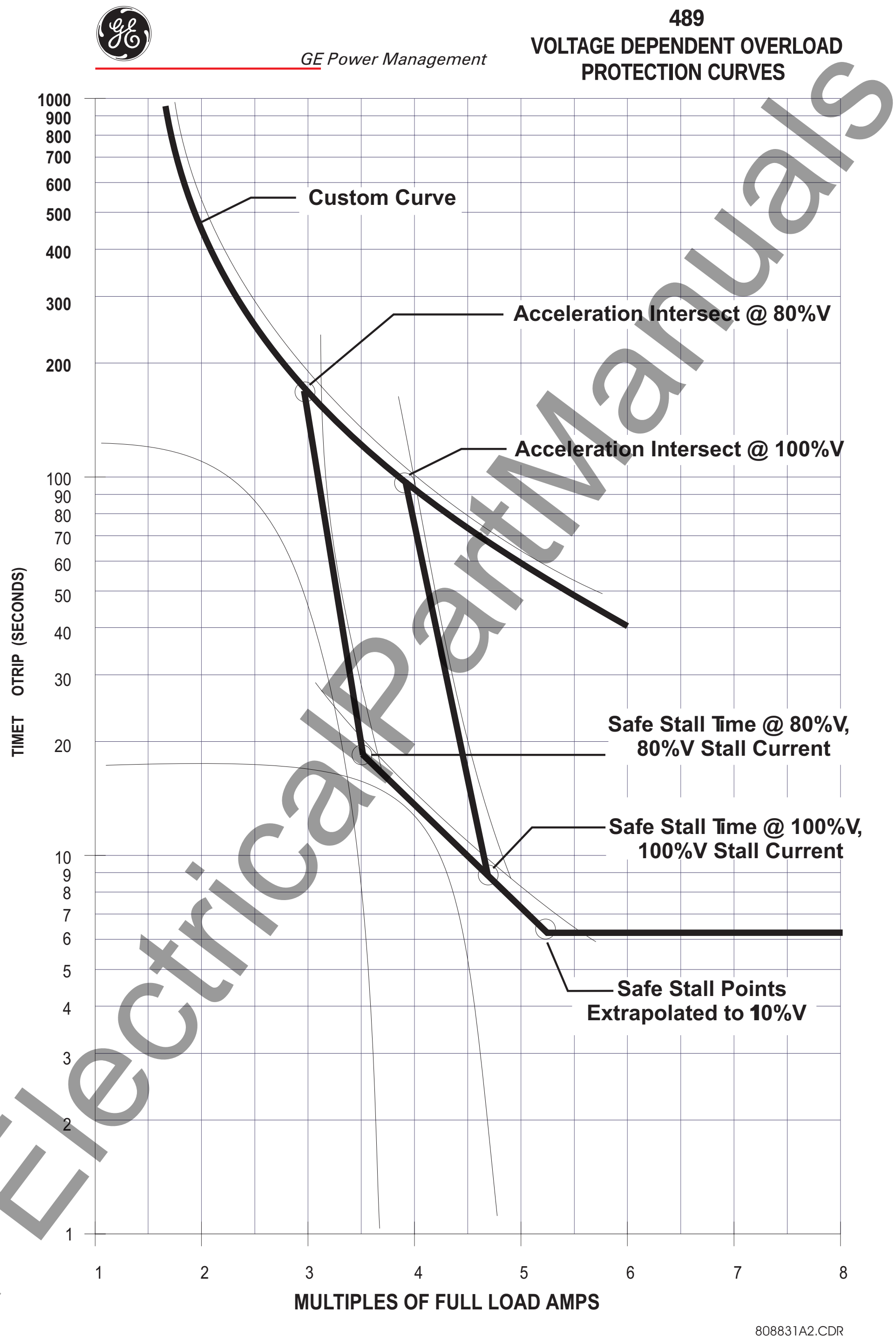

Figure 4-19 VOLTAGE DEPENDENT OVERLOAD PROTECTION CURVES

NOTE: The safe stall curve is in reality a series of safe stall points for different voltages. For a given voltage, there can only be one value of stall current and therefore, only one safe stall time.

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Figure 4-20 and Figure 4-21 illustrate the resultant overload protection curves for 80% and 100% voltage respectively. For voltages in between, the 489 will shift the acceleration curve linearly and constantly based on measured voltage during a generator start.

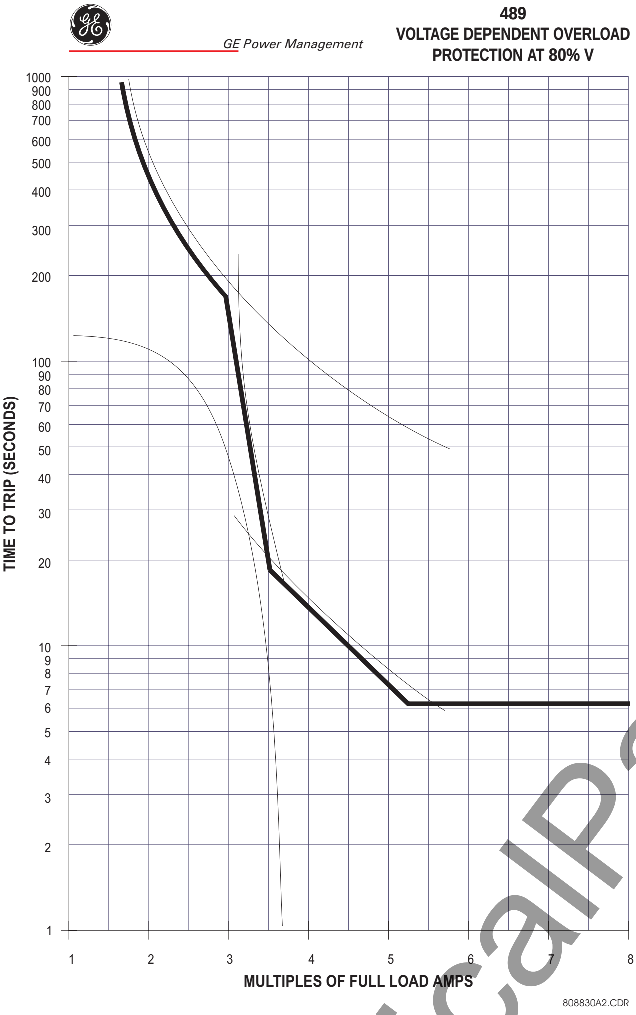

Figure 4-20 VOLTAGE DEPENDENT OVERLOAD PROTECTION @ 80% V

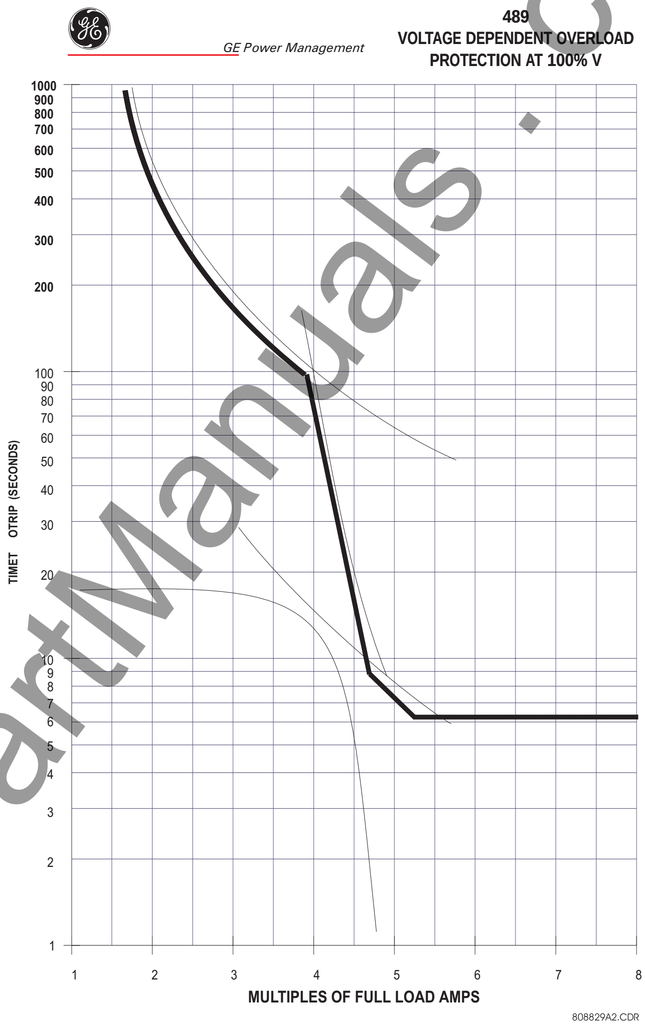

Figure 4-21 VOLTAGE DEPENDENT OVERLOAD PROTECTION @ 100% V

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4.10.3 THERMAL MODEL: UNBALANCE BIAS

Unbalanced phase currents will cause additional rotor heating that will not be accounted for by electromechanical relays and may not be accounted for in some electronic protective relays. When the generator is running, the rotor will rotate in the direction of the positive sequence current at near synchronous speed. Negative sequence current, which has a phase rotation that is opposite to the positive sequence current, and hence, opposite to the rotor rotation, will generate a rotor voltage that will produce a substantial rotor current. This induced current will have a frequency that is approximately 2 times the line frequency, 100 Hz for a 50 Hz system or 120 Hz for a 60 Hz system. Skin effect in the rotor bars at this frequency will cause a significant increase in rotor resistance and therefore, a significant increase in rotor heating. This extra heating is not accounted for in the thermal limit curves supplied by the generator manufacturer as these curves assume positive sequence currents only that come from a perfectly balanced supply and generator design.

The 489 measures the ratio of negative to positive sequence current. The thermal model may be biased to reflect the additional heating that is caused by negative sequence current when the machine is running. This biasing is done by creating an equivalent heating current rather than simply using average current (Iper_unit). This equivalent current is calculated using the equation shown below .

$$\mathrm{Ieq} = \sqrt{I_1^2 + kI_2^2}$$

where:
Ieq = equivalent heating current in per unit (based on FLA)
I_2 = negative sequence current in per unit (based on FLA)
I_1 = positive sequence current in per unit (based on FLA)
k = constant

NOTE: k is a constant that relates negative sequence rotor resistance to positive sequence rotor resistance, not to be confused with k that indicates generator negative sequence capability for an inverse time curve.

Figure 4-22 shows recommended induction machine derating as a function of voltage unbalance as recommended by the American organization NEMA (National Electrical Manufacturers Association). Assuming a typical inrush of 6 x FLA and a negative sequence impedance of 0.167, voltage unbalances of 1,2,3,4,5 % equals current unbalances of 6,12,18,24,30% respectively. Based on this assumption, Figure 4-23 illustrates the amount of machine derating for different values of k entered for the setpoint Unbalance Bias k Factor. Note that the curve created when k=8 is almost identical to the NEMA derating curve.

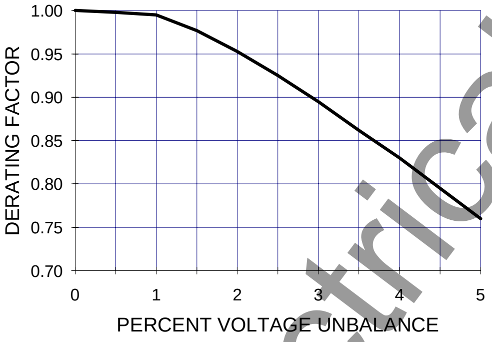

Figure 4-22 DERATING FACTOR DUE TO UNBALANCED VOLTAGE (NEMA)

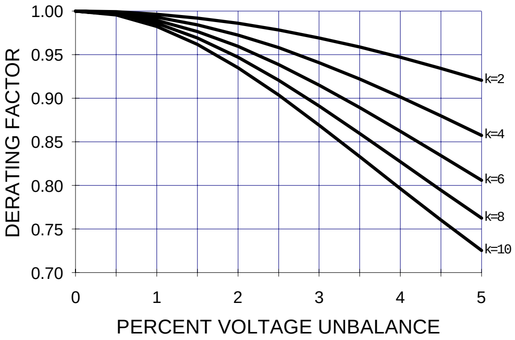

Figure 4-23 DERATING FACTOR DUE TO UNBALANCED VOLTAGE (GE POWER MANAGEMENT)

If a k value of 0 is entered, the unbalance biasing is defeated and the overload curve will time out against the measured per unit generator current. k may be calculated conservatively as:

$k = \frac{175}{I_{LR}^2}$ typical estimate

$k = \frac{230}{I_{LR}^2}$ conservative estimate

where I_{LR} is the per unit locked rotor current.

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4.10.4 THERMAL MODEL: MACHINE COOLING

The 489 thermal capacity used value is reduced in an exponential manner when the machine current is below the overload pickup setpoint. This reduction simulates machine cooling. The cooling time constants should be entered for both the running or stopped cases. (The generator is assumed to be running if current is measured or the generator is online.) When the rotor is not turning, the machine will normally cool significantly slower than when the rotor is turning.

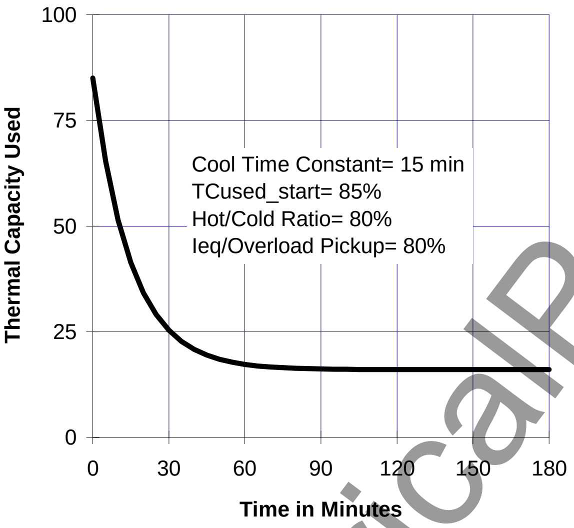
Machine cooling is calculated using the following formulas:

$$TC_{used} = (TC_{used\_start} - TC_{used\_end})(e^{-\frac{t}{\tau}}) + TC_{used\_end}$$

$$TC_{used\_end} = \left(\frac{I_{eq}}{overload\_pickup}\right)\left(1-\frac{hot}{cold}\right)x100\%$$

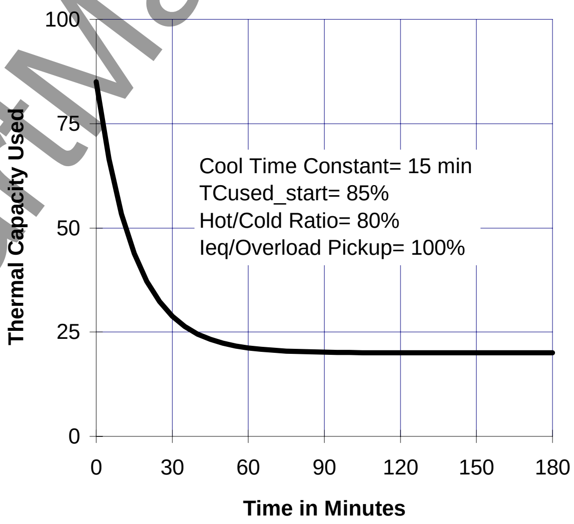
where:

TCused = thermal capacity used
TCused_start = TC used value caused by overload condition
TCused_end = TC used value dictated by the hot/cold curve ratio when the machine is running, ‘0’ when it is stopped.
t = time in minutes
τ = Cool Time Constant
Ieq = equivalent heating current
overload_pickup = overload pickup setpoint as a multiple of FLA
hot/cold = hot/cold curve ratio



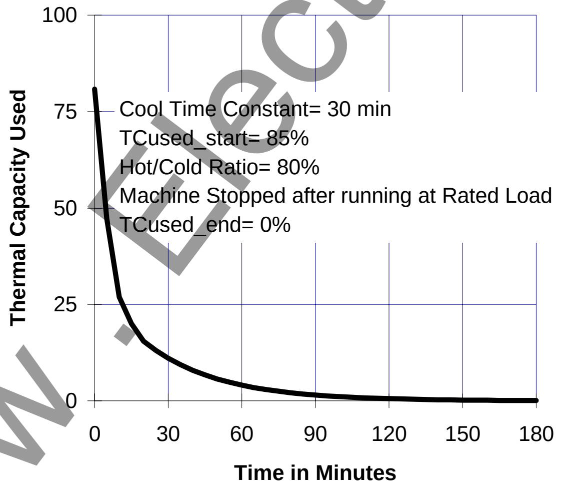
Cool Time Constant= 15 min
TCused_start= 85%
Hot/Cold Ratio= 80%
Ieq/Overload Pickup= 80%

Figure 4-24 THERMAL MODEL COOLING 80% LOAD



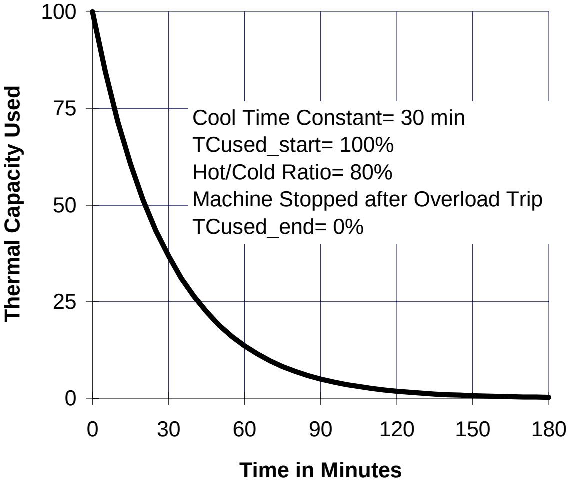
Cool Time Constant= 15 min
TCused_start= 85%
Hot/Cold Ratio= 80%
Ieq/Overload Pickup= 100%

Figure 4-25 THERMAL MODEL COOLING 100% LOAD



Cool Time Constant= 30 min
TCused_start= 85%
Hot/Cold Ratio= 80%
Machine Stopped after running at Rated Load
TCused_end= 0%

Figure 4-26 THERMAL MODEL COOLING OFFLINE



Cool Time Constant= 30 min
TCused_start= 100%
Hot/Cold Ratio= 80%
Machine Stopped after Overload Trip
TCused_end= 0%

Figure 4-27 THERMAL MODEL COOLING TRIPPED

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4.10.5 HOT/COLD CURVE RATIO

When thermal limit information is available for both a hot and cold machine, the 489 thermal model will adapt for the conditions if the Hot/Cold Curve Ratio is programmed. The value entered for this setpoint dictates the level of thermal capacity used that the relay will settle at for levels of current that are below the Overload Pickup Level. When the generator is running at a level that is below the Overload Pickup Level, the thermal capacity used will rise or fall to a value based on the average phase current and the entered Hot/Cold Curve Ratio. Thermal capacity used will either rise at a fixed rate of 5% per minute or fall as dictated by the running cool time constant.

$$\boxed{TC_{used\_end} = I_{eq} \times (1 - Hot / Cold) \times 100\%}$$

Where: TCused_end = Thermal Capacity Used if Iper_unit remains steady state
Ieq = equivalent generator heating current
Hot/Cold = Hot/Cold Curve Ratio Setpoint

The hot/cold curve ratio may be determined from the thermal limit curves, if provided, or the hot and cold safe stall times. Simply divide the hot safe stall time by the cold safe stall time. If hot and cold times are not provided, there can be no differentiation and the hot/cold curve ratio should be entered as 1.00.

4.10.6 RTD BIAS

The 489 thermal replica created by the features described in the sections above operates as a complete and independent model. The thermal overload curves however, are based solely on measured current, assuming a normal 40 °C ambient and normal machine cooling. If there is an unusually high ambient temperature, or if machine cooling is blocked, generator temperature will increase. If the stator has embedded RTDs, the 489 RTD bias feature should be used to correct the thermal model.

The RTD bias feature is a two part curve, constructed using 3 points. If the maximum stator RTD temperature is below the RTD Bias Minimum setpoint (typically 40°C), no biasing occurs. If the maximum stator RTD temperature is above the RTD Bias Maximum setpoint (typically at the stator insulation rating or slightly higher), then the thermal memory is fully biased and thermal capacity is forced to 100% used. At values in between, the present thermal capacity used created by the overload curve and other elements of the thermal model, is compared to the RTD Bias thermal capacity used from the RTD Bias curve. If the RTD Bias thermal capacity used value is higher, then that value is used from that point onward. The RTD bias Center point should be set at the rated running temperature of the machine. The 489 will automatically determine the thermal capacity used value for the center point using the Hot/Cold Safe stall ratio setpoint.

$$\boxed{TC_{used} @RTD\_Bias\_Center = (1 - Hot / Cold) \times 100\%}$$

At < RTD_Bias_Center temperature,

$$RTD\_Bias\_TC_{used} = \frac{Temp_{actual} - Temp_{min}}{Temp_{center} - Temp_{min}} \times TC_{used} @RTD\_Bias\_Center$$

At > RTD_Bias_Center temperature,

$$RTD\_Bias\_TC_{used} = \frac{Temp_{actual} - Temp_{center}}{Temp_{max} - Temp_{center}} \times (100 - TC_{used} @RTD\_Bias\_Center) + TC_{used} @RTD\_Bias\_Center$$

Where $RTD\_Bias\_TC_{USED}$ = TC used due to hottest stator RTD
$Temp_{ACTUAL}$ = Current temperature of hottest stator RTD
$Temp_{MIN}$ = RTD Bias minimum setpoint
$Temp_{CENTER}$ = RTD Bias center setpoint
$Temp_{MAX}$ = RTD Bias maximum setpoint
TC_{USED}@RTD_Bias_Center= TC used defined by HOT/COLD SAFE STALL RATIO setpoint

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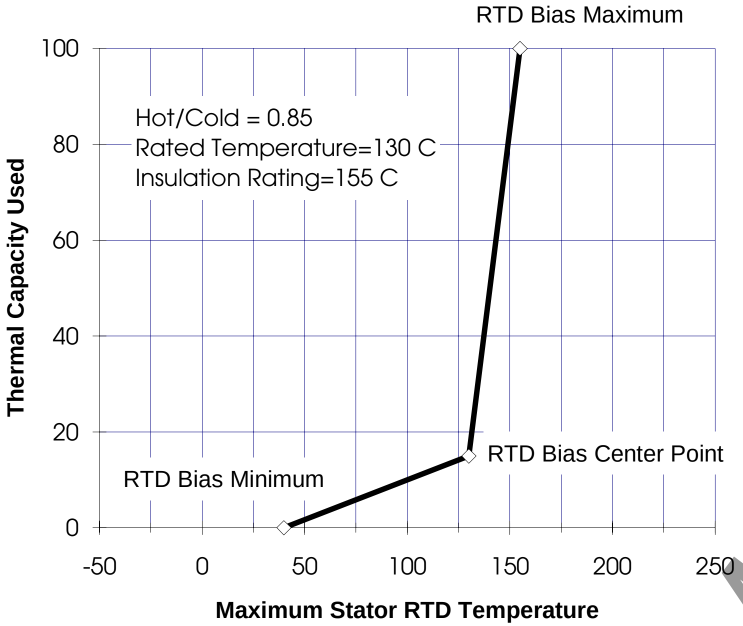

Figure 4-28 RTD BIAS CURVE

In simple terms, the RTD bias feature is real feedback of measured stator temperature. This feedback acts as correction of the thermal model for unforeseen situations. Since RTDs are relatively slow to respond, RTD biasing is good for correction and slow generator heating. The rest of the thermal model is required during high phase current conditions when machine heating is relatively fast.

It should be noted that the RTD bias feature alone cannot create a trip. If the RTD bias feature forces the thermal capacity used to 100%, the machine current must be above the overload pickup before an overload trip occurs. Presumably, the machine would trip on stator RTD temperature at that time.

4.10.7 THERMAL ELEMENTS

▌THERMAL ELEMENTS ▌[ENTER] for more	ENTER ⇨ / ESCAPE ⇦	
THERMAL MODEL ALARM: Off	ESCAPE / MESSAGE ⇳	RANGE: Off, Latched, Unlatched
ASSIGN ALARM RELAYS (2-5): ---5	ESCAPE / MESSAGE ⇳	RANGE: Any Combination of Relays 2-5
THERMAL ALARM LEVEL: 75% USED	ESCAPE / MESSAGE ⇳	RANGE: 10-100% STEP: 1
THERMAL MODEL ALARM EVENTS: Off	ESCAPE / MESSAGE ⇳	RANGE: On, Off
THERMAL MODEL TRIP: Off	ESCAPE / MESSAGE ⇳	RANGE: Off, Latched, Unlatched
ASSIGN TRIP RELAYS (1-4): 1---	ESCAPE / MESSAGE ⇧	RANGE: Any Combination of Relays 1-4

FUNCTION:

Once the thermal model is setup, an alarm and/or trip element can be enabled. If the generator has been offline for a long period of time, it will be at ambient temperature and thermal capacity used should be zero. If the generator is in overload, once the thermal capacity used reaches 100%, a trip will occur. The thermal model trip will remain active until a lockout time has expired. The lockout time will be based on the reduction of thermal capacity from 100% used to 15% used. This reduction will occur at a rate defined by the stopped cooling time constant. The thermal capacity used alarm may be used as a warning indication of an impending overload trip.

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4.11.1 TRIP COUNTER

TRIP COUNTER [ENTER] for more	ENTER ESCAPE	TRIP COUNTER ALARM: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE	TRIP COUNTER ALARM LEVEL: 25 Trips	RANGE: 1 - 50000 STEP: 1
	ESCAPE MESSAGE	TRIP COUNTER ALARM EVENTS: Off	RANGE: On, Off

FUNCTION:

If enabled the Trip Counter alarm will function as follows: when the Trip Counter Limit is reached, an alarm will occur. The trip counter must be cleared or the alarm level raised and the reset key must be pressed (if the alarm was latched) to reset the alarm.

EXAMPLE:

It might be useful to set a Trip Counter alarm at 100 such that if 100 trips occur, the resulting alarm would prompt the operator or supervisor to investigate the type of trips that have occurred. A breakdown of trips by type may be found on A4 MAINTENANCE, under TRIP COUNTERS. If a trend is detected, it would warrant further investigation.

4.11.2 BREAKER FAILURE

BREAKER FAILURE [ENTER] for more	ENTER ESCAPE	BREAKER FAILURE ALARM: Off	RANGE: Off, Latched, Unlatched
	ESCAPE MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	ESCAPE MESSAGE	BREAKER FAILURE LEVEL: 1.00 x CT	RANGE: 0.05 - 20.00 STEP: 0.01
	ESCAPE MESSAGE	BREAKER FAILURE DELAY: 100 ms	RANGE: 10 - 1000 STEP: 10
	ESCAPE MESSAGE	BREAKER FAILURE ALARM EVENTS: Off	RANGE: On, Off

FUNCTION:

If the breaker failure alarm feature may be enabled as latched or unlatched. If the R1 Trip output relay is operated and the generator current measured at any of the three output CTs is above the level programmed for the period of time specified by the delay, a breaker failure alarm will occur. The time delay should be slightly longer than the breaker clearing time.

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4.11.3 TRIP COIL MONITOR

▌TRIP COIL MONITOR
▌[ENTER] for more

Keys	Message	Range
ENTER ⇨ ⇦ ESCAPE	**TRIP COIL MONITOR** **ALARM: Off**	RANGE: Off, Latched, Unlatched
⬁ ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
⬁ ESCAPE MESSAGE ⇧	**SUPERVISION OF TRIP** **COIL: 52 Closed**	RANGE: 52 Closed, 52 Open/Closed
⬁ ESCAPE MESSAGE ⇧	**TRIP COIL MONITOR** **ALARM EVENTS: Off**	RANGE: On, Off

FUNCTION:

If the trip coil monitor alarm feature is enabled as latched or unlatched, the trip coil supervision circuitry will monitor the trip coil circuit for continuity any time that the breaker status input indicates that the breaker is closed. If that continuity is broken, a trip coil monitor alarm will occur in approximately 300ms.

If *52 Open/Closed* is selected, the trip coil supervision circuitry will monitor the trip coil circuit for continuity at all times regardless of breaker state. This requires an alternate path around the 52a contacts in series with the trip coil when the breaker is open. See the following figure for modifications to the wiring and proper resistor selection. If that continuity is broken, a Starter Failure alarm will indicate Trip Coil Supervision.

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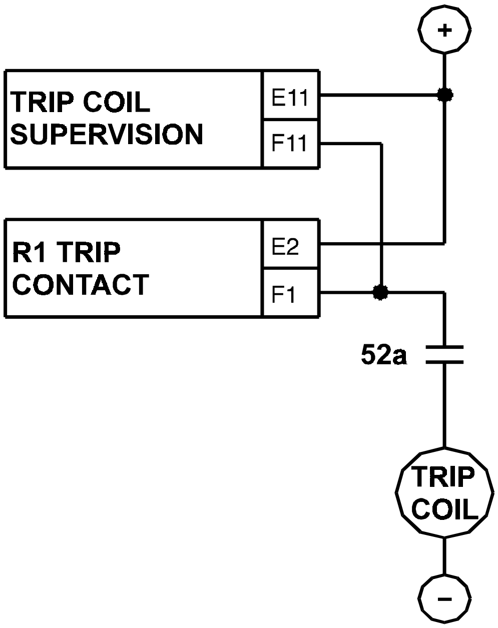
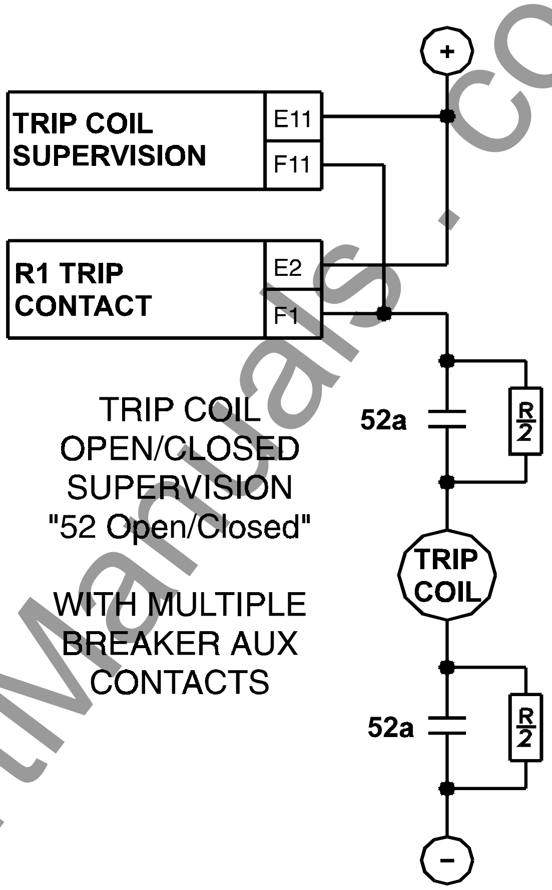
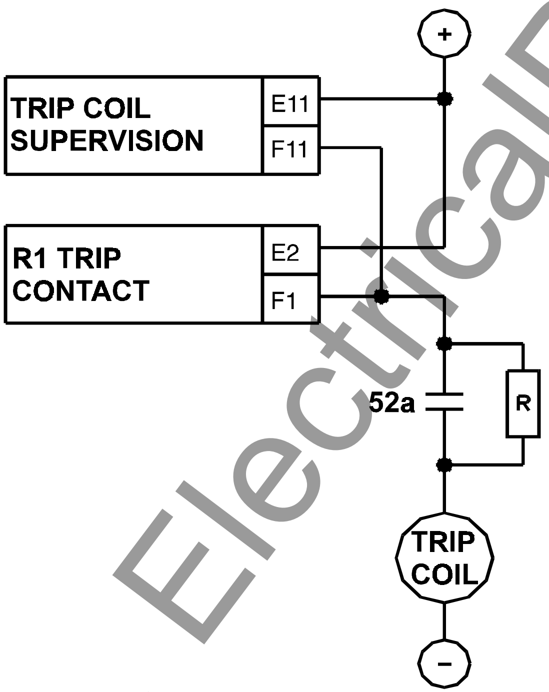


TRIP COIL CLOSED SUPERVISION
"52 Closed"



TRIP COIL
OPEN/CLOSED
SUPERVISION
"52 Open/Closed"

WITH MULTIPLE
BREAKER AUX
CONTACTS



TRIP COIL OPEN/CLOSED SUPERVISION
"52 Open/Closed"

VALUE OF RESISTOR 'R'

SUPPLY	OHMS	WATTS
48 VDC	10 K	2
125 VDC	25 K	5
250 VDC	50 K	5

Figure 4-29 TRIP COIL SUPERVISION

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4.11.4 VT FUSE FAILURE

VT FUSE FAILURE [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	VT FUSE FAILURE ALARM: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⬁ ESCAPE MESSAGE ⇧	VT FUSE FAILURE ALARM EVENTS: Off	RANGE: On, Off

FUNCTION:

A fuse failure is detected when there are significant levels of negative sequence voltage without correspondingly significant levels of negative sequence current measured at the output CTs. Also, if the generator is online and there is not a significant amount of positive sequence voltage, it could indicate that all the VT fuses have been pulled or the VTs have been racked out. If the alarm is enabled and a VT fuse failure has been detected elements that could nuisance operate will be blocked and an alarm will occur. Those elements that will be blocked include voltage restraint for the phase overcurrent, undervoltage, phase reversal, and all power elements.

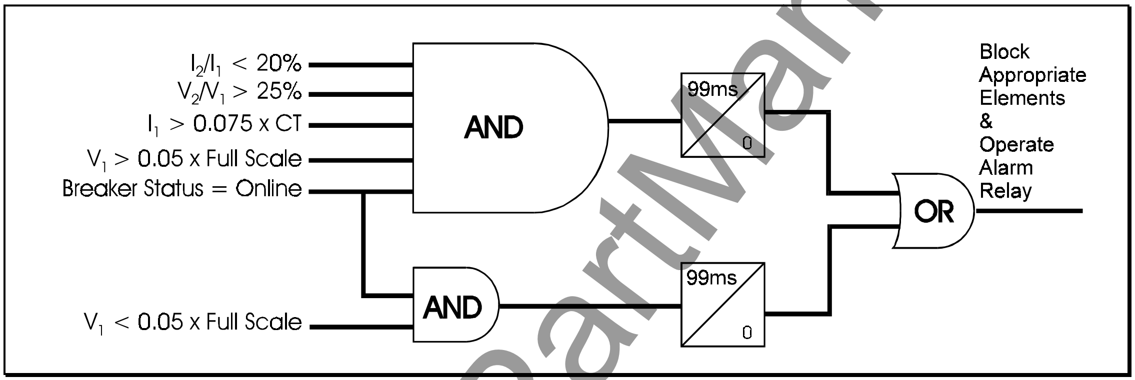

Figure 4-30 VT FUSE FAILURE

4.11.5 CURRENT, MW, Mvar, MVA DEMAND

CURRENT DEMAND [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	CURRENT DEMAND PERIOD: 15 min	RANGE: 5 -90 STEP: 1
	⬁ ESCAPE MESSAGE ⇳	CURRENT DEMAND ALARM: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⬁ ESCAPE MESSAGE ⇳	CURRENT DEMAND LIMIT: 1.25 x FLA	RANGE: 0.10 - 20.00 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	CURRENT DEMAND ALARM EVENTS: Off	RANGE: On, Off

MW DEMAND [ENTER] for more	ENTER ⇨ ⇦ ESCAPE	MW DEMAND PERIOD: 15 min	RANGE: 5 -90 STEP: 1
	⬁ ESCAPE MESSAGE ⇳	MW DEMAND ALARM: Off	RANGE: Off, Latched, Unlatched
	⬁ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
	⬁ ESCAPE MESSAGE ⇳	MW DEMAND LIMIT: 1.25 x Rated	RANGE: 0.10 - 2.00 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	MW DEMAND ALARM EVENTS: Off	RANGE: On, Off

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▌Mvar DEMAND **▌[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**Mvar DEMAND** **PERIOD: 15 min**	RANGE: 5 -90 STEP: 1
	⇖ ESCAPE MESSAGE ⇳	**Mvar DEMAND** **ALARM: Off**	RANGE: Off, Latched, Unlatched
	⇖ ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
	⇖ ESCAPE MESSAGE ⇳	**Mvar DEMAND** **LIMIT: 1.25 x Rated**	RANGE: 0.10 - 2.00 STEP: 0.01
	⇖ ESCAPE MESSAGE ⇧	**Mvar DEMAND** **ALARM EVENTS: Off**	RANGE: On, Off

▌MVA DEMAND **▌[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**MVA DEMAND** **PERIOD: 15 min**	RANGE: 5 -90 STEP: 1
	⇖ ESCAPE MESSAGE ⇳	**MVA DEMAND** **ALARM: Off**	RANGE: Off, Latched, Unlatched
	⇖ ESCAPE MESSAGE ⇳	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any Combination of Relays 2-5
	⇖ ESCAPE MESSAGE ⇳	**MVA DEMAND** **LIMIT: 1.25 x Rated**	RANGE: 0.10 - 2.00 STEP: 0.01
	⇖ ESCAPE MESSAGE ⇧	**MVA DEMAND** **ALARM EVENTS: Off**	RANGE: On, Off

FUNCTION:

The 489 can measure the demand of the generator for several parameters (current, MW, Mvar, MVA). The demand values of generators may be of interest for energy management programs where processes may be altered or scheduled to reduce overall demand on a feeder. The generator FLA is calculated as: generator rated MVA / (√3 x rated generator phase-phase voltage). Power quantities are programmed as per unit calculated from the rated MVA and rated power factor.

Demand is calculated in the following manner. Every minute, an average magnitude is calculated for current, +MW, +Mvar, and MVA based on samples taken every 5 seconds. These values are stored in a FIFO (First In, First Out buffer).The size of the buffer is dictated by the period that is selected for the setpoint. The average value of the buffer contents is calculated and stored as the new demand value every minute. Demand for real and reactive power is only positive quantities (+MW and +Mvar).

$$DEMAND = \frac{1}{N}\sum_{n=1}^{N}\left|Average_n\right|$$ where: N= programmed Demand Period in minutes, n= time in minutes

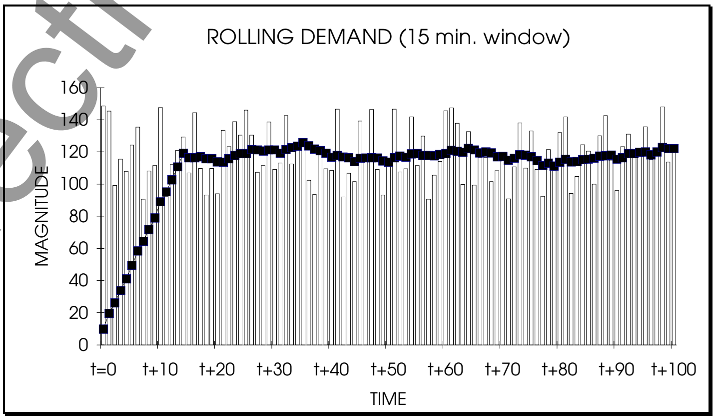

Figure 4-31 ROLLING DEMAND (15 min. window)

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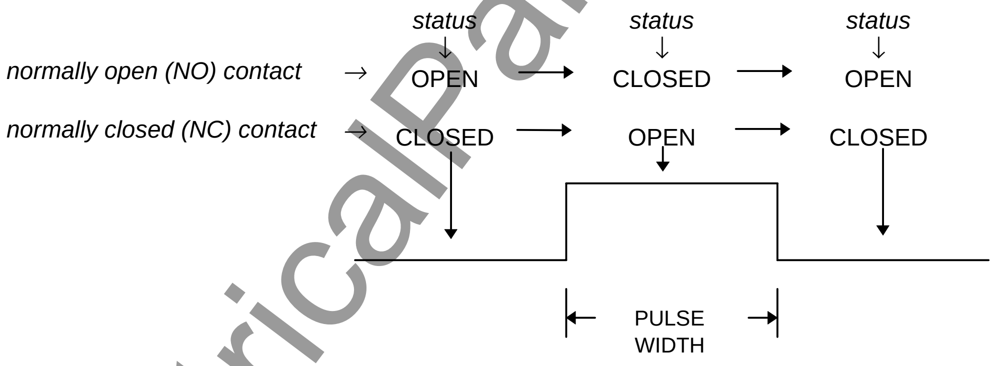
4.11.6 PULSE OUTPUT

	PULSE OUTPUT **[ENTER] for more**	
ENTER ESCAPE	**POS. kWh PULSE OUT** **RELAYS (2-5): ----**	RANGE: Any Combination of Relays 2 - 5
ESCAPE MESSAGE	**POS. kWh PULSE OUT** **INTERVAL: 10 kWh**	RANGE: 1 - 50000 STEP: 1
ESCAPE MESSAGE	**POS. kvarh PULSE OUT** **RELAYS (2-5): ----**	RANGE: Any Combination of Relays 2 - 5
ESCAPE MESSAGE	**POS. kvarh PULSE OUT** **INTERVAL: 10 kvarh**	RANGE: 1 - 50000 STEP: 1
ESCAPE MESSAGE	**NEG. kvarh PULSE OUT** **RELAYS (2-5): ----**	RANGE: Any Combination of Relays 2 - 5
ESCAPE MESSAGE	**NEG. kvarh PULSE OUT** **INTERVAL: 10 kvarh**	RANGE: 1 - 50000 STEP: 1
ESCAPE MESSAGE	**PULSE WIDTH** **200 ms**	RANGE: 200 - 1000 STEP: 1

FUNCTION:

The 489 can perform pulsed output of positive kWh and both positive and negative kvarh. Each output parameter can be assigned to any one of the alarm or auxilliary relays. Pulsed output is disabled for a parameter if the relay setpoint is selected as OFF for that pulsed output. The minimum time between pulses is fixed to 400 milliseconds. Note: This feature should be programmed such that no more than one pulse per 600 milliseconds is required or the pulsing will lag behind the interval activation. Do not assign pulsed outputs to the same relays as alarms and trip functions.



4.11.7 GENERATOR RUNNING HOUR SETUP

	RUNNING HOUR SETUP **[ENTER] for more**	
ENTER ESCAPE	**INITIAL GEN. RUNNING** **HOURS: 0 h**	RANGE: 0-999999 STEP: 1
ESCAPE MESSAGE	**GEN. RUNNING HOURS** **ALARM: Off**	RANGE: Off, Latched, Unlatched
ESCAPE MESSAGE	**ASSIGN ALARM** **RELAYS (2-5): ---5**	RANGE: Any combination of relays 2-5
ESCAPE MESSAGE	**GEN. RUNNING HOURS** **LIMIT: 1000 h**	RANGE: 1-1000000 STEP: 1

The 489 can measure the generator running hours. This value may be of interest for periodic maintenance of the generator.

The initial generator running hour allows the user to program existing accumulated running hours on a particular generator the relay is protecting. This feature allows the user to switch 489 relays without losing previous generator running hour values.

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4.12.1 ANALOG OUTPUTS 1-4

▌ANALOG OUTPUT 1 ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ANALOG OUTPUT 1: Real Power (MW)	RANGE: See Analog Output Table, Table 4-10
	⬁ ESCAPE MESSAGE ⇳	REAL POWER (MW) MIN: 0.00 x Rated	RANGE: 0,00 - 2.00 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	REAL POWER (MW) MAX: 1.25 x Rated	RANGE: 0,00 - 2.00 STEP: 0.01
▌ANALOG OUTPUT 2 ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ANALOG OUTPUT 2: Apparent Power (MVA)	RANGE: See Analog Output Table, Table 4-10
	⬁ ESCAPE MESSAGE ⇳	APPARENT POWER (MVA) MIN: 0.00 x Rated	RANGE: 0,00 - 2.00 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	APPARENT POWER MAX: 1.25 x Rated	RANGE: 0,00 - 2.00 STEP: 0.01
▌ANALOG OUTPUT 3 ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ANALOG OUTPUT 3: Avg. Output Current	RANGE: See Analog Output Table, Table 4-10
	⬁ ESCAPE MESSAGE ⇳	AVG. OUTPUT CURRENT MIN: 0.00 x FLA	RANGE: 0,00 - 20.00 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	AVG. OUTPUT CURRENT MAX: 1.25 x FLA	RANGE: 0,00 - 20.00 STEP: 0.01
▌ANALOG OUTPUT 4 ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	ANALOG OUTPUT 4: Average Voltage	RANGE: See Analog Output Table, Table 4-10
	⬁ ESCAPE MESSAGE ⇳	AVERAGE VOLTAGE MIN: 0.00 x Rated	RANGE: 0,00 - 1.50 STEP: 0.01
	⬁ ESCAPE MESSAGE ⇧	AVERAGE VOLTAGE MIN: 1.25 x Rated	RANGE: 0,00 - 1.50 STEP: 0.01

FUNCTION:

The 489 has four analog output channels (4-20mA or 0-1mA as ordered). Each channel may be individually configured to represent a number of different measured parameters as shown in the table below. The minimum value programmed represents the 4mA output. The maximum value programmed represents the 20mA output. All four of the outputs are updated once every 50ms. Each parameter may only be used once.

EXAMPLE:

The analog output parameter may be chosen as Real Power (MW) for a 4-20mA output. If rated power is 100 MW If the minimum is set for 0.00 x Rated and the maximum is set for 1.00 x Rated, when the real power measurement is 0 MW, the analog output channel will output 4 mA. When the real power measurement is 50 MW, the analog output channel will output 12 mA. When the real power measurement is 100 MW, the analog output channel will output 20 mA.

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Table 4-10 ANALOG OUTPUT PARAMETER SELECTION TABLE

ANALOG OUTPUT PARAMETER SELECTION TABLE

			DEFAULT	
PARAMETER NAME	**RANGE / UNITS**	**STEP**	**Minimum**	**Maximum**
IA Output Current	0-20.00 x FLA	0.01	0.00	1.25
IB Output Current	0-20.00 x FLA	0.01	0.00	1.25
IC Output Current	0-20.00 x FLA	0.01	0.00	1.25
Avg. Output Current	0-20.00 x FLA	0.01	0.00	1.25
Neg. Seq. Current	0-2000 % FLA	1	0	100
Averaged Gen. Load	0-20.00 x FLA	0.01	0.00	1.25
Hottest Stator RTD	-50 to +250°C or -58 to +482°F	1	0	200
Hottest Bearing RTD	-50 to +250°C or -58 to +482°F	1	0	200
Ambient RTD	-50 to +250°C or -58 to +482°F	1	0	70
RTD #1 - 12	-50 to +250°C or -58 to +482°F	1	0	200
AB Voltage	0.00-1.50 x Rated	0.01	0.00	1.25
BC Voltage	0.00-1.50 x Rated	0.01	0.00	1.25
CA Voltage	0.00-1.50 x Rated	0.01	0.00	1.25
Average Voltage	0.00-1.50 x Rated	0.01	0.00	1.25
Volts/Hertz	0.00 - 2.00 x rated	0.01	0.00	1.50
Frequency	0.00 - 90.00 Hz	0.01	59.00	61.00
Neutral Volt. (3rd)	0-25000.0 Volts	0.1	0.0	45.0
Power Factor	0.01 to 1.00 lead/lag	0.01	0.80 lag	0.80 lead
Reactive Power(Mvar)	-2.00 to +2.00 x Rated	0.01	0.00	+1.25
Real Power (MW)	-2.00 to +2.00 x Rated	0.01	0.00	+1.25
Apparent Power (MVA)	0.00 to 2.00 x Rated	0.01	0.00	1.25
Analog Inputs 1-4	-50000 to +50000 Units	1	0	+50000
Tachometer	0 to 7200 RPM	1	3500	3700
Therm. Capacity Used	0-100 %	1	0	100
Current Demand	0-20.00 x FLA	0.01	0.00	1.25
Mvar Demand	0.00 - 2.00 x Rated	0.01	0.00	1.25
MW Demand	0.00 - 2.00 x Rated	0.01	0.00	1.25
MVA Demand	0.00 - 2.00 x Rated	0.01	0.00	1.25

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4.12.2 ANALOG INPUTS 1-4

▌ANALOG INPUT 1
▌[ENTER] for more

ENTER ⇨ ⇦ ESCAPE	ANALOG INPUT1: Disabled	RANGE: Disabled, 4-20mA, 0-20mA, 0-1mA
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 NAME: Analog I/P 1	RANGE: 12 Character Alphanumeric
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 UNITS: Units	RANGE: 6 Character Alphanumeric
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 MINIMUM: 0	RANGE: -50000 to +50000 STEP: 1
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 MAXIMUM: 100	RANGE: -50000 to +50000 STEP: 1
⇖ ESCAPE MESSAGE ⇳	BLOCK ANALOG INPUT1 FROM ONLINE: 0 s	RANGE: 0-5000 STEP: 1
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 ALARM: Off	RANGE: Off, Latched, Unlatched
⇖ ESCAPE MESSAGE ⇳	ASSIGN ALARM RELAYS (2-5): ---5	RANGE: Any Combination of Relays 2-5
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 ALARM LEVEL: 10 Units	RANGE: -50000 to +50000 STEP: 1
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 ALARM PICKUP: Over	RANGE: Over, Under
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 ALARM DELAY: 0.1 s	RANGE: 0.1 - 300.0 STEP: 0.1
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 ALARM EVENTS: OFF	RANGE: On, Off
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 TRIP: Off	RANGE: Off, Latched, Unlatched
⇖ ESCAPE MESSAGE ⇳	ASSIGN TRIP RELAYS (1-4): 1---	RANGE: Any Combination of Relays 1-4
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 TRIP LEVEL: 20 Units	RANGE: -50000 to +50000 STEP: 1
⇖ ESCAPE MESSAGE ⇳	ANALOG INPUT1 TRIP PICKUP: Over	RANGE: Over, Under
⇖ ESCAPE MESSAGE ⇧	ANALOG INPUT1 TRIP DELAY: 0.1 s	RANGE: 0.1 - 300.0 STEP: 0.1

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FUNCTION:

There are 4 analog inputs, 4-20mA, 0-20mA, or 0-1mA as selected. These inputs may be used to monitor transducers such as vibration monitors, tachometers, pressure transducers, etc. These inputs may be used for alarm and/or tripping purposes. The inputs are sampled every 50 ms. The level of the analog input is also available over the communications port. With the 489PC program, the level of the transducer may be trended and graphed.

Before the input may be used, it must be configured. A name may be assigned for the input, units may be assigned, and a minimum and maximum value must be assigned. Also, the trip and alarm features may be blocked until the generator is online for a specified time delay. If the block time is 0, there is no block and the trip and alarm features will be active when the generator is offline or online. If a time is programmed other than 0, the feature will be disabled when the generator is offline and also from the time the machine is placed online until the time entered expires. Once the input is setup, both the trip and alarm features may be configured. In addition to programming a level and time delay, the PICKUP setpoint may be used to dictate whether the feature picks up when the measured value is over or under the level.

EXAMPLE:

If a vibration transducer is to be used, program the name as 'Vibration Monitor'. The units as 'mm/s'. The minimum as 0, the maximum as 25. Program the Block From Online as 0s. Set the alarm for a reasonable level slightly higher than the normal vibration level. Program a delay, 3 s, and pickup 'Over'.

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4.13.1 SIMULATION MODE

```
▌SIMULATION MODE        ENTER   ⇨  SIMULATION MODE:        RANGE: Off, Simulate Pre-Fault, Simulate Fault, Pre-Fault to Fault
▌[ENTER] for more   ⇦   ESCAPE     Off

                    ⬂   ESCAPE     PRE-FAULT TO FAULT      RANGE: 0 - 300
                        MESSAGE ⇧  TIME DELAY:    15 s     STEP: 1
```

FUNCTION:

The 489 may be placed in several simulation modes. This simulation may be useful for several purposes. First, it may be used to understand the operation of the 489 for learning or training purposes. Second, simulation may be used during startup to verify that control circuitry operates as it should in the event of a trip or alarm. In addition, simulation may be used to verify that setpoints had been set properly in the event of fault conditions.

Simulation mode may be entered only if the generator is offline, no current is measured, and there are no trips or alarms active. The values entered as Pre-Fault Values will be substituted for the measured values in the 489 when the simulation mode is 'Simulate Pre-Fault'. The values entered as Fault Values will be substituted for the measured values in the 489 when the simulation mode is 'Simulate Fault'. If the simulation mode: Pre-Fault to Fault is selected, the Pre-Fault values will be substituted for the period of time specified by the delay, followed by the Fault values. If a trip occurs, simulation mode will revert to Off. Selecting 'Off' for the simulation mode will place the 489 back in service. If the 489 measures current or control power is cycled, simulation mode will automatically revert to Off.

If the 489 is to be used for training, it might be desirable to allow all parameter averages, statistical information, and event recording to update when operating in simulation mode. If however, the 489 has been installed and will remain installed on a specific generator, it might be desirable assign a digital input to Test Input and to short that input to prevent all of this data from being corrupted or updated. In any event, when in simulation mode, the 489 in Service LED (indicator) will flash, indicating that the 489 is not in protection mode.

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4.13.2 PRE-FAULT SETUP

▌PRE-FAULT SETUP ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	PRE-FAULT Iphase OUTPUT: 0.00 x CT	RANGE: 0.00 - 20.00 STEP: 0.01
	ESCAPE MESSAGE ⇳	PRE-FAULT VOLTAGES PHASE-N: 1.00x Rated	RANGE: 0.00 - 1.50 STEP: 0.01 *entered as a phase to neutral quantity
	ESCAPE MESSAGE ⇳	PRE-FAULT CURRENT LAGS VOLTAGE: 0 °	RANGE: 0 - 359 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT Iphase NEUTRAL: 0.00 x CT	RANGE: 0.00 - 20.00 STEP: 0.01 *180 degrees phase shift with respect to Iphase OUTPUT
	ESCAPE MESSAGE ⇳	PRE-FAULT CURRENT GROUND: 0.00 x CT	RANGE: 0.00 -20.00 STEP: 0.01 *CT is either XXX:1 or 5:0.0025
	ESCAPE MESSAGE ⇳	PRE-FAULT VOLTAGE NEUTRAL: 0 Vsec	RANGE: 0.0 - 100.0 STEP: 0.1 *Fundamental value only in secondary volts
	ESCAPE MESSAGE ⇳	PRE-FAULT STATOR RTD TEMP: 40 °C	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT BEARING RTD TEMP: 40 °C	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT OTHER RTD TEMP: 40 °C	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT AMBIENT RTD TEMP: 40 °C	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT SYSTEM FREQUENCY: 60.00 Hz	RANGE: 5.0 - 90.0 STEP: 0.1
	ESCAPE MESSAGE ⇳	PRE-FAULT ANALOG INPUT 1: 0 %	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT ANALOG INPUT 2: 0 %	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE ⇳	PRE-FAULT ANALOG INPUT 3: 0 %	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE ⇧	PRE-FAULT ANALOG INPUT 4: 0 %	RANGE: 0 - 100 STEP: 1

FUNCTION:

The values entered under Pre-Fault Values will be substituted for the measured values in the 489 when the simulation mode is 'Simulate Pre-Fault'.

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4.13.3 FAULT SETUP

FAULT SETUP **[ENTER] for more**	ENTER ESCAPE	**FAULT Iphase** **OUTPUT: 0.00 x CT**	RANGE: 0.00 - 20.00 STEP: 0.01
	ESCAPE MESSAGE	**FAULT VOLTAGES** **PHASE-N: 1.00x Rated**	RANGE: 0.00 - 1.50 STEP: 0.01 *entered as a phase to neutral quantity
	ESCAPE MESSAGE	**FAULT CURRENT** **LAGS VOLTAGE: 0 °**	RANGE: 0 - 359 STEP: 1
	ESCAPE MESSAGE	**FAULT Iphase** **NEUTRAL: 0.00 x CT**	RANGE: 0.00 - 20.00 STEP: 0.01 *180 degrees phase shift with respect to Iphase OUTPUT
	ESCAPE MESSAGE	**FAULT CURRENT** **GROUND: 0.00 x CT**	RANGE: 0.00 -20.00 STEP: 0.01 *CT is either XXX:1 or 5:0.0025
	ESCAPE MESSAGE	**FAULT VOLTAGE** **NEUTRAL: 0 Vsec**	RANGE: 0.0- 100.0 STEP: 0.1 *Fundamental value only in secondary volts
	ESCAPE MESSAGE	**FAULT STATOR** **RTD TEMP: 40 °C**	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE	**FAULT BEARING** **RTD TEMP: 40 °C**	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE	**FAULT OTHER** **RTD TEMP: 40 °C**	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE	**FAULT AMBIENT** **RTD TEMP: 40 °C**	RANGE: -50 to +250 STEP: 1
	ESCAPE MESSAGE	**FAULT SYSTEM** **FREQUENCY: 60.00 Hz**	RANGE: 5.0 - 90.0 STEP: 0.1
	ESCAPE MESSAGE	**FAULT ANALOG** **INPUT 1: 0 %**	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE	**FAULT ANALOG** **INPUT 2: 0 %**	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE	**FAULT ANALOG** **INPUT 3: 0 %**	RANGE: 0 - 100 STEP: 1
	ESCAPE MESSAGE	**FAULT ANALOG** **INPUT 4: 0 %**	RANGE: 0 - 100 STEP: 1

FUNCTION:

The values entered under Fault Values will be substituted for the measured values in the 489 when the simulation mode is 'Simulate Fault'.

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4

4.13.4 TEST OUTPUT RELAYS

TEST OUTPUT RELAYS
[ENTER] for more

ENTER ⇨ / ⇦ ESCAPE

FORCE OPERATION OF
RELAYS: Disabled

RANGE: Disabled, R1 Trip, R2 Auxiliary, R3 Auxiliary, R4 Auxiliary, R5 Alarm , R6 Service, All Relays, No Relays

FUNCTION:

The test output relays setpoint may be used during startup or testing to verify that the output relays are functioning correctly. The output relays can be forced to operate only if the generator is offline, no current is measured, and there are no trips or alarms active. If any relay is forced to operate, the relay will toggle from its normal state when there are no trips or alarms to its operated state. The appropriate relay indicator will illuminate at that time. Selecting 'Disabled' will place the output relays back in service. If the 489 measures current or control power is cycled, the force operation of relays setpoint will automatically become disabled and the output relays will revert back to their normal states.

If any relay is forced, the 489 in Service indicator will flash, indicating that the 489 is not in protection mode.

4.13.5 TEST ANALOG OUTPUT

TEST ANALOG OUTPUT
[ENTER] for more

ENTER ⇨ / ⇦ ESCAPE

FORCE ANALOG OUTPUTS
FUNCTION: Disabled

RANGE: Enabled, Disabled

ESCAPE / MESSAGE ⇳

ANALOG OUTPUT 1
FORCED VALUE: 0 %

RANGE: 0 - 100
STEP: 1

ESCAPE / MESSAGE ⇳

ANALOG OUTPUT 2
FORCED VALUE: 0 %

RANGE: 0 - 100
STEP: 1

ESCAPE / MESSAGE ⇳

ANALOG OUTPUT 3
FORCED VALUE: 0 %

RANGE: 0 - 100
STEP: 1

ESCAPE / MESSAGE ⇧

ANALOG OUTPUT 4
FORCED VALUE: 0 %

RANGE: 0 - 100
STEP: 1

FUNCTION:

The test analog output setpoints may be used during startup or testing to verify that the analog outputs are functioning correctly.

The analog outputs can be forced only if the generator is offline, no current is measured, and there are no trips or alarms active. When the force analog outputs function is enabled, the output will reflect the forced value as a percentage of the range 4-20mA or 0-1mA. Selecting 'Disabled' will place all four of the analog output channels back in service, reflecting the parameters programmed to each. If the 489 measures current or control power is cycled, the force analog output function is automatically disabled and all analog outputs will revert back to their normal state.

Any time the analog outputs are forced, the 489 in Service indicator will flash, indicating that the 489 is not in protection mode.

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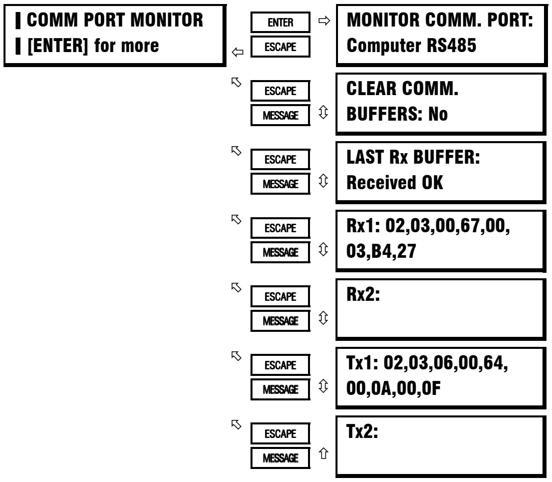
4.13.6 COMM PORT MONITOR



COMM PORT MONITOR
[ENTER] for more

MONITOR COMM. PORT: Computer RS485 — RANGE: Computer RS485, Auxiliary RS485, Front Panel RS232

CLEAR COMM. BUFFERS: No — RANGE: No, Yes

LAST Rx BUFFER: Received OK — RANGE: Buffer Cleared, Received OK, Wrong Slave Addr., Illegal Function, Illegal Count, Illegal Reg. Addr., CRC Error, Illegal Data,

Rx1: 02,03,00,67,00, 03,B4,27 — RANGE: Received data in HEX

Rx2: — RANGE: Received data in HEX

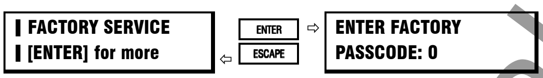
Tx1: 02,03,06,00,64, 00,0A,00,0F — RANGE: Transmitted data in HEX

Tx2: — RANGE: Transmitted data in HEX

FUNCTION:

During the course of troubleshooting communications problems, it can be very useful to see the data that is first being transmitted to the 489 from some master device, and then see the data that the 489 transmits back to that master device. The messages shown here should make it possible to view that data. Any of the three communications ports may be monitored. After the Comm. Buffers have been cleared, any data received from the communications port being monitored will be stored in the Rx1 and Rx2. If the 489 transmits a message, it will appear in the Tx1 and Tx2 buffers. In addition to these buffers, there is a message that will indicate the status of the last received message.

4.13.7 FACTORY SERVICE



FACTORY SERVICE
[ENTER] for more

ENTER FACTORY PASSCODE: 0 — RANGE: N/A

FUNCTION:

This section is for use by factory personnel for testing and calibration purposes.

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5.1.1 ACTUAL VALUES MESSAGES

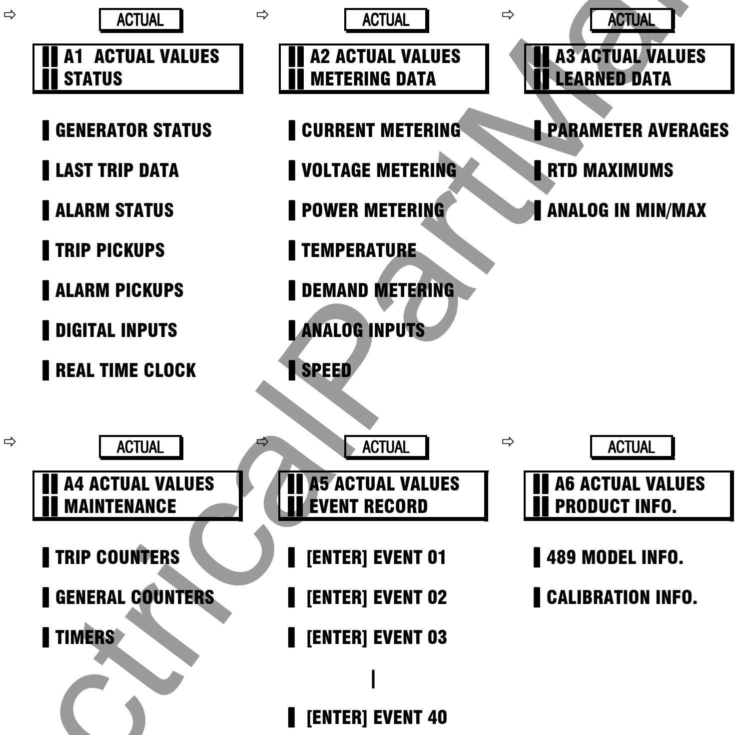
Measured values, maintenance and fault analysis information are accessed in the Actual Value mode. Actual values may be accessed via one of the following methods:

1) Front panel, using the keys and display.
2) Front program port, and a portable computer running the 489PC program supplied with the relay.
3) Rear terminal RS485 port, and a PLC/SCADA system running user-written software.

Any of these methods can be used to view the same information. A computer, however, makes viewing much more convenient, since many variables may be viewed at the same time.

Actual value messages are organized into logical groups, or pages, for easy reference, as shown below. All actual value messages are illustrated and described in blocks throughout this chapter. All values shown in these message illustrations assume that no inputs (besides control power) are connected to the 489.

Table 5-1 ACTUAL VALUE MESSAGE MAP



In addition to the Actual Value messages, there are also Diagnostic messages and Flash messages that appear only when certain conditions occur. They are described later in this chapter.

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5.2.1 GENERATOR STATUS

GENERATOR STATUS [ENTER] for more	ENTER ESCAPE	GENERATOR STATUS: Offline	RANGE: Online, Offline, Tripped
	ESCAPE MESSAGE	GENERATOR THERMAL CAPACITY USED: 0 %	RANGE: 0 -100 NOTE: this message is seen only if the thermal model is enabled
	ESCAPE MESSAGE	ESTIMATED TRIP TIME ON OVERLOAD: Never	RANGE: 0 - 10000s, Never NOTE: this message is seen only if the thermal model is enabled

DESCRIPTION:

These messages describe the status of the generator at any given point in time. If the generator has been tripped, is still offline, and the 489 has not yet been reset, the generator status will be 'Tripped'. The thermal capacity used reflects an integrated value of both the stator and rotor thermal capacity used. The values for estimated trip time on overload will appear whenever the 489 thermal model picks up on the overload curve.

5.2.2 LAST TRIP DATA

LAST TRIP DATA [ENTER] for more	ENTER ESCAPE	CAUSE OF LAST TRIP: No Trip To Date	RANGE: No Trip To Date, General Input A - G, Sequential Trip, Field-Bkr Discrep., Tachometer, Thermal Model, Offline Overcurrent, Phase Overcurrent, Neg.Seq. Overcurrent, Ground Overcurrent, Phase Differential, RTDs 1-12, Undervoltage, Overvoltage, Voltz/Hertz, Phase Reversal, Underfrequency, Overfrequency, Neutral O/V, Neutral U/V (3rd), Reactive Power, Reverse Power, Low Forward Power, Inadvertent Energ., Analog Inputs 1-4
	ESCAPE MESSAGE	TIME OF LAST TRIP: 00:00:00.0	RANGE: Hour/Min/Sec NOTE: this message is seen only if there has been a trip
	ESCAPE MESSAGE	DATE OF LAST TRIP: Jan 01 1999	RANGE: Mon/Day/Year NOTE: this message is seen only if there has been a trip
	ESCAPE MESSAGE	TACHOMETER Pretrip: 3600 RPM	RANGE: 0-3600 NOTE: this message is seen only if the function is assigned an input
	ESCAPE MESSAGE	A: 0 B: 0 C: 0 A PreTrip	RANGE: 0-999999 NOTE: this message represents current measured from the output CTs, seen only if there has been a trip
	ESCAPE MESSAGE	a: 0 b: 0 c: 0 DA PreTrip	RANGE: 0 - 999999 NOTE: this message seen only if the differential element is enabled and represents differential current
	ESCAPE MESSAGE	NEG. SEQ. CURRENT PreTrip: 0 % FLA	RANGE: 0 -2000 NOTE: this message is seen only if there has been a trip
	ESCAPE MESSAGE	GROUND CURRENT PreTrip: 0.00 A	RANGE: 0.00- 200000.00 NOTE: this message not seen if the ground CT is programmed as 'None'
	ESCAPE MESSAGE	Vab: 0 Vbc: 0 Vca: 0 V PreTrip	RANGE: 0-50000 NOTE: This message is not seen if VT Connection is programmed as 'None'
	ESCAPE MESSAGE	FREQUENCY Pretrip: 0.00 Hz	RANGE: 0.00 - 90.00 NOTE: This message is not seen if VT Connection is programmed as 'None'
	ESCAPE MESSAGE	NEUTRAL VOLT (FUND) PreTrip: 0.0 V	RANGE: 0.0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
	ESCAPE MESSAGE	NEUTRAL VOLT (3rd) PreTrip: 0.0 V	RANGE: 0.0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
	ESCAPE MESSAGE	REAL POWER (MW) PreTrip: 0.000	RANGE: 0 to ±2000.000 NOTE: This message is not seen if VT Connection is 'None'
	ESCAPE MESSAGE	REACTIVE POWER Mvar PreTrip: 0.000	RANGE: 0 to ±2000.000 NOTE: This message is not seen if VT Connection is 'None'
	ESCAPE MESSAGE	APPARENT POWER MVA PreTrip: 0.000	RANGE: 0 to 2000.000 NOTE: This message is not seen if VT Connection is 'None'
	ESCAPE MESSAGE	HOTTEST STATOR RTD RTD#1: 0°C PreTrip	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'STATOR'
	ESCAPE MESSAGE	HOTTEST BEARING RTD RTD#7: 0°C PreTrip	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'BEARING'

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⇖ ESCAPE MESSAGE ⇳	**HOTTEST OTHER RTD** **RTD#11: 0^{0}C PreTrip**	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'OTHER'
⇖ ESCAPE MESSAGE ⇳	**AMBIENT RTD** **RTD#12: 0^{0}C PreTrip**	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'AMBIENT'
⇖ ESCAPE MESSAGE ⇳	**ANALOG INPUT 1** **Pretrip: 0 Units**	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
⇖ ESCAPE MESSAGE ⇳	**ANALOG INPUT 2** **Pretrip: 0 Units**	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
⇖ ESCAPE MESSAGE ⇳	**ANALOG INPUT 3** **Pretrip: 0 Units**	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
⇖ ESCAPE MESSAGE ⇧	**ANALOG INPUT 4** **Pretrip: 0 Units**	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
⇖ ESCAPE MESSAGE ⇧	**Vab/Iab Pretrip** **0.0 Ω sec 0°**	RANGE: 0 - 65535 Ω sec RANGE: 0 - 359° NOTE: This message seen only if Loss of Excitation element is Enabled

DESCRIPTION:

Immediately prior to issuing a trip, the 489 takes a snapshot of generator parameters and stores them as pre-trip values which will allow for troubleshooting after the trip occurs. The cause of last trip message is updated with the current trip and the screen defaults to that message. All trip features are automatically logged as date and time stamped events as they occur. This information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. If the cause of last trip is 'No Trip To Date', the subsequent pretrip messages will not appear. Last Trip Data will not update if a digital input programmed as Test Input is shorted.

5.2.3 ALARM STATUS

▌ALARM STATUS **▌[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**NO ALARMS**	RANGE: N/A Note: This message seen when no alarms are active
	⇖ ESCAPE MESSAGE ⇳	**Input A ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input B ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input C ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input D ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input E ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input F ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**Input G ALARM** **STATUS: Active**	RANGE: Active, Latched *The first line of this alarm message will reflect the Input Name as programmed Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
	⇖ ESCAPE MESSAGE ⇳	**TACHOMETER** **ALARM: 3000 RPM**	RANGE: 0-3600 Note: The current measurement of the Tachometer Digital input will be shown here
	⇖ ESCAPE MESSAGE ⇳	**OVERCURRENT** **ALARM: 10.00 x FLA**	RANGE: 0-20.00 Note: Overcurrent level will be shown here
	⇖ ESCAPE MESSAGE ⇳	**NEG. SEQ. CURRENT** **ALARM: 15 % FLA**	RANGE: 0 - 100 Note: reflects the present negative sequence current level
	⇖ ESCAPE MESSAGE ⇳	**GROUND OVERCURRENT** **ALARM: 5.00 A**	RANGE: 0.00- 200000.00 NOTE: reflects the present ground current level, this message seen if the GE Power Management HGF CT is used
	⇖ ESCAPE MESSAGE ⇳	**GROUND DIRECTIONAL** **ALARM: 5.00 A**	RANGE: 0.00- 200000.00

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ESCAPE MESSAGE ⇕	**UNDERVOLTAGE ALARM** **Vab= 3245V 78% Rated**	RANGE: 0 - 20000, 50 -99 Note: Value of the lowest phase to phase voltage will be shown here
ESCAPE MESSAGE ⇕	**OVERVOLTAGE ALARM** **Vab=4992V 120% Rated**	RANGE: 0 - 20000, 101 - 150 Note: Value of the highest phase to phase voltage will be shown here
ESCAPE MESSAGE ⇕	**VOLTS/HERTZ ALARM** **PER UNIT V/Hz: 1.15**	RANGE: 0.00 - 2.00 NOTE: present value of V/Hz is shown here, message is not seen if VT Connection is 'None'
ESCAPE MESSAGE ⇕	**UNDERFREQUENCY** **ALARM: 59.4 Hz**	RANGE: 0.00 -90.00 Note: Value of voltage frequency will be shown here
ESCAPE MESSAGE ⇕	**OVERFREQUENCY** **ALARM: 60.6 Hz**	RANGE: 0.00- 90.00 Note: Value of voltage frequency will be shown here
ESCAPE MESSAGE ⇕	**NEUTRAL O/V (FUND)** **ALARM: 0.0 V**	RANGE: 0.0 - 25000.0 NOTE: the present value of fundamental neutral voltage will be seen here
ESCAPE MESSAGE ⇕	**NEUTRAL U/V (3rd)** **ALARM: 0.0 V**	RANGE: 0.0 - 25000.0 NOTE: the present value of 3rd harmonic neutral voltage will be seen here
ESCAPE MESSAGE ⇕	**REACTIVE POWER Mvar** **ALARM: +20.000**	RANGE: -2000.000 to +2000.000 Note: Current Mvar value will be shown here
ESCAPE MESSAGE ⇕	**REVERSE POWER** **ALARM: -20.000 MW**	RANGE: -2000.000 to +2000.000 Note: Current MW value will be shown here
ESCAPE MESSAGE ⇕	**LOW FORWARD POWER** **ALARM: -20.000 MW**	RANGE: -2000.000 to +2000.000 Note: Current MW value will be shown here
ESCAPE MESSAGE ⇕	**Stator RTD #1** **ALARM: 135° C**	RANGE: -50 to +250 *The first line of this alarm message will be the RTD Name as programmed for 1-12 Note: reflects the present RTD temperature
ESCAPE MESSAGE ⇕	**OPEN SENSOR ALARM:** **RTD # 1 2 3 4 5 6 ...**	RANGE: the number of the RTD with the open sensor as programmed for RTDs 1-12 Note: reflects the number of the RTD that caused the open alarm
ESCAPE MESSAGE ⇕	**SHORT/LOW TEMP ALARM** **RTD# 7 8 9 10 11 ...**	RANGE: 1-12 Note: reflects the number of the RTD that caused the short/low temp. alarm
ESCAPE MESSAGE ⇕	**THERMAL MODEL** **ALARM: 100% TC USED**	RANGE: 1 - 100 Note: Value of thermal capacity used is shown here.
ESCAPE MESSAGE ⇕	**TRIP COUNTER** **ALARM: 25 Trips**	RANGE: 1- 10000 Note: The total number of generator trips will be displayed here
ESCAPE MESSAGE ⇕	**BREAKER FAILURE** **ALARM: Active**	RANGE: Active, Latched Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
ESCAPE MESSAGE ⇕	**TRIP COIL MONITOR** **ALARM: Active**	RANGE: Active, Latched Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
ESCAPE MESSAGE ⇕	**VT FUSE FAILURE** **ALARM: Active**	RANGE: Active, Latched Note: Alarm status is 'Active ' if the condition that caused the alarm is still present
ESCAPE MESSAGE ⇕	**CURRENT DEMAND** **ALARM: 1053 A**	RANGE: 1 - 999999 Note: The current value of Running Current Demand will be shown here
ESCAPE MESSAGE ⇕	**MW DEMAND** **ALARM: 50.500 MW**	RANGE: -2000.000 to +2000.000 Note: The current value of Running MW Demand will be shown here
ESCAPE MESSAGE ⇕	**Mvar DEMAND** **ALARM: - 20.000**	RANGE: -2000.000 to +2000.000 Note: The current value of Running Mvar Demand will be shown here
ESCAPE MESSAGE ⇕	**MVA DEMAND** **ALARM: 20.000**	RANGE: 0 to 2000.000 Note: The current value of Running MVA Demand will be shown here
ESCAPE MESSAGE ⇕	**Analog I/P 1** **ALARM: 201 Units**	RANGE: -50000 to +50000 *The alarm message will reflect the Analog Input name and units as programmed, Note: The level of the analog input will be shown here
ESCAPE MESSAGE ⇕	**Analog I/P 2** **ALARM: 201 Units**	RANGE: -50000 to +50000 *The alarm message will reflect the Analog Input name and units as programmed, Note: The level of the analog input will be shown here
ESCAPE MESSAGE ⇕	**Analog I/P 3** **ALARM: 201 Units**	RANGE: -50000 to +50000 *The alarm message will reflect the Analog Input name and units as programmed, Note: The level of the analog input will be shown here

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ESCAPE MESSAGE	**Analog I/P 4** **ALARM: 201 Units**	RANGE: -50000 to +50000 *The alarm message will reflect the Analog Input name and units as programmed, Note: The level of the analog input will be shown here
ESCAPE MESSAGE	**ALARM, 489 NOT** **INSERTED PROPERLY**	Note: If the 489 chassis is only partially engaged with the 489 case, this Service alarm will appear after 1 second. Secure the chassis handle to ensure that all contacts mate properly.
ESCAPE MESSAGE	**489 NOT IN SERVICE** **Simulation Mode**	Range: Not Programmed, Simulation Mode, Output Relays Forced, Analog Output Forced, Test Switch Shorted.
ESCAPE MESSAGE	**IRIG-B FAILURE** **ALARM: Active**	Range: Active Note: this message is only seen if IRIG-B is enabled and the associated signal input is lost
ESCAPE MESSAGE	**GEN. RUNNING HOURS** **ALARM: 1000 h**	Range: 1-1000000 h Note: this message is only seen if Running Hour Alarm is enabled

DESCRIPTION:

Any active or latched alarms may be viewed here.

5.2.4 TRIP PICKUPS

TRIP PICKUPS
[ENTER] for more

ENTER ESCAPE	**Input A** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input B** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input C** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input D** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input E** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input F** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**Input G** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input (will reflect input name as programmed)
ESCAPE MESSAGE	**SEQUENTIAL TRIP** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input
ESCAPE MESSAGE	**FIELD-BKR DISCREP.** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input
ESCAPE MESSAGE	**TACHOMETER** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if the function is assigned an input
ESCAPE MESSAGE	**OFFLINE OVERCURRENT** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**INADVERTENT ENERG.** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**PHASE OVERCURRENT** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**NEG.SEQ. OVERCURRENT** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**GROUND OVERCURRENT** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**PHASE DIFFERENTIAL** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
ESCAPE MESSAGE	**GROUND DIRECTIONAL** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip

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⇖ ESCAPE MESSAGE ⇳	**HIGH-SET PHASE O/C** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**UNDERVOLTAGE** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**OVERVOLTAGE** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**VOLTS/HERTZ** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**PHASE REVERSAL** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**UNDERFREQUENCY** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**OVERFREQUENCY** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**NEUTRAL O/V (FUND)** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**NEUTRAL U/V (3rd)** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**LOSS OF EXCITATION 1** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**LOSS OF EXCITATION 2** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**DISTANCE ZONE 1** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**DISTANCE ZONE 2** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**REACTIVE POWER** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**REVERSE POWER** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**LOW FORWARD POWER** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #1** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #2** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #3** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #4** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #5** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #6** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #7** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #8** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE MESSAGE ⇳	**RTD #9** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip

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⇖ ESCAPE	MESSAGE ⇕	RTD #10 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE	MESSAGE ⇕	RTD #11 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE	MESSAGE ⇕	RTD #12 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE	MESSAGE ⇕	THERMAL MODEL PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip
⇖ ESCAPE	MESSAGE ⇕	Analog I/P 1 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE	MESSAGE ⇕	Analog I/P 2 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE	MESSAGE ⇕	Analog I/P 3 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE	MESSAGE ⇧	Analog I/P 4 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip NOTE: this message is seen only if input is enabled (will reflect input name as programmed)

DESCRIPTION:

The trip pickup messages may be very useful during testing. They will indicate if a trip feature has been enabled, if it is inactive (not picked up), timing out (picked up and timing), active trip (still picked up, timed out, and causing a trip), or latched tip (no longer picked up, but had timed out and caused a trip that is latched). These values may also be particularly useful as data transmitted to a master device for monitoring.

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5.2.5 ALARM PICKUPS

ALARM PICKUPS
[ENTER] for more

ENTER ESCAPE	Input A PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input B PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input C PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input D PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input E PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input F PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	Input G PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input (will reflect name as programmed)
ESCAPE MESSAGE	TACHOMETER PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if the function is assigned an input
ESCAPE MESSAGE	OVERCURRENT PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	NEG.SEQ. OVERCURRENT PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	GROUND OVERCURRENT PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	GROUND DIRECTIONAL PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	UNDERVOLTAGE PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	OVERVOLTAGE PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	VOLTS/HERTZ PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	UNDERFREQUENCY PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	OVERFREQUENCY PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	NEUTRAL O/V (FUND) PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	NEUTRAL U/V (3rd) PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	REACTIVE POWER PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	REVERSE POWER PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	LOW FORWARD POWER PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	RTD #1 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
ESCAPE MESSAGE	RTD #2 PICKUP: Not Enabled	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm

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⇖ ESCAPE MESSAGE ⇕	**RTD #3** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #4** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #5** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #6** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #7** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #8** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #9** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #10** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #11** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**RTD #12** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**OPEN SENSOR** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**SHORT/LOW TEMP** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**THERMAL MODEL** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**TRIP COUNTER** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**BREAKER FAILURE** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**TRIP COIL MONITOR** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**VT FUSE FAILURE** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**CURRENT DEMAND** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**MW DEMAND** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**Mvar DEMAND** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**MVA DEMAND** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 1** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 2** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 3** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if input is enabled (will reflect input name as programmed)
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 4** **PICKUP: Not Enabled**	RANGE: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm NOTE: this message is seen only if input is enabled (will reflect input name as programmed)

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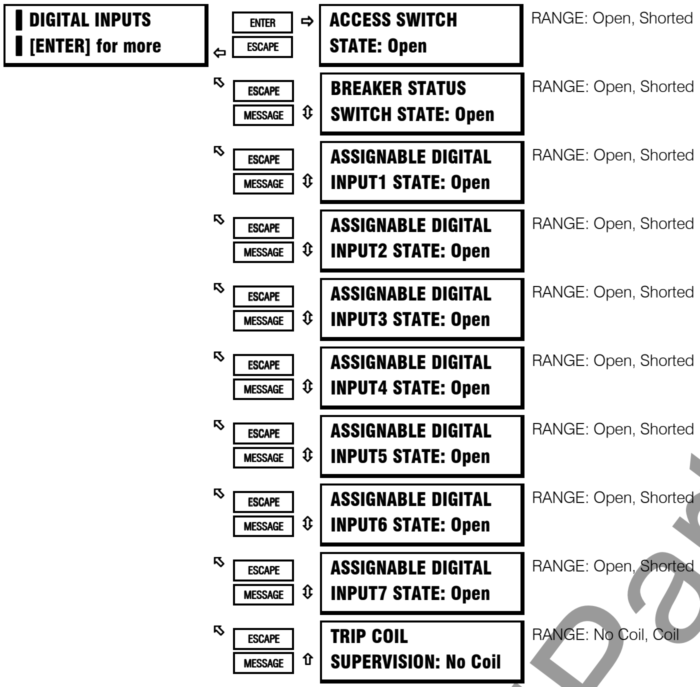
DESCRIPTION:
The alarm pickup messages may be very useful during testing. They will indicate if a alarm feature has been enabled, if it is inactive (not picked up), timing out (picked up and timing), active alarm (still picked up, timed out, and causing an alarm), or latched alarm (no longer picked up, but had timed out and caused a alarm that is latched). These values may also be particularly useful as data transmitted to a master device for monitoring.

5.2.6 DIGITAL INPUTS



▌DIGITAL INPUTS
▌[ENTER] for more

ACCESS SWITCH
STATE: Open
RANGE: Open, Shorted

BREAKER STATUS
SWITCH STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT1 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT2 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT3 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT4 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT5 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT6 STATE: Open
RANGE: Open, Shorted

ASSIGNABLE DIGITAL
INPUT7 STATE: Open
RANGE: Open, Shorted

TRIP COIL
SUPERVISION: No Coil
RANGE: No Coil, Coil

DESCRIPTION:
The messages shown here may be used to monitor digital input status. This may be useful during relay testing or during installation.

5.2.7 REAL TIME CLOCK

▌REAL TIME CLOCK
▌[ENTER] for more

DATE: 01/01/1994
TIME: 12:00:00
RANGE: 01-12/10-31/1995-2094
RANGE: 00-23:00-59:00 -59

DESCRIPTION:
The time and date from the 489 real time clock may be viewed here.

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5.3.1 CURRENT METERING

▌CURRENT METERING ▌[ENTER] for more	ENTER ⇨ ESCAPE ⇦	A: 0 B: 0 C: 0 Amps	RANGE: 0 - 999999
	ESCAPE MESSAGE ⇳	a: 0 b: 0 c: 0 Neut. Amps	RANGE: 0 - 999999
	ESCAPE MESSAGE ⇳	a: 0 b: 0 c: 0 Diff. Amps	RANGE: 0 - 999999
	ESCAPE MESSAGE ⇳	AVERAGE PHASE CURRENT: 0 Amps	RANGE: 0 - 999999
	ESCAPE MESSAGE ⇳	GENERATOR LOAD: 0% FLA	RANGE: 0 - 2000
	ESCAPE MESSAGE ⇳	NEGATIVE SEQUENCE CURRENT: 0 % FLA	RANGE: 0 -2000
	ESCAPE MESSAGE ⇳	PHASE A CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	PHASE B CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	PHASE C CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	NEUT. END A CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	NEUT. END B CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	NEUT. END C CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	DIFF. A CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	DIFF. B CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	DIFF. C CURRENT: 0 A 0° Lag	RANGE: 0 - 999999 A, 0 - 359°
	ESCAPE MESSAGE ⇳	GROUND CURRENT: 0.0 A 0° Lag	RANGE: 0.0 - 200000.0 NOTE: this message seen if the 1A ground CT input is used
	ESCAPE MESSAGE ⇧	GROUND CURRENT: 0.00 A 0° Lag	RANGE: 0.00- 100.00 NOTE: this message seen if the 50:0.025 ground CT is used

DESCRIPTION:

All measured current values are displayed here. ‘A,B,C Line Amps’ represent the output side CT measurements. ‘a,b,c Neut. Amps’ represent the neutral end CT measurements. ‘a,b,c Diff. Amps’ represent the differential operating current that is calculated as the vectorial difference between the output side CT measurements and the neutral end CT measurements on a per phase basis. 489 negative sequence current is defined as the ratio of negative sequence current to generator rated full load amps, I_2/ FLA x 100%. The generator full load amps is calculated as: generator rated MVA / (√3 x generator phase-phase voltage). Polar coordinates for measured currents are also shown using Va (wye connection) or Vab (open delta connection) as a zero angle reference vector. In the absence of a voltage signal (Va or Vab), IA output current is used as the zero angle reference vector.

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5.3.2 VOLTAGE METERING

VOLTAGE METERING
[ENTER] for more

ENTER ESCAPE	**Vab: 0 Vbc: 0** **Vca: 0 Volts**	RANGE: 0 - 50000 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**AVERAGE LINE** **VOLTAGE: 0 Volts**	RANGE: 0 - 50000 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**Van: 0 Vbn: 0** **Vcn: 0 Volts**	RANGE: 0 - 50000 NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**AVERAGE PHASE** **VOLTAGE: 0 Volts**	RANGE: 0 - 50000 NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**LINE A-B VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**LINE B-C VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**LINE C-A VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**PHASE A-N VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**PHASE B-N VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**PHASE C-N VOLTAGE:** **0 A 0° Lag**	RANGE: 0 - 50000 A, 0 - 359° NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**PER UNIT MEASUREMENT** **OF V/Hz: 0.00**	RANGE: 0.00 - 2.00 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**FREQUENCY:** **0.00 Hz**	RANGE: 0.00 - 90.00 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	**NEUTRAL VOLTAGE** **FUND: 0.0 V**	RANGE: 0.0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
ESCAPE MESSAGE	**NEUTRAL VOLTAGE** **3rd HARM: 0.0 V**	RANGE: 0.0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
ESCAPE MESSAGE	**TERMINAL VOLTAGE** **3rd HARM: 0.0 V**	RANGE: 0.0 - 25000.0 NOTE: This message seen only if VT Connection is programmed as 'Wye'
ESCAPE MESSAGE	**IMPEDANCE Vab / Iab** **0.0 Ω sec 0°**	RANGE: 0.0 - 6553.5 Ω sec RANGE: 0 - 359° NOTE: This message not seen if VT Connection is programmed as 'None'

DESCRIPTION:

Measured voltage parameters will be displayed here. The V/Hz measurement is a per unit value based on Vab voltage/measured frequency divided by VT nominal/nominal system frequency. Polar coordinates for measured phase and/or line voltages are also shown using Va (wye connection) or Vab (open delta connection) as a zero angle reference vector. In the absence of a voltage signal (Va or Vab), IA output current is used as the zero angle reference vector.

If VT Connection Type is programmed as 'None' and Neutral Voltage Transformer is 'No' in S2 SYSTEM, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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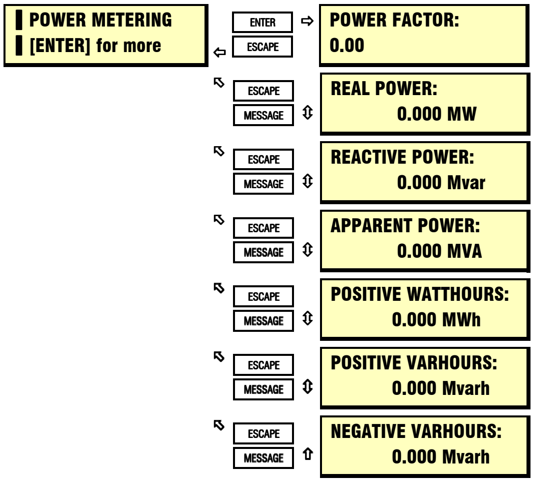
5.3.3 POWER METERING



POWER METERING
[ENTER] for more

POWER FACTOR:
0.00
RANGE: 0.01-0.99 Lead or Lag, 0.00, 1.00

REAL POWER:
0.000 MW
RANGE: 0 to ±2000.000

REACTIVE POWER:
0.000 Mvar
RANGE: 0 to ±2000.000

APPARENT POWER:
0.000 MVA
RANGE: 0 to 2000.000

POSITIVE WATTHOURS:
0.000 MWh
RANGE: 0.000 - 4000000.000

POSITIVE VARHOURS:
0.000 Mvarh
RANGE: 0.000 - 4000000.000

NEGATIVE VARHOURS:
0.000 Mvarh
RANGE: 0.000 - 4000000.000

DESCRIPTION:

The values for power metering appear here. 3 phase total power quantities are displayed here. Watthours and varhours are also shown here. Watthours and varhours will not update if a digital input programmed as Test Input is shorted.
NOTE: An induction generator, by convention generates Watts and consumes vars (+Watts and -vars). A synchronous generator can also generate vars (+vars).

If .VT Connection Type is programmed as ‘None’ in S2 SYSTEM SETUP, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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5.3.4 TEMPERATURE

TEMPERATURE **[ENTER] for more**	ENTER ⇨ ⇦ ESCAPE	**HOTTEST STATOR RTD** **RTD#1: 40 o C**	RANGE: -50 to +250, No RTD NOTE: this message seen only if at least 1 RTD is programmed as ‘STATOR’
	⬁ ESCAPE MESSAGE ⇳	**RTD #1** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #2** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #3** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #4** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #5** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #6** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #7** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #8** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #9** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #10** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇳	**RTD #11** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed
	⬁ ESCAPE MESSAGE ⇧	**RTD #12** **TEMPERATURE: 40° C**	RANGE: -50 to +250, No RTD * Message not seen if RTD programmed as “None” * The first line of this message will reflect the RTD name as programmed

DESCRIPTION:

The current level of the 12 RTDs will be displayed here. If the RTD is not connected, the value will be ‘No RTD’. If no RTDs are programmed in S7 RTD TEMPERATURE, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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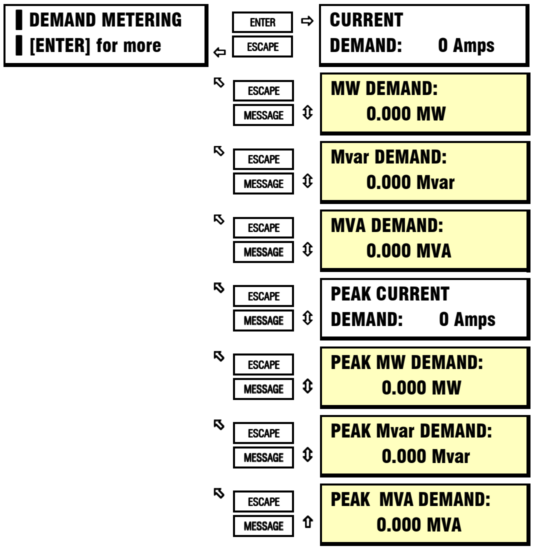
5.3.5 DEMAND METERING

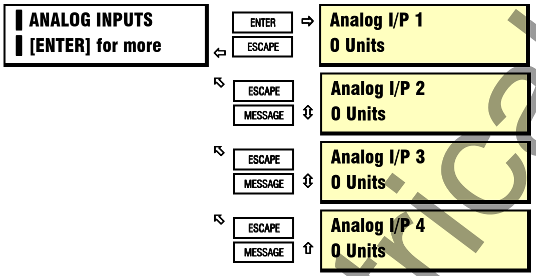


CURRENT DEMAND: 0 Amps	RANGE: 0 - 999999
MW DEMAND: 0.000 MW	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.
Mvar DEMAND: 0.000 Mvar	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.
MVA DEMAND: 0.000 MVA	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.
PEAK CURRENT DEMAND: 0 Amps	RANGE: 0 - 999999
PEAK MW DEMAND: 0.000 MW	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.
PEAK Mvar DEMAND: 0.000 Mvar	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.
PEAK MVA DEMAND: 0.000 MVA	RANGE: 0 - 2000.000 NOTE: This message is not seen if VT Connection Type is programmed as 'None'.

DESCRIPTION:

The values for current and power demand are shown here. Peak demand information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. Demand is shown only for positive real and positive reactive power (+Watts, +vars). Peak demand will not update if a digital input programmed as Test Input is shorted.

5.3.6 ANALOG INPUTS



Analog I/P 1 0 Units	RANGE: -50000 to +50000 * Message seen only if analog input is programmed *The alarm message will reflect the Analog Input name and units as programmed,
Analog I/P 2 0 Units	RANGE: -50000 to +50000 * Message seen only if analog input is programmed *The alarm message will reflect the Analog Input name and units as programmed,
Analog I/P 3 0 Units	RANGE: -50000 to +50000 * Message seen only if analog input is programmed *The alarm message will reflect the Analog Input name and units as programmed,
Analog I/P 4 0 Units	RANGE: -50000 to +50000 * Message seen only if analog input is programmed *The alarm message will reflect the Analog Input name and units as programmed,

DESCRIPTION:

The values for analog inputs are shown here. The name of the input and the units will reflect those programmed for each input.

If no Analog Inputs are programmed in S11 ANALOG I/O, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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5.3.7 SPEED

▌SPEED
▌[ENTER] for more

ENTER ⇨ ESCAPE ⇦

TACHOMETER: 0 RPM

RANGE: 0-7200
NOTE: This message seen only if a Digital Input is configured as Tachometer

DESCRIPTION:

If the Tachometer function is assigned to one of the digital inputs, the tachometer readout may be viewed here. A bargraph on the second line of this message represents speed from 0 RPM to rated speed.

If no digital input is configured as tachometer in S3 DIGITAL INPUTS, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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5.4.1 PARAMETER AVERAGES

	PARAMETER AVERAGES [ENTER] for more	
ENTER ⇨ ESCAPE ⇦	AVERAGE GENERATOR LOAD: 100% FLA	RANGE: 0 - 2000
ESCAPE MESSAGE ⇳	AVERAGE NEG. SEQ. CURRENT: 0% FLA	RANGE: 0 - 2000
ESCAPE MESSAGE ⇧	AVERAGE PHASE-PHASE VOLTAGE: 0 V	RANGE: 0 - 50000 NOTE: this message is not seen if the VT connection is programmed as 'None'

DESCRIPTION:

The 489 calculates the average magnitude of several parameters over a period of time. This time is specified by the setpoint in the preferences section of S1 489 SETUP (default 15 minutes). The calculation is a sliding window and is ignored when the generator is offline. (ie. the value that was calculated just prior to going offline will be held until the generator is brought back online and a new calculation is made. Parameter averages will not update if a digital input programmed as Test Input is shorted.

5.4.2 RTD MAXIMUMS

	RTD MAXIMUMS [ENTER] for more	
ENTER ⇨ ESCAPE ⇦	RTD #1 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #2 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #3 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #4 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #5 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #6 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #7 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #8 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #9 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #10 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇳	RTD #11 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed
ESCAPE MESSAGE ⇧	RTD#12 MAX. TEMP.: 40° C	RANGE: -50 to +250 * Message not seen if RTD programmed as "None" * The first line of this message will reflect the RTD name as programmed

DESCRIPTION:

The 489 will learn the maximum temperature for each RTD. This information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. RTD maximums will not update if a digital input programmed as Test Input is shorted.

If no RTDs are programmed in S7 RTD TEMPERATURE, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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5.4.3 ANALOG IN MIN/MAX

ANALOG IN MIN/MAX
[ENTER] for more

ENTER ⇨ ⇦ ESCAPE	**Analog I/P 1** **MIN:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 1** **MAX:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 2** **MIN:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 2** **MAX:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 3** **MIN:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 3** **MAX:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇳	**Analog I/P 4** **MIN:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,
ESCAPE MESSAGE ⇧	**Analog I/P 4** **MAX:0 Units**	RANGE: -50000 to +50000 * Message not seen if analog input programmed as “None” *The message will reflect the Analog Input name and units as programmed,

DESCRIPTION:
The 489 will learn the Minimum and Maximum values of the analog inputs since they were last cleared. This information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. When the data is cleared, the present value of each analog input will be loaded as a starting point for both minimum and maximum. The name of the input and the units will reflect those programmed for each input. Analog Input minimums and maximums will not update if a digital input programmed as Test Input is shorted.

If no Analog Inputs are programmed in S11 ANALOG I/O, the following flash message will appear when an attempt is made to enter this group of messages.

THIS FEATURE NOT
PROGRAMMED

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5.5.1 TRIP COUNTERS

▌TRIP COUNTERS ▌[ENTER] for more	ENTER ⇨ ⇦ ESCAPE	TOTAL NUMBER OF TRIPS: 0	RANGE: 0 - 50000
	⇖ ESCAPE MESSAGE ⇳	DIGITAL INPUT TRIPS: 0	RANGE: 0 -50000 *Caused by General Input Trip Features
	⇖ ESCAPE MESSAGE ⇳	SEQUENTIAL TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	FIELD-BKR DISCREP. TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	TACHOMETER TRIPS: 0	RANGE: 0 -50000 *Caused by Assignable Digital Input Programmed as Tachometer
	⇖ ESCAPE MESSAGE ⇳	OFFLINE OVERCURRENT TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	PHASE OVERCURRENT TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	NEG.SEQ. OVERCURRENT TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	GROUND OVERCURRENT TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	PHASE DIFFERENTIAL TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	GROUND DIRECTIONAL TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	HIGH-SET PHASE O/C TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	UNDERVOLTAGE TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	OVERVOLTAGE TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	VOLTS/HERTZ TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	PHASE REVERSAL TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	UNDERFREQUENCY TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	OVERFREQUENCY TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	NEUTRAL O/V (Fund) TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	NEUTRAL U/V (3rd) TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	LOSS OF EXCITATION 1 TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	LOSS OF EXCITATION 2 TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	DISTANCE ZONE 1 TRIPS: 0	RANGE: 0 -50000
	⇖ ESCAPE MESSAGE ⇳	DISTANCE ZONE 2 TRIPS: 0	RANGE: 0 -50000

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⇖ ESCAPE MESSAGE ⇕	**REACTIVE POWER** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**REVERSE POWER** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**LOW FORWARD POWER** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**STATOR RTD** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**BEARING RTD** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**OTHER RTD** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**AMBIENT RTD** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**THERMAL MODEL** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**INADVERTENT ENERG.** **TRIPS: 0**	RANGE: 0 -50000
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 1** **TRIPS: 0**	RANGE: 0 -50000 *The message will reflect the Analog Input name and units as programmed,
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 2** **TRIPS: 0**	RANGE: 0 -50000 *The message will reflect the Analog Input name and units as programmed,
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 3** **TRIPS: 0**	RANGE: 0 -50000 *The message will reflect the Analog Input name and units as programmed,
⇖ ESCAPE MESSAGE ⇕	**Analog I/P 4** **TRIPS: 0**	RANGE: 0 - 100 *The message will reflect the Analog Input name and units as programmed,
⇖ ESCAPE MESSAGE ⇧	**COUNTERS CLEARED:** **Jan 1, 1995**	

DESCRIPTION: A breakdown of number of trips by type is displayed here. When the Total reaches 50000, all counters reset. This information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. Trip counters will not update if a digital input programmed as Test Input is shorted. In the event of multiple trips, the only the first trip will increment the trip counters.

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5.5.2 GENERAL COUNTERS

▌GENERAL COUNTERS
▌[ENTER] for more

ENTER ⇨ ESCAPE ⇦

NUMBER OF BREAKER
OPERATIONS: 0

RANGE: 0 -50000

ESCAPE ⇖ MESSAGE ⇧

NUMBER OF THERMAL
RESETS: 0

RANGE: 0 -50000
NOTE: this message is seen only one of the assignable digital inputs is assigned to thermal reset

DESCRIPTION:

One of the 489 general counters will count the number of breaker operations over time. This may be useful information for breaker maintenance. The number of breaker operations is incremented whenever the breaker status changes from closed to open and all phase currents are zero. Another counter counts the number of thermal resets if one of the assignable digital inputs is assigned to thermal reset. This may be useful information when troubleshooting. When either of these counters reaches 50000, that counter will reset to 0. Each counter can also be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. Number of breaker operations will not update if a digital input programmed as Test Input is shorted.

5.5.3 TIMERS

▌TIMERS
▌[ENTER] for more

ENTER ⇨ ESCAPE ⇦

GENERATOR HOURS
ONLINE: 0 h

RANGE: 0 - 1000000

DESCRIPTION:

The 489 accumulates the total online time for the generator. This may be useful for scheduling routine maintenance. When this timer reaches 1 000 000, it will reset to 0. This timer can be cleared using the setpoints in S1 489 SETUP under CLEAR DATA. Generator hours online will not update if a digital input programmed as Test Input is shorted.

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5.6.1 EVENT RECORDER

▌[ENTER] for E65535
No Event

ENTER ESCAPE	TIME OF E65535: 00:00:00.0	RANGE: Hour/Min/Sec NOTE: this message is seen only if there has been a event
ESCAPE MESSAGE	DATE OF E65535: Jan. 01, 1992	RANGE: Mon/Day/Year NOTE: this message is seen only if there has been a event
ESCAPE MESSAGE	ACTIVE SETPOINT GROUP E65535: 1	RANGE: 1-2
ESCAPE MESSAGE	TACHOMETER E65535: 3600 RPM	RANGE: 0-3600 NOTE: this message is seen only if the function is assigned an input
ESCAPE MESSAGE	A: 0 B: 0 C: 0 A E65535	RANGE: 0-999999 NOTE: this message represents current measured from the output CTs, seen only if there has been a event
ESCAPE MESSAGE	a: 0 b: 0 c: 0 DA E65535	RANGE: 0 - 999999 NOTE: this message seen only if the differential element is enabled and represents differential current
ESCAPE MESSAGE	NEG. SEQ. CURRENT E65535: 0 % FLA	RANGE: 0 -2000 NOTE: this message is seen only if there has been a event
ESCAPE MESSAGE	GROUND CURRENT E65535: 0.00 A	RANGE: 0.00- 20000.00 NOTE: this message not seen if the ground CT is programmed as 'None'
ESCAPE MESSAGE	Vab: 0 Vbc: 0 Vca: 0 V E65535	RANGE: 0-50000 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	FREQUENCY E65535: 0.00 Hz	RANGE: 0.00 - 90.00 NOTE: This message is not seen if VT Connection is programmed as 'None'
ESCAPE MESSAGE	NEUTRAL VOLT (FUND) E65535: 0.0 V	RANGE: 0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
ESCAPE MESSAGE	NEUTRAL VOLT (3rd) E65535: 0.0 V	RANGE: 0 - 25000.0 NOTE: This message seen only if there is a neutral voltage transformer
ESCAPE MESSAGE	Vab/Iab E65535: 0.0 Ω sec 0°	RANGE: 0.0 - 6553.5 Ω sec RANGE: 0 - 359° NOTE: This message seen only if Loss of Excitation element is Enabled.
ESCAPE MESSAGE	REAL POWER (MW) E65535: 0.000	RANGE: 0 to ±2000.000 NOTE: This message is not seen if VT Connection is 'None'
ESCAPE MESSAGE	REACTIVE POWER Mvar E65535: 0.000	RANGE: 0 to ±2000.000 NOTE: This message is not seen if VT Connection is 'None'
ESCAPE MESSAGE	APPARENT POWER MVA E65535: 0.000	RANGE: 0 to 2000.000 NOTE: This message is not seen if VT Connection is 'None'
ESCAPE MESSAGE	HOTTEST STATOR RTD#1: 0°C E65535	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'STATOR'
ESCAPE MESSAGE	HOTTEST BEARING RTD#7: 0°C E65535	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'BEARING'
ESCAPE MESSAGE	HOTTEST OTHER RTD#11: 0°C E65535	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'OTHER'
ESCAPE MESSAGE	AMBIENT RTD#12: 0°C E65535	RANGE: -50 to +250 NOTE: this message seen only if at least 1 RTD is programmed as 'AMBIENT'
ESCAPE MESSAGE	ANALOG INPUT 1 E65535: 0 Units	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
ESCAPE MESSAGE	ANALOG INPUT 2 E65535: 0 Units	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
ESCAPE MESSAGE	ANALOG INPUT 3 E65535: 0 Units	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use
ESCAPE MESSAGE	ANALOG INPUT 4 E65535: 0 Units	RANGE: -50000 to +50000 NOTE: This message seen only if the Analog Input is in use

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DESCRIPTION:

The 489 Event Recorder stores generator and system information each time an event occurs. The description of the event is stored and a time and date stamp is also added to the record. This allows reconstruction of the sequence of events for troubleshooting. Events include: all trips, any alarm optionally (except Service Alarm, and 489 Not Inserted Alarm, which always records as events), loss of control power, application of control power, thermal resets, simulation, serial communication starts/stops and general input control functions optionally.

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The highest event number is the most recent event, and lowest event number is the oldest event. Each new event bumps the other event records down until the 40th event is reached. The 40th event record is lost when the next event occurs. This information can be cleared using the setpoint in S1 489 SETUP under CLEAR DATA. An event number of 65535 signifies that no event has occurred since the last clearing of the event record. The event record will not update if a digital input programmed as Test Input is shorted.

Table 5-2 CAUSE OF EVENT TABLE

TRIPS	ALARMS (optional events)	OTHER
*Input A Trip	*Input A Alarm	Service Alarm
*Input B Trip	*Input B Alarm	Control Power Lost
*Input C Trip	*Input C Alarm	Control Power Applied
*Input D Trip	*Input D Alarm	Thermal Reset Close
*Input E Trip	*Input E Alarm	Thermal Reset Open
*Input F Trip	*Input F Alarm	Serial Comm. Start
*Input G Trip	*Input G Alarm	Serial Comm. Stop
Sequential Trip	Tachometer Alarm	489 Not Inserted
Fld-Bkr Discr. Trip	Overcurrent Alarm	Simulation Started
Tachometer Trip	NegSeq Current Alarm	Simulation Stopped
Offline O/C Trip	Ground O/C Alarm	*Input A Control
Phase O/C Trip	Undervoltage Alarm	*Input B Control
Neg. Seq. O/C Trip	Overvoltage Alarm	*Input C Control
Ground O/C Trip	Volts/Hertz Alarm	*Input D Control
Differential Trip	Underfrequency Alarm	*Input E Control
Undervoltage Trip	Overfrequency Alarm	*Input F Control
Overvoltage Trip	Neutral O/V Alarm	*Input G Control
Phase Reversal Trip	Neut. U/V 3rd Alarm	Setpoint 1 Active
Volts/Hertz Trip	Reactive Power Alarm	Setpoint 2 Active
Underfrequency Trip	Reverse Power Alarm	Dig I/P Waveform Trig
Overfrequency Trip	Low Fwd Power Alarm	Serial Waveform Trig
Neutral O/V Trip	*Stator RTD 1 Alarm	IRIG-B Failure
Neut. U/V (3rd)Trip	*Stator RTD 2 Alarm	
Reactive Factor Trip	*Stator RTD 3 Alarm	
Reverse Power Trip	*Stator RTD 4 Alarm	
Low Fwd Power Trip	*Stator RTD 5 Alarm	
*Stator RTD 1 Trip	*Stator RTD 6 Alarm	
*Stator RTD 2 Trip	*Bearing RTD 7 Alarm	
*Stator RTD 3 Trip	*Bearing RTD 8 Alarm	
*Stator RTD 4 Trip	*Bearing RTD 9 Alarm	
*Stator RTD 5 Trip	*Bearing RTD10 Alarm	
*Stator RTD 6 Trip	*RTD11 Alarm	
*Bearing RTD 7 Trip	*Ambient RTD12 Alarm	
*Bearing RTD 8 Trip	Open RTD Alarm	
*Bearing RTD 9 Trip	Short/Low RTD Alarm	
*Bearing RTD10 Trip	Trip Counter Alarm	
*RTD11 Trip	Breaker Failure	
*Ambient RTD12 Trip	Trip Coil Monitor	
Thermal Model Trip	VT Fuse Fail Alarm	
*Analog I/P 1 Trip	Current Demand Alarm	
*Analog I/P 2 Trip	MW Demand Alarm	
*Analog I/P 3 Trip	Mvar Demand Alarm	
*Analog I/P 4 Trip	MVA Demand Alarm	
Loss of Excitation 1	Thermal Model Alarm	
Loss of Excitation 2	*Analog I/P 1 Alarm	
Gnd. Directional Trip	*Analog I/P 2 Alarm	
Hiset Phase O/C Trip	*Analog I/P 3 Alarm	
Distance Zone 1 Trip	*Analog I/P 4 Alarm	
Distance Zone 2 Trip	Gnd. Directional Alarm	* will reflect the name that is programmed

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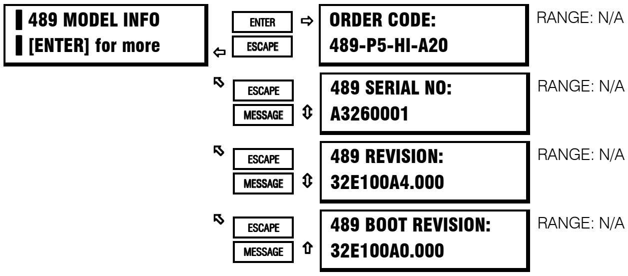
5.7.1 489 MODEL INFO



▌489 MODEL INFO
▌[ENTER] for more

ORDER CODE:
489-P5-HI-A20
RANGE: N/A

489 SERIAL NO:
A3260001
RANGE: N/A

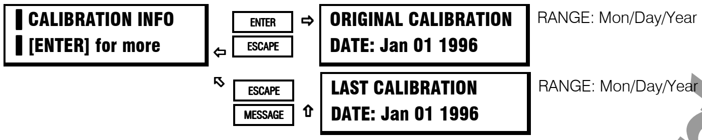
489 REVISION:
32E100A4.000
RANGE: N/A

489 BOOT REVISION:
32E100A0.000
RANGE: N/A

DESCRIPTION:

All of the 489 Model information may be viewed here when the unit is powered up. In the event of a product software upgrade or service question, the information shown here should be jotted down prior to any inquiry.

5.7.2 CALIBRATION INFO



▌CALIBRATION INFO
▌[ENTER] for more

ORIGINAL CALIBRATION
DATE: Jan 01 1996
RANGE: Mon/Day/Year

LAST CALIBRATION
DATE: Jan 01 1996
RANGE: Mon/Day/Year

DESCRIPTION:

The date of the original calibration and last calibration may be viewed here.

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5.8.1 DIAGNOSTIC MESSAGES FOR OPERATORS

In the event of a trip or alarm, some of the actual value messages are very helpful in diagnosing the cause of the condition. The 489 will automatically default to the most important message. The hierarchy is trip and pretrip messages, then alarm messages. In order to simplify things for the operator, the Message LED (indicator) will flash prompting the operator to press the [NEXT] key. When the [NEXT] key is pressed, the 489 will automatically display the next relevant message and continue to cycle through the messages with each keypress. When all of these conditions have cleared, the 489 will revert back to the normal default messages.

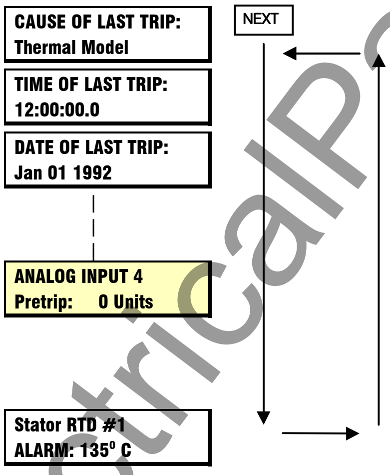
Any time the 489 is not displaying the default messages because other actual value or setpoint messages are being viewed and there are no trips or alarms, the Message LED (indicator) will be on solid. From any point in the message structure, pressing the [NEXT] key will cause the 489 to revert back to the normal default messages. When normal default messages are being displayed, pressing the [NEXT] will cause the 489 to display the next default message immediately.

EXAMPLE:

If a thermal model trip occurred, an RTD alarm may also occur as a result of the overload. The 489 would automatically default to the Cause of Last Trip Message at the top of the LAST TRIP DATA queue of A1 ACTUAL VALUES. The Message LED (indicator) would flash. Pressing the [NEXT] key would cycle through the time and date stamp information as well as all of the pre-trip data. When the bottom of this queue is reached, an additional press of the [NEXT] key would normally return to the top of the queue . However, because there is an alarm active, the display will skip to the alarm message at the top of the ALARM STATUS queue of A1 ACTUAL VALUES. Finally, another press of the [NEXT] key will cause the 489 to return to the original Cause of Last Trip message, and the cycle could be repeated.

When the [RESET] has been pressed and the hot RTD condition is no longer present, the display will revert back to the normal default messages.

LAST TRIP DATA



CAUSE OF LAST TRIP:
Thermal Model

TIME OF LAST TRIP:
12:00:00.0

DATE OF LAST TRIP:
Jan 01 1992

*Pre-Trip data for any measured parameter that is enabled.

ANALOG INPUT 4
Pretrip: 0 Units

ACTIVE ALARMS

Stator RTD #1
ALARM: 135^{0} C

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5.8.2 FLASH MESSAGES

Flash messages are warning, error, or general information messages that are temporarily displayed in response to certain key presses. These messages are intended to assist with navigation of the 489 messages by explaining what has happened or by prompting the user to perform certain actions.

Table 5-3 FLASH MESSAGES

NEW SETPOINT HAS BEEN STORED	ROUNDED SETPOINT HAS BEEN STORED	* OUT OF RANGE! ENTER: ####-##### by #	ACCESS DENIED, SHORT ACCESS SWITCH	ACCESS DENIED, ENTER PASSCODE
INVALID PASSCODE ENTERED !	NEW PASSCODE HAS BEEN ACCEPTED	PASSCODE SECURITY NOT ENABLED, ENTER 0	PLEASE ENTER A NON-ZERO PASSCODE	SETPOINT ACCESS IS NOW PERMITTED
SETPOINT ACCESS IS NOW RESTRICTED	DATE ENTRY WAS NOT COMPLETE	DATE ENTRY OUT OF RANGE	TIME ENTRY WAS NOT COMPLETE	TIME ENTRY OUT OF RANGE
NO TRIPS OR ALARMS TO RESET	RESET PERFORMED SUCCESSFULLY	ALL POSSIBLE RESETS HAVE BEEN PERFORMED	CONDITION IS PRESENT RESET NOT POSSIBLE	ARE YOU SURE? PRESS [ENTER] TO VERIFY
PRESS [ENTER] TO ADD DEFAULT MESSAGE	DEFAULT MESSAGE HAS BEEN ADDED	DEFAULT MESSAGE LIST IS FULL	PRESS [ENTER] TO REMOVE MESSAGE	DEFAULT MESSAGE HAS BEEN REMOVED
DEFAULT MESSAGES 6 of 20 ARE ASSIGNED	INVALID SERVICE CODE ENTERED	KEY PRESSED IS INVALID HERE	DATA CLEARED SUCCESSFULLY	[.] KEY IS USED TO ADVANCE THE CURSOR
TOP OF PAGE	END OF PAGE	TOP OF LIST	END OF LIST	NO ALARMS ACTIVE
THIS FEATURE NOT PROGRAMMED	THIS PARAMETER IS ALREADY ASSIGNED	THAT INPUT ALREADY USED FOR TACHOMETER	TACHOMETER MUST USE INPUT 4, 5, 6 OR 7	THAT DIGITAL INPUT IS ALREADY IN USE

NEW SETPOINT HAS BEEN STORED: This message appear each time a setpoint has been altered and stored as shown on the display.

ROUNDED SETPOINT HAS BEEN STORED: Since the 489 has a numeric keypad, a setpoint value may entered that is in between valid setpoint values. The 489 will detect this condition and store a value that has been rounded to the nearest valid setpoint value. To find the valid range and step for a given setpoint, simply press the [HELP] key while the setpoint is being displayed.

OUT OF RANGE! ENTER: #### - ##### by #: If a setpoint value that is outside of the acceptable range of values is entered, the 489 will display this message, substituting the proper values for that setpoint. An appropriate value may then be entered.

ACCESS DENIED, SHORT ACCESS SWITCH: In order to store any setpoint values, the Access Switch must be shorted. If this message appears and it is necessary to change a setpoint, short the Access terminals C1 & C2.

ACCESS DENIED, ENTER PASSCODE: The 489 has a PASSCODE SECURITY feature. If that feature has been enabled, not only do the Access Switch terminals have to be shorted, but the Passcode must also be entered. If the correct passcode has been lost or forgotten, contact the factory with the Encrypted access code. All passcode features may be found in S1 489 SETUP under PASSCODE.

INVALID PASSCODE ENTERED: If an invalid passcode is entered for passcode security feature, this message will flash on the display.

NEW PASSCODE HAS BEEN ACCEPTED: When changing the Passcode for the Passcode Security feature, this message will appear as an acknowledge that the new passcode has been accepted.

PASSCODE SECURITY NOT ENABLED, ENTER 0: The Passcode Security feature is disabled whenever the passcode is zero (factory default). Any attempts to enter a passcode when the feature is disabled will result in this flash message. It is meant to prompt the user to enter 0 as the passcode. When this has been done, the feature may be enabled by entering a non-zero passcode.

PLEASE ENTER A NON-ZERO PASSCODE: If the passcode is zero, the passcode security feature is disabled. If the Change Passcode Setpoint is entered as yes, this flash message will appear prompting the user to enter a non-zero passcode which in turn will enable the feature.

SETPOINT ACCESS IS NOW PERMITTED: Any time that the Passcode Security feature is enabled and a valid passcode is entered, this flash message will appear to notify that the Setpoint s may now be altered and stored.

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SETPOINT ACCESS IS NOW RESTRICTED: IF the passcode security feature is enabled and a valid passcode has been entered, when the setpoint under S1 489 SETUP, PASSCODE, SETPOINT ACCESS: is altered to ‘Restricted’, this message will appear. Also, any time that Setpoint access is permitted and the access jumper is removed, this message will also appear.

DATE ENTRY WAS NOT COMPLETE: Since the Date setpoint is special, consisting of MM/DD/YYYY, if the enter key is pressed before all of the information has been entered, this message will appear and the new value will not be store. Another attempt will have to be made with the complete information.

DATE ENTRY WAS OUT OF RANGE: If and invalid entry is made for the date (eg. 15 entered for month), this message will appear.

TIME ENTRY WAS NOT COMPLETE: Since the Time setpoint is special, consisting of HH/MM/SS.S, if the enter key is pressed before all of the information has been entered, this message will appear and the new value will not be store. Another attempt will have to be made with the complete information.

TIME ENTRY WAS OUT OF RANGE: If and invalid entry is made for the time (eg. 35 entered for hour), this message will appear.

NO TRIPS OR ALARMS TO RESET: If the [RESET] key is pressed when there are no trips or alarms present, this message will appear.

RESET PERFORMED SUCCESSFULLY: If all trip and alarm features that are active can be cleared (i.e. the conditions that caused these trips and/or alarms are no longer present), then this message will appear when a RESET is performed, indicating that all trips and alarms have been cleared.

ALL POSSIBLE RESETS HAVE BEEN PERFORMED: If only some of the trip and alarm features that are active can be cleared (ie. the conditions that caused some of these trips and/or alarms are still present), then this message will appear when a RESET is performed, indicating that only trips and alarms that could be reset have been reset.

CONDITION IS PRESENT RESET NOT POSSIBLE: If no trip and alarm features that are active can be cleared (ie. the condition that caused these trips and/or alarms is still present), then this message will appear when the [RESET] key is pressed.

ARE YOU SURE? PRESS [ENTER] TO VERIFY: If the [RESET] key is pressed and resetting of any trip or alarm feature is possible, this message will appear to ask for verification of the operation. If [RESET] is pressed again while the message is still on the display, the reset will be performed.

PRESS [ENTER] TO ADD DEFAULT MESSAGE: Any where in the 489 Actual Value Message Structure, if the[.] key is pressed, immediately followed by the [ENTER] key. This message will appear to prompt the user to press [ENTER] to add a new default message. To add a new default message, [ENTER] must be pressed while this message is being displayed.

DEFAULT MESSAGE HAS BEEN ADDED: Any time a new default message is added to the Default message list, this message will appear as verification.

DEFAULT MESSAGE LIST IS FULL: If an attempt is made to add a new default message to the default message list when 20 messages are already assigned, this message will appear. In order to add a message, one of the existing messages must be removed.

PRESS [ENTER] TO REMOVE MESSAGE: Under S1 489 SETUP, DEFAULT MESSAGES, if the[.] key is pressed, immediately followed by the [ENTER] key, this message will appear to prompt the user to press [ENTER] to remove a default message. To remove the default message, [ENTER] must be pressed while this message is being displayed.

DEFAULT MESSAGE HAS BEEN REMOVED: Any time a default message is removed from the Default message list, this message will appear as verification.

DEFAULT MESSAGES 6 of 20 ARE ASSIGNED: This message will appear each time the DEFAULT MESSAGES subgroup of S1 489 SETUP is entered. It is intended to notify the user of the number of default messages that are assigned.

INVALID SERVICE CODE ENTERED: Under S12 489 TESTING, FACTORY SERVICE, if an invalid code is entered, this message will appear.

KEY PRESSED HERE IS INVALID: Under certain situations, certain keys have no function (eg. any number key while viewing Actual Values). If a key is pressed where it should have no function, this message will appear.

DATA CLEARED SUCCESSFULLY: Under S1 489 SETUP, CLEAR DATA, if data is cleared or reset, this message will appear to confirm that action.

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[.] KEY IS USED TO ADVANCE THE CURSOR: Any time a setpoint that requires text editing is viewed, this message will appear immediately to prompt the user to use the [.] key for cursor control. If the setpoint is not altered for 1 minute, the message will flash again.

TOP OF PAGE: This message will indicate when the top of a page has been reached.

BOTTOM OF PAGE: This message will indicate when the bottom of a page has been reached.

TOP OF LIST: This message will indicate when the top of subgroup has been reached.

BOTTOM OF LIST: This message will indicate when the bottom of a subgroup has been reached.

NO ALARMS ACTIVE: If an attempt is made to enter the Alarm Status message subgroup, but there are no active alarms, this message will appear.

THIS FEATURE NOT PROGRAMMED: If an attempt is made to enter an actual value message subgroup, when the setpoints are not configured for that feature, this message will appear.

THIS PARAMETER IS ALREADY ASSIGNED: A given analog output parameters can only be assigned to one output. If an attempt is made to assign a parameter to a second output, this message will appear.

THAT INPUT ALREADY USED FOR TACHOMETER: If a digital input is assigned to the tachometer function, it cannot be used for any other digital input function. If an attempt is made to assign a digital input to a function when it is already assigned to tachometer, this message will appear.

TACHOMETER MUST USE INPUT 4, 5, 6, or 7: Only digital inputs 4,5,6,or 7 may be used for the tachometer function. If an attempt is made to assign inputs 1,2,3, or 4 to the tachometer function, this message will appear.

THAT DIGITAL INPUT IS ALREADY IN USE: If an attempt is made to assign a digital input to tachometer when it is already assigned to another function, this message will appear.

To edit use VALUE UP or VALUE DOWN key: If a numeric key is pressed on a setpoint parameter that is not numeric, this message will prompt the user to use the value keys.

GROUP 1 SETPOINT HAS BEEN STORED: This message appear each time a setpoint has been altered and stored to setpoint Group 1 as shown on the display.

GROUP 2 SETPOINT HAS BEEN STORED: This message appear each time a setpoint has been altered and stored to setpoint Group 2 as shown on the display.

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6.1.1 ELECTRICAL INTERFACE

The hardware or electrical interface is one of the following: one of two 2-wire RS485 ports from the rear terminal connector or the RS232 from the front panel connector. In a 2-wire RS485 link, data flow is bi-directional. Data flow is half-duplex for both the RS485 and the RS232 ports. That is, data is never transmitted and received at the same time. RS485 lines should be connected in a daisy chain configuration (avoid star connections) with a terminating network installed at each end of the link, i.e. at the master end and at the slave farthest from the master. The terminating network should consist of a 120 Ohm resistor in series with a 1 nF ceramic capacitor when used with Belden 9841 RS485 wire. The value of the terminating resistors should be equal to the characteristic impedance of the line. This is approximately 120 Ohms for standard #22 AWG twisted pair wire. Shielded wire should always be used to minimize noise. Polarity is important in RS485 communications. Each '+' terminal of every 489 must be connected together for the system to operate. See chapter 2 INSTALLATION for details on correct serial port wiring.

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6.2.1 MODBUS RTU PROTOCOL

The 489 implements a subset of the AEG Modicon Modbus RTU serial communication standard. Many popular programmable controllers support this protocol directly with a suitable interface card allowing direct connection of relays. Although the Modbus protocol is hardware independent, the 489 interfaces include two 2-wire RS485 ports and one RS232 port. Modbus is a single master, multiple slave protocol suitable for a multi-drop configuration as provided by RS485 hardware. In this configuration up to 32 slaves can be daisy-chained together on a single communication channel.

The 489 is always a slave. It cannot be programmed as a master. Computers or PLCs are commonly programmed as masters. The Modbus protocol exists in two versions: Remote Terminal Unit (RTU, binary) and ASCII. Only the RTU version is supported by the 489. Monitoring, programming and control functions are possible using read and write register commands.

6.2.2 DATA FRAME FORMAT AND DATA RATE

One data frame of an asynchronous transmission to or from a 489 is default to 1 start bit, 8 data bits, and 1 stop bit. This produces a 10-bit data frame. This is important for transmission through modems at high bit rates (11 bit data frames are not supported by Hayes modems at bit rates of greater than 300 bps). The parity bit is optional as odd or even. If it is programmed as odd or even, the data frame consists of 1 start bit, 8 data bits, 1 parity bit, and 1 stop bit.

Modbus protocol can be implemented at any standard communication speed. The 489 RS485 ports support operation at 1200, 2400, 4800, 9600, and 19200 baud. The front panel RS232 baud rate is fixed at 9600 baud.

6.2.3 DATA PACKET FORMAT

A complete request/response sequence consists of the following bytes (transmitted as separate data frames):

Master Request Transmission:
SLAVE ADDRESS - 1 byte
FUNCTION CODE - 1 byte
DATA - variable number of bytes depending on FUNCTION CODE
CRC - 2 bytes

Slave Response Transmission:
SLAVE ADDRESS - 1 byte
FUNCTION CODE - 1 byte
DATA - variable number of bytes depending on FUNCTION CODE
CRC - 2 bytes

SLAVE ADDRESS - This is the first byte of every transmission. This byte represents the user-assigned address of the slave device that is to receive the message sent by the master. Each slave device must be assigned a unique address and only the addressed slave will respond to a transmission that starts with its address. In a master request transmission the SLAVE ADDRESS represents the address of the slave to which the request is being sent. In a slave response transmission the SLAVE ADDRESS represents the address of the slave that is sending the response. The RS-232 port ignores the slave address, so it will respond regardless of the value in the message. Note: A master transmission with a SLAVE ADDRESS of 0 indicates a broadcast command. Broadcast commands can be used for specific functions.

FUNCTION CODE - This is the second byte of every transmission. Modbus defines function codes of 1 to 127. The 489 implements some of these functions. In a master request transmission the FUNCTION CODE tells the slave what action to perform. In a slave response transmission if the FUNCTION CODE sent from the slave is the same as the FUNCTION CODE sent from the master indicating the slave performed the function as requested. If the high order bit of the FUNCTION CODE sent from the slave is a 1 (i.e. if the FUNCTION CODE is > 127) then the slave did not perform the function as requested and is sending an error or exception response.

DATA - This will be a variable number of bytes depending on the FUNCTION CODE. This may be Actual Values, Setpoints, or addresses sent by the master to the slave or by the slave to the master. Data is sent MSByte first followed by the LSByte.

CRC - This is a two byte error checking code. CRC is sent LSByte first followed by the MSByte.

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6.2.4 ERROR CHECKING

The RTU version of Modbus includes a two byte CRC-16 (16-bit cyclic redundancy check) with every transmission. The CRC-16 algorithm essentially treats the entire data stream (data bits only; start, stop and parity ignored) as one continuous binary number. This number is first shifted left 16 bits and then divided by a characteristic polynomial (11000000000000101B). The 16-bit remainder of the division is appended to the end of the transmission, LSByte first. The resulting message including CRC, when divided by the same polynomial at the receiver will give a zero remainder if no transmission errors have occurred.

If a 489 Modbus slave device receives a transmission in which an error is indicated by the CRC-16 calculation, the slave device will not respond to the transmission. A CRC-16 error indicates than one or more bytes of the transmission were received incorrectly and thus the entire transmission should be ignored in order to avoid the 489 performing any incorrect operation.

The CRC-16 calculation is an industry standard method used for error detection. An algorithm is included here to assist programmers in situations where no standard CRC-16 calculation routines are available.

CRC-16 Algorithm

Once the following algorithm is complete, the working register "A" will contain the CRC value to be transmitted. Note that this algorithm requires the characteristic polynomial to be reverse bit ordered. The MSbit of the characteristic polynomial is dropped since it does not affect the value of the remainder. The following symbols are used in the algorithm:

-->	data transfer
A	16 bit working register
AL	low order byte of A
AH	high order byte of A
CRC	16 bit CRC-16 value
i, j	loop counters
(+)	logical exclusive or operator
Di	i-th data byte (i = 0 to N-1)
G	16 bit characteristic polynomial = 1010000000000001 with MSbit dropped and bit order reversed
shr(x)	shift right (the LSbit of the low order byte of x shifts into a carry flag, a '0' is shifted into the MSbit of the high order byte of x, all other bits shift right one location

algorithm:

```
1.   FFFF hex --> A
2.   0 --> i
3.   0 --> j
4.   Di (+) AL --> AL
5.   j+1 --> j
6.   shr(A)
7.   is there a carry?      No: go to 8.
                            Yes: G (+) A --> A
8.   is j = 8?              No:  go to 5.
                            Yes: go to 9.
9.   i+1 --> i
10.  is i = N?              No:  go to 3.
                            Yes: go to 11.
11.  A --> CRC
```

6.2.5 TIMING

Data packet synchronization is maintained by timing constraints. The receiving device must measure the time between the reception of characters. If three and one half character times elapse without a new character or completion of the packet, then the communication link must be reset (i.e. all slaves start listening for a new transmission from the master). Thus at 9600 baud a delay of greater than 3.5 * 1/9600 * 10 = 3.65 ms will cause the communication link to be reset.

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6.3.1 SUPPORTED MODBUS FUNCTIONS

The following functions are supported by the 489:

03 - Read Setpoints and Actual Values
04 - Read Setpoints and Actual Values
05 - Execute Operation
06 - Store Single Setpoint
07 - Read Device Status
08 - Loopback Test
16 - Store Multiple Setpoints

6.3.2 FUNCTION CODES 03 AND 04 - READ SETPOINTS AND ACTUAL VALUES

Modbus implementation:	Read Input and Holding Registers
489 Implementation:	Read Setpoints and Actual Values

For the 489 implementation of Modbus, these commands can be used to read any Setpoint ("holding registers") or Actual Value ("input registers"). Holding and input registers are 16 bit (two byte) values transmitted high order byte first. Thus all 489 Setpoints and Actual Values are sent as two bytes. The maximum number of registers that can be read in one transmission is 125. Function codes 03 and 04 are configured to read setpoints or actual values interchangeably because some PLCs do not support both function codes.

The slave response to these function codes is the slave address, function code, a count of the number of data bytes to follow, the data itself and the CRC. Each data item is sent as a two-byte number with the high order byte sent first. The CRC is sent as a two-byte number with the low order byte sent first.

Message Format and Example:

Request slave 11 to respond with 2 registers starting at address 0235.
For this example the register data in these addresses is:

Address	*Data*
0235	*0064*
0236	*000A*

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	03	read registers
DATA STARTING ADDRESS	2	02	data starting at 0235
		35	
NUMBER OF SETPOINTS	2	00	2 registers (4 bytes total)
		02	
CRC	2	D5	CRC calculated by the master
		17	
Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	03	read registers
BYTE COUNT	1	04	2 registers = 4 bytes
DATA 1	2	00	value in address 0235
		64	
DATA 2	2	00	value in address 0236
		0A	
CRC	2	EB	CRC calculated by the slave
		91	

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6.3.3 FUNCTION CODE 05 - EXECUTE OPERATION

Modbus Implementation:	Force Single Coil
489 Implementation:	Execute Operation

This function code allows the master to request a 489 to perform specific command operations. The command numbers listed in the Commands area of the memory map correspond to operation code for function code 05.

The operation commands can also be initiated by writing to the Commands area of the memory map using function code 16. Refer to FUNCTION 16 - STORE MULTIPLE SETPOINTS for complete details.

<u>Supported Operations</u>

Reset 489 (operation code 1)
Generator Start (operation code 2)
Generator Stop (operation code 3)
Waveform Trigger (operation code 4)

<u>Message Format and Example:</u>

Reset 489 (operation code 1).

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	05	execute operation
OPERATION CODE	2	00 01	reset command (operation code 1)
CODE VALUE	2	FF 00	perform function
CRC	2	DD 50	CRC calculated by the master
Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	05	execute operation
OPERATION CODE	2	00 01	reset command (operation code 1)
CODE VALUE	2	FF 00	perform function
CRC	2	DD 50	CRC calculated by the slave

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6.3.4 FUNCTION CODE 06 - STORE SINGLE SETPOINT

Modbus Implementation:	Preset Single Register
489 Implementation:	Store Single Setpoint

This command allows the master to store a single setpoint into the memory of a 489. The slave response to this function code is to echo the entire master transmission.

Message Format and Example:

Request slave 11 to store the value 01F4 in Setpoint address 1180
After the transmission in this example is complete, Setpoints address 1180 will contain the value 01F4.

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	06	store single setpoint
DATA STARTING ADDRESS	2	11 80	Setpoint address 1180
DATA	2	01 F4	data for address 1180
CRC	2	8D A3	CRC calculated by the master

Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	06	store single Setpoint
DATA STARTING ADDRESS	2	11 80	Setpoint address 1180
DATA	2	01 F4	data stored in address 1180
CRC	2	8D A3	CRC calculated by the slave

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6.3.5 FUNCTION CODE 07 - READ DEVICE STATUS

Modbus Implementation: Read Exception Status
489 Implementation: Read Device Status

This is a function used to quickly read the status of a selected device. A short message length allows for rapid reading of status. The status byte returned has individual bits set to 1 or 0 depending on the status of the slave device.

489 General Status Byte:

LSBit B0: R1 Trip relay operated = 1
B1: R2 Auxiliary relay operated = 1
B2: R3 Auxiliary relay operated = 1
B3: R4 Auxiliary relay operated = 1
B4: R5 Alarm relay operated = 1
B5: R6 Service relay operated = 1
B6: Stopped = 1
MSBit B7: Running =1

Note: if status is neither stopped or running, generator is starting.

Message Format and Example:

Request status from slave 11.

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	07	read device status
CRC	2	47 42	CRC calculated by the master
Slave Response			
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	07	read device status
DEVICE STATUS	1	59	status = 01011001 in binary
CRC	2	C2 08	CRC calculated by the slave

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6.3.6 FUNCTION CODE 08 - LOOPBACK TEST

Modbus Implementation:	Loopback Test
489 Implementation:	Loopback Test

This function is used to test the integrity of the communication link. The 489 will echo the request.

Message Format and Example:

Loopback test from slave 11.

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	08	loopback test
DIAG CODE	2	00	must be 00 00
		00	
DATA	2	00	must be 00 00
		00	
CRC	2	E0	CRC calculated by the master
		A1	
Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	08	loopback test
DIAG CODE	2	00	must be 00 00
		00	
DATA	2	00	must be 00 00
		00	
CRC	2	E0	CRC calculated by the slave
		A1	

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6.3.7 FUNCTION CODE 16 - STORE MULTIPLE SETPOINTS

Modbus Implementation:	Preset Multiple Registers
489 Implementation:	Store Multiple Setpoints

This function code allows multiple Setpoints to be stored into the 489 memory. Modbus "registers" are 16 bit (two byte) values transmitted high order byte first. Thus all 489 setpoints are sent as two bytes. The maximum number of Setpoints that can be stored in one transmission is dependent on the slave device. Modbus allows up to a maximum of 60 holding registers to be stored. The 489 response to this function code is to echo the slave address, function code, starting address, the number of Setpoints stored, and the CRC.

Message Format and Example:

Request slave 11 to store the value 01F4 to Setpoint address 1180 and the value 0001 to setpoint address 1181. After the transmission in this example is complete, 489 slave 11 will have the following Setpoints information stored:

Address	*Data*
1180	*01F4*
1181	*0001*

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	10	store Setpoints
DATA STARTING ADDRESS	2	11	Setpoint address 1180
		80	
NUMBER OF SETPOINTS	2	00	2 Setpoints (4 bytes total)
		02	
BYTE COUNT	1	04	4 bytes of data
DATA 1	2	01	data for address 1180
		F4	
DATA 2	2	00	data for address 1181
		01	
CRC	2	9B	CRC calculated by the master
		89	

Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	10	store Setpoints
DATA STARTING ADDRESS	2	11	Setpoint address 1180
		80	
NUMBER OF SETPOINTS	2	00	2 setpoints
		02	
CRC	2	45	CRC calculated by the slave
		B6	

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6.3.8 FUNCTION CODE 16 - PERFORMING COMMANDS

Some PLCs may not support execution of commands using function code 5 but do support storing multiple setpoints using function code 16. To perform this operation using function code 16 (10H), a certain sequence of commands must be written at the same time to the 489. The sequence consists of: Command Function register, Command operation register and Command Data (if required). The Command Function register must be written with the value of 5 indicating an execute operation is requested. The Command Operation register must then be written with a valid command operation number from the list of commands shown in the memory map. The Command Data registers must be written with valid data if the command operation requires data. The selected command will execute immediately upon receipt of a valid transmission.

Message Format and Example:

Perform a reset on 489 (operation code 1).

Master Transmission	**Bytes**	**Example (hex)**	
SLAVE ADDRESS	1	0B	message for slave 11
FUNCTION CODE	1	10	store Setpoints
DATA STARTING ADDRESS	2	00 80	Setpoint address 0080
NUMBER OF SETPOINTS	2	00 02	2 Setpoints (4 bytes total)
BYTE COUNT	1	04	4 bytes of data
COMMAND FUNCTION	2	00 05	data for address 0080
COMMAND OPERATION	2	00 01	data for address 0081
CRC	2	0B D6	CRC calculated by the master
Slave Response			
SLAVE ADDRESS	1	0B	message from slave 11
FUNCTION CODE	1	10	store Setpoints
DATA STARTING ADDRESS	2	00 80	Setpoint address 0080
NUMBER OF SETPOINTS	2	00 02	2 setpoints
CRC	2	40 8A	CRC calculated by the slave

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6.4.1 ERROR RESPONSES

When a 489 detects an error other than a CRC error, a response will be sent to the master. The MSbit of the FUNCTION CODE byte will be set to 1 (i.e. the function code sent from the slave will be equal to the function code sent from the master plus 128). The following byte will be an exception code indicating the type of error that occurred.

Transmissions received from the master with CRC errors will be ignored by the 489.

The slave response to an error (other than CRC error) will be:

SLAVE ADDRESS	- 1 byte
FUNCTION CODE	- 1 byte (with MSbit set to 1)
EXCEPTION CODE	- 1 byte
CRC	- 2 bytes

The 489 implements the following exception response codes.

01 - ILLEGAL FUNCTION
The function code transmitted is not one of the functions supported by the 489.

02 - ILLEGAL DATA ADDRESS
The address referenced in the data field transmitted by the master is not an allowable address for the 489.

03 - ILLEGAL DATA VALUE
The value referenced in the data field transmitted by the master is not within range for the selected data address.

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6.5.1 MEMORY MAP INFORMATION

The data stored in the 489 is grouped as Setpoints and Actual Values. Setpoints can be read and written by a master computer. Actual Values are read only. All Setpoints and Actual Values are stored as two byte values. That is, each register address is the address of a two-byte value. Addresses are listed in hexadecimal. Data values (Setpoint ranges, increments, and factory values) are in decimal.

Note: Many Modbus communications drivers add 40001d to the actual address of the register addresses. For example: if address 0h was to be read, 40001d would be the address required by the Modbus communications driver; if address 320h (800d) was to be read, 40801d would be the address required by the Modbus communications driver.

6.5.2 USER DEFINABLE MEMORY MAP AREA

The 489 contains a User Definable area in the memory map. This area allows remapping of the addresses of all Actual Values and Setpoints registers. The User Definable area has two sections:

1. A Register Index area (memory map addresses 0180h-01FCh) that contains 125 Actual Values or Setpoints register addresses.
2. A Register area (memory map addresses 0100h-017Ch) that contains the data at the addresses in the Register Index.

Register data that is separated in the rest of the memory map may be remapped to adjacent register addresses in the User Definable Registers area. This is accomplished by writing to register addresses in the User Definable Register Index area. This allows for improved throughput of data and can eliminate the need for multiple read command sequences.

For example, if the values of Average Phase Current (register addresses 0412h and 0413h) and Hottest Stator RTD Temperature (register address 04A0h) are required to be read from an 489, their addresses may be remapped as follows:

1. Write 0412h to address 0180h (User Definable Register Index 0000) using function code 06 or 16.
2. Write 0413h to address 0181h (User Definable Register Index 0001) using function code 06 or 16.
   (Average Phase Current is a double register number)
3. Write 04A0h to address 0182h (User Definable Register Index 0001) using function code 06 or 16.

A read (function code 03 or 04) of registers 0100h (User Definable Register 0000) and 0101h (User Definable Register 0001) will return the Average Phase Current and register 0102h (User Definable Register 0002) will return the Hottest Stator RTD Temperature.

6.5.3 EVENT RECORDER

The 489 event recorder data starts at address 3000h. Address 3003h is the ID number of the event of interest (a high number representing the latest event and a low number representing the oldest event). Event numbers start at zero each time the event record is cleared, and count upwards. To retrieve event 1, write ‘1’ to the Event Record Selector (3003h) and read the data from 3004h to 30E7h. To retrieve event 2, write ‘2’ to the Event Record Selector (3003h) and read the data from 3004h to 30E7h. All 40 events may be retrieved in this manner. The time and date stamp of each event may be used to ensure that all events have been retrieved in order without new events corrupting the sequence of events (event 0 should be less recent than event 1, event 1 should be less recent than event 2, etc.).

If more than 40 events have been recorded since the last time the event record was cleared, the earliest events will not be accessible. For example, if 100 events have been recorded (i.e., the total events since last clear in register 3002h is 100), events 60 through 99 may be retrieved. Writing any other value to the event record selector (register 3003h) will result in an “invalid data value” error.

Each communications port can individually select the ID number of the event of interest by writing address 3003h. This way the front port, rear port and auxiliary port can read different events from the event recorder simultaneously.

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6.5.4 WAVEFORM CAPTURE

The 489 stores up to 64 cycles of A/D samples in a waveform capture buffer each time a trip occurs. The waveform capture buffer is time and date stamped and may therefore be correlated to a trip in the event record. To access the waveform capture memory, select the channel of interest by writing the number to the Waveform Capture Channel Selector (30F5h). Then read the waveform capture data from address 3100h-31BFh, and read the date, time and line frequency from addresses 30F0h-30F4h.

Each communications port can individually select a Waveform Channel Selector of interest by writing address 30F5h. This way the front port, rear port and auxiliary port can read different Waveform Channels simultaneously.

The channel selector must be one of the following values:

Value	Selected A/D samples	Scale Factor
0	Phase A line current	500 counts equals 1xCT primary
1	Phase B line current	500 counts equals 1xCT primary
2	Phase C line current	500 counts equals 1xCT primary
3	Neutral-end phase A current	500 counts equals 1xCT primary
4	Neutral-end phase B current	500 counts equals 1xCT primary
5	Neutral-end phase C current	500 counts equals 1xCT primary
6	Ground current	500 counts equals 1xCT primary or 1A for 50:0.025
7	Phase A to neutral voltage	2500 counts equals 120 secondary volts
8	Phase B to neutral voltage	2500 counts equals 120 secondary volts
9	Phase C to neutral voltage	2500 counts equals 120 secondary volts

6.5.5 DUAL SETPOINTS

Each communications port can individually select an Edit Setpoint Group of interest by writing address 1342h. This way the front port, rear port and auxiliary port can read and alter different setpoints simultaneously.

6.5.6 PASSCODE OPERATION

Each communications port can individually set the Passcode Access by writing address 88h with the correct Passcode. This way the front port, rear port and auxiliary port have individual access to the setpoints. Reading address 203h, COMMUNICATIONS SETPOINT ACCESS register, will provide the user with the current state of access for the given port. A value of 1 read from this register indicates that the user has full access rights to changing setpoints from the given port.

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489 MEMORY MAP

Addr	Name	Range	Step	Units	Fmt	Default

Product ID (Input Registers) -- Addresses 0000 to 007F

PRODUCT ID

Addr	Name	Range	Step	Units	Fmt	Default
0000	GE POWER MANAGEMENT PRODUCT DEVICE CODE	N/A	N/A	N/A	F1	32
0001	PRODUCT HARDWARE REVISION	1 to 26	1	N/A	F15	N/A
0002	PRODUCT SOFTWARE REVISION	N/A	N/A	N/A	F16	N/A
0003	PRODUCT MODIFICATION NUMBER	0 to 999	1	N/A	F1	N/A
0010	BOOT PROGRAM REVISION	N/A	N/A	N/A	F16	N/A
0011	BOOT PROGRAM MODIFICATION NUMBER	0 to 999	1	N/A	F1	N/A

MODEL ID

Addr	Name	Range	Step	Units	Fmt	Default
0040	ORDER CODE	0 to 16	1	N/A	F22	N/A
0050	489 REVISION	12	1	N/A	F22	N/A
0060	489 BOOT REVISION	12	1	N/A	F22	N/A

Commands (Holding Registers) -- Addresses 0080 to 00FF

COMMANDS

Addr	Name	Range	Step	Units	Fmt	Default
0080	COMMAND FUNCTION CODE (always 5)	5	N/A	N/A	F1	N/A
0081	COMMAND OPERATION CODE	0 to 65535	1	N/A	F1	N/A
0088	COMMUNICATIONS PORT PASSCODE	0 to 99999999	1	N/A	F12	0
00F0	TIME (BROADCAST)	N/A	N/A	N/A	F24	N/A
00F2	DATE (BROADCAST)	N/A	N/A	N/A	F18	N/A

User Map -- Addresses 0100 to 01FF

USER_MAP / USER MAP VALUES

Addr	Name	Range	Step	Units	Fmt	Default
0100	USER MAP VALUE #1 of 125...	5	N/A	N/A	F1	N/A
017C	USER MAP VALUE #125 of 125	5	N/A	N/A	F1	N/A

USER_MAP / USER MAP ADDRESSES

Addr	Name	Range	Step	Units	Fmt	Default
0180	USER MAP ADDRESS #1 of 125...	0 to 3FFF	1	hex	F1	0
01FC	USER MAP ADDRESS #125 of 125	0 to 3FFF	1	hex	F1	0

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Actual Values (Input Registers) -- Addresses 0200 to 0FFF

STATUS / GENERATOR STATUS

Addr	Name	Range	Step	Units	Fmt	Default
0200	GENERATOR STATUS	0 to 4	1	-	F133	1
0201	GENERATOR THERMAL CAPACITY USED	0 to 100	1	%	F1	0
0202	ESTIMATED TRIP TIME ON OVERLOAD	0 to 65535 [1]	1	s	F12	-1
0203	COMMUNICATIONS SETPOINT ACCESS	0 to 1	N/A	N/A	F126	N/A

STATUS / SYSTEM STATUS

0210	GENERAL STATUS	0 to 65535	1	N/A	F140	0
0211	OUTPUT RELAY STATUS	0 to 63	1	N/A	F141	0
0212	ACTIVE SETPOINT GROUP	0 to 1	1	N/A	F118	0

STATUS / LAST TRIP DATA

0220	CAUSE OF LAST TRIP	0 to 139	1	-	F134	0
0221	TIME OF LAST TRIP	N/A	N/A	N/A	F19	N/A
0223	DATE OF LAST TRIP	N/A	N/A	N/A	F18	N/A
0225	TACHOMETER PreTrip	0 to 7200	1	RPM	F1	0
0226	PHASE A PRE-TRIP CURRENT	0 to 999999	1	Amps	F12	0
0228	PHASE B PRE-TRIP CURRENT	0 to 999999	1	Amps	F12	0
022A	PHASE C PRE-TRIP CURRENT	0 to 999999	1	Amps	F12	0
022C	PHASE A PRE-TRIP DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
022E	PHASE B PRE-TRIP DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
0230	PHASE C PRE-TRIP DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
0232	NEG. SEQ. CURRENT PreTrip	0 to 2000	1	% FLA	F1	0
0233	GROUND CURRENT PreTrip	0 to 20000000	1	A	F14	0
0235	PRE-TRIP A-B VOLTAGE	0 to 50000	1	Volts	F1	0
0236	PRE-TRIP B-C VOLTAGE	0 to 50000	1	Volts	F1	0
0237	PRE-TRIP C-A VOLTAGE	0 to 50000	1	Volts	F1	0
0238	FREQUENCY Pretrip	0 to 12000	1	Hz	F3	0
023B	REAL POWER (MW) PreTrip	-2000000 to 2000000	1	MW	F13	0
023D	REACTIVE POWER Mvar PreTrip	-2000000 to 2000000	1	Mvar	F13	0
023F	APPARENT POWER MVA PreTrip	0 to 2000000	1	MVA	F13	0
0241	LAST TRIP DATA STATOR RTD	1 to 12	1	-	F1	1
0242	HOTTEST STATOR RTD TEMPERATURE	-50 to 250	1	°C	F4	0
0243	LAST TRIP DATA BEARING RTD	1 to 12	1	-	F1	1
0244	HOTTEST BEARING RTD TEMPERATURE	-50 to 250	1	°C	F4	0
0245	LAST TRIP DATA OTHER RTD	1 to 12	1	-	F1	1
0246	HOTTEST OTHER RTD TEMPERATURE	-50 to 250	1	°C	F4	0
0247	LAST TRIP DATA AMBIENT RTD	1 to 12	1	-	F1	1
0248	HOTTEST AMBIENT RTD TEMPERATURE	-50 to 250	1	°C	F4	0
0249	ANALOG IN 1 PreTrip	-50000 to 50000	1	Units	F12	0
024B	ANALOG IN 2 PreTrip	-50000 to 50000	1	Units	F12	0
024D	ANALOG IN 3 PreTrip	-50000 to 50000	1	Units	F12	0
024F	ANALOG IN 4 PreTrip	-50000 to 50000	1	Units	F12	0
025C	HOTTEST STATOR RTD TEMPERATURE	-50 to 250	1	°F	F4	0
025D	HOTTEST BEARING RTD TEMPERATURE	-50 to 250	1	°F	F4	0
025E	HOTTEST OTHER RTD TEMPERATURE	-50 to 250	1	°F	F4	0
025F	HOTTEST AMBIENT RTD TEMPERATURE	-50 to 250	1	°F	F4	0
0260	NEUTRAL VOLT FUND PreTrip	0 to 250000	1	Volts	F10	0
0262	NEUTRAL VOLT 3rd PreTrip	0 to 250000	1	Volts	F10	0
0264	PRE-TRIP Vab/Iab	0 to 65535	1	ohms s	F2	0
0265	PRE-TRIP Vab/Iab ANGLE	0 to 359	1	°	F1	0

STATUS / TRIP PICKUPS

0280	INPUT A PICKUP	0 to 4	1	-	F123	0
0281	INPUT B PICKUP	0 to 4	1	-	F123	0
0282	INPUT C PICKUP	0 to 4	1	-	F123	0
0283	INPUT D PICKUP	0 to 4	1	-	F123	0
0284	INPUT E PICKUP	0 to 4	1	-	F123	0
0285	INPUT F PICKUP	0 to 4	1	-	F123	0
0286	INPUT G PICKUP	0 to 4	1	-	F123	0

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[1] Value of 65535 indicates ‘Never’

Actual Values (Input Registers) -- Addresses 0200 to 0FFF

Addr	Name	Range	Step	Units	Fmt	Default
0287	SEQUENTIAL TRIP PICKUP	0 to 4	1	-	F123	0
0288	FIELD-BKR DISCREP. PICKUP	0 to 4	1	-	F123	0
0289	TACHOMETER PICKUP	0 to 4	1	-	F123	0
028A	OFFLINE OVERCURRENT PICKUP	0 to 4	1	-	F123	0
028B	INADVERTENT ENERG. PICKUP	0 to 4	1	-	F123	0
028C	PHASE OVERCURRENT PICKUP	0 to 4	1	-	F123	0
028D	NEG.SEQ. OVERCURRENT PICKUP	0 to 4	1	-	F123	0
028E	GROUND OVERCURRENT PICKUP	0 to 4	1	-	F123	0
028F	PHASE DIFFERENTIAL PICKUP	0 to 4	1	-	F123	0
0290	UNDERVOLTAGE PICKUP	0 to 4	1	-	F123	0
0291	OVERVOLTAGE PICKUP	0 to 4	1	-	F123	0
0292	VOLTS/HERTZ PICKUP	0 to 4	1	-	F123	0
0293	PHASE REVERSAL PICKUP	0 to 4	1	-	F123	0
0294	UNDERFREQUENCY PICKUP	0 to 4	1	-	F123	0
0295	OVERFREQUENCY PICKUP	0 to 4	1	-	F123	0
0296	NEUTRAL O/V (FUND) PICKUP	0 to 4	1	-	F123	0
0297	NEUTRAL U/V (3rd) PICKUP	0 to 4	1	-	F123	0
0298	REACTIVE POWER PICKUP	0 to 4	1	-	F123	0
0299	REVERSE POWER PICKUP	0 to 4	1	-	F123	0
029A	LOW FORWARD POWER PICKUP	0 to 4	1	-	F123	0
029B	THERMAL MODEL PICKUP	0 to 4	1	-	F123	0
029C	RTD #1 PICKUP	0 to 4	1	-	F123	0
029D	RTD #2 PICKUP	0 to 4	1	-	F123	0
029E	RTD #3 PICKUP	0 to 4	1	-	F123	0
029F	RTD #4 PICKUP	0 to 4	1	-	F123	0
02A0	RTD #5 PICKUP	0 to 4	1	-	F123	0
02A1	RTD #6 PICKUP	0 to 4	1	-	F123	0
02A2	RTD #7 PICKUP	0 to 4	1	-	F123	0
02A3	RTD #8 PICKUP	0 to 4	1	-	F123	0
02A4	RTD #9 PICKUP	0 to 4	1	-	F123	0
02A5	RTD #10 PICKUP	0 to 4	1	-	F123	0
02A6	RTD #11 PICKUP	0 to 4	1	-	F123	0
02A7	RTD #12 PICKUP	0 to 4	1	-	F123	0
02A8	Analog I/P 1 PICKUP	0 to 4	1	-	F123	0
02A9	Analog I/P 2 PICKUP	0 to 4	1	-	F123	0
02AA	Analog I/P 3 PICKUP	0 to 4	1	-	F123	0
02AB	Analog I/P 4 PICKUP	0 to 4	1	-	F123	0
02AC	LOSS OF EXCITATION 1 PICKUP	0 to 4	1	-	F123	0
02AD	LOSS OF EXCITATION 2 PICKUP	0 to 4	1	-	F123	0
02AE	GROUND DIRECTIONAL PICKUP	0 to 4	1	-	F123	0
02AF	HIGH-SET PHASE O/C PICKUP	0 to 4	1	-	F123	0
02B0	DISTANCE ZONE 1 PICKUP	0 to 4	1	-	F123	0
02B1	DISTANCE ZONE 2 PICKUP	0 to 4	1	-	F123	0

STATUS / ALARM PICKUPS

Addr	Name	Range	Step	Units	Fmt	Default
0300	INPUT A PICKUP	0 to 4	1	-	F123	0
0301	INPUT B PICKUP	0 to 4	1	-	F123	0
0302	INPUT C PICKUP	0 to 4	1	-	F123	0
0303	INPUT D PICKUP	0 to 4	1	-	F123	0
0304	INPUT E PICKUP	0 to 4	1	-	F123	0
0305	INPUT F PICKUP	0 to 4	1	-	F123	0
0306	INPUT G PICKUP	0 to 4	1	-	F123	0
0307	TACHOMETER PICKUP	0 to 4	1	-	F123	0
0308	OVERCURRENT PICKUP	0 to 4	1	-	F123	0
0309	NEG SEQ OVERCURRENT PICKUP	0 to 4	1	-	F123	0
030A	GROUND OVERCURRENT PICKUP	0 to 4	1	-	F123	0
030B	UNDERVOLTAGE PICKUP	0 to 4	1	-	F123	0
030C	OVERVOLTAGE PICKUP	0 to 4	1	-	F123	0
030D	VOLTS/HERTZ PICKUP	0 to 4	1	-	F123	0
030E	UNDERFREQUENCY PICKUP	0 to 4	1	-	F123	0
030F	OVERFREQUENCY PICKUP	0 to 4	1	-	F123	0
0310	NEUTRAL O/V (FUND) PICKUP	0 to 4	1	-	F123	0
0311	NEUTRAL U/V (3rd) PICKUP	0 to 4	1	-	F123	0
0312	REACTIVE POWER PICKUP	0 to 4	1	-	F123	0
0313	REVERSE POWER PICKUP	0 to 4	1	-	F123	0

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Actual Values (Input Registers) -- Addresses 0200 to 0FFF

Addr	Name	Range	Step	Units	Fmt	Default
0314	LOW FORWARD POWER PICKUP	0 to 4	1	-	F123	0
0315	RTD #1 PICKUP	0 to 4	1	-	F123	0
0316	RTD #2 PICKUP	0 to 4	1	-	F123	0
0317	RTD #3 PICKUP	0 to 4	1	-	F123	0
0318	RTD #4 PICKUP	0 to 4	1	-	F123	0
0319	RTD #5 PICKUP	0 to 4	1	-	F123	0
031A	RTD #6 PICKUP	0 to 4	1	-	F123	0
031B	RTD #7 PICKUP	0 to 4	1	-	F123	0
031C	RTD #8 PICKUP	0 to 4	1	-	F123	0
031D	RTD #9 PICKUP	0 to 4	1	-	F123	0
031E	RTD #10 PICKUP	0 to 4	1	-	F123	0
031F	RTD #11 PICKUP	0 to 4	1	-	F123	0
0320	RTD #12 PICKUP	0 to 4	1	-	F123	0
0321	OPEN SENSOR PICKUP	0 to 4	1	-	F123	0
0322	SHORT/LOW TEMP PICKUP	0 to 4	1	-	F123	0
0323	THERMAL MODEL PICKUP	0 to 4	1	-	F123	0
0324	TRIP COUNTER PICKUP	0 to 4	1	-	F123	0
0325	BREAKER FAILURE PICKUP	0 to 4	1	-	F123	0
0326	TRIP COIL MONITOR PICKUP	0 to 4	1	-	F123	0
0327	VT FUSE FAILURE PICKUP	0 to 4	1	-	F123	0
0328	CURRENT DEMAND PICKUP	0 to 4	1	-	F123	0
0329	MW DEMAND PICKUP	0 to 4	1	-	F123	0
032A	Mvar DEMAND PICKUP	0 to 4	1	-	F123	0
032B	MVA DEMAND PICKUP	0 to 4	1	-	F123	0
032C	ANALOG INPUT 1 PICKUP	0 to 4	1	-	F123	0
032D	ANALOG INPUT 2 PICKUP	0 to 4	1	-	F123	0
032E	ANALOG INPUT 3 PICKUP	0 to 4	1	-	F123	0
032F	ANALOG INPUT 4 PICKUP	0 to 4	1	-	F123	0
0330	NOT PROGRAMMED PICKUP	0 to 4	1	-	F123	0
0331	SIMULATION MODE PICKUP	0 to 4	1	-	F123	0
0332	OUTPUT RELAYS FORCED PICKUP	0 to 4	1	-	F123	0
0333	ANALOG OUTPUT FORCED PICKUP	0 to 4	1	-	F123	0
0334	TEST SWITCH SHORTED PICKUP	0 to 4	1	-	F123	0
0335	GROUND DIRECTIONAL PICKUP	0 to 4	1	-	F123	0
0336	IRIG-B ALARM PICKUP	0 to 4	1	-	F123	0
0337	GENERATOR RUNNING HOUR PICKUP	0 to 4	1	-	F123	0
STATUS / DIGITAL INPUTS						
0380	ACCESS SWITCH STATE	0 to 1	1	-	F207	0
0381	BREAKER STATUS SWITCH STATE	0 to 1	1	-	F207	0
0382	ASSIGNABLE DIGITAL INPUT1 STATE	0 to 1	1	-	F207	0
0383	ASSIGNABLE DIGITAL INPUT2 STATE	0 to 1	1	-	F207	0
0384	ASSIGNABLE DIGITAL INPUT3 STATE	0 to 1	1	-	F207	0
0385	ASSIGNABLE DIGITAL INPUT4 STATE	0 to 1	1	-	F207	0
0386	ASSIGNABLE DIGITAL INPUT5 STATE	0 to 1	1	-	F207	0
0387	ASSIGNABLE DIGITAL INPUT6 STATE	0 to 1	1	-	F207	0
0388	ASSIGNABLE DIGITAL INPUT7 STATE	0 to 1	1	-	F207	0
0389	TRIP COIL SUPERVISION	0 to 1	1	-	F132	0
STATUS / REAL TIME CLOCK						
03FC	DATE (READ-ONLY)	N/A	N/A	N/A	F18	N/A
03FE	TIME (READ-ONLY)	N/A	N/A	N/A	F19	N/A
METERING DATA / CURRENT METERING						
0400	PHASE A OUTPUT CURRENT	0 to 999999	1	Amps	F12	0
0402	PHASE B OUTPUT CURRENT	0 to 999999	1	Amps	F12	0
0404	PHASE C OUTPUT CURRENT	0 to 999999	1	Amps	F12	0
0406	PHASE A NEUTRAL-SIDE CURRENT	0 to 999999	1	Amps	F12	0
0408	PHASE B NEUTRAL-SIDE CURRENT	0 to 999999	1	Amps	F12	0
040A	PHASE C NEUTRAL-SIDE CURRENT	0 to 999999	1	Amps	F12	0
040C	PHASE A DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
040E	PHASE B DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
0410	PHASE C DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
0412	AVERAGE PHASE CURRENT	0 to 999999	1	Amps	F12	0
0414	GENERATOR LOAD	0 to 2000	1	% FLA	F1	0
0415	NEGATIVE SEQUENCE CURRENT	0 to 2000	1	% FLA	F1	0

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Actual Values (Input Registers) -- Addresses 0200 to 0FFF

Addr	Name	Range	Step	Units	Fmt	Default
0416	GROUND CURRENT	0 to 10000	1	Amps	F14	0
0420	PHASE A CURRENT ANGLE	0 to 359	1	°	F1	0
0421	PHASE B CURRENT ANGLE	0 to 359	1	°	F1	0
0422	PHASE A CURRENT ANGLE	0 to 359	1	°	F1	0
0423	PHASE A NEUTRAL-SIDE ANGLE	0 to 359	1	°	F1	0
0424	PHASE B NEUTRAL-SIDE ANGLE	0 to 359	1	°	F1	0
0425	PHASE C NEUTRAL-SIDE ANGLE	0 to 359	1	°	F1	0
0426	PHASE A DIFFERENTIAL ANGLE	0 to 359	1	°	F1	0
0427	PHASE B DIFFERENTIAL ANGLE	0 to 359	1	°	F1	0
0428	PHASE C DIFFERENTIAL ANGLE	0 to 359	1	°	F1	0
0429	GROUND CURRENT ANGLE	0 to 359	1	°	F1	0
METERING DATA / VOLTAGE METERING						
0440	PHASE A-B VOLTAGE	0 to 50000	1	Volts	F1	0
0441	PHASE B-C VOLTAGE	0 to 50000	1	Volts	F1	0
0442	PHASE C-A VOLTAGE	0 to 50000	1	Volts	F1	0
0443	AVERAGE LINE VOLTAGE	0 to 50000	1	Volts	F1	0
0444	PHASE A-N VOLTAGE	0 to 50000	1	Volts	F1	0
0445	PHASE B-N VOLTAGE	0 to 50000	1	Volts	F1	0
0446	PHASE C-N VOLTAGE	0 to 50000	1	Volts	F1	0
0447	AVERAGE PHASE VOLTAGE	0 to 50000	1	Volts	F1	0
0448	PER UNIT MEASUREMENT OF V/Hz [2]	0 to 200	1	-	F3	0
0449	FREQUENCY	500 to 9000	1	Hz	F3	0
044A	NEUTRAL VOLTAGE FUND	0 to 250000	1	Volts	F10	0
044C	NEUTRAL VOLTAGE 3rd HARM	0 to 250000	1	Volts	F10	0
044E	NEUTRAL VOLTAGE Vp3 3rd HARM	0 to 250000	1	Volts	F10	0
0450	Vab/Iab	0 to 65535	1	ohms s	F2	0
0451	Vab/Iab ANGLE	0 to 359	1	°	F1	0
0460	LINE A-B VOLTAGE ANGLE	0 to 359	1	°	F1	0
0461	LINE B-C VOLTAGE ANGLE	0 to 359	1	°	F1	0
0462	LINE C-A VOLTAGE ANGLE	0 to 359	1	°	F1	0
0463	PHASE A-N VOLTAGE ANGLE	0 to 359	1	°	F1	0
0464	PHASE B-N VOLTAGE ANGLE	0 to 359	1	°	F1	0
0465	PHASE C-N VOLTAGE ANGLE	0 to 359	1	°	F1	0
0466	NEUTRAL VOLTAGE ANGLE	0 to 359	1	-	F1	0
METERING DATA / POWER METERING						
0480	POWER FACTOR	-100 to 100	1	-	F6	0
0481	REAL POWER	-2000000 to 2000000	1	MW	F13	0
0483	REACTIVE POWER	-2000000 to 2000000	1	Mvar	F13	0
0485	APPARENT POWER	-2000000 to 2000000	1	MVA	F13	0
0487	POSITIVE WATTHOURS	0 to 4000000000	1	MWh	F13	0
0489	POSITIVE VARHOURS	0 to 4000000000	1	Mvarh	F13	0
048B	NEGATIVE VARHOURS	0 to 4000000000	1	Mvarh	F13	0
METERING DATA / TEMPERATURE						
04A0	HOTTEST STATOR RTD	1 to 12	1	-	F1	0
04A1	HOTTEST STATOR RTD TEMPERATURE	-52 to 250	1	°C	F4	-52
04A2	RTD #1 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A3	RTD #2 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A4	RTD #3 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A5	RTD #4 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A6	RTD #5 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A7	RTD #6 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A8	RTD #7 TEMPERATURE	-52 to 251	1	°C	F4	-52
04A9	RTD #8 TEMPERATURE	-52 to 251	1	°C	F4	-52
04AA	RTD #9 TEMPERATURE	-52 to 251	1	°C	F4	-52
04AB	RTD #10 TEMPERATURE	-52 to 251	1	°C	F4	-52
04AC	RTD #11 TEMPERATURE	-52 to 251	1	°C	F4	-52
04AD	RTD #12 TEMPERATURE	-52 to 251	1	°C	F4	-52
04C0	HOTTEST STATOR RTD TEMPERATURE	-52 to 250	1	°F	F4	-52
04C1	RTD #1 TEMPERATURE	-52 to 251	1	°F	F4	-52

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[2] A value of 0xFFFF indicates “no measurable value”.

Actual Values (Input Registers) -- Addresses 0200 to 0FFF

Addr	Name	Range	Step	Units	Fmt	Default
04C2	RTD #2 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C3	RTD #3 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C4	RTD #4 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C5	RTD #5 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C6	RTD #6 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C7	RTD #7 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C8	RTD #8 TEMPERATURE	-52 to 251	1	°F	F4	-52
04C9	RTD #9 TEMPERATURE	-52 to 251	1	°F	F4	-52
04CA	RTD #10 TEMPERATURE	-52 to 251	1	°F	F4	-52
04CB	RTD #11 TEMPERATURE	-52 to 251	1	°F	F4	-52
04CC	RTD #12 TEMPERATURE	-52 to 251	1	°F	F4	-52

METERING DATA / DEMAND METERING

Addr	Name	Range	Step	Units	Fmt	Default
04E0	CURRENT DEMAND	0 to 1000000	1	Amps	F12	0
04E2	MW DEMAND	0 to 2000000	1	MW	F13	0
04E4	Mvar DEMAND	0 to 2000000	1	Mvar	F13	0
04E6	MVA DEMAND	0 to 2000000	1	MVA	F13	0
04E8	PEAK CURRENT DEMAND	0 to 1000000	1	Amps	F12	0
04EA	PEAK MW DEMAND	0 to 2000000	1	MW	F13	0
04EC	PEAK Mvar DEMAND	0 to 2000000	1	Mvar	F13	0
04EE	PEAK MVA DEMAND	0 to 2000000	1	MVA	F13	0

METERING DATA / ANALOG INPUTS

Addr	Name	Range	Step	Units	Fmt	Default
0500	ANALOG INPUT 1	-50000 to 50000	1	Units	F12	0
0502	ANALOG INPUT 2	-50000 to 50000	1	Units	F12	0
0504	ANALOG INPUT 3	-50000 to 50000	1	Units	F12	0
0506	ANALOG INPUT 4	-50000 to 50000	1	Units	F12	0

METERING DATA / SPEED

Addr	Name	Range	Step	Units	Fmt	Default
0520	TACHOMETER	0 to 7200	1	RPM	F1	0

LEARNED DATA / PARAMETER AVERAGES

Addr	Name	Range	Step	Units	Fmt	Default
0600	AVERAGE GENERATOR LOAD	0 to 2000	1	% FLA	F1	0
0601	AVERAGE NEG. SEQ. CURRENT	0 to 2000	1	% FLA	F1	0
0602	AVERAGE PHASE-PHASE VOLTAGE	0 to 50000	1	V	F1	0
0603	RESERVED	-	-	-	-	-
0604	RESERVED	-	-	-	-	-

LEARNED DATA / RTD MAXIMUMS

Addr	Name	Range	Step	Units	Fmt	Default
0620	RTD #1 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0621	RTD #2 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0622	RTD #3 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0623	RTD #4 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0624	RTD #5 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0625	RTD #6 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0626	RTD #7 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0627	RTD #8 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0628	RTD #9 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0629	RTD #10 MAX. TEMP.	-52 to 251	1	°C	F4	-52
062A	RTD #11 MAX. TEMP.	-52 to 251	1	°C	F4	-52
062B	RTD #12 MAX. TEMP.	-52 to 251	1	°C	F4	-52
0640	RTD #1 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0641	RTD #2 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0642	RTD #3 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0643	RTD #4 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0644	RTD #5 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0645	RTD #6 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0646	RTD #7 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0647	RTD #8 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0648	RTD #9 MAX. TEMP.	-52 to 251	1	°F	F4	-52
0649	RTD #10 MAX. TEMP.	-52 to 251	1	°F	F4	-52
064A	RTD #11 MAX. TEMP.	-52 to 251	1	°F	F4	-52
064B	RTD #12 MAX. TEMP.	-52 to 251	1	°F	F4	-52

LEARNED DATA / ANALOG IN MIN/MAX

Addr	Name	Range	Step	Units	Fmt	Default
0700	ANALOG INPUT 1 MINIMUM	-50000 to 50000	1	Units	F12	0
0702	ANALOG INPUT 1 MAXIMUM	-50000 to 50000	1	Units	F12	0
0704	ANALOG INPUT 2 MINIMUM	-50000 to 50000	1	Units	F12	0

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Actual Values (Input Registers) -- Addresses 0200 to 0FFF

Addr	Name	Range	Step	Units	Fmt	Default
0706	ANALOG INPUT 2 MAXIMUM	-50000 to 50000	1	Units	F12	0
0708	ANALOG INPUT 3 MINIMUM	-50000 to 50000	1	Units	F12	0
070A	ANALOG INPUT 3 MAXIMUM	-50000 to 50000	1	Units	F12	0
070C	ANALOG INPUT 4 MINIMUM	-50000 to 50000	1	Units	F12	0
070E	ANALOG INPUT 4 MAXIMUM	-50000 to 50000	1	Units	F12	0

MAINTENANCE / TRIP COUNTERS

077F	TRIP COUNTERS LAST CLEARED (DATE)	N/A	N/A	N/A	F18	N/A
0781	TOTAL NUMBER OF TRIPS	0 to 50000	1	-	F1	0
0782	DIGITAL INPUT TRIPS	0 to 50000	1	-	F1	0
0783	SEQUENTIAL TRIPS	0 to 50000	1	-	F1	0
0784	FIELD-BKR DISCREP. TRIPS	0 to 50000	1	-	F1	0
0785	TACHOMETER TRIPS	0 to 50000	1	-	F1	0
0786	OFFLINE OVERCURRENT TRIPS	0 to 50000	1	-	F1	0
0787	PHASE OVERCURRENT TRIPS	0 to 50000	1	-	F1	0
0788	NEG.SEQ. OVERCURRENT TRIPS	0 to 50000	1	-	F1	0
0789	GROUND OVERCURRENT TRIPS	0 to 50000	1	-	F1	0
078A	PHASE DIFFERENTIAL TRIPS	0 to 50000	1	-	F1	0
078B	UNDERVOLTAGE TRIPS	0 to 50000	1	-	F1	0
078C	OVERVOLTAGE TRIPS	0 to 50000	1	-	F1	0
078D	VOLTS/HERTZ TRIPS	0 to 50000	1	-	F1	0
078E	PHASE REVERSAL TRIPS	0 to 50000	1	-	F1	0
078F	UNDERFREQUENCY TRIPS	0 to 50000	1	-	F1	0
0790	OVERFREQUENCY TRIPS	0 to 50000	1	-	F1	0
0791	NEUTRAL O/V (FUND) TRIPS	0 to 50000	1	-	F1	0
0792	NEUTRAL U/V (3rd) TRIPS	0 to 50000	1	-	F1	0
0793	REACTIVE POWER TRIPS	0 to 50000	1	-	F1	0
0794	REVERSE POWER TRIPS	0 to 50000	1	-	F1	0
0795	LOW FORWARD POWER TRIPS	0 to 50000	1	-	F1	0
0796	STATOR RTD TRIPS	0 to 50000	1	-	F1	0
0797	BEARING RTD TRIPS	0 to 50000	1	-	F1	0
0798	OTHER RTD TRIPS	0 to 50000	1	-	F1	0
0799	AMBIENT RTD TRIPS	0 to 50000	1	-	F1	0
079A	THERMAL MODEL TRIPS	0 to 50000	1	-	F1	0
079B	INADVERTENT ENERG. TRIPS	0 to 50000	1	-	F1	0
079C	ANALOG INPUT 1 TRIPS	0 to 50000	1	-	F1	0
079D	ANALOG INPUT 2 TRIPS	0 to 50000	1	-	F1	0
079E	ANALOG INPUT 3 TRIPS	0 to 50000	1	-	F1	0
079F	ANALOG INPUT 4 TRIPS	0 to 50000	1	-	F1	0

MAINTENANCE / GENERAL COUNTERS

07A0	NUMBER OF BREAKER OPERATIONS	0 to 50000	1	-	F1	0
07A1	NUMBER OF THERMAL RESETS	0 to 50000	1	-	F1	0

MAINTENANCE / TRIP COUNTERS

07A2	LOSS OF EXCITATION 1 TRIPS	0 to 50000	1	-	F1	0
07A3	LOSS OF EXCITATION 2 TRIPS	0 to 50000	1	-	F1	0
07A4	GROUND DIRECTIONAL TRIPS	0 to 50000	1	-	F1	0
07A5	HIGH-SET PHASE O/C TRIPS	0 to 50000	1	-	F1	0
07A6	DISTANCE ZONE 1 TRIPS	0 to 50000	1	-	F1	0
07A7	DISTANCE ZONE 2 TRIPS	0 to 50000	1	-	F1	0

MAINTENANCE / TIMERS

07E0	GENERATOR HOURS ONLINE	0 to 1000000	1	h	F12	0

PRODUCT INFO. / 489 MODEL INFO.

0800	ORDER CODE	0 to 65535	1	N/A	F136	N/A
0801	489 SERIAL NUMBER	3000000 to 9999999	1	-	F12	3000000

PRODUCT INFO. / CALIBRATION INFO.

0810	ORIGINAL CALIBRATION DATE	N/A	N/A	N/A	F18	N/A
0812	LAST CALIBRATION DATE	N/A	N/A	N/A	F18	N/A

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Setpoints (Holding Registers) -- Addresses 1000 to 2FFF

Addr	Name	Range	Step	Units	Fmt	Default
489 SETUP / PREFERENCES						
1000	DEFAULT MESSAGE CYCLE TIME	5 to 100	5	s	F2	20
1001	DEFAULT MESSAGE TIMEOUT	10 to 900	1	s	F1	300
1003	PARAMETER AVERAGES CALC. PERIOD	1 to 90	1	min	F1	15
1004	TEMPERATURE DISPLAY	0 to 1	1	-	F100	0
1005	WAVEFORM TRIGGER POSITION	1 to 100	1	%	F1	25
1006	PASSCODE (WRITE ONLY)	0 to 99999999	1	N/A	F12	0
1008	ENCRYPTED PASSCODE (READ ONLY)	N/A	N/A	N/A	F12	N/A
100A	WAVEFORM MEMORY BUFFER	1 to 16	1	-	F1	8
489 SETUP / SERIAL PORTS						
1010	SLAVE ADDRESS	1 to 254	1	-	F1	254
1011	COMPUTER RS485 BAUD RATE	0 to 5	1	-	F101	4
1012	COMPUTER RS485 PARITY	0 to 2	1	-	F102	0
1013	AUXILIARY RS485 BAUD RATE	0 to 5	1	-	F101	4
1014	AUXILIARY RS485 PARITY	0 to 2	1	-	F102	0
1015	PORT USED FOR DNP	0 to 3	1	-	F216	0
1016	DNP SLAVE ADDRESS	0 to 255	1	-	F1	255
1017	DNP TURNAROUND TIME	0 to 100	10	ms	F1	10
489 SETUP / REAL TIME CLOCK						
1030	DATE	N/A	N/A	N/A	F18	N/A
1032	TIME	N/A	N/A	N/A	F19	N/A
1034	IRIG-B TYPE	0 to 2	1	-	F220	0
489 SETUP / MESSAGE SCRATCHPAD						
1060	Scratchpad	0 to 40	1	-	F22	_
1080	Scratchpad	0 to 40	1	-	F22	_
10A0	Scratchpad	0 to 40	1	-	F22	_
10C0	Scratchpad	0 to 40	1	-	F22	_
10E0	Scratchpad	0 to 40	1	-	F22	_
489 SETUP / CLEAR DATA						
1130	CLEAR LAST TRIP DATA	0 to 1	1	-	F103	0
1131	CLEAR MWh and Mvarh METERS	0 to 1	1	-	F103	0
1132	CLEAR PEAK DEMAND DATA	0 to 1	1	-	F103	0
1133	CLEAR RTD MAXIMUMS	0 to 1	1	-	F103	0
1134	CLEAR ANALOG I/P MIN/MAX	0 to 1	1	-	F103	0
1135	CLEAR TRIP COUNTERS	0 to 1	1	-	F103	0
1136	CLEAR EVENT RECORD	0 to 1	1	-	F103	0
1137	CLEAR GENERATOR INFORMATION	0 to 1	1	-	F103	0
1138	CLEAR BREAKER INFORMATION	0 to 1	1	-	F103	0
SYSTEM SETUP / CURRENT SENSING						
1180	PHASE CT PRIMARY	10 to 50001	1	Amps	F1	50001
1181	GROUND CT	0 to 3	1	-	F104	0
1182	GROUND CT RATIO	10 to 10000	1	: 1 / : 5	F1	100
SYSTEM SETUP / VOLTAGE SENSING						
11A0	VT CONNECTION TYPE	0 to 2	1	-	F106	0
11A1	VOLTAGE TRANSFORMER RATIO	100 to 30000	1	: 1	F3	500
11A2	NEUTRAL V.T. RATIO	100 to 24000	1	: 1	F3	500
11A3	NEUTRAL VOLTAGE TRANSFORMER	0 to 1	1	-	F103	0
SYSTEM SETUP / GEN. PARAMETERS						
11C0	GENERATOR RATED MVA	50 to 2000001	1	MVA	F13	2000001
11C2	GENERATOR RATED POWER FACTOR	5 to 100	1	-	F3	100
11C3	GENERATOR VOLTAGE PHASE-PHASE	100 to 30001	1	V	F1	30001
11C4	GENERATOR NOMINAL FREQUENCY	0 to 3	1	Hz	F107	0
11C5	GENERATOR PHASE SEQUENCE	0 to 2	1	-	F124	0
SYSTEM SETUP / SERIAL START/STOP						
11E0	SERIAL START/STOP INITIATION	0 to 1	1	-	F105	0
11E1	STARTUP INITIATION RELAYS (2-5)	1 to 4	1	-	F50	0
11E2	SHUTDOWN INITIATION RELAYS (1-4)	0 to 3	1	-	F50	0
11E3	SERIAL START/STOP EVENTS	0 to 1	1	-	F105	0
DIGITAL INPUTS / BREAKER STATUS						
1200	BREAKER STATUS	0 to 1	1	-	F209	1
DIGITAL INPUTS / GENERAL INPUT A						

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1210	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1211	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
1212	INPUT NAME	0 to 12	1	-	F22	_
1218	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
1219	GENERAL INPUT A CONTROL	0 to 1	1	-	F105	0
121A	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
121B	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
121C	GENERAL INPUT A CONTROL EVENTS	0 to 1	1	-	F105	0
121D	GENERAL INPUT A ALARM	0 to 2	1	-	F115	0
121E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
121F	GENERAL INPUT A ALARM DELAY	1 to 50000	1	s	F2	50
1220	GENERAL INPUT A ALARM EVENTS	0 to 1	1	-	F105	0
1221	GENERAL INPUT A TRIP	0 to 2	1	-	F115	0
1222	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1223	GENERAL INPUT A TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT B

1230	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1231	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
1232	INPUT NAME	0 to 12	1	-	F22	_
1238	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
1239	GENERAL INPUT B CONTROL	0 to 1	1	-	F105	0
123A	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
123B	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
123C	GENERAL INPUT B CONTROL EVENTS	0 to 1	1	-	F105	0
123D	GENERAL INPUT B ALARM	0 to 2	1	-	F115	0
123E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
123F	GENERAL INPUT B ALARM DELAY	1 to 50000	1	s	F2	50
1240	GENERAL INPUT B ALARM EVENTS	0 to 1	1	-	F105	0
1241	GENERAL INPUT B TRIP	0 to 2	1	-	F115	0
1242	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1243	GENERAL INPUT B TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT C

1250	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1251	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
1252	INPUT NAME	0 to 12	1	-	F22	_
1258	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
1259	GENERAL INPUT C CONTROL	0 to 1	1	-	F105	0
125A	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
125B	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
125C	GENERAL INPUT C CONTROL EVENTS	0 to 1	1	-	F105	0
125D	GENERAL INPUT C ALARM	0 to 2	1	-	F115	0
125E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
125F	GENERAL INPUT C ALARM DELAY	1 to 50000	1	s	F2	50
1260	GENERAL INPUT C ALARM EVENTS	0 to 1	1	-	F105	0
1261	GENERAL INPUT C TRIP	0 to 2	1	-	F115	0
1262	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1263	GENERAL INPUT C TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT D

1270	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1271	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
1272	INPUT NAME	0 to 12	1	-	F22	_
1278	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
1279	GENERAL INPUT D CONTROL	0 to 1	1	-	F105	0
127A	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
127B	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
127C	GENERAL INPUT D CONTROL EVENTS	0 to 1	1	-	F105	0
127D	GENERAL INPUT D ALARM	0 to 2	1	-	F115	0
127E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
127F	GENERAL INPUT D ALARM DELAY	1 to 50000	1	s	F2	50
1280	GENERAL INPUT D ALARM EVENTS	0 to 1	1	-	F105	0
1281	GENERAL INPUT D TRIP	0 to 2	1	-	F115	0
1282	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1283	GENERAL INPUT D TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT E

1290	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1291	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
1292	INPUT NAME	0 to 12	1	-	F22	_

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1298	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
1299	GENERAL INPUT E CONTROL	0 to 1	1	-	F105	0
129A	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
129B	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
129C	GENERAL INPUT E CONTROL EVENTS	0 to 1	1	-	F105	0
129D	GENERAL INPUT E ALARM	0 to 2	1	-	F115	0
129E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
129F	GENERAL INPUT E ALARM DELAY	1 to 50000	1	s	F2	50
12A0	GENERAL INPUT E ALARM EVENTS	0 to 1	1	-	F105	0
12A1	GENERAL INPUT E TRIP	0 to 2	1	-	F115	0
12A2	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
12A3	GENERAL INPUT E TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT F

12B0	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
12B1	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
12B2	INPUT NAME	0 to 12	1	-	F22	_
12B8	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
12B9	GENERAL INPUT F CONTROL	0 to 1	1	-	F105	0
12BA	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
12BB	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
12BC	GENERAL INPUT F CONTROL EVENTS	0 to 1	1	-	F105	0
12BD	GENERAL INPUT F ALARM	0 to 2	1	-	F115	0
12BE	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
12BF	GENERAL INPUT F ALARM DELAY	1 to 50000	1	s	F2	50
12C0	GENERAL INPUT F ALARM EVENTS	0 to 1	1	-	F105	0
12C1	GENERAL INPUT F TRIP	0 to 2	1	-	F115	0
12C2	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
12C3	GENERAL INPUT F TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / GENERAL INPUT G

12D0	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
12D1	ASSERTED DIGITAL INPUT STATE	0 to 1	1	-	F131	0
12D2	INPUT NAME	0 to 12	1	-	F22	_
12D8	BLOCK INPUT FROM ONLINE	0 to 5000	1	s	F1	0
12D9	GENERAL INPUT G CONTROL	0 to 1	1	-	F105	0
12DA	PULSED CONTROL RELAY DWELL TIME	0 to 250	1	s	F2	0
12DB	ASSIGN CONTROL RELAYS (1-5)	0 to 4	1	-	F50	0
12DC	GENERAL INPUT G CONTROL EVENTS	0 to 1	1	-	F105	0
12DD	GENERAL INPUT G ALARM	0 to 2	1	-	F115	0
12DE	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
12DF	GENERAL INPUT G ALARM DELAY	1 to 50000	1	s	F2	50
12E0	GENERAL INPUT G ALARM EVENTS	0 to 1	1	-	F105	0
12E1	GENERAL INPUT G TRIP	0 to 2	1	-	F115	0
12E2	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
12E3	GENERAL INPUT G TRIP DELAY	1 to 50000	1	s	F2	50

DIGITAL INPUTS / REMOTE RESET

1300	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0

DIGITAL INPUTS / TEST INPUT

1310	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0

DIGITAL INPUTS / THERMAL RESET

1320	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0

DIGITAL INPUTS / DUAL SETPOINTS

1340	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1341	ACTIVE SETPOINT GROUP	0 to 1	1	-	F118	0
1342	EDIT SETPOINT GROUP	0 to 1	1	-	F118	0

DIGITAL INPUTS / SEQUENTIAL TRIP

1360	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1361	SEQUENTIAL TRIP TYPE	0 to 1	1	-	F206	0
1362	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1363	SEQUENTIAL TRIP LEVEL	2 to 99	1	xRated MW	F14	5
1365	SEQUENTIAL TRIP DELAY	2 to 1200	1	s	F2	10

DIGITAL INPUTS / FIELD-BKR DISCREP.

1380	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
1381	FIELD STATUS CONTACT	0 to 1	1	-	F109	0
1382	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1383	FIELD-BKR DISCREP. TRIP DELAY	1 to 5000	1	s	F2	10

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DIGITAL INPUTS / TACHOMETER

13A0	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
13A1	RATED SPEED	100 to 3600	1	RPM	F1	3600
13A2	TACHOMETER ALARM	0 to 2	1	-	F115	0
13A3	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
13A4	TACHOMETER ALARM SPEED	101 to 175	1	% Rated	F1	110
13A5	TACHOMETER ALARM DELAY	1 to 250	1	s	F1	1
13A6	TACHOMETER ALARM EVENTS	0 to 1	1	-	F105	0
13A7	TACHOMETER TRIP	0 to 2	1	-	F115	0
13A8	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
13A9	TACHOMETER TRIP SPEED	101 to 175	1	% Rated	F1	110
13AA	TACHOMETER TRIP DELAY	1 to 250	1	s	F1	1

DIGITAL INPUTS / WAVEFORM CAPTURE

13C0	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0

DIGITAL INPUTS / GND. SWITCH STATUS

13D0	ASSIGN DIGITAL INPUT	0 to 7	1	-	F210	0
13D1	GROUND SWITCH CONTACT	0 to 1	1	-	F109	0

OUTPUT RELAYS / RELAY RESET MODE

1400	R1 TRIP	0 to 1	1	-	F117	0
1401	R2 AUXILIARY	0 to 1	1	-	F117	0
1402	R3 AUXILIARY	0 to 1	1	-	F117	0
1403	R4 AUXILIARY	0 to 1	1	-	F117	0
1404	R5 ALARM	0 to 1	1	-	F117	0
1405	R6 SERVICE	0 to 1	1	-	F117	0

CURRENT ELEMENTS / OVERCURRENT ALARM

1500	OVERCURRENT ALARM	0 to 2	1	-	F115	0
1501	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
1502	OVERCURRENT ALARM LEVEL	10 to 150	1	x FLA	F3	101
1503	OVERCURRENT ALARM DELAY	1 to 2500	1	s	F2	1
1504	OVERCURRENT ALARM EVENTS	0 to 1	1	-	F105	0

CURRENT ELEMENTS / OFFLINE O/C

1520	OFFLINE OVERCURRENT TRIP	0 to 2	1	-	F115	0
1521	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1522	OFFLINE OVERCURRENT PICKUP	5 to 100	1	x CT	F3	5
1523	OFFLINE OVERCURRENT TRIP DELAY	3 to 99	1	Cycles	F1	5

CURRENT ELEMENTS / INADVERTENT ENERG.

1540	INADVERTENT ENERGIZE TRIP	0 to 2	1	-	F115	0
1541	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1542	ARMING SIGNAL	0 to 1	1	-	F202	0
1543	INADVERTENT ENERGIZE O/C PICKUP	5 to 300	1	x CT	F3	5
1544	INADVERTENT ENERGIZE PICKUP	50 to 99	1	xRated V	F3	50

CURRENT ELEMENTS / PHASE OVERCURRENT

1600	PHASE OVERCURRENT TRIP	0 to 2	1	-	F115	0
1601	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1602	ENABLE VOLTAGE RESTRAINT	0 to 1	1	-	F103	0
1603	PHASE OVERCURRENT PICKUP	15 to 2000	1	x CT	F3	1000
1604	CURVE SHAPE	0 to 13	1	-	F128	0
1605	FLEXCURVE TRIP TIME AT 1.03xPU	0 to 65535	1	ms	F1	65535
1606	FLEXCURVE TRIP TIME AT 1.05xPU	0 to 65535	1	ms	F1	65535
1607	FLEXCURVE TRIP TIME AT 1.10xPU	0 to 65535	1	ms	F1	65535
1608	FLEXCURVE TRIP TIME AT 1.20xPU	0 to 65535	1	ms	F1	65535
1609	FLEXCURVE TRIP TIME AT 1.30xPU	0 to 65535	1	ms	F1	65535
160A	FLEXCURVE TRIP TIME AT 1.40xPU	0 to 65535	1	ms	F1	65535
160B	FLEXCURVE TRIP TIME AT 1.50xPU	0 to 65535	1	ms	F1	65535
160C	FLEXCURVE TRIP TIME AT 1.60xPU	0 to 65535	1	ms	F1	65535
160D	FLEXCURVE TRIP TIME AT 1.70xPU	0 to 65535	1	ms	F1	65535
160E	FLEXCURVE TRIP TIME AT 1.80xPU	0 to 65535	1	ms	F1	65535
160F	FLEXCURVE TRIP TIME AT 1.90xPU	0 to 65535	1	ms	F1	65535
1610	FLEXCURVE TRIP TIME AT 2.00xPU	0 to 65535	1	ms	F1	65535
1611	FLEXCURVE TRIP TIME AT 2.10xPU	0 to 65535	1	ms	F1	65535
1612	FLEXCURVE TRIP TIME AT 2.20xPU	0 to 65535	1	ms	F1	65535
1613	FLEXCURVE TRIP TIME AT 2.30xPU	0 to 65535	1	ms	F1	65535
1614	FLEXCURVE TRIP TIME AT 2.40xPU	0 to 65535	1	ms	F1	65535
1615	FLEXCURVE TRIP TIME AT 2.50xPU	0 to 65535	1	ms	F1	65535

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1616	FLEXCURVE TRIP TIME AT 2.60xPU	0 to 65535	1	ms	F1	65535
1617	FLEXCURVE TRIP TIME AT 2.70xPU	0 to 65535	1	ms	F1	65535
1618	FLEXCURVE TRIP TIME AT 2.80xPU	0 to 65535	1	ms	F1	65535
1619	FLEXCURVE TRIP TIME AT 2.90xPU	0 to 65535	1	ms	F1	65535
161A	FLEXCURVE TRIP TIME AT 3.00xPU	0 to 65535	1	ms	F1	65535
161B	FLEXCURVE TRIP TIME AT 3.10xPU	0 to 65535	1	ms	F1	65535
161C	FLEXCURVE TRIP TIME AT 3.20xPU	0 to 65535	1	ms	F1	65535
161D	FLEXCURVE TRIP TIME AT 3.30xPU	0 to 65535	1	ms	F1	65535
161E	FLEXCURVE TRIP TIME AT 3.40xPU	0 to 65535	1	ms	F1	65535
161F	FLEXCURVE TRIP TIME AT 3.50xPU	0 to 65535	1	ms	F1	65535
1620	FLEXCURVE TRIP TIME AT 3.60xPU	0 to 65535	1	ms	F1	65535
1621	FLEXCURVE TRIP TIME AT 3.70xPU	0 to 65535	1	ms	F1	65535
1622	FLEXCURVE TRIP TIME AT 3.80xPU	0 to 65535	1	ms	F1	65535
1623	FLEXCURVE TRIP TIME AT 3.90xPU	0 to 65535	1	ms	F1	65535
1624	FLEXCURVE TRIP TIME AT 4.00xPU	0 to 65535	1	ms	F1	65535
1625	FLEXCURVE TRIP TIME AT 4.10xPU	0 to 65535	1	ms	F1	65535
1626	FLEXCURVE TRIP TIME AT 4.20xPU	0 to 65535	1	ms	F1	65535
1627	FLEXCURVE TRIP TIME AT 4.30xPU	0 to 65535	1	ms	F1	65535
1628	FLEXCURVE TRIP TIME AT 4.40xPU	0 to 65535	1	ms	F1	65535
1629	FLEXCURVE TRIP TIME AT 4.50xPU	0 to 65535	1	ms	F1	65535
162A	FLEXCURVE TRIP TIME AT 4.60xPU	0 to 65535	1	ms	F1	65535
162B	FLEXCURVE TRIP TIME AT 4.70xPU	0 to 65535	1	ms	F1	65535
162C	FLEXCURVE TRIP TIME AT 4.80xPU	0 to 65535	1	ms	F1	65535
162D	FLEXCURVE TRIP TIME AT 4.90xPU	0 to 65535	1	ms	F1	65535
162E	FLEXCURVE TRIP TIME AT 5.00xPU	0 to 65535	1	ms	F1	65535
162F	FLEXCURVE TRIP TIME AT 5.10xPU	0 to 65535	1	ms	F1	65535
1630	FLEXCURVE TRIP TIME AT 5.20xPU	0 to 65535	1	ms	F1	65535
1631	FLEXCURVE TRIP TIME AT 5.30xPU	0 to 65535	1	ms	F1	65535
1632	FLEXCURVE TRIP TIME AT 5.40xPU	0 to 65535	1	ms	F1	65535
1633	FLEXCURVE TRIP TIME AT 5.50xPU	0 to 65535	1	ms	F1	65535
1634	FLEXCURVE TRIP TIME AT 5.60xPU	0 to 65535	1	ms	F1	65535
1635	FLEXCURVE TRIP TIME AT 5.70xPU	0 to 65535	1	ms	F1	65535
1636	FLEXCURVE TRIP TIME AT 5.80xPU	0 to 65535	1	ms	F1	65535
1637	FLEXCURVE TRIP TIME AT 5.90xPU	0 to 65535	1	ms	F1	65535
1638	FLEXCURVE TRIP TIME AT 6.00xPU	0 to 65535	1	ms	F1	65535
1639	FLEXCURVE TRIP TIME AT 6.50xPU	0 to 65535	1	ms	F1	65535
163A	FLEXCURVE TRIP TIME AT 7.00xPU	0 to 65535	1	ms	F1	65535
163B	FLEXCURVE TRIP TIME AT 7.50xPU	0 to 65535	1	ms	F1	65535
163C	FLEXCURVE TRIP TIME AT 8.00xPU	0 to 65535	1	ms	F1	65535
163D	FLEXCURVE TRIP TIME AT 8.50xPU	0 to 65535	1	ms	F1	65535
163E	FLEXCURVE TRIP TIME AT 9.00xPU	0 to 65535	1	ms	F1	65535
163F	FLEXCURVE TRIP TIME AT 9.50xPU	0 to 65535	1	ms	F1	65535
1640	FLEXCURVE TRIP TIME AT 10.0xPU	0 to 65535	1	ms	F1	65535
1641	FLEXCURVE TRIP TIME AT 10.5xPU	0 to 65535	1	ms	F1	65535
1642	FLEXCURVE TRIP TIME AT 11.0xPU	0 to 65535	1	ms	F1	65535
1643	FLEXCURVE TRIP TIME AT 11.5xPU	0 to 65535	1	ms	F1	65535
1644	FLEXCURVE TRIP TIME AT 12.0xPU	0 to 65535	1	ms	F1	65535
1645	FLEXCURVE TRIP TIME AT 12.5xPU	0 to 65535	1	ms	F1	65535
1646	FLEXCURVE TRIP TIME AT 13.0xPU	0 to 65535	1	ms	F1	65535
1647	FLEXCURVE TRIP TIME AT 13.5xPU	0 to 65535	1	ms	F1	65535
1648	FLEXCURVE TRIP TIME AT 14.0xPU	0 to 65535	1	ms	F1	65535
1649	FLEXCURVE TRIP TIME AT 14.5xPU	0 to 65535	1	ms	F1	65535
164A	FLEXCURVE TRIP TIME AT 15.0xPU	0 to 65535	1	ms	F1	65535
164B	FLEXCURVE TRIP TIME AT 15.5xPU	0 to 65535	1	ms	F1	65535
164C	FLEXCURVE TRIP TIME AT 16.0xPU	0 to 65535	1	ms	F1	65535
164D	FLEXCURVE TRIP TIME AT 16.5xPU	0 to 65535	1	ms	F1	65535
164E	FLEXCURVE TRIP TIME AT 17.0xPU	0 to 65535	1	ms	F1	65535
164F	FLEXCURVE TRIP TIME AT 17.5xPU	0 to 65535	1	ms	F1	65535
1650	FLEXCURVE TRIP TIME AT 18.0xPU	0 to 65535	1	ms	F1	65535
1651	FLEXCURVE TRIP TIME AT 18.5xPU	0 to 65535	1	ms	F1	65535
1652	FLEXCURVE TRIP TIME AT 19.0xPU	0 to 65535	1	ms	F1	65535
1653	FLEXCURVE TRIP TIME AT 19.5xPU	0 to 65535	1	ms	F1	65535
1654	FLEXCURVE TRIP TIME AT 20.0xPU	0 to 65535	1	ms	F1	65535
1655	OVERCURRENT CURVE MULTIPLIER	0 to 100000	1	-	F14	100
1657	OVERCURRENT CURVE RESET	0 to 1	1	-	F201	0
1658	VOLTAGE LOWER LIMIT	10 to 60	1	%	F1	10

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CURRENT ELEMENTS / NEGATIVE SEQUENCE

1700	NEGATIVE SEQUENCE ALARM	0 to 2	1	-	F115	0
1701	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
1702	NEG. SEQUENCE ALARM PICKUP	3 to 100	1	% FLA	F1	3
1703	NEGATIVE SEQUENCE ALARM DELAY	1 to 1000	1	s	F2	50
1704	NEGATIVE SEQUENCE ALARM EVENTS	0 to 1	1	-	F105	0
1705	NEGATIVE SEQUENCE O/C TRIP	0 to 2	1	-	F115	0
1706	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1707	NEG. SEQUENCE O/C TRIP PICKUP	3 to 100	1	% FLA	F1	8
1708	NEG. SEQUENCE O/C CONSTANT K	1 to 100	1	-	F1	1
1709	NEG. SEQUENCE O/C MAX. TIME	10 to 1000	1	s	F1	1000
170A	NEG. SEQUENCE O/C RESET RATE	0 to 9999	1	s	F2	2270

CURRENT ELEMENTS / GROUND O/C

1720	GROUND OVERCURRENT ALARM	0 to 2	1	-	F115	0
1721	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
1722	GROUND O/C ALARM PICKUP	5 to 2000	1	x CT	F3	20
1723	GROUND O/C ALARM DELAY	0 to 100	1	Cycles	F1	0
1724	GROUND OVERCURRENT ALARM EVENTS	0 to 1	1	-	F105	0
1725	GROUND OVERCURRENT TRIP	0 to 2	1	-	F115	0
1726	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1727	GROUND O/C TRIP PICKUP	5 to 2000	1	x CT	F3	20
1728	CURVE SHAPE	0 to 13	1	-	F128	0
1729	FLEXCURVE TRIP TIME AT 1.03xPU	0 to 65535	1	ms	F1	65535
172A	FLEXCURVE TRIP TIME AT 1.05xPU	0 to 65535	1	ms	F1	65535
172B	FLEXCURVE TRIP TIME AT 1.10xPU	0 to 65535	1	ms	F1	65535
172C	FLEXCURVE TRIP TIME AT 1.20xPU	0 to 65535	1	ms	F1	65535
172D	FLEXCURVE TRIP TIME AT 1.30xPU	0 to 65535	1	ms	F1	65535
172E	FLEXCURVE TRIP TIME AT 1.40xPU	0 to 65535	1	ms	F1	65535
172F	FLEXCURVE TRIP TIME AT 1.50xPU	0 to 65535	1	ms	F1	65535
1730	FLEXCURVE TRIP TIME AT 1.60xPU	0 to 65535	1	ms	F1	65535
1731	FLEXCURVE TRIP TIME AT 1.70xPU	0 to 65535	1	ms	F1	65535
1732	FLEXCURVE TRIP TIME AT 1.80xPU	0 to 65535	1	ms	F1	65535
1733	FLEXCURVE TRIP TIME AT 1.90xPU	0 to 65535	1	ms	F1	65535
1734	FLEXCURVE TRIP TIME AT 2.00xPU	0 to 65535	1	ms	F1	65535
1735	FLEXCURVE TRIP TIME AT 2.10xPU	0 to 65535	1	ms	F1	65535
1736	FLEXCURVE TRIP TIME AT 2.20xPU	0 to 65535	1	ms	F1	65535
1737	FLEXCURVE TRIP TIME AT 2.30xPU	0 to 65535	1	ms	F1	65535
1738	FLEXCURVE TRIP TIME AT 2.40xPU	0 to 65535	1	ms	F1	65535
1739	FLEXCURVE TRIP TIME AT 2.50xPU	0 to 65535	1	ms	F1	65535
173A	FLEXCURVE TRIP TIME AT 2.60xPU	0 to 65535	1	ms	F1	65535
173B	FLEXCURVE TRIP TIME AT 2.70xPU	0 to 65535	1	ms	F1	65535
173C	FLEXCURVE TRIP TIME AT 2.80xPU	0 to 65535	1	ms	F1	65535
173D	FLEXCURVE TRIP TIME AT 2.90xPU	0 to 65535	1	ms	F1	65535
173E	FLEXCURVE TRIP TIME AT 3.00xPU	0 to 65535	1	ms	F1	65535
173F	FLEXCURVE TRIP TIME AT 3.10xPU	0 to 65535	1	ms	F1	65535
1740	FLEXCURVE TRIP TIME AT 3.20xPU	0 to 65535	1	ms	F1	65535
1741	FLEXCURVE TRIP TIME AT 3.30xPU	0 to 65535	1	ms	F1	65535
1742	FLEXCURVE TRIP TIME AT 3.40xPU	0 to 65535	1	ms	F1	65535
1743	FLEXCURVE TRIP TIME AT 3.50xPU	0 to 65535	1	ms	F1	65535
1744	FLEXCURVE TRIP TIME AT 3.60xPU	0 to 65535	1	ms	F1	65535
1745	FLEXCURVE TRIP TIME AT 3.70xPU	0 to 65535	1	ms	F1	65535
1746	FLEXCURVE TRIP TIME AT 3.80xPU	0 to 65535	1	ms	F1	65535
1747	FLEXCURVE TRIP TIME AT 3.90xPU	0 to 65535	1	ms	F1	65535
1748	FLEXCURVE TRIP TIME AT 4.00xPU	0 to 65535	1	ms	F1	65535
1749	FLEXCURVE TRIP TIME AT 4.10xPU	0 to 65535	1	ms	F1	65535
174A	FLEXCURVE TRIP TIME AT 4.20xPU	0 to 65535	1	ms	F1	65535
174B	FLEXCURVE TRIP TIME AT 4.30xPU	0 to 65535	1	ms	F1	65535
174C	FLEXCURVE TRIP TIME AT 4.40xPU	0 to 65535	1	ms	F1	65535
174D	FLEXCURVE TRIP TIME AT 4.50xPU	0 to 65535	1	ms	F1	65535
174E	FLEXCURVE TRIP TIME AT 4.60xPU	0 to 65535	1	ms	F1	65535
174F	FLEXCURVE TRIP TIME AT 4.70xPU	0 to 65535	1	ms	F1	65535
1750	FLEXCURVE TRIP TIME AT 4.80xPU	0 to 65535	1	ms	F1	65535
1751	FLEXCURVE TRIP TIME AT 4.90xPU	0 to 65535	1	ms	F1	65535
1752	FLEXCURVE TRIP TIME AT 5.00xPU	0 to 65535	1	ms	F1	65535
1753	FLEXCURVE TRIP TIME AT 5.10xPU	0 to 65535	1	ms	F1	65535
1754	FLEXCURVE TRIP TIME AT 5.20xPU	0 to 65535	1	ms	F1	65535
1755	FLEXCURVE TRIP TIME AT 5.30xPU	0 to 65535	1	ms	F1	65535

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1756	FLEXCURVE TRIP TIME AT 5.40xPU	0 to 65535	1	ms	F1	65535
1757	FLEXCURVE TRIP TIME AT 5.50xPU	0 to 65535	1	ms	F1	65535
1758	FLEXCURVE TRIP TIME AT 5.60xPU	0 to 65535	1	ms	F1	65535
1759	FLEXCURVE TRIP TIME AT 5.70xPU	0 to 65535	1	ms	F1	65535
175A	FLEXCURVE TRIP TIME AT 5.80xPU	0 to 65535	1	ms	F1	65535
175B	FLEXCURVE TRIP TIME AT 5.90xPU	0 to 65535	1	ms	F1	65535
175C	FLEXCURVE TRIP TIME AT 6.00xPU	0 to 65535	1	ms	F1	65535
175D	FLEXCURVE TRIP TIME AT 6.50xPU	0 to 65535	1	ms	F1	65535
175E	FLEXCURVE TRIP TIME AT 7.00xPU	0 to 65535	1	ms	F1	65535
175F	FLEXCURVE TRIP TIME AT 7.50xPU	0 to 65535	1	ms	F1	65535
1760	FLEXCURVE TRIP TIME AT 8.00xPU	0 to 65535	1	ms	F1	65535
1761	FLEXCURVE TRIP TIME AT 8.50xPU	0 to 65535	1	ms	F1	65535
1762	FLEXCURVE TRIP TIME AT 9.00xPU	0 to 65535	1	ms	F1	65535
1763	FLEXCURVE TRIP TIME AT 9.50xPU	0 to 65535	1	ms	F1	65535
1764	FLEXCURVE TRIP TIME AT 10.0xPU	0 to 65535	1	ms	F1	65535
1765	FLEXCURVE TRIP TIME AT 10.5xPU	0 to 65535	1	ms	F1	65535
1766	FLEXCURVE TRIP TIME AT 11.0xPU	0 to 65535	1	ms	F1	65535
1767	FLEXCURVE TRIP TIME AT 11.5xPU	0 to 65535	1	ms	F1	65535
1768	FLEXCURVE TRIP TIME AT 12.0xPU	0 to 65535	1	ms	F1	65535
1769	FLEXCURVE TRIP TIME AT 12.5xPU	0 to 65535	1	ms	F1	65535
176A	FLEXCURVE TRIP TIME AT 13.0xPU	0 to 65535	1	ms	F1	65535
176B	FLEXCURVE TRIP TIME AT 13.5xPU	0 to 65535	1	ms	F1	65535
176C	FLEXCURVE TRIP TIME AT 14.0xPU	0 to 65535	1	ms	F1	65535
176D	FLEXCURVE TRIP TIME AT 14.5xPU	0 to 65535	1	ms	F1	65535
176E	FLEXCURVE TRIP TIME AT 15.0xPU	0 to 65535	1	ms	F1	65535
176F	FLEXCURVE TRIP TIME AT 15.5xPU	0 to 65535	1	ms	F1	65535
1770	FLEXCURVE TRIP TIME AT 16.0xPU	0 to 65535	1	ms	F1	65535
1771	FLEXCURVE TRIP TIME AT 16.5xPU	0 to 65535	1	ms	F1	65535
1772	FLEXCURVE TRIP TIME AT 17.0xPU	0 to 65535	1	ms	F1	65535
1773	FLEXCURVE TRIP TIME AT 17.5xPU	0 to 65535	1	ms	F1	65535
1774	FLEXCURVE TRIP TIME AT 18.0xPU	0 to 65535	1	ms	F1	65535
1775	FLEXCURVE TRIP TIME AT 18.5xPU	0 to 65535	1	ms	F1	65535
1776	FLEXCURVE TRIP TIME AT 19.0xPU	0 to 65535	1	ms	F1	65535
1777	FLEXCURVE TRIP TIME AT 19.5xPU	0 to 65535	1	ms	F1	65535
1778	FLEXCURVE TRIP TIME AT 20.0xPU	0 to 65535	1	ms	F1	65535
1779	OVERCURRENT CURVE MULTIPLIER	0 to 100000	1	-	F14	100
177B	OVERCURRENT CURVE RESET	0 to 1	1	-	F201	0

CURRENT ELEMENTS / PHASE DIFFERENTIAL

17E0	PHASE DIFFERENTIAL TRIP	0 to 2	1	-	F115	0
17E1	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
17E2	DIFFERENTIAL TRIP MIN. PICKUP	5 to 100	1	x CT	F3	10
17E3	DIFFERENTIAL TRIP SLOPE 1	1 to 100	1	%	F1	10
17E4	DIFFERENTIAL TRIP SLOPE 2	1 to 100	1	%	F1	20
17E5	DIFFERENTIAL TRIP DELAY	0 to 100	1	Cycles	F1	0

CURRENT ELEMENTS / GROUND DIRECTIONAL

1800	SUPERVISE WITH DIGITAL INPUT	0 to 1	1	-	F103	1
1801	GROUND DIRECTIONAL MTA	0 to 3	1	-	F217	0
1802	GROUND DIRECTIONAL ALARM	0 to 2	1	-	F115	0
1803	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
1804	GROUND DIR. ALARM PICKUP	5 to 2000	1	x CT	F3	5
1805	GROUND DIR. ALARM DELAY	1 to 1200	1	s	F2	30
1806	GROUND DIR. ALARM EVENTS	0 to 1	1	-	F105	0
1807	GROUND DIRECTIONAL TRIP	0 to 2	1	-	F115	0
1808	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1809	GROUND DIR. TRIP PICKUP	5 to 2000	1	x CT	F3	5
180A	GROUND DIR. TRIP DELAY	1 to 1200	1	s	F2	30

CURRENT ELEMENTS / HIGH-SET PHASE O/C

1830	HIGH-SET PHASE O/C TRIP	0 to 2	1	-	F115	0
1831	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
1832	HIGH-SET PHASE O/C PICKUP	15 to 2000	1	x CT	F3	500
1833	HIGH-SET PHASE O/C DELAY	0 to 10000	1	s	F3	100

VOLTAGE ELEMENTS / UNDERVOLTAGE

2000	UNDERVOLTAGE ALARM	0 to 2	1	-	F115	0
2001	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2002	UNDERVOLTAGE ALARM PICKUP	50 to 99	1	x Rated	F3	85

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2003	UNDERVOLTAGE ALARM DELAY	2 to 1200	1	s	F2	30
2004	UNDERVOLTAGE ALARM EVENTS	0 to 1	1	-	F105	0
2005	UNDERVOLTAGE TRIP	0 to 2	1	-	F115	0
2006	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2007	UNDERVOLTAGE TRIP PICKUP	50 to 99	1	x Rated	F3	80
2008	UNDERVOLTAGE TRIP DELAY	2 to 100	1	s	F2	10
2009	UNDERVOLTAGE CURVE RESET RATE	0 to 9999	1	s	F2	14
200A	UNDERVOLTAGE CURVE ELEMENT	0 to 1	1	-	F208	0

VOLTAGE ELEMENTS / OVERVOLTAGE

2020	OVERVOLTAGE ALARM	0 to 2	1	-	F115	0
2021	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2022	OVERVOLTAGE ALARM PICKUP	101 to 150	1	x Rated	F3	115
2023	OVERVOLTAGE ALARM DELAY	1 to 1200	1	s	F2	30
2024	OVERVOLTAGE ALARM EVENTS	0 to 1	1	-	F105	0
2025	OVERVOLTAGE TRIP	0 to 2	1	-	F115	0
2026	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2027	OVERVOLTAGE TRIP PICKUP	101 to 150	1	x Rated	F3	120
2028	OVERVOLTAGE TRIP DELAY	1 to 100	1	s	F2	10
2029	OVERVOLTAGE CURVE RESET RATE	0 to 9999	1	s	F2	14
202A	OVERVOLTAGE CURVE ELEMENT	0 to 1	1	-	F208	0

VOLTAGE ELEMENTS / VOLTS/HERTZ

2040	VOLTS/HERTZ ALARM	0 to 2	1	-	F115	0
2041	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2042	VOLTS/HERTZ ALARM PICKUP	50 to 199	1	x Nominal	F3	100
2043	VOLTS/HERTZ ALARM DELAY	1 to 1500	1	s	F2	30
2044	VOLTS/HERTZ ALARM EVENTS	0 to 1	1	-	F105	0
2045	VOLTS/HERTZ TRIP	0 to 2	1	-	F115	0
2046	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2047	VOLTS/HERTZ TRIP PICKUP	50 to 199	1	x Nominal	F3	100
2048	VOLTS/HERTZ TRIP DELAY	1 to 1500	1	s	F2	10
2049	VOLTS/HERTZ CURVE RESET RATE	0 to 9999	1	s	F2	14
204A	VOLTS/HERTZ TRIP ELEMENT	0 to 3	1	-	F211	0

VOLTAGE ELEMENTS / PHASE REVERSAL

2060	PHASE REVERSAL TRIP	0 to 2	1	-	F115	0
2061	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1

VOLTAGE ELEMENTS / UNDERFREQUENCY

2080	BLOCK UNDERFREQUENCY FROM ONLINE	0 to 5	1	s	F1	1
2081	VOLTAGE LEVEL CUTOFF	50 to 99	1	x Rated	F3	50
2082	UNDERFREQUENCY ALARM	0 to 2	1	-	F115	0
2083	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2084	UNDERFREQUENCY ALARM LEVEL	2000 to 6000	1	Hz	F3	5950
2085	UNDERFREQUENCY ALARM DELAY	1 to 50000	1	s	F2	50
2086	UNDERFREQUENCY ALARM EVENTS	0 to 1	1	-	F105	0
2087	UNDERFREQUENCY TRIP	0 to 2	1	-	F115	0
2088	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2089	UNDERFREQUENCY TRIP LEVEL1	2000 to 6000	1	Hz	F3	5950
208A	UNDERFREQUENCY TRIP DELAY1	1 to 50000	1	s	F2	600
208B	UNDERFREQUENCY TRIP LEVEL2	2000 to 6000	1	Hz	F3	5800
208C	UNDERFREQUENCY TRIP DELAY2	1 to 50000	1	s	F2	300

VOLTAGE ELEMENTS / OVERFREQUENCY

20A0	BLOCK OVERFREQUENCY FROM ONLINE	0 to 5	1	s	F1	1
20A1	VOLTAGE LEVEL CUTOFF	50 to 99	1	x Rated	F3	50
20A2	OVERFREQUENCY ALARM	0 to 2	1	-	F115	0
20A3	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
20A4	OVERFREQUENCY ALARM LEVEL	2501 to 7000	1	Hz	F3	6050
20A5	OVERFREQUENCY ALARM DELAY	1 to 50000	1	s	F2	50
20A6	OVERFREQUENCY ALARM EVENTS	0 to 1	1	-	F105	0
20A7	OVERFREQUENCY TRIP	0 to 2	1	-	F115	0

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20A8	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
20A9	OVERFREQUENCY TRIP LEVEL1	2501 to 7000	1	Hz	F3	6050
20AA	OVERFREQUENCY TRIP DELAY1	1 to 50000	1	s	F2	600
20AB	OVERFREQUENCY TRIP LEVEL2	2501 to 7000	1	Hz	F3	6200
20AC	OVERFREQUENCY TRIP DELAY2	1 to 50000	1	s	F2	300

VOLTAGE ELEMENTS / NEUTRAL O/V (FUND)

20C0	NEUTRAL OVERVOLTAGE ALARM	0 to 2	1	-	F115	0
20C1	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
20C2	NEUTRAL O/V ALARM LEVEL	20 to 1000	1	V	F2	30
20C3	NEUTRAL OVERVOLTAGE ALARM DELAY	1 to 1200	1	s	F2	10
20C4	NEUTRAL OVERVOLTAGE ALARM EVENTS	0 to 1	1	-	F105	0
20C5	NEUTRAL OVERVOLTAGE TRIP	0 to 2	1	-	F115	0
20C6	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
20C7	NEUTRAL O/V TRIP LEVEL	20 to 1000	1	V	F2	50
20C8	NEUTRAL OVERVOLTAGE TRIP DELAY	1 to 1200	1	s	F2	10
20C9	SUPERVISE WITH DIGITAL INPUT	0 to 1	1	-	F103	0
20CA	NEUTRAL O/V CURVE RESET RATE	0 to 9999	1	s	F2	0
20CB	NEUTRAL O/V TRIP ELEMENT	0 to 1	1	-	F208	1

VOLTAGE ELEMENTS / NEUTRAL U/V (3rd)

20E0	LOW POWER BLOCKING LEVEL	2 to 99	1	xRated MW	F14	5
20E2	LOW VOLTAGE BLOCKING LEVEL	50 to 100	1	x Rated	F3	75
20E3	NEUTRAL UNDERVOLTAGE ALARM	0 to 2	1	-	F115	0
20E4	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
20E5	NEUTRAL U/V ALARM LEVEL	5 to 200	1	V	F2	5
20E6	NEUTRAL UNDERVOLTAGE ALARM DELAY	5 to 120	1	s	F1	30
20E7	NEUTRAL UNDERVOLTAGE ALARM EVENTS	0 to 1	1	-	F105	0
20E8	NEUTRAL UNDERVOLTAGE TRIP	0 to 2	1	-	F115	0
20E9	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
20EA	NEUTRAL U/V TRIP LEVEL	5 to 200	1	V	F2	10
20EB	NEUTRAL UNDERVOLTAGE TRIP DELAY	5 to 120	1	s	F1	30

VOLTAGE ELEMENTS / LOSS OF EXCITATION

2100	ENABLE VOLTAGE SUPERVISION	0 to 1	1	-	F103	0
2101	VOLTAGE LEVEL	70 to 100	1	x rated	F3	70
2102	CIRCLE 1 TRIP	0 to 2	1	-	F115	0
2103	ASSIGN CIRCLE 1 TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2104	CIRCLE 1 DIAMETER	25 to 3000	1	ohms s	F2	250
2105	CIRCLE 1 OFFSET	10 to 3000	1	ohms s	F2	25
2106	CIRCLE 1 TRIP DELAY	1 to 100	1	s	F2	50
2107	CIRCLE 2 TRIP	0 to 2	1	-	F115	0
2108	ASSIGN CIRCLE 2 TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2109	CIRCLE 2 DIAMETER	25 to 3000	1	ohms s	F2	350
210A	CIRCLE 2 OFFSET	10 to 3000	1	ohms s	F2	25
210B	CIRCLE 2 TRIP DELAY	1 to 100	1	s	F2	50

VOLTAGE ELEMENTS / DISTANCE ELEMENT

2130	STEP UP TRANSFORMER SETUP	0 to 1	1	-	F219	0
2131	FUSE FAILURE SUPERVISION	0 to 1	1	-	F105	0
2132	ZONE 1 TRIP	0 to 2	1	-	F115	0
2133	ASSIGN ZONE 1 TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2134	ZONE 1 REACH	1 to 5000	1	ohms s	F2	100
2135	ZONE 1 ANGLE	50 to 85	1	°	F1	75
2136	ZONE 1 TRIP DELAY	0 to 1500	1	s	F2	4
2137	ZONE 2 TRIP	0 to 2	1	-	F115	0
2138	ASSIGN ZONE 2 TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2139	ZONE 2 REACH	1 to 5000	1	ohms s	F2	100
213A	ZONE 2 ANGLE	50 to 85	1	°	F1	75
213B	ZONE 2 TRIP DELAY	0 to 1500	1	s	F2	20

POWER ELEMENTS / REACTIVE POWER

2200	BLOCK Mvar ELEMENT FROM ONLINE	0 to 5000	1	s	F1	1
2201	REACTIVE POWER ALARM	0 to 2	1	-	F115	0
2202	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2203	POSITIVE Mvar ALARM LEVEL [3]	2 to 201	1	x rated	F14	85
2205	NEGATIVE Mvar ALARM LEVEL [3]	2 to 201	1	x rated	F14	85

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[3] Maximum value turns feature 'Off'

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2207	NEGATIVE Mvar ALARM DELAY	2 to 1200	1	s	F2	10
2208	REACTIVE POWER ALARM EVENTS	0 to 1	1	-	F105	0
2209	REACTIVE POWER TRIP	0 to 2	1	-	F115	0
220A	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
220B	POSITIVE Mvar TRIP LEVEL [3]	2 to 201	1	Mvar	F14	80
220D	NEGATIVE Mvar TRIP LEVEL [3]	2 to 201	1	Mvar	F14	80
220F	NEGATIVE Mvar TRIP DELAY	2 to 1200	1	s	F2	10
2210	POSITIVE Mvar TRIP DELAY	2 to 1200	1	s	F2	200
2211	POSITIVE Mvar ALARM DELAY	2 to 1200	1	s	F2	100

POWER ELEMENTS / REVERSE POWER

2240	BLOCK REVERSE POWER FROM ONLINE	0 to 5000	1	s	F1	1
2241	REVERSE POWER ALARM	0 to 2	1	-	F115	0
2242	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2243	REVERSE POWER ALARM LEVEL	2 to 99	1	xRated	F14	5
MW						
2245	REVERSE POWER ALARM DELAY	2 to 1200	1	s	F2	100
2246	REVERSE POWER ALARM EVENTS	0 to 1	1	-	F105	0
2247	REVERSE POWER TRIP	0 to 2	1	-	F115	0
2248	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2249	REVERSE POWER TRIP LEVEL	2 to 99	1	xRated	F14	5
MW						
224B	REVERSE POWER TRIP DELAY	2 to 1200	1	s	F2	200

POWER ELEMENTS / LOW FORWARD POWER

2280	BLOCK LOW FWD POWER FROM ONLINE	0 to 15000	1	s	F1	0
2281	LOW FORWARD POWER ALARM	0 to 2	1	-	F115	0
2282	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2283	LOW FWD POWER ALARM LEVEL	2 to 99	1	xRated MW	F14	5
2285	LOW FWD POWER ALARM DELAY	2 to 1200	1	s	F2	100
2286	LOW FWD POWER ALARM EVENTS	0 to 1	1	-	F105	0
2287	LOW FORWARD POWER TRIP	0 to 2	1	-	F115	0
2288	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2289	LOW FWD POWER TRIP LEVEL	2 to 99	1	xRated MW	F14	5
228B	LOW FWD POWER TRIP DELAY	2 to 1200	1	s	F2	200

RTD TEMPERATURE / RTD TYPES

2400	STATOR RTD TYPE	0 to 3	1	-	F120	0
2401	BEARING RTD TYPE	0 to 3	1	-	F120	0
2402	AMBIENT RTD TYPE	0 to 3	1	-	F120	0
2403	OTHER RTD TYPE	0 to 3	1	-	F120	0

RTD TEMPERATURE / RTD #1

2420	RTD #1 APPLICATION	0 to 4	1	-	F121	1
2421	RTD #1 ALARM	0 to 2	1	-	F115	0
2422	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2423	RTD #1 ALARM TEMPERATURE	1 to 250	1	°C	F1	130
2424	RTD #1 ALARM EVENTS	0 to 1	1	-	F105	0
2425	RTD #1 TRIP	0 to 2	1	-	F115	0
2426	RTD #1 TRIP VOTING	1 to 12	1	-	F122	1
2427	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2428	RTD #1 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
2429	RTD #1 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #2

2460	RTD #2 APPLICATION	0 to 4	1	-	F121	1
2461	RTD #2 ALARM	0 to 2	1	-	F115	0
2462	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2463	RTD #2 ALARM TEMPERATURE	1 to 250	1	°C	F1	130
2464	RTD #2 ALARM EVENTS	0 to 1	1	-	F105	0
2465	RTD #2 TRIP	0 to 2	1	-	F115	0
2466	RTD #2 TRIP VOTING	1 to 12	1	-	F122	2
2467	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2468	RTD #2 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
2469	RTD #2 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #3

24A0	RTD #3 APPLICATION	0 to 4	1	-	F121	1
24A1	RTD #3 ALARM	0 to 2	1	-	F115	0
24A2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
24A3	RTD #3 ALARM TEMPERATURE	1 to 250	1	°C	F1	130

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24A4	RTD #3 ALARM EVENTS	0 to 1	1	-	F105	0
24A5	RTD #3 TRIP	0 to 2	1	-	F115	0
24A6	RTD #3 TRIP VOTING	1 to 12	1	-	F122	3
24A7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
24A8	RTD #3 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
24A9	RTD #3 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #4

24E0	RTD #4 APPLICATION	0 to 4	1	-	F121	1
24E1	RTD #4 ALARM	0 to 2	1	-	F115	0
24E2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
24E3	RTD #4 ALARM TEMPERATURE	1 to 250	1	°C	F1	130
24E4	RTD #4 ALARM EVENTS	0 to 1	1	-	F105	0
24E5	RTD #4 TRIP	0 to 2	1	-	F115	0
24E6	RTD #4 TRIP VOTING	1 to 12	1	-	F122	4
24E7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
24E8	RTD #4 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
24E9	RTD #4 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #5

2520	RTD #5 APPLICATION	0 to 4	1	-	F121	1
2521	RTD #5 ALARM	0 to 2	1	-	F115	0
2522	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2523	RTD #5 ALARM TEMPERATURE	1 to 250	1	°C	F1	130
2524	RTD #5 ALARM EVENTS	0 to 1	1	-	F105	0
2525	RTD #5 TRIP	0 to 2	1	-	F115	0
2526	RTD #5 TRIP VOTING	1 to 12	1	-	F122	5
2527	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2528	RTD #5 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
2529	RTD #5 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #6

2560	RTD #6 APPLICATION	0 to 4	1	-	F121	1
2561	RTD #6 ALARM	0 to 2	1	-	F115	0
2562	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2563	RTD #6 ALARM TEMPERATURE	1 to 250	1	°C	F1	130
2564	RTD #6 ALARM EVENTS	0 to 1	1	-	F105	0
2565	RTD #6 TRIP	0 to 2	1	-	F115	0
2566	RTD #6 TRIP VOTING	1 to 12	1	-	F122	6
2567	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2568	RTD #6 TRIP TEMPERATURE	1 to 250	1	°C	F1	155
2569	RTD #6 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #7

25A0	RTD #7 APPLICATION	0 to 4	1	-	F121	2
25A1	RTD #7 ALARM	0 to 2	1	-	F115	0
25A2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
25A3	RTD #7 ALARM TEMPERATURE	1 to 250	1	°C	F1	80
25A4	RTD #7 ALARM EVENTS	0 to 1	1	-	F105	0
25A5	RTD #7 TRIP	0 to 2	1	-	F115	0
25A6	RTD #7 TRIP VOTING	1 to 12	1	-	F122	7
25A7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
25A8	RTD #7 TRIP TEMPERATURE	1 to 250	1	°C	F1	90
25A9	RTD #7 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #8

25E0	RTD #8 APPLICATION	0 to 4	1	-	F121	2
25E1	RTD #8 ALARM	0 to 2	1	-	F115	0
25E2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
25E3	RTD #8 ALARM TEMPERATURE	1 to 250	1	°C	F1	80
25E4	RTD #8 ALARM EVENTS	0 to 1	1	-	F105	0
25E5	RTD #8 TRIP	0 to 2	1	-	F115	0
25E6	RTD #8 TRIP VOTING	1 to 12	1	-	F122	8
25E7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
25E8	RTD #8 TRIP TEMPERATURE	1 to 250	1	°C	F1	90
25E9	RTD #8 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #9

2620	RTD #9 APPLICATION	0 to 4	1	-	F121	2
2621	RTD #9 ALARM	0 to 2	1	-	F115	0
2622	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2623	RTD #9 ALARM TEMPERATURE	1 to 250	1	°C	F1	80

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2624	RTD #9 ALARM EVENTS	0 to 1	1	-	F105	0
2625	RTD #9 TRIP	0 to 2	1	-	F115	0
2626	RTD #9 TRIP VOTING	1 to 12	1	-	F122	9
2627	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2628	RTD #9 TRIP TEMPERATURE	1 to 250	1	°C	F1	90
2629	RTD #9 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #10

2660	RTD #10 APPLICATION	0 to 4	1	-	F121	2
2661	RTD #10 ALARM	0 to 2	1	-	F115	0
2662	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2663	RTD #10 ALARM TEMPERATURE	1 to 250	1	°C	F1	80
2664	RTD #10 ALARM EVENTS	0 to 1	1	-	F105	0
2665	RTD #10 TRIP	0 to 2	1	-	F115	0
2666	RTD #10 TRIP VOTING	1 to 12	1	-	F122	10
2667	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2668	RTD #10 TRIP TEMPERATURE	1 to 250	1	°C	F1	90
2669	RTD #10 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #11

26A0	RTD #11 APPLICATION	0 to 4	1	-	F121	4
26A1	RTD #11 ALARM	0 to 2	1	-	F115	0
26A2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
26A3	RTD #11 ALARM TEMPERATURE	1 to 250	1	°C	F1	80
26A4	RTD #11 ALARM EVENTS	0 to 1	1	-	F105	0
26A5	RTD #11 TRIP	0 to 2	1	-	F115	0
26A6	RTD #11 TRIP VOTING	1 to 12	1	-	F122	11
26A7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
26A8	RTD #11 TRIP TEMPERATURE	1 to 250	1	°C	F1	90
26A9	RTD #11 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / RTD #12

26E0	RTD #12 APPLICATION	0 to 4	1	-	F121	3
26E1	RTD #12 ALARM	0 to 2	1	-	F115	0
26E2	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
26E3	RTD #12 ALARM TEMPERATURE	1 to 250	1	°C	F1	60
26E4	RTD #12 ALARM EVENTS	0 to 1	1	-	F105	0
26E5	RTD #12 TRIP	0 to 2	1	-	F115	0
26E6	RTD #12 TRIP VOTING	1 to 12	1	-	F122	12
26E7	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
26E8	RTD #12 TRIP TEMPERATURE	1 to 250	1	°C	F1	80
26E9	RTD #12 NAME	0 to 8	1	-	F22	_

RTD TEMPERATURE / OPEN RTD SENSOR

2720	OPEN RTD SENSOR ALARM	0 to 2	1	-	F115	0
2721	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2722	OPEN RTD SENSOR ALARM EVENTS	0 to 1	1	-	F105	0

RTD TEMPERATURE / RTD SHORT/LOW TEMP

2740	RTD SHORT/LOW TEMP ALARM	0 to 2	1	-	F115	0
2741	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2742	RTD SHORT/LOW TEMP ALARM EVENTS	0 to 1	1	-	F105	0

THERMAL MODEL / MODEL SETUP

2800	ENABLE THERMAL MODEL	0 to 1	1	-	F103	0
2801	OVERLOAD PICKUP LEVEL	101 to 125	1	x FLA	F3	101
2802	UNBALANCE BIAS K FACTOR	0 to 12	1	-	F1	0
2803	COOL TIME CONSTANT ONLINE	0 to 500	1	min	F1	15
2804	COOL TIME CONSTANT OFFLINE	0 to 500	1	min	F1	30
2805	HOT/COLD SAFE STALL RATIO	1 to 100	1	-	F3	100
2806	ENABLE RTD BIASING	0 to 1	1	-	F103	0
2807	RTD BIAS MINIMUM	0 to 250	1	°C	F1	40
2808	RTD BIAS CENTER POINT	0 to 250	1	°C	F1	130
2809	RTD BIAS MAXIMUM	0 to 250	1	°C	F1	155
280A	SELECT CURVE STYLE	0 to 2	1	-	F142	0
280B	STANDARD OVERLOAD CURVE NUMBER	1 to 15	1	-	F1	4
280C	TIME TO TRIP AT 1.01 x FLA	5 to 999999	1	s	F10	5
280E	TIME TO TRIP AT 1.05 x FLA	5 to 999999	1	s	F10	5
2810	TIME TO TRIP AT 1.10 x FLA	5 to 999999	1	s	F10	5
2812	TIME TO TRIP AT 1.20 x FLA	5 to 999999	1	s	F10	5
2814	TIME TO TRIP AT 1.30 x FLA	5 to 999999	1	s	F10	5
2816	TIME TO TRIP AT 1.40 x FLA	5 to 999999	1	s	F10	5
2818	TIME TO TRIP AT 1.50 x FLA	5 to 999999	1	s	F10	5

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281A	TIME TO TRIP AT 1.75 x FLA	5 to 999999	1	s	F10	5
281C	TIME TO TRIP AT 2.00 x FLA	5 to 999999	1	s	F10	5
281E	TIME TO TRIP AT 2.25 x FLA	5 to 999999	1	s	F10	5
2820	TIME TO TRIP AT 2.50 x FLA	5 to 999999	1	s	F10	5
2822	TIME TO TRIP AT 2.75 x FLA	5 to 999999	1	s	F10	5
2824	TIME TO TRIP AT 3.00 x FLA	5 to 999999	1	s	F10	5
2826	TIME TO TRIP AT 3.25 x FLA	5 to 999999	1	s	F10	5
2828	TIME TO TRIP AT 3.50 x FLA	5 to 999999	1	s	F10	5
282A	TIME TO TRIP AT 3.75 x FLA	5 to 999999	1	s	F10	5
282C	TIME TO TRIP AT 4.00 x FLA	5 to 999999	1	s	F10	5
282E	TIME TO TRIP AT 4.25 x FLA	5 to 999999	1	s	F10	5
2830	TIME TO TRIP AT 4.50 x FLA	5 to 999999	1	s	F10	5
2832	TIME TO TRIP AT 4.75 x FLA	5 to 999999	1	s	F10	5
2834	TIME TO TRIP AT 5.00 x FLA	5 to 999999	1	s	F10	5
2836	TIME TO TRIP AT 5.50 x FLA	5 to 999999	1	s	F10	5
2838	TIME TO TRIP AT 6.00 x FLA	5 to 999999	1	s	F10	5
283A	TIME TO TRIP AT 6.50 x FLA	5 to 999999	1	s	F10	5
283C	TIME TO TRIP AT 7.00 x FLA	5 to 999999	1	s	F10	5
283E	TIME TO TRIP AT 7.50 x FLA	5 to 999999	1	s	F10	5
2840	TIME TO TRIP AT 8.00 x FLA	5 to 999999	1	s	F10	5
2842	TIME TO TRIP AT 10.0 x FLA	5 to 999999	1	s	F10	5
2844	TIME TO TRIP AT 15.0 x FLA	5 to 999999	1	s	F10	5
2846	TIME TO TRIP AT 20.0 x FLA	5 to 999999	1	s	F10	5
2848	MINIMUM ALLOWABLE VOLTAGE	70 to 95	1	%	F1	80
2849	STALL CURRENT @ MIN VOLTAGE	200 to 1500	1	x FLA	F3	480
284A	SAFE STALL TIME @ MIN VOLTAGE	5 to 9999	1	s	F2	200
284B	ACCEL. INTERSECT @ MIN VOLT	200 to 1500	1	x FLA	F3	380
284C	STALL CURRENT @ 100% VOLTAGE	200 to 1500	1	x FLA	F3	600
284D	SAFE STALL TIME @ 100% VOLTAGE	5 to 9999	1	s	F2	100
284E	ACCEL. INTERSECT @ 100% VOLT	200 to 1500	1	x FLA	F3	500

THERMAL MODEL / THERMAL ELEMENTS

2900	THERMAL MODEL ALARM	0 to 2	1	-	F115	0
2901	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2902	THERMAL ALARM LEVEL	10 to 100	1	% Used	F1	75
2903	THERMAL MODEL ALARM EVENTS	0 to 1	1	-	F105	0
2904	THERMAL MODEL TRIP	0 to 2	1	-	F115	0
2905	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1

MONITORING / TRIP COUNTER

2A00	TRIP COUNTER ALARM	0 to 2	1	-	F115	0
2A01	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A02	TRIP COUNTER ALARM LEVEL	1 to 50000	1	Trips	F1	25
2A03	TRIP COUNTER ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / BREAKER FAILURE

2A20	BREAKER FAILURE ALARM	0 to 2	1	-	F115	0
2A21	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A22	BREAKER FAILURE LEVEL	5 to 2000	1	x CT	F3	100
2A23	BREAKER FAILURE DELAY	10 to 1000	10	ms	F1	100
2A24	BREAKER FAILURE ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / TRIP COIL MONITOR

2A30	TRIP COIL MONITOR ALARM	0 to 2	1	-	F115	0
2A31	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A32	TRIP COIL MONITOR ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / VT FUSE FAILURE

2A50	VT FUSE FAILURE ALARM	0 to 2	1	-	F115	0
2A51	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A52	VT FUSE FAILURE ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / CURRENT DEMAND

2A60	CURRENT DEMAND PERIOD	5 to 90	1	min	F1	15
2A61	CURRENT DEMAND ALARM	0 to 2	1	A	F115	0
2A62	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	A	F50	16
2A63	CURRENT DEMAND LIMIT	10 to 2000	1	x FLA	F14	125
2A65	CURRENT DEMAND ALARM EVENTS	0 to 1	1	A	F105	0

MONITORING / MW DEMAND

2A70	MW DEMAND PERIOD	5 to 90	1	min	F1	15
2A71	MW DEMAND ALARM	0 to 2	1	-	F115	0

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2A72	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A73	MW DEMAND LIMIT	10 to 200	1	x Rated	F14	125
2A75	MW DEMAND ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / Mar DEMAND

2A80	Mar DEMAND PERIOD	5 to 90	1	min	F1	15
2A81	Mar DEMAND ALARM	0 to 2	1	-	F115	0
2A82	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A83	Mar DEMAND LIMIT	10 to 200	1	x Rated	F14	125
2A85	Mar DEMAND ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / MVA DEMAND

2A90	MVA DEMAND PERIOD	5 to 90	1	min	F1	15
2A91	MVA DEMAND ALARM	0 to 2	1	-	F115	0
2A92	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2A93	MVA DEMAND LIMIT	10 to 200	1	x Rated	F14	125
2A95	MVA DEMAND ALARM EVENTS	0 to 1	1	-	F105	0

MONITORING / PULSE OUTPUT

2AB0	POS. kWh PULSE OUT RELAYS (2-5)	1 to 4	1	-	F50	0
2AB1	POS. kWk PULSE OUT INTERVAL	1 to 50000	1	-	F1	10
2AB2	POS. kvarh PULSE OUT RELAYS (2-5)	1 to 4	1	-	F50	0
2AB3	POS. kvarh PULSE OUT INTERVAL	1 to 50000	1	-	F1	10
2AB4	NEG. kvarh PULSE OUT RELAYS (2-5)	1 to 4	1	-	F50	0
2AB5	NEG. kvarh PULSE OUT INTERVAL	1 to 50000	1	-	F1	10
2AB6	PULSE WIDTH	200 to 1000	1	-	F1	200

MONITORING / RUNNING HOUR SETUP

2AC0	INITIAL GEN. RUNNING HOUR	0 to 999999	1	h	F12	0
2AC2	GEN. RUNNING HOUR ALARM	0 to 2	1	-	F115	0
2AC3	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2AC4	GEN. RUNNING HOUR LIMIT	1 to 1000000	1	h	F12	1000
2AC6	RESERVED					

ANALOG I/O / ANALOG OUTPUT 1

2B00	ANALOG OUTPUT 1	0 to 42	1	-	F127	0

ANALOG I/O / ANALOG OUTPUT 2

2B01	ANALOG OUTPUT 2	0 to 42	1	-	F127	0

ANALOG I/O / ANALOG OUTPUT 3

2B02	ANALOG OUTPUT 3	0 to 42	1	-	F127	0

ANALOG I/O / ANALOG OUTPUT 4

2B03	ANALOG OUTPUT 4	0 to 42	1	-	F127	0

ANALOG I/O / ANALOG OUTPUTS

2B04	IA OUTPUT CURRENT MIN	0 to 2000	1	x FLA	F3	0
2B05	IA OUTPUT CURRENT MAX	0 to 2000	1	x FLA	F3	125
2B06	IB OUTPUT CURRENT MIN	0 to 2000	1	x FLA	F3	0
2B07	IB OUTPUT CURRENT MAX	0 to 2000	1	x FLA	F3	125
2B08	IC OUTPUT CURRENT MIN	0 to 2000	1	x FLA	F3	0
2B09	IC OUTPUT CURRENT MAX	0 to 2000	1	x FLA	F3	125
2B0A	AVG OUTPUT CURRENT MIN	0 to 2000	1	x FLA	F3	0
2B0B	AVG OUTPUT CURRENT MAX	0 to 2000	1	x FLA	F3	125
2B0C	NEG. SEQ. CURRENT MIN	0 to 2000	1	% FLA	F1	0
2B0D	NEG. SEQ. CURRENT MAX	0 to 2000	1	% FLA	F1	100
2B0E	AVERAGED GEN. LOAD MIN	0 to 2000	1	x FLA	F3	0
2B0F	AVERAGED GEN. LOAD MAX	0 to 2000	1	x FLA	F3	125
2B10	HOTTEST STATOR RTD MIN	-50 to 250	1	°C	F4	0
2B11	HOTTEST STATOR RTD MAX	-50 to 250	1	°C	F4	200
2B12	HOTTEST BEARING RTD MIN	-50 to 250	1	°C	F4	0
2B13	HOTTEST BEARING RTD MAX	-50 to 250	1	°C	F4	200
2B14	AMBIENT RTD MIN	-50 to 250	1	°C	F4	0
2B15	AMBIENT RTD MAX	-50 to 250	1	°C	F4	70
2B16	RTD #1 MIN	-50 to 250	1	°C	F4	0
2B17	RTD #1 MAX	-50 to 250	1	°C	F4	200
2B18	RTD #2 MIN	-50 to 250	1	°C	F4	0
2B19	RTD #2 MAX	-50 to 250	1	°C	F4	200
2B1A	RTD #3 MIN	-50 to 250	1	°C	F4	0
2B1B	RTD #3 MAX	-50 to 250	1	°C	F4	200
2B1C	RTD #4 MIN	-50 to 250	1	°C	F4	0
2B1D	RTD #4 MAX	-50 to 250	1	°C	F4	200

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2B1E	RTD #5 MIN	-50 to 250	1	°C	F4	0
2B1F	RTD #5 MAX	-50 to 250	1	°C	F4	200
2B20	RTD #6 MIN	-50 to 250	1	°C	F4	0
2B21	RTD #6 MAX	-50 to 250	1	°C	F4	200
2B22	RTD #7 MIN	-50 to 250	1	°C	F4	0
2B23	RTD #7 MAX	-50 to 250	1	°C	F4	200
2B24	RTD #8 MIN	-50 to 250	1	°C	F4	0
2B25	RTD #8 MAX	-50 to 250	1	°C	F4	200
2B26	RTD #9 MIN	-50 to 250	1	°C	F4	0
2B27	RTD #9 MAX	-50 to 250	1	°C	F4	200
2B28	RTD #10 MIN	-50 to 250	1	°C	F4	0
2B29	RTD #10 MAX	-50 to 250	1	°C	F4	200
2B2A	RTD #11 MIN	-50 to 250	1	°C	F4	0
2B2B	RTD #11 MAX	-50 to 250	1	°C	F4	200
2B2C	RTD #12 MIN	-50 to 250	1	°C	F4	0
2B2D	RTD #12 MAX	-50 to 250	1	°C	F4	200
2B2E	AB VOLTAGE MIN	0 to 150	1	x Rated	F3	0
2B2F	AB VOLTAGE MAX	0 to 150	1	x Rated	F3	125
2B30	BC VOLTAGE MIN	0 to 150	1	x Rated	F3	0
2B31	BC VOLTAGE MAX	0 to 150	1	x Rated	F3	125
2B32	CA VOLTAGE MIN	0 to 150	1	x Rated	F3	0
2B33	CA VOLTAGE MAX	0 to 150	1	x Rated	F3	125
2B34	AVERAGE VOLTAGE MIN	0 to 150	1	x Rated	F3	0
2B35	AVERAGE VOLTAGE MAX	0 to 150	1	x Rated	F3	125
2B36	VOLTS/HERTZ MIN	0 to 200	1	x Rated	F3	0
2B37	VOLTS/HERTZ MAX	0 to 200	1	x Rated	F3	150
2B38	FREQUENCY MIN	0 to 9000	1	Hz	F3	5900
2B39	FREQUENCY MAX	0 to 9000	1	Hz	F3	6100
2B3C	POWER FACTOR MIN	-99 to 100	1	-	F6	80
2B3D	POWER FACTOR MAX	-99 to 100	1	-	F6	-80
2B3E	REACTIVE POWER MIN	-200 to 200	1	x Rated	F6	0
2B3F	REACTIVE POWER MAX	-200 to 200	1	x Rated	F6	125
2B40	REAL POWER (MW) MIN	-200 to 200	1	x Rated	F6	0
2B41	REAL POWER (MW) MAX	-200 to 200	1	x Rated	F6	125
2B42	APPARENT POWER MIN	0 to 200	1	x Rated	F3	0
2B43	APPARENT POWER MAX	0 to 200	1	x Rated	F3	125
2B44	ANALOG INPUT 1 MIN	-50000 to 50000	1	Units	F12	0
2B46	ANALOG INPUT 1 MAX	-50000 to 50000	1	Units	F12	50000
2B48	ANALOG INPUT 2 MIN	-50000 to 50000	1	Units	F12	0
2B4A	ANALOG INPUT 2 MAX	-50000 to 50000	1	Units	F12	50000
2B4C	ANALOG INPUT 3 MIN	-50000 to 50000	1	Units	F12	0
2B4E	ANALOG INPUT 3 MAX	-50000 to 50000	1	Units	F12	50000
2B50	ANALOG INPUT 4 MIN	-50000 to 50000	1	Units	F12	0
2B52	ANALOG INPUT 4 MAX	-50000 to 50000	1	Units	F12	50000
2B54	TACHOMETER MIN	0 to 7200	1	RPM	F1	3500
2B55	TACHOMETER MAX	0 to 7200	1	RPM	F1	3700
2B56	THERM. CAPACITY USED MIN	0 to 100	1	%	F1	0
2B57	THERM. CAPACITY USED MAX	0 to 100	1	%	F1	100
2B58	NEUTRAL VOLT THIRD MIN	0 to 250000	1	Volts	F10	0
2B5A	NEUTRAL VOLT THIRD MAX	0 to 250000	1	Volts	F10	450
2B5C	CURRENT DEMAND MIN	0 to 2000	1	x FLA	F3	0

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2B5D	CURRENT DEMAND MAX	0 to 2000	1	x FLA	F3	125
2B5E	Mar DEMAND MIN	0 to 200	1	x Rated	F3	0
2B5F	Mar DEMAND MAX	0 to 200	1	x Rated	F3	125
2B60	MW DEMAND MIN	0 to 200	1	x Rated	F3	0
2B61	MW DEMAND MAX	0 to 200	1	x Rated	F3	125
2B62	MVA DEMAND MIN	0 to 200	1	x Rated	F3	0
2B63	MVA DEMAND MAX	0 to 200	1	x Rated	F3	125

ANALOG I/O / ANALOG INPUT 1

2C00	ANALOG INPUT1	0 to 3	1	-	F129	0
2C05	ANALOG INPUT1 UNITS	0 to 6	1	-	F22	_
2C08	ANALOG INPUT1 MINIMUM	-50000 to 50000	1	Units	F12	0
2C0A	ANALOG INPUT1 MAXIMUM	-50000 to 50000	1	Units	F12	100
2C0C	BLOCK ANALOG INPUT1 FROM ONLINE	0 to 5000	1	s	F1	0
2C0D	ANALOG INPUT1 ALARM	0 to 2	1	-	F115	0
2C0E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2C0F	ANALOG INPUT1 ALARM LEVEL	-50000 to 50000	1	Units	F12	10
2C11	ANALOG INPUT1 ALARM PICKUP	0 to 1	1	-	F130	0
2C12	ANALOG INPUT1 ALARM DELAY	1 to 3000	1	s	F2	1
2C13	ANALOG INPUT1 ALARM EVENTS	0 to 1	1	-	F105	0
2C14	ANALOG INPUT1 TRIP	0 to 2	1	-	F115	0
2C15	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2C16	ANALOG INPUT1 TRIP LEVEL	-50000 to 50000	1	Units	F12	20
2C18	ANALOG INPUT1 TRIP PICKUP	0 to 1	1	-	F130	0
2C19	ANALOG INPUT1 TRIP DELAY	1 to 3000	1	s	F2	1
2C1A	ANALOG INPUT1 NAME	0 to 12	1	-	F22	_

ANALOG I/O / ANALOG INPUT 2

2C40	ANALOG INPUT2	0 to 3	1	-	F129	0
2C45	ANALOG INPUT2 UNITS	0 to 6	1	-	F22	_
2C48	ANALOG INPUT2 MINIMUM	-50000 to 50000	1	Units	F12	0
2C4A	ANALOG INPUT2 MAXIMUM	-50000 to 50000	1	Units	F12	100
2C4C	BLOCK ANALOG INPUT2 FROM ONLINE	0 to 5000	1	s	F1	0
2C4D	ANALOG INPUT2 ALARM	0 to 2	1	-	F115	0
2C4E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2C4F	ANALOG INPUT2 ALARM LEVEL	-50000 to 50000	1	Units	F12	10
2C51	ANALOG INPUT2 ALARM PICKUP	0 to 1	1	-	F130	0
2C52	ANALOG INPUT2 ALARM DELAY	1 to 3000	1	s	F2	1
2C53	ANALOG INPUT2 ALARM EVENTS	0 to 1	1	-	F105	0
2C54	ANALOG INPUT2 TRIP	0 to 2	1	-	F115	0
2C55	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2C56	ANALOG INPUT2 TRIP LEVEL	-50000 to 50000	1	Units	F12	20
2C58	ANALOG INPUT2 TRIP PICKUP	0 to 1	1	-	F130	0
2C59	ANALOG INPUT2 TRIP DELAY	1 to 3000	1	s	F2	1
2C5A	ANALOG INPUT2 NAME	0 to 12	1	-	F22	_

ANALOG I/O / ANALOG INPUT 3

2C80	ANALOG INPUT3	0 to 3	1	-	F129	0
2C85	ANALOG INPUT3 UNITS	0 to 6	1	-	F22	_
2C88	ANALOG INPUT3 MINIMUM	-50000 to 50000	1	Units	F12	0
2C8A	ANALOG INPUT3 MAXIMUM	-50000 to 50000	1	Units	F12	100
2C8C	BLOCK ANALOG INPUT3 FROM ONLINE	0 to 5000	1	s	F1	0
2C8D	ANALOG INPUT3 ALARM	0 to 2	1	-	F115	0
2C8E	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2C8F	ANALOG INPUT3 ALARM LEVEL	-50000 to 50000	1	Units	F12	10
2C91	ANALOG INPUT3 ALARM PICKUP	0 to 1	1	-	F130	0
2C92	ANALOG INPUT3 ALARM DELAY	1 to 3000	1	s	F2	1
2C93	ANALOG INPUT3 ALARM EVENTS	0 to 1	1	-	F105	0
2C94	ANALOG INPUT3 TRIP	0 to 2	1	-	F115	0
2C95	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2C96	ANALOG INPUT3 TRIP LEVEL	-50000 to 50000	1	Units	F12	20
2C98	ANALOG INPUT3 TRIP PICKUP	0 to 1	1	-	F130	0
2C99	ANALOG INPUT3 TRIP DELAY	1 to 3000	1	s	F2	1
2C9A	ANALOG INPUT3 NAME	0 to 12	1	-	F22	_

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ANALOG I/O / ANALOG INPUT 4

2CC0	ANALOG INPUT4	0 to 3	1	-	F129	0
2CC5	ANALOG INPUT4 UNITS	0 to 6	1	-	F22	_
2CC8	ANALOG INPUT4 MINIMUM	-50000 to 50000	1	Units	F12	0
2CCA	ANALOG INPUT4 MAXIMUM	-50000 to 50000	1	Units	F12	100
2CCC	BLOCK ANALOG INPUT4 FROM ONLINE	0 to 5000	1	s	F1	0
2CCD	ANALOG INPUT4 ALARM	0 to 2	1	-	F115	0
2CCE	ASSIGN ALARM RELAYS (2-5)	1 to 4	1	-	F50	16
2CCF	ANALOG INPUT4 ALARM LEVEL	-50000 to 50000	1	Units	F12	10
2CD1	ANALOG INPUT4 ALARM PICKUP	0 to 1	1	-	F130	0
2CD2	ANALOG INPUT4 ALARM DELAY	1 to 3000	1	s	F2	1
2CD3	ANALOG INPUT4 ALARM EVENTS	0 to 1	1	-	F105	0
2CD4	ANALOG INPUT4 TRIP	0 to 2	1	-	F115	0
2CD5	ASSIGN TRIP RELAYS (1-4)	0 to 3	1	-	F50	1
2CD6	ANALOG INPUT4 TRIP LEVEL	-50000 to 50000	1	Units	F12	20
2CD8	ANALOG INPUT4 TRIP PICKUP	0 to 1	1	-	F130	0
2CD9	ANALOG INPUT4 TRIP DELAY	1 to 3000	1	s	F2	1
2CDA	ANALOG INPUT4 NAME	0 to 12	1	-	F22	_

489 TESTING / SIMULATION MODE

2D00	SIMULATION MODE	0 to 3	1	-	F138	0
2D01	PRE-FAULT TO FAULT TIME DELAY	0 to 300	1	s	F1	15

489 TESTING / PRE-FAULT SETUP

2D20	PRE-FAULT Iphase OUTPUT	0 to 2000	1	x CT	F3	0
2D21	PRE-FAULT VOLTAGES PHASE-N	0 to 150	1	x Rated	F3	100
2D22	PRE-FAULT CURRENT LAGS VOLTAGE	0 to 359	1	°	F1	0
2D23	PRE-FAULT Iphase NEUTRAL	0 to 2000	1	x CT	F3	0
2D24	PRE-FAULT CURRENT GROUND	0 to 2000	1	x CT	F3	0
2D25	PRE-FAULT VOLTAGE NEUTRAL	0 to 1000	1	Volts	F2	0
2D26	PRE-FAULT STATOR RTD TEMP	-50 to 250	1	°C	F4	40
2D27	PRE-FAULT BEARING RTD TEMP	-50 to 250	1	°C	F4	40
2D28	PRE-FAULT OTHER RTD TEMP	-50 to 250	1	°C	F4	40
2D29	PRE-FAULT AMBIENT RTD TEMP	-50 to 250	1	°C	F4	40
2D2A	PRE-FAULT SYSTEM FREQUENCY	50 to 900	1	Hz	F2	600
2D2B	PRE-FAULT ANALOG INPUT 1	0 to 100	1	%	F1	0
2D2C	PRE-FAULT ANALOG INPUT 2	0 to 100	1	%	F1	0
2D2D	PRE-FAULT ANALOG INPUT 3	0 to 100	1	%	F1	0
2D2E	PRE-FAULT ANALOG INPUT 4	0 to 100	1	%	F1	0
2D4C	PRE-FAULT STATOR RTD TEMP	-50 to 250	1	°F	F4	40
2D4D	PRE-FAULT BEARING RTD TEMP	-50 to 250	1	°F	F4	40
2D4E	PRE-FAULT OTHER RTD TEMP	-50 to 250	1	°F	F4	40
2D4F	PRE-FAULT AMBIENT RTD TEMP	-50 to 250	1	°F	F4	40

489 TESTING / FAULT SETUP

2D80	FAULT Iphase OUTPUT	0 to 2000	1	x CT	F3	0
2D81	FAULT VOLTAGES PHASE-N	0 to 150	1	x Rated	F3	100
2D82	FAULT CURRENT LAGS VOLTAGE	0 to 359	1	°	F1	0
2D83	FAULT Iphase NEUTRAL	0 to 2000	1	x CT	F3	0
2D84	FAULT CURRENT GROUND	0 to 2000	1	x CT	F3	0
2D85	FAULT VOLTAGE NEUTRAL	0 to 1000	1	Volts	F2	0
2D86	FAULT STATOR RTD TEMP	-50 to 250	1	°C	F4	40
2D87	FAULT BEARING RTD TEMP	-50 to 250	1	°C	F4	40
2D88	FAULT OTHER RTD TEMP	-50 to 250	1	°C	F4	40
2D89	FAULT AMBIENT RTD TEMP	-50 to 250	1	°C	F4	40
2D8A	FAULT SYSTEM FREQUENCY	50 to 900	1	Hz	F2	600
2D8B	FAULT ANALOG INPUT 1	0 to 100	1	%	F1	0
2D8C	FAULT ANALOG INPUT 2	0 to 100	1	%	F1	0
2D8D	FAULT ANALOG INPUT 3	0 to 100	1	%	F1	0
2D8E	FAULT ANALOG INPUT 4	0 to 100	1	%	F1	0
2DBC	FAULT STATOR RTD TEMP	-50 to 250	1	°F	F4	40
2DBD	FAULT BEARING RTD TEMP	-50 to 250	1	°F	F4	40
2DBE	FAULT OTHER RTD TEMP	-50 to 250	1	°F	F4	40
2DBF	FAULT AMBIENT RTD TEMP	-50 to 250	1	°F	F4	40

489 TESTING / TEST OUTPUT RELAYS

2DE0	FORCE OPERATION OF RELAYS	0 to 8	1	-	F139	0

489 TESTING / TEST ANALOG OUTPUT

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2DF0	FORCE ANALOG OUTPUTS FUNCTION	0 to 1	1	-	F126	0
2DF1	ANALOG OUTPUT 1 FORCED VALUE	0 to 100	1	%	F1	0
2DF2	ANALOG OUTPUT 2 FORCED VALUE	0 to 100	1	%	F1	0
2DF3	ANALOG OUTPUT 3 FORCED VALUE	0 to 100	1	%	F1	0
2DF4	ANALOG OUTPUT 4 FORCED VALUE	0 to 100	1	%	F1	0

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Event Recorder (Input Registers) -- Addresses 3000 to 30EF

Addr	Name	Range	Step	Units	Fmt	Default
EVENT RECORDER / GENERAL						
3000	EVENT RECORDER LAST RESET DATE (2 WORDS)	N/A	N/A	N/A	F18	N/A
3002	TOTAL NUMBER OF EVENTS SINCE LAST CLEAR	0 to 65535	1	N/A	F1	N/A
3003	EVENT RECORD SELECTOR	0 to 65535	1	-	F1	0
EVENT RECORDER / SELECTED EVENT						
3004	CAUSE OF EVENT	0 to 139	1	-	F134	0
3005	TIME OF EVENT (2 WORDS)	N/A	N/A	N/A	F19	N/A
3007	DATE OF EVENT (2 WORDS)	N/A	N/A	N/A	F18	N/A
3009	TACHOMETER	0 to 7200	1	RPM	F1	0
300A	PHASE A CURRENT	0 to 999999	1	Amps	F12	0
300C	PHASE B CURRENT	0 to 999999	1	Amps	F12	0
300E	PHASE C CURRENT	0 to 999999	1	Amps	F12	0
3010	PHASE A DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
3012	PHASE B DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
3014	PHASE C DIFFERENTIAL CURRENT	0 to 999999	1	Amps	F12	0
3016	NEG. SEQ. CURRENT	0 to 2000	1	% FLA	F1	0
3017	GROUND CURRENT	0 to 20000000	1	A	F14	0
3019	A-B VOLTAGE	0 to 50000	1	Volts	F1	0
301A	B-C VOLTAGE	0 to 50000	1	Volts	F1	0
301B	C-A VOLTAGE	0 to 50000	1	Volts	F1	0
301C	FREQUENCY	0 to 12000	1	Hz	F3	0
301D	ACTIVE GROUP	0 to 1	1	-	F1	0
301F	REAL POWER (MW)	-2000000 to 2000000	1	MW	F13	0
3021	REACTIVE POWER Mar	-2000000 to 2000000	1	Mar	F13	0
3023	APPARENT POWER MVA	0 to 2000000	1	MVA	F13	0
3025	HOTTEST STATOR RTD #	1 to 12	1	-	F1	1
3026	HOTTEST STATOR RTD TEMPERATURE	-50 to 250	1	°C	F4	0
3027	HOTTEST BEARING RTD #	1 to 12	1	-	F1	1
3028	HOTTEST BEARING RTD TEMPERATURE	-50 to 250	1	°C	F4	0
3029	HOTTEST OTHER RTD #	1 to 12	1	-	F1	1
302A	HOTTEST OTHER RTD TEMPERATURE	-50 to 250	1	°C	F4	0
302B	HOTTEST AMBIENT RTD #	1 to 12	1	-	F1	1
302C	HOTTEST AMBIENT RTD TEMPERATURE	-50 to 250	1	°C	F4	0
302D	ANALOG IN 1	-50000 to 50000	1	Units	F12	0
302F	ANALOG IN 2	-50000 to 50000	1	Units	F12	0
3031	ANALOG IN 3	-50000 to 50000	1	Units	F12	0
3033	ANALOG IN 4	-50000 to 50000	1	Units	F12	0
30E0	HOTTEST STATOR RTD TEMPERATURE	-50 to 250	1	°F	F4	0
30E1	HOTTEST BEARING RTD TEMPERATURE	-50 to 250	1	°F	F4	0
30E2	HOTTEST OTHER RTD TEMPERATURE	-50 to 250	1	°F	F4	0
30E3	HOTTEST AMBIENT RTD TEMPERATURE	-50 to 250	1	°F	F4	0
30E5	NEUTRAL VOLT (FUND)	0 to 250000	1	Volts	F10	0
30E7	NEUTRAL VOLT (3rd)	0 to 250000	1	Volts	F10	0
30E9	Vab/Iab	0 to 65535	1	ohms s	F1	0
30EA	Vab/Iab ANGLE	0 to 359	1	°	F1	0

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Waveform Memory (Input Registers) -- Addresses 30F0 to 31FF

Addr	Name	Range	Step	Units	Fmt	Default
WAVEFORM MEMORY SETUP						
30F0	WAVEFORM MEMORY TRIGGER DATE	N/A	N/A	N/A	F18	N/A
30F2	WAVEFORM MEMORY TRIGGER TIME	N/A	N/A	N/A	F19	N/A
30F4	FREQUENCY DURING TRACE ACQUISITION	0 to 12000	1	Hz	F3	0
30F5	WAVEFORM MEMORY CHANNEL SELECTOR (HOLDING REGISTER)	0 to 9	1	N/A	F214	0
30F6	WAVEFORM TRIGGER SELECTOR	1 to 65535	1	N/A	F1	0
30F7	WAVEFORM TRIGGER CAUSE (READ-ONLY)	0 to 139	1	N/A	F134	0
30F8	NUMBER OF SAMPLES PER WAVEFORM CAPTURE	1 to 768	1	N/A	F1	168
30F9	NUMBER OF WAVEFORM CAPTURES TAKEN	0 to 65535	1	N/A	F1	0
WAVEFORM MEMORY SAMPLES						
3100	FIRST WAVEFORM MEMORY SAMPLE	-32767 to 32767	1	N/A	F4	0
3400	LAST WAVEFORM MEMORY SAMPLE	-32767 to 32767	1	N/A	F4	0

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489 MEMORY MAP DATA FORMATS

FORMAT CODE	TYPE	DEFINITION
F1	**16 bits**	**Unsigned Value**
		Example: 1234 stored as 1234
F2	**16 bits**	**Unsigned Value, 1 Decimal Place**
		Example: 123.4 stored as 1234
F3	**16 bits**	**Unsigned Value, 2 Decimal Places**
		Example: 12.34 stored as 1234
F4	**16 bits**	**2’s Complement Signed Value**
		Example, -1234 storead as -1234 (ie, 64032)
F5	**16 bits**	**2’s Complement Signed Value, 1 Decimal Place**
		Example, -1.234 storead as -1234 (ie, 64032)
F6	**16 bits**	**2’s Complement Signed Value, 2 Decimal Places**
		Example, -12.34 storead as -1234 (ie, 64032)
F10	**32 bits**	**2’s Complement Signed Long Value, 1 Decimal Place**
	1st 16 bits	High order word of long value
	2nd 16 bits	Low order word of long value
	Example:	-12345.6 stored as -123456 (ie, 1st word FFFE hex, 2nd word 1DC0 hex)
F12	**32 bits**	**2’s Complement Signed Long Value**
	1st 16 bits	High order word of long value
	2nd 16 bits	Low order word of long value
	Example:	-123456 stored as 1st word FFFE hex, 2nd word 1DC0 hex
F13	**32 bits**	**2’s Compliment Signed Long Value, 3 Decimal Places**
	1st 16 bits	High order word of long value
	2nd 16 bits	Low order word of long value
	Example:	-123.456 stored as -123456 (ie, 1st word FFFE hex, 2nd word 1DC0 hex)
F14	**32 bits**	**2’s Complement Signed Long Value, 2 Decimal Places**
	1st 16 bits	High order word of long value
	2nd 16 bits	Low order word of long value
	Example:	-1234.56 stored as -123456 (ie, 1st word FFFE hex, 2nd word 1DC0 hex)
F15	**16 bits**	**Hardware Revision**
	1	revision A
	2	revision B
	3	revision C ...
	26	revision Z
F16	**16 bits**	**Software Revision**
	1111 1111 XXXX XXXX	Major revision number -- 0 to 9 in steps of 1
	XXXX XXXX 1111 1111	Minor revision number (two BCD digits) 00 to 99 in steps of 1
	Example:	Revision 2.30 stored as 0230 hex
F18	**32 bits**	**Date (MM/DD/YYYY)**
	1st byte	Month (1 to 12)
	2nd byte	Day (1 to 31)
	3rd and 4th byte	Year (1996 to 2094)
	Example:	Feb 20, 1996 stored as 34867148 (ie, first word 0214, 2nd word 07CC)
F19	**32 bits**	**Time (HH:MM:SS:hh)**
	1st byte	Hours (0 to 23)
	2nd byte	Minutes (0 to 59)
	3rd byte	Seconds (0 to 59)
	4th byte	Hundredths of seconds (0 to 99)
	Example:	2:05pm stored as 235208704 (ie, 1st word 0E05, 2nd word 0000)
F22	**16 bits**	**Character String (Note: Range indicates number of chars)**
	1st byte (MSB) of each word	First of a pair of characters
	2nd byte (LSB) of each word	Second of a pair of characters
	Example:	String “AB” stored as 4142 hex

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FORMAT CODE	TYPE	DEFINITION
F24	**32 bits**	**Time Format for Broadcast**
	1st byte	Hours (0 to 23)
	2nd byte	Minutes (0 to 59)
	3rd and 4th bytes	Milliseconds (0 to 59999). Note: Clock resolution limited to 1/100 sec
	Example:	1:15:48:572 stored as 17808828 (ie, 1st word 010F, 2nd word BDBC)
F50	**16 bits**	**Relay List (Bitmap)**
	Bit 0	Relay 1
	Bit 1	Relay 2
	Bit 2	Relay 3
	Bit 3	Relay 4
	Bit 4	Relay 5
	Bit 5	Relay 6
F100	**Unsigned 16 bit integer**	**Temperature display units**
	0	Celsius
	1	Fahrenheit
F101	**Unsigned 16 bit integer**	**RS485 baud rate**
	0	300
	1	1200
	2	2400
	3	4800
	4	9600
	5	19200
F102	**Unsigned 16 bit integer**	**RS485 parity**
	0	None
	1	Odd
	2	Even
F103	**Unsigned 16 bit integer**	**No / Yes selection**
	0	No
	1	Yes
F104	**Unsigned 16 bit integer**	**Ground CT type**
	0	None
	1	1 A Secondary
	2	50:0.025 Ground CT
	3	5 A Secondary
F105	**Unsigned 16 bit integer**	**Off / On selection**
	0	Off
	1	On
F106	**Unsigned 16 bit integer**	**VT connection type**
	0	None
	1	Open Delta
	2	Wye
F107	**Unsigned 16 bit integer**	**Nominal frequency selection**
	0	-----
	1	60 Hz
	2	50 Hz
	3	25 Hz
F109	**Unsigned 16 bit integer**	**Breaker status switch type**
	0	Auxiliary a
	1	Auxiliary b
F115	**Unsigned 16 bit integer**	**Alarm / trip type selection**
	0	Off

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FORMAT CODE	TYPE	DEFINITION
	1	Latched
	2	Unlatched
F117	**Unsigned 16 bit integer**	**Reset mode**
	0	All Resets
	1	Remote Reset Only
F118	**Unsigned 16 bit integer**	**Setpoint Group**
	0	Group 1
	1	Group 2
F120	**Unsigned 16 bit integer**	**RTD type**
	0	100 Ohm Platinum
	1	120 Ohm Nickel
	2	100 Ohm Nickel
	3	10 Ohm Copper
F121	**Unsigned 16 bit integer**	**RTD application**
	0	None
	1	Stator
	2	Bearing
	3	Ambient
	4	Other
F122	**Unsigned 16 bit integer**	**RTD voting selection**
	1	RTD #1
	2	RTD #2
	3	RTD #3
	4	RTD #4
	5	RTD #5
	6	RTD #6
	7	RTD #7
	8	RTD #8
	9	RTD #9
	10	RTD #10
	11	RTD #11
	12	RTD #12
F123	**Unsigned 16 bit integer**	**Alarm / trip status**
	0	Not Enabled
	1	Inactive
	2	Timing Out
	3	Active Trip
	4	Latched Trip
F124	**Unsigned 16 bit integer**	**Phase rotation selection**
	0	---
	1	ABC
	2	ACB
F126	**Unsigned 16 bit integer**	**Disabled / Enabled selection**
	0	Disabled
	1	Enabled
F127	**Unsigned 16 bit integer**	**Analog output parameter selection**
	0	None
	1	IA Output Current
	2	IB Output Current
	3	IC Output Current
	4	Avg. Output Current

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FORMAT CODE	TYPE	DEFINITION
	5	Neg. Seq. Current
	6	Averaged Gen. Load
	7	Hottest Stator RTD
	8	Hottest Bearing RTD
	9	Ambient RTD
	10	RTD #1
	11	RTD #2
	12	RTD #3
	13	RTD #4
	14	RTD #5
	15	RTD #6
	16	RTD #7
	17	RTD #8
	18	RTD #9
	19	RTD #10
	20	RTD #11
	21	RTD #12
	22	AB Voltage
	23	BC Voltage
	24	CA Voltage
	25	Average Voltage
	26	Volts / Hertz
	27	Frequency
	28	Neutral Voltage(3rd)
	29	Power Factor
	30	Reactive Power(Mar)
	31	Real Power (MW)
	32	Apparent Power (MVA)
	33	Analog Input 1
	34	Analog Input 2
	35	Analog Input 3
	36	Analog Input 4
	37	Tachometer
	38	Therm. Capacity Used
	39	Current Demand
	40	Mar Demand
	41	MW Demand
	42	MVA Demand
F128	**Unsigned 16 bit integer**	**Overcurrent curve style selection**
	0	ANSI Extremely Inv.
	1	ANSI Very Inverse
	2	ANSI Normally Inv.
	3	ANSI Moderately Inv.
	4	IEC Curve A (BS142)
	5	IEC Curve B (BS142)
	6	IEC Curve C (BS142)
	7	IEC Short Inverse
	8	IAC Extremely Inv.
	9	IAC Very Inverse
	10	IAC Inverse
	11	IAC Short Inverse
	12	Flexcurve (TM)
	13	Definite Time
F129	**Unsigned 16 bit integer**	**Analog input selection**
	0	Disabled
	1	4-20 mA
	2	0-20 mA
	3	0-1 mA

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FORMAT CODE	TYPE	DEFINITION
F130	**Unsigned 16 bit integer**	**Pickup type**
	0	Over
	1	Under
F131	**Unsigned 16 bit integer**	**Input switch status**
	0	Closed
	1	Open
F132	**Unsigned 16 bit integer**	**Trip coil supervision status**
	0	No Coil
	1	Coil
F133	**Unsigned 16 bit integer**	**Generator status**
	0	Offline
	1	Offline
	2	Online
	3	Overload
	4	Tripped
F134	**Unsigned 16 bit integer**	**Cause of event / Cause of trip**
	0	No Event
	1	General Sw. A Trip
	2	General Sw. B Trip
	3	General Sw. C Trip
	4	General Sw. D Trip
	5	General Sw. E Trip
	6	General Sw. F Trip
	7	General Sw. G Trip
	8	Sequential Trip
	9	Tachometer Trip
	10	UNKNOWN TRIP
	11	UNKNOWN TRIP
	12	Overload Trip
	13	UNKNOWN TRIP
	14	Neutral O/V Trip
	15	Neut. U/V (3rd) Trip
	16	
	17	
	18	
	19	
	20	Differential Trip
	21	Acceleration Trip
	22	RTD 1 Trip
	23	RTD 2 Trip
	24	RTD 3 Trip
	25	RTD 4 Trip
	26	RTD 5 Trip
	27	RTD 6 Trip
	28	RTD 7 Trip
	29	RTD 8 Trip
	30	RTD 9 Trip
	31	RTD 10 Trip
	32	RTD 11 Trip
	33	RTD 12 Trip
	34	Undervoltage Trip
	35	Overvoltage Trip
	36	Phase Reversal Trip
	37	Overfrequency Trip
	38	Power Factor Trip

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FORMAT CODE	TYPE	DEFINITION
	39	Reactive Power Trip
	40	Underfrequency Trip
	41	Analog I/P 1 Trip
	42	Analog I/P 2 Trip
	43	Analog I/P 3 Trip
	44	Analog I/P 4 Trip
	45	Single Phasing Trip
	46	Reverse Power Trip
	47	Field-Bkr Discrep.
	48	Offline O/C Trip
	49	Phase O/C Trip
	50	Neg. Seq. O/C Trip
	51	General Sw. A Alarm
	52	General Sw. B Alarm
	53	General Sw. C Alarm
	54	General Sw. D Alarm
	55	General Sw. E Alarm
	56	General Sw. F Alarm
	57	General Sw. G Alarm
	58	
	59	Tachometer Alarm
	60	Thermal Model Alarm
	61	Overload Alarm
	62	Underfrequency Alarm
	63	
	64	Ground Fault Alarm
	65	RTD 1 Alarm
	66	RTD 2 Alarm
	67	RTD 3 Alarm
	68	RTD 4 Alarm
	69	RTD 5 Alarm
	70	RTD 6 Alarm
	71	RTD 7 Alarm
	72	RTD 8 Alarm
	73	RTD 9 Alarm
	74	RTD 10 Alarm
	75	RTD 11 Alarm
	76	RTD 12 Alarm
	77	Open RTD Alarm
	78	Short/Low RTD Alarm
	79	Undervoltage Alarm
	80	Overvoltage Alarm
	81	Overfrequency Alarm
	82	Power Factor Alarm
	83	Reactive Power Alarm
	84	Low Fwd Power Alarm
	85	Trip Counter Alarm
	86	Breaker Fail Alarm
	87	Current Demand Alarm
	88	kW Demand Alarm
	89	kvar Demand Alarm
	90	kVA Demand Alarm
	91	Broken Rotor Bar
	92	Analog I/P 1 Alarm
	93	Analog I/P 2 Alarm
	94	Analog I/P 3 Alarm
	95	Analog I/P 4 Alarm
	96	Reverse Power Alarm
	97	Incomplete Seq.Alarm
	98	Negative Seq. Alarm

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FORMAT CODE	TYPE	DEFINITION
	99	Ground O/C Alarm
	100	
	101	Service Alarm
	102	Control Power Lost
	103	Cont. Power Applied
	104	Thermal Reset Close
	105	Emergency Rst. Open
	106	Start While Blocked
	107	Relay Not Inserted
	108	Trip Coil Super.
	109	Breaker Failure
	110	VT Fuse Failure
	111	Simulation Started
	112	Simulation Stopped
	113	Ground O/C Trip
	114	Volts/Hertz Trip
	115	Volts/Hertz Alarm
	116	Low Fwd Power Trip
	117	Inadvertent Energ.
	118	Serial Start Command
	119	Serial Stop Command
	120	Input A Control
	121	Input B Control
	122	Input C Control
	123	Input D Control
	124	Input E Control
	125	Input F Control
	126	Input G Control
	127	Neutral O/V Alarm
	128	Neut. U/V 3rd Alarm
	129	Setpoint 1 Active
	130	Setpoint 2 Active
	131	Loss of Excitation 1
	132	Loss of Excitation 2
	133	Gnd. Directional Trip
	134	Gnd. Directional Alarm
	135	HiSet Phase O/C Trip
	136	Distance Zone 1 Trip
	137	Distance Zone 2 Trip
	138	Dig I/P Wavefrm Trig
	139	Serial Waveform Trig
	140	IRIG-B Failure
F136	**16 bits**	**Order Code**
	Bit 0	0 = Code P5 (5A CT secondaries), 1 = Code P1 (1A CT secondaries)
	Bit 1	0 = Code HI (High voltage power supply), 1 = Code LO (Low voltage power supply)
	Bit 2	0 = Code A20 (4-20 mA analog outputs), 1 = Code A1 (0-1 mA analog outputs)
F138	**Unsigned 16 bit integer**	**Simulation mode**
	0	Off
	1	Simulate Pre-Fault
	2	Simulate Fault
	3	Pre-Fault to Fault
F139	**Unsigned 16 bit integer**	**Force operation of relays**
	0	Disabled
	1	R1 Trip
	2	R2 Auxiliary
	3	R3 Auxiliary
	4	R4 Auxiliary

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FORMAT CODE	TYPE	DEFINITION
	5	R5 Alarm
	6	R6 Service
	7	All Relays
	8	No Relays
F140	**16 bits**	**General Status**
	Bit 0	Relay in Service
	Bit 1	Active Trip Condition
	Bit 2	Active Alarm Condition
	Bit 3	Reserved
	Bit 4	Reserved
	Bit 5	Reserved
	Bit 6	Reserved
	Bit 7	Simulation Mode Enabled
	Bit 8	Breaker Open LED
	Bit 9	Breaker Closed LED
	Bit 10	Hot Stator LED
	Bit 11	Neg. Sequence LED
	Bit 12	Ground LED
	Bit 13	Loss of Field LED
	Bit 14	VT Failure LED
	Bit 15	Breaker Failure LED
F141	**16 bits**	**Output Relay Status**
	Bit 0	R1 Trip
	Bit 1	R2 Auxiliary
	Bit 2	R3 Auxiliary
	Bit 3	R4 Auxiliary
	Bit 4	R5 Alarm
	Bit 5	R6 Service
	Bit 6	Reserved
	Bit 7	Reserved
	Bit 8	Reserved
	Bit 9	Reserved
	Bit 10	Reserved
	Bit 11	Reserved
	Bit 12	Reserved
	Bit 13	Reserved
	Bit 14	Reserved
	Bit 15	Reserved
F142	**Unsigned 16 bit integer**	**Thermal Model curve style selection**
	0	Standard
	1	Custom
	2	Voltage Dependent
F200	**Unsigned 16 bit integer**	**Comm. monitor buffer status**
	0	Buffer Cleared
	1	Received OK
	2	Wrong Slave Addr.
	3	Illegal Function
	4	Illegal Count
	5	Illegal Reg. Addr.
	6	CRC Error
	7	Illegal Data
F201	**Unsigned 16 bit integer**	**Curve reset type**
	0	Instantaneous
	1	Linear
F202	**Unsigned 16 bit integer**	**Inadvertent energization arming type**
	0	U/V and Offline
	1	U/V or Offline

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FORMAT CODE	TYPE	DEFINITION
F206	**Unsigned 16 bit integer**	**Sequential trip type**
	0	Low Forward Power
	1	Reverse Power
F207	**Unsigned 16 bit integer**	**Switch status**
	0	Open
	1	Shorted
F208	**Unsigned 16 bit integer**	**Undervoltage trip element type**
	0	Curve
	1	DefiniteTime
F209	**Unsigned 16 bit integer**	**Breaker operation type**
	0	Breaker Auxiliary a
	1	Breaker Auxiliary b
F210	**Unsigned 16 bit integer**	**Assignable input selection**
	0	None
	1	Input 1
	2	Input 2
	3	Input 3
	4	Input 4
	5	Input 5
	6	Input 6
	7	Input 7
F211	**Unsigned 16 bit integer**	**Volts/Hertz element type**
	0	Curve #1
	1	Curve #2
	2	Curve #3
	3	DefiniteTime
F212	**Unsigned 16 bit integer**	**RTD number**
	0	All
	1	RTD #1
	2	RTD #2
	3	RTD #3
	4	RTD #4
	5	RTD #5
	6	RTD #6
	7	RTD #7
	8	RTD #8
	9	RTD #9
	10	RTD #10
	11	RTD #11
	12	RTD #12
	13	RTD #13
	14	RTD #14
	15	RTD #15
	16	RTD #16
F213	**Unsigned 16 bit integer**	**Communications monitor port selection**
	0	Computer RS485
	1	Auxiliary RS485
	2	Front Panel RS232
F214	**Unsigned 16 bit integer**	**Waveform Memory Channel Selector**
	0	Phase A line current 512 counts equals 1xCT
	1	Phase B line current 512 counts equals 1xCT

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FORMAT CODE	TYPE	DEFINITION
	2	Phase C line current 512 counts equals 1xCT
	3	Neutral-end phase A line current 512 counts equals 1xCT
	4	Neutral-end phase B line current 512 counts equals 1xCT
	5	Neutral-end phase C line current 512 counts equals 1xCT
	6	Ground current 512 counts equals 1xCT
	7	Phase A to neutral voltage 3500 counts equals 120 secondary volts
	8	Phase B to neutral voltage 3500 counts equals 120 secondary volts
	9	Phase C to neutral voltage 3500 counts equals 120 secondary volts
F215	**Unsigned 16 bit integer**	**Current Source**
	0	NEUTRAL END CTS
	1	OUTPUT END CTS
F216	**Unsigned 16 bit integer**	**DNP Port Selection**
	0	None
	1	Computer RS485
	2	Auxiliary RS485
	3	Front Panel RS232
F217	**Unsigned 16 bit integer**	**Ground Directional MTA**
	0	0°
	1	90°
	2	180°
	3	270°
F218	**Unsigned 16 bit integer**	**Breaker State**
	0	52 Closed
	1	52 Open/Closed
F219	**Unsigned 16 bit integer**	**Step Up Transformer Type**
	0	NONE
	1	DELTA/WYE
F220	**Unsigned 16 bit integer**	**IRIG-B Type**
	0	None
	1	DC Shift
	2	Amplitude Modulated

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DNP 3.0
DEVICE PROFILE DOCUMENT

Vendor Name: General Electric Power Management Limited

Device Name: 489 Generator Management Relay

Highest DNP Level Supported: For Requests: Level 2 For Responses: Level 2	Device Function: ☐ Master ☒ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

Binary Input (Object 1, Variations 1 and 2)
Binary Output (Object 10, Variation 2)
Binary Counter (Object 20, Variations 5 and 6)
Frozen Counter (Object 21, Variations 9 and 10)
Analog Input (Object 30, Variations 1, 2, 3 and 4)
Analog Input Change (Object 32, Variations 1, 2, 3 and 4)
Warm Restart (Function code 14)

Maximum Data Link Frame Size (octets): Transmitted: 292 Received: 292	Maximum Application Fragment Size (octets): Transmitted: 2048 Received: 2048
Maximum Data Link Re-tries: ☒ None ☐ Fixed ☐ Configurable	Maximum Application Layer Re-tries: ☒ None ☐ Configurable

Requires Data Link Layer Confirmation:
- ☒ Never
- ☐ Always
- ☐ Sometimes
- ☐ Configurable

Requires Application Layer Confirmation:
- ☐ Never
- ☐ Always
- ☒ When reporting Event Data
- ☐ When sending multi-fragment responses
- ☐ Sometimes
- ☐ Configurable

Timeouts while waiting for:

Data Link Confirm	☒ None	☐ Fixed	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed	☐ Variable	☐ Configurable
Application Confirm	☒ None	☐ Fixed	☐ Variable	☐ Configurable
Complete Appl. Response	☒ None	☐ Fixed	☐ Variable	☐ Configurable

Others: (None)

Executes Control Operations:

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT/OPERATE	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK	☐ Never	☒ Always	☐ Sometimes	☐ Configurable

Count > 1	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Pulse Off	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch On	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Latch Off	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

(For an explanation of the above, refer to the discussion accompanying the point list for the Binary Output/Control Relay Output Block objects)

Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

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Reports Binary Input Change Events when no specific variations requested: ☐ Never ☒ Only time-tagged ☐ Only non-time-tagged ☐ Configurable to send both, one or the other	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☒ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable
Sends Unsolicited Responses: ☒ Never ☐ Configurable ☐ Only certain objects ☐ Sometimes ☐ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable ☒ Default Object: 20 Default Variation: 6 ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable ☐ 16 Bits ☐ 32 Bits ☐ Other Value ☒ Point-by-point list attached
Sends Multi-Fragment Responses: ☐ Yes ☒ No	

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The table below gives a list of all objects recognized and returned by the relay. Additional information is provided on the following pages including a list of the default variations returned for each object and lists of defined point numbers for each object.

IMPLEMENTATION TABLE

OBJECT			REQUEST		RESPONSE	
Obj	Var	Description	Func Codes	Qual Codes (Hex)	Func Codes	Qual Codes (Hex)
1	0	Binary Input - All Variations	1	06		
1	1	Binary Input	1	00, 01, 06	129	00, 01
1	2	Binary Input With Status	1	00, 01, 06	129	00, 01
2	0	Binary Input Change - All Variations	1	06, 07, 08		
2	1	Binary Input Change Without Time	1	06, 07, 08	129	17, 28
2	2	Binary Input Change With Time	1	06, 07, 08	129	17, 28
10	0	Binary Output - All Variations	1	06		
10	2	Binary Output Status	1	00, 01, 06	129	00, 01
12	1	Control Relay Output Block	5, 6	17, 28	129	17, 28
20	0	Binary Counter - All Variations	1,7,8,9,10	06	129	00, 01
20	5	32-Bit Binary Counter without Flag	1,7,8,9,10	06	129	00, 01
20	6	16-Bit Binary Counter without Flag	1,7,8,9,10	06	129	00, 01
21	0	Frozen Counter - All Variations	1	06	129	00, 01
21	9	32-Bit Frozen Counter without Flag	1	06	129	00, 01
21	10	16-Bit Frozen Counter without Flag	1	06	129	00, 01
30	0	Analog Input - All Variations	1	06		
30	1	32-Bit Analog Input With Flag	1	00, 01, 06	129	00, 01
30	2	16-Bit Analog Input With Flag	1	00, 01, 06	129	00, 01
30	3	32-Bit Analog Input Without Flag	1	00, 01, 06	129	00, 01
30	4	16-Bit Analog Input Without Flag	1	00, 01, 06	129	00, 01
32	0	Analog Input Change - All Variations	1	06, 07, 08		
32	1	32-Bit Analog Input Change Without Time	1	06, 07, 08	129	17, 28
32	2	16-Bit Analog Input Change Without Time	1	06, 07, 08	129	17, 28
32	3	32-Bit Analog Input Change With Time	1	06, 07, 08	129	17, 28
32	4	16-Bit Analog Input Change With Time	1	06, 07, 08	129	17, 28
50	1	Time and Date	1, 2	07 (Note 1)	129	07
60	1	Class 0 Data (Note 2)	1	06	129	
60	2	Class 1 Data (Note 3)	1	06, 07, 08	129	
60	3	Class 2 Data (Note 3)	1	06, 07, 08	129	
60	4	Class 3 Data (Note 3)	1	06, 07, 08	129	
80	1	Internal Indications	2	00 (Note 4)	129	
		No object (cold restart command)	13			
		No object (warm restart command)	14			
		No object (delay measurement command) (Note 5)	23			

Notes:

1. For this object, the quantity specified in the request must be exactly 1 as there is only one instance of this object defined in the relay.
2. All static data known to the relay is returned in response to a request for Class 0. This includes all objects of type 1 (Binary Input), type 10 (Binary Output), type 20 (Binary Counter), type 21 (Frozen Counter) and type 30 (Analog Input).
3. The point tables for Binary Input and Analog Input objects contain a field that defines to which event class the corresponding static data point has been assigned.
4. For this object, the qualifier code must specify an index of 7 only.
5. Delay Measurement (function code 23) is supported since the relay allows for writing the time via object 50 and it also periodically sets the “Time Synchronization Required” Internal Indication (IIN). The IIN is set at power-up and will be set again 24 hours after it was last cleared. The IIN is cleared when time is written as object 50 data or if IRIG-B is enabled and reiay time is updated as a result of a successful decoding of this signal.

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The following table specifies the default variation for all objects returned by the relay. These are the variations that will be returned for the object in a response when no specific variation is specified in a request.

DEFAULT VARIATIONS

Object	Description	Default Variation
1	Binary Input - Single Bit	1
2	Binary Input Change With Time	2
10	Binary Output Status	2
20	16-Bit Binary Counter without Flag	6
21	16-Bit Frozen Counter without Flag	10
30	32-Bit Analog Input Without Flag	3
32	32-Bit Analog Input Change Without Time	1

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POINT LIST FOR: BINARY INPUT (OBJECT 01)
BINARY INPUT CHANGE (OBJECT 02)

Index	Description	Event Class Assigned To
0	Relay In Service	Class 1
1	Trip Condition Active	Class 1
2	Alarm Condition Active	Class 1
3	Simulation Mode Enabled	Class 1
4	Breaker Is Open	Class 1
5	Breaker Is Closed	Class 1
6	Hot Stator Fault Active	Class 1
7	Negative Sequence Fault Active	Class 1
8	Ground Fault Active	Class 1
9	Loss Of Field Fault Active	Class 1
10	VT Failure Detected	Class 1
11	Breaker Failure Detected	Class 1
12	Relay 1 Trip Operated	Class 1
13	Relay 2 Auxiliary Operated	Class 1
14	Relay 3 Auxiliary Operated	Class 1
15	Relay 4 Auxiliary Operated	Class 1
16	Relay 5 Alarm Operated	Class 1
17	Relay 6 Service Operated	Class 1
18	Setpoint Access Input Closed	Class 1
19	Breaker Status Input Closed	Class 1
20	Assignable Input 1 Closed	Class 1
21	Assignable Input 2 Closed	Class 1
22	Assignable Input 3 Closed	Class 1
23	Assignable Input 4 Closed	Class 1
24	Assignable Input 5 Closed	Class 1
25	Assignable Input 6 Closed	Class 1
26	Assignable Input 7 Closed	Class 1
27	Trip Coil Supervision - Coil Detected	Class 1
28	… Reserved …	
29	… Reserved …	
30	… Reserved …	
31	… Reserved …	
32	… Reserved …	
33	… Reserved …	
34	… Reserved …	
35	… Reserved …	
36	… Reserved …	
37	… Reserved …	
38	… Reserved …	
39	… Reserved …	
40	Assignable Input 1 Trip Active or Latched	Class 1
41	Assignable Input 2 Trip Active or Latched	Class 1
42	Assignable Input 3 Trip Active or Latched	Class 1
43	Assignable Input 4 Trip Active or Latched	Class 1
44	Assignable Input 5 Trip Active or Latched	Class 1
45	Assignable Input 6 Trip Active or Latched	Class 1
46	Assignable Input 7 Trip Active or Latched	Class 1
47	Sequential Trip Active or Latched	Class 1
48	Field-Breaker Discrepancy Trip Active or Latched	Class 1
49	Tachometer Trip Active or Latched	Class 1
50	Offline Overcurrent Trip Active or Latched	Class 1
51	Inadvertent Energization Trip Active or Latched	Class 1
52	Phase Overcurrent Trip Active or Latched	Class 1
53	Negative Sequence Overcurrent Trip Active or Latched	Class 1
54	Ground Overcurrent Trip Active or Latched	Class 1
55	Phase Differential Trip Active or Latched	Class 1
56	Undervoltage Trip Active or Latched	Class 1
57	Overvoltage Trip Active or Latched	Class 1

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POINT LIST FOR: BINARY INPUT (OBJECT 01)
BINARY INPUT CHANGE (OBJECT 02)

Index	Description	Event Class Assigned To
58	Volts/Hertz Trip Active or Latched	Class 1
59	Phase Reversal Trip Active or Latched	Class 1
60	Underfrequency Trip Active or Latched	Class 1
61	Overfrequency Trip Active or Latched	Class 1
62	Neutral Overvoltage (Fundamental) Trip Active or Latched	Class 1
63	Neutral Undervoltage (3rd Harmonic) Trip Active or Latched	Class 1
64	Reactive Power Trip Active or Latched	Class 1
65	Reverse Power Trip Active or Latched	Class 1
66	Low Forward Power Trip Active or Latched	Class 1
67	Thermal Model Trip Active or Latched	Class 1
68	RTD #1 Trip Active or Latched	Class 1
69	RTD #2 Trip Active or Latched	Class 1
70	RTD #3 Trip Active or Latched	Class 1
71	RTD #4 Trip Active or Latched	Class 1
72	RTD #5 Trip Active or Latched	Class 1
73	RTD #6 Trip Active or Latched	Class 1
74	RTD #7 Trip Active or Latched	Class 1
75	RTD #8 Trip Active or Latched	Class 1
76	RTD #9 Trip Active or Latched	Class 1
77	RTD #10 Trip Active or Latched	Class 1
78	RTD #11 Trip Active or Latched	Class 1
79	RTD #12 Trip Active or Latched	Class 1
80	Analog Input 1 Trip Active or Latched	Class 1
81	Analog Input 2 Trip Active or Latched	Class 1
82	Analog Input 3 Trip Active or Latched	Class 1
83	Analog Input 4 Trip Active or Latched	Class 1
84	Loss of Excitation Circle 1 Trip Active or Latched	Class 1
85	Loss of Excitation Circle 2 Trip Active or Latched	Class 1
86	Ground Directional Trip Active or Latched	Class 1
87	High Set Phase Overcurrent Trip Active or Latched	Class 1
88	Distance Zone 1 Trip Active or Latched	Class 1
89	Distance Zone 2 Trip Active or Latched	Class 1
90	… Reserved …	
91	… Reserved …	
92	… Reserved …	
93	… Reserved …	
94	… Reserved …	
95	… Reserved …	
96	… Reserved …	
97	… Reserved …	
98	… Reserved …	
99	… Reserved …	
100	Assignable Input 1 Alarm Active or Latched	Class 1
101	Assignable Input 2 Alarm Active or Latched	Class 1
102	Assignable Input 3 Alarm Active or Latched	Class 1
103	Assignable Input 4 Alarm Active or Latched	Class 1
104	Assignable Input 5 Alarm Active or Latched	Class 1
105	Assignable Input 6 Alarm Active or Latched	Class 1
106	Assignable Input 7 Alarm Active or Latched	Class 1
107	Tachometer Alarm Active or Latched	Class 1
108	Overcurrent Alarm Active or Latched	Class 1
109	Negative Sequence Alarm Active or Latched	Class 1
110	Ground Overcurrent Alarm Active or Latched	Class 1
111	Undervoltage Alarm Active or Latched	Class 1
112	Overvoltage Alarm Active or Latched	Class 1
113	Volts/Hertz Alarm Active or Latched	Class 1
114	Underfrequency Alarm Active or Latched	Class 1
115	Overfrequency Alarm Active or Latched	Class 1
116	Neutral Overvoltage (fundamental) Alarm Active or Latched	Class 1
117	Neutral Undervoltage (3rd harmonic) Alarm Active or Latched	Class 1

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POINT LIST FOR: BINARY INPUT (OBJECT 01)
BINARY INPUT CHANGE (OBJECT 02)

Index	Description	Event Class Assigned To
118	Reactive Power Alarm Active or Latched	Class 1
119	Reverse Power Alarm Active or Latched	Class 1
120	Low Forward Power Alarm Active or Latched	Class 1
121	RTD #1 Alarm Active or Latched	Class 1
122	RTD #2 Alarm Active or Latched	Class 1
123	RTD #3 Alarm Active or Latched	Class 1
124	RTD #4 Alarm Active or Latched	Class 1
125	RTD #5 Alarm Active or Latched	Class 1
126	RTD #6 Alarm Active or Latched	Class 1
127	RTD #7 Alarm Active or Latched	Class 1
128	RTD #8 Alarm Active or Latched	Class 1
129	RTD #9 Alarm Active or Latched	Class 1
130	RTD #10 Alarm Active or Latched	Class 1
131	RTD #11 Alarm Active or Latched	Class 1
132	RTD #12 Alarm Active or Latched	Class 1
133	Open Sensor Alarm Active or Latched	Class 1
134	Short/Low Temperature Alarm Active or Latched	Class 1
135	Thermal Model Alarm Active or Latched	Class 1
136	Trip Counter Alarm Active or Latched	Class 1
137	Breaker Failure Alarm Active or Latched	Class 1
138	Trip Coil Monitor Alarm Active or Latched	Class 1
139	VT Fuse Failure Alarm Active or Latched	Class 1
140	Current Demand Alarm Active or Latched	Class 1
141	MW Demand Alarm Active or Latched	Class 1
142	Mar Demand Alarm Active or Latched	Class 1
143	MVA Alarm Active or Latched	Class 1
144	Analog Input 1 Alarm Active or Latched	Class 1
145	Analog Input 2 Alarm Active or Latched	Class 1
146	Analog Input 3 Alarm Active or Latched	Class 1
147	Analog Input 4 Alarm Active or Latched	Class 1
148	Not Programmed Alarm Active or Latched	Class 1
149	Simulation Mode Alarm Active or Latched	Class 1
150	Output Relays Forced Alarm Active or Latched	Class 1
151	Analog Output Forced Alarm Active or Latched	Class 1
152	Test Switch Shorted Alarm Active or Latched	Class 1
153	Ground Directional Alarm Active or Latched	Class 1
154	IRIG-B Failure Alarm Active or Latched	Class 1
155	Generator Running Hour Alarm Active or Latched	Class 1

Notes:

1. Any detected change in the state of any point assigned to Class 1 will cause the generation of an event object.

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POINT LIST FOR: BINARY OUTPUT (OBJECT 10) CONTROL RELAY OUTPUT BLOCK (OBJECT 12)

Index	Description
0	Reset
1	Generator Start
2	Generator Stop
3	Clear Trip Counters
4	Clear Last Trip Data
5	Clear MWh and Mvarh
6	Clear Peak Demand Data
7	Clear Generator Information
8	Clear Breaker Information

The following restrictions should be noted when using object 12 to control the points listed in the above table.

1. The Count field is checked first. If it is zero, the command will be accepted but no action will be taken. If this field is non-zero, the command will be executed exactly once regardless of its value.
2. The Control Code field of object 12 is then inspected:
   - The Queue and Clear sub-fields are ignored.
   - If the Control Code field is zero (i.e., NUL operation) the command is accepted but no action is taken.
   - For all points, the only valid control is “Close - Pulse On” (41 hex). This is used to initiate the function (e.g., Reset) associated with the point.
   - Any value in the Control Code field not specified above is invalid and will be rejected.
3. The On Time and Off Time fields are ignored. A ”Pulse On” control takes effect immediately when received. Thus, the timing is irrelevant.
4. The Status field in the response will reflect the success or failure of the control attempt thus:
   - A Status of “Request Accepted” (0) will be returned if the command was accepted.
   - A Status of “Request not Accepted due to Formatting Errors” (3) will be returned if the Control Code field was incorrectly formatted or an invalid Code was present in the command.
   - A Status of “Control Operation not Supported for this Point” (4) will be returned if an attempt was made to operate the point and the relay, owing to its configuration, does not allow the point to perform its function.

An operate of the Reset point may fail (even if the command is accepted) due to other inputs or conditions (e.g., blocks) existing at the time. To verify the success or failure of an operate of this point it is necessary that the associated Binary Input(s) be examined after the control attempt is performed.

When using object 10 to read the status of any Binary Output, a value of zero will always be returned. This is due to the fact that all points are “Pulse On” and are deemed to be normally off.

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POINT LIST FOR: BINARY COUNTER (OBJECT 20)
FROZEN COUNTER (OBJECT 21)

Index	Rollover Point	Description	Notes
0	50,000	Number of Breaker Operations	
1	50,000	Number of Thermal Resets	
2	50,000	Number of Trips (total)	
3	50,000	Number of Digital Input Trips	
4	50,000	Number of Sequential Trips	
5	50,000	Number of Field-Breaker Discrepancy Trips	
6	50,000	Number of Tachometer Trips	
7	50,000	Number of Offline Overcurrent Trips	
8	50,000	Number of Phase Overcurrent Trips	
9	50,000	Number of Negative Sequence Overcurrent Trips	
10	50,000	Number of Ground Overcurrent Trips	
11	50,000	Number of Phase Differential Trips	
12	50,000	Number of Undervoltage Trips	
13	50,000	Number of Overvoltage Trips	
14	50,000	Number of Volts/Hertz Trips	
15	50,000	Number of Phase Reversal Trips	
16	50,000	Number of Underfrequency Trips	
17	50,000	Number of Overfrequency Trips	
18	50,000	Number of Neutral Overvoltage (Fundamental) Trips	
19	50,000	Number of Neutral Undervoltage (3rd Harmonic) Trips	
20	50,000	Number of Reactive Power Trips	
21	50,000	Number of Reverse Power Trips	
22	50,000	Number of Underpower Trips	
23	50,000	Number of Stator RTD Trips	
24	50,000	Number of Bearing RTD Trips	
25	50,000	Number of Other RTD Trips	
26	50,000	Number of Ambient RTD Trips	
27	50,000	Number of Thermal Model Trips	
28	50,000	Number of Inadvertent Energization Trips	
29	50,000	Number of Analog Input 1 Trips	
30	50,000	Number of Analog Input 2 Trips	
31	50,000	Number of Analog Input 3 Trips	
32	50,000	Number of Analog Input 4 Trips	
33	50,000	Number of Loss of Excitation Circle 1 Trips	
34	50,000	Number of Loss of Excitation Circle 2 Trips	
35	50,000	Number of Ground Directional Trips	
36	50,000	Number of High Set Phase Overcurrent Trips	
37	50,000	Number of Distance Zone 1 Trips	
38	50,000	Number of Distance Zone 2 Trips	

Note: The counters cannot be cleared with the Freeze/Clear function codes (9/10). Instead, the control relay output block points can be used to clear groups of counters. There is only one copy of each counter, so clearing a counter via Modbus or the front panel display causes the corresponding DNP counter point to be cleared and vice-versa.

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In the following table, the entry in the “Format” column indicates that the format of the associated data point can be determined by looking up the entry in the 489 Memory Map Data Formats table. For example, an “F1” format is described in that table as a (16-bit) unsigned value without any decimal places. Therefore, the value read should be interpreted in this manner. Many of the values reported by the 489 have a size of 32-bits and have had their upper and lower 16-bit components assigned to separate points. Where indicated, refer to the appropriate note following the table for more detail.

POINT LIST FOR: ANALOG INPUT (OBJECT 30)
ANALOG INPUT CHANGE (OBJECT 32)

Index	Format	Description	Event Class Assigned To	Notes
0	F133	Generator Status	Class 1	Note 3
1	F1	Generator Thermal Capacity Used	Class 1	
2	F1	Estimated Trip Time On Overload (seconds, 65535 means never)	Class 1	
3	F134	Cause Of Last Trip	Class 1	Note 3
4	F19	Time Of Last Trip (Upper 16 Bits)	Class 1	Notes 3,4
5	F19	Time Of Last Trip (Lower 16 Bits)	Class 1	Notes 3,4
6	F18	Date Of Last Trip (Upper 16 Bits)	Class 1	Notes 3,4
7	F18	Date Of Last Trip (Lower 16 Bits)	Class 1	Notes 3,4
8	F1	Tachometer Pre-Trip	Class 1	Note 3
9	F1	Scale factor for pre-trip current readings (pre-trip points marked with “Note 6”) Will always be a power of 10 (1, 10, 100, etc) Changes only when the configuration setpoints are changed.	Class 1	Note 3
10	F1	Phase A Pre-Trip Current	Class 1	Notes 3, 6
11	F1	Phase B Pre-Trip Current	Class 1	Notes 3, 6
12	F1	Phase C Pre-Trip Current	Class 1	Notes 3, 6
13	F1	Phase A Pre-Trip Differential Current	Class 1	Notes 3, 6
14	F1	Phase B Pre-Trip Differential Current	Class 1	Notes 3, 6
15	F1	Phase C Pre-Trip Differential Current	Class 1	Notes 3, 6
16	F1	Pre-Trip Negative Sequence Current	Class 1	Note 3
17	F1	Ground Current Scale Factor Will always be a power of 10 (1, 10, 100, etc) Changes only when the configuration setpoints are changed.	Class 1	Note 3
18	F6	Pre-Trip Ground Current (scaled according to previous setpoint)	Class 1	Note 3
19	F1	Phase A-B Pre-Trip Voltage	Class 1	Note 3
20	F1	Phase B-C Pre-Trip Voltage	Class 1	Note 3
21	F1	Phase C-A Pre-Trip Voltage	Class 1	Note 3
22	F3	Pre-Trip Frequency	Class 1	Note 3
23	F1	Pre-Trip Real Power (MW)	Class 1	Notes 3,8
24	F1	Pre-Trip Real Power (kW)	Class 1	Notes 3,8
25	F1	Pre-Trip Reactive Power (Mar	Class 1	Notes 3,8
26	F1	Pre-Trip Reactive Power (kvar)	Class 1	Notes 3,8
27	F1	Pre-Trip Apparent Power (MVA)	Class 1	Notes 3,8
28	F1	Pre-Trip Apparent Power (kVA)	Class 1	Notes 3,8
29	F1	Last Trip Stator RTD	Class 1	Note 3
30	F4	Last Trip Hottest Stator RTD Temperature (°C)	Class 1	Note 3
31	F1	Last Trip Bearing RTD	Class 1	Note 3
32	F4	Last Trip Hottest Bearing RTD Temperature (°C)	Class 1	Note 3
33	F1	Last Trip Other RTD	Class 1	Note 3
34	F4	Last Trip Hottest Other RTD Temperature (°C)	Class 1	Note 3
35	F1	Last Trip Ambient RTD	Class 1	Note 3
36	F4	Last Trip Hottest Ambient RTD Temperature (°C)	Class 1	Note 3
37	F12	Pre-Trip Analog Input 1	Class 1	Notes 3,9
38	F12	Pre-Trip Analog Input 2	Class 1	Notes 3,9
39	F12	Pre-Trip Analog Input 3	Class 1	Notes 3,9
40	F12	Pre-Trip Analog Input 4	Class 1	Notes 3,9
41	F1	Pre-Trip Fundamental Frequency Neutral Voltage (volts)	Class 1	Notes 3,10
42	F10	Pre-Trip Fundamental Frequency Neutral Voltage (tenths of a volt)	Class 1	Notes 3,10
43	F1	Pre-Trip Third Harmonic Neutral Voltage (volts)	Class 1	Notes 3,10
44	F10	Pre-Trip Third Harmonic Neutral Voltage (tenths of a volt)	Class 1	Notes 3,10
45	F2	Pre-Trip Vab/Iab (loss of excitation impedance)	Class 1	Note 3
46	F1	Pre-Trip Vab/Iab Angle (loss of excitation impedance angle)	Class 1	Note 3
47	F1	Scale factor for current readings (points marked with “Note 7”) Will always be a power of 10 (1, 10, 100, etc.) Changes only when the configuration setpoints are changed.	Class 1	Note 3

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POINT LIST FOR: ANALOG INPUT (OBJECT 30)
ANALOG INPUT CHANGE (OBJECT 32)

Index	Format	Description	Event Class Assigned To	Notes
48	F1	Phase A Output Current	Class 2	Note 7
49	F1	Phase B Output Current	Class 2	Note 7
50	F1	Phase C Output Current	Class 2	Note 7
51	F1	Phase A Neutral-Side Current	Class 2	Note 7
52	F1	Phase B Neutral-Side Current	Class 2	Note 7
53	F1	Phase C Neutral-Side Current	Class 2	Note 7
54	F1	Phase A Differential Current	Class 2	Note 7
55	F1	Phase B Differential Current	Class 2	Note 7
56	F1	Phase C Differential Current	Class 2	Note 7
57	F1	Average Phase Current	Class 2	Note 7
58	F1	Generator Load (percent)	Class 2	
59	F1	Negative Sequence Current	Class 2	
60	F1	Ground Current Scale Factor Will always be a power of 10 (1, 10, 100, etc) Changes only when the configuration setpoints are changed.	Class 1	Note 3
61	F3	Ground Current (scaled according to the previous point)	Class 2	
62	F1	Phase A-B Voltage	Class 2	
63	F1	Phase B-C Voltage	Class 2	
64	F1	Phase C-A Voltage	Class 2	
65	F1	Average Line Voltage	Class 2	
66	F1	Phase A-N Voltage	Class 2	
67	F1	Phase B-N Voltage	Class 2	
68	F1	Phase C-N Voltage	Class 2	
69	F1	Average Phase Voltage	Class 2	
70	F3	Per Unit Measurement Of V/Hz	Class 2	
71	F3	Frequency	Class 2	Note 2
72	F1	Fundamental Frequency Neutral Voltage (volts)	Class 2	Note 10
73	F10	Fundamental Frequency Neutral Voltage (tenths of a volt)	Class 2	Note 10
74	F1	Third Harmonic Neutral Voltage (volts)	Class 2	Note 10
75	F10	Third Harmonic Neutral Voltage (tenths of a volt)	Class 2	Note 10
76	F1	Third Harmonic Terminal Voltage (volts)	Class 2	Note 10
77	F10	Third Harmonic Terminal Voltage (tenths of a volt)	Class 2	Note 10
78	F2	Vab/Iab (loss of excitation impedance)	Class 2	
79	F1	Vab/Iab Angle (loss of excitation impedance angle)	Class 2	
80	F6	Power Factor	Class 2	
81	F1	Real Power (MW)	Class 2	Note 8
82	F1	Real Power (kW)	Class 2	Note 8
83	F1	Reactive Power (Mar)	Class 2	Note 8
84	F1	Reactive Power (kvar)	Class 2	Note 8
85	F1	Apparent Power (MVA)	Class 2	Note 8
86	F1	Apparent Power (kVA)	Class 2	Note 8
87	F1	Hottest Stator RTD	Class 2	Note 3
88	F4	Hottest Stator RTD Temperature (°C)	Class 2	
89	F4	RTD #1 Temperature (°C)	Class 2	
90	F4	RTD #2 Temperature (°C)	Class 2	
91	F4	RTD #3 Temperature (°C)	Class 2	
92	F4	RTD #4 Temperature (°C)	Class 2	
93	F4	RTD #5 Temperature (°C)	Class 2	
94	F4	RTD #6 Temperature (°C)	Class 2	
95	F4	RTD #7 Temperature (°C)	Class 2	
96	F4	RTD #8 Temperature (°C)	Class 2	
97	F4	RTD #9 Temperature (°C)	Class 2	
98	F4	RTD #10 Temperature (°C)	Class 2	
99	F4	RTD #11 Temperature (°C)	Class 2	
100	F4	RTD #12 Temperature (°C)	Class 2	
101	F1	Current Demand	Class 2	Note 7
102	F1	MW Demand	Class 2	Note 8
103	F1	kW Demand	Class 2	Note 8
104	F1	Mvar Demand	Class 2	Note 8

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POINT LIST FOR: ANALOG INPUT (OBJECT 30)
ANALOG INPUT CHANGE (OBJECT 32)

Index	Format	Description	Event Class Assigned To	Notes
105	F1	kvar Demand	Class 2	Note 8
106	F1	MVA Demand	Class 2	Note 8
107	F1	kVA Demand	Class 2	Note 8
108	F1	Peak Current Demand	Class 2	Note 7
109	F1	Peak MW Demand	Class 2	Note 8
110	F1	Peak kW Demand	Class 2	Note 8
111	F1	Peak Mvar Demand	Class 2	Note 8
112	F1	Peak kvar Demand	Class 2	Note 8
113	F1	Peak MVA Demand	Class 2	Note 8
114	F1	Peak kVA Demand	Class 2	Note 8
115	F12	Analog Input 1	Class 2	Note 9
116	F12	Analog Input 2	Class 2	Note 9
117	F12	Analog Input 3	Class 2	Note 9
118	F12	Analog Input 4	Class 2	Note 9
119	F1	Tachometer RPM	Class 2	
120	F1	Average Generator Load	Class 2	
121	F1	Average Negative Sequence Current	Class 2	
122	F1	Average Phase-Phase Voltage	Class 2	
123	-	User Map Value 1		Note 5
124	-	User Map Value 2		Note 5
	-	…		Note 5
246	-	User Map Value 124		Note 5
247	-	User Map Value 125		Note 5
248	F118	Active Setpoint Group	Class 1	Note 3
249	F13	Positive kWh	Class 2	
250	F13	Positive kvarh	Class 2	
251	F13	Negative kvarh	Class 2	
252	F12	Generator Hours Online	Class 2	

Notes:

1. Unless otherwise specified, an event object will be generated for a point if the current value of the point changes by an amount greater than or equal to two percent of its previous value.
2. An event object is created for the Frequency point if the frequency changes by 0.04 Hz or more from its previous value.
3. An event object is created for these points if the current value of a point is in any way changed from its previous value.
4. To support existing SCADA hardware that is not capable of 32-bit data reads, the upper and lower 16-bit portions of these 32-bit values have been assigned to separate points. To read this data, it is necessary to read both the upper and lower 16-bit portions, concatenate these two values to form a 32-bit value and interpret the result in the format associated with the point as specified in the 489 Memory Map Data Formats table.
5. The data returned by a read of the User Map Value points is determined by the values programmed into the corresponding User Map Address registers (which are only accessible via Modbus). Refer to the section titled “User Definable Memory Map Area” in this chapter for more information. Changes in User Map Value points never generate event objects. Note that it is possible to refer to a 32-bit quantity in a user map register, which may require the use of a 32-bit variation to read the associated analog input point.
6. The scale for pre-trip currents is determined by the value in point 9, which should not normally change
7. The scale for currents is determined by the value in point 47, which should not normally change
8. Each power quantity is available at two different points, with two different scale factors (kW and MW, for example). The user should select the unit which is closest to providing the resolution and range desired. If 32-bit analog input capability is present, the higher-resolution (kW, kvar, kVA) points should generally be used, since they provide the greatest resolution.
9. Analog input values may be -50,000 to +50,000 if so configured. Therefore, 32-bit analog input capability is required to read the full possible range. If the SCADA equipment can only read 16-bit registers, the analog inputs should be configured to operate within the range -32,768 to +32,767.
10. Each neutral voltage quantity is available at two different points, with two different scale factors (volts and tenths of a volt). The user should select the unit which is closest to providing the resolution and range desired. If 32-bit analog input capability is present, the higher-resolution (tenths of a volt) points should generally be used, since they provide the greatest resolution.

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7.1.1. TESTING

The purpose of this testing description is to demonstrate the procedures necessary to perform a complete functional test of all the 489 hardware while also testing firmware/hardware interaction in the process. Since the 489 is packaged in a drawout case, a demo case (metal carry case in which an 489 may be mounted) may be useful for creating a portable test set with a wiring harness for all of the I/O. Testing of the relay during commissioning using a primary injection test set will ensure that CTs and wiring are correct and complete.

TEST CONTENTS

(For following tests refer to Fig. 7-1)

1. OUTPUT CURRENT ACCURACY TEST
2. PHASE VOLTAGE INPUT ACCURACY TEST
3. GROUND, NEUTRAL AND DIFFERENTIAL CURRENT ACCURACY TEST
4. NEUTRAL VOLTAGE (FUNDAMENTAL) ACCURACY TEST
5. NEGATIVE SEQUENCE CURRENT ACCURACY TEST
6. RTD ACCURACY TEST
7. DIGITAL INPUT AND TRIP COIL SUPERVISION TEST
8. ANALOG INPUT AND OUTPUTS TEST
9. OUTPUT RELAY TEST
10. OVERLOAD CURVE TEST
11. POWER MEASUREMENT TEST
12. REACTIVE POWER TEST
13. VOLTAGE PHASE REVERSAL TEST

(For the following tests refer to Fig. 7-2)

1. GE POWER MANAGEMENT (HGF) GROUND CURRENT ACCURACY TEST
2. NEUTRAL VOLTAGE (3RD HARMONIC) ACCURACY TEST
3. PHASE DIFFERENTIAL TRIP TEST

(For the following test refer to Fig. 7-3)

1. VOLTAGE RESTRAINED OVERCURRENT

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7.1.2. SECONDARY INJECTION TEST SETUP

Wire the 489 unit as shown below and perform the proceeding tests.

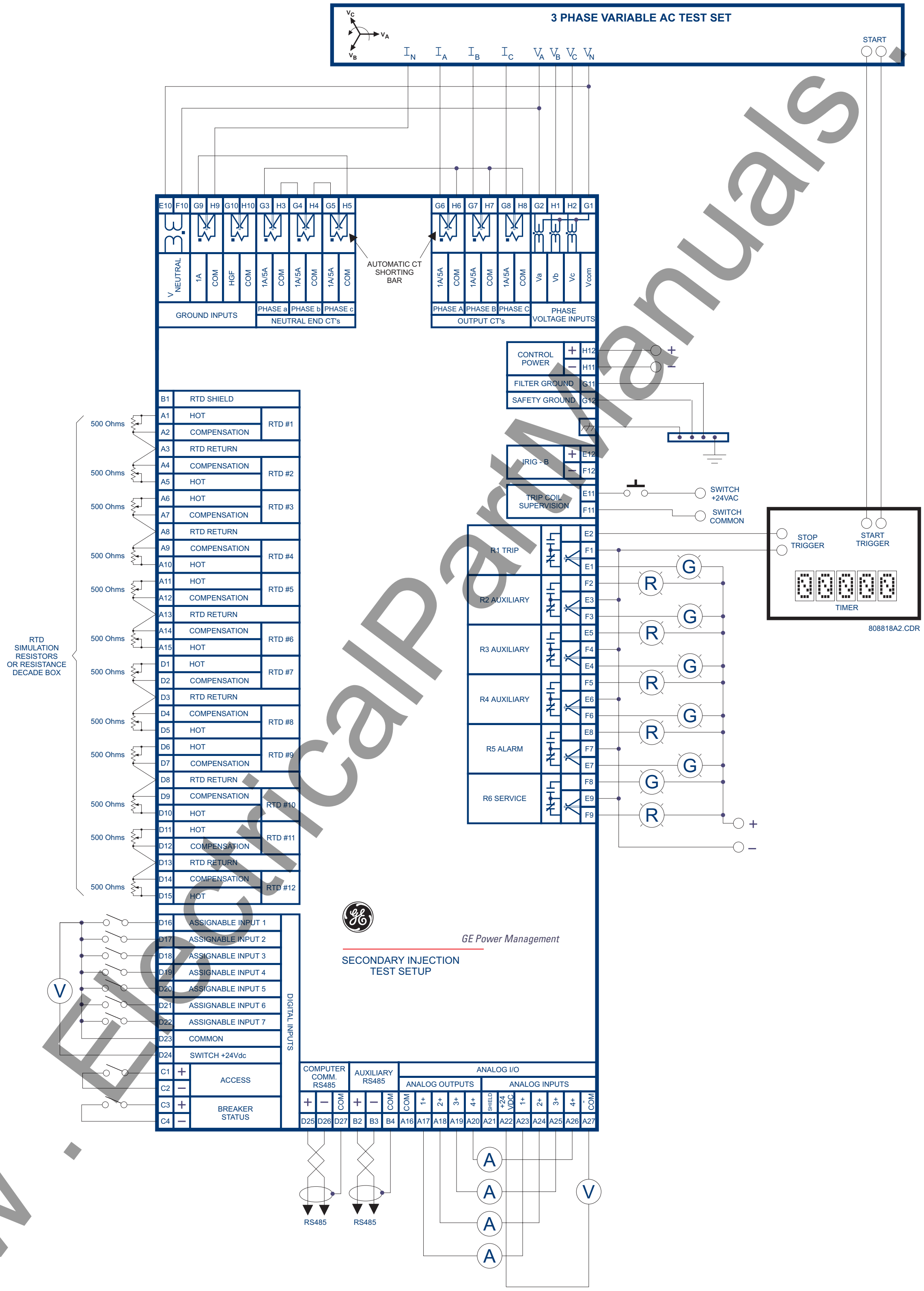

Figure 7-1 SECONDARY INJECTION TEST SETUP

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7.2.1. OUTPUT CURRENT ACCURACY TEST

The 489 specification for output and neutral end current input is ±0.5% of 2xCT when the injected current is < 2xCT. Perform the steps below to verify accuracy.

1. Alter the following setpoint:
SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000A

2. Measured values should be ±10A. Inject the values shown in the table below and verify accuracy of the measured values. View the measured values in:
ACTUAL VALUES A2:\METERING DATA\CURRENT METERING

Table 7-1 OUTPUT CURRENT TEST

INJECTED CURRENT 1 A UNIT (A)	INJECTED CURRENT 5 A UNIT (A)	EXPECTED CURRENT READING (A)	MEASURED CURRENT PHASE A (A)	MEASURED CURRENT PHASE B (A)	MEASURED CURRENT PHASE C (A)
0.1	0.5	100			
0.2	1.0	200			
0.5	2.5	500			
1	5	1000			
1.5	7.5	1500			
2	10	2000			

7.2.2. PHASE VOLTAGE INPUT ACCURACY TEST

The 489 specification for phase voltage input accuracy is ±0.5% of full scale(200V). Perform the steps below to verify accuracy.

1. Alter the following setpoints:
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VT CONNECTION TYPE: Wye
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VOLTAGE TRANSFORMER RATIO: 10.00:1

2. Measured values should be ±1.0V. Apply the voltage values shown in the table and verify accuracy of the measured values. View the measured values in:
ACTUAL VALUES A2:\METERING DATA\VOLTAGE METERING

Table 7-2 PHASE VOLTAGE INPUT TEST

APPLIED LINE-NEUTRAL VOLTAGE (V)	EXPECTED VOLTAGE READING (V)	MEASURED VOLTAGE A-N (V)	MEASURED VOLTAGE B-N (V)	MEASURED VOLTAGE C-N (V)
30	300			
50	500			
100	1000			
150	1500			
200	2000			
270	2700			

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7.2.3. GROUND (1A), NEUTRAL AND DIFFERENTIAL CURRENT ACCURACY TEST

The 489 specification for neutral, differential and 1A ground current input accuracy is ±0.5% of 2xCT. Perform the steps below to verify accuracy.

1. Alter the following setpoints:

SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\GROUND CT: 1A Secondary
SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\GROUND CT RATIO: 1000:1
SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000 A
SETPOINT S5:CURRENT ELEMENTS\PHASE DIFFERENTIAL\PHASE DIFFERENTIAL TRIP: unlatched
SETPOINT S5:CURRENT ELEMENTS\PHASE DIFFERENTIAL\DIFFERENTIAL TRIP MIN. PICKUP: 0.1xCT
(Note: Last two setpoints are needed to view the neutral and the differential current. The trip element will operate when diff. current exceeds 100 A.)

2. Measured values should be ±10A. Inject (I_A only) the values shown in the table below into one phase only and verify accuracy of the measured values. View the measured values in:

ACTUAL VALUES A2:\METERING DATA\CURRENT METERING
OR
Press NEXT button to view the current values when diff. trip element is active.

Table 7-3 NEUTRAL AND GROUND CURRENT TEST (1A)

INJECTED CURRENT 1 A UNIT (A)	EXPECTED CURRENT READING (A)	MEASURED GROUND CURRENT (A)	MEASURED NEUTRAL CURRENT PHASE A (A)	MEASURED NEUTRAL CURRENT PHASE B (A)	MEASURED NEUTRAL CURRENT PHASE C (A)
0.1	100				
0.2	200				
0.5	500				
1	1000				

Table 7-4 DIFFERENTIAL CURRENT TEST

INJECTED CURRENT (A)	EXPECTED CURRENT READING DIFF. PHASE A (A)	EXPECTED CURRENT READING DIFF. PHASE B,C (A)	MEASURED DIFF. CURRENT PHASE A (A)	MEASURED DIFF. CURRENT PHASE B (A)	MEASURED DIFF. CURRENT PHASE C (A)
0.1	200	100			
0.2	400	200			
0.5	1000	500			
1	2000	1000			

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7.2.4. NEUTRAL VOLTAGE (FUNDAMENTAL) ACCURACY TEST

The 489 specification for neutral voltage (fundamental) accuracy is ±0.5% of full scale (100V). Perform the steps below to verify accuracy.

1. Alter the following setpoints:
   SETPOINT S2: SYSTEM SETUP\VOLTAGE SENSING\NEUTRAL VOLTAGE TRANSFORMER: Yes
   SETPOINT S2: SYSTEM SETUP\VOLTAGE SENSING\NEUTRAL V.T. RATIO: 10.00:1
   SETPOINT S2: SYSTEM SETUP\GEN. PARAMETERS\GENERATOR NOMINAL FREQUENCY: 60 Hz

2. Measured values should be ±5.0V. Apply the voltage values shown in the table and verify accuracy of the measured values. View the measured values in:
   ACTUAL VALUES A2: METERING DATA\VOLTAGE METERING

Table 7-5 NEUTRAL VOLTAGE (FUNDAMENTAL) INPUT TEST

APPLIED NEUTRAL VOLTAGE (V) @ 60Hz	EXPECTED NEUTRAL VOLTAGE (V)	MEASURED NEUTRAL VOLTAGE (V)
10	100	
30	300	
50	500	

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7.2.5. NEGATIVE SEQUENCE CURRENT ACCURACY TEST

The 489 measures negative sequence current as a percent of Full Load Amperes (FLA). A sample calculation of negative sequence current is given below:

Generator Parameters

Rated MVA (P_A): 1.04
Voltage Phase to Phase (V_{PP}): 600

$$FLA = \frac{P_A}{\sqrt{3} \times V_{pp}} = \frac{1.04 \times 10^6}{\sqrt{3} \times 600} \approx 1000 \text{ A}$$

Output Currents

$$I_a = 780\angle 0°$$

$$I_b = 1000\angle 113° \; lag$$

$$I_c = 1000\angle 247° \; lag$$

Negative Sequence Current

$$I_{ns} = \frac{1}{3}(I_a + a^2 I_b + aI_c) \qquad \text{where } a = 1\angle 120° = -0.5 + i0.866$$

$$I_{ns} = \frac{1}{3}\left[780\angle 0° + (1\angle 120°)^2 (1000\angle -113°) + (1\angle 120°)(1000\angle 113°)\right]$$

$$I_{ns} = \frac{1}{3}\left(780\angle 0° + 1000\angle 127° + 1000\angle 233°\right)$$

$$I_{ns} = \frac{1}{3}\left(780 - 601.8 + i798.6 - 601.8 - i798.6\right)$$

$$I_{ns} = -141.2$$

$$\%I_{ns} = \frac{I_{ns}}{FLA} \times 100 = 14\%$$

∴ Negative Sequence Current is 14% of FLA.

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The 489 specification for negative sequence current accuracy is per output current inputs. Perform the steps below to verify accuracy.

1. Alter the following setpoints:
   SETPOINT S2:SYSTEM SETUP\GENERATOR PARAMETER\GENERATOR RATED MVA: 1.04
   SETPOINT S2:SYSTEM SETUP\GENERATOR PARAMETER\VOLTAGE PHASE-PHASE: 600
   (Note: This is equivalent to setting FLA = 1000 A -- For testing purposes ONLY!)

SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000A

2. Inject the values shown in the table below and verify accuracy of the measured values. View the measured values in:
   ACTUAL VALUES A2:\METERING DATA\CURRENT METERING

Table 7-6 NEGATIVE SEQUENCE CURRENT

INJECTED CURRENT 1A UNIT (A)	INJECTED CURRENT 5A UNIT (A)	EXPECTED NEAGTIVE SEQUENCE CURRENT LEVEL (% FLA)	MEASURED NEGATIVE SEQUENCE CURRENT LEVEL (% FLA)
Ia= 0.78 ∠0° Ib=1 ∠113° lag Ic=1 ∠247° lag	Ia= 3.9 ∠0° Ib=5 ∠113° lag Ic=5 ∠247° lag	14	
Ia=1.56 ∠0° Ib=2 ∠113° lag Ic=2 ∠247° lag	Ia=7.8 ∠0° Ib=10 ∠113° lag Ic=10 ∠247° lag	28	
Ia= 0.39 ∠0° Ib=0.5 ∠113° lag Ic=0.5 ∠247° lag	Ia= 1.95 ∠0° Ib=2.5 ∠113° lag Ic=2.5 ∠247° lag	7	

7.2.6. RTD ACCURACY TEST

The 489 specification for RTD input accuracy is ±2° for Platinum/Nickel and ±5° for Copper. Perform the steps below to verify accuracy.

1. alter the following setpoints:

SETPOINT S8:RTD TEMPERATURE\RTD TYPE\STATOR RTD TYPE: 100 ohm Platinum
(select desired type)
SETPOINT S8:RTD TEMPERATURE\RTD #1\RTD #1 APPLICATION: Stator
(repeat for RTDs 2-12)

2. Measured values should be ±2° C or ±4° F for Platinum/Nickel and ±5° C or ±9° F for Copper. Alter the resistances applied to the RTD inputs as per the table below to simulate RTDs and verify accuracy of the measured values. View the measured values in:
   ACTUAL VALUES A2:\METERING DATA\TEMPERATURE

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Table 7-7 RTD 100 OHM PLATINUM TEST

APPLIED RESISTANCE 100 OHM PLATINUM (ohm)	EXPECTED RTD TEMPERATURE READING (°C)	EXPECTED RTD TEMPERATURE READING (°F)	MEASURED RTD TEMPERATURE ✔ SELECT ONE ____(°C) ____(°F)											
			1	2	3	4	5	6	7	8	9	10	11	12
84.27	-40	-40												
100.00	0	32												
119.39	50	122												
138.50	100	212												
157.32	150	302												
175.84	200	392												
194.08	250	482												

Table 7-8 RTD 120 OHM NICKEL TEST

APPLIED RESISTANCE 120 OHM NICKEL (ohm)	EXPECTED RTD TEMPERATURE READING (°C)	EXPECTED RTD TEMPERATURE READING (°F)	MEASURED RTD TEMPERATURE ✔ SELECT ONE ____(°C) ____(°F)											
			1	2	3	4	5	6	7	8	9	10	11	12
92.76	-40	-40												
120.00	0	32												
157.74	50	122												
200.64	100	212												
248.95	150	302												
303.46	200	392												
366.53	250	482												

Table 7-9 RTD 100 OHM NICKEL TEST

APPLIED RESISTANCE 100 OHM NICKEL (ohm)	EXPECTED RTD TEMPERATURE READING (°C)	EXPECTED RTD TEMPERATURE READING (°F)	MEASURED RTD TEMPERATURE ✔ SELECT ONE ____(°C) ____(°F)											
			1	2	3	4	5	6	7	8	9	10	11	12
77.30	-40	-40												
100.00	0	32												
131.45	50	122												
167.20	100	212												
207.45	150	302												
252.88	200	392												
305.44	250	482												

Table 7-10 RTD 10 OHM COPPER TEST

APPLIED RESISTANCE 10 OHM COPPER (ohm)	EXPECTED RTD TEMPERATURE READING (°C)	EXPECTED RTD TEMPERATURE READING (°F)	MEASURED RTD TEMPERATURE ✔ SELECT ONE ____(°C) ____(°F)											
			1	2	3	4	5	6	7	8	9	10	11	12
7.49	-40	-40												
9.04	0	32												
10.97	50	122												
12.90	100	212												
14.83	150	302												
16.78	200	392												
18.73	250	482												

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7.2.7. DIGITAL INPUTS AND TRIP COIL SUPERVISION

The digital inputs and trip coil supervision can be verified easily with a simple switch or pushbutton. Verify the SWITCH +24Vdc with a voltmeter. Perform the steps below to verify functionality of the digital inputs.

1. Open switches of all of the digital inputs and the trip coil supervision circuit.

2. View the status of the digital inputs and trip coil supervision in:
ACTUAL VALUES A1:\STATUS\DIGITAL INPUTS

3. Close switches of all of the digital inputs and the trip coil supervision circuit.

4. View the status of the digital inputs and trip coil supervision in:
ACTUAL VALUES A1:\STATUS\DIGITAL INPUTS

Table 7-11 DIGITAL INPUTS

INPUT	EXPECTED STATUS (SWITCH OPEN)	✔ PASS ✘ FAIL	EXPECTED STATUS (SWITCH CLOSED)	✔ PASS ✘ FAIL
ACCESS	Open		Shorted	
BREAKER STATUS	Open		Shorted	
ASSIGNABLE INPUT 1	Open		Shorted	
ASSIGNABLE INPUT 2	Open		Shorted	
ASSIGNABLE INPUT 3	Open		Shorted	
ASSIGNABLE INPUT 4	Open		Shorted	
ASSIGNABLE INPUT 5	Open		Shorted	
ASSIGNABLE INPUT 6	Open		Shorted	
ASSIGNABLE INPUT 7	Open		Shorted	
TRIP COIL SUPERVISION	No Coil		Coil	

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7.2.8. ANALOG INPUTS AND OUTPUTS

The 489 specification for analog input and analog output accuracy is ±1% of full scale. Perform the steps below to verify accuracy. Verify the Analog Input +24Vdc with a voltmeter.

4-20mA

1. alter the following setpoints:

SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1: 4-20 mA
SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1 MINIMUM:0
SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1 MAXIMUM:1000
(repeat for analog inputs 2-4)

2. Analog output values should be ±0.2mA on the ammeter. Measured analog input values should be ±10 units. Force the analog outputs using the following setpoints:

SETPOINT S12:TESTING\TEST ANALOG OUTPUT\FORCE ANALOG OUTPUTS FUNCTION: Enabled
SETPOINT S12:TESTING\TEST ANALOG OUTPUT\ANALOG OUTPUT 1 FORCED VALUE: 0 %
(enter desired percent, repeat for analog outputs 2-4)

3. Verify the ammeter readings as well as the measured analog input readings. For the purposes of testing, the analog input is fed in from the analog output (see Figure 7-1). View the measured values in:

ACTUAL VALUES A2:\METERING DATA\ANALOG INPUTS

Table 7-12 ANALOG I/O TEST 4-20mA

ANALOG OUTPUT FORCE VALUE (%)	EXPECTED AMMETER READING (mA)	MEASURED AMMETER READING (mA)				EXPECTED ANALOG INPUT READING (units)	MEASURED ANALOG INPUT READING (units)			
		1	2	3	4		1	2	3	4
0	4					0				
25	8					250				
50	12					500				
75	16					750				
100	20					1000				

0-1mA

1. alter the following setpoints:

SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1: 0-1 mA
SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1 MINIMUM:0
SETPOINT S11:ANALOG I/O\ANALOG INPUT1\ANALOG INPUT1 MAXIMUM:1000
(repeat for analog inputs 2-4)

2. Analog output values should be ±0.01mA on the ammeter. Measured analog input values should be ±10 units. Force the analog outputs using the following setpoints:

SETPOINT S12:TESTING\TEST ANALOG OUTPUT\FORCE ANALOG OUTPUTS FUNCTION: Enabled
SETPOINT S12:TESTING\TEST ANALOG OUTPUT\ANALOG OUTPUT 1 FORCED VALUE: 0 %
(enter desired percent, repeats for analog output 2-4)

3. Verify the ammeter readings as well as the measured analog input readings. View the measured values in:

ACTUAL VALUES A2:\METERING DATA\ANALOG INPUTS

Table 7-13 ANALOG I/O TEST 0-1mA

ANALOG OUTPUT FORCE VALUE (%)	EXPECTED AMMETER READING (mA)	MEASURED AMMETER READING (mA)				EXPECTED ANALOG INPUT READING (units)	MEASURED ANALOG INPUT READING (units)			
		1	2	3	4		1	2	3	4
0	0					0				
25	0.25					250				
50	0.50					500				
75	0.75					750				
100	1.00					1000				

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7.2.9. OUTPUT RELAYS

To verify the functionality of the output relays, perform the following steps:

1. Using the setpoint:
SETPOINT S12:TESTING\TEST OUTPUT RELAYS\FORCE OPERATION OF RELAYS: R1 TRIP
select and store values as per the table below, verifying operation

Table 7-14 OUTPUT RELAYS

FORCE OPERATION SETPOINT	EXPECTED MEASUREMENT ✔ for SHORT												ACTUAL MEASUREMENT ✔ for SHORT											
	R1		R2		R3		R4		R5		R6		R1		R2		R3		R4		R5		R6	
	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc
R1 Trip	✔			✔		✔		✔		✔	✔													
R2 Auxiliary		✔	✔			✔		✔		✔	✔													
R3 Auxiliary		✔		✔	✔			✔		✔	✔													
R4 Auxiliary		✔		✔		✔	✔			✔	✔													
R5 Alarm		✔		✔		✔		✔	✔		✔													
R6 Service		✔		✔		✔		✔		✔		✔												
All Relays	✔		✔		✔		✔		✔			✔												
No Relays		✔		✔		✔		✔		✔	✔													

NOTE: R6 Service relay is failsafe or energized normally, operating R6 causes it to de-energize.

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7.3.1. OVERLOAD CURVE TEST

The 489 specification for overload curve timing accuracy is ±100ms or ±2% of time to trip. Pickup accuracy is as per the current inputs (±0.5% of 2xCT when the injected current is < 2xCT and ±1% of 20xCT when the injected current is ≥ 2xCT). Perform the steps below to verify accuracy.

1. Alter the following setpoints:

SETPOINT S2 SYSTEM SETUP\GEN. PARAMETERS\GENERATOR RATED: 1.04
SETPOINT S2 SYSTEM SETUP\GEN. PARAMETERS\GENERATOR VOLTAGE PHASE-PHASE: 600
(Note: This is equivalent to setting FLA = 1000 A -- For testing purposes ONLY!)
SETPOINT S2 SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000
SETPOINT S9 THERMAL MODEL\MODEL SETUP\SELECT CURVE STYLE: Standard
SETPOINT S9 THERMAL MODEL\MODEL SETUP\OVERLOAD PICKUP LEVEL: 1.10xFLA
SETPOINT S9 THERMAL MODEL\MODEL SETUP\UNBALANCE BIAS K FACTOR: 0
SETPOINT S9 THERMAL MODEL\MODEL SETUP\HOT/COLD SAFE STALL RATIO: 1.00
SETPOINT S9 THERMAL MODEL\MODEL SETUP\ENABLE RTD BIASING: No
SETPOINT S9 THERMAL MODEL\MODEL SETUP\STANDARD OVERLOAD CURVE NUMBER: 4
SETPOINT S9 THERMAL MODEL\MODEL SETUP\ENABLE THERMAL MODEL: Yes
SETPOINT S9 THERMAL MODEL\THERMAL ELEMENTS\THERMAL MODEL TRIP: Latched or Unlatched

2. Any trip must be reset prior to each test. Short the emergency restart terminals momentarily immediately prior to each overload curve test to ensure that the thermal capacity used is zero. Failure to do so will result in shorter trip times. Inject the current of the proper amplitude to obtain the values as shown and verify the trip times. Motor load may be viewed in:

ACTUAL VALUES A2:\METERING DATA\CURRENT METERING
Thermal capacity used and estimated time to trip may be viewed in:
ACTUAL VALUES A1:\STATUS\GENERATOR STATUS

Table 7-15 OVERLOAD TEST (STANDARD CURVE #4)

AVERAGE PHASE CURRENT DISPLAYED (A)	PICKUP LEVEL	EXPECTED TIME TO TRIP (s)	TOLERANCE RANGE (s)	MEASURED TIME TO TRIP (s)
1050	1.05	never	n/a	
1200	1.20	795.44	779.53-811.35	
1750	1.75	169.66	166.27-173.05	
3000	3.00	43.73	42.86-44.60	
6000	6.00	9.99	9.79-10.19	
10000	10.00	5.55	5.44-5.66	

NOTE: $FLA = \frac{Generator\_Rated\_MVA}{\sqrt{3} \times Generator\_Phase\_to\_Phase\_Voltage}$

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7.3.2. POWER MEASUREMENT TEST

The 489 specification for reactive and apparent power is ± 1% of √3x2xCTxVTx(VT full scale) @ Iavg <2xCT. Perform the steps below to verify accuracy.

1. Alter the following setpoints:
SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VT CONNECTION TYPE: Wye
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VOLTAGE TRANSFORMER RATIO: 10.00:1

2. Inject current and apply voltage as per the table below. Verify accuracy of the measured values. View the measured values in:
ACTUAL VALUES A2:\METERING DATA\POWER METERING

Table 7-16 POWER MEASUREMENT TEST

INJECTED CURRENT 1A UNIT, APPLIED VOLTAGE (Ia is reference vector)	INJECTED CURRENT 5A UNIT, APPLIED VOLTAGE (Ia is reference vector)	EXPECTED LEVEL OF POWER QUANTITY	TOLERANCE RANGE OF POWER QUANTITY	MEASURED POWER QUANTITY	EXPECTED POWER FACTOR	MEASURED POWER FACTOR
Ia=1A ∠0° Ib=1A ∠120° lag Ic=1A ∠240° lag Va=120V ∠342° lag Vb=120V ∠102° lag Vc=120V ∠222° lag	Ia=5A ∠0° Ib=5A ∠120° lag Ic=5A ∠240° lag Va=120V ∠342° lag Vb=120V ∠102° lag Vc=120V ∠222° lag	+ 3424 kW	3329-3519 kW		0.95 lag	
Ia=1A ∠0° Ib=1A ∠120° lag Ic=1A ∠240° lag Va=120V ∠288° lag Vb=120V ∠48° lag Vc=120V ∠168° lag	Ia=5A ∠0° Ib=5A ∠120° lag Ic=5A ∠240° lag Va=120V ∠288° lag Vb=120V ∠48° lag Vc=120V ∠168° lag	+ 3424 kvar	3329-3519 kvar		0.31 lag	

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7.3.3. REACTIVE POWER TEST

The 489 specification for reactive power is ± 1% of √3x2xCTxVTx(VT full scale) @ Iavg <2xCT. Perform the steps below to verify accuracy and trip element.

1. Alter the following system setpoints:

SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 5000
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VT CONNECTION TYPE: Wye
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VOLTAGE TRANSFORMER RATIO: 100:1
SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR RATED MVA: 100
SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR RATED POWER FACTOR: 0.85
SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR VOLTAGE PHASE-PHASE: 12000

RATED REACTIVE POWER = 100 sin(cos^{-1}(0.85)) = ±52.7 Mvar

2. Alter the following reactive power setpoints:

SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\REACTIVE POWER ALARM: Unlatched
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\ASSIGN ALARM RELAYS(2-5): ---5
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\POSTIVE Mvar ALARM LEVEL: 0.6 x Rated
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\NEGATIVE Mvar ALARM LEVEL: 0.6 x Rated
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\REACTIVE POWER ALARM DELAY: 5 s
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\REACTIVE POWER ALARM EVENT: On
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\REACTIVE POWER TRIP: Unlatched
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\ASSIGN TRIP RELAYS(1-4): 1---
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\POSTIVE Mvar TRIP LEVEL: 0.75 x Rated
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\NEGATIVE Mvar TRIP LEVEL: 0.75 x Rated
SETPOINT S7:POWER ELEMENTS\REACTIVE POWER\REACTIVE POWER TRIP DELAY: 10 s

3. Inject current and apply voltage as per the table below. Verify the alarm/trip elements and the accuracy of the measured values. View the measured values in:

ACTUAL VALUES A2:\METERING DATA\POWER METERING
View the Event Records in:
ACTUAL VALUES A5:\EVENT RECORD

Table 7-17 REACTIVE POWER TEST

CURRENT (A) VOLTAGE (V) (Secondary Injection)	Expected Mvar	Mvar Tolerance	Measured Mvar	Expected Alarm (R5)	Observed Alarm (R5)	Alarm Delay (sec)	Expected Trip (R1)	Observed Trip (R1)	Trip Delay (sec)
Vab = 120 ∠ 0° Vbc = 120 ∠ 120°lag Vca = 120 ∠ 240°lag Ian = 5A ∠ 10°lag Ibn = 5A ∠ 130°lag Icn = 5A ∠ 250°lag	+18	+13 to +23		✘		N/A	✘		N/A
Vab = 120 ∠ 0° Vbc = 120 ∠ 120°lag Vca = 120 ∠ 240°lag Ian = 5A ∠ 340°lag Ibn = 5A ∠ 100°lag Icn = 5A ∠ 220°lag	–35	–40 to –30		✔			✘		N/A
Vab = 120 ∠ 0° Vbc = 120 ∠ 120°lag Vca = 120 ∠ 240°lag Ian = 5A ∠ 330°lag Ibn = 5A ∠ 90°lag Icn = 5A ∠ 210°lag	–52	–57 to –47		✔			✔		
Vab = 120 ∠ 0° Vbc = 120 ∠ 120°lag Vca = 120 ∠ 240°lag Ian = 5A ∠ 30°lag Ibn = 5A ∠ 150°lag Icn = 5A ∠ 270°lag	+52	+47 to +57		✔			✔		

✔ Activated
✘ Not Activated

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7.3.4. VOLTAGE PHASE REVERSAL TEST

The 489 can detect voltage phase rotation and protect against phase reversal. To test the phase reversal element, perform the following steps:

1. Alter the following setpoints:

SETPOINT S3:DIGITAL INPUTS\BREAKER STATUS\BREAKER STATUS: Breaker Auxiliary a
SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VT CONNECTION TYPE: Wye
SETPOINT S6:VOLTAGE ELEMENTS\PHASE REVERSAL\PHASE REVERSAL TRIP: Unlatched
SETPOINT S6:VOLTAGE ELEMENTS\PHASE REVERSAL\ASSIGN TRIP RELAYS: Trip
SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR PHASE SEQUENCE: ABC

2. Apply voltages as per the table below. Verify the 489 operation on voltage phase reversal.

Table 7-18 VOLTAGE PHASE REVERSAL TEST

APPLIED VOLTAGE	EXPECTED RESULT ✘ NO TRIP ✔ PHASE REVERSAL TRIP	OBSERVED RESULT ✘ NO TRIP ✔ PHASE REVERSAL TRIP
Va=120V ∠0° Vb=120V ∠120° lag Vc=120V ∠240° lag	✘	
Va=120V ∠0° Vb=120V ∠240° lag Vc=120V ∠120° lag	✔	

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7.3.5. INJECTION TEST SETUP 2

Setup the 489 device as follows for the following tests.

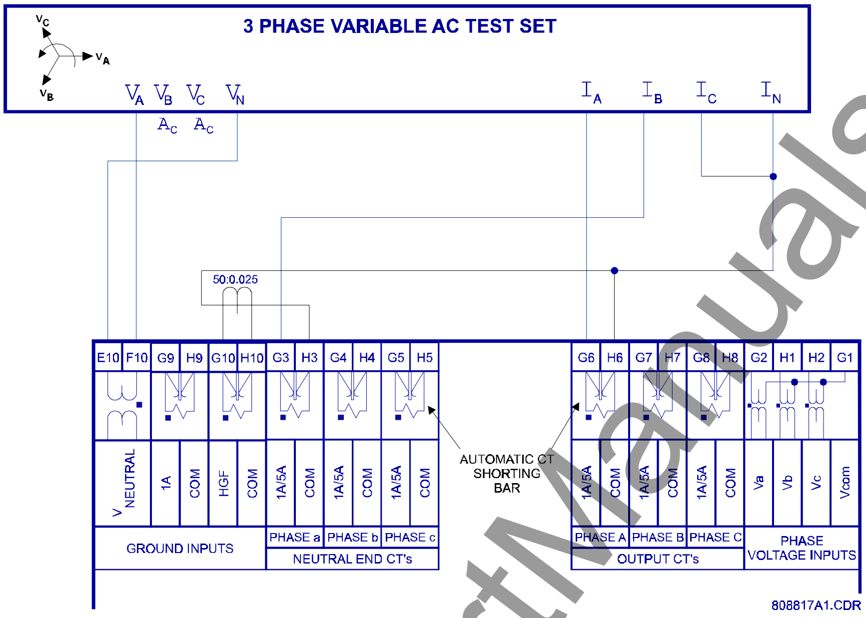

Figure 7-2 SECONDARY INJECTION SETUP 2

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7.3.6. GE POWER MANAGEMENT HGF GROUND ACCURACY TEST

The 489 specification for GE Power Management HGF (50:0.025) ground current input accuracy is ±0.5% of 2xCT rated primary (25A). Perform the steps below to verify accuracy.

1. Alter the following setpoint:
SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\GROUND CT: 50:0.025 CT

2. Measured values should be ±0.25A. Inject the values shown in the table below either as primary values into a GE Power Management 50:0.025 Core Balance CT or as secondary values that simulate the core balance CT. Verify accuracy of the measured values in:
ACTUAL VALUES A2:\METERING DATA\CURRENT METERING

Table 7-19 GE POWER MANAGEMENT 50:0.025 GROUND CURRENT TEST

PRIMARY INJECTED CURRENT 50:0.025 CT (A)	SECONDARY INJECTED CURRENT (mA)	EXPECTED CURRENT READING (A)	MEASURED GROUND CURRENT (A)
0.25	0.125	0.25	
1	0.5	1.00	
5	2.5	5.00	
10	5	10.00	

7.3.7. NEUTRAL VOLTAGE (3RD HARMONIC) ACCURACY TEST

The 489 specification for neutral voltage (3rd harmonic) accuracy is ±0.5% of full scale (100V). Perform the steps below to verify accuracy.

1. Alter the following setpoints:
SETPOINT S2: SYSTEM SETUP\VOLTAGE SENSING\NEUTRAL VOLTAGE TRANSFORMER: Yes
SETPOINT S2: SYSTEM SETUP\VOLTAGE SENSING\NEUTRAL V.T. RATIO: 10.00:1
SETPOINT S2: SYSTEM SETUP\GEN. PARAMETERS\GENERATOR NOMINAL FREQUENCY: 60 Hz

2. Measured values should be ±5.0V. Apply the voltage values shown in the table and verify accuracy of the measured values. View the measured values in:
ACTUAL VALUES A2: METERING DATA\VOLTAGE METERING

Table 7-20 NEUTRAL VOLTAGE (3RD HARMONIC) INPUT TEST

APPLIED NEUTRAL VOLTAGE (V) @ 180Hz	EXPECTED NEUTRAL VOLTAGE (V)	MEASURED NEUTRAL VOLTAGE (V)
10	100	
30	300	
50	500	

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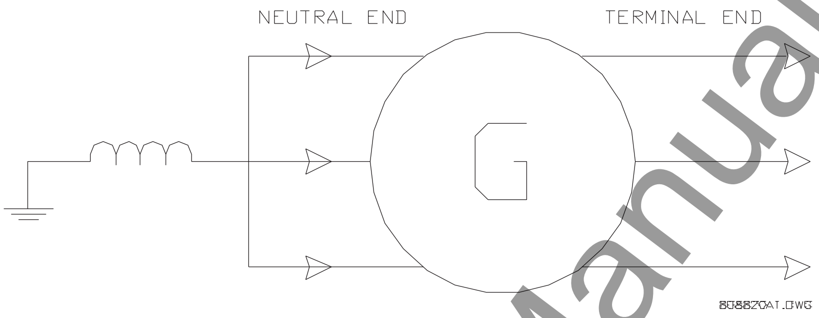
7.3.8. PHASE DIFFERENTIAL TRIP TEST

The 489 phase differential compares the current level at terminal end with the current level at neutral end. The differential element will trip when: (Also see section 4.6.8)

$$I_{diff} > k \times I_{\mathrm{Re}stra\,\mathrm{int}}$$

where,



$$I_{diff} = \left| \overline{I_A} + \overline{I_a} \right|$$

$$I_{\mathrm{Re}\,stra\,\mathrm{int}} = \frac{\left| I_A \right| + \left| I_a \right|}{2}$$

I_{diff} = Differential current
$I_{Restraint}$ = Restraint current
k = characteristic slope of differential element in percent (Use Slope1 if $I_R < 2$xCT, Slope2 if $I_R \geq 2$xCT)
I_A = phase current measured at the output CT
I_a = phase current measured at the neutral end CT

The following is a sample calculation of a trip scenario.

Settings & Values:

DIFFERENTIAL TRIP SLOPE1: 10% (user setting)
DIFFERENTIAL TRIP SLOPE2: 20% (user setting)

I_A = 1.5 x CT @ 0° I_a = 1.47 x CT @ 190° lag

Calculations:

$$I_d = \left| \overline{I_A} + \overline{I_a} \right| = \left| 1.5 - 1.448 + i0.255 \right| = 0.26 \text{ x CT}$$

$$I_R = \frac{\left| I_A \right| + \left| I_a \right|}{2} = 1.485 \text{ x CT}$$

Since $I_R < 2$ x CT, the differential trip slope (k) = 0.1 or 10%

$$I_{Trip} = k \times I_R = 0.1 \times 1.485 = 0.1485 \text{ x CT}$$

∴ Since $I_d > I_{Trip}$, the differential TRIP will operate.

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The 489 specification for differential phase timing accuracy is ±0.5% of total time. Pickup accuracy is per the output current inputs (±0.5% of 2xCT when the injected current is < 2xCT and ±1% of 20xCT when the injected current is ≥2xCT). Perform the steps below to verify accuracy for phase A.

1. Alter the following setpoints:
   SETPOINT S2:SYSTEM SETUP\CURRENT SENSING\PHASE CT PRIMARY: 1000A
   SETPOINT S5:CURRENT ELEMENT\PHASE DIFFERENTIAL\PHASE DIFFERENTIAL TRIP: Unlatched
   SETPOINT S5:CURRENT ELEMENT\PHASE DIFFERENTIAL\DIFFERENTIAL TRIP MIN. PICKUP: 0.10xCT
   SETPOINT S5:CURRENT ELEMENT\PHASE DIFFERENTIAL\DIFFERENTIAL TRIP SLOPE1: 10%
   SETPOINT S5:CURRENT ELEMENT\PHASE DIFFERENTIAL\DIFFERENTIAL TRIP SLOPE2: 20%

2. Measured values should be ±5.0A (Note: There could be further error due to uncertainty in the phase measurement. It is recommended that the phase be measured from 489 instead of the current source for the purposes of this test). Apply the values shown in the table below and verify the accuracy and the operation of phase differential element. View the measured values in :
   ACTUAL VALUES A2:METERING DATA\CURRENT METERING
   OR
   Press NEXT button when the trip element is activated.

NOTE: As in Fig. 7-2; I_A (Test Set) = I_A and I_B (Test Set) = I_a

Table 7-21 PHASE DIFFERENTIAL TEST

APPLIED CURRENT **AS SHOWN ON 489** (A)	EXPECTED RESULT ✘ NO TRIP ✔ PHASE DIFFERENTIAL TRIP	EXPECTED DIFFERENTIAL CURRENT (A)	OBSERVED RESULT ✘ NO TRIP ✔ PHASE DIFFERENTIAL TRIP	MEASURED DIFFERENTIAL CURRENT (A)
I_A=1000$\angle$0° I_a=1000$\angle$180° lag	✘	0		
I_A=1000$\angle$0° I_a=940$\angle$190° lag	✔	179		

3. Repeat for phases B & C. (need rewiring of Fig. 7-2)

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Setup the 489 as shown below for the final test (Open Delta Connection).

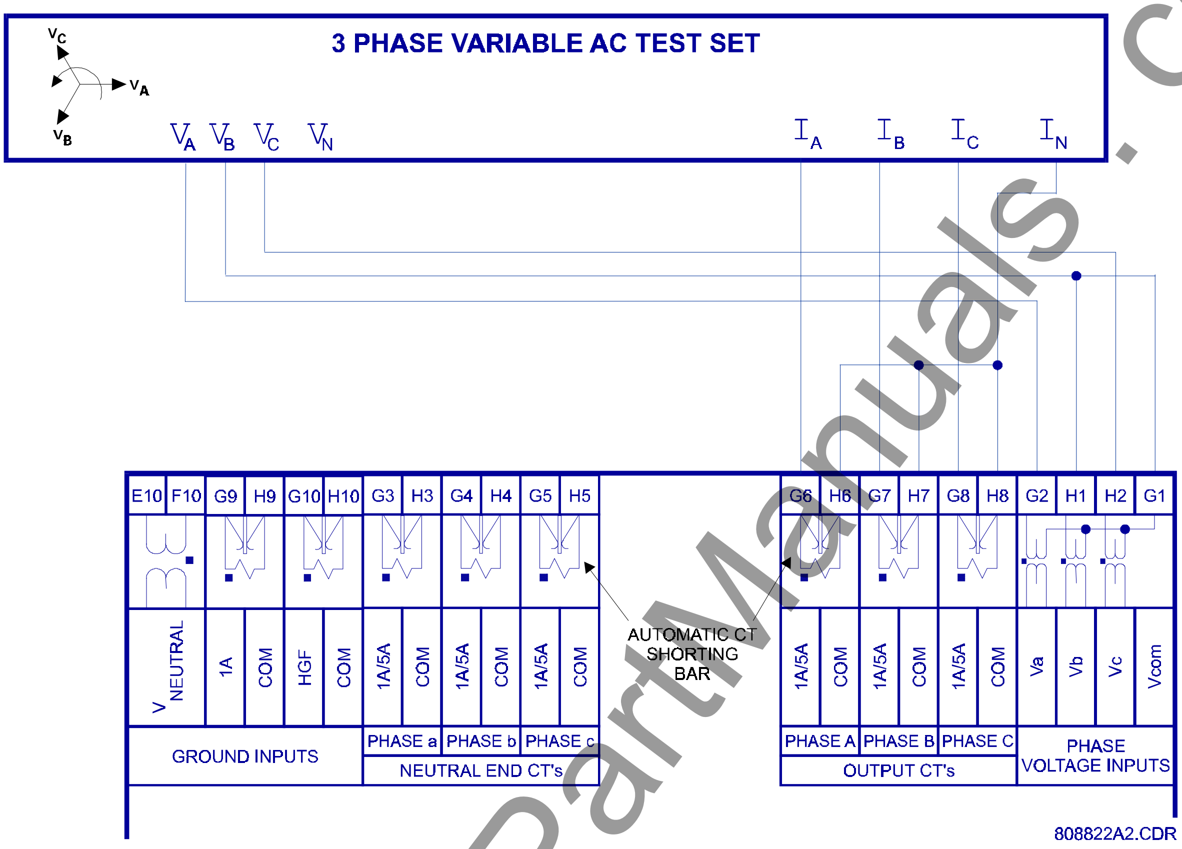

Figure 7-3 SECONDARY INJECTION TEST SETUP 3

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7.3.9. VOLTAGE RESTRAINED OVERCURRENT TEST

Perform the steps below to verify the trip element.

1. Alter the following setpoints.
   SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR SETTING: 100 MVA
   SETPOINT S2:SYSTEM SETUP\GEN. PARAMETERS\GENERATOR VOLTAGE PHASE-PHASE: 12000
   SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VT CONNECTION TYPE: Open Delta
   SETPOINT S2:SYSTEM SETUP\VOLTAGE SENSING\VOLTAGE TRANSFORMER RATIO: 100:1
   SETPOINT S5:CURRENT ELEMENTS\OVERCURRENT ALARM\OVERCURRENT ALARM:Unlatched
   SETPOINT S5:CURRENT ELEMENTS\OVERCURRENT ALARM\O/C ALARM LEVEL:1.10 x FLA
   SETPOINT S5:CURRENT ELEMENTS\OVERCURRENT ALARM\OVERCURRENT ALARM DELAY: 2 s
   SETPOINT S5:CURRENT ELEMENTS\OVERCURRENT ALARM\O/C ALARM EVENTS: On
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\PHASE OVERCURRENT TRIP: Latched
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\ENABLE VOLTAGE RESTRAINT: Yes
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\PHASE O/C PICKUP: 1.5 x CT
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\CURVE SHAPE: ANSI Extremly Inv.
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\O/C CURVE MULTIPLIER: 2.00
   SETPOINT S5:CURRENT ELEMENTS\PHASE OVERCURRENT\O/C CURVE RESET: Instantaneous

ANSI CURVE (EXTREMELY INVERSE)

$$\text{Time To Trip} = M\left[A + \frac{B}{\left(\frac{I}{<K>\times I_P} - C\right)} + \frac{D}{\left(\frac{I}{<K>\times I_P} - C\right)^2} + \frac{E}{\left(\frac{I}{<K>\times I_P} - C\right)^3}\right]$$

where, M = Multiplier Setpoint
I = Input Current
I_P = Pickup Current Setpoint
A, B, C, D, E = Curve Constants
A = 0.0399
B = 0.2294
C = 0.5000
D = 3.0094
E = 0.7222
K = Voltage Restrained Multiplier <optional>

VOLTAGE RESTRAINED MULTIPLIER

$$K = \frac{Phase - Phase\_Voltage}{Rated\_Phase - Phase\_Voltage}$$ ****Range: 0.1 - 0.9**

3. Inject current and apply voltage as per the table below. Verify the alarm/trip elements and view the Event Records in:
   ACTUAL VALUES A5:\EVENT RECORD

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Table 7-22 VOLTAGE RESTRAINED OVERCURRENT TEST

CURRENT (A) VOLTAGE (V) (5A UNIT)	Expected Alarm (R5)	Observed Alarm (R5)	Alarm Delay (sec)	Expected Trip (R1)	Observed Trip (R1)	Expected Trip Delay	Trip Delay (sec)
Ian =5A ∠ 0° Ibn =5A ∠ 120°lag Icn =5A ∠ 240°lag Vab=120 ∠ 0°lag Vbc=120 ∠ 120°lag Vca=120 ∠ 240°lag	✘		N/A	✘		N/A	N/A
Ian =6A ∠ 0° Ibn =6A ∠ 120°lag Icn =6A ∠ 240°lag Vab=120 ∠ 0° Vbc=120 ∠ 120°lag Vca=120 ∠ 240°lag	✔			✘		N/A	N/A
Ian=10A ∠ 0° Ibn=10A ∠ 120°lag Icn=10A ∠ 240°lag Vab=120 ∠ 0° Vbc=120 ∠ 120°lag Vca=120 ∠ 240°lag	✔			✔		11.8 sec	
Ian=10A ∠ 0° Ibn=10A ∠ 120°lag Icn=10A ∠ 240°lag Vab=100 ∠ 0° Vbc=100 ∠ 120°lag Vca=100 ∠ 240°lag	✔			✔		6.6 sec	
Ian =10A ∠ 0° Ibn=10A ∠ 120°lag Icn=10A ∠ 240°lag Vab=60 ∠ 0° Vbc=60 ∠ 120°lag Vca=60 ∠ 240°lag	✔			✔		1.7 sec	

✔ Activated
✘ Not Activated

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This document provides all the necessary information to install and/or upgrade a previous installation of the 489PC Program, upgrade the relay firmware and write/edit setpoint files.

The 489 PC Program is *not* compatible with Mods and could cause errors if setpoints are edited. It can however be used to upgrade older versions of relay firmware. When doing this however all previously programmed setpoints will be erased and should be saved to a file for reprogramming with the new Firmware.

The following sections are included in this document:

- System requirements
- 489PC program version for previous installation check
- 489PC program installation/upgrade procedure
- 489PC program system configuration
- Relay firmware upgrade procedure
- Creating/Editing/Upgrading/Downloading Setpoint Files
- Printing Setpoints and Actual Values
- Using Trending and Waveform Capture
- Troubleshooting

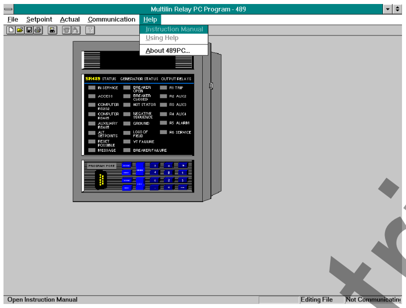
8.1 INSTALLATION / UPGRADE

The following minimum requirements must be met for the 489PC Program to properly operate on a computer.

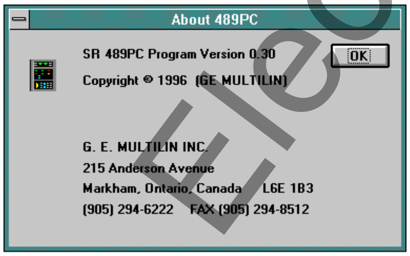
Processor:	minimum 486, Pentium recommended
Memory:	minimum 4 Mb, 16 Mb recommended minimum 540 K of conventional memory
Hard Drive:	20 Mb free space required before installation of PC program.
O/S:	Windows 3.1, Windows 3.11 for Workgroup, Windows NT, or Windows 95

Windows 3.1 Users must ensure that **SHARE.EXE** is installed.

How to check if a currently installed version of 489PC program needs upgrading:



1. Run 489PC program
2. Select **Help**
3. Select **About 489PC**



SR 489PC Program Version 0.30

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G. E. MULTILIN INC.
215 Anderson Avenue
Markham, Ontario, Canada L6E 1B3
(905) 294-6222 FAX (905) 294-8512

4. Compare version number located here with one on installation disks.
5. If number here is lower, program needs upgrading.

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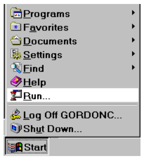
Installation/Upgrading the 489PC program:

START WINDOWS™

1. Start Windows.

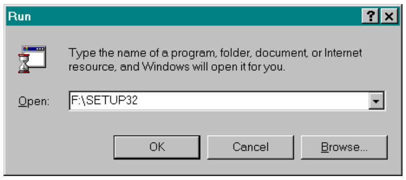
INSERT PRODUCT CD INTO
CD-ROM DRIVE

2. Under Windows 95, the CD should launch automatically when inserted. If not, or if you are running Windows 3.x, continue with step 3. Otherwise, skip to step 6.



3. From **Program Manager** (Win 3.x) or **Start Menu** (Win 95), select **Run**.

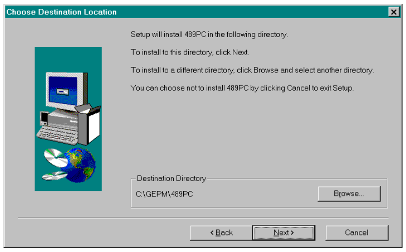
4. Type in the CD-ROM drive letter (usually D or E) and the filename as shown, e.g. *D:\index.htm*.



Type the name of a program, folder, document, or Internet resource, and Windows will open it for you.

Open: F:\SETUP32

5. Select **OK** to begin installation. The file will be opened by your default web browser.
6. The Products CD contains a "snapshot" of the GE Power Management website. Alternately, this installation can be performed from the GE Power Management website at www.ge.com/indsys/pm.
7. Click the **Products** item and select the 489 entry. The 489 Generator Management Relay page is displayed.
8. Select **Software** from the menu list and follow the instructions to begin the 489PC Setup program.



Setup will install 489PC in the following directory.

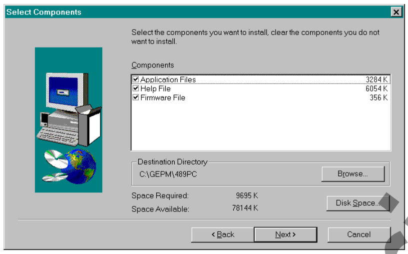
To install to this directory, click Next.

To install to a different directory, click Browse and select another directory.

You can choose not to install 489PC by clicking Cancel to exit Setup.

Destination Directory: C:\GEPM\489PC

9. After a few seconds of initializing the Setup program, a Welcome screen will appear. Click on the "**Next >**" button. If the program is not to be located in the default directory (C:\GEPM\489PC), click on the **Browse** button to locate the path where you wish to install the program.
10. If the program already exists and is to be upgraded, choose the path of the current installation if not the same as the default path. Select "**Next >**" to continue to the next step.
11. Choose your installation preference, Typical, Compact, or Custom. If you choose Custom, the following screen will appear:



Select the components you want to install, clear the components you do not want to install.

Components

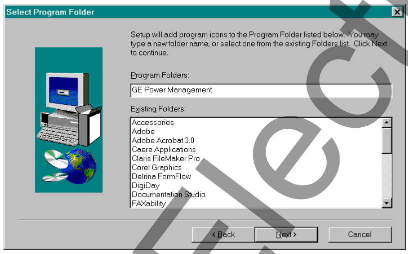
- ☑ Application Files 3284 K
- ☑ Help File 6054 K
- ☑ Firmware File 356 K

Destination Directory: C:\GEPM\489PC

Space Required: 9695 K

Space Available: 78144 K

12. Select the option(s) you wish to install, then click "**Next >**" to continue.



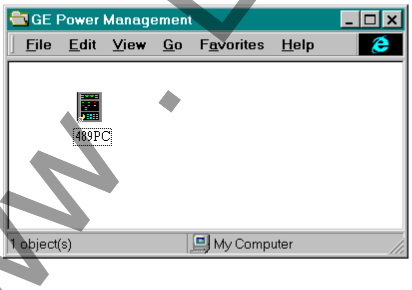
Setup will add program icons to the Program Folder listed below. You may type a new folder name, or select one from the existing Folders list. Click Next to continue.

Program Folders: GE Power Management

Existing Folders:

Accessories
Adobe
Adobe Acrobat 3.0
Caere Applications
Claris FileMaker Pro
Corel Graphics
Delrina FormFlow
DigiDay
Documentation Studio
FAXability

13. Choose the name of the program group where 489PC is to be installed. By default this is set to "GE Power Management". Select "**Next >**". When installation is complete a group will be created in the **Program Manager** or **Explorer** if not already present containing the 489PC icon.



14. **GE Power Management** group located in **Program Manager/Explorer** containing all PC program icons.

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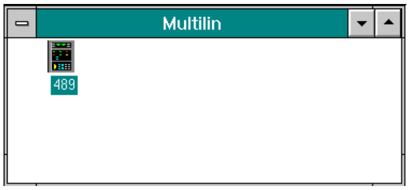
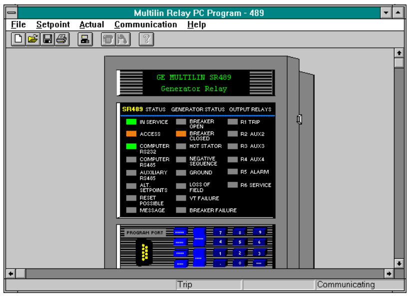
8.2 CONFIGURATION

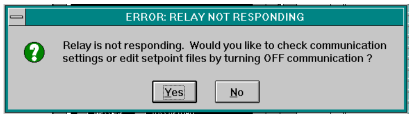
Connect the computer running the 489PC program to the relay via one of the RS485 ports (see manual section 2.2.12) or directly via the RS232 front port.



1. Double click on the 489 icon inside the GE Power Management group.

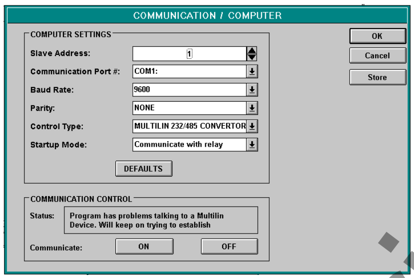


2. Once the 489PC program starts to operate it will attempt to communicate with the relay. If communications are established the relay shown on the display will display the same information as displayed by the actual relay.
3. LED status and display message shown will match actual relays if communications established.



Relay is not responding. Would you like to check communication settings or edit setpoint files by turning OFF communication ?

4. If the 489PC program cannot establish communications with the relay this message will appear.
5. Select **Yes** to edit the communication settings for the 489PC program.



Slave Address: 1
Communication Port #: COM1:
Baud Rate: 9600
Parity: NONE
Control Type: MULTILIN 232/485 CONVERTOR
Startup Mode: Communicate with relay

Status: Program has problems talking to a Multilin Device. Will keep on trying to establish
Communicate:

6. Set **Slave Address** to match that programmed into relay.
7. Set **Communication Port#** to the computer port connected to the relay.
8. Set **Baud Rate** and **Parity** to match that programmed into relay.
9. Set **Control Type** to type used.

10. Select **ON** to enable communications with new settings.

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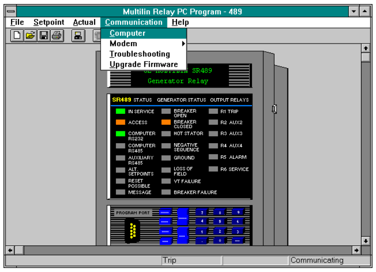
8.3 UPGRADING RELAY FIRMWARE

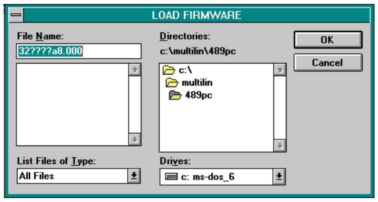
1. To upgrade relay firmware connect a computer to the 489 ***via the front RS232 port***. Then run the 489PC program and establish communications with the relay. Next follow the steps listed below.



2. Select **Upgrade Firmware** from the **Communication** menu.

!!! WARNING !!! Relay firmware will be ERASED and reprogrammed. Are you sure you want to do this?

3. Select **Yes** to proceed or **No** to abort.
4. Remember all previously programmed setpoints will be erased.



File Name: 32????a8.000

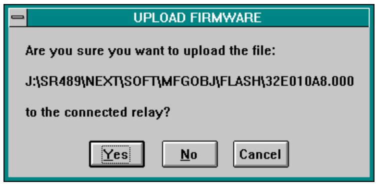
Directories: c:\multilin\489pc

c:\
multilin
489pc

List Files of Type: All Files

Drives: c: ms-dos_6

5. Locate the firmware file to load into the relay.
6. Select **OK** to proceed or **Cancel** to abort.

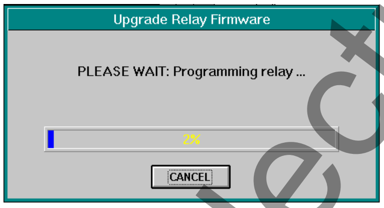


Are you sure you want to upload the file:

J:\SR489\NEXT\SOFT\MFGOBJ\FLASH\32E010A8.000

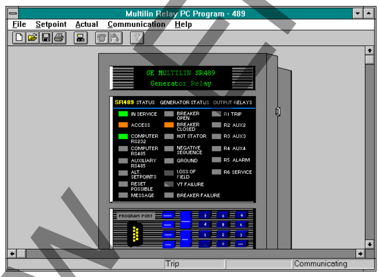
to the connected relay?

7. Select **Yes** to proceed, **No** to load a different file or **Cancel** to abort the process.



PLEASE WAIT: Programming relay ...

8. The program will automatically put the relay into upload mode and then begin loading the file selected.



9. When loading is complete the relay will not be in service and will require programming.
10. To communicate with the relay via the RS485 ports, Slave Address, Baud Rate and Parity may have to be manually programmed.

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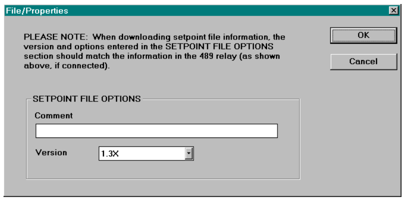
8.4 CREATING A NEW SETPOINT FILE

1. To create a new Setpoint file, run the 489PC Program. It is not necessary to have a 489 connected to the computer. The 489PC status bar will indicate that the program is in “Editing File” mode and “Not Communicating”

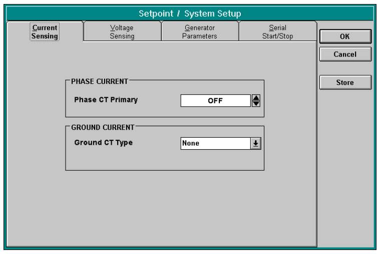


PLEASE NOTE: When downloading setpoint file information, the version and options entered in the SETPOINT FILE OPTIONS section should match the information in the 489 relay (as shown above, if connected).

Comment

Version: 1.3X

2. Select **File**, **New** from the menu, then select the current firmware version the relay is programmed and select **OK** from the **File/Properties** pop-up screen. This action will put the program in editing mode (Not Communicating) and store factory default setpoint values into computer scratchpad memory (note this action does store the information as a file on a disk).

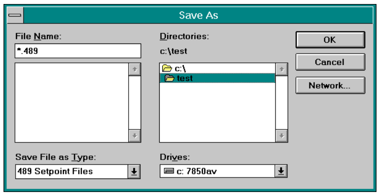


Phase CT Primary: OFF

Ground CT Type: None

3. Select **Setpoints** from the menu and choose the appropriate section of setpoints to program, e.g. **System Setup** and enter the new setpoints. When you are finished programming a page, select **OK** and store the information to the computer’s scratchpad memory (note this action does store the information as a file on a disk)

4. Repeat step 3. until all the desired setpoints are programmed.



File Name: *.489

Directories: c:\test

Save File as Type: 489 Setpoint Files

Drives: c: 7850av

5. Select **File**, **Save** to store this file to disk. Enter the location and file name of the setpoint file with a file extension of ‘**.489**’ and select **OK.**

- The file is now saved to disk. See section 8.6 for downloading this setpoint file to the 489 relay.

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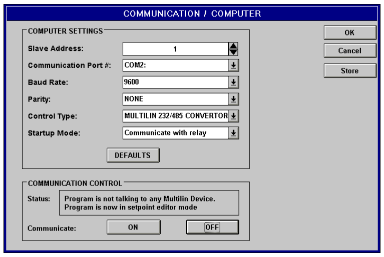
8.5 EDITING A SETPOINT FILE

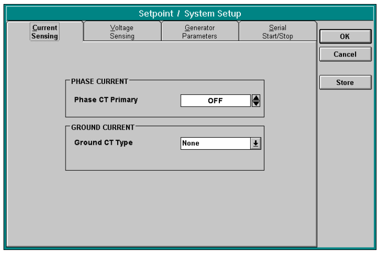
1. To edit an existing Setpoint file, run the 489 PC program and establish communications with the connected relay via the front panel RS232 port. The 489PC status bar should indicate "Communicating"



COMPUTER SETTINGS
Slave Address: 1
Communication Port #: COM2:
Baud Rate: 9600
Parity: NONE
Control Type: MULTILIN 232/485 CONVERTOR
Startup Mode: Communicate with relay

COMMUNICATION CONTROL
Status: Program is not talking to any Multilin Device.
Program is now in setpoint editor mode
Communicate:

2. Select **<u>C</u>ommunication**, **<u>C</u>omputer** from the menu, and select **Off** and **<u>O</u>K** to turn off computer communications with the relay and place the PC program in "Editing File" mode.

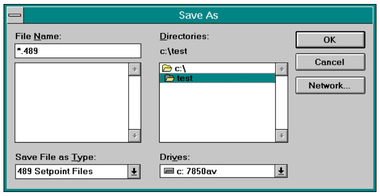


PHASE CURRENT
Phase CT Primary: OFF

GROUND CURRENT
Ground CT Type: None

3. Select **<u>S</u>etpoints** from the menu and choose the appropriate section of setpoints to program, e.g. **489 Setup** and enter any new setpoints. When you are finished programming a page, select **<u>O</u>K** and store the information to the computer's scratchpad memory (note this action does store the information as a file on a disk).

4. Repeat step 3. until all the desired setpoints are programmed.



File Name: *.489
Directories: c:\test
c:\
test
Save File as Type: 489 Setpoint Files
Drives: c: 7850av

5. Select **<u>F</u>ile**, **<u>S</u>ave** to store this file to disk. Enter the location and file name of the setpoint file with a file extension of '**.489**'

- The file is now saved to disk, see section 8.6 for downloading this setpoint file to the 489 relay.

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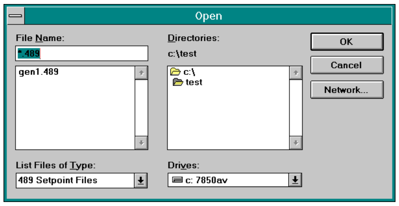
8.6 DOWNLOADING A SETPOINT FILE TO THE 489

1. To download a preprogrammed setpoint file (See Section 8.4, 8.5) to the 489 Relay, run the 489 PC program and establish communications with the connected relay via the front panel RS232 port.



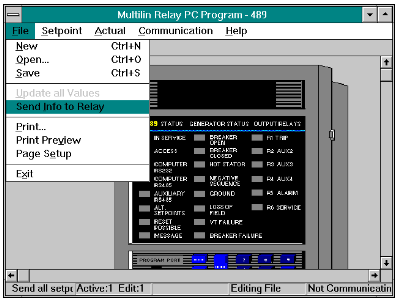
File Name: *.489

Directories: c:\test

List Files of Type: 489 Setpoint Files

Drives: c: 7850av

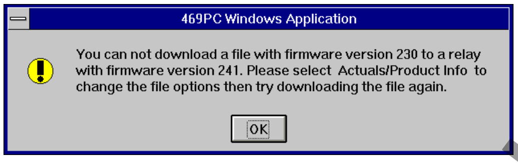
2. Select **File**, **Open** from the menu on the 489PC program.
3. Locate the setpoint file to be loaded into the relay, and select **OK**.
4. When the file is completely loaded from disk, the PC program will break communications with the connected relay and change the Status bar to say “Editing File” , “Not Communicating”.



Send all setpc Active:1 Edit:1 Editing File Not Communicatin

5. Select **File**, **Send Info To Relay**, to download the setpoint file to the connected relay.
6. When the file is completely downloaded, the status bar will revert back to “Communicating”

- The relay now contains all the setpoints as programmed in the setpoint file.



You can not download a file with firmware version 230 to a relay with firmware version 241. Please select Actuals/Product Info to change the file options then try downloading the file again.

NOTE: The following message will appear when attempting to download a setpoint file with a revision number that does not match the revision of the relay firmware. See section 8.7 for changing the revision number for the setpoint file.

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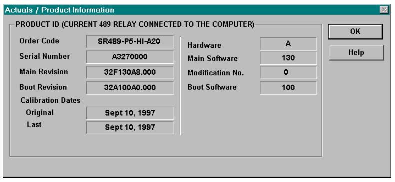
8.7 UPGRADING SETPOINT FILE TO NEW REVISION

It may be necessary to upgrade the revision code for a previously saved Setpoint file when the firmware of the 489 is upgraded.

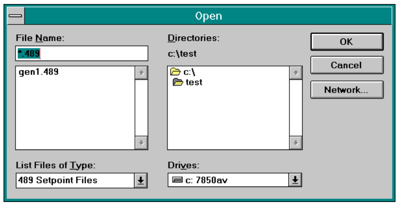
1. To upgrade the revision of a previously saved Setpoint file, run the 489 PC program and establish communications with the 489 through the front RS232 port.



PRODUCT ID (CURRENT 489 RELAY CONNECTED TO THE COMPUTER)

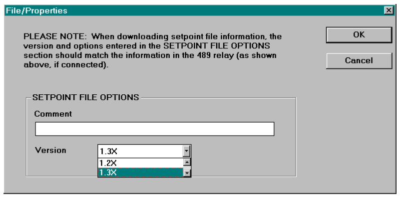
Order Code: SR489-P5-HI-A20
Serial Number: A3270000
Main Revision: 32F130A8.000
Boot Revision: 32A100A0.000
Calibration Dates
Original: Sept 10, 1997
Last: Sept 10, 1997
Hardware: A
Main Software: 130
Modification No.: 0
Boot Software: 100

2. Select **Actual** , **Product Information** from the menu and record the Main Revision number of the relay's firmware, e.g. 32E**130**A8.000, where **130** is the Main Revision identifier.



File Name: *.489
gen1.489
Directories: c:\test
c:\
test
List Files of Type: 489 Setpoint Files
Drives: c: 7850av

3. Select **File**, **Open** from the menu and enter the location and file name of the saved Setpoint File to be downloaded to the connected relay. When the file is open, the 489PC program will be in "File Editing" mode and "Not Communicating".



PLEASE NOTE: When downloading setpoint file information, the version and options entered in the SETPOINT FILE OPTIONS section should match the information in the 489 relay (as shown above, if connected).

SETPOINT FILE OPTIONS
Comment:
Version: 1.3X
1.2X
1.3X

4. Select **File**, **Properties** from the menu and note the version code of the setpoint file. If the Main Revision code of the Setpoint File (e.g. **1.2X**) is different than the Main Revision code of the Firmware (as noted in step 2, as **130**), use the pull-down tab to expose the available revision codes and select the one which matches the Firmware
e.g. Firmware revision: 32E**130**A8.000
current setpoint file revision: **1.2X**
change Setpoint file revision to **1.3X**

5. Select **File**, **Save** to save the Setpoint file to Disk.

6. See Section 8.6 for downloading this setpoint file to the connected 489.

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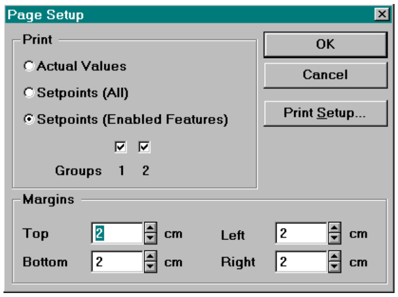
8.8 PRINTING

1. To print the Relay **Setpoints**, run the 489PC program, it is not necessary to establish communications with a connected 489.

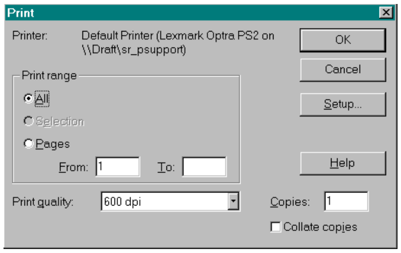

Page Setup

Print
○ Actual Values
○ Setpoints (All)
● Setpoints (Enabled Features)
☑ ☑
Groups 1 2

Margins
Top 2 cm Left 2 cm
Bottom 2 cm Right 2 cm

2. Select **File**, **Open** to open a previously saved Setpoint File\
   or
   Establish communications with a 489 connected to the computer to print the current Setpoint.

3. Select **File**, **Page Setup** and highlight the **Setpoints (All) or Setpoints (Enabled)** bubble and appropriate **Group**. Select OK.


Print

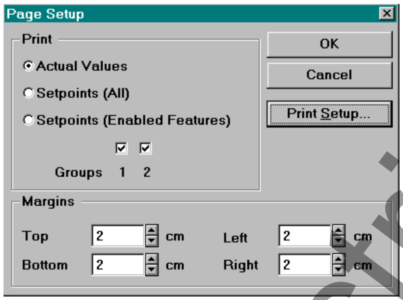
Printer: Default Printer (Lexmark Optra PS2 on \\Draft\sr_psupport)

Print range
● All
○ Selection
○ Pages
From: 1 To:

Print quality: 600 dpi
Copies: 1
☐ Collate copies

4. Select **File**, **Print** and OK to send the Setpoint file to the connected printer.

1. To print the Relay **Actual Values**, run the 489PC program and establish communications with a connected 489.


Page Setup

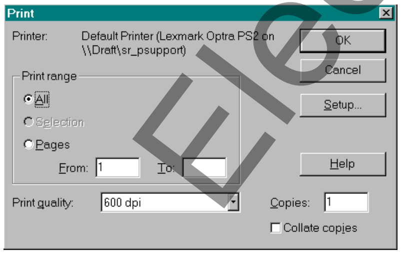
Print
● Actual Values
○ Setpoints (All)
○ Setpoints (Enabled Features)
☑ ☑
Groups 1 2

Margins
Top 2 cm Left 2 cm
Bottom 2 cm Right 2 cm

2. Select **File**, **Page Setup** and highlight the **Actual Values** bubble.

3. Under **Print Setup**, ensure that your specific printer is setup to **Print True Types as Graphics.**

4. Select **OK** to close this window.


Print

Printer: Default Printer (Lexmark Optra PS2 on \\Draft\sr_psupport)

Print range
● All
○ Selection
○ Pages
From: 1 To:

Print quality: 600 dpi
Copies: 1
☐ Collate copies

5. Select **File**, **Print** and **OK** to send the Setpoint file to the connected printer.

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8.9 TRENDING

Trending from the 489 can be accomplished via the 489PC program. Many different parameters can be trended and graphed at sampling periods ranging from 1 second up to 1 hour.

The parameters which can be **Trended** by the 489PC program are:

Currents/Voltages

Phase Currents A,B&C
Ground Current
Voltages Vab, Vbc, Vca Van, Vbn, Vcn
Neutral Volt (3rd)
Neutral Currents A,B&C
Differential Currents A,B & C
Volt/Hz
Terminal Volt (3rd)
Generator Load
System Frequency
Neutral Volt (fund)
Neg Seq Current

Power

Power Factor
Positive Watthours
Real Power (MW)
Positive Varhours
Reactive Power (Mvar)
Negative Varhours
Apparent Power (MVA)

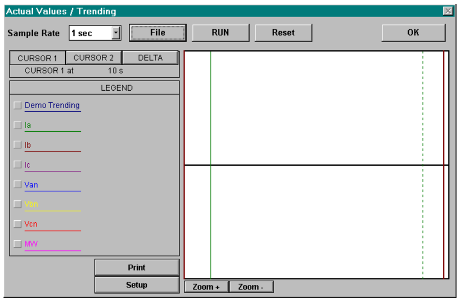
Temperature

Hottest Stator RTD
Thermal Capacity Used
RTD's 1 through 12

Others

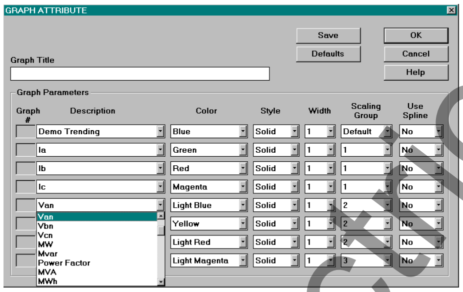
Analog Inputs 1,2 3 & 4
Tachometer

1. To use the Trending function, run the **489PC** program and establish communications with a connected 489 relay.



Sample Rate: 1 sec
CURSOR 1 at 10 s

2. Select **Actual** , **Trending** from the main menu to open the **Trending** window.



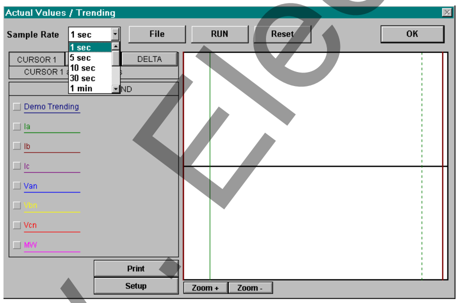
Graph #	Description	Color	Style	Width	Scaling Group	Use Spline
	Demo Trending	Blue	Solid	1	Default	No
	Ia	Green	Solid	1	1	No
	Ib	Red	Solid	1	1	No
	Ic	Magenta	Solid	1	1	No
	Van	Light Blue	Solid	1	2	No
		Yellow	Solid	1	2	No
		Light Red	Solid	1	2	No
		Light Magenta	Solid	1	3	No

3. Press the **Setup** button to enter the **Graph Attribute** page.

4. Program the **Graphs** which are to be displayed by selecting the pull down menu beside each **Graph Description**. Change the **Color, Style, Width, Group #**, and **Spline** selection as desired.

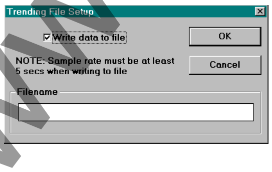
5. Select the same Group # for all parameters to be scaled together.

6. Select Save to store these **Graph Attributes**, and **OK** to close this window.



7. Use the pulldown menu to select the **Sample Rate**, click the checkboxes of the **Graphs** to be displayed, and select **RUN** to begin the trending sampling.

8. **Print** will copy the window to the system printer. More information for navigating through Trending can be found under **Help**.



☑ Write data to file

NOTE: Sample rate must be at least 5 secs when writing to file

9. The **File** button can be used to write the graph data to a file in a standard spreadsheet format. Ensure that the **Write Data to File** box is checked, and that the **Sample Rate** is at a minimum of **5 seconds**.

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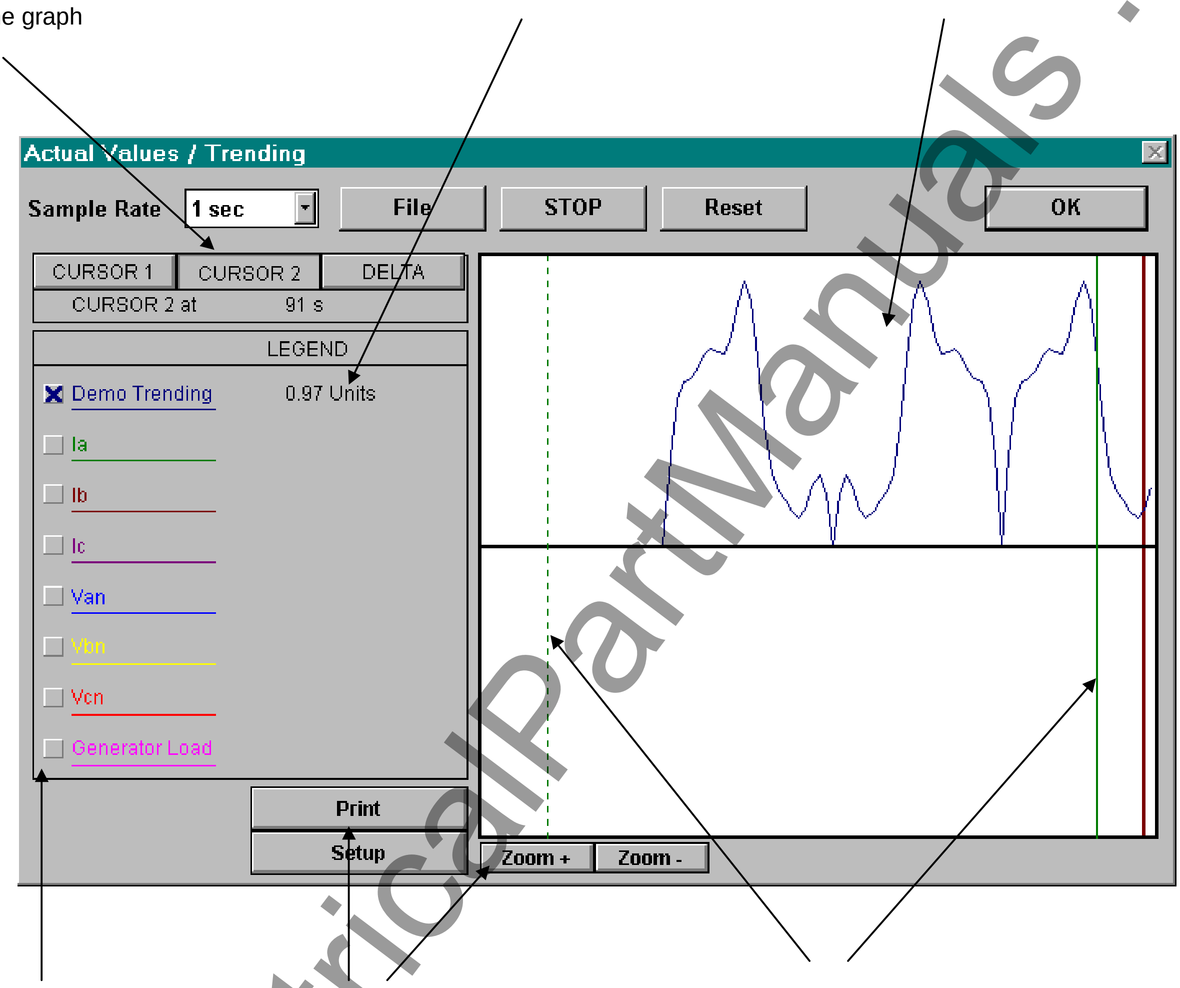
Mode Select
Click on These buttons to view
Cursor Line1, Cursor Line2, or Delta (difference)
values for the graph

Level
Displays the value of the Graph
at the active Cursor Line

Waveform
The trended data
from 489



Actual Values / Trending

Sample Rate 1 sec

CURSOR 2 at 91 s

LEGEND

☒ Demo Trending 0.97 Units

☐ Ia

☐ Ib

☐ Ic

☐ Van

☐ Vbn

☐ Vcn

☐ Generator Load

Check Box
Toggle the Check Box to
view the desired graphs.

Buttons
Print, Setup (to edit Graph Attributes)
Zoom In, Zoom Out

Cursor Lines
Move Lines: Move mouse pointer
over the cursor line. Hold the left
mouse button and drag the
Cursor Line to the new location

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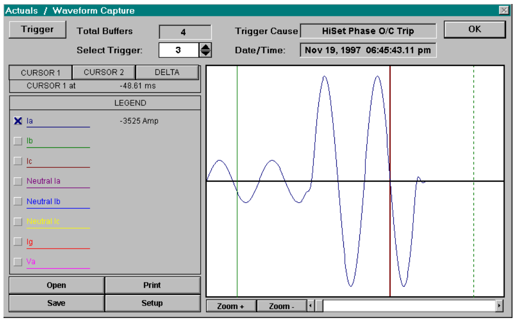
8.10 WAVEFORM CAPTURE

The 489PC program can be used to capture waveforms from the 489 at the instant of a trip. Maximum of 64 cycles can be captured and the trigger point can be adjusted to anywhere within the set cycles. Maximum of 16 waveforms can be buffered (stored) with the buffer/cycle trade off.

The waveforms captured are:
Phase Currents A, B & C
Neutral Currents A, B & C
Ground Current
Phase Voltages A-N, B-N & C-N

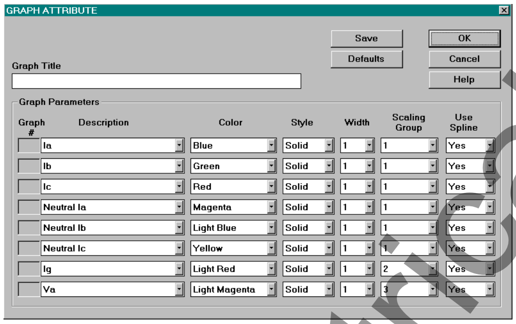
1. To use the **Waveform Capture** function, run the 489PC program and establish communications with a connected 489 Relay.



Total Buffers: 4
Select Trigger: 3
Trigger Cause: HiSet Phase O/C Trip
Date/Time: Nov 19, 1997 06:45:43.11 pm
CURSOR 1 at -48.61 ms
Ia -3525 Amp

2. Select **Actual** , **Waveform Capture** from the main menu to open the **Waveform Capture** Window.

   What will appear is the waveform of Phase A current of the last trip of the 489. The date and time of this trip is displayed on the top of the window. The RED vertical line indicates the trigger point of the relay.



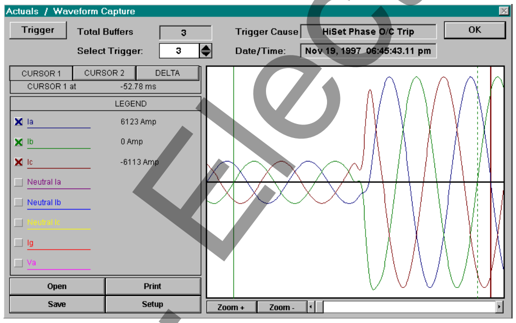
Graph #	Description	Color	Style	Width	Scaling Group	Use Spline
☐	Ia	Blue	Solid	1	1	Yes
☐	Ib	Green	Solid	1	1	Yes
☐	Ic	Red	Solid	1	1	Yes
☐	Neutral Ia	Magenta	Solid	1	1	Yes
☐	Neutral Ib	Light Blue	Solid	1	1	Yes
☐	Neutral Ic	Yellow	Solid	1	1	Yes
☐	Ig	Light Red	Solid	1	2	Yes
☐	Va	Light Magenta	Solid	1	3	Yes

3. Press the **Setup** button to enter the **Graph Attribute** page.

4. Program the **Graphs** to be displayed by selecting the pull down menu beside each **Graph Description**. Change the **Color, Style, Width, Group #**, and **Spline** selection as desired.

   Select the same **Group #** for all parameters to be scaled together.

5. Select Save to store these **Graph Attributes**, and **OK** to close this window.



Total Buffers: 3
Select Trigger: 3
Trigger Cause: HiSet Phase O/C Trip
Date/Time: Nov 19, 1997 06:45:43.11 pm
CURSOR 1 at -52.78 ms
Ia 6123 Amp
Ib 0 Amp
Ic -6113 Amp

6. Click the checkboxes of the **Graphs** to be displayed,

7. The **Save** button can be used to store the current image on the screen, and **Open** can be used to recall a saved image. **Print** will copy the window to the system printer. More information for navigating through Waveform Capture can be found under **Help**.

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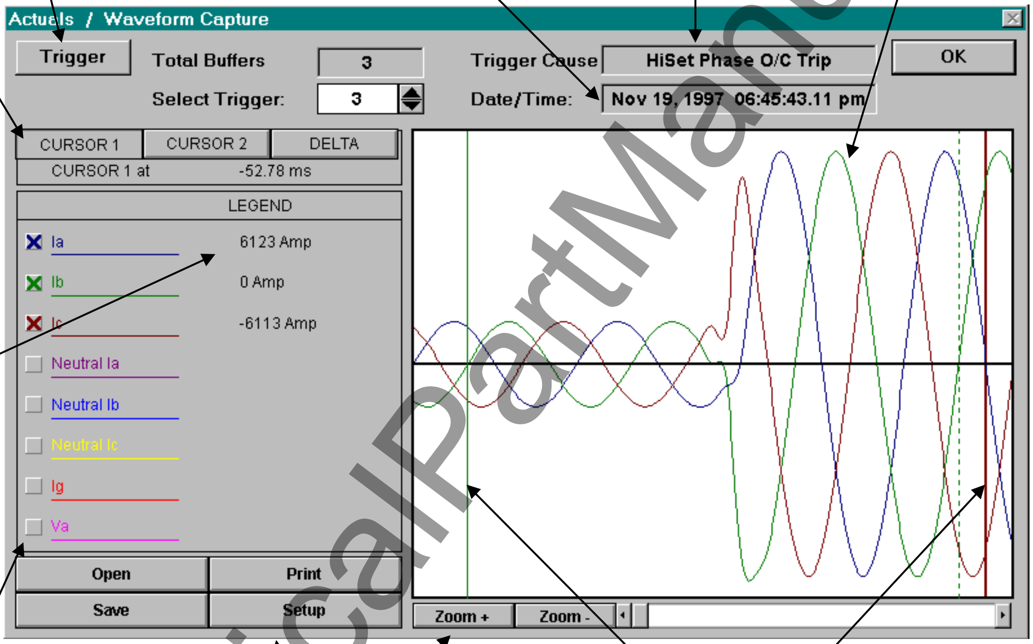
Mode Select
Click on These buttons to view Cursor Line1, Cursor Line2, or Delta (difference) values for the graph

Waveform
The waveform data from 489

Trigger
Click to manually Trigger and Capture waveforms

Date/Time
Displays the Date and Time of Trigger cause

Trigger Cause
Displays the cause of Trigger



Actuals / Waveform Capture

Trigger Total Buffers: 3
Select Trigger: 3
Trigger Cause: HiSet Phase O/C Trip
Date/Time: Nov 19, 1997 06:45:43.11 pm

CURSOR 1 at -52.78 ms

LEGEND

☒	Ia	6123 Amp
☒	Ib	0 Amp
☒	Ic	-6113 Amp
☐	Neutral Ia	
☐	Neutral Ib	
☐	Neutral Ic	
☐	Ig	
☐	Va	

Level
Displays the value of Graph at Solid Cursor Line

Check Box
Toggle the Check Box to view the desired graphs

Buttons
Print, Help
Save (to save graph to a file)
Open (to open a graph file)
Zoom In, Zoom Out

Cursor Lines
Move Lines: Move mouse pointer over the cursor line. Hold the left mouse button and drag the Cursor Line to new location

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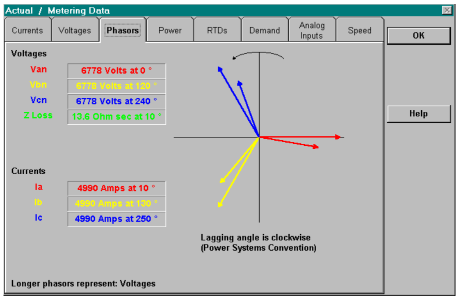
8.11 PHASORS

The 489PC program can be used to view the phasor diagram of three phase currents and voltages.

The phasors are for:
Phase Voltages A, B & C
Phase Currents A, B & C
Impedance Z_{Loss}

1. To use the **Phasor Metering** function, run the 489PC program and establish communications with a connected 489 Relay.



Voltages
Van 6778 Volts at 0 °
Vbn 6778 Volts at 120 °
Vcn 6778 Volts at 240 °
Z Loss 13.6 Ohm sec at 10 °

Currents
Ia 4990 Amps at 10 °
Ib 4990 Amps at 130 °
Ic 4990 Amps at 250 °

Lagging angle is clockwise
(Power Systems Convention)

Longer phasors represent: Voltages

2. Select **Actual** , **Metering Data** from the main menu, then click on the **Phasors** tab on the **Metering Data** Window. The phasor diagram and the values of voltage phasors, and current phasors are displayed.

   Note: Longer arrows are the voltage phasors, shorter arrows are the current phasors.
   Va and Ia are the references (i.e. zero degree phase).
   Lagging angle is clockwise.

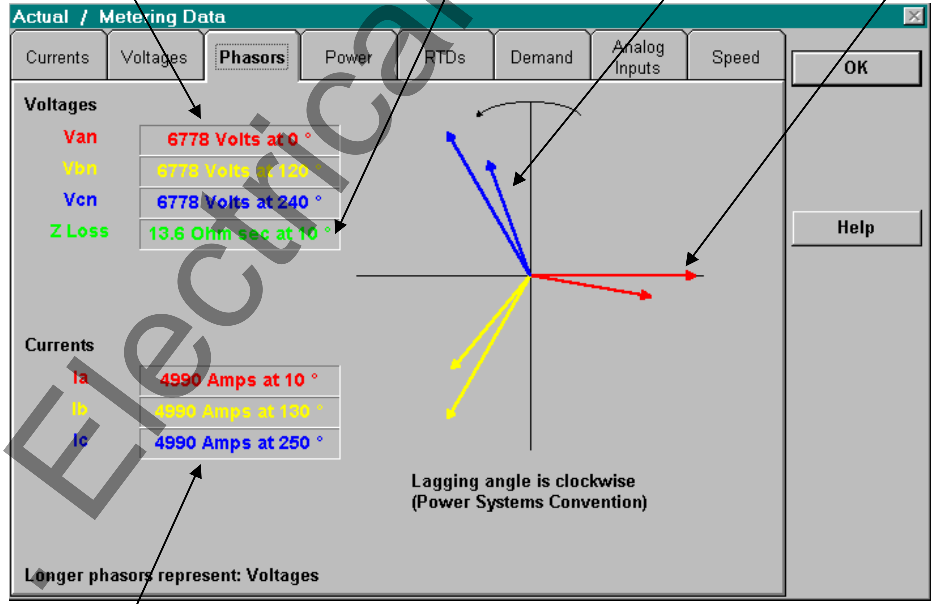
3. More information for **Phasors** can be found under **Help**.

Voltage Level
Displays the value and the angle of Voltage Phasors

Impedance
Displays the value and angle of Z=Vab/Iab.

Current Phasor
Short Arrow

Voltage Phasor
Long Arrow



Voltages
Van 6778 Volts at 0 °
Vbn 6778 Volts at 120 °
Vcn 6778 Volts at 240 °
Z Loss 13.6 Ohm sec at 10 °

Currents
Ia 4990 Amps at 10 °
Ib 4990 Amps at 130 °
Ic 4990 Amps at 250 °

Lagging angle is clockwise
(Power Systems Convention)

Longer phasors represent: Voltages

Current Level
Displays the value and the angle of Current Phasors

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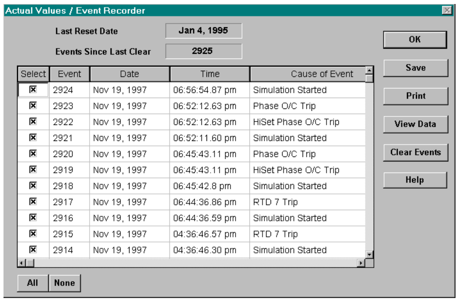
8.12 EVENT RECORDING

The 489PC program can be used to view the 489 Event Recorder. The Event Recorder stores generator and system information each time an event occurs (i.e. generator trip). The Event Recorder stores upto 40 events, but 489 keeps a running tally of total number of events occurred since last clear.

1. To use **Event Recording** function, run the 489PC program and establish communications with a connected 489 Relay.

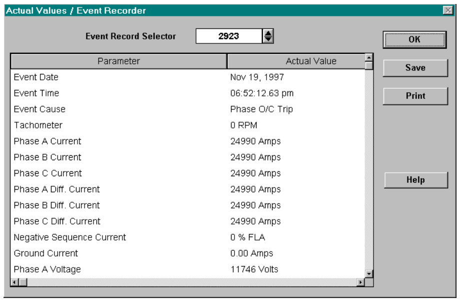


Last Reset Date: Jan 4, 1995

Events Since Last Clear: 2925

Select	Event	Date	Time	Cause of Event
☒	2924	Nov 19, 1997	06:56:54.87 pm	Simulation Started
☒	2923	Nov 19, 1997	06:52:12.63 pm	Phase O/C Trip
☒	2922	Nov 19, 1997	06:52:12.63 pm	HiSet Phase O/C Trip
☒	2921	Nov 19, 1997	06:52:11.60 pm	Simulation Started
☒	2920	Nov 19, 1997	06:45:43.11 pm	Phase O/C Trip
☒	2919	Nov 19, 1997	06:45:43.11 pm	HiSet Phase O/C Trip
☒	2918	Nov 19, 1997	06:45:42.8 pm	Simulation Started
☒	2917	Nov 19, 1997	06:44:36.86 pm	RTD 7 Trip
☒	2916	Nov 19, 1997	06:44:36.59 pm	Simulation Started
☒	2915	Nov 19, 1997	04:36:46.57 pm	RTD 7 Trip
☒	2914	Nov 19, 1997	04:36:46.30 pm	Simulation Started

2. Select **<u>A</u>ctual** , **<u>E</u>vent Recording** from the main menu to open the **Event Recording** Window. The Event Recording Window displays the list of events with the most current event displayed on top.



Event Record Selector: 2923

Parameter	Actual Value
Event Date	Nov 19, 1997
Event Time	06:52:12.63 pm
Event Cause	Phase O/C Trip
Tachometer	0 RPM
Phase A Current	24990 Amps
Phase B Current	24990 Amps
Phase C Current	24990 Amps
Phase A Diff. Current	24990 Amps
Phase B Diff. Current	24990 Amps
Phase C Diff. Current	24990 Amps
Negative Sequence Current	0 % FLA
Ground Current	0.00 Amps
Phase A Voltage	11746 Volts

3. Press the **View Data** button to view the details of selected events.

   The **Event Record Selector** at the top of the **View Data** Window allows the user to scroll through different events.

4. Select **Save** to store the details of the selected events to a file.

5. Select **Print** to send the events to the system printer, and **OK** to close the window.

6. More information for **Event Recording** can be found under **Help**.

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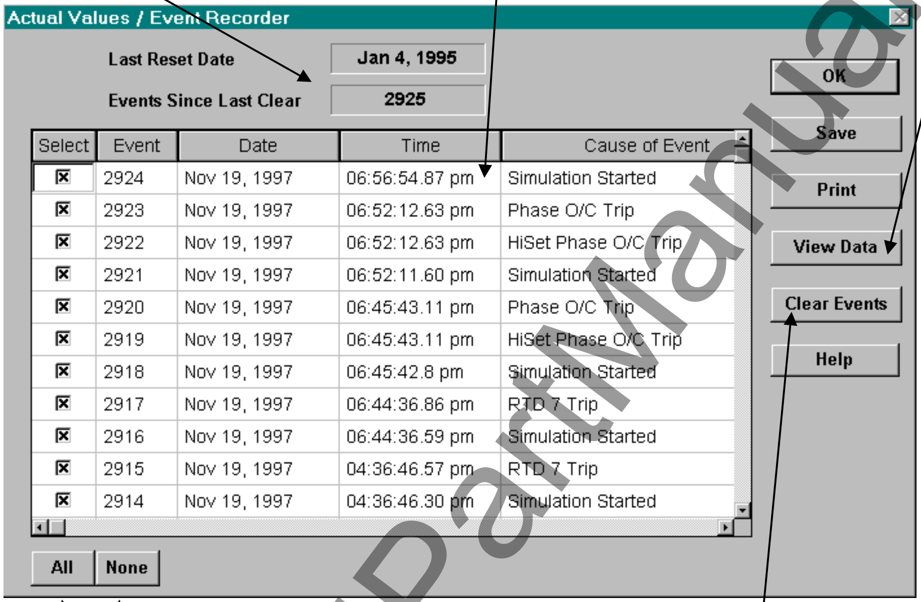
Display
Displays the date of last event and total number of events since last clear

Event Listing
List of Events with the most recent Event displayed on top

View Data
Click to display the details of selected Events



Last Reset Date: Jan 4, 1995

Events Since Last Clear: 2925

Select	Event	Date	Time	Cause of Event
☒	2924	Nov 19, 1997	06:56:54.87 pm	Simulation Started
☒	2923	Nov 19, 1997	06:52:12.63 pm	Phase O/C Trip
☒	2922	Nov 19, 1997	06:52:12.63 pm	HiSet Phase O/C Trip
☒	2921	Nov 19, 1997	06:52:11.60 pm	Simulation Started
☒	2920	Nov 19, 1997	06:45:43.11 pm	Phase O/C Trip
☒	2919	Nov 19, 1997	06:45:43.11 pm	HiSet Phase O/C Trip
☒	2918	Nov 19, 1997	06:45:42.8 pm	Simulation Started
☒	2917	Nov 19, 1997	06:44:36.86 pm	RTD 7 Trip
☒	2916	Nov 19, 1997	06:44:36.59 pm	Simulation Started
☒	2915	Nov 19, 1997	04:36:46.57 pm	RTD 7 Trip
☒	2914	Nov 19, 1997	04:36:46.30 pm	Simulation Started

Event Select Buttons
Push the All button to
Select all Events
Push the None button to
Clear all Selections

Clear Events
Push the Clear Events button to clear the Event Listing from memory

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8.13 TROUBLESHOOTING

This section provides some procedures for troubleshooting the 489PC when troubles are encountered within the Windows™ Environment, e.g. **General Protection Fault (GPF),** system lockup, popup window missing etc....

If the 489 program causes Windows™ system errors:

1. Check system resources by selecting **Help, About Program Manager** from the Program Manager menu.

   Verify that the available system resources are 60% or higher. If it is lower, close any other programs running concurrently in Windows™.

2. There exists a file in the Windows directory structure which is used by the 489PC program and possibly other Windows™ programs, **threed.vbx**. Some older versions of this file are not compatible with the 489PC program and therefore it is required to update this file with the latest version which is supplied on the Setup disks of the 489PC program shipped with every new 489 Relay. After installation of the 489PC, this file will be located in **\Program Files\gepm\489PC\threed.vbx**.

   Steps to Update the **threed.vbx** file.

   1. Locate the currently used **threed.vbx** file and make a backup of it, e.g. **threed.bak.**

      A **Find** or **Search** should be conducted to locate any threed.vbx files on the computer's hard drive. The file which will need replacing is the one located in the **\windows** or the **\windows\system** directory.

   2. Replace the original **threed.vbx** with **\Progarm Files\gepm\489pc\threed.vbx**. Ensure that the new **threed.vbx** is copied to the same directory where the original one was.

   3. If Windows™ prevents the replacing of this file, restart windows and perform the replacing of **threed.vbx** before any programs are opened.

   4. Restart Windows™ for these changes to take full effect.

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S1 SETPOINTS
489 SETUP

PASSCODE	
Passcode	

PREFERENCES	
Default Msg. Cycle Time	
Default Msg. Time-out	
Parameter Averages Calculation Period	
Temperature Display	
Waveform Trigger	

SERIAL PORTS	
Slave Address	
Comp. RS485 Baud Rate	
Comp. RS485 Parity	
Aux. RS485 Baud Rate	
Aux. RS485 Parity	

MESSAGE SCRATCHPAD
Text 1
Text 2
Text 3
Text 4
Text 5

S2 SETPOINTS
SYSTEM SETUP

CURRENT SENSING	
Phase CT Primary	
Ground CT	
Ground CT Ratio	

VOLTAGE SENSING	
VT Connection Type	
Voltage Transformer Ratio	
Neutral Voltage Transformer	
Neutral VT Ratio	

GENERATOR PARAMETERS	
Generator Rating	
Rated Power Factor	
Voltage Phase-Phase	
Nominal Frequency	
Phase Sequence	

SERIAL START/STOP	
Serial Start/Stop Initiation	
Startup Initiation Relays	
Shutdown Initiation Relays	
Serial Start/Stop Events	

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S3 SETPOINTS
DIGITAL INPUTS

BREAKER STATUS

GENERAL INPUT A
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input A Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input A Control Events
General Input A Alarm
Assign Alarm Relays
General Input A Alarm Delay
General Input A Alarm Event
General Input A Trip
Assign Trip Relays
General Input A Trip Delay

GENERAL INPUT B
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input B Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input B Control Events
General Input B Alarm
Assign Alarm Relays
General Input B Alarm Delay
General Input B Alarm Event
General Input B Trip
Assign Trip Relays
General Input B Trip Delay

GENERAL INPUT C
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input C Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input C Control Events
General Input C Alarm
Assign Alarm Relays
General Input C Alarm Delay
General Input C Alarm Event
Gnarl Input C Trip
Assign Trip Relays
General Input C Trip Delay

GENERAL INPUT D
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input D Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input D Control Events
General Input D Alarm
Assign Alarm Relays
General Input D Alarm Delay
General Input D Alarm Event
General Input D Trip
Assign Trip Relays
General Input D Trip Delay

GENERAL INPUT E
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input E Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input E Control Events
General Input E Alarm
Assign Alarm Relays
General Input E Alarm Delay
General Input E Alarm Event
Gnarl Input E Trip
Assign Trip Relays
General Input E Trip Delay

GENERAL INPUT F
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input F Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input F Control Event
General Input F Alarm
Assign Alarm Relays
General Input F Alarm Delay
General Input F Alarm Event
Gnarl Input F Trip
Assign Trip Relays
General Input F Trip Delay

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GENERAL INPUT G
Assign Digital Input
Asserted Digital Input State
Input Name
Block Input from On-line
General Input G Control
Pulsed Control Relay Dwell Time
Assign Control Relays
General Input G Control Events
General Input G Alarm
Assign Alarm Relays
General Input G Alarm Delay
General Input G Alarm Event
Gnarl Input G Trip
Assign Trip Relays
General Input G Trip Delay

REMOTE RESET
Assign Digital Input

TEST INPUT
Assign Digital Input

THERMAL RESET
Assign Digital Input

DUAL SETPOINTS
Assign Digital Input
Active Setpoint Group
Edit Setpoint Group

SEQUENTIAL TRIP
Assign Digital Input
Sequential Trip Type
Assign Trip Relays
Sequential Trip Level
Sequential Trip Delay

FIELD BREAKER DISCREPANCY
Assign Digital Input
Field Status Contact
Assign Trip Relays
Trip Delay

TACHOMETER
Assign Digital Input
Rated Speed
Alarm
Assign Alarm Relays
Alarm Speed
Alarm Delay
Alarm Events
Tachometer Trip
Assign Trip Relays
Trip Speed
Trip Delay

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S4 SETPOINTS
OUTPUT RELAYS

RESET MODE			
R1 Trip		R4 Auxiliary	
R2 Auxiliary		R5 Alarm	
R3 Auxiliary		R6 Service	

S5 SETPOINTS
CURRENT ELEMENTS SETPOINT GROUP 1

OVERCURRENT ALARM
Overcurrent Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events

INADVERTENT ENERGIZATION
Inad. Energ. Trip
Assign Trip Relays
Arming Signal
Inad. Energ. O/C Pickup
Inad. Energ. Pickup Volt.

OFF-LINE OVERCURRENT
Off-line Overcurrent Trip
Assign Trip Relays
Off-line Overcurrent Pickup
Trip Delay

PHASE OVERCURRENT
Phase O/C Trip
Assign Trip Relays
Enable Voltage Restraint
Phase O/C Pickup
Curve Shape
O/C Curve Multiplier
O/C Curve Reset

PHASE OVERCURRENT (con't)

Flexcurve Trip Time at 1.03×PU	Flexcurve Trip Time at 3.60×PU	Flexcurve Trip Time at 7.50×PU
at 1.05×PU	at 3.70×PU	at 8.00×PU
at 1.10×PU	at 3.80×PU	at 8.50×PU
at 1.20×PU	at 3.90×PU	at 9.00×PU
at 1.30×PU	at 4.00×PU	at 9.50×PU
at 1.40×PU	at 4.10×PU	at 10.00×PU
at 6.00×PU	at 4.20×PU	at 10.50×PU
at 6.50×PU	at 4.30×PU	at 11.00×PU
at 1.70×PU	at 4.40×PU	at 11.50×PU
at 1.80×PU	at 4.50×PU	at 12.00×PU
at 1.90×PU	at 4.60×PU	at 12.50×PU
at 2.00×PU	at 4.70×PU	at 13.00×PU
at 2.10×PU	at 4.80×PU	at 13.50×PU
at 2.20×PU	at 4.90×PU	at 14.00×PU
at 2.30×PU	at 5.00×PU	at 14.50×PU
at 2.40×PU	at 5.10×PU	at 15.00×PU
at 2.50×PU	at 5.20×PU	at 15.50×PU
at 2.60×PU	at 5.30×PU	at 16.00×PU
at 2.70×PU	at 5.40×PU	at 16.50×PU
at 2.80×PU	at 5.50×PU	at 17.50×PU
at 2.90×PU	at 5.60×PU	at 18.00×PU
at 3.00×PU	at 5.70×PU	at 18.50×PU
at 3.10×PU	at 5.80×PU	at 19.00×PU
at 3.20×PU	at 5.90×PU	at 19.50×PU
at 3.30×PU	at 6.00×PU	at 20.00×PU
at 3.40×PU	at 6.50×PU	
at 3.50×PU	at 7.00×PU	

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NEGATIVE SEQUENCE	
Neg. Sequence Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Neg. Sequence O/C Trip	
Assign Trip Relays	
O/C Trip Pickup	
O/C Constant K	
O/C Max. Time	
O/C Reset Rate	

PHASE DIFFERENTIAL	
Phase Diff. Trip	
Assign Trip Relays	
Diff.Trip Minimum Pickup	
Differential Trip Slope 1	
Differential Trip Slope 2	
Differential Trip Delay	

GROUND OVERCURRENT	
Ground O/C Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Ground O/C Trip	
Assign Trip Relays	
Trip Pickup	
Curve Shape	
O/C Curve Multiplier	
O/C Curve Reset	

GROUND OVERCURRENT (con't)				
Flexcurve Trip Time		Flexcurve Trip Time		Flexcurve Trip Time
at 1.03×PU		at 3.60×PU		at 7.50×PU
at 1.05×PU		at 3.70×PU		at 8.00×PU
at 1.10×PU		at 3.80×PU		at 8.50×PU
at 1.20×PU		at 3.90×PU		at 9.00×PU
at 1.30×PU		at 4.00×PU		at 9.50×PU
at 1.40×PU		at 4.10×PU		at 10.00×PU
at 6.00×PU		at 4.20×PU		at 10.50×PU
at 6.50×PU		at 4.30×PU		at 11.00×PU
at 1.70×PU		at 4.40×PU		at 11.50×PU
at 1.80×PU		at 4.50×PU		at 12.00×PU
at 1.90×PU		at 4.60×PU		at 12.50×PU
at 2.00×PU		at 4.70×PU		at 13.00×PU
at 2.10×PU		at 4.80×PU		at 13.50×PU
at 2.20×PU		at 4.90×PU		at 14.00×PU
at 2.30×PU		at 5.00×PU		at 14.50×PU
at 2.40×PU		at 5.10×PU		at 15.00×PU
at 2.50×PU		at 5.20×PU		at 15.50×PU
at 2.60×PU		at 5.30×PU		at 16.00×PU
at 2.70×PU		at 5.40×PU		at 16.50×PU
at 2.80×PU		at 5.50×PU		at 17.50×PU
at 2.90×PU		at 5.60×PU		at 18.00×PU
at 3.00×PU		at 5.70×PU		at 18.50×PU
at 3.10×PU		at 5.80×PU		at 19.00×PU
at 3.20×PU		at 5.90×PU		at 19.50×PU
at 3.30×PU		at 6.00×PU		at 20.00×PU
at 3.40×PU		at 6.50×PU		
at 3.50×PU		at 7.00×PU		

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S5 SETPOINTS
CURRENT ELEMENTS SETPOINT GROUP 2

OVERCURRENT ALARM

Overcurrent Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events

OFF-LINE OVERCURRENT

Off-line Overcurrent Trip
Assign Trip Relays
Off-line Overcurrent Pickup
Trip Delay

INADVERTENT ENERGIZATION

Inad. Energ. Trip
Assign Trip Relays
Arming Signal
Inad. Energ. O/C Pickup
Inad. Energ. Pickup Volt.

PHASE OVERCURRENT

Phase O/C Trip
Assign Trip Relays
Enable Voltage Restraint
Phase O/C Pickup
Curve Shape
O/C Curve Multiplier
O/C Curve Reset

PHASE OVERCURRENT (con't)

Flexcurve Trip Time
at 1.03×PU
at 1.05×PU
at 1.10×PU
at 1.20×PU
at 1.30×PU
at 1.40×PU
at 6.00×PU
at 6.50×PU
at 1.70×PU
at 1.80×PU
at 1.90×PU
at 2.00×PU
at 2.10×PU
at 2.20×PU
at 2.30×PU
at 2.40×PU
at 2.50×PU
at 2.60×PU
at 2.70×PU
at 2.80×PU
at 2.90×PU
at 3.00×PU
at 3.10×PU
at 3.20×PU
at 3.30×PU
at 3.40×PU
at 3.50×PU

Flexcurve Trip Time
at 3.60×PU
at 3.70×PU
at 3.80×PU
at 3.90×PU
at 4.00×PU
at 4.10×PU
at 4.20×PU
at 4.30×PU
at 4.40×PU
at 4.50×PU
at 4.60×PU
at 4.70×PU
at 4.80×PU
at 4.90×PU
at 5.00×PU
at 5.10×PU
at 5.20×PU
at 5.30×PU
at 5.40×PU
at 5.50×PU
at 5.60×PU
at 5.70×PU
at 5.80×PU
at 5.90×PU
at 6.00×PU
at 6.50×PU
at 7.00×PU

Flexcurve Trip Time
at 7.50×PU
at 8.00×PU
at 8.50×PU
at 9.00×PU
at 9.50×PU
at 10.00×PU
at 10.50×PU
at 11.00×PU
at 11.50×PU
at 12.00×PU
at 12.50×PU
at 13.00×PU
at 13.50×PU
at 14.00×PU
at 14.50×PU
at 15.00×PU
at 15.50×PU
at 16.00×PU
at 16.50×PU
at 17.50×PU
at 18.00×PU
at 18.50×PU
at 19.00×PU
at 19.50×PU
at 20.00×PU

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NEGATIVE SEQUENCE	
Neg. Sequence Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Neg. Sequence O/C Trip	
Assign Trip Relays	
O/C Trip Pickup	
O/C Constant K	
O/C Max. Time	
O/C Reset Rate	

PHASE DIFFERENTIAL	
Phase Diff. Trip	
Assign Trip Relays	
Diff.Trip Minimum Pickup	
Differential Trip Slope 1	
Differential Trip Slope 2	
Differential Trip Delay	

GROUND OVERCURRENT	
Ground O/C Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Ground O/C Trip	
Assign Trip Relays	
Trip Pickup	
Curve Shape	
O/C Curve Multiplier	
O/C Curve Reset	

GROUND OVERCURRENT (con’t)		
Flexcurve Trip Time	Flexcurve Trip Time	Flexcurve Trip Time
at 1.03×PU	at 3.60×PU	at 7.50×PU
at 1.05×PU	at 3.70×PU	at 8.00×PU
at 1.10×PU	at 3.80×PU	at 8.50×PU
at 1.20×PU	at 3.90×PU	at 9.00×PU
at 1.30×PU	at 4.00×PU	at 9.50×PU
at 1.40×PU	at 4.10×PU	at 10.00×PU
at 6.00×PU	at 4.20×PU	at 10.50×PU
at 6.50×PU	at 4.30×PU	at 11.00×PU
at 1.70×PU	at 4.40×PU	at 11.50×PU
at 1.80×PU	at 4.50×PU	at 12.00×PU
at 1.90×PU	at 4.60×PU	at 12.50×PU
at 2.00×PU	at 4.70×PU	at 13.00×PU
at 2.10×PU	at 4.80×PU	at 13.50×PU
at 2.20×PU	at 4.90×PU	at 14.00×PU
at 2.30×PU	at 5.00×PU	at 14.50×PU
at 2.40×PU	at 5.10×PU	at 15.00×PU
at 2.50×PU	at 5.20×PU	at 15.50×PU
at 2.60×PU	at 5.30×PU	at 16.00×PU
at 2.70×PU	at 5.40×PU	at 16.50×PU
at 2.80×PU	at 5.50×PU	at 17.50×PU
at 2.90×PU	at 5.60×PU	at 18.00×PU
at 3.00×PU	at 5.70×PU	at 18.50×PU
at 3.10×PU	at 5.80×PU	at 19.00×PU
at 3.20×PU	at 5.90×PU	at 19.50×PU
at 3.30×PU	at 6.00×PU	at 20.00×PU
at 3.40×PU	at 6.50×PU	
at 3.50×PU	at 7.00×PU	

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S6 SETPOINTS
VOLTAGE ELEMENTS
SETPOINT GROUP 1

UNDERVOLTAGE	
Undervoltage Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Undervoltage Trip	
Assign Trip Relays	
Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

OVERVOLTAGE	
Overvoltage Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Overvoltage Trip	
Assign Trip Relays	
O/V Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

VOLTS / HERTZ	
Volts / Hertz Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Volts / Hertz Trip	
Assign Trip Relays	
Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

PHASE REVERSAL	
Phase Reversal Trip	
Assign Trip Relays	

UNDER FREQUENCY	
Block U/F From On-line	
Underfrequency Voltage Cutoff	
Underfrequency Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Underfrequency Trip	
Assign Trip Relays	
Trip Level 1	
Trip Delay 1	
Trip Level 2	
Trip Delay 2	

OVER FREQUENCY	
Block O/F From On-line	
Overfrequency Voltage Cutoff	
Overfrequency Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Overfrequency Trip	
Assign Trip Relays	
Trip Level 1	
Trip Delay 1	
Trip Level 2	
Trip Delay 2	

NEUTRAL OVER VOLTAGE (FUND)	
Neutral Overvoltage Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Neutral Overvoltage Trip	
Assign Trip Relays	
Trip Level	
Trip Delay	

NEUTRAL UNDER VOLTAGE (3rd)	
Low Power Blocking Level	
Low Voltage Blocking Level	
Neutral Undervoltage Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Neutral Undervoltage Trip	
Assign Trip Relays	
Trip Level	
Trip Delay	

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S6 SETPOINTS
VOLTAGE ELEMENTS
SETPOINT GROUP 2

UNDERVOLTAGE	
Undervoltage Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Undervoltage Trip	
Assign Trip Relays	
Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

OVERVOLTAGE	
Overvoltage Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Overvoltage Trip	
Assign Trip Relays	
O/V Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

VOLTS / HERTZ	
Volts / Hertz Alarm	
Assign Alarm Relays	
Alarm Pickup	
Alarm Delay	
Alarm Events	
Volts / Hertz Trip	
Assign Trip Relays	
Trip Pickup	
Trip Delay	
Curve Reset Rate	
Trip Element	

PHASE REVERSAL	
Phase Reversal Trip	
Assign Trip Relays	

UNDER FREQUENCY	
Block U/F From On-line	
Underfrequency Voltage Cutoff	
Underfrequency Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Underfrequency Trip	
Assign Trip Relays	
Trip Level 1	
Trip Delay 1	
Trip Level 2	
Trip Delay 2	

OVER FREQUENCY	
Block O/F From On-line	
Overfrequency Voltage Cutoff	
Overfrequency Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Overfrequency Trip	
Assign Trip Relays	
Trip Level 1	
Trip Delay 1	
Trip Level 2	
Trip Delay 2	

NEUTRAL OVER VOLTAGE (FUND)	
Neutral Overvoltage Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Neutral Overvoltage Trip	
Assign Trip Relays	
Trip Level	
Trip Delay	

NEUTRAL UNDER VOLTAGE (3rd)	
Low Power Blocking Level	
Low Voltage Blocking Level	
Neutral Undervoltage Alarm	
Assign Alarm Relays	
Alarm Level	
Alarm Delay	
Alarm Events	
Neutral Undervoltage Trip	
Assign Trip Relays	
Trip Level	
Trip Delay	

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S7 SETPOINTS
POWER ELEMENTS SETPOINT GROUP 1

REACTIVE POWER
Block Mvar Element From On-line
Reactive Power Alarm
Assign Alarm Relays
Positive Mvar Alarm Level
Negative Mvar Alarm Level
Alarm Delay
Alarm Events
Reactive Power Trip
Assign Trip Relays
Positive Mvar Trip Level
Negative Mvar Trip Level
Trip Delay

REVERSE POWER
Block Reverse Power From On-line
Reverse Power Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events
Reverse Power Trip
Assign Trip Relays
Trip Level
Trip Delay

LOW FORWARD POWER
Block From On-line
Low Forward Power Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events
Low Forward Power Trip
Assign Trip Relays
Trip Level
Trip Delay

S7 SETPOINTS
POWER ELEMENTS SETPOINT GROUP 2

REACTIVE POWER
Block Mvar Element From On-line
Reactive Power Alarm
Assign Alarm Relays
Positive Mvar Alarm Level
Negative Mvar Alarm Level
Alarm Delay
Alarm Events
Reactive Power Trip
Assign Trip Relays
Positive Mvar Trip Level
Negative Mvar Trip Level
Trip Delay

REVERSE POWER
Block Reverse Power From On-line
Reverse Power Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events
Reverse Power Trip
Assign Trip Relays
Trip Level
Trip Delay

LOW FORWARD POWER
Block From On-line
Low Forward Power Alarm
Assign Alarm Relays
Alarm Level
Alarm Delay
Alarm Events
Low Forward Power Trip
Assign Trip Relays
Trip Level
Trip Delay

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S8 SETPOINTS
RTD TEMPERATURE SETPOINT GROUP 1

RTD TYPES			
Stator RTD Type		Ambient RTD Type	
Bearing RTD Type		Other RTD Type	

RTD	Application	Name	Alarm	Assign Alarm Relays	Alarm Temperature	Alarm Events
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

RTD	Trip	Trip Voting	Assign Trip Relays	Trip Temperature
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

OPEN RTD SENSOR	
Open RTD Sensor Alarm	
Assign Alarm Relays	
Open RTD Sensor Alarm Events	

RTD SHORT/LOW TEMPERATURE	
RTD Short/Low Temp. Alarm	
Assign Alarm Relays	
RTD Short/Low Temp. Alarm Events	

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S8 SETPOINTS
RTD TEMPERATURE SETPOINT GROUP 2

RTD TYPES			
Stator RTD Type		Ambient RTD Type	
Bearing RTD Type		Other RTD Type	

RTD	Application	Name	Alarm	Assign Alarm Relays	Alarm Temperature	Alarm Events
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						

RTD	Trip	Trip Voting	Assign Trip Relays	Trip Temperature
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

OPEN RTD SENSOR	
Open RTD Sensor Alarm	
Assign Alarm Relays	
Open RTD Sensor Alarm Events	

RTD SHORT/LOW TEMPERATURE	
RTD Short/Low Temp. Alarm	
Assign Alarm Relays	
RTD Short/Low Temp. Alarm Events	

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S9 SETPOINTS

THERMAL MODEL SETPOINT GROUP 1

THERMAL MODEL SETUP

Enable Thermal Model
Overload Pickup Level
Unbalance Bias K Factor
Cool Time Constant On-line
Cool Time Constant Off-line
Hot/Cold Safe Stall Ratio
Enable RTD Biasing
Select Curve Style
Standard Overload Curve Number
Minimum Allowable Voltage
Stall Current @ Min. Voltage
Safe Stall Time @ Min. Voltage
Accel. Intersect @ Min. Voltage
Stall Current @ 100% Voltage
Accel. Intersect @ 100% Voltage

THERMAL ELEMENTS

Thermal Model Alarm
Assign Alarm Relays
Alarm Level
Alarm Events
Thermal Model Trip
Assign Trip Relays

THERMAL MODEL SETUP (con't)

Flexcurve Trip Time
at 1.03×PU
at 1.05×PU
at 1.10×PU
at 1.20×PU
at 1.30×PU
at 1.40×PU
at 6.00×PU
at 6.50×PU
at 1.70×PU
at 1.80×PU
at 1.90×PU
at 2.00×PU
at 2.10×PU
at 2.20×PU
at 2.30×PU
at 2.40×PU
at 2.50×PU
at 2.60×PU
at 2.70×PU
at 2.80×PU
at 2.90×PU
at 3.00×PU
at 3.10×PU
at 3.20×PU
at 3.30×PU
at 3.40×PU
at 3.50×PU

Flexcurve Trip Time
at 3.60×PU
at 3.70×PU
at 3.80×PU
at 3.90×PU
at 4.00×PU
at 4.10×PU
at 4.20×PU
at 4.30×PU
at 4.40×PU
at 4.50×PU
at 4.60×PU
at 4.70×PU
at 4.80×PU
at 4.90×PU
at 5.00×PU
at 5.10×PU
at 5.20×PU
at 5.30×PU
at 5.40×PU
at 5.50×PU
at 5.60×PU
at 5.70×PU
at 5.80×PU
at 5.90×PU
at 6.00×PU
at 6.50×PU
at 7.00×PU

Flexcurve Trip Time
at 7.50×PU
at 8.00×PU
at 8.50×PU
at 9.00×PU
at 9.50×PU
at 10.00×PU
at 10.50×PU
at 11.00×PU
at 11.50×PU
at 12.00×PU
at 12.50×PU
at 13.00×PU
at 13.50×PU
at 14.00×PU
at 14.50×PU
at 15.00×PU
at 15.50×PU
at 16.00×PU
at 16.50×PU
at 17.50×PU
at 18.00×PU
at 18.50×PU
at 19.00×PU
at 19.50×PU
at 20.00×PU

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S9 SETPOINTS
THERMAL MODEL SETPOINT GROUP 2

THERMAL MODEL SETUP

Enable Thermal Model
Overload Pickup Level
Unbalance Bias K Factor
Cool Time Constant On-line
Cool Time Constant Off-line
Hot/Cold Safe Stall Ratio
Enable RTD Biasing
Select Curve Style
Standard Overload Curve Number
Minimum Allowable Voltage
Stall Current @ Min. Voltage
Safe Stall Time @ Min. Voltage
Accel. Intersect @ Min. Voltage
Stall Current @ 100% Voltage
Accel. Intersect @ 100% Voltage

THERMAL ELEMENTS

Thermal Model Alarm
Assign Alarm Relays
Alarm Level
Alarm Events
Thermal Model Trip
Assign Trip Relays

THERMAL MODEL SETUP (con't)

Flexcurve Trip Time
at 1.03×PU
at 1.05×PU
at 1.10×PU
at 1.20×PU
at 1.30×PU
at 1.40×PU
at 6.00×PU
at 6.50×PU
at 1.70×PU
at 1.80×PU
at 1.90×PU
at 2.00×PU
at 2.10×PU
at 2.20×PU
at 2.30×PU
at 2.40×PU
at 2.50×PU
at 2.60×PU
at 2.70×PU
at 2.80×PU
at 2.90×PU
at 3.00×PU
at 3.10×PU
at 3.20×PU
at 3.30×PU
at 3.40×PU
at 3.50×PU

Flexcurve Trip Time
at 3.60×PU
at 3.70×PU
at 3.80×PU
at 3.90×PU
at 4.00×PU
at 4.10×PU
at 4.20×PU
at 4.30×PU
at 4.40×PU
at 4.50×PU
at 4.60×PU
at 4.70×PU
at 4.80×PU
at 4.90×PU
at 5.00×PU
at 5.10×PU
at 5.20×PU
at 5.30×PU
at 5.40×PU
at 5.50×PU
at 5.60×PU
at 5.70×PU
at 5.80×PU
at 5.90×PU
at 6.00×PU
at 6.50×PU
at 7.00×PU

Flexcurve Trip Time
at 7.50×PU
at 8.00×PU
at 8.50×PU
at 9.00×PU
at 9.50×PU
at 10.00×PU
at 10.50×PU
at 11.00×PU
at 11.50×PU
at 12.00×PU
at 12.50×PU
at 13.00×PU
at 13.50×PU
at 14.00×PU
at 14.50×PU
at 15.00×PU
at 15.50×PU
at 16.00×PU
at 16.50×PU
at 17.50×PU
at 18.00×PU
at 18.50×PU
at 19.00×PU
at 19.50×PU
at 20.00×PU

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S10 SETPOINTS
MONITORING

TRIP COUNTER
Trip Counter Alarm
Assign Alarm Relays
Trip Count. Alarm Level
Alarm Events

BREAKER FAILURE
Breaker Failure Alarm
Assign Alarm Relays
Breaker Failure Level
Breaker Failure Delay
Alarm Events

TRIP COIL MONITOR
Trip Coil Monitor Alarm
Assign Alarm Relays
Alarm Events

VT FUSE FAILURE
VT Fuse Failure Alarm
Assign Alarm Relays
Alarm Events

DEMANDS

SETPOINT	DEMAND PERIOD	DEMAND ALARM	ASSIGN ALARM RELAYS	DEMAND LIMIT	ALARM EVENTS
CURRENT					
kW					
kvar					
kVA					

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S12 SETPOINTS
ANALOG I/O

ANALOG OUTPUTS				
Setpoint	**Analog Output 1**	**Analog Output 2**	**Analog Output 3**	**Analog Output 4**
Setup				
Minimum				
Maximum				

ANALOG INPUTS				
Setpoint	**Analog Input 1**	**Analog Input 2**	**Analog Input 3**	**Analog Input 4**
Setup				
Name				
Units				
Minimum				
Maximum				
Block From On-line				
Alarm				
Assign Alarm Relays				
Alarm Level				
Alarm Pickup				
Alarm Delay				
Alarm Events				
Trip				
Assign Trip Relays				
Trip Level				
Trip Pickup				
Trip Delay				

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STATOR GROUND FAULT PROTECTION USING THE 489

CAUTION: *This application note describes general protection concepts and provides guidelines on the use of the 489 to protect a generator stator against ground faults. Detailed connections for specific features must be obtained from the relay manual. Users are also urged to review the material contained in the 489 manual on each specific protection feature discussed here.*

The 489 Generator Management Relay® offers a number of elements to protect a generator against stator ground faults. Inputs are provided for a neutral-point voltage signal and for a zero sequence current signal; the zero sequence current input can be either into a nominal 1-ampere secondary circuit or into an input reserved for a special GE Power Management type HGF ground CT for very sensitive ground current detection, Using the HGF CT allows the measurement of ground current values as low as 0.25 ampere primary. With impedance-grounded generators, a single ground fault on the stator does not require that the unit be removed from service quickly. The grounding impedance limits the fault current to a few amperes. A second ground fault can, however, result in significant damage to the unit. Thus the importance of detecting all ground faults, even those in the bottom 5% of the stator, if possible. The fault detection methods depend on the grounding arrangement, the availability of core balance CT, and the size of the unit. With modern full-featured digital generator protection relays such as the 489, users do not incur additional costs for extra protection elements as they are all part of the same device. This application note provides general descriptions of each of the elements in the 489, suitable for stator ground protection, and discusses some special applications.

Neutral Overvoltage Element

The simplest, and one of the oldest method to detect stator ground faults, on high-impedance-grounded generators, is to sense the voltage across the stator grounding resistor/1, 2/. This is illustrated, in a simplified form in Figure 1. The voltage signal is connected to the $V_{neutral}$ input of the 489, terminals E10 and F10. The $V_{neutral}$ signal is the input signal for the **Neutral Overvoltage** protection element in the 489. This element has both an alarm and a trip function, with separately adjustable operate levels and time delays. The trip function offers a choice of timing curves, in addition to a definite time delay. The Neutral Overvoltage function responds to **fundamental frequency** voltage at the generator neutral. It provides ground fault protection for approximately 95% of the stator winding. The limiting factor is the level of voltage signal available for a fault in the bottom 5% of the stator winding. The element has a range of adjustment, for the operate levels, of 2 to 100 volts.

The operating time of this element should be coordinated with protective elements downstream, such as feeder ground fault elements, since the Neutral Overvoltage element will respond to external ground faults if the generator is directly connected to a power grid, without the use of a delta-wye transformer.

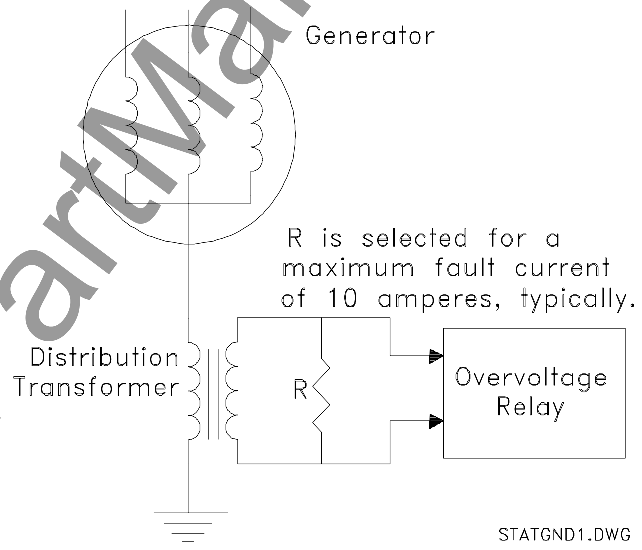

Figure 1: Stator Ground Fault Protection Using An Overvoltage Relay.

In addition, the time delay should be coordinated with the Ground Directional element (discussed later), if it is enabled, by using a longer delay on the Neutral Overvoltage element than on the directional element.

It is recommended that an isolation transformer be used between the relay and the grounding impedance to reduce common mode voltage problems, particularly on installations requiring long leads between the relay and the grounding impedance.

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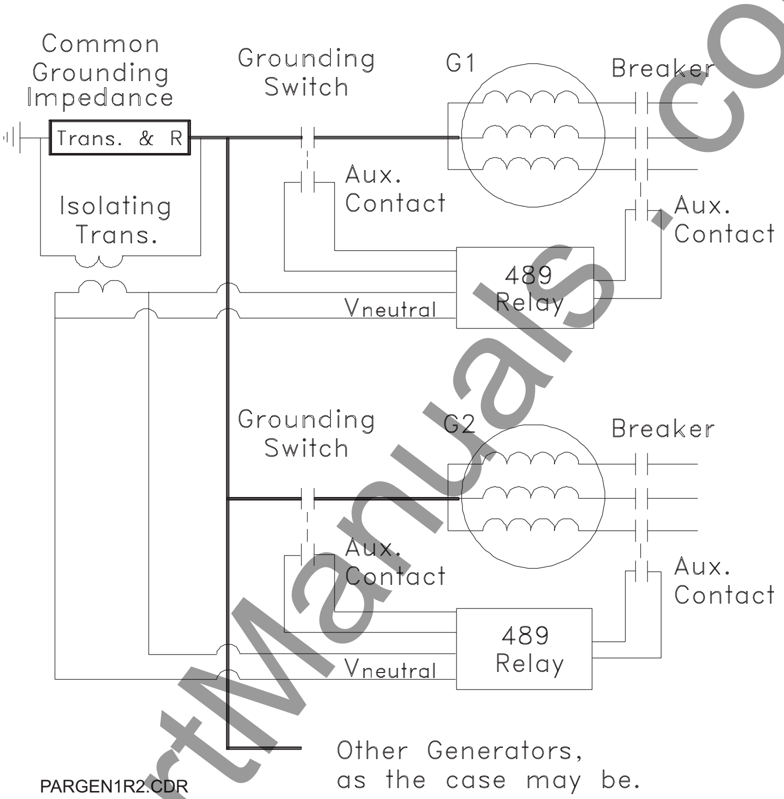
When several small generators are operated in parallel, with a single step-up transformer, all generators may be grounded through the same impedance (the impedance will normally consist of a distribution transformer and a properly sized resistor). Possibly, only one generator is grounded while the others have a floating neutral point when connected to the power grid, Figure 2. This operating mode is often adopted to prevent circulation of third-harmonic currents through the generators, if the installation is such that all the star points would end up connected together, ahead of the common grounding impedance. (If each generator has its own grounding impedance, the magnitude of the circulating third harmonic current will be quite small.) With a common ground point, the same $V_{neutral}$ signal is brought to all the relays but only the one which is grounded should have the Neutral Overvoltage element in service.

For these cases, the Neutral Overvoltage element has been provided with a supervising signal obtained from an auxiliary contact off the grounding switch. When the grounding switch is opened, the element is disabled. The grounding switch auxiliary contact is also used in the Ground Directional element, as is the breaker auxiliary contact, as discussed later.



PARGEN1R2.CDR

Figure 2: Parallel Generators With Common Grounding Impedance

If all the generators are left grounded through the same impedance, the Neutral overvoltage element in each relay will respond to a ground fault in any of the generators. For this reason, the ground directional element should be used in each relay, in addition to the Neutral Overvoltage element.

Ground Overcurrent Element

The **Ground Overcurrent element** can be used as a direct replacement or as a backup for the Neutral Overvoltage element, with the appropriate current signal from the generator neutral point, for grounded generators. This element can also be used with a core balance CT, either in the neutral end or the output end of the generator, as shown in Figure 3. The use of the special CT, with its dedicated input to the relay, offers very sensitive current detection, but still does not offer protection for the full stator. The setting of this element must be above the maximum unbalance current that normally flows in the neutral circuit. Having the element respond only to the fundamental frequency component allows an increase in sensitivity.

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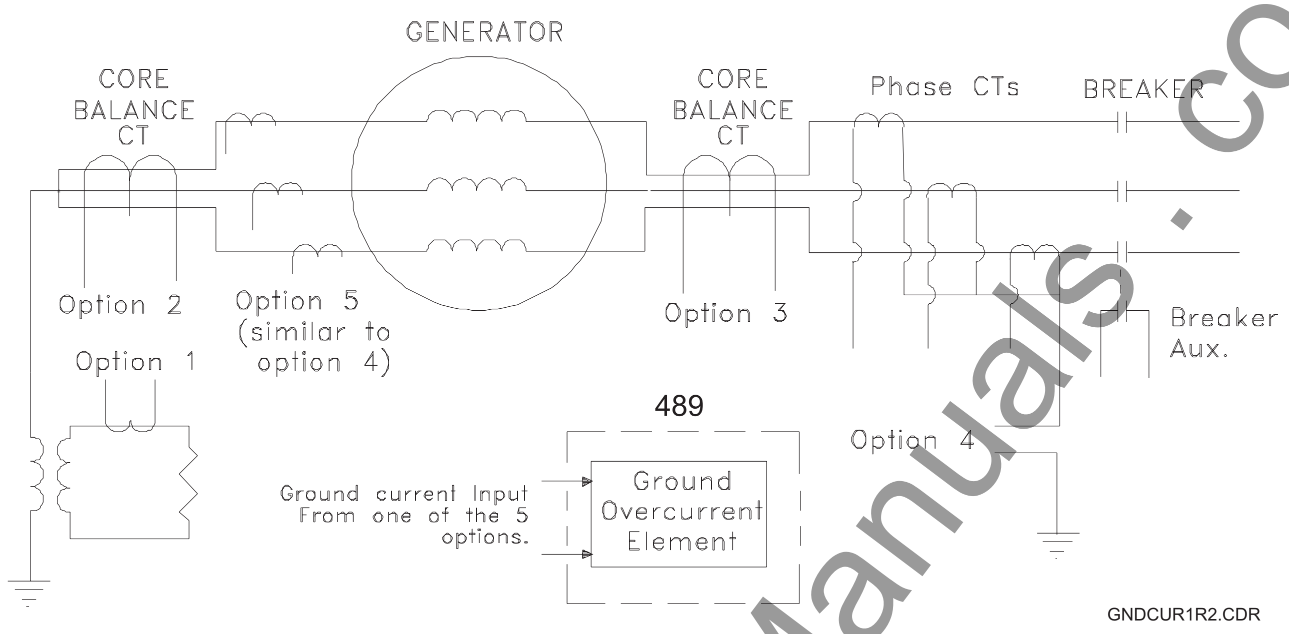

Figure 3: Ground O/C Element With Different Sources For Current Signal.

The core balance CT can be a conventional CT or a 50:0.025 ground CT, allowing the measurement of primary-side current levels down to 0.25 ampere. Using a core balance CT, on the output side of the transformer will provide protection against stator ground faults in ungrounded generators, provided that there is a source of zero sequence current from the grid.

Though in theory one could use this element with a zero sequence current signal obtained from a summation of the three phase currents (neutral end or output end), by connecting it in the star point of the phase CTs, options 4 and 5 in Figure 3, this approach is not very useful. The main drawback, for impedance-grounded generators is that the zero sequence current produced by the CT ratio and phase errors could be much larger than the zero sequence current produced by a real ground fault inside the generator.

Again the time delay on this element must be coordinated with protection elements downstream, if the generator is grounded. Refer to the relay manual/3/ for the range of settings of the pickup levels and the time delays. The time delay on this element should always be longer than the longest delay on line protection downstream.

Ground Directional Element

The 489 can detect internal stator ground faults using a **Ground Directional element** implemented using the $V_{neutral}$ and the ground current inputs. The voltage signal is obtained across the grounding impedance of the generator. The ground, or zero sequence, current is obtained from a core balance CT, as per Figure 4. (Generally, it is not possible to sum the outputs of the conventional phase CTs to derive the generator high-side zero sequence current, for an impedance-grounded generator, due to CT inaccuracies.)

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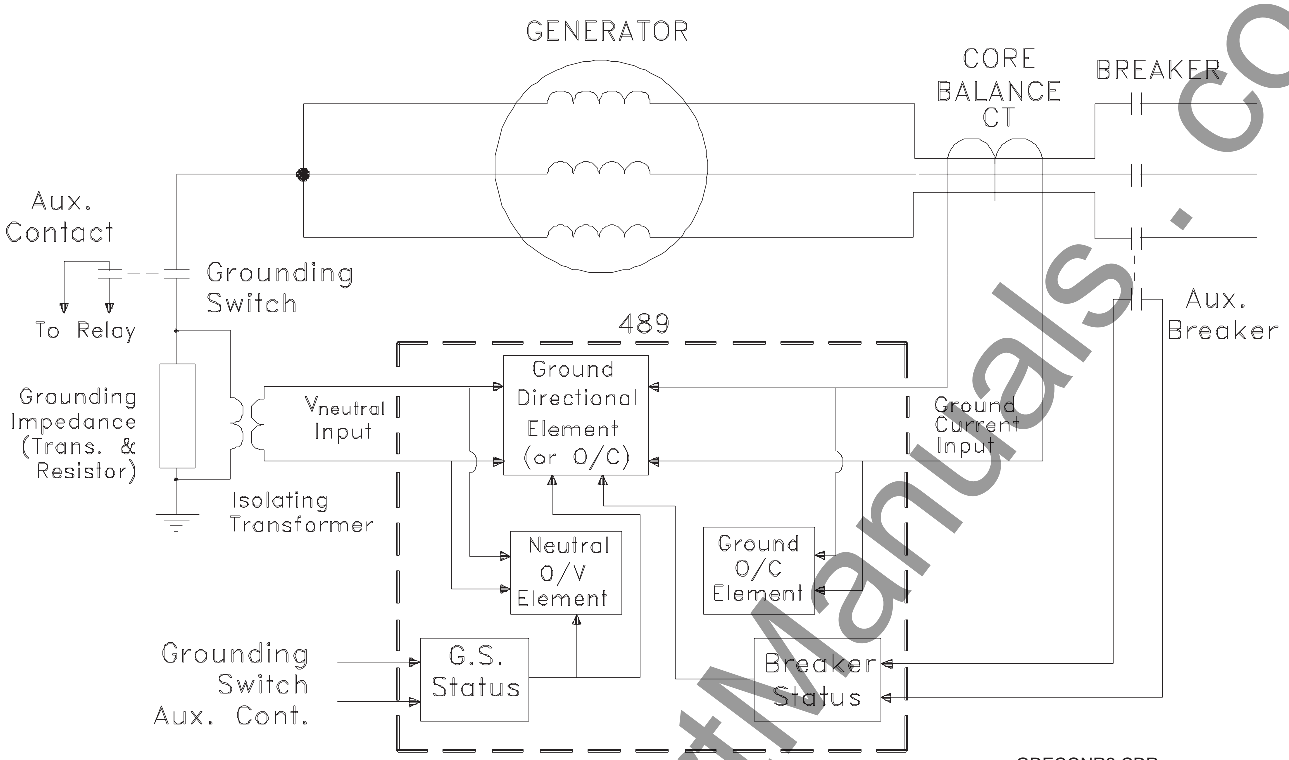

Figure 4: Conceptual Arrangement of Ground Directional Element

If correct polarities are observed in the connection of all signals to the relay, the $V_{neutral}$ signal will be in phase with the ground current signal. The element has been provided with a setting allowing the user to change the plane of operation to cater to reactive grounding impedances or to polarity inversions.

The normal "plane of operation" for this element, for a resistor-grounded generator is the 180-degree plane, as shown in Figure 5, for an internal ground fault. That is, for an internal stator-to-ground fault, the V_o signal will be 180 degrees away from the I_o signal, if the polarity convention of Figure 5 are observed. If the grounding impedance is inductive, the plane of operation will be the 270-degree plane, again, with the polarity convention of Figure 5. If the polarity convention is reversed on one input, the user will need to change the plane of operation by 180 degrees.

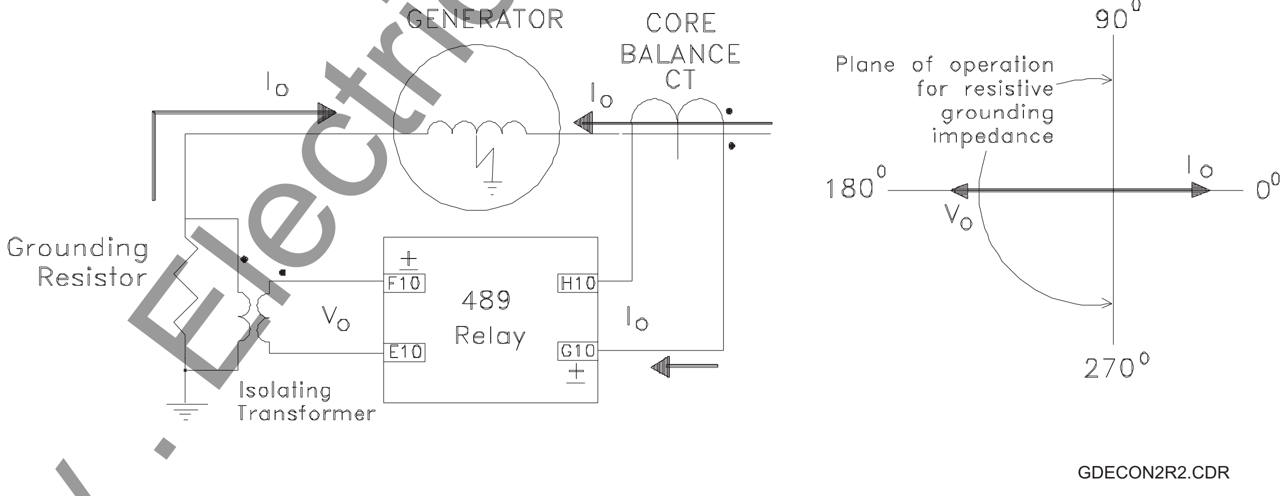

Figure 5: Polarities and Plane of Operation of Ground Directional Element

The operating principle of this element is quite simple: for internal ground faults the two signals will be 180 degrees out of phase and for external ground faults, the two signals will be in phase. This simple principle allows the element to be set with a high sensitivity, not normally possible with an overcurrent element.

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The current pickup level of the element can be adjusted down to 0.05 x CT primary, allowing an operate level of 0.25 ampere primary if the 50:0.025 ground CT is used for the core balance. The minimum level of $V_{neutral}$ at which the element will operate is determined by hardware limitations and is internally set at 2.0 volts.

Because this element is directional, it does not need to be coordinated with downstream protections and a short operating time can be used. Definite time delays are suitable for this element.

Applications with generators operated in parallel and grounded through a common impedance require special considerations. If only one generator is grounded and the other ones left floating, the directional element for the floating generators does not receive a correct $V_{neutral}$ signal and therefore cannot operate correctly. In those applications, the element makes use of auxiliary contacts off the grounding switch and the unit breaker to turn the element into a simple overcurrent element, with the pickup level set for the Directional element. (Note that the Ground Directional element and the Ground Overcurrent elements are totally separate elements.) In this mode, the element can retain a high sensitivity and fast operate time since it will only respond to internal stator ground faults. Table 1 illustrates the status of different elements under various operating conditions.

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Table 1
Status of Detection Elements As functions of Breaker and Ground Switch Positions

			Element		
Generator Condition	Unit Breaker	Grounding Switch	Ground Directional	Neutral Overvoltage	Ground Overcurrent
Shutdown	Open	Open	Out-of-service	Out-of-service	In-service
Open Circuit and grounded	Open	Closed	In-service (but will not operate due to lack of Io)	In-service	In-service
Loaded and Grounded	Closed	Closed	In-service	In-service	In-service
Loaded and Not Grounded	Closed	Open	In service as a simple overcurrent element	Out-of-service	In-service

Third-harmonic Voltage Element

The conventional neutral overvoltage element or the ground overcurrent element are not capable of reliably detecting stator ground faults in the bottom 5% of the stator, due to lack of sensitivity. In order to provide reliable coverage for the bottom part of the stator, protective elements, utilizing the third harmonic voltage signals in the neutral and at the generator output terminals, have been developed /4/.

In the 489 relay, the third-harmonic voltage element, **Neutral Undervoltage (3rd Harmonic)** derives the third harmonic component of the neutral-point voltage signal from the $V_{neutral}$ signal as one signal, called V_{N3}. The third harmonic component of the internally summed phase-voltage signals is derived as the second signal, called V_{P3}. For this element to perform as originally intended, it is necessary to use wye-connected VTs.

Since the amount of third harmonic voltage that appears in the neutral is both load and machine dependent, the protection method of choice is an adaptive method. The following formula is used to create an adaptive third-harmonic scheme:

$$\frac{V_{N3}}{\left(\frac{V_{P3}}{3}+V_{N3}\right)} \le 0.15 \quad \textit{which simplifies to :} \quad V_{P3} \ge 17 V_{N3}$$

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The 489 tests the following conditions prior to testing the basic operating equation to ensure that V_{N3} is of a measurable magnitude: where:

$$V_{P'3} > 0.25\,volts \quad \& \quad V_{P'3} \geq Permissive\_Threshold \times 17 \times \frac{Neutral\,VT\ Ratio}{Phase\,VT\ Ratio}$$

V_{N3} is the magnitude of third harmonic voltage at the generator neutral
V_{P3} is the magnitude of third harmonic voltage at the generator terminals
V_{P3}'and V_{N3}' are the corresponding voltage transformer secondary values
Permissive_Threshold is 0.15 volts for the alarm element and 0.1875 volts for the trip element.

In addition, the logic for this element verifies that the generator positive sequence terminal voltage is at least 30% of nominal, to ensure that the generator is actually excited.

NOTE: *This method of using 3rd harmonic voltages to detect stator ground faults near the generator neutral has proved feasible on larger generators with unit transformers. Its usefulness in other generator applications is unknown.*

If the phase VT connection is "open delta", it is not possible to measure the third harmonic voltage at the generator terminals and a simple third harmonic neutral undervoltage element is used. In this case, the element is supervised by both a terminal voltage level and by a power level. When used as a simple undervoltage element, settings should be based on measured 3rd harmonic neutral voltage of the healthy machine. It is recommended that the element only be used for alarm purposes with open delta VT connections.

References:

1. C. R. Mason, "The Art & Science of Protective Relaying", John Wiley & Sons, Inc., 1956, Chapter 10.

2. J. Lewis Blackburn, "Protective Relaying - Principles and Applications", Marcel Dekker, Inc, New York, 1987, chapter 8.

3. GE Power Management, "Instruction Manual for the 489 Generator Management Relay".

4. R. J. Marttila, "Design Principles of a New Generator Stator Ground Relay for 100% Coverage of the Stator Winding", IEEE Transactions on Power Delivery, Vol. PWRD-1, No. 4, October 1986.

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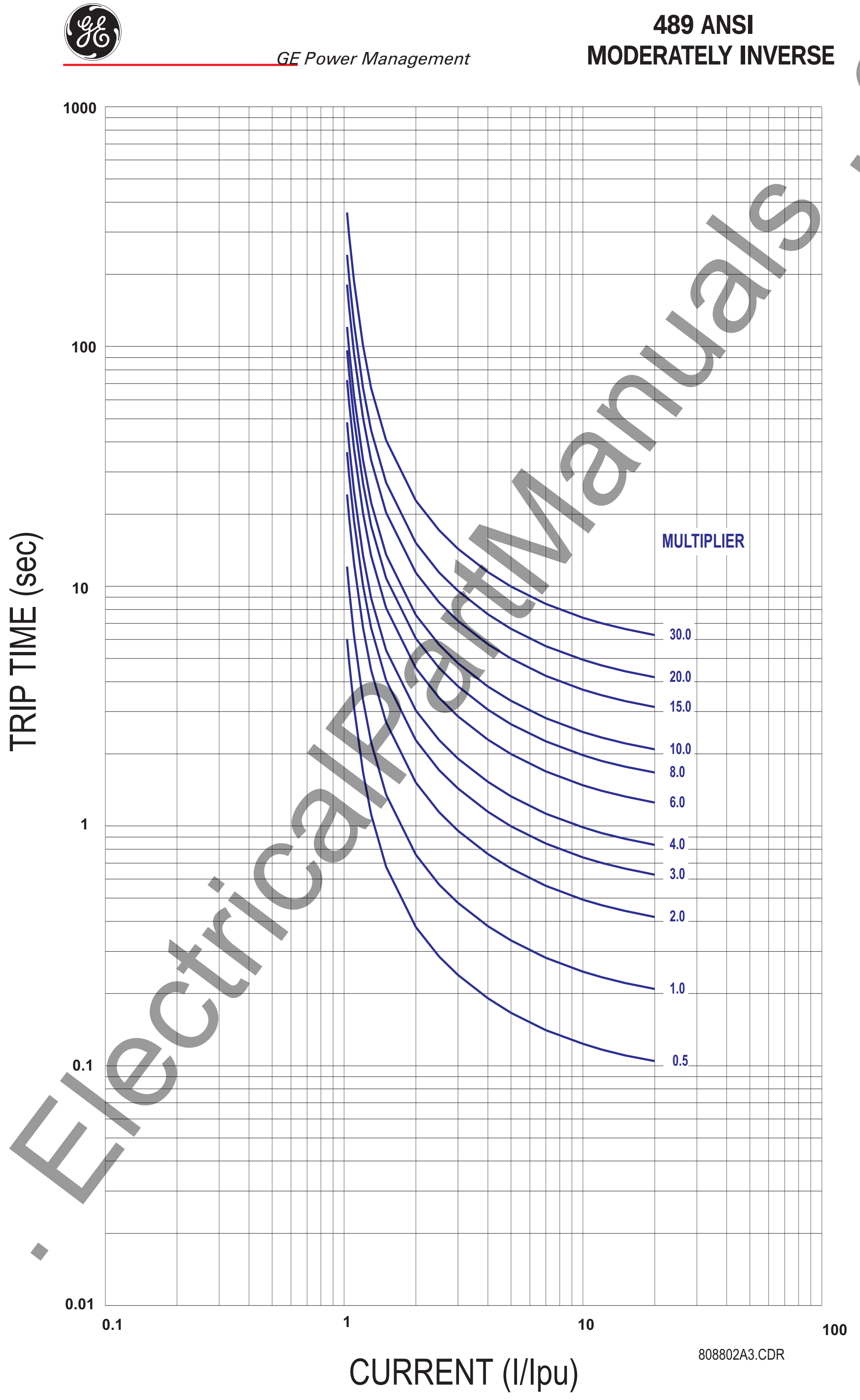

Figure C 1 Moderately Inverse Curve (ANSI)

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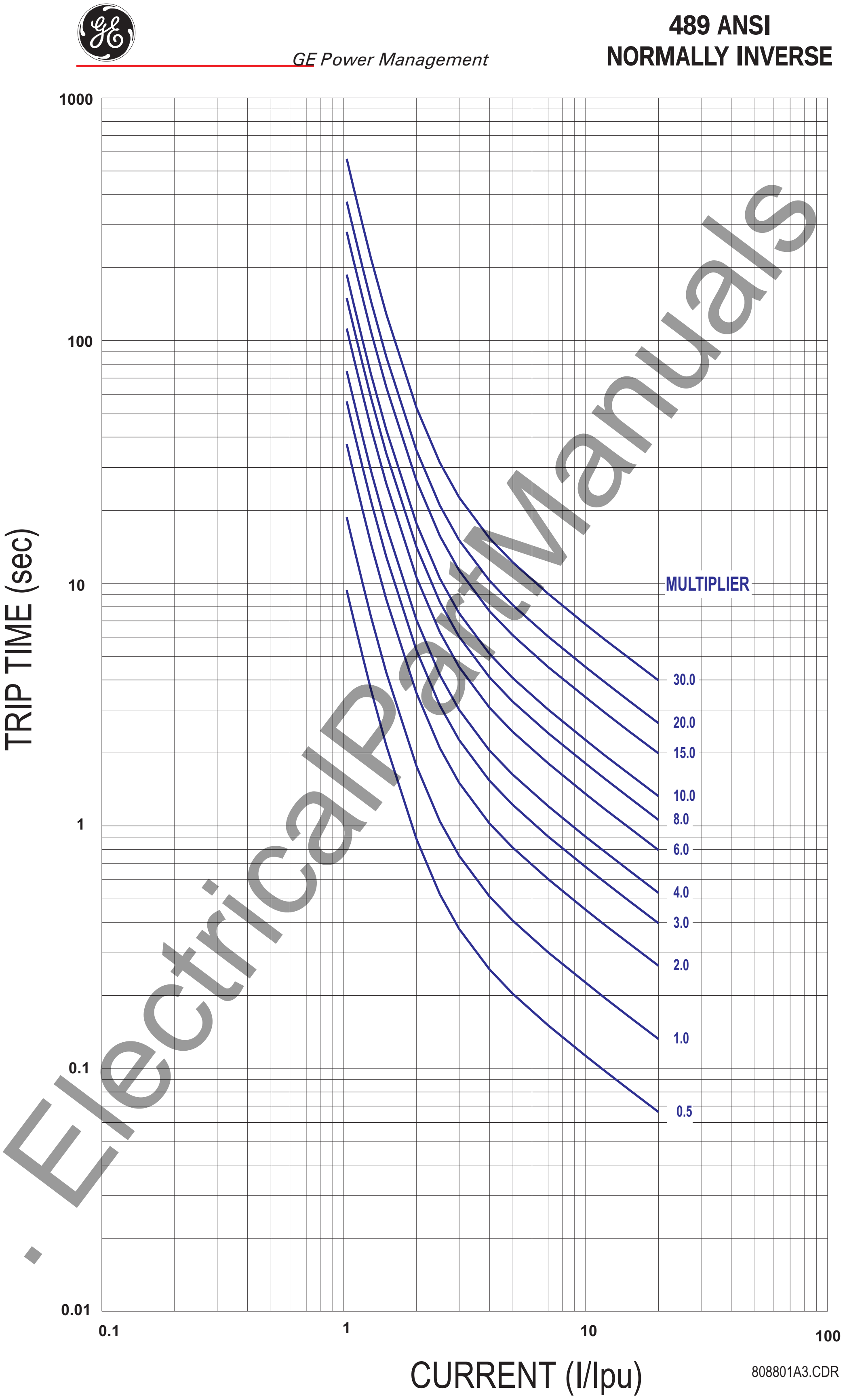

Figure C 2 Normally Inverse Curve (ANSI)

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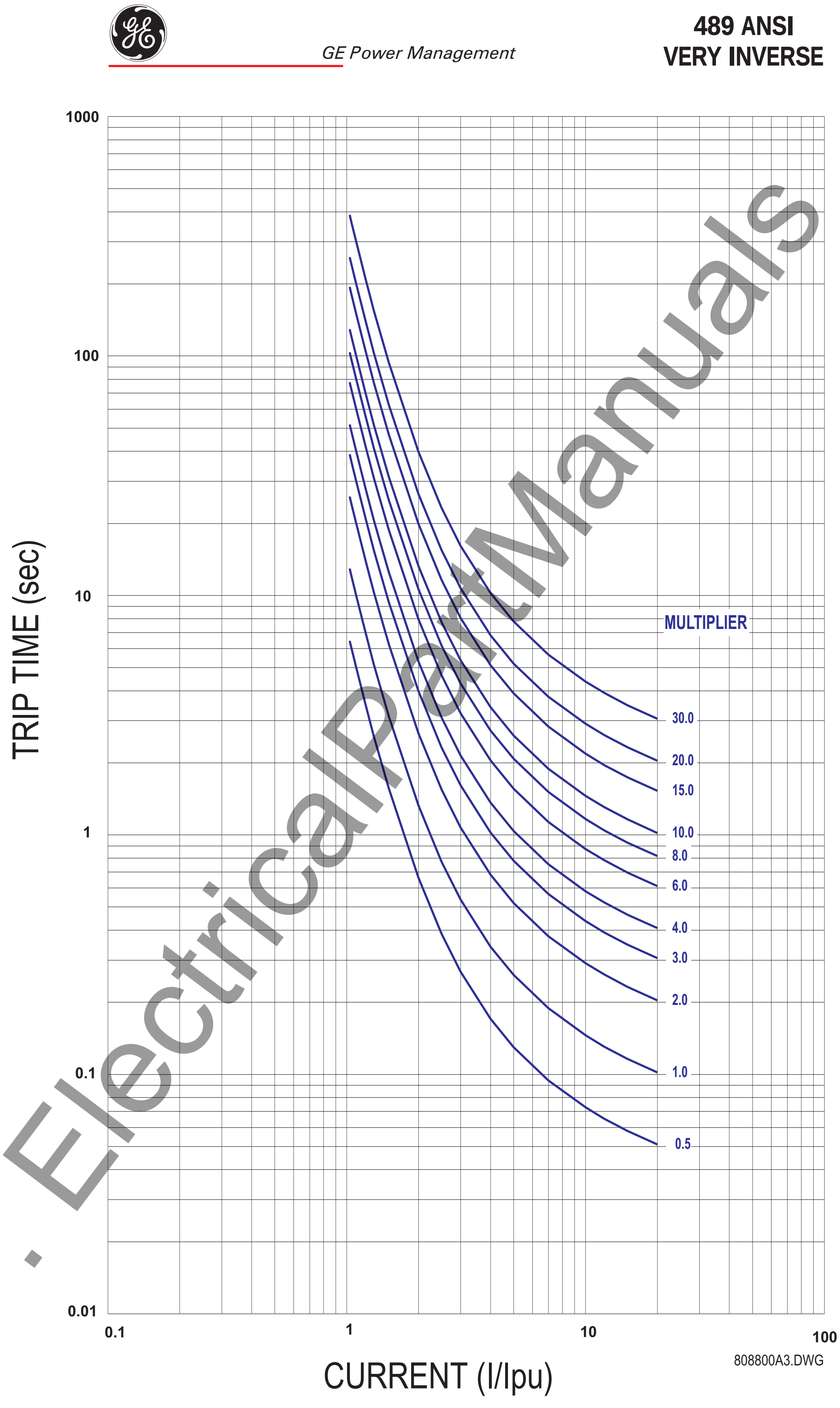

Figure C 3 Very Inverse Curve (ANSI)

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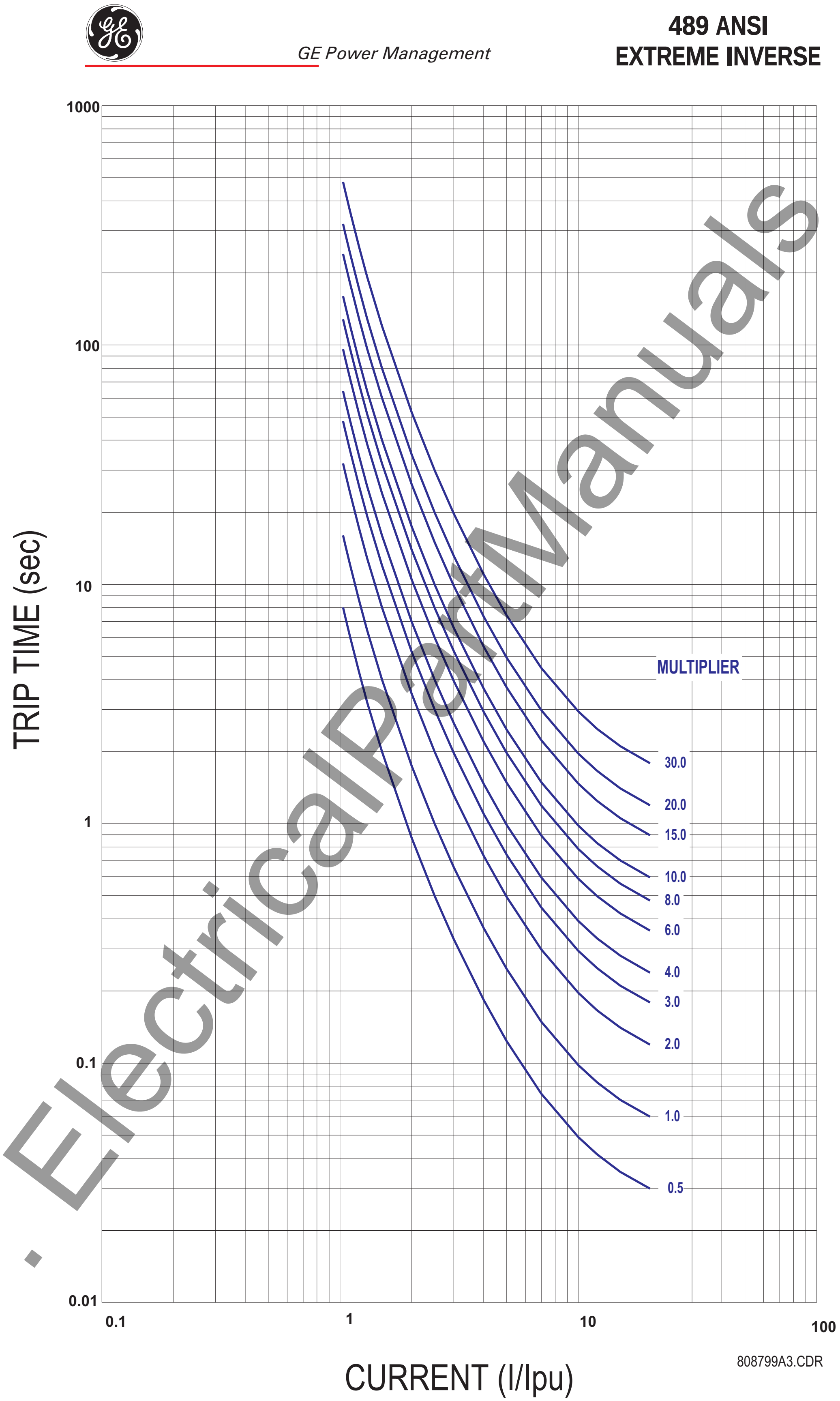

Figure C 4 Extreme Inverse Curve (ANSI)

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GE Power Management

489
DEFINITE TIME

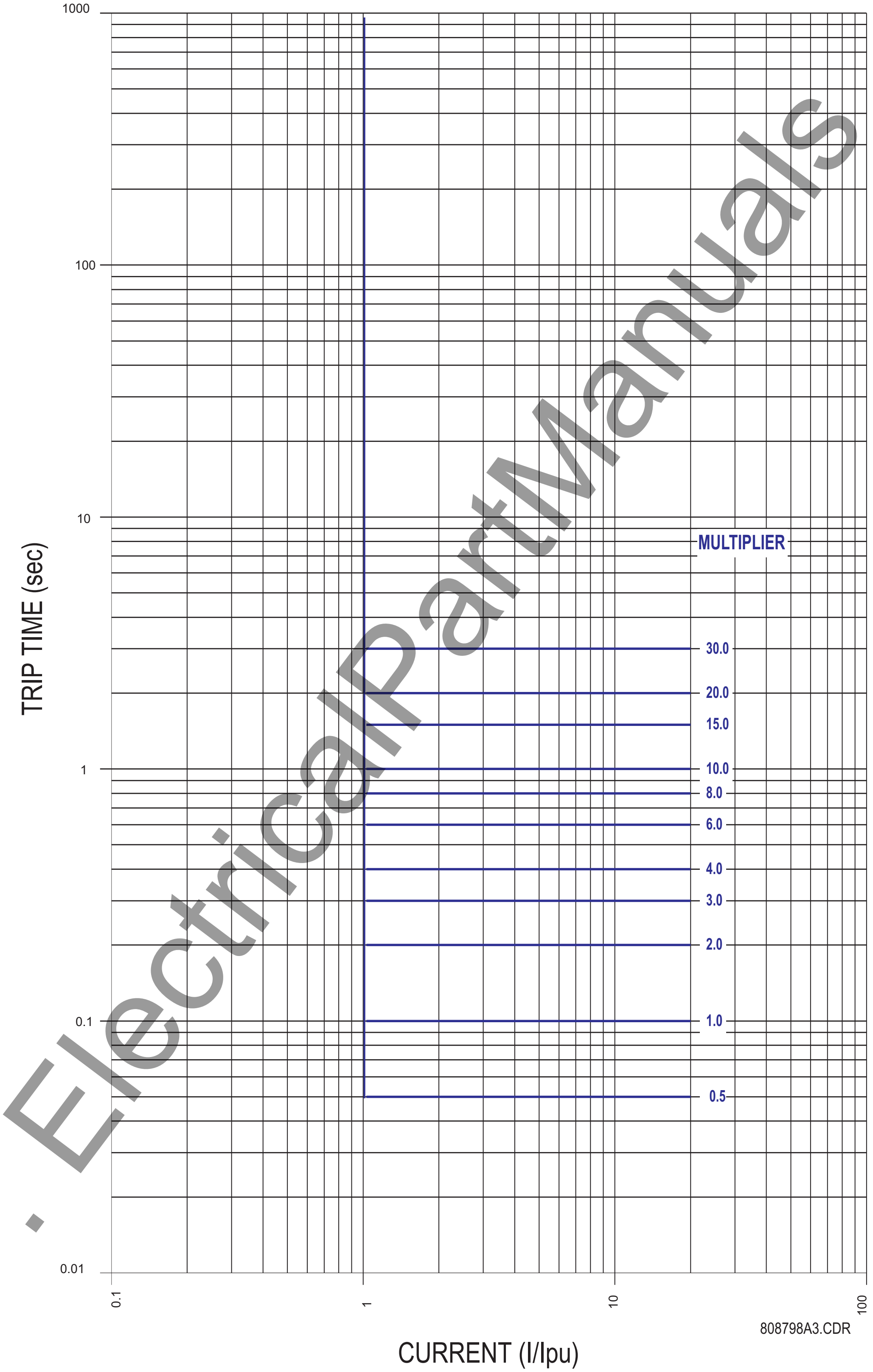

Figure C 5 Definite Time Curve

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GE Power Management

489 IAC
SHORT INVERSE

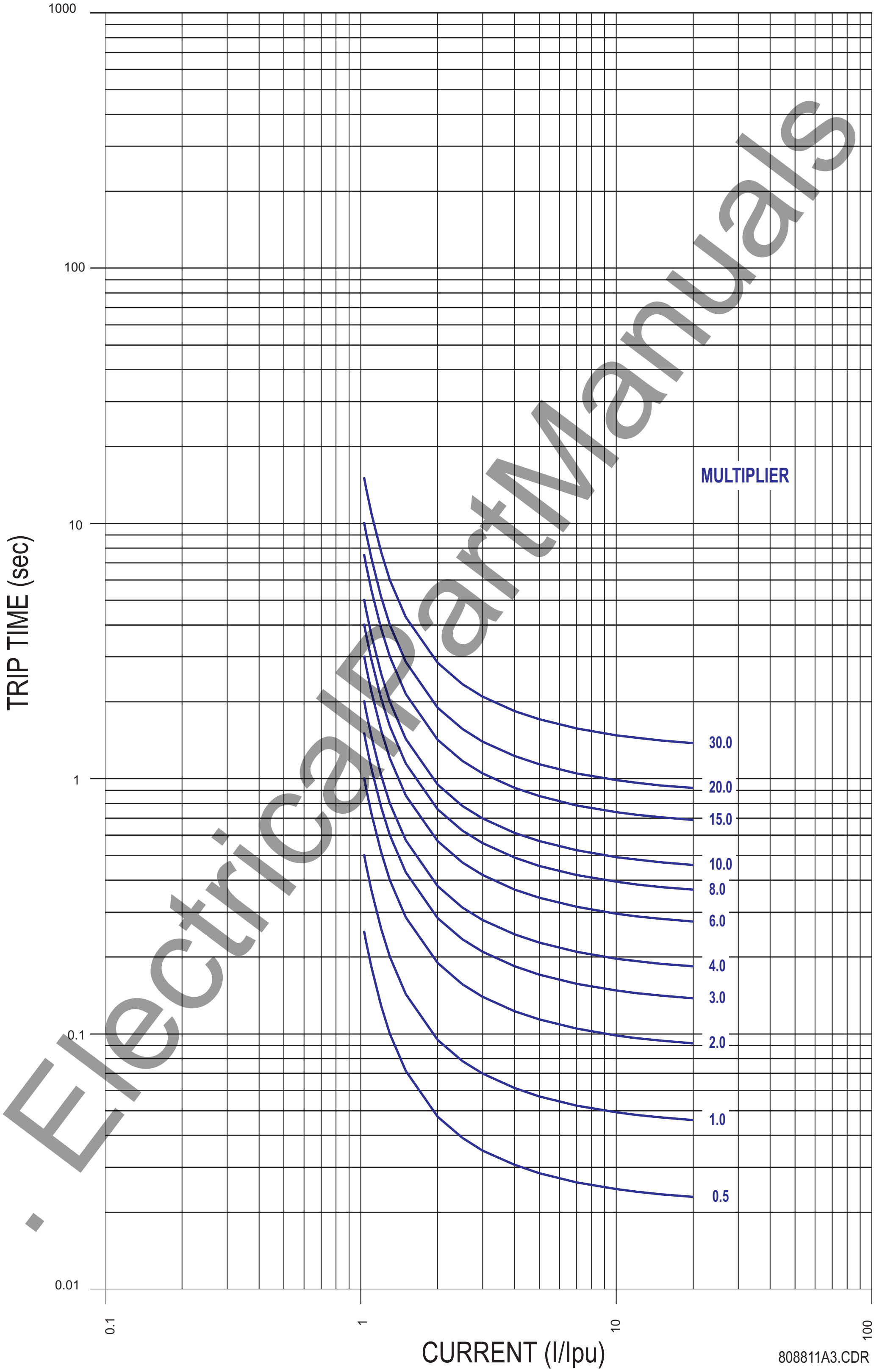

Figure C 6 IAC Short Inverse Curve

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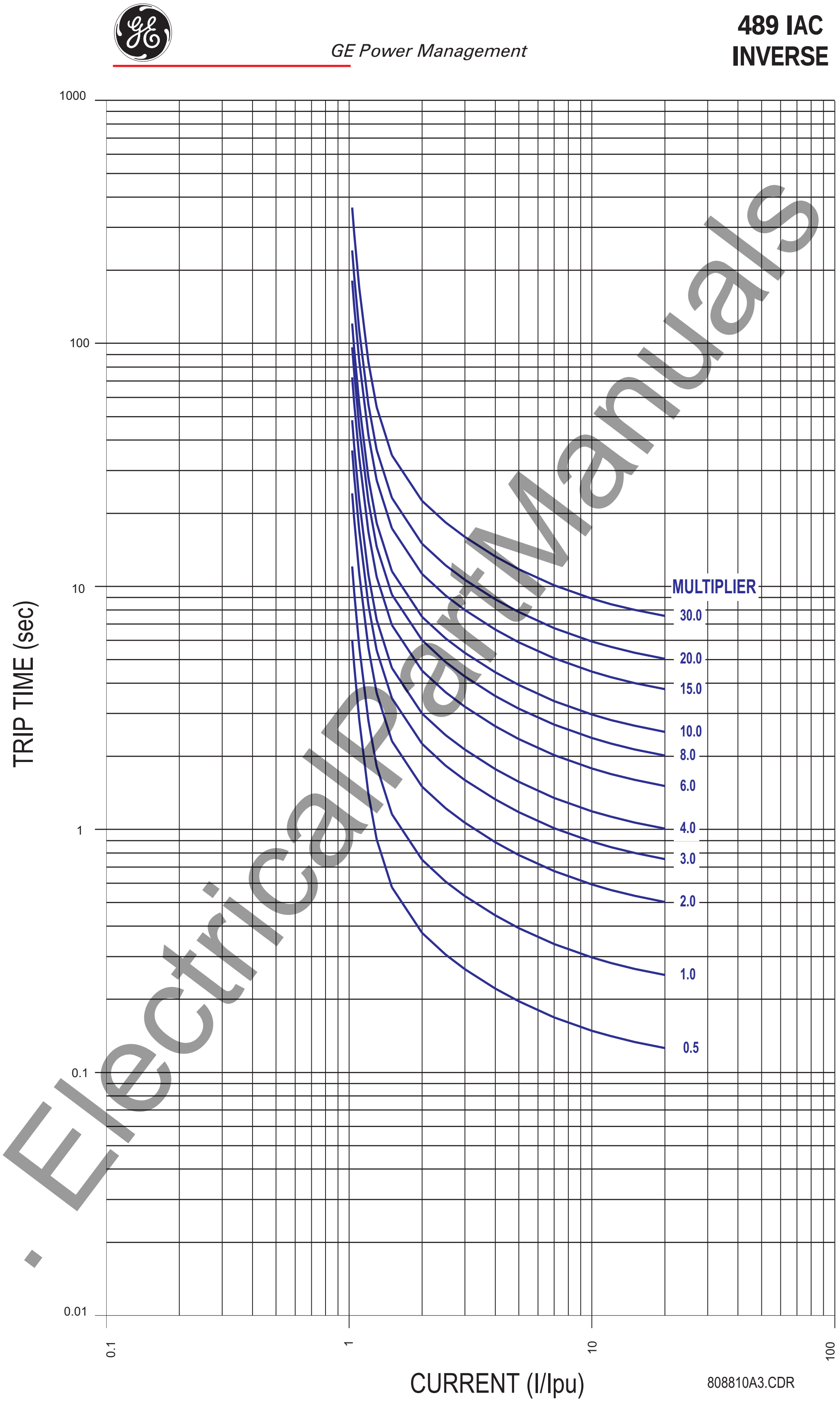

Figure C 7 IAC Inverse Curve

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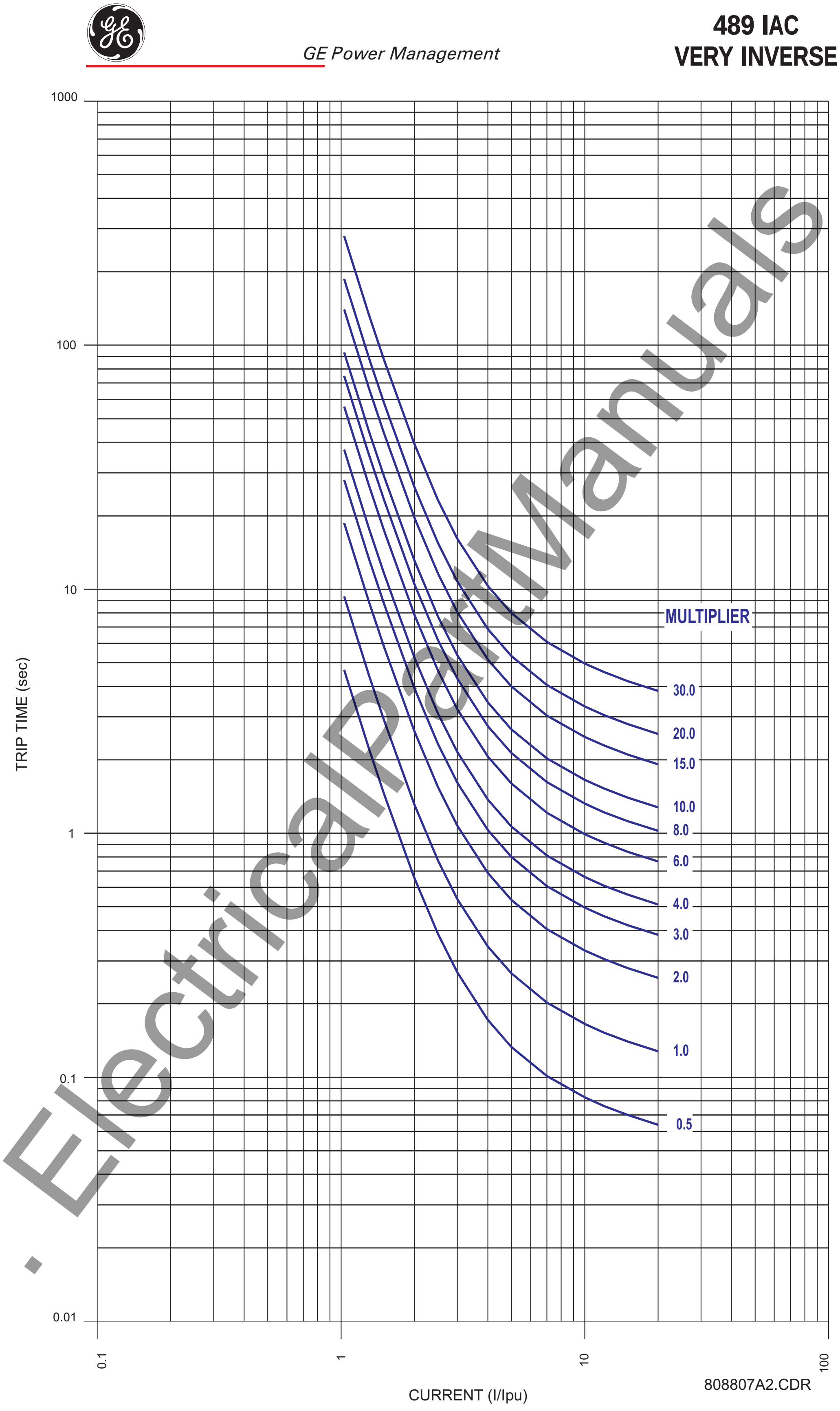

Figure C 8 IAC Very Inverse Curve

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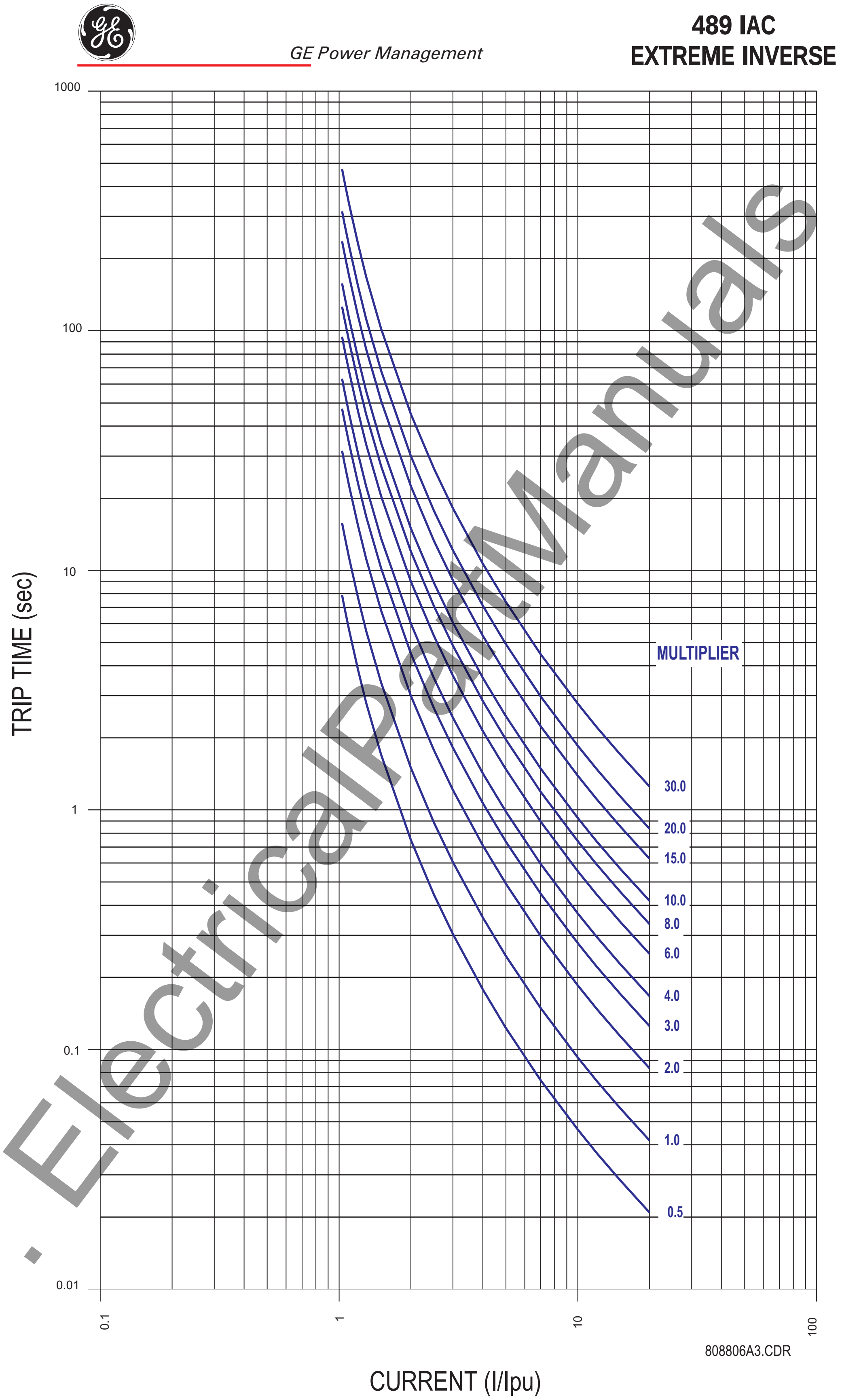

Figure C 9 IAC Extreme Inverse Curve

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GE Power Management

489 IEC
CURVE A (BS142)

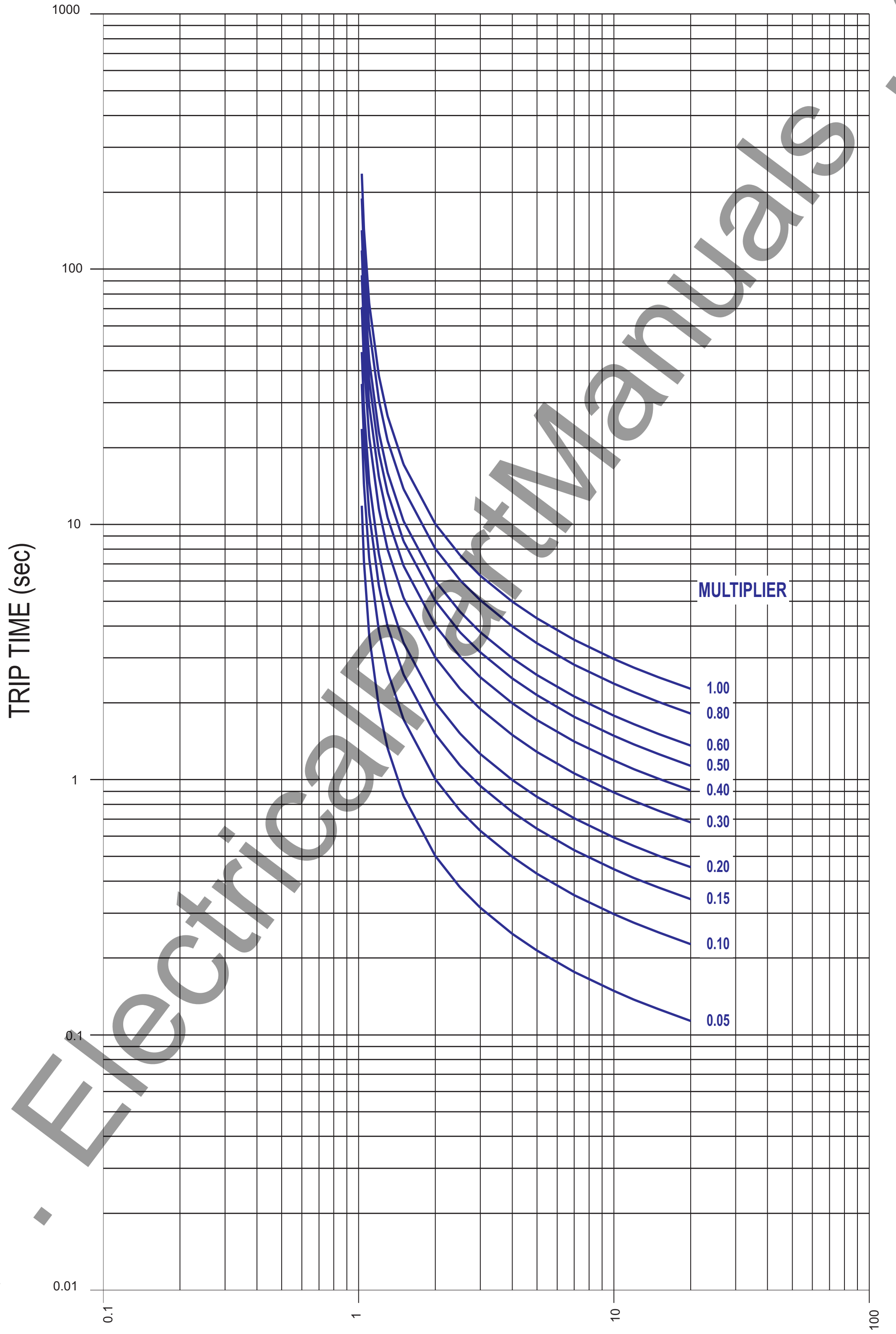

Figure C 10 IEC Curve A (BS142)

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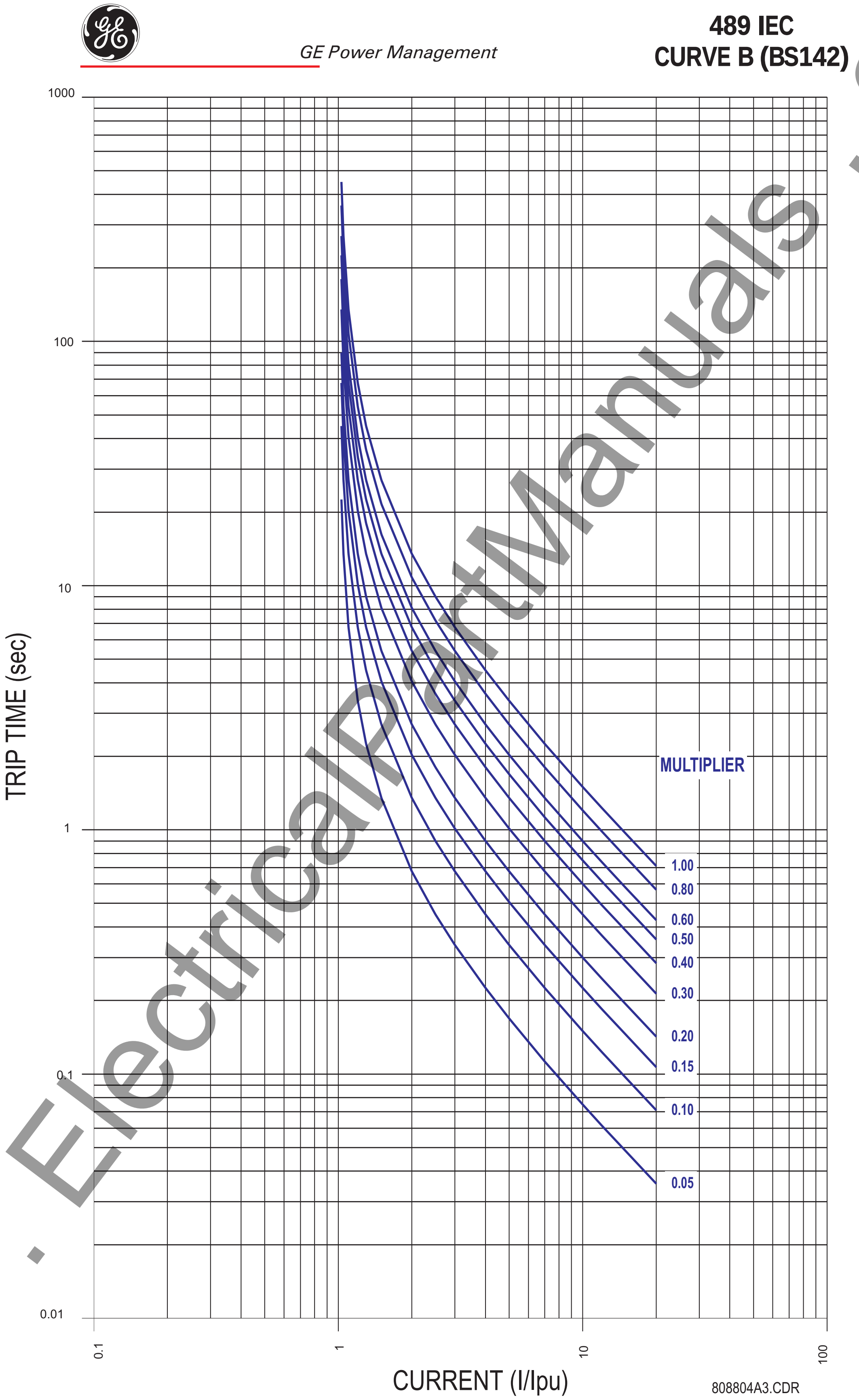

Figure C 11 IEC Curve B (BS142)

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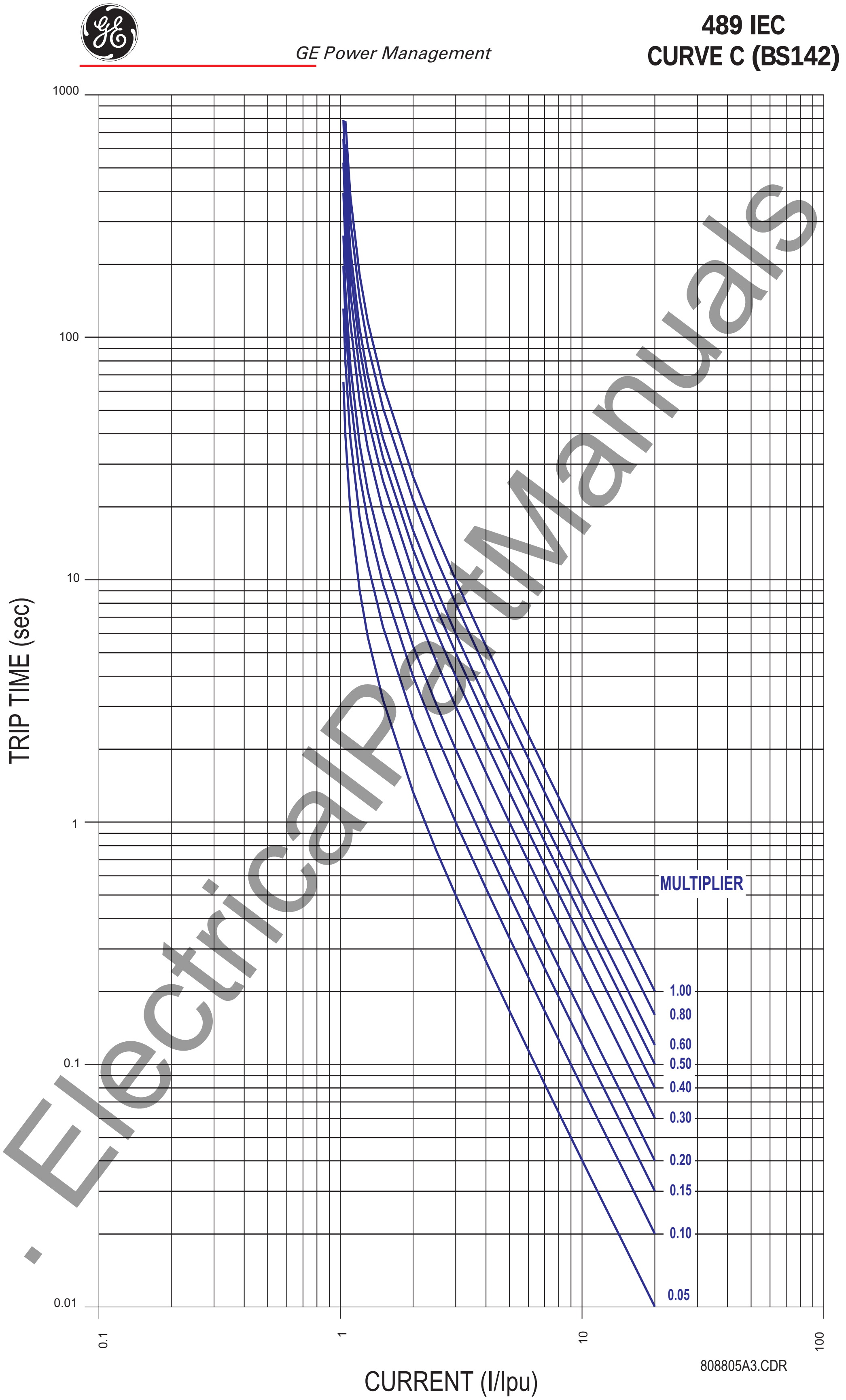
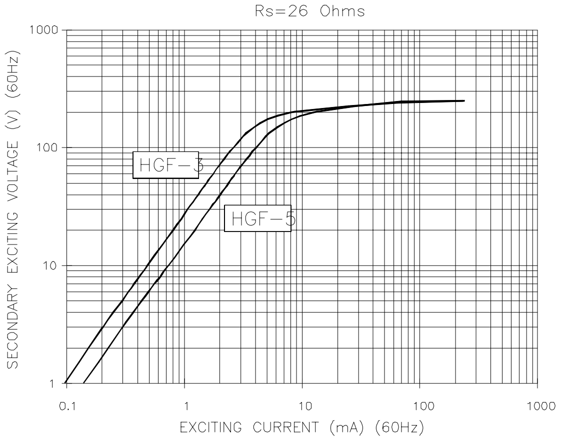


Figure C 12 IEC Curve C (BS142)

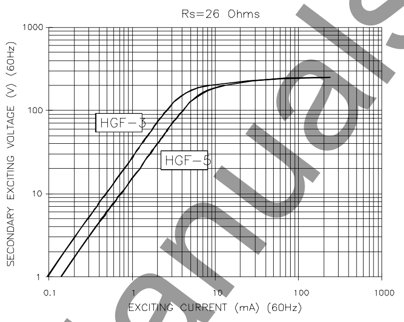
GROUND FAULT CTS FOR 50:0.025 A CT

CTs that are specially designed to match the ground fault input of GE Power Management motor protection relays should be used to ensure correct performance. These CTs have a 50:0.025A (2000:1 ratio) and can sense low leakage currents over the relay setting range with minimum error. Three sizes are available with 3½", 5½", or 8" diameter windows.

HGF3 / HGF5



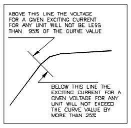
HGF8



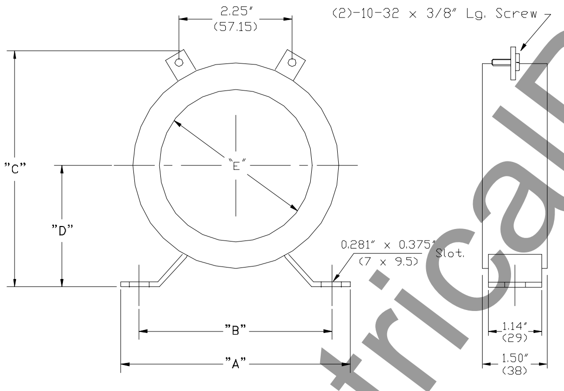
CURRENT RATIO	TURNS RATIO	SEC RES.*
50:0.025	2000:1	24.85

* OHMS AT 75° C.

This test report is in accordance with ANSI/IEEE C57.13 1993

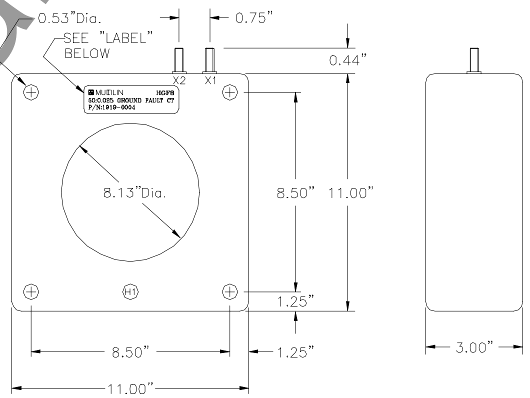


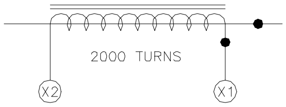
DIMENSIONS



PART NO.	A		B		C						D		E					
					Min.		Nom.		Max.				Min.		Nom.		Max.	
	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm	in	mm
CT-HGF5	7.80	198	7.00	178	8.40	213	8.50	216	8.60	218	4.50	114	5.50	140	5.70	145	5.90	150
CT-HGF3	6.00	152	5.25	133	5.65	144	5.75	146	5.85	149	2.90	74	3.50	89	3.70	94	3.90	99

DIMENSIONS





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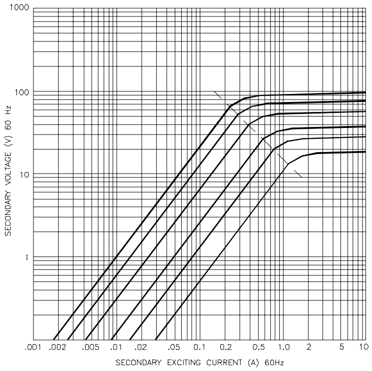
GROUND FAULT CTS FOR 5A SECONDARY CT

For low resistance or solidly grounded systems, a 5 A secondary CT should be used. Two sizes are available with 5½” or 13”x16” windows. Various Primary amp CTs can be chosen (50 to 250).

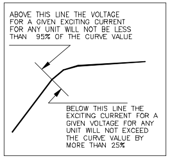
GCT5



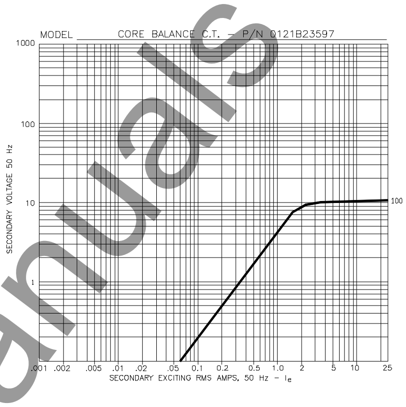
MULTILIN NO.	CURRENT RATIO	TURNS RATIO	SEC RES.*
X021-0251	250:5	50:1	0.097
X021-0201	200:5	40:1	0.078
X021-0151	150:5	30:1	0.058
X021-0101	100:5	20:1	0.039
X021-0076	75:5	15:1	0.029
X021-0051	50:5	10:1	0.019

* OHMS AT 75° C.

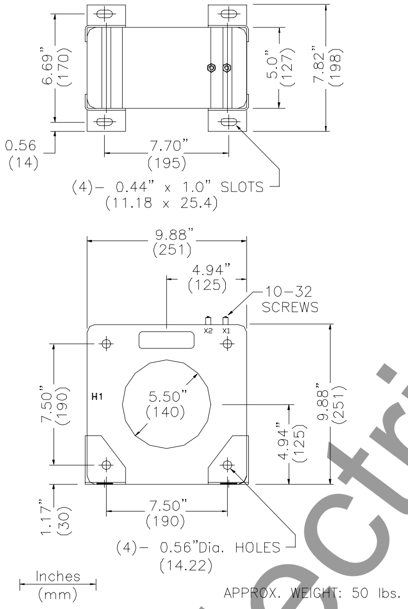
This test report is in accordance with ANSI/IEEE C57.13 1993



GCT16

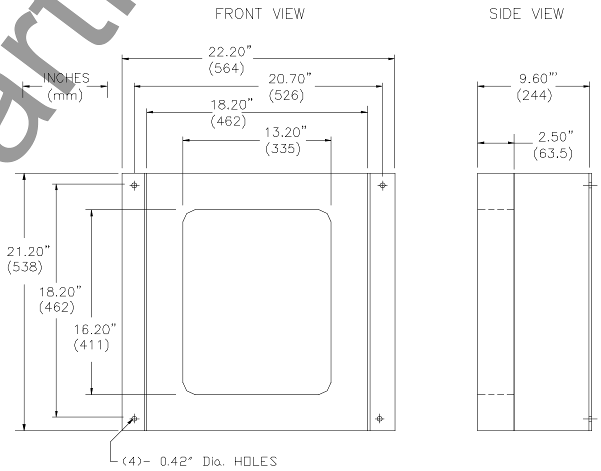


DIMENSIONS



APPROX. WEIGHT: 50 lbs.

DIMENSIONS



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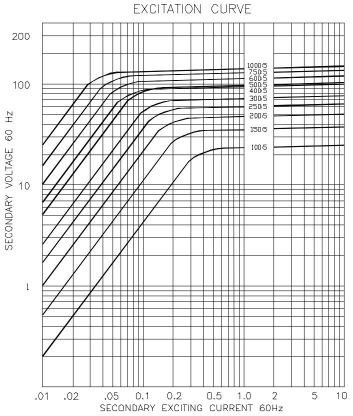
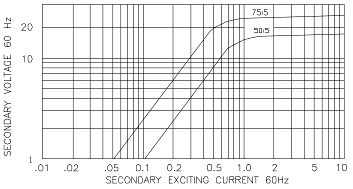
PHASE CTS

Current transformers in most common ratios from 50:5 to 1000:5 are available for use as phase current inputs with motor protection relays. These come with mounting hardware and are also available with 1 A secondaries. Voltage class - 600V BIL 10 KV.



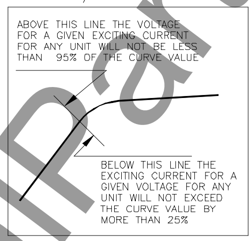


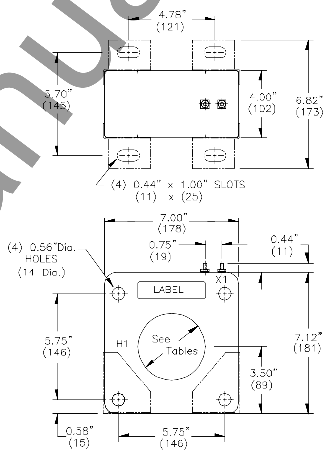
CURRENT TRANSFORMER SPECIFICATIONS

CURRENT RATIO	WINDOW SIZE	CT CLASS	MULTILIN No.	CT Dims.
50:5	2.75"	C10	X911–0010	A
75:5	2.75"	C10	X911–0011	A
100:5	3.00"	C10	X911–0012	B
150:5	3.00"	C10	X911–0013	B
200:5	3.00"	C20	X911–0014	B
250:5	3.00"	C20	X911–0015	B
300:5	3.00"	C20	X911–0016	B
400:5	3.00"	C20	X911–0017	B
500:5	3.00"	C50	X911–0018	B
600:5	3.00"	C50	X911–0019	B
750:5	3.00"	C50	X911–0020	B
1000:5	3.75"	C50	X911–0021	B

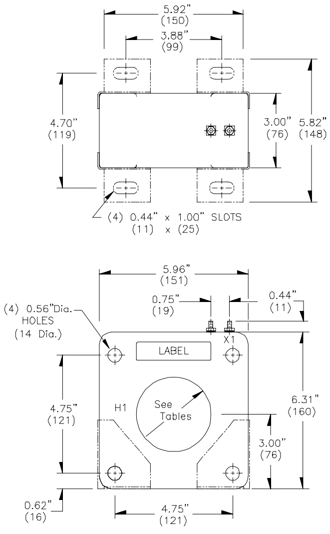
90906BA1.DWG

This test report is in accordance with ANSI/IEEE C57.13 1993





CT DIMENSIONS "A"



CT DIMENSIONS "B"

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GE POWER MANAGEMENT RELAY WARRANTY

General Electric Power Management Inc. (GE Power Management) warrants each relay it manufactures to be free from defects in material and workmanship under normal use and service for a period of 24 months from date of shipment from factory.

In the event of a failure covered by warranty, GE Power Management will undertake to repair or replace the relay providing the warrantor determined that it is defective and it is returned with all transportation charges prepaid to an authorized service centre or the factory. Repairs or replacement under warranty will be made without charge.

Warranty shall not apply to any relay which has been subject to misuse, negligence, accident, incorrect installation or use not in accordance with instructions nor any unit that has been altered outside a GE Power Management authorized factory outlet.

GE Power Management is not liable for special, indirect or consequential damages or for loss of profit or for expenses sustained as a result of a relay malfunction, incorrect application or adjustment.

For complete text of Warranty (including limitations and disclaimers) refer to GE Power Management Standard Conditions of Sale.

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