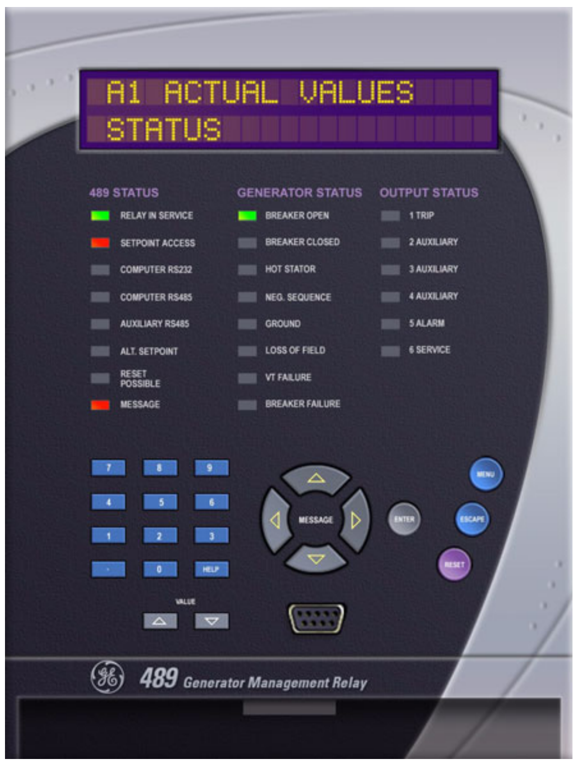
Digital Energy
Multilin

489 Generator Management Relay
Instruction Manual

Firmware Revision: 4.0X

Manual Part Number: 1601-0150-AD
Manual Order Code: GEK-106494M



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REGISTERED ISO9001:2000 GE MULTILIN

GE Multilin's Quality Management System is registered to ISO9001:2000

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GE Multilin 489 Generator Management Relay instruction manual for revision 4.0x.

Part numbers contained in this manual are subject to change without notice, and should therefore be verified by GE Multilin before ordering.

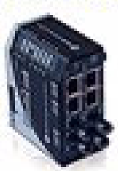
Part number: 1601-0150-AD (September 2009)

Multilink Hardened Ethernet Switch -
A Dependable way to Network your Relays and Meters

ML2400
19" Rack-mounted Managed Switch

ML1600
9" Rack-mounted Managed Switch

ML600
Unmanaged Compact Switch



Ability to withstand Harsh Environments

- IEC 61850-3 compliant for electric utility substations
- IEEE 1613 Class 2 compliant for transient immunity
- -40° C to +85°C Operating temperature

High Degree of network and management Security

- SNMPv3 Encryption Supported
- Secure Web Management
- Remote Access Security

Enhanced network reliability with fast fault recovery

- Less than 5ms recovery per hop
- Link-Loss-Alert for detecting broken connections

Simple Switch Configuration

- Powerful Graphical Interface simplifying network management
- Enhanced web statistics, alarm management and security configurations

Support of all Common Network Communication Ports

- 10 Mb-ST multimode
- 100 Mb-ST or SC multimode and singlemode
- 10/100 Mb-RJ45 Copper
- 1000 Mb SC multimode or singlemode fiber and RJ45 Copper

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489 Generator Management Relay

Chapter 1: Getting Started

1.1 Important Procedures

1.1.1 Cautions and Warnings

Please read this chapter to guide you through the initial setup of your new relay.

WARNING CAUTION

Before attempting to install or use the relay, it is imperative that all WARNINGS and CAUTIONS in this manual are reviewed to help prevent personal injury, equipment damage, and/or downtime.

1.1.2 Inspection Checklist

- Open the relay packaging and inspect the unit for physical damage.
- View the rear nameplate and verify that the correct model has been ordered.
- Ensure that the following items are included:
  - Instruction Manual
  - GE EnerVista CD (includes software and relay documentation)
  - mounting screws
- For product information, instruction manual updates, and the latest software updates, please visit the GE Multilin website at http://www.GEmultilin.com.

NOTE

If there is any noticeable physical damage, or any of the contents listed are missing, please contact GE Multilin immediately.

1.1.3 Manual Organization

Reading a lengthy instruction manual on a new product is not a task most people enjoy. To speed things up, this introductory chapter provides guidelines for basic relay usability. Important wiring considerations and precautions discussed in *Electrical Installation* on page 3–9 should be observed for reliable operation. Detailed information regarding accuracy, output relay contact ratings, and so forth are detailed in *Specifications* on page 2–6. The remainder of this manual should be read and kept for reference to ensure maximum benefit from the 489 Generator Management Relay. For further information, please consult your local sales representative or the factory. Comments about new features or modifications for your specific requirements are welcome and encouraged.

Setpoints and actual values are indicated as follows in the manual:

A4 MAINTENANCE ▷▽ TRIP COUNTERS ▷ TOTAL NUMBER OF TRIPS

This 'path representation' illustrates the location of an specific actual value or setpoint with regards to its previous menus and sub-menus. In the example above, the **TOTAL NUMBER OF TRIPS** actual value is shown to be an item in the **TRIP COUNTERS** sub-menu, which itself is an item in the **A4 MAINTENANCE** menu, which is an item of **ACTUAL VALUES**.

Sub-menu levels are entered by pressing the MESSAGE ▶ or ENTER key. When inside a submenu, the ◀ MESSAGE or ESCAPE key returns to the previous sub-menu. The MESSAGE ▼ and MESSAGE ▲ keys are used to scroll through the settings in a sub-menu. The display indicates which keys can be used at any given point.

1.2 Using the Relay

1.2.1 Menu Navigation

The relay has three types of display messages: actual value, setpoint, and target messages. A summary of the menu structure for setpoints and actual values can be found at the beginning of chapters 5 and 6, respectively.

Setpoints are programmable settings entered by the user. These types of messages are located within a menu structure that groups the information into categories. Navigating the menu structure is described below.

Actual values include the following information:

1. Generator and System Status:
    a. Generator status either online, offline, or tripped.
    b. The status of digital inputs.
    c. Last trip information, including values such as cause of last trip, time and date of trip, pre-trip temperature measurements, pre-trip analog inputs values, and pre-trip instantaneous values of power system quantities.
    d. Active alarms.
    e. Relay date and time.
2. Metering Data:
    a. Instantaneous current measurements including phase, neutral, and ground currents.
    b. Instantaneous phase to phase and phase to ground voltages (depending on the VT connections), average voltage, and system frequency.
    c. Power quantities including apparent, real and reactive power.
    d. Current and power demand including peak values.
    e. Analog inputs.
    f. Generator speed.
    g. System phasors.
    h. RTD temperatures.
3. Learned Data:
    a. Average magnitudes of generator load, negative-sequence current, and phase-phase voltage.
    b. RTD learned data, which includes the maximum temperature measured by each of the twelve (12) RTDs.
    c. Minimum and maximum values of analog inputs.
4. Maintenance data. This is useful statistical information that may be used for preventive maintenance. It includes:
    a. Trip counters

b. General counters such as number of breaker operations and number of thermal resets.

c. Generator hours online timer.

5. Event recorder downloading tool.
6. Product information including model number, firmware version, additional product information, and calibration dates.
7. Oscillography and data logger downloading tool.

Alarm, trip conditions, diagnostics, and system flash messages are grouped under *Target Messages*.

▷ Press the MENU key to access the header of each menu, which will be displayed in the following sequence:

```
■ SETPOINTS          [▷]
```

```
■ ACTUAL VALUES      [▷]
```

```
■ TARGET MESSAGES    [▷]
```

To access setpoints,

▷ press the MENU key until the display shows the header of the setpoints menu.

▷ Press the MESSAGE ▶ or ENTER key to display the header for the first setpoints page.
The setpoint pages are numbered, have an 'S' prefix for easy identification and have a name which provides a general idea of the settings available in that page.

▷ Press the MESSAGE ▼ and MESSAGE ▲ keys to scroll through all the available setpoint page headers.
Setpoint page headers look as follows:

```
■ SETPOINTS          [▷]
  S1 489 SETUP
```

To enter a given setpoints page,

▷ Press the MESSAGE ▶ or ENTER key.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through sub-page headers until the required message is reached.
The end of a page is indicated by the message **END OF PAGE**. The beginning of a page is indicated by the message **TOP OF PAGE**.

To access actual values,

▷ Press the MENU key until the display shows the header of the actual values menu.

▷ Press the MESSAGE ▶ or ENTER key to display the header for the first actual values page.
The actual values pages are numbered, have an 'A' prefix for easy identification and have a name, which gives a general idea of the information available in that page.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through all the available actual values page headers.
Actual values page headers look as follows:

```
■ ACTUAL VALUES      [▷]
  A1 STATUS
```

To enter a given actual values page,

▷ Press the MESSAGE ▶ or ENTER key.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through sub-page headers until the required message is reached.
The end of a page is indicated by the message **END OF PAGE**. The beginning of a page is indicated by the message **TOP OF PAGE**.

Similarly, to access additional sub-pages,

▷ Press the MESSAGE ▶ or ENTER key to enter the first sub-page,

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through the available sub-pages, until the desired message is reached.
The process is identical for both setpoints and actual values.

The following procedure illustrates the key sequence to access the Current Demand actual values.

▷ Press the MENU key until you reach the actual values main menu.

```
■ ACTUAL VALUES      [▷]
```

▷ Press MESSAGE ▶ or ENTER key to enter the first actual values page.

▷ Press the MESSAGE ▼ or MESSAGE ▲ key to scroll through pages, until the A2 METERING DATA page appears.

```
■ ACTUAL VALUES      [▷]
  A2 METERING DATA
```

▷ Press the MESSAGE ▶ or ENTER key to display the first sub-page heading for the Metering Data actual values page:

```
■ CURRENT            [▷]
  METERING
```

Pressing the MESSAGE ▼ or MESSAGE ▲ keys will scroll the display up and down through the sub-page headers. Pressing the ◀ MESSAGE or ESCAPE key at any sub-page heading will return the display to the heading of the corresponding setpoint or actual value page, and pressing it again, will return the display to the main menu header.

▷ Press the MESSAGE ▼ key until the **DEMAND METERING** sub-page heading appears.

```
■ DEMAND           [▷]
  METERING
```

At this point, pressing MESSAGE ▶ or ENTER key will display the messages under this sub-page. If instead you press the MESSAGE ▲ key, it will return to the previous sub-page heading. In this case,

```
■ TEMPERATURE      [▷]
```

When the symbols ■ and [▷] appear on the top line, it indicates that additional sub-pages are available and can be accessed by pressing the MESSAGE ▶ or ENTER key.

▷ Press the MESSAGE ▶ or ENTER while at the Demand Metering sub-page heading to display the following:

```
CURRENT
DEMAND:        0 Amps
```

▷ Press ◀ MESSAGE key to return to the Demand Metering sub-page heading.

▷ Press the MESSAGE ▼ key to display the next actual value of this sub-page.
Actual values and setpoints messages always have a colon separating the name of the value and the actual value or setpoint. This particular message displays the current demand as measured by the relay.

The menu path to the value shown above is indicated as **A2 METERING DATA ▷▽ DEMAND METERING ▷ CURRENT DEMAND**. Setpoints and actual values messages are referred to in this manner throughout the manual.

For example, the **A4 MAINTENANCE ▷ TRIP COUNTERS ▷ TOTAL NUMBER OF TRIPS** path representation describes the following key-press sequence:

▷ Press the MENU key until the actual value header appears on the display.

```
■ ACTUAL VALUES    [▷]
```

▷ Press MESSAGE ▶ or the ENTER key, and then MESSAGE ▼ key until the **A4 MAINTENANCE** message is displayed.

```
■ ACTUAL VALUES    [▷]
   A4 MAINTENANCE
```

▷ Press the MESSAGE ▶ or ENTER key to display **TRIP COUNTERS** message.

```
■ TRIP            [▷]
  COUNTERS
```

▷ Press the MESSAGE ▶ or ENTER key to reach the **TOTAL NUMBER OF TRIPS** message and the corresponding actual value.

```
TOTAL NUMBER OF
TRIPS:      0
```

▷ Press the MESSAGE ▼ key to display the next actual value message as shown below:

```
DIGITAL INPUT
TRIPS:       0
```

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll the display up and down through all the actual value displays in this corresponding sub-page.

▷ Press the ◀ MESSAGE key to reverse the process described above and return the display to the previous level.

```
■ TRIP            [▷]
  COUNTERS
```

▷ Press the ◀ MESSAGE key twice to return to the **A4 MAINTENANCE** page header.

```
■ ACTUAL VALUES    [▷]
  A4 MAINTENANCE
```

1.2.2 Panel Keying Example

The following figure provides a graphical example of how the keypad is used to navigate through the menu structure. Specific locations are referred to throughout this manual by using a ‘path representation’. The example shown in the figure gives the key presses required to read the average negative-sequence current denoted by the path **A3 LEARNED DATA ▷ PARAMETER AVERAGES ▷▽ AVERAGE NEG. SEQ. CURRENT**.

▷ Press the menu key until the relay displays the actual values page.

```
■ ACTUAL VALUES     [▷]
```

Press the MESSAGE ▷ or ENTER key

```
■ ACTUAL VALUES     [▷]
  A1 STATUS
```

Press the MESSAGE ▽ key

```
■ ACTUAL VALUES     [▷]
  A2 METERING DATA
```

Press the MESSAGE ▽ key

```
■ ACTUAL VALUES     [▷]
  A3 LEARNED DATA
```

MESSAGE ▷

```
■ PARAMETER         [▷]
  AVERAGES
```

MESSAGE ▷

```
AVERAGE GENERATOR
LOAD:   100% FLA
```

MESSAGE ▽

```
AVERAGE NEG. SEQ.
CURRENT:      0% FLA
```

1.3 Changing Setpoints

1.3.1 Introduction

There are several classes of setpoints, each distinguished by the way their values are displayed and edited.

The relay's menu is arranged in a tree structure. Each setting in the menu is referred to as a setpoint, and each setpoint in the menu may be accessed as described in the previous section.

The settings are arranged in pages with each page containing related settings; for example, all the Phase Overcurrent settings are contained within the same page. As previously explained, the top menu page of each setting group describes the settings contained within that page. Pressing the MESSAGE keys allows the user to move between these top menus.

All of the 489 settings fall into one of following categories: device settings, system settings, digital input settings, output relay settings, current element settings, voltage element settings, power element settings, RTD temperature settings, thermal model settings, monitoring settings, analog input/output settings, and testing settings.

NOTE

IMPORTANT NOTE: Settings are stored and used by the relay immediately after they are entered. As such, caution must be exercised when entering settings while the relay is in service. Modifying or storing protection settings is not recommended when the relay is in service since any incompatibility or lack of coordination with other previously saved settings may cause unwanted operations.

Now that we have become more familiar with maneuvering through messages, we can learn how to edit the values used by all setpoint classes.

Hardware and passcode security features are designed to provide protection against unauthorized setpoint changes. Since we will be programming new setpoints using the front panel keys, a hardware jumper must be installed across the setpoint access terminals (C1 and C2) on the back of the relay case. Attempts to enter a new setpoint without this electrical connection will result in an error message.

The jumper does not restrict setpoint access via serial communications. The relay has a programmable passcode setpoint, which may be used to disallow setpoint changes from both the front panel and the serial communications ports. This passcode consists of up to eight (8) alphanumeric characters.

The factory default passcode is "0". When this specific value is programmed into the relay it has the effect of removing all setpoint modification restrictions. Therefore, only the setpoint access jumper can be used to restrict setpoint access via the front panel and there are no restrictions via the communications ports.

When the passcode is programmed to any other value, setpoint access is restricted for the front panel and all communications ports. Access is not permitted until the passcode is entered via the keypad or is programmed into a specific register (via communications). Note that enabling setpoint access on one interface does not automatically enable access for any of the other interfaces (i.e., the passcode must be explicitly set in the relay via the interface from which access is desired).

A front panel command can disable setpoint access once all modifications are complete. For the communications ports, writing an invalid passcode into the register previously used to enable setpoint access disables access. In addition, setpoint access is automatically disabled on an interface if no activity is detected for thirty minutes.

The EnerVista 489 Setup software incorporates a facility for programming the relay passcode as well as enabling and disabling setpoint access. For example, when an attempt is made to modify a setpoint but access is restricted, the software will prompt the user to enter the passcode and send it to the relay before the setpoint is actually written to the relay. If a SCADA system is used for relay programming, it is the programmer's responsibility to incorporate appropriate security for the application.

1.3.2 The HELP Key

Pressing the HELP key displays context-sensitive information about setpoints such as the range of values and the method of changing the setpoint. Help messages will automatically scroll through all messages currently appropriate.

1.3.3 Numerical Setpoints

Each numerical setpoint has its own minimum, maximum, and step value. These parameters define the acceptable setpoint value range. Two methods of editing and storing a numerical setpoint value are available.

The first method uses the 489 numeric keypad in the same way as any electronic calculator. A number is entered one digit at a time with the 0 to 9 and decimal keys. The left-most digit is entered first and the right-most digit is entered last. Pressing ESCAPE before the ENTER key returns the original value to the display.

The second method uses the VALUE ▲ key to increment the displayed value by the step value, up to a maximum allowed value. Likewise, the VALUE ▼ key decrements the displayed value by the step value, down to a minimum value. For example:

▷ Select the **S1 489 SETUP ▷▽ PREFERENCES ▷▽ DEFAULT MESSAGE TIMEOUT** setpoint message.

```
DEFAULT MESSAGE
TIMEOUT: 300 s
```

▷ Press the 1, 2, and 0 keys. The display message will change as shown.

```
DEFAULT MESSAGE
TIMEOUT: 120 s
```

Until the ENTER key is pressed, editing changes are not registered by the relay. Therefore,

▷ Press the ENTER key to store the new value in memory.
The following message will momentarily appear as confirmation of the storing process.

```
NEW SETPOINT HAS
BEEN STORED
```

1.3.4 Enumeration Setpoints

The example shown in the following figures illustrates the keypress sequences required to enter system parameters such as the phase CT primary rating, ground CT primary rating, bus VT connection type, secondary voltage, and VT ratio.

The following values will be entered:

Phase CT primary rating: 600 A
Ground CT type: 1 A secondary
Ground CT ratio: 200:1
Neutral Voltage Transformer: None
Voltage Transformer Connection Type: Open Delta
VT Ratio: 115:1

To set the phase CT primary rating, modify the **S2 SYSTEM SETUP ▷ CURRENT SENSING ▷ PHASE CT PRIMARY** setpoint as shown below.

▷ Press the MENU key until the relay displays the setpoints menu header.

```
■ SETPOINTS        [▷]
```

Press MESSAGE ▶ or ENTER

```
■ SETPOINTS        [▷]
 S1 489 SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS        [▷]
 S2 SYSTEM SETUP
```

Press MESSAGE ▶ or ENTER

```
■ CURRENT          [▷]
 SENSING
```

Press MESSAGE ▶ or ENTER

```
PHASE CT PRIMARY:
-------------
```

Press the VALUE keys until 600 A is displayed, or enter the value directly via the numeric keypad.

```
PHASE CT PRIMARY:
 600 A
```

Press the ENTER key to store the setpoint.

```
NEW SETPOINT HAS
BEEN STORED
```

To select the Ground CT type, modify the **S2 SYSTEM SETUP ▷ CURRENT SENSING ▷▽ GROUND CT** setpoint as shown below.

▷ Press the MENU key until the relay displays the setpoints menu header.

```
■ SETPOINTS              [▷]
```

Press MESSAGE ▶ or ENTER

```
■ SETPOINTS              [▷]
  S1 489 SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS              [▷]
  S2 SYSTEM SETUP
```

Press MESSAGE ▶ or ENTER

```
■ CURRENT                [▷]
  SENSING
```

Press MESSAGE ▶ or ENTER

```
PHASE CT PRIMARY:
  600 A
```

Press MESSAGE ▼

```
GROUND CT:
50:0.025
```

Press the VALUE keys until “1 A Secondary” is displayed.

```
GROUND CT:
1 A Secondary
```

Press the ENTER key to store the setpoint.

```
  NEW SETPOINT HAS
  BEEN STORED
```

To set the ground CT ratio, modify the **S2 SYSTEM SETUP ▷ CURRENT SENSING ▷▽ GROUND CT RATIO** setpoint as shown below.

▷ Press the MENU key until the relay displays the setpoints menu header.

```
■ SETPOINTS              [▷]
```

Press MESSAGE ▶ or ENTER

```
■ SETPOINTS              [▷]
  S1 489 SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS              [▷]
  S2 SYSTEM SETUP
```

Press MESSAGE ▶ or ENTER

```
■ CURRENT                [▷]
  SENSING
```

Press MESSAGE ▶ or ENTER

```
PHASE CT PRIMARY:
 600 A
```

Press MESSAGE ▼

```
GROUND CT:
1 A Secondary
```

Press MESSAGE ▼

```
GROUND CT RATIO:
100: 1
```

Press the VALUE keys until 200: 1 is displayed, or enter the value directly via the numeric keypad.

```
GROUND CT RATIO:
200: 1
```

Press the ENTER key to store the setpoint.

```
  NEW SETPOINT HAS
  BEEN STORED
```

To set the VT connection type and ratings, modify the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING ▷▽ VT CONNECTION TYPE** and the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING ▷▽ VOLTAGE TRANSFORMER RATIO** setpoints as shown below.

▷ Press the MENU key until the relay displays the setpoints menu header.

```
■ SETPOINTS              [▷]
```

Press MESSAGE ▶ or ENTER

```
■ SETPOINTS              [▷]
  S1 489 SETUP
```

Press MESSAGE ▼

```
■ SETPOINTS              [▷]
  S2 SYSTEM SETUP
```

Press MESSAGE ▶ or ENTER

```
■ CURRENT                [▷]
  SENSING
```

Press MESSAGE ▼

```
■ VOLTAGE                [▷]
  SENSING
```

Press MESSAGE ▶ or ENTER

```
VT CONNECTION TYPE:
None
```

Press the VALUE keys until "Open Delta" is displayed.

```
VT CONNECTION TYPE:
Open Delta
```

Press the ENTER key to store the setpoint.

```
  NEW SETPOINT HAS
  BEEN STORED
```

Press MESSAGE ▼	VOLTAGE TRANSFORMER RATIO: 5.00: 1
Press the VALUE keys until 115.00 : 1 is displayed, or enter the value directly via the numeric keypad.	VOLTAGE TRANSFORMER RATIO: 115.0: 1
Press the ENTER key to store the setpoint.	NEW SETPOINT HAS BEEN STORED

If an entered setpoint value is out of range, the relay displays a message with the following format:

OUT-OF-RANGE! ENTER: 1-300:1 by 0.01:1	*"1-300:1" indicates the range and "0.01:1" indicates the step value*

In this case, 1 is the minimum setpoint value, 300 is the maximum, and 0.01 is the step value. To have access to information on maximum, minimum, and step value, press the HELP key.

1.3.5 Output Relay Setpoints

The output relays 1 Trip and 5 Alarm can be associated to auxiliary relays 2 to 4. Each can be selected individually, or in combination, in response to customer specific requirements. These relays are initiated through the **ASSIGN ALARM RELAYS** or **ASSIGN TRIP RELAYS** setpoints specific to a protection element or function.

▷ Select the **S6 VOLTAGE ELEMENTS ▷ UNDERVOLTAGE ▷▽ ASSIGN TRIP RELAYS (1-4)** setpoint message.

```
ASSIGN TRIP
RELAYS (1-4): 1---
```

If an application requires the undervoltage protection element to trip the 3 Auxiliary relay,

▷ Select this output relay by pressing the "3" key; pressing the "3" key again disables the 3 Auxiliary relay.
Enable/disable relays 1, 3, and 4 in the same manner until the desired combination appear in the display.

```
ASSIGN TRIP
RELAYS (1-4): --3-
```

▷ Press the ENTER key to store this change into memory.
As before, confirmation of this action will momentarily flash on the display.

```
NEW SETPOINT HAS
BEEN STORED
```

1.3.6 Text Setpoints

Text setpoints have data values, which are fixed in length, but user defined in character. They may be comprised of uppercase letters, lowercase letters, numerals, and a selection of special characters. The editing and storing of a text value is accomplished with the use of the decimal [.], VALUE, and ENTER keys.

For example:

▷ Move to the **S3 DIGITAL INPUTS ▷ GENERAL INPUT A ▷▽ INPUT NAME** message:

```
INPUT NAME:
Input A
```

The name of this user-defined input will be changed in this example from the generic “Input A” to something more descriptive.

If an application is to be using the relay as a station monitor, it is more informative to rename this input “Stn. Monitor”.

▷ Press the decimal [.] key to enter the text editing mode. The first character will appear underlined as follows:

```
INPUT NAME:
Input A
```

▷ Press the VALUE keys until the character “S” is displayed in the first position.

▷ Press the decimal [.] key to store the character and advance the cursor to the next position.

▷ Change the second character to a “t” in the same manner.

▷ Continue entering characters in this way until all characters of the text “Stn. Monitor” are entered.
Note that a space is selected like a character. If a character is entered incorrectly, press the decimal [.] key repeatedly until the cursor returns to the position of the error. Re-enter the character as required.

▷ Once complete, press the ENTER key to remove the solid cursor and view the result.
Once a character is entered, by pressing the ENTER key, it is automatically saved in flash memory, as a new setpoint.

```
INPUT NAME:
Stn. Monitor
```

1.4 Installation

1.4.1 Placing the Relay in Service

The relay is defaulted to the Not Ready state when it leaves the factory. A minor self-test warning message informs the user that the 489 Generator Management Relay has not yet been programmed. If this warning is ignored, protection will be active using factory default setpoints and the Relay In Service LED Indicator will be on.

1.4.2 Testing

Extensive commissioning tests are available in Chapter 7. Tables for recording required settings are available in Microsoft Excel format from the GE Multilin website at http://www.GEmultilin.com. The website also contains additional technical papers and FAQs relevant to the 489 Generator Management Relay.

Digital Energy
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489 Generator Management Relay

Chapter 2: Introduction

2.1 Overview

2.1.1 Description

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 illustrates the 489 functionality using 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_2^2t)	●	●
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	●	●

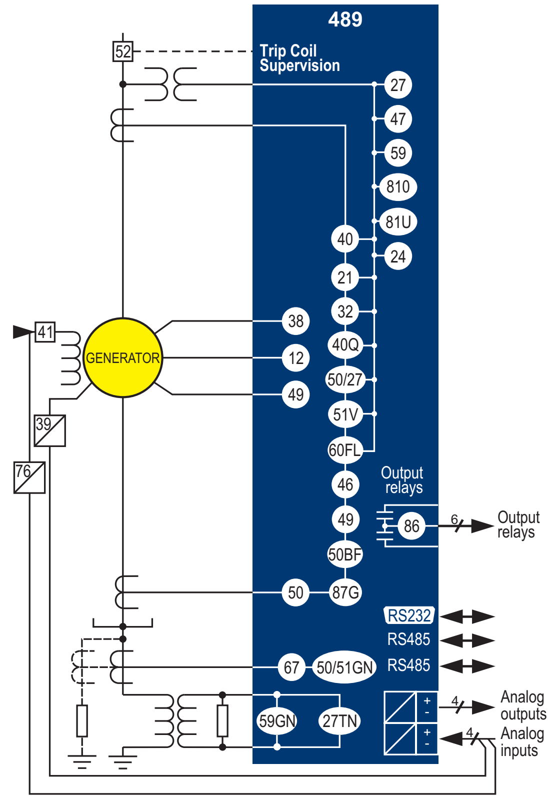


FIGURE 2–1: Single Line Diagram

Fault diagnostics are provided through pretrip data, event record, waveform capture, and statistics. Prior to issuing a trip, the 489 takes a snapshot of the measured parameters and stores 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 in actual values page 1. The event recorder stores a maximum of 256 time and date stamped events including the pre-trip data. Every time a trip occurs, the 489 stores a 16 cycle trace 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 allow the operator to pinpoint a problem quickly and with certainty.

A complete list protection features is shown below:

Table 2–1: Trip and Alarm Protection Features

Trip Protection	Alarm Protection
Seven (7) Assignable Digital Inputs: General Input, Sequential Trip (low forward power or reverse power), Field-Breaker discrepancy, and Tachometer	7 assignable digital inputs: general input and tachometer
	Overload
	Negative Sequence
Offline Overcurrent (protection during startup)	Ground Overcurrent
Inadvertent Energization	Ground Directional
Phase Overcurrent with Voltage Restraint	Undervoltage
Negative-Sequence Overcurrent	Overvoltage
Ground Overcurrent	Volts Per Hertz
Percentage Phase Differential	Underfrequency
Ground Directional	Overfrequency
High-Set Phase Overcurrent	Neutral Overvoltage (Fundamental)
Undervoltage	Neutral Undervoltage (3rd Harmonic)
Overvoltage	Reactive Power (kvar)
Volts Per Hertz	Reverse Power
Voltage Phase Reversal	Low Forward Power
Underfrequency (two step)	RTD: Stator, Bearing, Ambient, Other
Overfrequency (two step)	Short/Low RTD
Neutral Overvoltage (Fundamental)	Open RTD
Neutral Undervoltage (3rd Harmonic)	Thermal Overload
Loss of Excitation (2 impedance circles)	Trip Counter
Distance Element (2 zones of protection)	Breaker Failure
Reactive Power (kvar) for loss of field	Trip Coil Monitor
Reverse Power for anti-motoring	VT Fuse Failure
Low Forward Power	Demand: Current, MW, Mvar, MVA
RTDs: Stator, Bearing, Ambient, Other	Generator Running Hours
Thermal Overload	Analog Inputs 1 to 4
Analog Inputs 1 to 4	Service (Self-Test Failure)
Electrical Lockout	IRIG-B Failure

NOTE

The following protection elements require neutral-end current inputs.

- Distance Element
- Offline Overcurrent
- Phase Differential

Power metering is a standard feature in the 489. The table below outlines the metered parameters available to the operator through the front panel and communications ports. The 489 is equipped with three independent communications ports. The front panel RS232 port may be used for setpoint programming, local interrogation or control, and firmware upgrades. The computer RS485 port may be connected to a PLC, DCS, or PC based interface software. 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 to 20 mA transducer outputs that may be assigned to any measured parameter. The range of these outputs is scalable. Additional features are outlined below.

Table 2–2: Metering and Additional Features

Metering
Voltage (phasors)
Current (phasors) and Amps Demand
Real Power, MW Demand, MWh
Apparent Power and MVA demand
MW, Mvar, and ±MVarh demand
Frequency
Power Factor
RTD
Speed in RPM with a Key Phasor Input
User-Programmable Analog Inputs

Additional Features
Drawout Case (maintenance and testing)
Breaker Failure
Trip Coil Supervision
VT Fuse Failure
Simulation
Flash Memory for easy firmware upgrades

2.1.2 Ordering

All features of the 489 are standard, there are no options. The phase CT secondaries, control power, and analog output range must be specified at the time of order. There are two ground CT inputs: one for a 50:0.025 CT and one for a ground CT with a 1 A secondary (may also accommodate a 5 A secondary). The VT inputs accommodate VTs in either a delta or wye configuration. The output relays are always non-failsafe with the exception of the service relay. The EnerVista 489 Setup software is provided with each unit. A metal demo case may be ordered for demonstration or testing purposes.

Table 2–3: 489 Order Codes

	489 –	* –	* –	* –	* –	*	
Base unit	489	|	|	|	|	|	489 Generator Management Relay
Phase current inputs		P1	|	|	|	|	1 A phase CT secondaries
		P5	|	|	|	|	5 A phase CT secondaries
Control power			LO	|	|	|	20 to 60 V DC; 20 to 48 V AC at 48 to 62 Hz
			HI	|	|	|	90 to 300 V DC; 70 to 265 V AC at 48 to 62 Hz
Analog outputs				A1	|	|	0 to 1 mA analog outputs
				A20	|	|	4 to 20 mA analog outputs
Display					|	|	Basic display
					E	|	Enhanced display, larger LCD
					T	|	Enhanced with Ethernet (10Base-T)
Harsh environment						H	Harsh (chemical) environment conformal coating

For example, the 489-P1-LO-A20-E code specifies a 489 Generator Management Relay with 1 A CT inputs, 20 to 60 V DC or 20 to 48 V AC control voltage, 4 to 20 mA analog outputs, and an enhanced display.

2.1.3 Other Accessories

Additional 489 accessories are listed below.

- **EnerVista 489 Setup software:** no-charge software provided with the 489
- **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
- **Phase CT:** 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-inch Collar:** For shallow switchgear, reduces the depth of the relay by 1 3/8 inches
- **489 3-inch Collar:** For shallow switchgear, reduces the depth of the relay by 3 inches

2.2 Specifications

2.2.1 Inputs

ANALOG CURRENT INPUTS

Inputs: ...0 to 1 mA, 0 to 20 mA, 4 to 20mA (setpoint)
Input impedance: ...226 Ω ±10%
Conversion range: ...0 to 20 mA
Accuracy: ...±1% of full scale
Type: ...Passive
Analog input supply: ...+24 V DC at 100 mA max.
Sampling Interval: ...50 ms

ANALOG INPUTS FREQUENCY TRACKING

Frequency tracking: Va for wye, Vab for open delta; 6 V minimum, 10 Hz/s

DIGITAL INPUTS

Inputs: 9 opto-isolated inputs
External switch: dry contact < 400 Ω, or open collector NPN transistor from sensor. 6 mA sinking from internal 4K pull-up at 24 V DC with Vce < 4 V DC
489 sensor supply: 24 V DC at 20 mA max.

GROUND CURRENT INPUT

CT primary: 10 to 10000 A (1 A / 5 A CTs)
CT secondary: ...1 A / 5 A or 50:0.025 (HGF CTs)
Conversion range: 0.02 to 20 × CT for 1A/5A CTs
0.0 to 100 A primary for 50:0.025 CTs (HGF)
50:0.025 CT accuracy: ±0.1 A at < 10 A
±1.0 A at ≥ 10 to 100 A
1 A / 5 A CT accuracy: at < 2 × CT: ±0.5% of 2 × CT
at ≥ 2 × CT: ±1% of 20 × CT

GROUND CT BURDEN

<table>
<tr><th rowspan="2">Ground CT</th><th rowspan="2">Input</th><th colspan="2">Burden</th></tr>
<tr><th>VA</th><th>Ω</th></tr>
<tr><td rowspan="3">1 A / 5 A</td><td>1 A</td><td>0.024</td><td>0.024</td></tr>
<tr><td>5 A</td><td>0.605</td><td>0.024</td></tr>
<tr><td>20 A</td><td>9.809</td><td>0.024</td></tr>
<tr><td rowspan="3">50:0.025 HGF</td><td>0.025 A</td><td>0.057</td><td>90.7</td></tr>
<tr><td>0.1 A</td><td>0.634</td><td>90.7</td></tr>
<tr><td>0.5 A</td><td>18.9</td><td>75.6</td></tr>
</table>

GROUND CT CURRENT WITHSTAND (SECONDARY)

<table>
<tr><th rowspan="2">Ground CT</th><th colspan="3">Withstand Time</th></tr>
<tr><th>1 sec.</th><th>2 sec.</th><th>continuous</th></tr>
<tr><td>1 A / 5 A</td><td>80 × CT</td><td>40 × CT</td><td>3 × CT</td></tr>
<tr><td>50:0.025 HGF</td><td>N/A</td><td>N/A</td><td>150 mA</td></tr>
</table>

NEUTRAL VOLTAGE INPUT

VT ratio: 1.00 to 240.00:1 in steps of 0.01
VT secondary: 100 V AC (full-scale)
Conversion range: 0.005 to 1.00 × Full Scale
Accuracy: ...*Fundamental*:+/-0.5% of Full Scale
3rd Harmonic at >3V secondary: +/-5% of reading
3rd Harmonic at < 3V secondary: +/- 0.15% of full scale

Max. continuous: 280 V AC

OUTPUT AND NEUTRAL END CURRENT INPUTS

CT primary: 10 to 50000 A
CT secondary: 1 A or 5 A (specify with order)
Conversion range: 0.02 to 20 × CT
Accuracy: at < 2 × CT: ±0.5% of 2 × CT
at ≥ 2 × CT: ±1% of 20 × CT
Burden: Less than 0.2 VA at rated load
CT withstand: 1 s at 80 × rated current
2 s at 40 × rated current
continuous at 3 × rated current

PHASE VOLTAGE INPUTS

VT ratio: 1.00 to 300.00:1 in steps of 0.01
VT secondary: 200 V AC (full-scale)
Conversion range: 0.02 to 1.00 × full-scale
Accuracy: ±0.5% of full-scale
Max. continuous: 280 V AC
Burden: > 500 KΩ

RTD INPUTS

RTDs (3-wire type): 100 Ω Platinum (DIN.43760)
100 Ω Nickel, 120 Ω Nickel,
10 Ω Copper
RTD sensing current: 5 mA
Isolation: 36 Vpk (isolated with analog inputs and outputs)
Range: –50 to +250°C
Accuracy: ±2°C/±4°F for Pt and Ni
±5°C/±9°F for Cu
Lead resistance: 25 Ω max. per lead (Pt and Ni types); 3 Ω max. per lead (Cu type)
NO sensor: >1 kΩ
Short/low alarm: <–50°C

2.2.2 Outputs

ANALOG CURRENT OUTPUT

Type: Active
Range: 4 to 20mA, 0 to 1 mA
(must be specified with order)
Accuracy: ±1% of full scale
4 to 20 mA max. load: 1.2 kΩ
0 to 1 mA max. load: 10 kΩ
Isolation: 36 Vpk (isolated with RTDs and analog inputs)
4 assignable outputs: phase A, B, C output current, three-phase average current, negative sequence current, generator load, hottest stator RTD, hottest bearing RTD, RTDs 1 to 12, voltage (AB, BC, and CA), average phase-phase voltage, volts/hertz, frequency, third harmonic neutral voltage, power (3-phase Mvar, MW, and MVA), power factor, analog inputs 1 to 4, tachometer, thermal capacity used, demand (I, Mvar, MW, and MVA), torque

PULSE OUTPUT

Parameters: + kwh, +kvarh, –kvarh
Interval: 1 to 50000 in steps of 1
Pulse width: 200 to 1000 ms in steps of 1

RELAYS

WARNING

Relay contacts must be considered unsafe to touch when the relay is energized! If the output relay contacts are required for low voltage accessible applications, it is the customer's responsibility to ensure proper insulation levels.

Configuration: 6 electromechanical Form-C relays
Contact material: silver alloy
Operate time: 10 ms
Make/carry: 30 A for 0.2 s,
10 A continuous (for 100000 operations)
Maximum ratings for 100000 operations:

Voltage		Break	Max. Load
DC Resistive	30 V	10 A	300 W
	125 V	0.5 A	62.5 W
	250 V	0.3 A	75 W
DC inductive L/R = 40 ms	30 V	5 A	150 W
	125 V	0.25 A	31.3 W
	250 V	0.15 A	37.5 W
AC Resistive	120 V	10 A	2770 VA
	250 V	10 A	2770 VA
AC Inductive PF = 0.4	120 V	4 A	480 VA
	250 V	3 A	750 VA

2.2.3 Protection

PHASE DISTANCE (IMPEDANCE)

Characteristics: offset mho
Reach (secondary Ω): 0.1 to 500.0 Ω in steps of 0.1
Reach accuracy: ±5%
Characteristic angle: 50 to 85° in steps of 1
Time delay: 0.15 to 150.0 s in steps of 0.1
Timing accuracy: ±50 ms or ±0.5% of total time
Number of zones: 2

GROUND DIRECTIONAL

Pickup level: 0.05 to 20.00 × CT in steps of 0.01
Time delay: 0.1 to 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

GROUND OVERCURRENT

Pickup level: 0.05 to 20.00 × CT in steps of 0.01
Curve shapes: ANSI, IEC, IAC, Flexcurve, Definite Time
Time delay: 0.00 to 100.00 s in steps of 0.01
Pickup accuracy: as per ground current input
Timing accuracy: +50 ms at 50/60 Hz or ±0.5% total time
Elements: Trip

HIGH-SET PHASE OVERCURRENT

Pickup level: 0.15 to 20.00 × CT in steps of 0.01
Time delay: 0.00 to 100.00 s in steps of 0.01
Pickup accuracy: as per phase current inputs

Timing accuracy: ±50 ms at 50/60 Hz or ±0.5% total time
Elements: Trip

INADVERTENT ENERGIZATION
Arming signal: undervoltage and/or offline from breaker status
Pickup level: 0.05 to 3.00 × CT in steps of 0.01 of any one phase
Time delay: no intentional delay
Pickup accuracy: as per phase current inputs
Timing accuracy: +50 ms at 50/60 Hz
Elements: Trip

LOSS OF EXCITATION (IMPEDANCE)
Pickup level: 2.5 to 300.0 Ω secondary in steps of 0.1 with adjustable impedance offset 1.0 to 300.0 Ω secondary in steps of 0.1
Time delay: 0.1 to 10.0 s in steps of 0.1
Pickup accuracy: as per voltage and phase current inputs
Timing accuracy: ±100 ms or ±0.5% of total time
Elements: Trip (2 zones using impedance circles)

NEGATIVE SEQUENCE OVERCURRENT
Pickup level: 3 to 100% FLA in steps of 1
Curve shapes: I_2^2t trip defined by *k*, definite time alarm
Time delay: 0.1 to 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

NEUTRAL OVERVOLTAGE (FUNDAMENTAL)
Pickup level: 2.0 to 100.0 V secondary in steps of 0.01
Time delay: 0.1 to 120.0 s in steps of 0.1
Pickup accuracy: as per neutral voltage input
Timing accuracy: ±100 ms or ±0.5% of total time
Elements: Trip and Alarm

NEUTRAL UNDERVOLTAGE (3RD HARMONIC)
Blocking signals: low power and low voltage if open delta
Pickup level: 0.5 to 20.0 V secondary in steps of 0.01 if open delta VT; adaptive if wye VT
Time delay: 5 to 120 s in steps of 1
Pickup accuracy: as per Neutral Voltage Input
Timing accuracy: ±3.0 s
Elements: Trip and Alarm

OFFLINE OVERCURRENT
Pickup level: 0.05 to 1.00 × CT in steps of 0.01 of any one phase
Time delay: 3 to 99 cycles in steps of 1
Pickup accuracy: as per phase current inputs
Timing accuracy: +50ms at 50/60 Hz
Elements: Trip

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, IRIG-B Failure Alarm

OVERCURRENT ALARM
Pickup level: 0.10 to 1.50 × FLA in steps of 0.01 (average phase current)

Time delay:	0.1 to 250.0 s in steps of 0.1
Pickup accuracy:	as per phase current inputs
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Alarm

OVERFREQUENCY

Required voltage:	0.50 to 0.99 × rated voltage in Phase A
Block from online:	0 to 5 sec. in steps of 1
Pickup level:	25.01 to 70.00 in steps of 0.01
Curve shapes:	1 level alarm, 2 level trip definite time
Time delay:	0.1 to 5000.0 s in steps of 0.1
Pickup accuracy:	±0.02 Hz
Timing accuracy:	±150 ms or ±1% of total time at 50Hz and 60Hz; ±300 ms or 2% of total time at 25Hz
Elements:	Trip and Alarm

OVERLOAD / STALL PROTECTION / THERMAL MODEL

Overload curves:	15 Standard Overload Curves, Custom Curve, and 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 to 1.25
Pickup accuracy:	as per phase current inputs
Timing accuracy:	±100 ms or ±2% of total time
Elements:	Trip and Alarm

OVERVOLTAGE

Pickup level:	1.01 to 1.50 × rated V in steps of 0.01
Curve shapes:	Inverse Time, definite time alarm
Time Delay:	0.2 to 120.0 s in steps of 0.1
Pickup accuracy:	as per Voltage Inputs
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip and Alarm

PHASE DIFFERENTIAL

Pickup level:	0.05 to 1.00 × CT in steps of 0.01
Curve shape:	Dual Slope
Time delay:	0 to 100 cycles in steps of 1
Pickup accuracy:	as per phase current inputs
Timing accuracy:	+50 ms at 50/60 Hz or ±0.5% total time
Elements:	Trip

PHASE OVERCURRENT

Voltage restraint:	programmable fixed characteristic
Pickup level:	0.15 to 20.00 × CT in steps of 0.01 of any one phase
Curve shapes:	ANSI, IEC, IAC, FlexCurve, Definite Time
Time delay:	0.000 to 100.000 s in steps of 0.001
Pickup accuracy:	as per phase current inputs
Timing accuracy:	+50 ms at 50/60 Hz or ±0.5% total time
Elements:	Trip

RTDS 1 TO 12

Pickup:	1 to 250°C in steps of 1
Pickup hysteresis:	2°C
Time delay:	3 sec.
Elements:	Trip and Alarm

UNDERFREQUENCY

Required voltage:	0.50 to 0.99 × rated voltage in Phase A
Block from online:	0 to 5 sec. in steps of 1
Pickup level:	20.00 to 60.00 in steps of 0.01
Curve shapes:	1 level alarm, two level trip definite time
Time delay:	0.1 to 5000.0 sec. in steps of 0.1
Pickup accuracy:	±0.02 Hz
Timing accuracy:	±150 ms or ±1% of total time at 50Hz and 60Hz; ±300 ms or 2% of total time at 25Hz
Elements:	Trip and Alarm

UNDERVOLTAGE

Pickup level:	0.50 to 0.99 × rated V in steps of 0.01
Curve shapes:	Inverse Time, definite time alarm
Time Delay:	0.2 to 120.0 s in steps of 0.1
Pickup accuracy:	as per voltage inputs
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip and Alarm

VOLTAGE PHASE REVERSAL

Configuration:	ABC or ACB phase rotation
Timing accuracy:	200 to 400 ms
Elements:	Trip

VOLTS PER HERTZ

Pickup level:	1.00 to 1.99 × nominal in steps of 0.01
Curve shapes:	Inverse Time, definite time alarm
Time delay:	0.1 to 120.0 s in steps of 0.1
Pickup accuracy:	as per voltage inputs
Timing accuracy:	±100 ms at ≥ 1.2 × Pickup ±300 ms at < 1.2 × Pickup
Elements:	Trip and Alarm

2.2.4 Digital Inputs

FIELD BREAKER DISCREPANCY

Configurable:	assignable to Digital Inputs 1 to 7
Time delay:	0.1 to 500.0 s in steps of 0.1
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip

GENERAL INPUT A TO G

Configurable:	ssignable Digital Inputs 1 to 7
Time delay:	0.1 to 5000.0 s in steps of 0.1
Block from online:	0 to 5000 s in steps of 1
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip, Alarm, and Control

SEQUENTIAL TRIP

Configurable:	assignable to Digital Inputs 1 to 7
Pickup level:	0.02 to 0.99 × rated MW in steps of 0.01, Low Forward Power / Reverse Power
Time delay:	0.2 to 120.0 s in steps of 0.1
Pickup accuracy:	see power metering
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip

TACHOMETER

Configurable:	assignable to Digital Inputs 4 to 7
RPM measurement:	0 to 7200 RPM
Duty cycle of pulse:	>10%
Pickup level:	101 to 175 × rated speed in steps of 1
Time delay:	1 to 250 s in steps of 1
Timing accuracy:	±0.5 s or ±0.5% of total time
Elements:	Trip and Alarm

2.2.5 Monitoring

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 to 90 min. in steps of 1
Update rate:	1 minute
Elements:	Alarm

ENERGY METERING

Description:	continuous total of +watthours and ±varhours
Range:	0.000 to 4000000.000 Mvarh
Timing accuracy:	±0.5%
Update Rate:	50 ms

LOW FORWARD POWER

Block from online:	0 to 15000 s in steps of 1
Pickup level:	0.02 to 0.99 × rated MW
Time delay:	0.2 to 120.0 s in steps of 0.1
Pickup accuracy:	see power metering
Timing accuracy:	±100 ms or ±0.5% of total time
Elements:	Trip and Alarm

POWER METERING

Range: -2000.000 to 2000.000 MW,
−2000.000 to 2000.000 Mvar,
0 to 2000.000 MVA

Accuracy at $I_{avg} < 2 \times$ CT: $\pm 1\%$ of $\sqrt{3} \times 2 \times CT \times VT_{ratio} \times VT_{full\text{-}scale}$

Accuracy at $I_{avg} > 2 \times$ CT: $\pm 1.5\%$ of $\sqrt{3} \times 20 \times CT \times VT_{ratio} \times VT_{full\text{-}scale}$

REACTIVE POWER

Block from online: 0 to 5000 s in steps of 1
Pickup level: 0.02 to 1.50 × rated Mvar
(positive and negative)
Time delay: 0.2 to 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 to 5000 s in steps of 1
Pickup level: 0.02 to 0.99 × rated MW
Time delay: 0.2 to 120.0 s in steps of 0.1
Pickup accuracy: see power metering
Timing accuracy: ±100 ms or ±0.5% of total time
Elements: Trip and Alarm

TRIP COIL SUPERVISION

Applicable voltage: 20 to 300 V DC/AC
Trickle current: 2 to 5 mA

2.2.6 Power Supply

CONTROL POWER

Options: LO / HI (specify with order)
LO range: 20 to 60 V DC
20 to 48 V AC at 48 to 62 Hz
HI range: 90 to 300 V DC
70 to 265 V AC at 48 to 62 Hz
Power: 45 VA (max.), 25 VA typical
Total loss of voltage ride through time (0% control power): 16.7 ms

WARNING

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

FUSE

Current rating: 2.5 A
Type: 5x20mm HRC SLO-BLO Littelfuse
Model: 215-02.5

WARNING

An external fuse must be used if the supply voltage exceeds 250 V

2.2.7 Communications

COMMUNICATIONS PORTS

RS232 port:	1, front panel, non-isolated
RS485 ports:	2, isolated together at 36 Vpk
RS485 baud rates:	300, 1200, 2400, 4800, 9600, 19200
RS232 baud rate:	9600
Parity:	None, Odd, Even
Protocol:	Modbus® RTU / half duplex, DNP 3.0

2.2.8 Testing

PRODUCTION TESTS

Thermal cycling:	Operational test at ambient, reducing to −40°C and then increasing to 60°C
Dielectric strength:	1.9 kV AC for 1 second or 1.6 kV AC for one minute, per UL 508.

DO NOT CONNECT FILTER GROUND TO SAFETY GROUND DURING ANY PRODUCTION TESTS!

TYPE TESTING

The table below lists the 489 type tests:

Standard	Test Name	Level
EIA 485	RS485 Communications Test	32 units at 4000 ft.
GE Multilin	Temperature Cycling	−50°C / +80°C
IEC 60068-2-38	Composite Temperature/Humidity	65/−10°C at 93% RH
IEC 60255-5	Dielectric Strength	2300 V AC
IEC 60255-5	Impulse Voltage	5 kV
IEC 60255-5	Insulation Resistance	>100 MΩ / 500 V AC / 10 s
IEC 60255-21-1	Sinusoidal Vibration	2 g
IEC 60255-22-2	Electrostatic Discharge: Direct	8 kV
IEC 60255-22-3	Radiated RF Immunity	10 V/m
IEC 60255-22-4	Electrical Fast Transient / Burst Immunity	4 kV
IEC 60255-22-5	Surge Immunity	4 kV / 2 kV
IEC 60255-22-6	Conducted RF Immunity, 150 kHz to 80 MHz	10 V/m
IEC 60255-25	Radiated RF Emission	Group 1 Class A
IEC 60255-25	Conducted RF Emission	Group 1 Class A
IEC 60529	Ingress of Solid Objects and Water (IP)	IP40 (front), IP20 (back)
IEC 61000-4-8	Power frequency magnetic field immunity	30 A/m
IEC 61000-4-11	Voltage Dip; Voltage Interruption	0%, 40%, 100%
IEEE C37.90	Make and carry	30 A DC
IEEE C37.90.1	Fast Transient SWC	±4 kV
IEEE C37.90.1	Oscillatory Transient SWC	±2.5 kV

2.2.9 Certification

CERTIFICATION

IEC 1010-1:	LVD - CE for Europe
EN 50263:	EMC - CE for Europe
ACA Tick Mark:	RF emissions for Australia
FCC part 15:	RF emissions for North America
UL:	listed E83849
ISO 9001:	registered

2.2.10 Physical

CASE

Drawout:	Fully drawout (automatic CT shorts)
Seal:	Seal provision
Door:	Dust tight door
Mounting:	Panel or 19" rack mount
IP Class:	IP20-X

PACKAGING

Shipping box:	12” × 11” × 10” (W × H × D) 30.5cm × 27.9cm × 25.4cm
Shipping weight:	17 lbs / 7.7 kg max.

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

2.2.11 Environmental

ENVIRONMENTAL

Ambient operating temperature:–40°C to +60°C

Ambient storage temperature:40°C to +80°C

Humidity:	up to 90%, non-condensing
Altitude:	up to 2000 m
Pollution degree:	2

NOTE

At temperatures less than –20°C, the LCD contrast may be impaired.

2.2.12 Long-term Storage

LONG-TERM STORAGE

Environment: In addition to the above environmental considerations, the relay should be stored in an environment that is dry, corrosive-free, and not in direct sunlight.

Correct storage: Prevents premature component failures caused by environmental factors such as moisture or corrosive gases. Exposure to high humidity or corrosive environments will prematurely degrade the electronic components in any electronic device regardless of its use or manufacturer, unless specific precautions, such as those mentioned in the Environmental section above, are taken.

NOTE

It is recommended that all relays be powered up once per year, for one hour continuously, to avoid deterioration of electrolytic capacitors and subsequent relay failure.

Digital Energy
Multilin

489 Generator Management Relay

Chapter 3: Installation

3.1 Mechanical Installation

3.1.1 Description

The 489 is packaged in the standard GE Multilin 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.

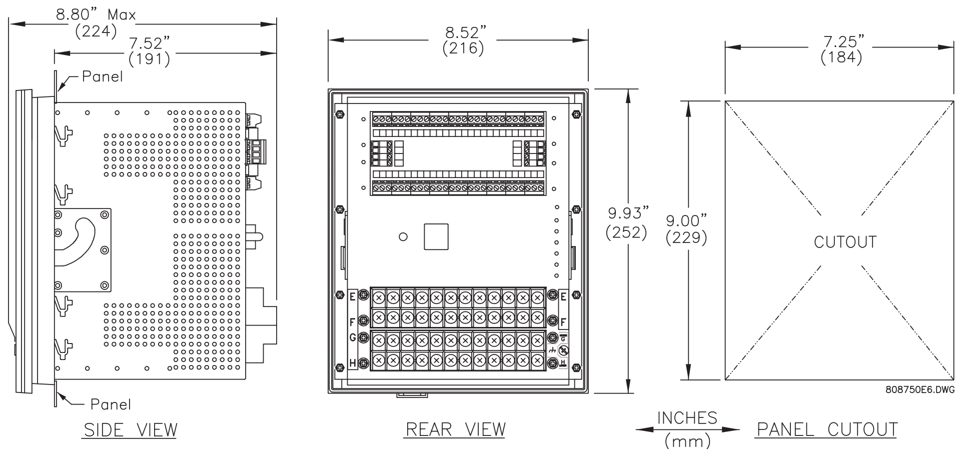


FIGURE 3–1: 489 Dimensions

To prevent unauthorized removal of the drawout unit, a wire lead seal can be installed in the slot provided on the handle as shown below. 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 3–2: Drawout Unit Seal

WARNING

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

3.1.2 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 model number, manufacture date, and special notes.

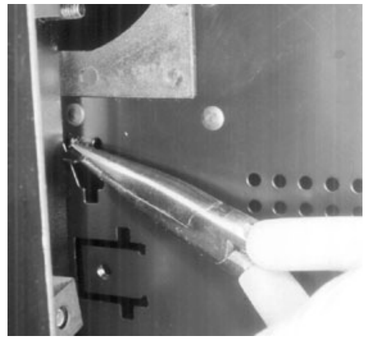
The unit label details the model number, type, serial number, file number, manufacture date, phase current inputs, special notes, overvoltage category, insulation voltage, pollution degree, control power, and output contact rating.

FIGURE 3–3: Product Case and Unit Labels

3.1.3 Installation

The 489 case, alone or adjacent to another SR-series unit, can be installed in a standard 19-inch rack panel (see *489 Dimensions* on page 3–2). Provision must be made for the front door to swing open without interference to, or from, adjacent equipment. The 489 unit is normally 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 the next section.

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 below. The case is now securely mounted, ready for panel wiring.



808704A1.CDR

FIGURE 3–4: Bend Up Mounting Tabs

3.1.4 Unit Withdrawal and Insertion

CAUTION

TURN OFF CONTROL POWER BEFORE DRAWING OUT OR RE-INSERTING THE RELAY TO PREVENT MALOPERATION!

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.

To remove the unit from the case:

- ▷ Open the cover by pulling the upper or lower corner of the right side, which will rotate about the hinges on the left.
- ▷ Release the locking latch, located below the locking handle, by pressing upward on the latch with the tip of a screwdriver.

FIGURE 3–5: Press Latch to Disengage Handle

- ▷ Grasp the locking handle in the center and pull firmly, rotating the handle up from the bottom of the unit until movement ceases.

FIGURE 3–6: Rotate Handle to Stop Position

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 3–7: Slide Unit out of Case

To insert the unit into the case:

- ▷ Raise the locking handle to the highest position.
- ▷ 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.
- ▷ Slide the unit into the case until the guide pins on the unit have engaged the guide slots on either side of the case.
- ▷ Grasp the locking handle from the center and press down firmly, rotating the handle from the raised position toward the bottom of the unit.

When the unit is fully inserted, the latch will be heard to click, locking the handle in the final position.

3.1.5 Ethernet Connection

If using the 489 with the Ethernet 10Base-T option, ensure that the network cable is disconnected from the rear RJ45 connector before removing the unit from the case. This prevents any damage to the connector.

The unit may also be removed from the case with the network cable connector still attached to the rear RJ45 connector, provided that there is at least 16 inches of network cable available when removing the unit from the case. This extra length allows the network cable to be disconnected from the RJ45 connector from the front of the switchgear panel. Once disconnected, the cable can be left hanging safely outside the case for re-inserting the unit back into the case.

The unit may be re-inserted by first connecting the network cable to the rear RJ45 connector of the 489 (see step 3 of *Unit Withdrawal and Insertion* on page 3–4).

CAUTION

Ensure that the network cable does not get caught inside the case while sliding in the unit. This may interfere with proper insertion to the case terminal blocks and damage the cable.

FIGURE 3–8: Ethernet Cable Connection

To ensure optimal response from the relay, the typical connection timeout should be set as indicated in the following table:

TCP/IP sessions	Timeout setting
up to 2	2 seconds
up to 4	3 seconds

CAUTION

The RS485 COM2 port is disabled if the Ethernet option is ordered.

3.1.6 Terminal Locations

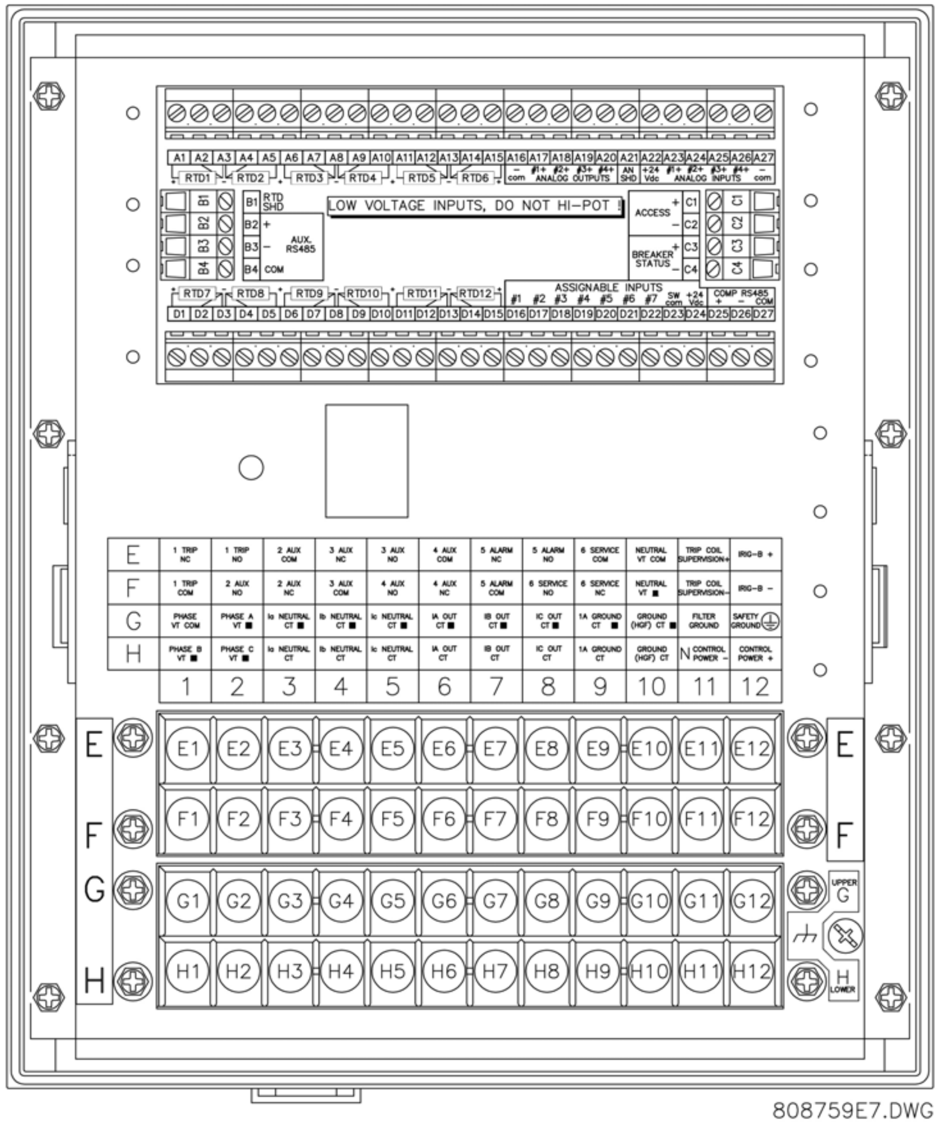


FIGURE 3–9: Terminal Layout

Table 3–1: 489 Terminal List

Terminal	Description	Terminal	Description
A01	RTD #1 Hot	D21	Assignable Switch 6
A02	RTD #1 Compensation	D22	Assignable Switch 7
A03	RTD Return	D23	Switch Common
A04	RTD #2 Compensation	D24	Switch +24 V DC
A05	RTD #2 Hot	D25	Computer RS485 +
A06	RTD #3 Hot	D26	Computer RS485 –
A07	RTD #3 Compensation	D27	Computer RS485 Common
A08	RTD Return	E01	1 Trip NC
A09	RTD #4 Compensation	E02	1 Trip NO
A10	RTD #4 Hot	E03	2 Auxiliary Common
A11	RTD #5 Hot	E04	3 Auxiliary NC
A12	RTD #5 Compensation	E05	3 Auxiliary NO
A13	RTD Return	E06	4 Auxiliary Common
A14	RTD #6 Compensation	E07	5 Alarm NC
A15	RTD #6 Hot	E08	5 Alarm NO
A16	Analog Output Common –	E09	6 Service Common
A17	Analog Output 1 +	E10	Neutral VT Common
A18	Analog Output 2 +	E11	Coil Supervision +
A19	Analog Output 3 +	E12	IRIG-B +
A20	Analog Output 4 +	F01	1 Trip Common
A21	Analog Shield	F02	2 Auxiliary NO
A22	Analog Input 24 V DC Supply +	F03	2 Auxiliary NC
A23	Analog Input 1 +	F04	3 Auxiliary Common
A24	Analog Input 2 +	F05	4 Auxiliary NO
A25	Analog Input 3 +	F06	4 Auxiliary NC
A26	Analog Input 4 +	F07	5 Alarm Common
A27	Analog Input Common –	F08	6 Service NO
B01	RTD Shield	F09	6 Service NC
B02	Auxiliary RS485 +	F10	Neutral VT +
B03	Auxiliary RS485 –	F11	Coil Supervision –
B04	Auxiliary RS485 Common	F12	IRIG-B –
C01	Access +	G01	Phase VT Common
C02	Access –	G02	Phase A VT •
C03	Breaker Status +	G03	Neutral Phase A CT •
C04	Breaker Status –	G04	Neutral Phase B CT •
D01	RTD #7 Hot	G05	Neutral Phase C CT •
D02	RTD #7 Compensation	G06	Output Phase A CT •
D03	RTD Return	G07	Output Phase B CT •
D04	RTD #8 Compensation	G08	Output Phase C CT •
D05	RTD #8 Hot	G09	1A Ground CT •
D06	RTD #9 Hot	G10	HGF Ground CT •
D07	RTD #9 Compensation	G11	Filter Ground
D08	RTD Return	G12	Safety Ground
D09	RTD #10 Compensation	H01	Phase B VT •
D10	RTD #10 Hot	H02	Phase C VT •
D11	RTD #11 Hot	H03	Neutral Phase A CT
D12	RTD #11 Compensation	H04	Neutral Phase B CT
D13	RTD Return	H05	Neutral Phase C CT
D14	RTD #12 Compensation	H06	Output Phase A CT
D15	RTD #12 Hot	H07	Output Phase B CT
D16	Assignable Switch 1	H08	Output Phase C CT
D17	Assignable Switch 2	H09	1A Ground CT
D18	Assignable Switch 3	H10	HGF Ground CT
D19	Assignable Switch 4	H11	Control Power –
D20	Assignable Switch 5	H12	Control Power +

3.2 Electrical Installation

3.2.1 Typical Wiring

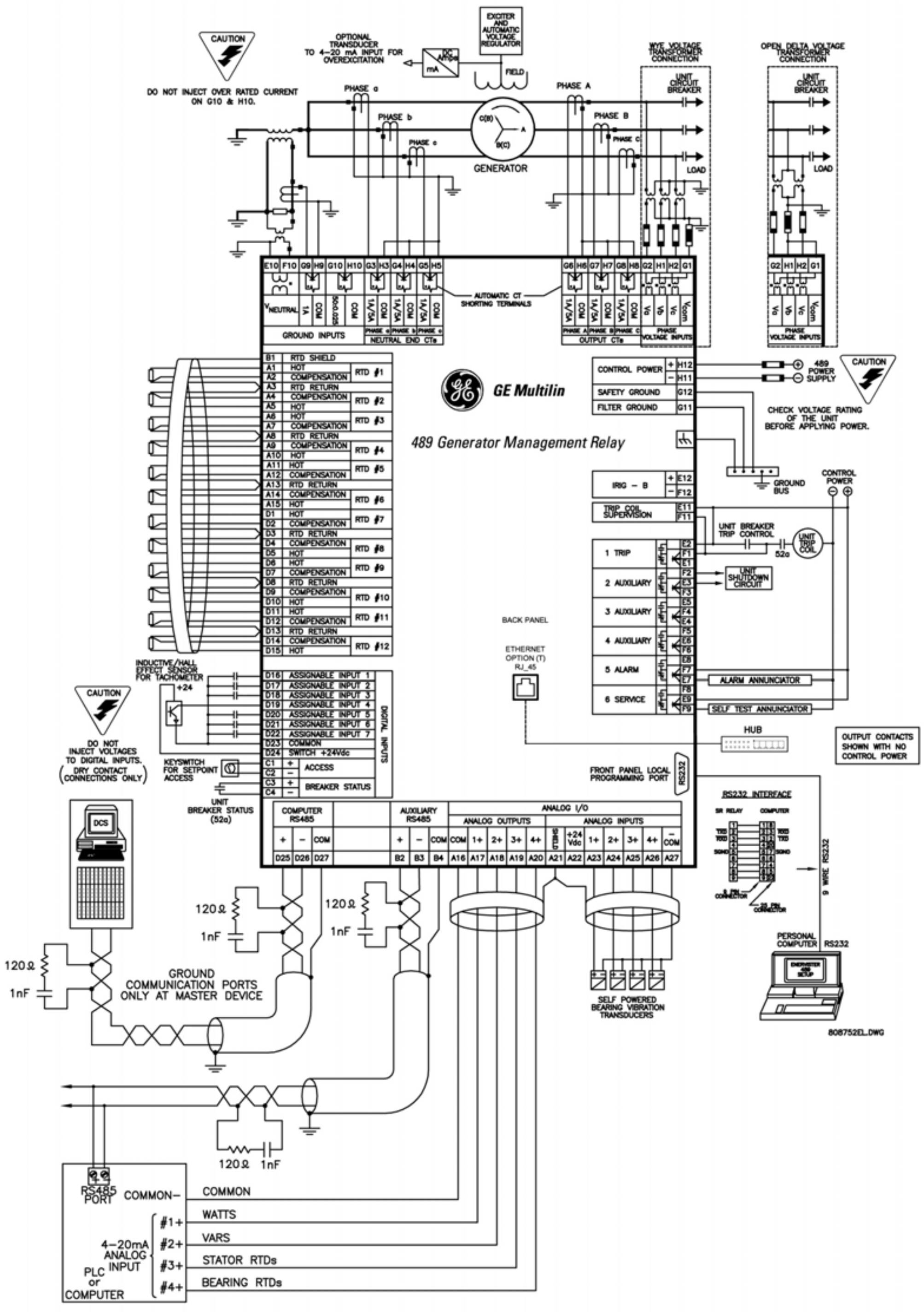


FIGURE 3–10: Typical Wiring Diagram

3.2.2 General Wiring Considerations

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 *Terminal Layout* on page 3–7 and *489 Terminal List* on page 3–8 for terminal arrangement, and *Typical Wiring Diagram* on page 3–10 for typical connections.

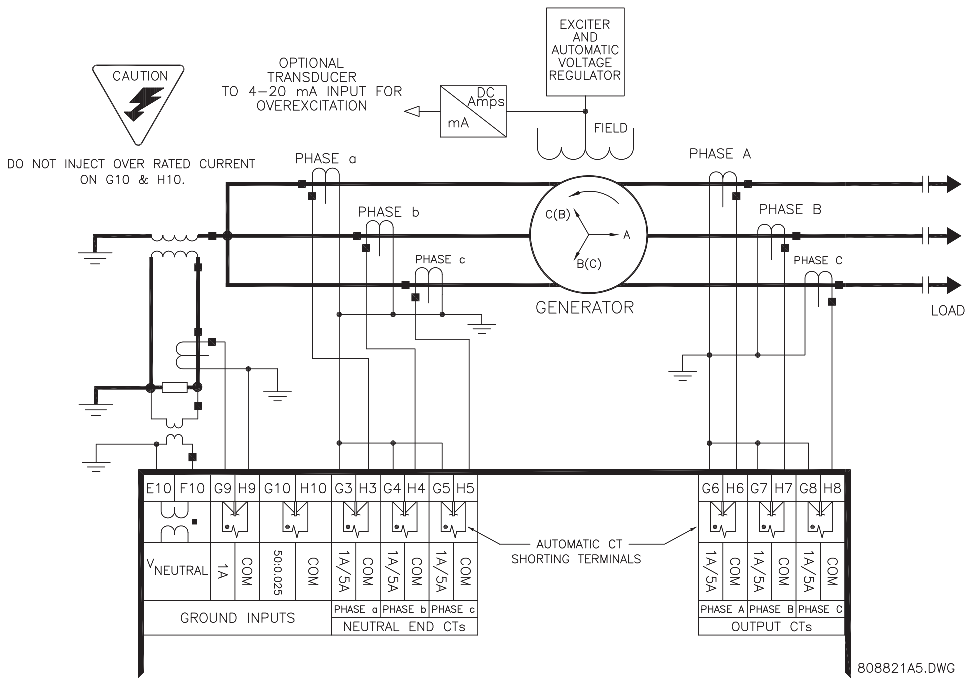


FIGURE 3–11: Typical Wiring (Detail)

3.2.3 Control Power

Control power supplied to the relay must match the installed power supply range. If the applied voltage does not match, damage to the unit may occur. All grounds MUST be connected for normal operation regardless of control power supply type.

The label found on the left side of the relay specifies its order code or model number. The installed power supply's operating range will be one of the following.

LO: 20 to 60 V DC or 20 to 48 V AC
HI: 88 to 300 V DC or 70 to 265 V AC

The relay should be connected directly to the ground bus, using the shortest practical path. A tinned copper, braided, shielding and bonding cable should be used. As a minimum, 96 strands of number 34 AWG should be used. Belden catalog number 8660 is suitable.

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.

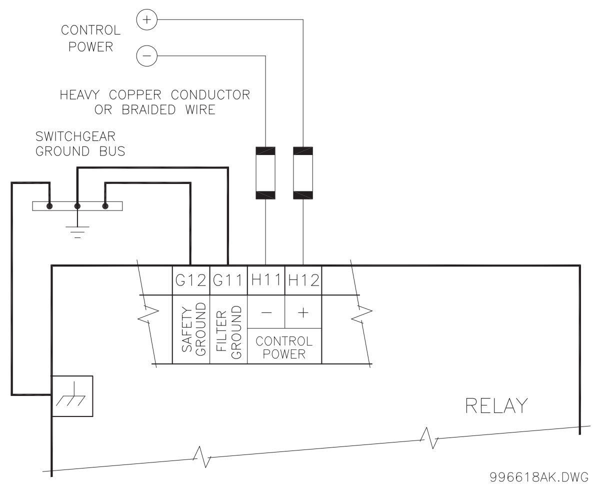


FIGURE 3–12: Control Power Connection

3.2.4 Current Inputs

Phase Current

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).

Ground Current

The 489 has a dual primary isolating transformer for ground CT connections. There are no internal ground connections on the ground current inputs. The ground CT circuits are shorted by automatic mechanisms on the case if the unit is withdrawn. The 1 A tap is used for 1 A or 5 A secondary CTs in either core balance or residual ground configurations. If the 1 A tap is used, the 489 measures up to 20 A secondary with a maximum ground CT ratio of 10000:1. The ground CT must be capable of driving the ground CT burden.

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

The HGF CT has a rating of 50:0.025. However if the HGF CT is used in conjunction with the 489, the relay assumes a fixed ratio of 5:0.0025. Therefore, the pickup level in primary amps will be Pickup × CT, where CT is equal to 5.

NOTE

Only one ground input should be wired. The other input should be unconnected.

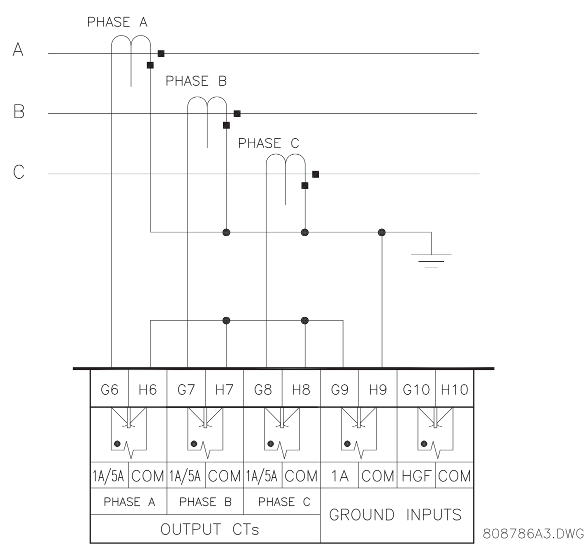


FIGURE 3–13: Residual Ground CT Connection

CAUTION

DO NOT INJECT OVER THE RATED CURRENT TO HGF TERMINAL (0.25 to 25 A PRIMARY).

The exact placement of a zero sequence CT to detect ground fault current is shown below. 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.

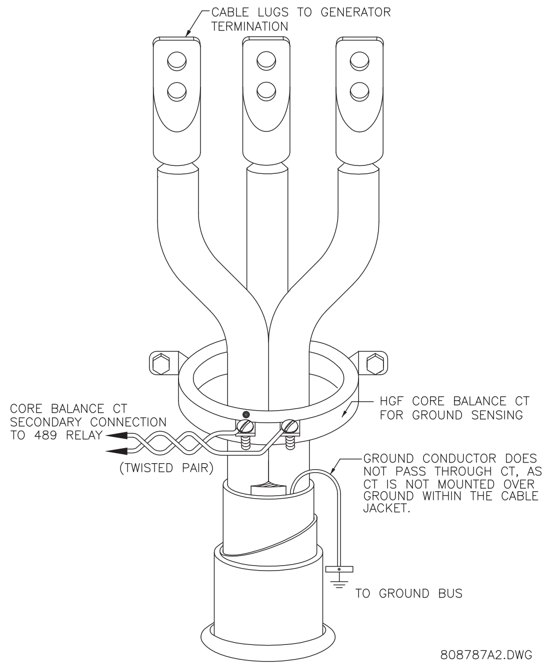


FIGURE 3–14: Core Balance Ground CT Installation – Unshielded Cable

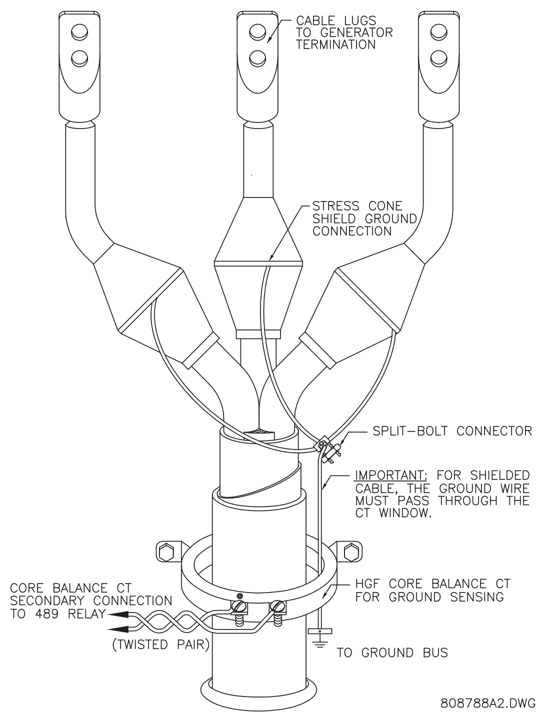


FIGURE 3–15: Core Balance Ground CT Installation – Shielded Cable

3.2.5 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 phase VT ratio is 300.00:1 and the maximum neutral VT ratio is 240.00:1. The two possible VT connections for generator terminal voltage measurement are open delta or wye (see *Typical Wiring Diagram* on page 3–10). The voltage channels are connected in wye internally, which means that the jumper shown on the delta-source connection of the Typical Wiring Diagram, 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.

3.2.6 Digital Inputs

CAUTION

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 *Typical Wiring Diagram* on page 3–10).

In addition, the +24 V DC 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 +24 V DC switch supply.

CAUTION

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

3.2.7 Analog Inputs

Terminals are provided on the 489 for the input of four 0 to 1 mA, 0 to 20 mA, or 4 to 20 mA 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 V with respect to the 489 safety ground.

In addition, the +24 V DC analog input supply is brought out for control power of loop powered transducers. Refer to the Specifications section of this manual for maximum current draw from this supply.

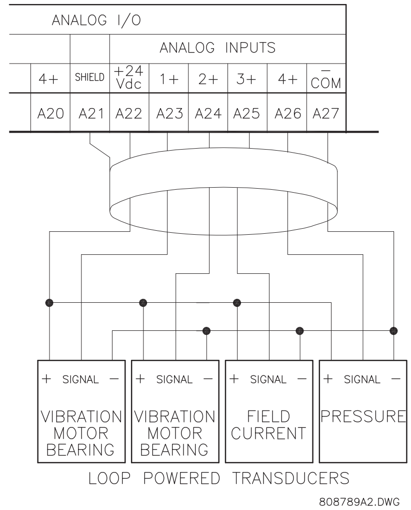


FIGURE 3–16: Loop Powered Transducer Connection

3.2.8 Analog Outputs

The 489 provides four analog output channels, which when ordered, provide a full-scale range of either 0 to 1 mA (into a maximum 10 kΩ impedance), or 4 to 20 mA (into a maximum 1.2K Ω impedance). Each channel can be configured to provide full-scale output sensitivity for any range of any measured parameter.

As shown in the *Typical Wiring Diagram* on page 3–10, these outputs share one common return. The 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 V 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:

$$R_{LOAD} = \frac{V_{FULL\text{-}SCALE}}{I_{MAX}} \quad \textbf{(EQ 3.1)}$$

For example, for a 0 to 1 mA input, if 5 V full scale corresponds to 1 mA, then R_{LOAD} = 5 V / 0.001 A = 5000 Ω. For a 4 to 20 mA input, this resistor would be R_{LOAD} = 5 V / 0.020 A = 250 Ω.

3.2.9 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: 100 Ω Platinum (DIN 43760), 100 Ω Nickel, 120 Ω 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 25 Ω per lead for platinum and nickel RTDs and 3 Ω per lead for copper RTDs. 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.

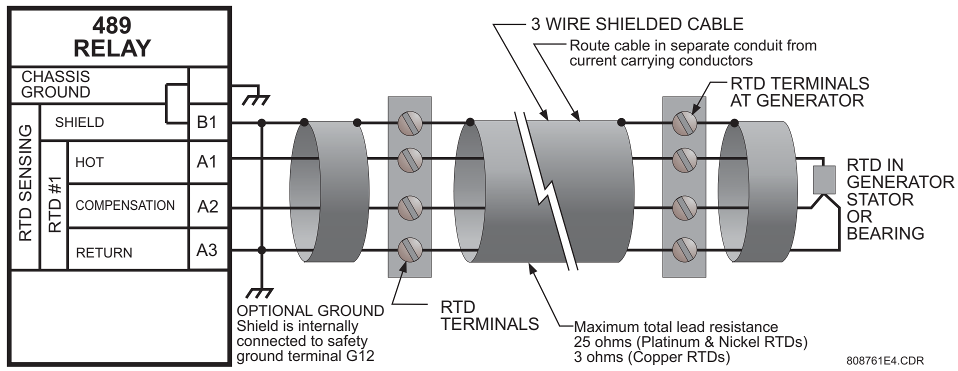


FIGURE 3–17: RTD Wiring

NOTE

IMPORTANT NOTE: 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 V 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.

3.2.10 Output Relays

There are six Form-C output relays (see *Outputs* on page 2–7). Five of the six relays are always non-failsafe, the 6 Service relay is always failsafe. As a failsafe, the 6 Service 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 6 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.

- **1 TRIP**: The trip relay should be wired such that the generator is taken offline when conditions warrant. For a breaker application, the NO 1 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 1 Trip relay output contacts, as shown in the *Typical Wiring Diagram* on page 3–10. With this connection made, the supervision input circuits will place an impedance across the contacts that will draw a current of 2 to 5 mA (for an external supply voltage from 30 to 250 V DC) 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.

- **2 AUXILIARY, 3 AUXILIARY, 4 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.
- **5 ALARM**: The alarm relay should connect to the appropriate annunciator or monitoring device.
- **6 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.

WARNING

Relay contacts must be considered unsafe to touch when the system is energized! If the customer requires the relay contacts for low voltage accessible applications, it is their responsibility to ensure proper insulation levels.

3.2.11 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.

3.2.12 RS485 Ports

Two independent two-wire RS485 ports are provided. Up to 32 489 relays 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. A suitable cable should have a characteristic impedance of 120 Ω (e.g. Belden #9841) and total wire length should not exceed 4000 feet (approximately 1200 metres). 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.

NOTE

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 below, to avoid ground loops.

Correct polarity is also essential. All 489s 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 Ω ¼ W resistor in series with a 1 nF capacitor across the '+' and '–' terminals. Observing these guidelines will result in a reliable communication system that is immune to system transients.

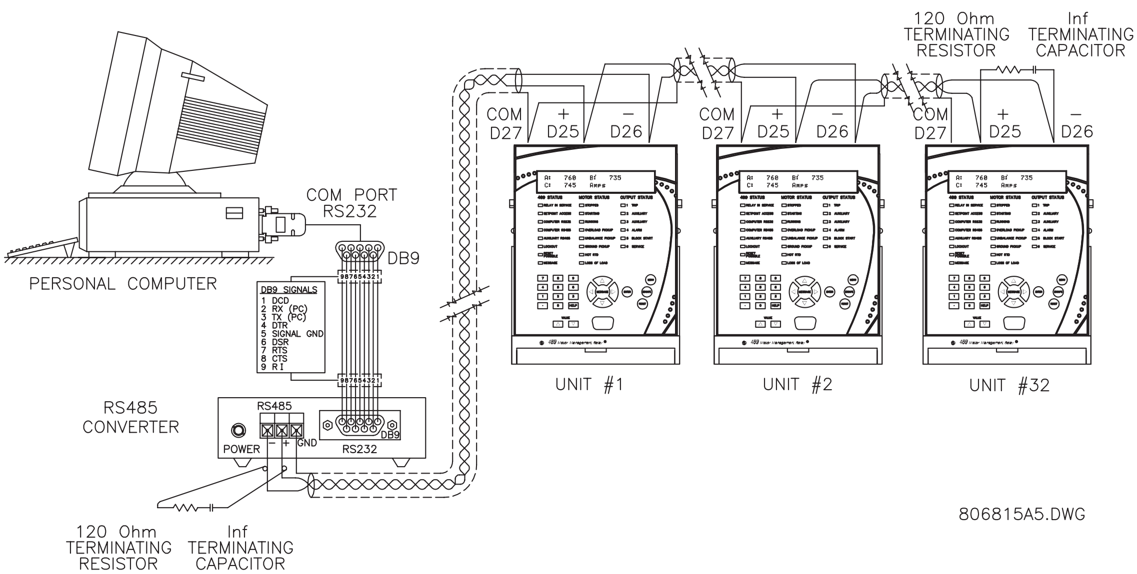


FIGURE 3–18: RS485 Communications Wiring

3.2.13 Dielectric Strength

It may be required to test a complete motor starter for dielectric strength ("flash" or hi-pot") with the 489 installed. The 489 is rated for 1.9 kV AC for 1 second, or 1.6 kV AC for 1 minute (per UL 508) isolation between relay contacts, CT inputs, VT inputs, trip coil supervision, and the safety ground terminal G12. Some precautions are required to prevent damage to the 489 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 electromagnetic 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 (<30 V), RTDs, analog inputs, analog outputs, digital inputs, and RS485 communication ports are not to be tested for dielectric strength under any circumstance (see below).

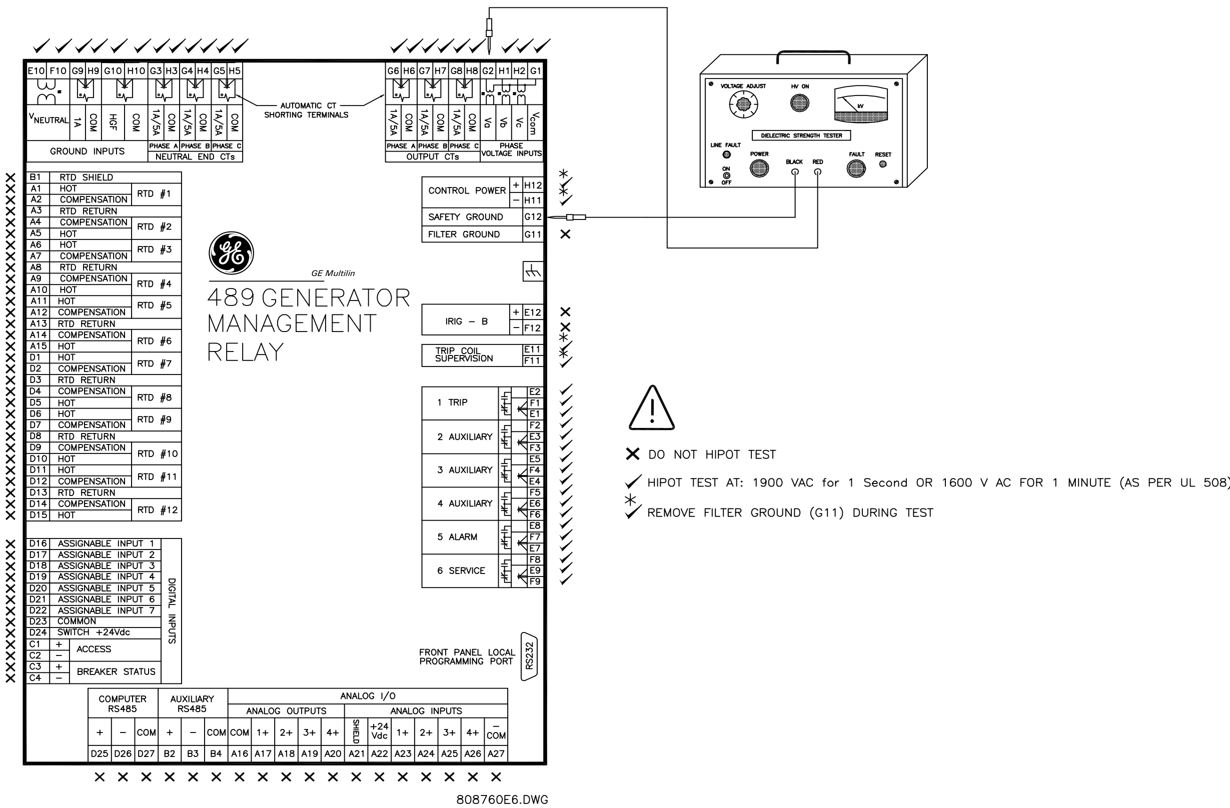


FIGURE 3–19: Testing the 489 for Dielectric Strength

Digital Energy
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489 Generator Management Relay

Chapter 4: Interfaces

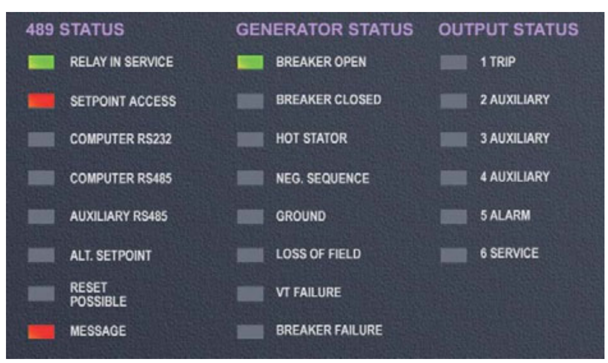
4.1 Faceplate Interface

4.1.1 Display

All messages appear on a 40-character liquid crystal display. Messages are in plain English and do not require the aid of an instruction manual for deciphering. When the user interface is not being used, the display defaults to the user-defined status messages. Any trip or alarm automatically overrides the default messages and is immediately displayed.

4.1.2 LED Indicators

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



808732A3.CDR

FIGURE 4–1: 489 LED Indicators

489 Status LED Indicators

- **489 IN SERVICE:** Indicates that control power is applied, all monitored input/output and internal systems are OK, the 489 has been programmed, and is in protection mode, not simulation mode. When in simulation or testing mode, the LED indicator will flash.
- **SETPOINT ACCESS:** Indicates that the 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 RS232 communications port. Remains on continuously if incoming data is valid.
- **COMPUTER RS485 / AUXILIARY RS485:** Flashes when there is any activity on the computer/auxiliary RS485 communications port. These LEDs remain on continuously 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 and the primary setpoint group is active. Remains on continuously 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 by setting the S3 DIGITAL INPUTS ▷▽ DUAL SETPOINTS ▷▽ ACTIVATE SETPOINT GROUP setpoint to “Group 2”.
- **RESET POSSIBLE:** A trip or latched alarm may be reset. Pressing the RESET key clears the trip/alarm.
- **MESSAGE:** Under normal conditions, the default messages selected during setpoint programming are displayed. If any alarm or trip condition is generated, a diagnostic message overrides the displayed message and this indicator flashes. If there is more than one condition present, MESSAGE ▼ can be used to scroll through the messages. Pressing any other key return to the normally displayed messages. While viewing normally displayed messages, the Message LED continues to flash if any diagnostic message is active.

▷ To return to the diagnostic messages from the normally displayed messages, press the MENU key until the following message is displayed:

```
■ TARGET MESSAGES [w]
```

▷ Now, press the MESSAGE ▶ key followed by the message ▼ key to scroll through the messages.
Note that diagnostic messages for alarms disappear with the condition while diagnostic messages for trips remain until cleared by a reset.

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 model trip 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 Status LED Indicators

- **1 TRIP:** The 1 Trip relay has operated (energized).
- **2 AUXILIARY:** The 2 Auxiliary relay has operated (energized).
- **3 AUXILIARY:** The 3 Auxiliary relay has operated (energized).
- **4 AUXILIARY:** The 4 Auxiliary relay has operated (energized).
- **5 ALARM:** The 5 Alarm relay has operated (energized).
- **6 SERVICE:** The 6 Service relay has operated (de-energized, 6 Service is fail-safe, normally energized).

4.1.3 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 with the EnerVista 489 Setup software. Local interrogation of setpoint and actual values is also possible. New firmware may be downloaded to the 489 flash memory through this port. Upgrading the relay firmware does not require a hardware EEPROM change.

4.1.4 Keypad

Description

The 489 display messages are organized into main menus, pages, and sub-pages. There are three main menus labeled Setpoints, Actual Values, and Target Messages.

▷ Press the MENU key followed by the MESSAGE ▼ key to scroll through the three main menu headers, which appear in sequence as follows:

```
SETPOINTS          [w]
```

```
ACTUAL VALUES      [w]

```

```
TARGET MESSAGES    [w]

```

▷ Press the MESSAGE ▶ key or the ENTER key from these main menu pages to display the corresponding menu page.
Use the MESSAGE ▼ and MESSAGE ▲ keys to scroll through the page headers.

When the display shows **SETPOINTS**,

▷ Press the MESSAGE ▶ key or the ENTER key to display the page headers of programmable parameters (referred to as setpoints in the manual).

When the display shows **ACTUAL VALUES**,

▷ Press the MESSAGE ▶ key or the ENTER key to display the page headers of measured parameters (referred to as actual values in the manual).

When the display shows **TARGET MESSAGES**,

▷ Press the MESSAGE ▶ key or the ENTER key to display the page headers of event messages or alarm conditions.

Each page is broken down further into logical sub-pages. The MESSAGE ▼ and MESSAGE ▲ keys are used to navigate through the sub-pages. A summary of the setpoints and actual values can be found in the chapters 5 and 6, respectively.

The ENTER key is dual-purpose. It is used to enter the sub-pages and to store altered setpoint values into memory to complete the change. The MESSAGE ▶ key can also be used to enter sub-pages but not to store altered setpoints.

The ESCAPE key is also dual-purpose. It is used to exit the sub-pages and to cancel a setpoint change. The MESSAGE ◀ key can also be used to exit sub-pages and to cancel setpoint changes.

The VALUE keys are used to scroll through the possible choices of an enumerated setpoint. They also decrement and increment numerical setpoints. Numerical setpoints may also be entered through the numeric keypad.

▷ Press the HELP key to display context-sensitive information about setpoints such as the range of values and the method of changing the setpoint.
Help messages will automatically scroll through all messages currently appropriate.

The RESET key resets any latched conditions that are not presently active. This includes resetting latched output relays, latched Trip LEDs, breaker operation failure, and trip coil failure.

The MESSAGE ▼ and MESSAGE ▲ keys scroll through any active conditions in the relay. Diagnostic messages are displayed indicating the state of protection and monitoring elements that are picked up, operating, or latched. When the Message LED is on, there are messages to be viewed with the MENU key by selecting target messages as described earlier.

Entering Alphanumeric Text

Text setpoints have data values that are fixed in length but user-defined in character. They may be comprised of upper case letters, lower case letters, numerals, and a selection of special characters. The editing and storing of a text value is accomplished with the use of the decimal [.], VALUE, and ENTER keys.

▷ Move to message **S3 DIGITAL INPUTS** ▷▽ **GENERAL INPUT A** ▷ **ASSIGN DIGITAL INPUT**, and scrolling with the VALUE keys, select “Input 1”. The relay will display the following message:

```
ASSIGN DIGITAL
INPUT: Input 1
```

▷ Press the MESSAGE ▼ key to view the **INPUT NAME** setpoint. The name of this user-defined input will be changed in this example from the generic “Input A” to something more descriptive.

If an application is to be using the relay as a station monitor, it is more informative to rename this input “Stn. Monitor”.

▷ Press the decimal [.] to enter the text editing mode. The first character will appear underlined as follows:

```
INPUT NAME:
Input A
```

▷ Press the VALUE keys until the character “S” is displayed in the first position.

▷ Press the decimal [.] key to store the character and advance the cursor to the next position.

▷ Change the second character to a “t” in the same manner.

▷ Continue entering characters in this way until all characters of the text “Stn. Monitor” are entered.
Note that a space is selected like a character.
If a character is entered incorrectly, press the decimal [.] key repeatedly until the cursor returns to the position of the error. Re-enter the character as required.

▷ Once complete, press the ENTER key to remove the solid cursor and view the result.
Once a character is entered, by pressing the ENTER key, it is automatically saved in Flash Memory, as a new setpoint.

```
INPUT NAME:
Stn. Monitor
```

The 489 does not have '+' or '–' keys. Negative numbers may be entered in one of two manners.

- Immediately pressing one of the VALUE keys causes the setpoint to scroll through its range including any negative numbers.
- After entering at least one digit of a numeric setpoint value, pressing the VALUE keys changes the sign of the value where applicable.

4.1.5 Setpoint Entry

To store any setpoints, terminals C1 and C2 (access terminals) must be shorted (a keyswitch may be used for security). There is also a setpoint passcode feature that restricts access to setpoints. The passcode must be entered to allow the changing of setpoint values. A passcode of "0" effectively turns off the passcode feature - in this case only the access jumper is required for changing setpoints. If no key is pressed for 5 minutes, access to setpoint values will be restricted until the passcode is entered again. To prevent setpoint access before the 5 minutes expires, the unit may be turned off and back on, the access jumper may be removed, or the SETPOINT ACCESS setpoint may be changed to "Restricted". The passcode cannot be entered until terminals C1 and C2 (access terminals) are shorted. When setpoint access is allowed, the Setpoint Access LED indicator on the front of the 489 will be lit.

Setpoint changes take effect immediately, even when generator is running. However, changing setpoints while the generator is running is not recommended as any mistake may cause a nuisance trip.

The following procedure may be used to access and alter setpoints. This specific example refers to entering a valid passcode to allow access to setpoints if the passcode was "489".

▷ Press the MENU key to access the header of each menu, which will be displayed in the following sequence:

```
SETPOINTS            [w]
```

```
ACTUAL VALUES        [w]
```

```
TARGET MESSAGES      [w]
```

▷ Press the MENU key until the display shows the header of the setpoints menu.

▷ Press the MESSAGE ▶ or ENTER key to display the header for the first setpoints page.
The set point pages are numbered, have an 'S' prefix for easy identification and have a name which gives a general idea of the setpoints available in that page.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through all the available setpoint page headers.
Setpoint page headers look as follows:

```
■ SETPOINTS          [w]
  S1 489 SETUP
```

To enter a given setpoints page,

▷ Press the MESSAGE ▶ or ENTER key.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through sub-page headers until the required message is reached.
The end of a page is indicated by the message **END OF PAGE**. The beginning of a page is indicated by the message **TOP OF PAGE**.

Each page is broken further into subgroups.

▷ Press MESSAGE ▼ or MESSAGE ▲ to cycle through subgroups until the desired subgroup appears on the screen.

▷ Press the MESSAGE ▶ or ENTER key to enter a subgroup.

```
■ PASSCODE           [w]
```

Each sub-group has one or more associated setpoint messages.

▷ Press the MESSAGE ▼ or MESSAGE ▲ keys to scroll through setpoint messages until the desired message appears.

```
ENTER PASSCODE
FOR ACCESS:
```

The majority of setpoints are changed by pressing the VALUE keys until the desired value appears, and then pressing ENTER. Numeric setpoints may also be entered through the numeric keys (including decimals). If the entered setpoint is out of range, the original setpoint value reappears. If the entered setpoint is out of step, an adjusted value will be stored (e.g. 101 for a setpoint that steps 95, 100, 105 is stored as 100). If a mistake is made entering the new value, pressing ESCAPE returns the setpoint to its original value. Text editing is a special case described in detail in *Entering Alphanumeric Text* on page 4–5. Each time a new setpoint is successfully stored, a message will flash on the display stating **NEW SETPOINT HAS BEEN STORED**.

▷ Press the 4, 8, 9 keys, then press ENTER.
The following flash message is displayed:

```
NEW SETPOINT
HAS BEEN STORED
```

and the display returns to:

```
SETPOINT ACCESS:
PERMITTED
```

▷ Press ESCAPE or MESSAGE ◀ to exit the subgroup.
Pressing ESCAPE or MESSAGE ◀ numerous times will always return the cursor to the top of the page.

4.1.6 Diagnostic Messages

Diagnostic messages are automatically displayed for any active conditions in the relay such as trips, alarms, or asserted logic inputs. These messages provide a summary of the present state of the relay. The Message LED flashes when there are diagnostic messages available; press the MENU key until the relay displays **TARGET MESSAGES**, then press the MESSAGE ▶ key, followed by the MESSAGE ▼ key, to scroll through the messages. For additional information and a complete list of diagnostic messages, refer to *Diagnostic Messages* on page 6–32.

4.1.7 Self-Test Warnings

The 489 relay performs self test diagnostics at initialization (after power up), and continuously as a background task to ensure every testable unit of the hardware and software is functioning correctly. There are two types of self-test warnings indicating either a minor or major problem. Minor problems indicate a problem with the relay that does not compromise protection. Major problems indicate a very serious relay problem which comprises all aspects of relay operation.

Upon detection of either a minor or a major problem the relay will:

- De-energize the self-test warning relay
- Light the self-test warning LED
- Flash a diagnostic message periodically on the display screen

The 489 self-test warnings are shown below.

Table 4–1: Self-Test Warnings

Message	Severity	Description
`Self-Test Warning 1` `Replace Immediately`	Major	This warning is caused by detection of a corrupted location in the program memory as determined by a CRC error checking code. Any function of the relay is susceptible to malfunction from this failure.
`Self-Test Warning 2` `Replace Immediately`	Major	This warning is caused by a failure of the analog to digital converter. The integrity of system input measurements is affected by this failure.
`Self-Test Warning 3` `Replace Immediately`	Major	This warning is caused by a failure of the analog to digital converter. The integrity of system input measurements is affected by this failure.
`Self-Test Warning 5` `Replace Immediately`	Major	This warning is caused by out of range reading of self test RTD 13. The integrity of system input measurements is affected by this failure.
`Self-Test Warning 6` `Replace Immediately`	Major	This warning is caused by out of range reading of self test RTD 14. The integrity of system input measurements is affected by this failure.
`Self-Test Warning 7` `Replace Immediately`	Major	This warning is caused by out of range reading of self test RTD15. The integrity of system input measurements is affected by this failure.

Table 4–1: Self-Test Warnings

Message	Severity	Description
`Self-Test Warning 8` `Replace Immediately`	Major	This warning is caused by out of range reading of self test RTD16. The integrity of system input measurements is affected by this failure.
`Clock Not Set` `Program Date/Time`	Minor	Occurs if the clock has not been set.
`Unit Temp. Exceeded` `Service/CheckAmbient`	Minor	Caused by the detection of unacceptably low (less than –40°C) or high (greater than 85°C) temperatures detected inside the unit.
`Unit Not Calibrated` `Replace Immediately`	Minor	This warning occurs when the relay has not been factory calibrated.
`Relay Not Configured` `Consult User Manual`	Minor	This warning occurs when the 489 CT Primary or Generator parameters are not set.
`Service Required` `Schedule Maintenance`	Minor	This warning is caused by a failure of the Real Time Clock circuit. The ability of the relay to maintain the current date and time is lost.

4.1.8 Flash Messages

Flash messages are warning, error, or general information messages displayed in response to certain key presses. The length of time these messages remain displayed can be programmed in **S1 RELAY SETUP** ▷▽ **PREFERENCES** ▷▽ **DEFAULT MESSAGE CYCLE TIME**. The factory default flash message time is 4 seconds. For additional information and a complete list of flash messages, refer to *Flash Messages* on page 6–33.

4.2 EnerVista Software Interface

4.2.1 Overview

The front panel provides local operator interface with a liquid crystal display. The EnerVista 489 Setup software provides a graphical user interface (GUI) as one of two human interfaces to a 489 device. The alternate human interface is implemented via the device's faceplate keypad and display (see the first section in this chapter).

The EnerVista 489 Setup software provides a single facility to configure, monitor, maintain, and trouble-shoot the operation of relay functions, connected over serial communication networks. It can be used while disconnected (i.e. off-line) or connected (i.e. on-line) to a 489 device. In off-line mode, setpoint files can be created for eventual downloading to the device. In on-line mode, you can communicate with the device in real-time.

This no-charge software, provided with every 489 relay, can be run from any computer supporting Microsoft Windows® 95 or higher. This chapter provides a summary of the basic EnerVista 489 Setup software interface features. The EnerVista 489 Setup help file provides details for getting started and using the software interface.

With the EnerVista 489 Setup running on your PC, it is possible to

- Program and modify setpoints
- Load/save setpoint files from/to disk
- Read actual values and monitor status
- Perform waveform capture and log data
- Plot, print, and view trending graphs of selected actual values
- Download and playback waveforms
- Get help on any topic

4.2.2 Hardware

Communications from the EnerVista 489 Setup to the 489 can be accomplished three ways: RS232, RS485, and Ethernet (requires the MultiNet adapter) communications. The following figures below illustrate typical connections for RS232 and RS485 communications. For additional details on Ethernet communications, please see the MultiNet manual (GE Publication number GEK-106498).

FIGURE 4–2: Communications using The Front RS232 Port

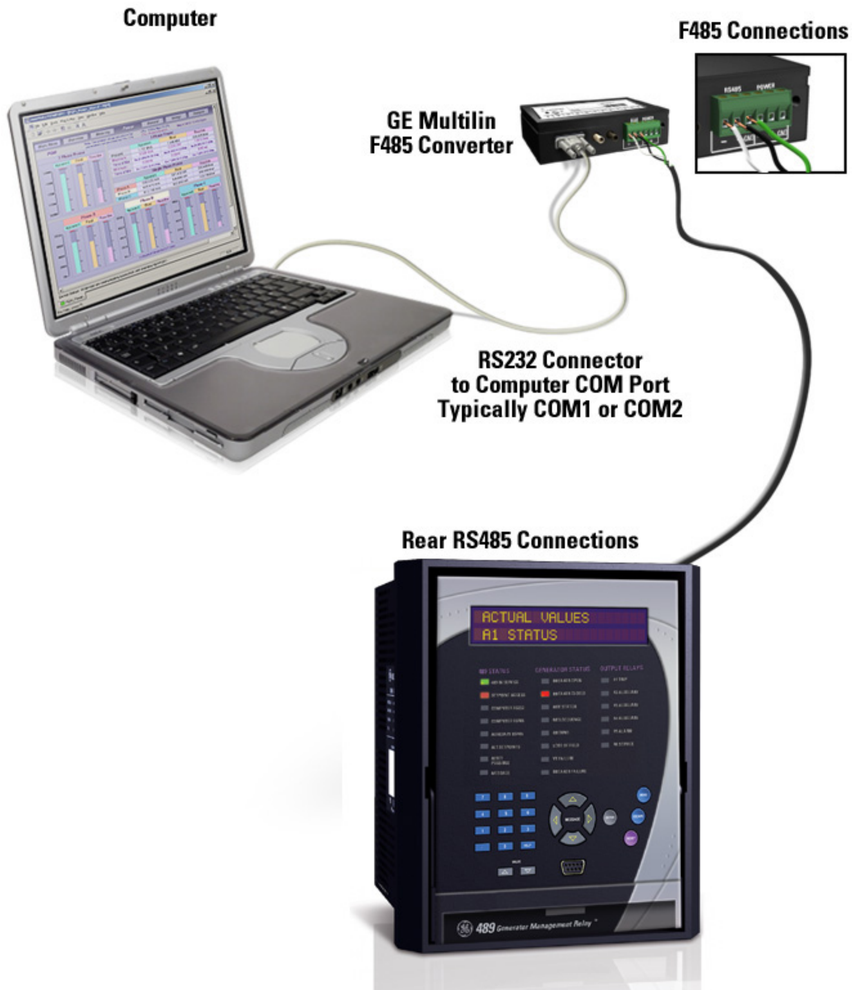


FIGURE 4–3: Communications using Rear RS485 Port

4.2.3 Installing the EnerVista 489 Setup Software

The following minimum requirements must be met for the EnerVista 489 Setup software to operate on your computer.

- Pentium class or higher processor (Pentium II 400 MHz or better recommended)
- Microsoft Windows 95, 98, 98SE, ME, NT 4.0 (SP4 or higher), 2000, XP
- Internet Explorer version 4.0 or higher (required libraries)
- 128 MB of RAM (256 MB recommended)
- Minimum of 200 MB hard disk space

A list of qualified modems for serial communications is shown below:

- US Robotics external 56K Faxmodem 5686
- US Robotics external Sportster 56K X2
- PCTEL 2304WT V.92 MDC internal modem

After ensuring these minimum requirements, use the following procedure to install the EnerVista 489 Setup software from the enclosed GE EnerVista CD.

▷ Insert the GE EnerVista CD into your CD-ROM drive.

▷ Click the **Install Now** button and follow the installation instructions to install the no-charge EnerVista software on the local PC.

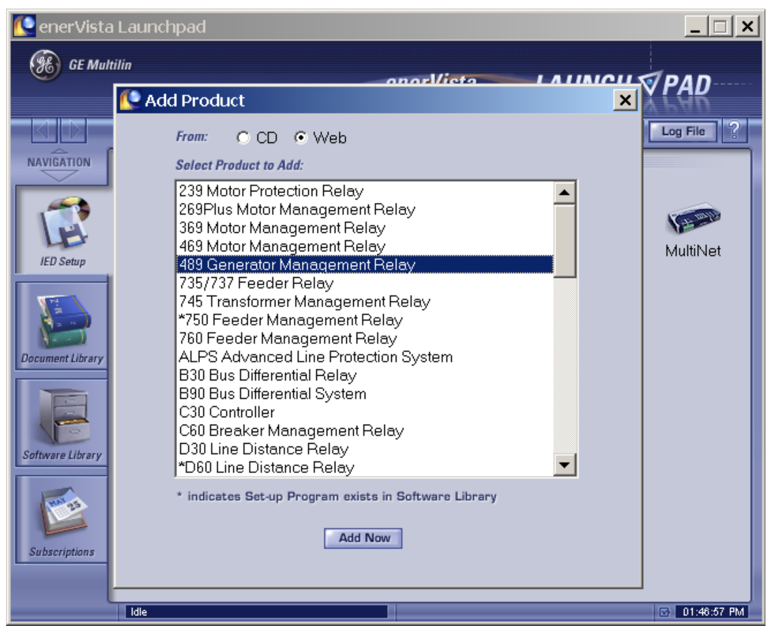
▷ When installation is complete, start the EnerVista Launchpad application.

▷ Click the **IED Setup** section of the **Launch Pad** window.

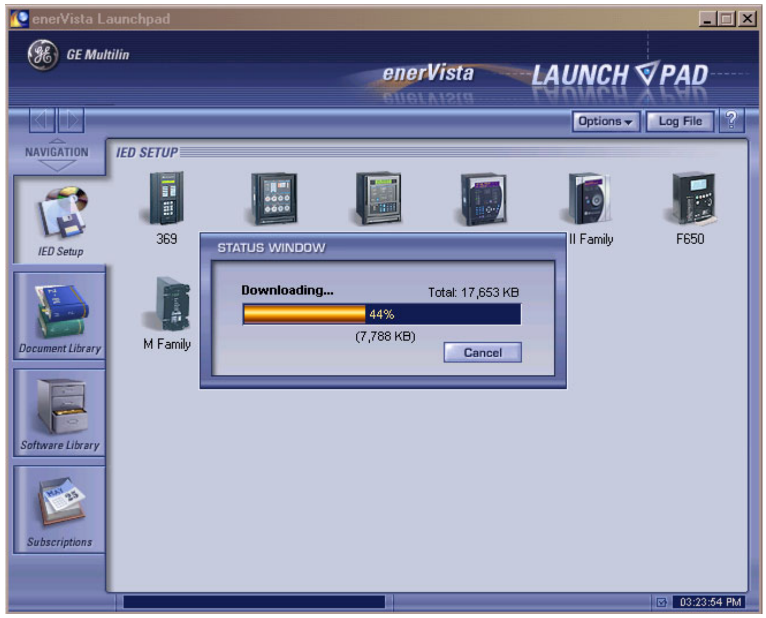
▷ In the EnerVista Launch Pad window, click the **Add Product** button and select the "489 Generator Management Relay" from the Install Software window as shown below.

▷ Select the "Web" option to ensure the most recent software release, or select "CD" if you do not have a web connection.

▷ Click the **Add Now** button to list software items for the 489.



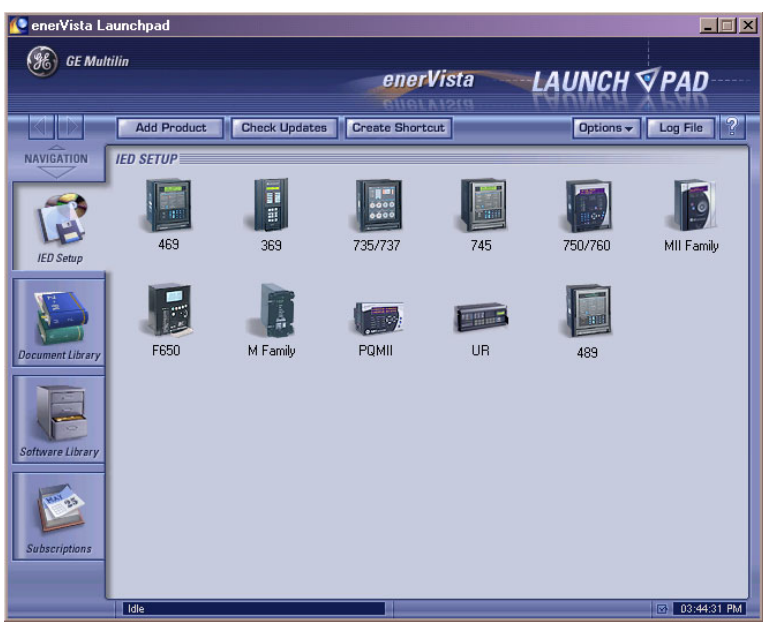
EnerVista Launchpad will obtain the latest installation software from the Web or CD and automatically start the installation process. A status window with a progress bar will be shown during the downloading process.



▷ Select the complete path, including the new directory name, where the EnerVista 489 Setup software will be installed.

▷ Click on Next to begin the installation.
The files will be installed in the directory indicated and the installation program will automatically create icons and add EnerVista 489 Setup software to the Windows start menu.

▷ Click Finish to end the installation.
The 489 device will be added to the list of installed IEDs in the EnerVista Launchpad window, as shown below.



4.3 Connecting EnerVista 489 Setup to the Relay

4.3.1 Configuring Serial Communications

Before starting, verify that the serial cable is properly connected to either the RS232 port on the front panel of the device (for RS232 communications) or to the RS485 terminals on the back of the device (for RS485 communications). See *Hardware* on page 4–10 for connection details.

This example demonstrates an RS232 connection. For RS485 communications, the GE Multilin F485 converter will be required. Refer to the F485 manual for additional details. To configure the relay for Ethernet communications, see *Configuring Ethernet Communications* on page 4–17.

▷ Install and start the latest version of the EnerVista 489 Setup software (available from the GE EnerVista CD).
See the previous section for the installation procedure.

▷ Click on the **Device Setup** button to open the Device Setup window.

▷ Click the **Add Site** button to define a new site.

▷ Enter the desired site name in the **Site Name** field.
If desired, a short description of site can also be entered along with the display order of devices defined for the site.
In this example, we will use “Pumping Station 1” as the site name.

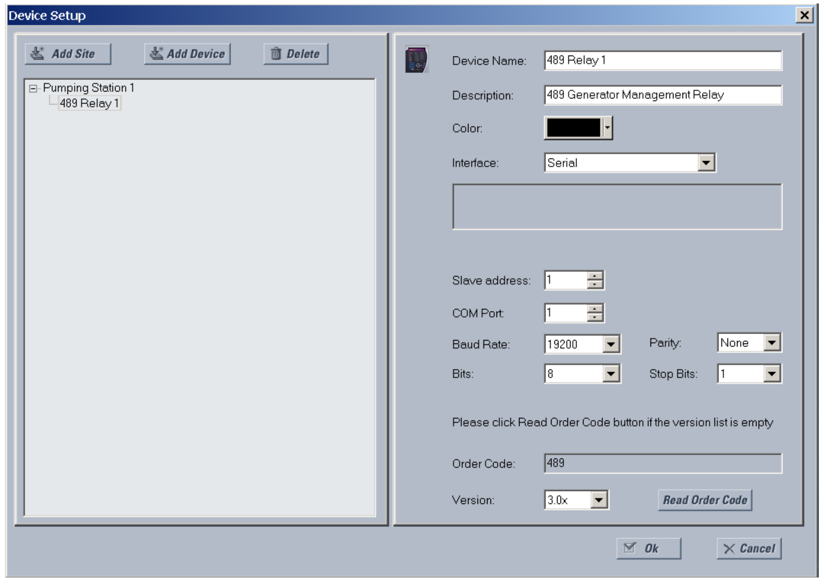
▷ Click the **OK** button when complete.

The new site will appear in the upper-left list in the EnerVista 489 Setup window.

▷ Click the **Add Device** button to define the new device.

▷ Enter the desired name in the **Device Name** field and a description (optional) of the site.

▷ Select "Serial" from the Interface drop-down list.
This will display a number of interface parameters that must be entered for proper RS232 functionality.



▷ Enter the slave address and COM port values (from the **S1 489 SETUP** ▷▽ **COMMUNICATIONS** menu) in the Slave Address and COM Port fields.

▷ Enter the physical communications parameters (baud rate and parity setpoints) in their respective fields.
Note that when communicating to the relay from the front port, the default communications setpoints are a baud rate of 9600, with slave address of 1, no parity, 8 bits, and 1 stop bit. **These values cannot be changed**.

▷ Click the **Read Order Code** button to connect to the 489 device and upload the order code.
If a communications error occurs, ensure that the 489 serial communications values entered in the previous step correspond to the relay setting values.

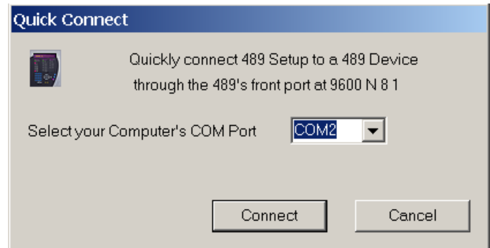
▷ Click **OK** when the relay order code has been received.
The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 489 Setup window.

The 489 Site Device has now been configured for serial communications. Proceed to *Connecting to the Relay* on page 4–19 to begin communications.

4.3.2 Using the Quick Connect Feature

The Quick Connect button can be used to establish a fast connection through the front panel RS232 port of a 489 relay.

▷ Press the Quick Connect button.
The following window will appear:

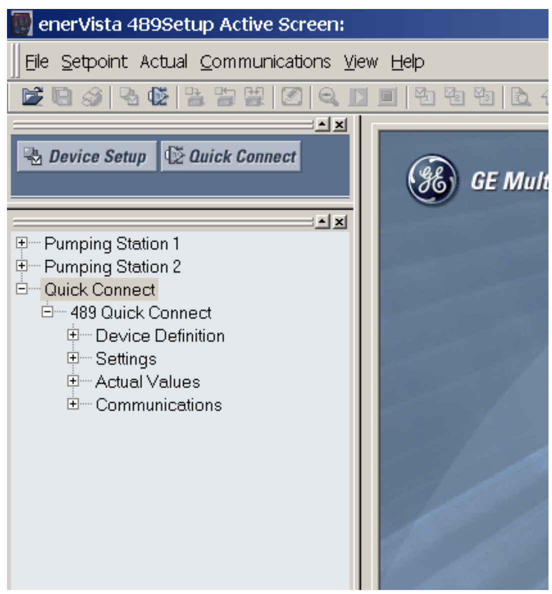


As indicated by the window, the Quick Connect feature quickly connects the EnerVista 489 Setup software to a 489 front port with the following setpoints: 9600 baud, no parity, 8 bits, 1 stop bit.

▷ Select the PC communications port connected to the relay.

▷ Press the **Connect** button.

The EnerVista 489 Setup software will display a window indicating the status of communications with the relay. When connected, a new Site called "Quick Connect" will appear in the Site List window. ***The properties of this new site cannot be changed***.



The 489 Site Device has now been configured via the Quick Connect feature for serial communications. Proceed to *Connecting to the Relay* on page 4–19 to begin communications.

4.3.3 Configuring Ethernet Communications

▷ Before starting, verify that the Ethernet cable is properly connected to the RJ-45 Ethernet port.

▷ Install and start the latest version of the EnerVista 489 Setup software (available from the GE EnerVista CD).
See the previous section for the installation procedure.

▷ Click on the **Device Setup** button to open the Device Setup window.

▷ Click the **Add Site** button to define a new site.

▷ Enter the desired site name in the **Site Name** field.
If desired, a short description of site can also be entered along with the display order of devices defined for the site. In this example, we will use “Pumping Station 2” as the site name.

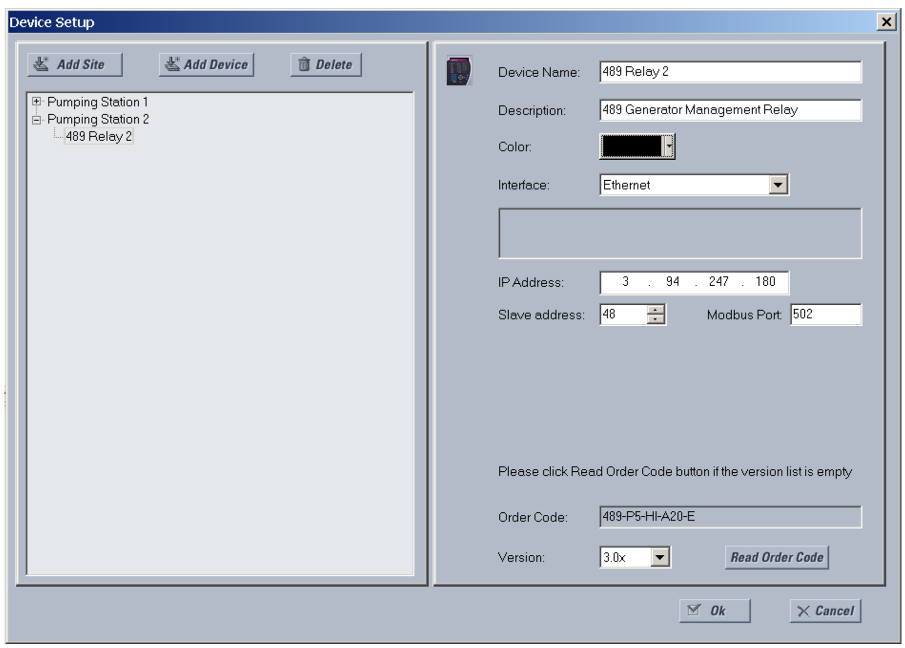
▷ Click the **OK** button when complete.

The new site will appear in the upper-left list.

▷ Click the **Add Device** button to define the new device.

▷ Enter the desired name in the **Device Name** field and a description (optional).

▷ Select “Ethernet” from the Interface drop-down list.
This will display a number of interface parameters that must be entered for proper Ethernet functionality.



▷ Enter the IP address assigned to the relay.

▷ Enter the slave address and Modbus port values (from the **S1 489 SETUP** ▷▽ **COMMUNICATIONS** menu) in the **Slave Address** and **Modbus Port** fields.

▷ Click the **Read Order Code** button to connect to the 489 device and upload the order code.
If a communications error occurs, ensure that the 489 Ethernet communications values entered in the previous step correspond to the relay setting values.

▷ Click **OK** when the relay order code has been received.
The new device will be added to the Site List window (or Online window) located in the top left corner of the main EnerVista 489 Setup window.

The 489 Site Device has now been configured for Ethernet communications. Proceed to the following section to begin communications.

4.3.4 Connecting to the Relay

Now that the communications parameters have been properly configured, the user can easily connect to the relay.

▷ Expand the Site list by double clicking on the site name or clicking on the «+» box to list the available devices for the given site (for example, in the “Pumping Station 1” site shown below).

▷ Expand the desired device trees by clicking the «+» box.
The following list of headers is shown for each device:

- Device Definitions
- Setpoints
- Actual Values
- Commands
- Communications

▷ Expand the **Setpoints > Protection > Current Elements** list item and select the Phase Overcurrent tab to open the Phase Overrcurrent setpoint window as shown below:

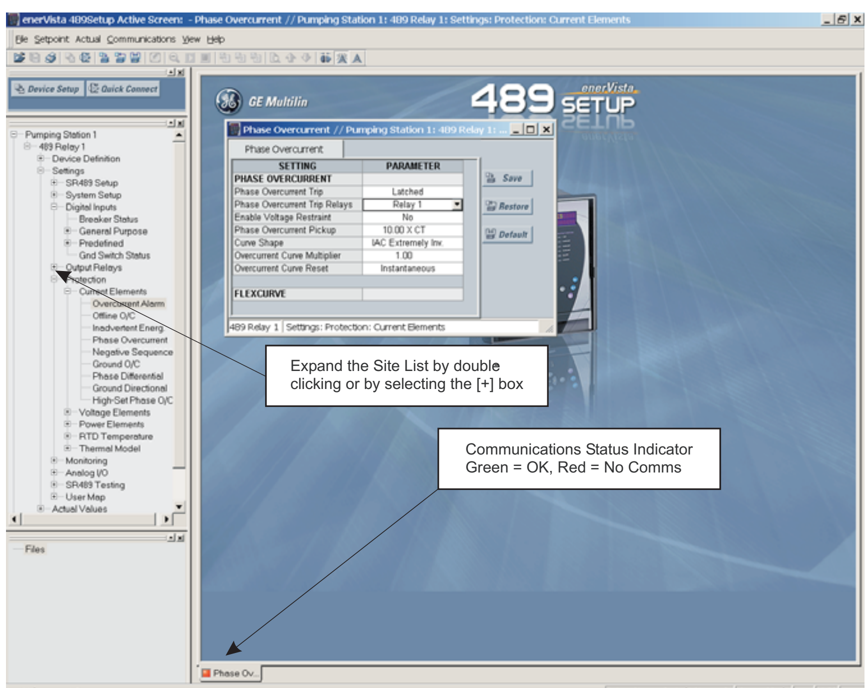


FIGURE 4–4: Main Window after Connection

The Phase Overcurrent setpoint window will open with a corresponding status indicator on the lower left of the EnerVista 489 Setup window.

▷ If the status indicator is red, verify that the serial cable is properly connected to the relay, and that the relay has been properly configured for communications (steps described earlier).

Setpoints can now be edited, printed, or changed according to user specifications. Other setpoint and commands windows can be displayed and edited in a similar manner. Actual values windows are also available for display. These windows can be locked, arranged, and resized at will.

Note

NOTE

Refer to the EnerVista 489 Setup help file for additional information about using the software.

4.4 Working with Setpoints and Setpoint Files

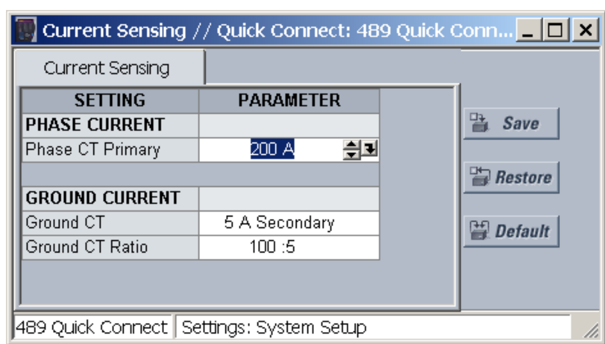
4.4.1 Engaging a Device

The EnerVista 489 Setup software may be used in on-line mode (relay connected) to directly communicate with a 489 relay. Communicating relays are organized and grouped by communication interfaces and into sites. Sites may contain any number of relays selected from the SR or UR product series.

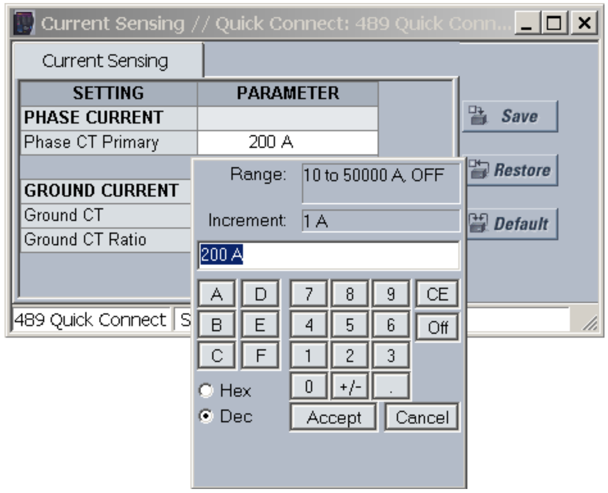
4.4.2 Entering Setpoints

The System Setup page will be used as an example to illustrate the entering of setpoints. In this example, we will be changing the current sensing setpoints.

- ▷ Establish communications with the relay.
- ▷ Select the **Setpoint > System Setup** menu item.
  This can be selected from the device setpoint tree or the main window menu bar.
- ▷ Select the **Current Sensing** menu item.
- ▷ Select the **PHASE CT PRIMARY** setpoint by clicking anywhere in the parameter box.
  This will display three arrows: two to increment/decrement the value and another to launch the numerical calculator.



▷ Click the arrow at the end of the box to display a numerical keypad interface that allows the user to enter a value within the setpoint range displayed near the top of the keypad:



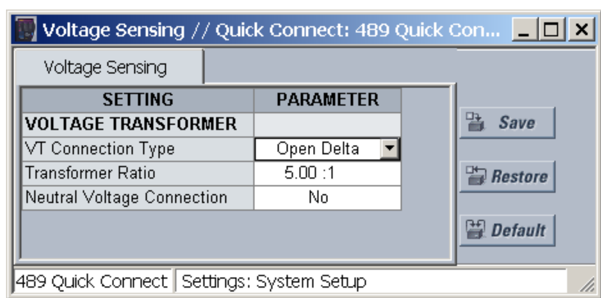
▷ Click **Accept** to exit from the keypad and keep the new value.

▷ Click on **Cancel** to exit from the keypad and retain the old value.

For setpoints requiring non-numerical pre-set values (e.g. VT CONNECTION TYPE below, in the Voltage Sensing window),

▷ Click anywhere within the setpoint value box to display a drop-down selection menu arrow.

▷ Click on the arrow to select the desired setpoint.



For setpoints requiring an alphanumeric text string (e.g. message scratchpad messages), the value may be entered directly within the setpoint value box.

▷ In the Setpoint / System Setup dialog box, click on **Save** to save the values into the 489.

▷ Click **Yes** to accept any changes.

▷ Click **No**, and then **Restore** to retain previous values and exit.

4.4.3 Using Setpoint Files

Overview

The EnerVista 489 Setup software interface supports three ways of handling changes to relay setpoints:

- In ***off-line*** mode (relay disconnected) to create or edit relay setpoint files for later download to communicating relays.
- Directly modifying relay setpoints while ***connected*** to a communicating relay, then saving the setpoints when complete.
- Creating/editing setpoint files while ***connected*** to a communicating relay, then saving them to the relay when complete.

Settings files are organized on the basis of file names assigned by the user. A settings file contains data pertaining to the following types of relay settings:

- Device Definition
- Product Setup
- System Setup
- Digital Inputs
- Output Relays
- Voltage Elements
- Power Elements
- RTD Temperature
- Thermal Model
- Monitoring Functions
- Analog Inputs and Outputs
- Relay Testing
- User Memory Map Setting Tool

Factory default values are supplied and can be restored after any changes.

The EnerVista 489 Setup display relay setpoints with the same hierarchy as the front panel display. For specific details on setpoints, refer to Chapter 5.

Downloading and Saving Setpoints Files

Setpoints must be saved to a file on the local PC before performing any firmware upgrades. Saving setpoints is also highly recommended before making any setpoint changes or creating new setpoint files.

The EnerVista 489 Setup window, setpoint files are accessed in the Setpoints List control bar window or the Files window. Use the following procedure to download and save setpoint files to a local PC.

▷ Ensure that the site and corresponding device(s) have been properly defined and configured as shown in *Connecting EnerVista 489 Setup to the Relay* on page 4–15.

▷ Select the desired device from the site list.

▷ Select the **File > Read Settings from Device** menu item to obtain settings information from the device.

After a few seconds of data retrieval, the software will request the name and destination path of the setpoint file. The corresponding file extension will be automatically assigned.

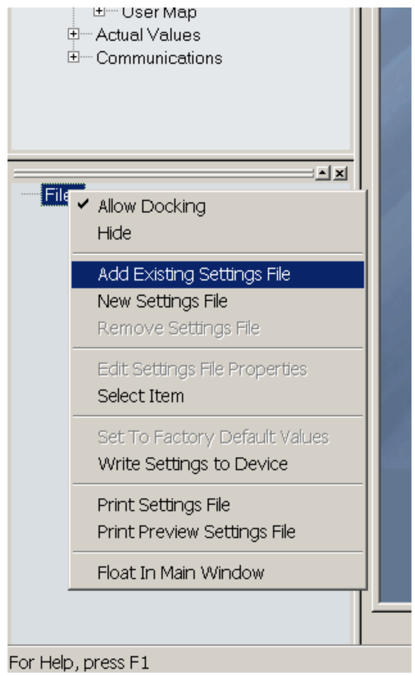
▷ Press **Save** to complete the process.
A new entry will be added to the tree, in the File pane, showing path and file name for the setpoint file.

Adding Setpoints Files to the Environment

The EnerVista 489 Setup software provides the capability to review and manage a large group of setpoint files. Use the following procedure to add a new or existing file to the list.

▷ In the files pane, right-click on 'Files'

▷ Select the **Add Existing Setting File** item as shown:



The Open dialog box will appear, prompting for a previously saved setting file. As for any other Windows® application,

▷ Browse for the file to add.

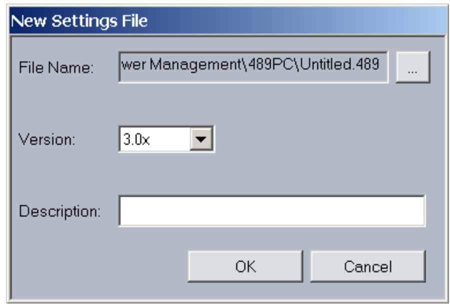
▷ Click **Open**.
The new file and complete path will be added to the file list.

Creating a New Setpoint File

The EnerVista 489 Setup software allows the user to create new setpoint files independent of a connected device. These can be uploaded to a relay at a later date. The following procedure illustrates how to create new setpoint files.

▷ In the File pane, right click on 'File'.

▷ Select the **New Settings File** item. The EnerVista 489 Setup software displays the following box, allowing for the configuration of the setpoint file for the correct firmware version. It is important to define the correct firmware version to ensure that setpoints not available in a particular version are not downloaded into the relay.



▷ Select the Firmware **Version** for the new setpoint file.

▷ For future reference, enter some useful information in the **Description** box to facilitate the identification of the device and the purpose of the file.

▷ To select a file name and path for the new file, click the button beside the **Enter File Name** box.

▷ Select the file name and path to store the file, or select any displayed file name to update an existing file.
All 489 setpoint files should have the extension '489' (for example, 'motor1.489').

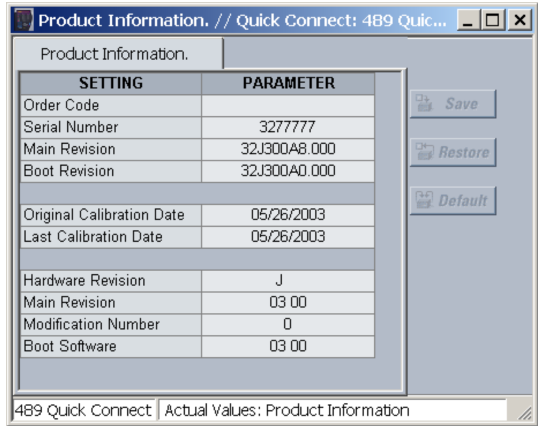
▷ Click **Save** and **OK** to complete the process.
Once this step is completed, the new file, with a complete path, will be added to the EnerVista 489 Setup software environment.

Upgrading Setpoint Files to a New Revision

It is often necessary to upgrade the revision code for a previously saved setpoint file after the 489 firmware has been upgraded (for example, this is required for firmware upgrades). This is illustrated in the following procedure.

▷ Establish communications with the 489 relay.

▷ Select the **Actual > Product Information** menu item and record the Software Revision identifier of the relay firmware as shown below.

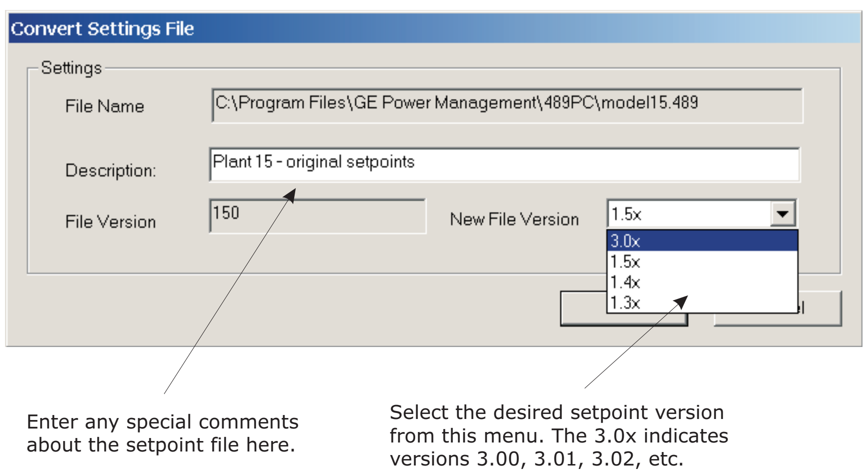


▷ Load the setpoint file to be upgraded into the EnerVista 489 Setup environment as described in *Adding Setpoints Files to the Environment* on page 4–24.

▷ In the File pane, select the saved setpoint file.

▷ From the main window menu bar, select the **File > Properties** menu item and note the version code of the setpoint file.
If this version (e.g. 4.0X shown below) is different than the **Software Revision** code noted in step 2, select a **New File Version** that matches the Software Revision code from the pull-down menu.

For example, if the software revision is 3.00 and the current setpoint file revision is 1.50, change the setpoint file revision to "3.0X", as shown below.



▷ When complete, click Convert to convert the setpoint file to the desired revision.
A dialog box will request confirmation. See *Loading Setpoints from a File* on page 4–28 for instructions on loading this setpoint file into the 489.

Printing Setpoints and Actual Values

The EnerVista 489 Setup software allows the user to print partial or complete lists of setpoints and actual values. Use the following procedure to print a list of setpoints:

▷ Select a previously saved setpoints file in the File pane or establish communications with a 489 device.

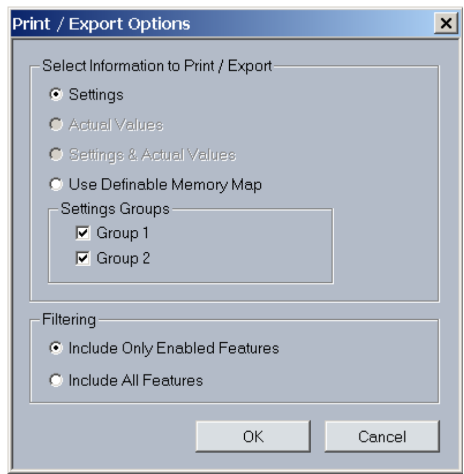
▷ From the main window, select the **File > Print Settings** menu item.

The Print/Export Options dialog box will appear.

▷ Select **Settings** in the upper section.

▷ Select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section.

▷ Click **OK**.



The process for **File** > **Print Preview Settings** is identical to the steps above.

Setpoints lists can be printed in the same manner by right clicking on the desired file (in the file list) or device (in the device list) and selecting the **Print Device Information** or **Print Settings File** options.

A complete list of actual values can also be printed from a connected device with the following procedure:

▷ Establish communications with the desired 489 device.

▷ From the main window, select the **File > Print Settings** menu item.

The Print/Export Options dialog box will appear.

▷ Select **Actual Values** in the upper section.

▷ Select either **Include All Features** (for a complete list) or **Include Only Enabled Features** (for a list of only those features which are currently used) in the filtering section.

▷ Click **OK**.

Actual values can be printed in the same manner by right clicking on the desired device (in the device list) and selecting the **Print Device Information** option.

Loading Setpoints from a File

An error message will occur when attempting to download a setpoint file with a revision number that does not match the relay firmware. If the firmware has been upgraded since saving the setpoint file, see *Upgrading Setpoint Files to a New Revision* on page 4–25 **for instructions on changing the revision number of a setpoint file.**

The following procedure illustrates how to load setpoints from a file. Before loading a setpoint file, it must first be added to the EnerVista 489 Setup environment as described in *Adding Setpoints Files to the Environment* on page 4–24.

▷ Select the previously saved setpoint file from the File pane of the EnerVista 489 Setup software main window.

▷ Select the **File > Properties** menu item and verify that the corresponding file is fully compatible with the hardware and firmware version of the target relay.
If the versions are not identical, see *Upgrading Setpoint Files to a New Revision* on page 4–25 for details on changing the setpoints file version.

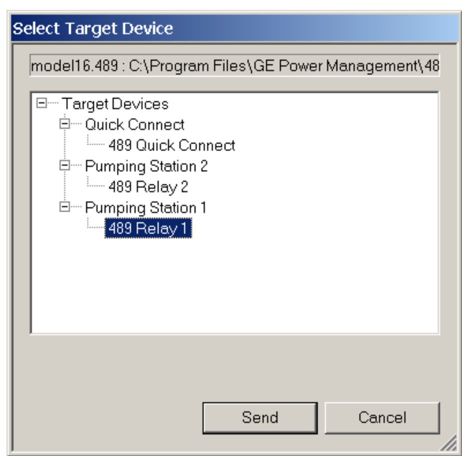
▷ Right-click on the selected file.

▷ Select the **Write Settings to Device** item.

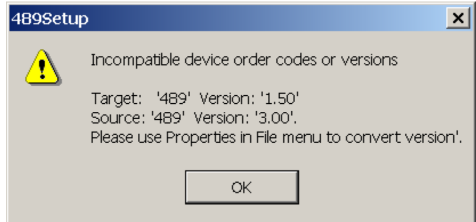
The software will prompt for a target device.

▷ Select the desired device.

▷ Click **Send**.



If there is an incompatibility, an error of the following type will occur.



If there are no incompatibilities between the target device and the Setpoints file, the data will be transferred to the relay. An indication of the percentage completed will be shown in the bottom of the main menu.

4.5 Upgrading Relay Firmware

4.5.1 Description

To upgrade the 489 firmware, follow the procedures listed in this section. Upon successful completion of this procedure, the 489 will have new firmware installed with the original setpoints.

The latest firmware files are available from the GE Multilin website at

http://www.GEmultilin.com.

4.5.2 Saving Setpoints to a File

Before upgrading firmware, it is very important to save the current 489 settings to a file on your PC. After the firmware has been upgraded, it will be necessary to load this file back into the 489.

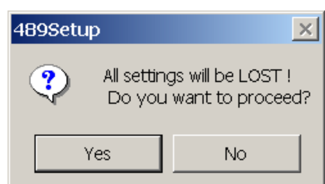
Refer to *Downloading and Saving Setpoints Files* on page 4–23 for details on saving relay setpoints to a file.

4.5.3 Loading New Firmware

Loading new firmware into the 489 flash memory is accomplished as follows:

▷ Connect the relay to the local PC and save the setpoints to a file as shown in *Downloading and Saving Setpoints Files* on page 4–23.

▷ Select the **Communications > Update Firmware** menu item.
The following warning message will appear.



▷ Select **Yes** to proceed or **No** to cancel the process.
Do not proceed unless you have saved the current setpoints

An additional message will be displayed to ensure the PC is connected to the relay front port, as the 489 cannot be upgraded via the rear RS485 ports.

The EnerVista 489 Setup software will request the new firmware file. Locate the file to load into the 489. The firmware filename has the following format:

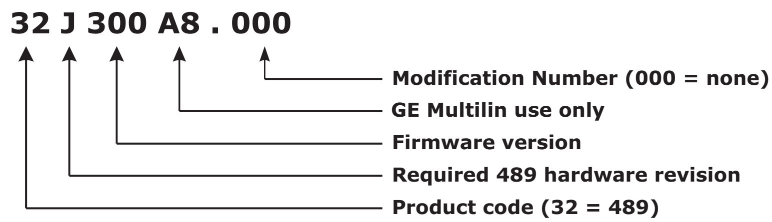


FIGURE 4–5: Firmware File Format

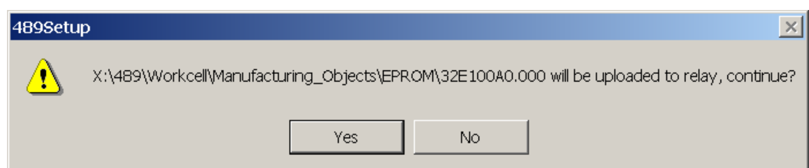
The EnerVista 489 Setup software automatically lists all filenames beginning with '32'.

▷ Select the appropriate file.

▷ Click **OK** to continue.

The software will prompt with another Upload Firmware Warning window. This will be the final chance to cancel the firmware upgrade before the flash memory is erased.

▷ Click **Yes** to continue or **No** to cancel the upgrade.



The EnerVista 489 Setup software now prepares the 489 to receive the new firmware file. The 489 will display a message indicating that it is in Upload Mode. While the file is being loaded into the 489, a status box appears showing how much of the new firmware file has been transferred and how much is remaining, as well as the upgrade status. The entire transfer process takes approximately five minutes.

The EnerVista 489 Setup software will notify the user when the 489 has finished loading the file.

▷ Carefully read any displayed messages and click **OK** to return the main screen.

Note

NOTE

Cycling power to the relay is recommended after a firmware upgrade.

After successfully updating the 489 firmware, the relay will not be in service and will require setpoint programming. To communicate with the relay, the following settings will have to be manually programmed.

MODBUS COMMUNICATION ADDRESS
BAUD RATE
PARITY (if applicable)

When communications is established, the saved setpoints must be reloaded back into the relay. See *Loading Setpoints from a File* on page 4–28 for details.

Modbus addresses assigned to firmware modules, features, settings, and corresponding data items (i.e. default values, min/max values, data type, and item size) may change slightly from version to version of firmware.

The addresses are rearranged when new features are added or existing features are enhanced or modified. The **EEPROM DATA ERROR** message displayed after upgrading/ downgrading the firmware is a resettable, self-test message intended to inform users that the Modbus addresses have changed with the upgraded firmware. This message does not signal any problems when appearing after firmware upgrades.

4.6 Advanced EnerVista 489 Setup Features

4.6.1 Triggered Events

While the interface is in either on-line or off-line mode, data generated by triggered specified parameters can be viewed and analyzed via one of the following:

- **Event Recorder**: The event recorder captures contextual data associated with the last 256 events, listed in chronological order from most recent to the oldest.
- **Oscillography**: The oscillography waveform traces provide a visual display of power system and relay operation data captured during specific triggered events.

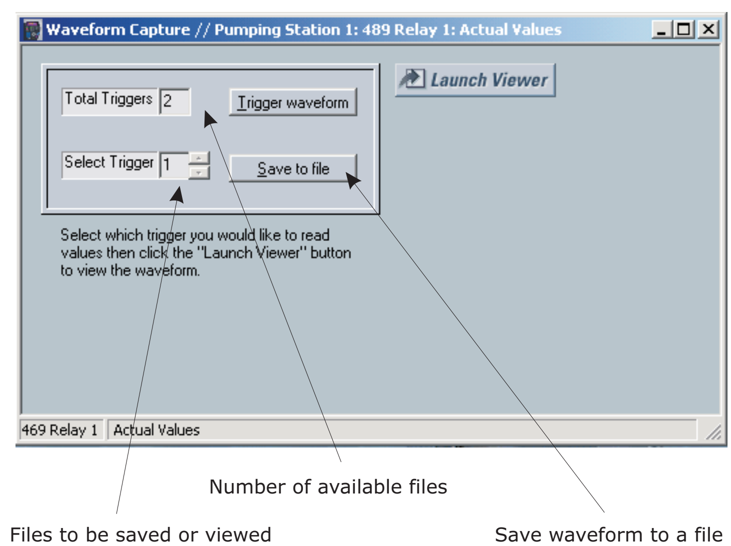
4.6.2 Waveform Capture (Trace Memory)

The EnerVista 489 Setup software can be used to capture waveforms (or view trace memory) from the 489 relay at the instance of a trip. A maximum of 128 cycles can be captured and the trigger point can be adjusted to anywhere within the set cycles. A maximum of 16 waveforms can be buffered (stored) with the buffer/cycle trade-off.

The following waveforms can be captured:

- Phase A, B, and C currents (I_a, I_b, and I_c)
- Neutral end A, B, and C currents ($I_{neutral\_a}$, $I_{neutral\_b}$, and $I_{neutral\_c}$)
- Ground currents (I_g)
- Phase A-N, B-N, and C-N voltages (V_a, V_b, and V_c)

▷ With EnerVista 489 Setup running and communications established, select the **Actual > Waveform Capture** menu item to open the waveform capture setup window:



▷ Click on **Trigger Waveform** to trigger a waveform capture.

The waveform file numbering starts with the number zero in the 489; therefore, the maximum trigger number will always be one less then the total number triggers available.

▷ Click on the **Save to File** button to save the selected waveform to the local PC.
A new window will appear requesting for file name and path.

The file is saved as a CSV (comma delimited values) file, which can be viewed and manipulated with compatible third-party software.

To view a previously saved file,

▷ Click the **Open** button and select the corresponding CSV file.

To view the captured waveforms,

▷ Click the **Launch Viewer** button.
A detailed Waveform Capture window will appear as shown below:

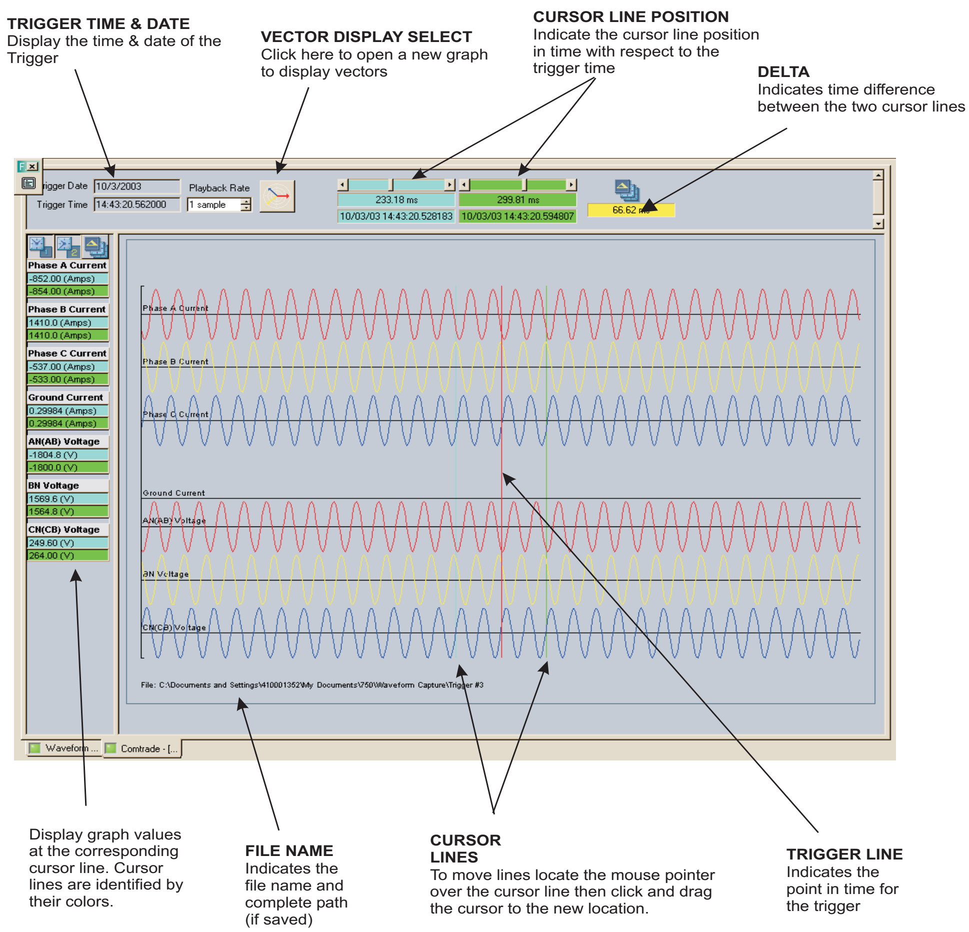


FIGURE 4–6: Waveform Capture Window Attributes

The red vertical line indicates the trigger point of the relay.

The date and time of the trigger is displayed at the top left corner of the window. To match the captured waveform with the event that triggered it,

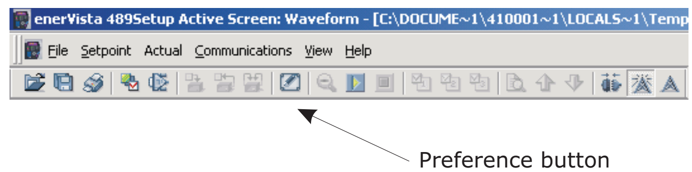
▷ Make note of the time and date shown in the graph.

▷ Find the event that matches the same time and date in the event recorder.

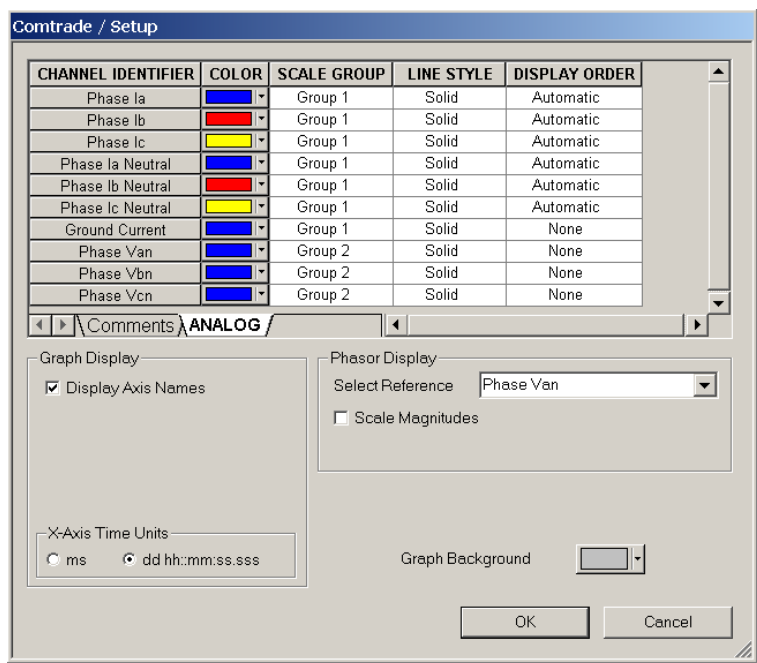
The event record will provide additional information on the cause and the system conditions at the time of the event.

Additional information on how to download and save events is shown in *Event Recorder* on page 4–40.

▷ From the window main menu bar, press the Preference button to open the Setup page to change the graph attributes.



The following window will appear:



▷ Change the Color of each graph as desired, and select other options, as required, by checking the appropriate boxes.

▷ Click **OK** to store these graph attributes, and to close the window.

The Waveform Capture window will reappear with the selected graph attributes available for use.

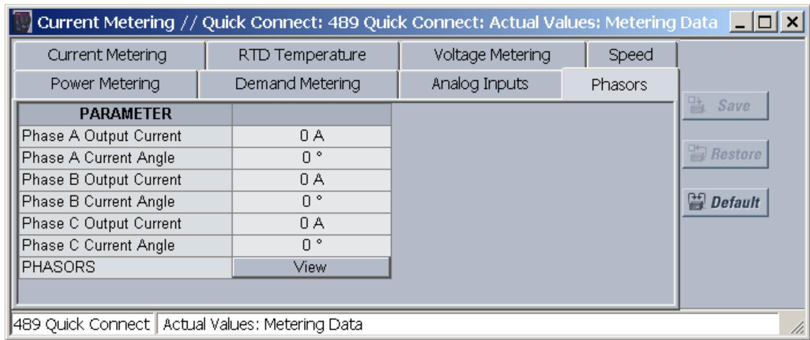
4.6.3 Phasors

The EnerVista 489 Setup software can be used to view the phasor diagram of three-phase currents and voltages. The phasors are for: Phase Voltages Va, Vb, and Vc; Phase Currents Ia, Ib, and Ic.

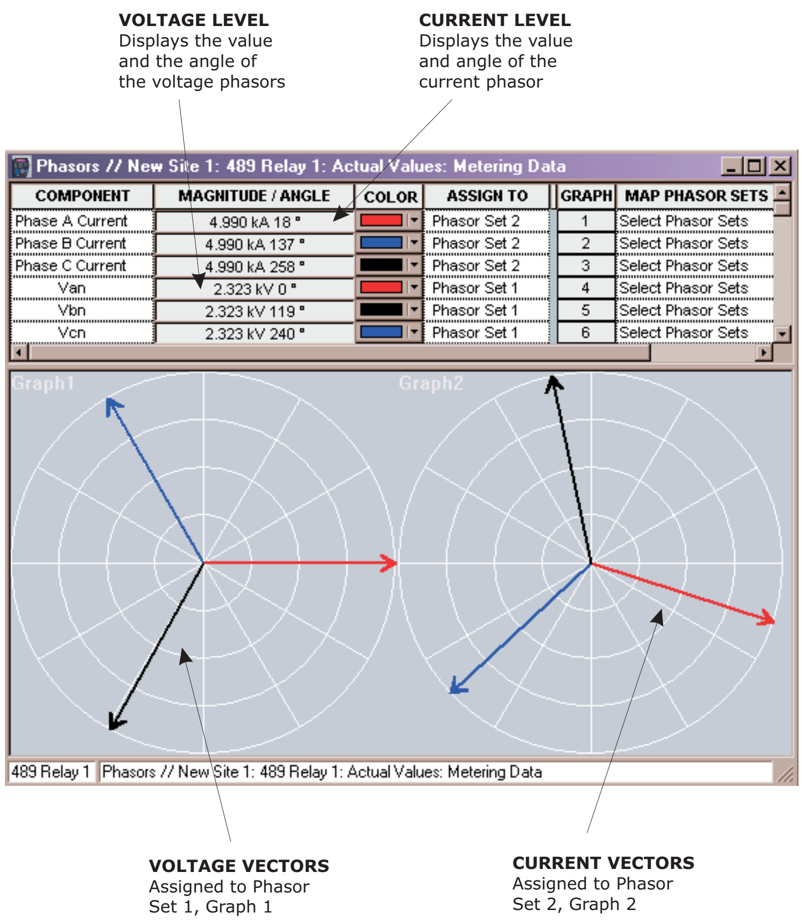
▷ With the EnerVista 489 Setup software running and communications established, open the **Actual Values > Metering Data** window.

▷ Click on the Phasors tab.

The EnerVista 489 Setup software will display the following window:



▷ Press the “View” button to display the following window:



The 489 Generator Management Relay was designed to display lagging angles. Therefore, if a system condition would cause the current to lead the voltage by 45°, the 489 relay will display such angle as 315° Lag instead of 45° Lead.

When the currents and voltages measured by the relay are zero, the angles displayed by the relay and those shown by the EnerVista 489 Setup software are not fixed values.

4.6.4 Trending (Data Logger)

The trending or data logger feature is used to sample and record up to eight actual values at an interval defined by the user. Several 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 EnerVista 489 Setup software are:

- **Currents/Voltages**:

  Phase Currents A, B, and C
  Generator Load
  Negative-Sequence Current
  Ground Current and Neutral Current
  Differential Currents A, B, and C
  System Frequency
  Voltages Vab, Vbc, Vca Van, Vbn & Vcn

- **Power**:

  Power Factor
  Real (kW) Reactive (kvar), and Apparent (kVA) Power
  Positive Watthours
  Positive and Negative Varhours

- **Temperature**:

  Hottest Stator RTD
  Thermal Capacity Used
  RTDs 1 through 12

- **Demand**:

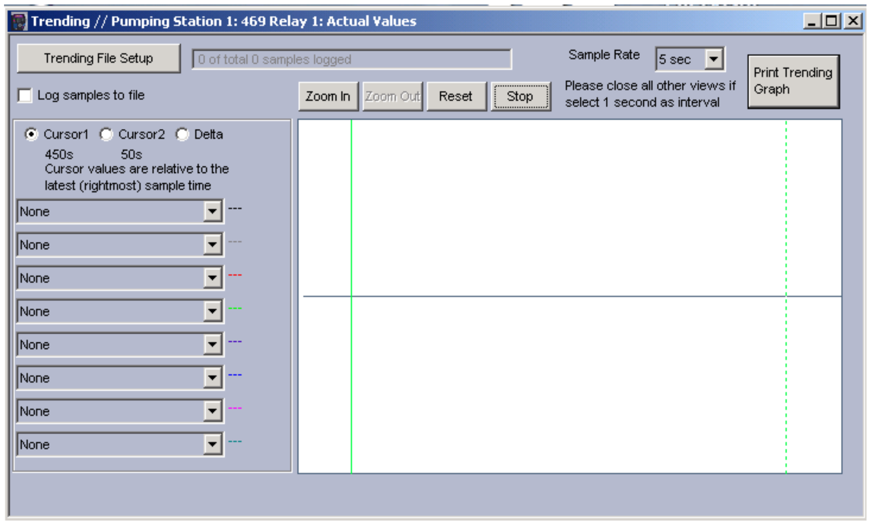
  Current
  Peak Current
  Reactive Power
  Peak Reactive Power
  Apparent Power
  Peak Apparent Power

- **Others**:

  Analog Inputs 1, 2, 3, and 4
  Tachometer

With EnerVista 489 Setup running and communications established,

▷ Select the **Actual Values > Trending** menu item to open the trending window.
The following window will appear.



To prepare for new trending,

▷ Select **Stop** to stop the data logger and **Reset** to clear the screen.

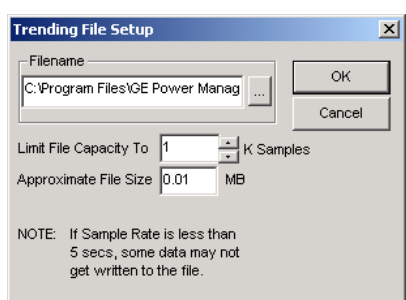
▷ Select the graphs to be displayed through the pull-down menu beside each channel description.

▷ Select the Sample Rate through the pull-down menu.

If you want to save the information captured by trending,

▷ Check the box besides **Log Samples to File**.
The following dialog box will appear requesting for file name and path. The file is saved as 'csv' (comma delimited values) file, which can be viewed and manipulated with compatible third-party software.

▷ Ensure that the sample rate is not less than 5 seconds, otherwise, some data may not get written to the file.



To limit the size of the saved file,

▷ Enter a number in the **Limit File Capacity To** box.
The minimum number of samples is 1000. At a sampling rate of 5 seconds (or 1 sample every 5 seconds), the file will contain data collected during the past 5000 seconds. The EnerVista 489 Setup software will automatically estimate the size of the trending file.

▷ Press “Run” to start the data logger.
If the **Log Samples to File** item is selected, the EnerVista 489 Setup software will begin collecting data at the selected sampling rate and will display it on the screen. The data log will continue until the **Stop** button is pressed or until the selected number of samples is reached, whichever occurs first.

During the process of data logging, the trending screen appears as shown below.

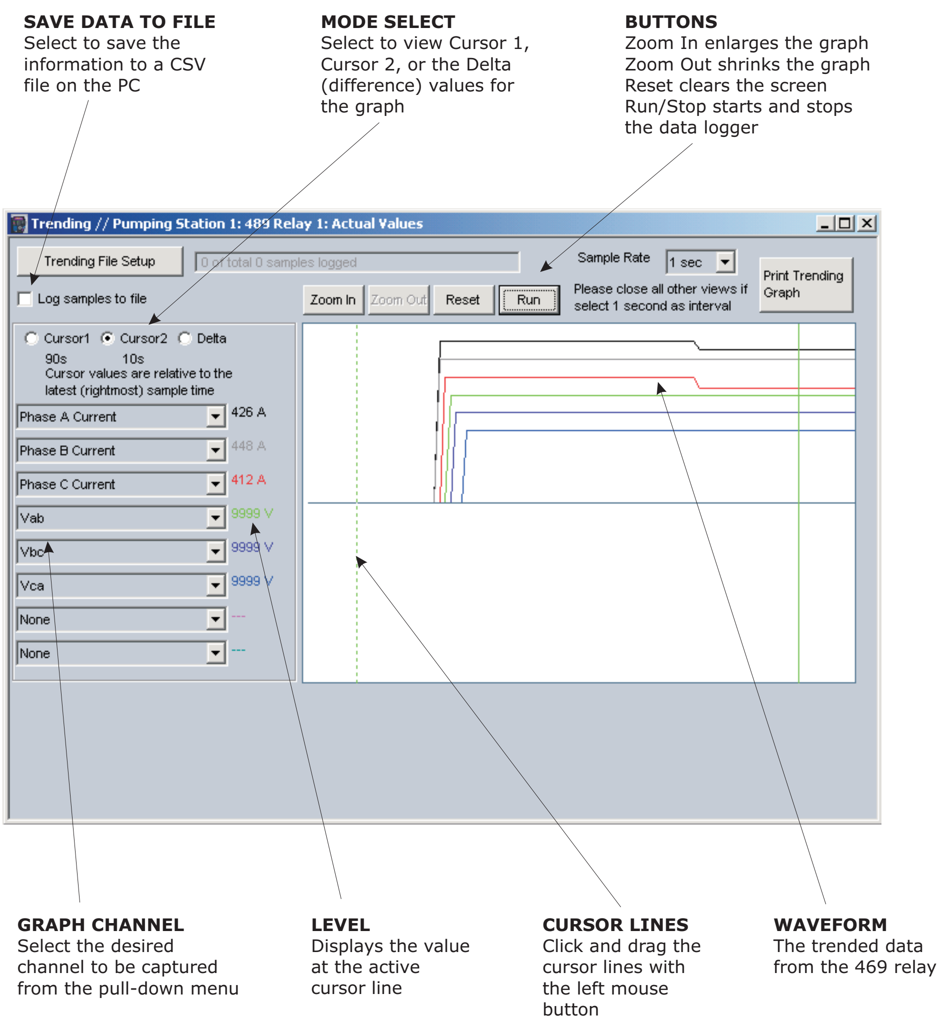


FIGURE 4–7: Trending Screen

4.6.5 Event Recorder

The 489 event recorder can be viewed through the EnerVista 489 Setup software. The event recorder stores generator and system information each time an event occurs (e.g. breaker failure). A maximum of 256 events can be stored. Each event is assigned an event number, from E001 to E256. When the E256 is reached, E001 is assigned to the next event. Refer to *Event Recorder* on page 6–28 for additional information on the event recorder.

Use the following procedure to view the event recorder with EnerVista 489 Setup:

With EnerVista 489 Setup running and communications established,

▷ Select the **Actual > A4 Event Recorder** item from the main menu. This displays the Event Recorder window indicating the list of recorded events, with the most current event displayed first.

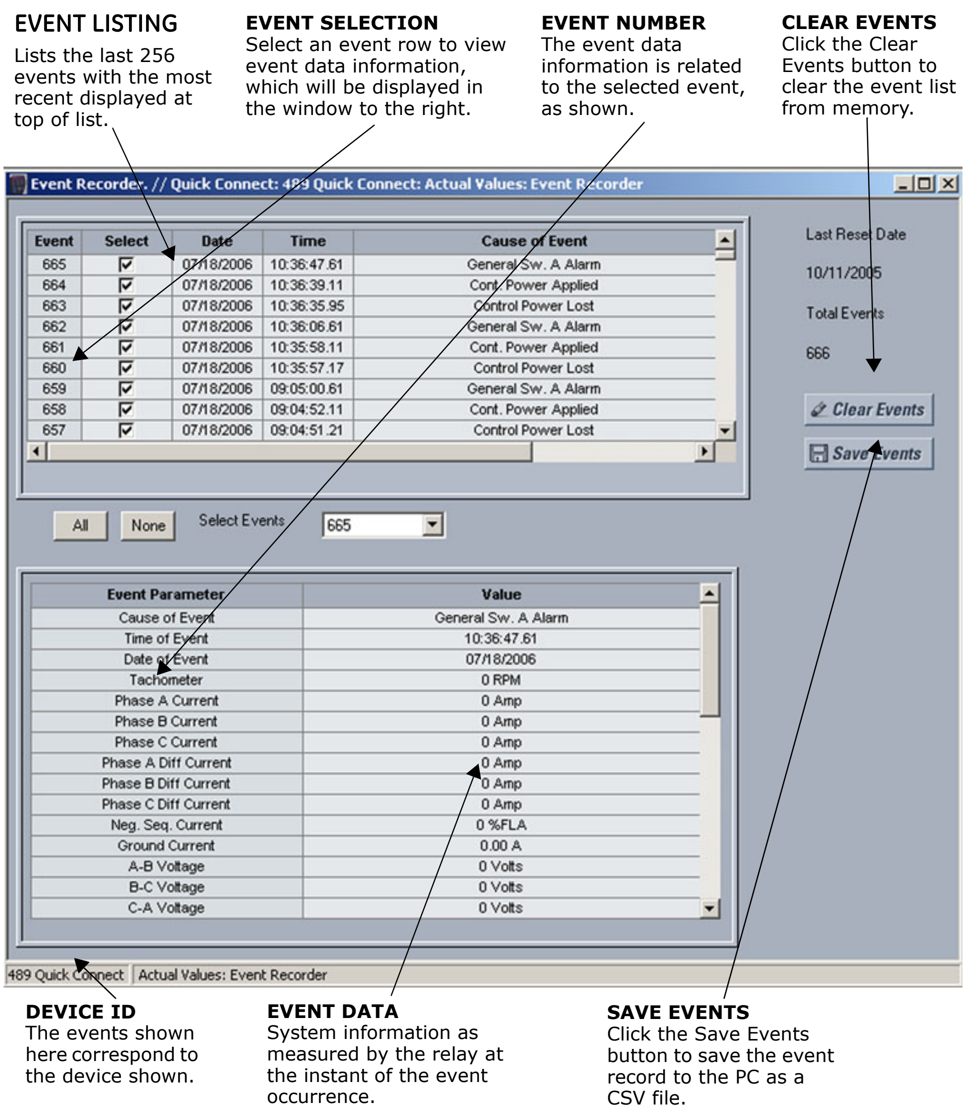


FIGURE 4–8: Event Recorder Window (shown unconnected)

To view detailed information for a given event and the system information at the moment of the event occurrence,

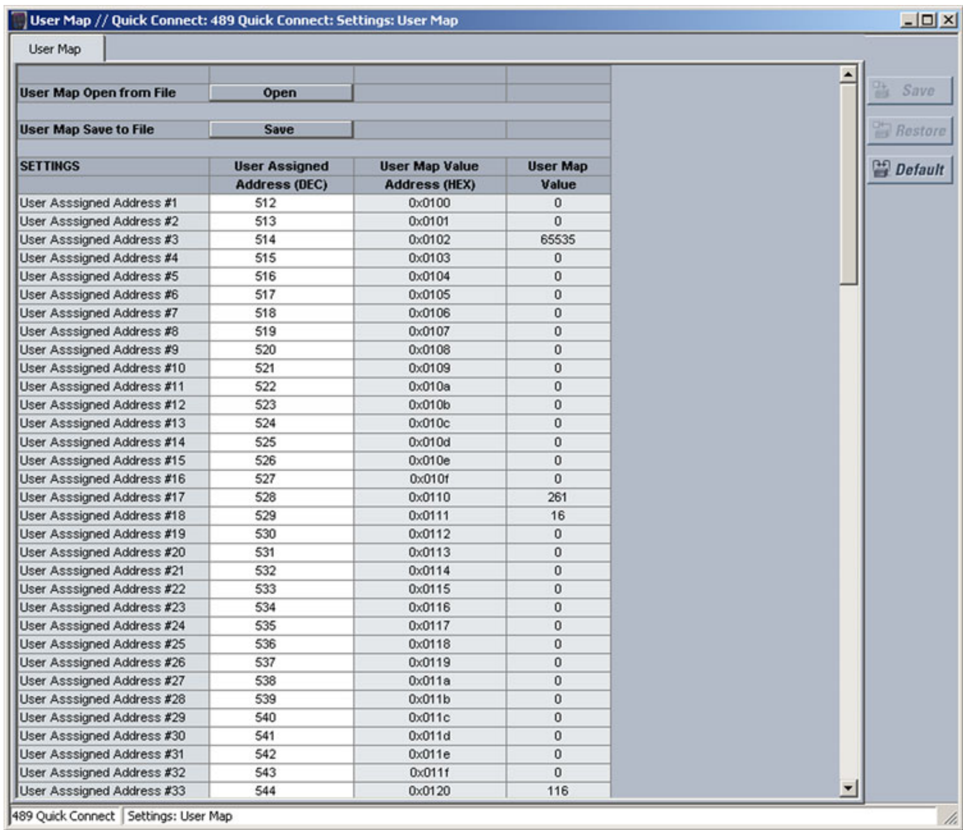
▷ Change the event number on the **Select Event** box.

4.6.6 Modbus User Map

The EnerVista 489 Setup software provides a means to program the 489 User Map (Modbus addresses 0180h to 01F7h). Refer to GE Publication GEK-106491: ***489 Communications Guide*** for additional information on the User Map.

▷ Select a connected device in EnerVista 489 Setup.

▷ Select the **Setpoint > User Map** menu item to open the following window.



SETTINGS	User Assigned Address (DEC)	User Map Value Address (HEX)	User Map Value
User Map Open from File	Open		
User Map Save to File	Save		
User Assigned Address #1	512	0x0100	0
User Assigned Address #2	513	0x0101	0
User Assigned Address #3	514	0x0102	65535
User Assigned Address #4	515	0x0103	0
User Assigned Address #5	516	0x0104	0
User Assigned Address #6	517	0x0105	0
User Assigned Address #7	518	0x0106	0
User Assigned Address #8	519	0x0107	0
User Assigned Address #9	520	0x0108	0
User Assigned Address #10	521	0x0109	0
User Assigned Address #11	522	0x010a	0
User Assigned Address #12	523	0x010b	0
User Assigned Address #13	524	0x010c	0
User Assigned Address #14	525	0x010d	0
User Assigned Address #15	526	0x010e	0
User Assigned Address #16	527	0x010f	0
User Assigned Address #17	528	0x0110	261
User Assigned Address #18	529	0x0111	16
User Assigned Address #19	530	0x0112	0
User Assigned Address #20	531	0x0113	0
User Assigned Address #21	532	0x0114	0
User Assigned Address #22	533	0x0115	0
User Assigned Address #23	534	0x0116	0
User Assigned Address #24	535	0x0117	0
User Assigned Address #25	536	0x0118	0
User Assigned Address #26	537	0x0119	0
User Assigned Address #27	538	0x011a	0
User Assigned Address #28	539	0x011b	0
User Assigned Address #29	540	0x011c	0
User Assigned Address #30	541	0x011d	0
User Assigned Address #31	542	0x011e	0
User Assigned Address #32	543	0x011f	0
User Assigned Address #33	544	0x0120	116

This window allows the desired addresses to be written to User Map locations. The User Map values that correspond to these addresses are then displayed.

4.6.7 Viewing Actual Values

You can view real-time relay data such as input/output status and measured parameters. From the main window menu bar, selecting Actual Values opens a window with tabs, each tab containing data in accordance with the following list:

1. **Generator and System Status**:

- Generator status either stopped, starting, or running. It includes values such as generator load, thermal capacity used, generator speed, and instantaneous values of power system quantities.
- The status of digital inputs.
- Last trip information, including values such as cause of last trip, time and date of trip, generator speed and load at the time of trip, pre-trip temperature measurements, pre-trip analog inputs values, and pre-trip instantaneous values of power system quantities.
- Active alarms.
- Relay date and time.
- Present blocking conditions.
- General system status indication including the status of output relays, active pickup, alarm and trip conditions.

2. **Metering Data**:
    - Instantaneous current measurements including phase, differential, unbalance, ground, average, generator load, and differential currents.
    - RTD Temperatures including hottest RTDs.
    - Instantaneous phase to phase and phase to ground voltages (depending on the VT connections), average voltage, and system frequency.
    - Generator Speed
    - Power Quantities including Apparent, Real and Reactive Power.
    - Current and power demand including peak values.
    - Analog inputs
    - Vector information.
3. **Generator Learned Data**:
    - Average Generator Load
    - Average Negative-Sequence Current
    - Phase-Phase Voltage
    - RTD Maximum Values
4. **Maintenance data**.
   This is useful statistical information that may be used for preventive maintenance. It includes:
    - Trip counters
    - General counter such as Number of Breaker Operations.
    - Timers such as Generator Running Hours.
5. **RTD Learned Data** - includes the maximum temperature measured by each of the 12 RTDs.
6. **Event recorder downloading tool**.
7. Product information including model number, firmware version, additional product information, and calibration dates.
8. Oscillography and Data Logger downloading tool.

Selecting an actual values window also opens the actual values tree from the corresponding device in the site list and highlights the current location in the hierarchy.

For complete details on actual values, refer to Chapter 6.

To view a separate window for each group of actual values, select the desired item from the tree, and double click with the left mouse button. Each group will be opened on a separate tab. The windows can be re-arranged to maximize data viewing as shown in the following figure (showing actual current, voltage, and generator status values tiled in the same window):

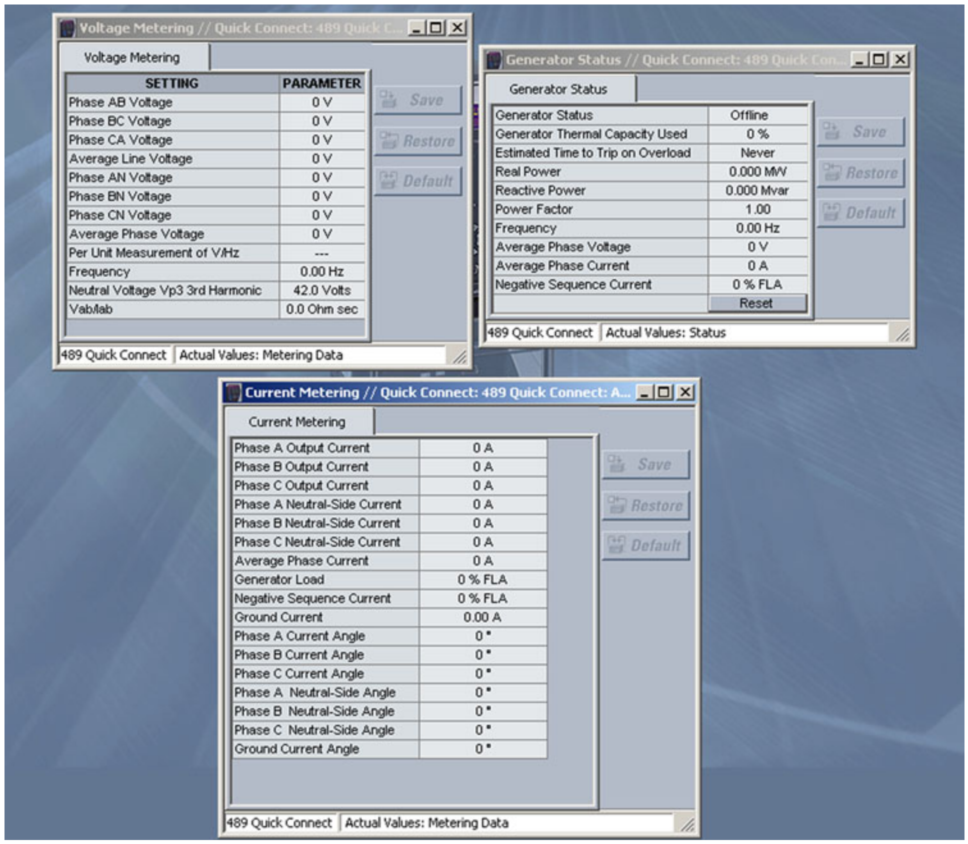


FIGURE 4–9: Actual Values Display (shown unconnected)

4.7 Using EnerVista Viewpoint with the 489

4.7.1 Plug and Play Example

EnerVista Viewpoint is an optional software package that puts critical 489 information on any PC with plug-and-play simplicity. EnerVista Viewpoint connects instantly to the 489 via serial, ethernet or modem and automatically generates detailed overview, metering, power, demand, energy and analysis screens. Installing EnerVista Launchpad (see previous section) allows the user to install a fifteen-day trial version of EnerVista Viewpoint. After the fifteen day trial period you will need to purchase a license to continue using EnerVista Viewpoint. Information on license pricing can be found at http://www.EnerVista.com.

▷ Install the EnerVista Viewpoint software from the GE EnerVista CD.

▷ Ensure that the 489 device has been properly configured for either serial or Ethernet communications (see previous sections for details).

▷ Click the **Viewpoint** window in EnerVista to log into EnerVista Viewpoint.
At this point, you will be required to provide a login and password if you have not already done so.

FIGURE 4–10: EnerVista Viewpoint Main Window

▷ Click the **Device Setup** button to open the Device Setup window.

▷ Click the **Add Site** button to define a new site.

▷ Enter the desired site name in the **Site Name** field.
If desired, a short description of site can also be entered along with the display order of devices defined for the site.

▷ Click the **OK** button when complete.
The new site will appear in the upper-left list in the EnerVista 489 Setup window.

▷ Click the **Add Device** button to define the new device.

▷ Enter the desired name in the **Device Name** field and a description (optional) of the site.

▷ Select the appropriate communications interface (Ethernet or Serial) and fill in the required information for the 489. See *Connecting EnerVista 489 Setup to the Relay* on page 4–15 for details.

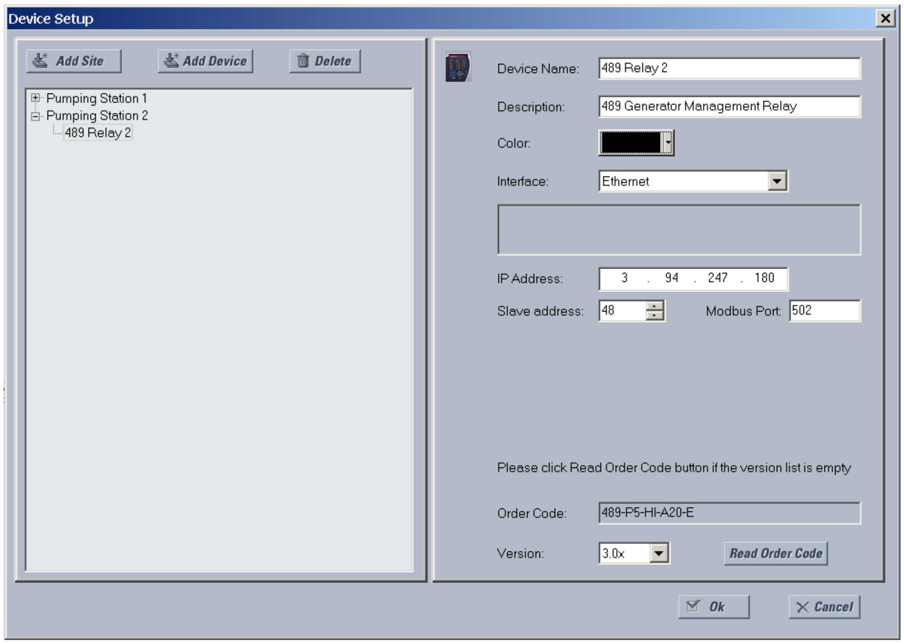


FIGURE 4–11: Device Setup Screen (Example)

▷ Click the **Read Order Code** button to connect to the 489 device and upload the order code. If an communications error occurs, ensure that communications values entered in the previous step correspond to the relay setting values.

▷ Click **OK** when complete.

▷ From the EnerVista main window, select the **IED Dashboard** item to open the Plug and Play IED dashboard.
An icon for the 489 will be displayed.

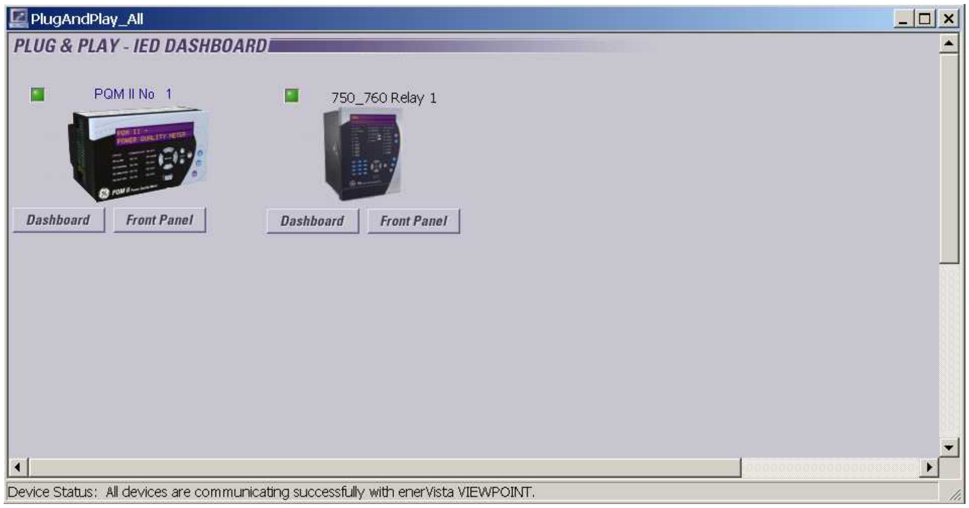


FIGURE 4–12: 'Plug and Play' Dashboard

▷ Click the **Dashboard** button below the 489 icon to view the device information.

We have now successfully accessed our 489 through EnerVista Viewpoint.

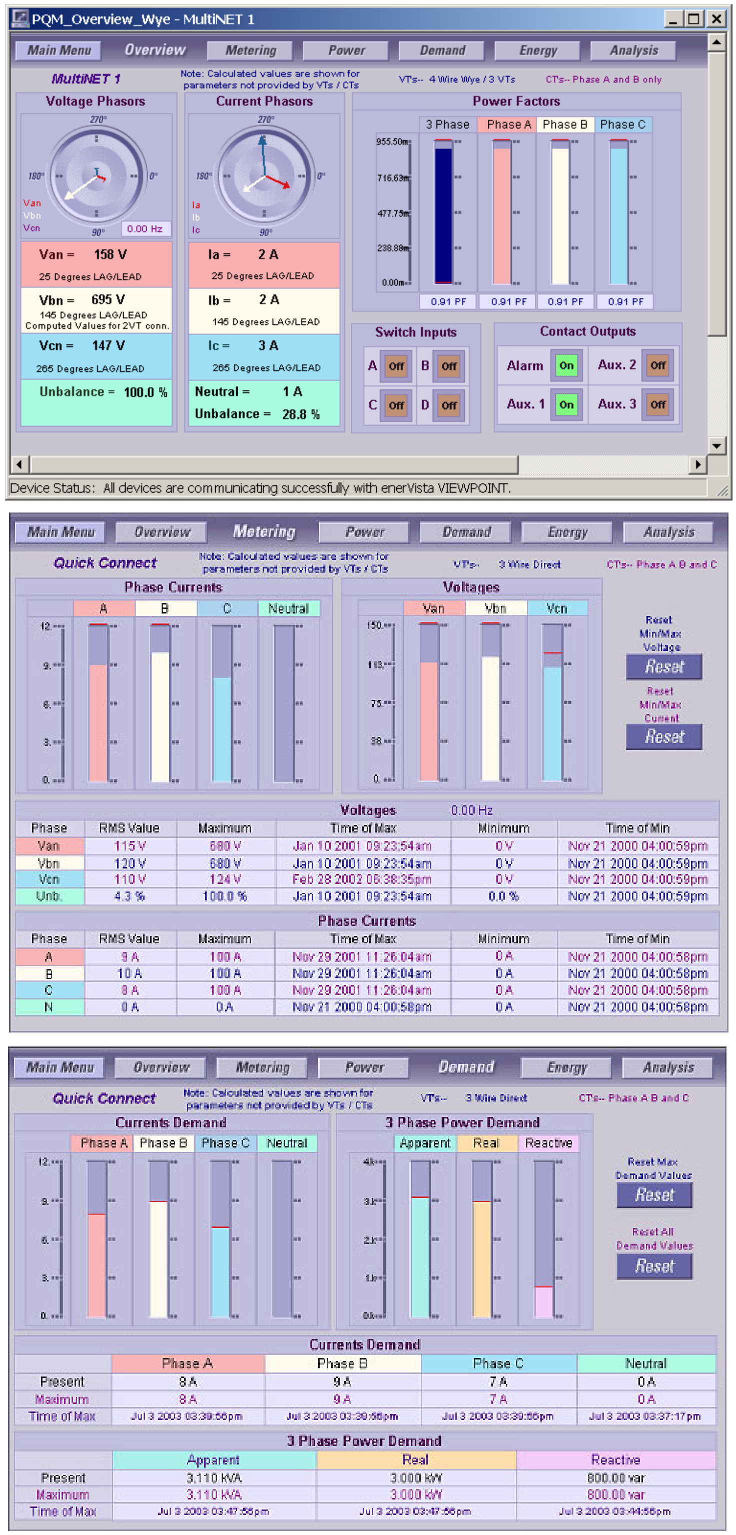


FIGURE 4–13: EnerVista Plug and Play Screens

For additional information on EnerVista viewpoint, please visit the EnerVista website at http://www.EnerVista.com.

Digital Energy
Multilin

489 Generator Management Relay

Chapter 5: Setpoints

5.1 Overview

5.1.1 Setpoint Message Map

The 489 has a considerable number of programmable setpoints which makes it extremely flexible. The setpoints have been grouped into a number of pages and sub-pages as shown below. Each page of setpoints (e.g. S2 SYSTEM SETUP) has a section which describes in detail all the setpoints found on that page.

■ SETPOINTS [▷]		■ PASSCODE [▷]	See page 5–9.
	MESSAGE	■ PREFERENCES [▷]	See page 5–10.
	MESSAGE	■ COMMUNICATIONS [▷]	See page 5–12.
	MESSAGE	■ REAL TIME CLOCK [▷]	See page 5–13.
	MESSAGE	■ DEFAULT [▷]	See page 5–14.
	MESSAGE	■ MESSAGE [▷]	See page 5–15.
	MESSAGE	■ CLEAR DATA [▷]	See page 5–16.
	MESSAGE	END OF PAGE	

	Display	
■ SETPOINTS [▷]	■ CURRENT [▷]	See page 5–18.
MESSAGE	■ VOLTAGE [▷]	See page 5–18.
MESSAGE	■ GENERATOR [▷]	See page 5–19.
MESSAGE	■ SERIAL [▷]	See page 5–20.
MESSAGE	END OF PAGE	

	Display	
■ SETPOINTS [▷]	■ BREAKER [▷]	See page 5–21.
MESSAGE	■ GENERAL [▷]	See page 5–22.
MESSAGE	■ GENERAL [▷]	See page 5–22.
	↓	
MESSAGE	■ GENERAL [▷]	See page 5–22.
MESSAGE	■ REMOTE RESET [▷]	See page 5–23.
MESSAGE	■ TEST INPUT [▷]	See page 5–23.
MESSAGE	■ THERMAL RESET [▷]	See page 5–23.
MESSAGE	■ DUAL [▷]	See page 5–24.
MESSAGE	■ SEQUENTIAL [▷]	See page 5–25.
MESSAGE	■ FIELD-BREAKER [▷]	See page 5–26.
MESSAGE	■ TACHOMETER [▷]	See page 5–26.
MESSAGE	■ WAVEFORM [▷]	See page 5–27.
MESSAGE	■ GROUND [▷]	See page 5–27.
MESSAGE	END OF PAGE	

■ SETPOINTS [▷]		■ RELAY [▷]	See page 5-28.
	MESSAGE	END OF PAGE	
1 SETPOINTS [▷] S5 CURRENT ELEM.		1 OVERCURRENT [▷] ALARM	See page 5-33.
	MESSAGE	1 OFFLINE [▷] OVERCURRENT	See page 5-33.
	MESSAGE	1 INADVERTENT [▷] ENERGIZATION	See page 5-34.
	MESSAGE	1 PHASE [▷] OVERCURRENT	See page 5-35.
	MESSAGE	1 NEGATIVE [▷] SEQUENCE	See page 5-36.
	MESSAGE	1 GROUND [▷] OVERCURRENT	See page 5-38.
	MESSAGE	1 PHASE [▷] DIFFERENTIAL	See page 5-39.
	MESSAGE	1 GROUND [▷] DIRECTIONAL	See page 5-40.
	MESSAGE	1 HIGH-SET [▷] PHASE OVERCURRENT	See page 5-42.
	MESSAGE	END OF PAGE	
1 SETPOINTS [▷] S6 VOLTAGE ELEM.		1 UNDERVOLTAGE [▷]	See page 5-43.
	MESSAGE	1 OVERVOLTAGE [▷]	See page 5-44.
	MESSAGE	1 VOLTS/HERTZ [▷]	See page 5-45.
	MESSAGE	1 PHASE [▷] REVERSAL	See page 5-48.
	MESSAGE	1 UNDERFREQUENCY [▷]	See page 5-49.
	MESSAGE	1 OVERFREQUENCY [▷]	See page 5-50.
	MESSAGE	1 NEUTRAL O/V [▷] (FUNDAMENTAL)	See page 5-51.

	MESSAGE	1 NEUTRAL U/V [▷] (3rd HARMONIC)	See page 5-53.
	MESSAGE	1 LOSS OF [▷] EXCITATION	See page 5-55.
	MESSAGE	1 DISTANCE [▷] ELEMENT	See page 5-56.
	MESSAGE	END OF PAGE	
1 SETPOINTS [▷] S7 POWER ELEMENTS		1 REACTIVE [▷] POWER	See page 5-61.
	MESSAGE	1 REVERSE [▷] POWER	See page 5-62.
	MESSAGE	1 LOW FORWARD [▷] POWER	See page 5-63.
	MESSAGE	END OF PAGE	
1 SETPOINTS [▷] S8 RTD TEMPERATURE		1 RTD TYPES [▷]	See page 5-64.
	MESSAGE	1 RTD #1 [▷]	See page 5-65.
	MESSAGE	1 RTD #2 [▷]	See page 5-65.
	MESSAGE	1 RTD #3 [▷]	See page 5-65.
		↓	
	MESSAGE	1 RTD #12 [▷]	See page 5-67.
	MESSAGE	1 OPEN RTD [▷] SENSOR	See page 5-68.
	MESSAGE	1 RTD [▷] SHORT/LOW TEMP	See page 5-69.
	MESSAGE	END OF PAGE	
1 SETPOINTS [▷] S9 THERMAL MODEL		1 MODEL SETUP [▷]	See page 5-71.
	MESSAGE	1 THERMAL [▷] ELEMENTS	See page 5-89.

	MESSAGE	END OF PAGE	
■ SETPOINTS [▷]		■ TRIP [▷]	See page 5-90.
	MESSAGE	■ BREAKER [▷]	See page 5-90.
	MESSAGE	■ TRIP COIL MONITOR [▷]	See page 5-91.
	MESSAGE	■ VT FUSE FAILURE [▷]	See page 5-92.
	MESSAGE	■ CURRENT [▷]	See page 5-93.
	MESSAGE	■ MW DEMAND [▷]	See page 5-93.
	MESSAGE	■ Mvar DEMAND [▷]	See page 5-93.
	MESSAGE	■ MVA DEMAND [▷]	See page 5-93.
	MESSAGE	■ PULSE [▷]	See page 5-94.
	MESSAGE	■ RUNNING [▷]	See page 5-95.
	MESSAGE	END OF PAGE	
■ SETPOINTS [▷]		■ ANALOG [▷]	See page 5-96.
	MESSAGE	■ ANALOG [▷]	See page 5-96.
	MESSAGE	■ ANALOG [▷]	See page 5-96.
	MESSAGE	■ ANALOG [▷]	See page 5-96.
	MESSAGE	■ ANALOG [▷]	See page 5-98.
	MESSAGE	■ ANALOG [▷]	See page 5-98.
	MESSAGE	■ ANALOG [▷]	See page 5-98.

	MESSAGE	■ ANALOG [▷]	See page 5-98.
	MESSAGE	END OF PAGE	
■ SETPOINTS [▷]		■ SIMULATION [▷]	See page 5-100.
	MESSAGE	■ PRE-FAULT [▷]	See page 5-101.
	MESSAGE	■ FAULT [▷]	See page 5-102.
	MESSAGE	■ TEST [▷]	See page 5-102.
	MESSAGE	■ TEST [▷]	See page 5-103.
	MESSAGE	■ COMMUNICATION [▷]	See page 5-104.
	MESSAGE	■ FACTORY [▷]	See page 5-104.
	MESSAGE	END OF PAGE	

5.1.2 Trips / Alarms/ Control Features

The 489 Generator Management Relay has three basic function categories: TRIPS, ALARMS, and CONTROL.

Trips

A 489 trip feature may be assigned to any combination of the four output relays: 1 Trip, 2 Auxiliary, 3 Auxiliary, and 4 Auxiliary. If a Trip becomes active, the appropriate LED (indicator) on the 489 faceplate illuminates to indicate which output relay 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 (for example, hot RTD) the trip relay(s) will not reset until the condition disappears. On the other hand, if an unlatched trip feature becomes active, that trip resets 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, allowing for troubleshooting after the trip. 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 that a lockout time will occur due to overload trip (see *Model Setup* on page 5–71 for additional details).

Alarms

A 489 alarm feature may be assigned to operate any combination of four output relays: 2 Auxiliary, 3 Auxiliary, 4 Auxiliary, and 5 Alarm. 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 (for example, 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: 1 Trip, 2 Auxiliary, 3 Auxiliary, 4 Auxiliary, and 5 Alarm. 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.

5.1.3 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, 1 Trip, is intended to be used as a trip relay wired to the unit trip breaker. Another relay, 5 Alarm, is intended to be used as the main alarm relay. The three remaining relays, 2 Auxiliary, 3 Auxiliary, and 4 Auxiliary, are intended for special requirements.

When assigning features to relays 2, 3, and 4, it is a good idea to decide early on what is required since features that may be assigned may conflict. For example, if relay 2 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 1 Trip output relay and all alarms default to the 5 Alarm relay. It is recommended that relay assignments be reviewed once all the setpoints have been programmed.

5.1.4 Dual Setpoints

The 489 has dual settings for the current, voltage, power, RTD, and thermal model protection elements (setpoints pages S5 to S9). These setpoints are organized in two groups: the main 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 the S3 Digital Inputs setpoints page. 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.

If only one setting group is required, edit and activate only Group 1 (that is, 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**).

5.1.5 Commissioning

Tables for recording of 489 programmed setpoints are available as a Microsoft Word document from the GE Multilin website at http://www.GEmultilin.com. See the Support Documents section of the 489 Generator Management Relay page for the latest version. This document is also available in print from the GE Multilin literature department (request publication number GET-8445).

5.2 S1 489 Setup

5.2.1 Passcode

PATH: SETPOINTS ▷ S1 489 SETUP ▷ PASSCODE

■ PASSCODE [▷]	ENTER PASSCODE FOR ACCESS:	*Range: 1 to 8 numeric digits*
MESSAGE	SETPOINT ACCESS: Permitted	*Range: Permitted, Restricted*
MESSAGE	CHANGE PASSCODE: No	*Range: No, Yes*

A passcode access security feature is provided with the 489. The passcode is defaulted to "0" (without the quotes) at the time of shipping. 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.

The **ENTER PASSCODE FOR ACCESS** setpoint is seen only if the passcode is not 0 and **SETPOINT ACCESS** is "Restricted". The **SETPOINT ACCESS** and **CHANGE PASSWORD** setpoints are seen only if the passcode is 0 and the **SETPOINT ACCESS** is "Permitted".

To enable passcode protection on a new relay, follow the procedure below:

▷ Press **ENTER** then MESSAGE DOWN until **CHANGE PASSCODE** message is displayed.

▷ Select **Yes** and follow directions to enter a new passcode 1 to 8 digits in length.

Once a new passcode (other than "0") is programmed, it must be entered to gain setpoint access whenever setpoint access is restricted. Assuming that a non-zero passcode has been programmed and setpoint access is restricted, then selecting the passcode subgroup causes the **ENTER PASSCODE AGAIN** message to appear.

▷ Enter the correct passcode. 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, the **SETPOINT ACCESS: Permitted** message appears.

Setpoints can now be entered.

▷ Exit the passcode message with the **ESCAPE** key and program the appropriate setpoints.
If no keypress occurs for 30 minutes, access will be disabled and the passcode must be re-entered. Removing the setpoint access jumper or setting **SETPOINT ACCESS** to **Restricted** also disables setpoint access immediately.

If a new passcode is required, gain setpoint access as follows:

▷ Enter the current valid passcode.

▷ Press **MESSAGE DOWN** to display the **CHANGE PASSCODE** message and follow the directions.
If an invalid passcode is entered, the encrypted passcode is viewable by pressing HELP.

▷ Consult GE Multilin with this number if the currently programmed passcode is unknown. The passcode can be determined with deciphering software.

5.2.2 Preferences

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ PREFERENCES

■ PREFERENCES [▷]		DEFAULT MESSAGE CYCLE TIME: 2.0 s	*Range: 0.5 to 10.0 s in steps of 1*
	MESSAGE	DEFAULT MESSAGE TIMEOUT: 300 s	*Range: 10 to 900 s in steps of 1*
	MESSAGE	PARAMETER AVERAGES CALC. PERIOD: 15 min	*Range: 1 to 90 min. in steps of 1*
	MESSAGE	TEMPERATURE DISPLAY: Celsius	*Range: Celsius, Fahrenheit*
	MESSAGE	WAVEFORM TRIGGER POSITION: 25%	*Range: 1 to 100% in steps of 1*
	MESSAGE	WAVEFORM MEM BUFFER 8x14 cycles	*Range: 1x64, 2x42, 3x32, 4x35, 5x21, 6x18, 7x16, 8x14, 9x12, 10x11, 11x10, 12x9, 13x9, 14x8, 15x8, 16x7 cycles*

Some of the 489 characteristics can be modified to suit different situations. Normally the **S1 489 SETUP ▷▽ PREFERENCES** setpoints group will not require any changes.

- **DEFAULT MESSAGE CYCLE TIME:** If multiple default messages are chosen, the display automatically cycles through these messages. The messages display time can be changed to accommodate different reading rates.
- **DEFAULT MESSAGE TIMEOUT:** If no keys are pressed for a period of time then the relay automatically scans through 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 temperature message 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 “7 x 16" 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.

5.2.3 Communications

Serial Communications

The following setpoints appear when the relay is ordered with the regular enhanced (E) option.

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ COMMUNICATIONS

■ SERIAL PORTS [▷]		SLAVE ADDRESS: 254	*Range: 1 to 254 in steps of 1*
	MESSAGE	COMPUTER RS485 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200*
	MESSAGE	COMPUTER RS485 PARITY: None	*Range: None, Odd, Even*
	MESSAGE	AUXILIARY RS485 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200*
	MESSAGE	AUXILIARY RS485 PARITY: None	*Range: None, Odd, Even*

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 EnerVista 489 Setup software. This program may be used for downloading and uploading setpoint files, viewing measured parameters, and upgrading the 489 firmware to the latest revision.

For RS485 communications, each relay must have a unique address from 1 to 254. Address 0 is the broadcast address monitored by all relays. Addresses do not have to be sequential but no two units can have the same address or 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 Multilin devices in the future.

Ethernet Communications

The following setpoints appear when the relay is ordered with the Ethernet (T) option.

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ COMMUNICATIONS

■ COMMUNICATIONS [▷]		SLAVE ADDRESS: 254	*Range: 1 to 254 in steps of 1*
	MESSAGE	COMPUTER RS485 BAUD RATE: 9600	*Range: 300, 1200, 2400, 4800, 9600, 19200*
	MESSAGE	COMPUTER RS485 PARITY: None	*Range: None, Odd, Even*
	MESSAGE	FRONT PORT RS232 BAUD RATE: 19200	*Range: 300, 1200, 2400, 4800, 9600, 19200*
	MESSAGE	IP ADDRESS: 0.0.0.0	*Range: standard IP address format*
	MESSAGE	SUBNET IP MASK: 255.255.255.000	*Range: standard IP address format*
	MESSAGE	GATEWAY IP ADDRESS: 0.0.0.0	*Range: standard IP address format*

The IP addresses are used with the Modbus protocol. Enter the dedicated IP, subnet IP, and gateway IP addresses provided by the network administrator.

To ensure optimal response from the relay, the typical connection timeout should be set as indicated in the following table:

TCP/IP sessions	Timeout setting
up to 2	2 seconds
up to 4	3 seconds

NOTE

The RS485 COM2 port is disabled if the Ethernet option is ordered.

5.2.4 Real Time Clock

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ REAL TIME CLOCK

■ REAL TIME [▷] CLOCK		DATE (MM, DD, YYYY): 01/01/1995	*Range: 01/01/1995 to 12/31/2094*
	MESSAGE	TIME (HH.MM.SS): 12:00:00	*Range: 00:00:00 to 23:59:59*
	MESSAGE	IRIG-B SIGNAL TYPE: NONE	*Range: None, DC Shift, Amplitude Modulated*

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 100 ms of delay in receiving serial commands so the clock time in each relay is ±100 ms, ± the 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 correspondingly. The “signal type” setpoint must be set to match the signal provided by the receiver.

5.2.5 Default Messages

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ DEFAULT MESSAGES

■ DEFAULT [▷]		GENERATOR STATUS: Stopped	*Range: N/A*
	MESSAGE	A: 0 B: 0 C: 0 Amps	*Range: N/A*
	MESSAGE	Vab: 0 Vbc: 0 Vca: 0 Volts	*Range: N/A*
	MESSAGE	FREQUENCY: 0.00 Hz	*Range: N/A*
	MESSAGE	POWER FACTOR: 0.00	*Range: N/A*
	MESSAGE	REAL POWER: 0 MW	*Range: N/A*
	MESSAGE	REACTIVE POWER 0 Mvar	*Range: N/A*
	MESSAGE	DATE: 01/01/1995 TIME: 12:00:00	*Range: N/A*
	MESSAGE	GE MULTILIN 489 GENERATOR RELAY	*Range: N/A*

The 489 displays default messages after a period of keypad inactivity. Up to 20 default messages can be selected for display. If more than one message is chosen, they will automatically scroll at a rate determined by the **S1 489 SETUP ▷▽ PREFERENCES ▷ DEFAULT MESSAGE CYCLE TIME** setpoint. Any actual value can be selected for display. In addition, up to 5 user-programmable messages can be created and displayed with the 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. Currently selected default messages can be viewed in **DEFAULT MESSAGES** subgroup.

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

▷ Enter the correct passcode at **S1 489 SETUP ▷ PASSCODE ▷ ENTER PASSCODE FOR ACCESS** to allow setpoint entry (unless it has already been entered or is "0", defeating the passcode security feature).

▷ Select the message to be add to the default message list using the MESSAGE keys.
The selected message can be any actual value or message scratchpad message.

▷ Press ENTER.
The **PRESS [ENTER] TO ADD DEFAULT MESSAGES** message will be displayed for 5 seconds:

▷ Press ENTER again while this message is displayed to add the current message to the end of the default message list.

If the procedure was followed correctly, the **DEFAULT MESSAGE HAS BEEN ADDED** flash message is displayed:

▷ To verify that the message was added, view the last message under the **S1 489 SETUP ▷▽ DEFAULT MESSAGES** menu.

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

▷ Enter the correct passcode at **S1 489 SETUP ▷ PASSCODE ▷ ENTER PASSCODE FOR ACCESS** to allow setpoint entry (unless the passcode has already been entered or unless the passcode is "0" defeating the passcode security feature).

▷ Select the message to remove from the default message list under the **S1 489 SETUP ▷▽ DEFAULT MESSAGES** menu.

▷ Select the default message to remove and press ENTER.
The relay will display **PRESS [ENTER] TO REMOVE MESSAGE**.

▷ Press ENTER while this message is displayed to remove the current message out of the default message list.

If the procedure was followed correctly, the **DEFAULT MESSAGE HAS BEEN REVOVED** flash message is displayed.

5.2.6 Message Scratchpad

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ MESSAGE SCRATCHPAD

■ MESSAGE [▷]		TEXT 1	*Range: 40 alphanumeric characters*
	MESSAGE	TEXT 2	*Range: 40 alphanumeric characters*
	MESSAGE	TEXT 3	*Range: 40 alphanumeric characters*

MESSAGE	TEXT 4	*Range: 40 alphanumeric characters*
MESSAGE	GE MULTILIN 489 GENERATOR RELAY	*Range: 40 alphanumeric characters*

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 decimal [.] key to enter text mode.
An underscore cursor will appear under the first character.

▷ Use the VALUE keys to display the desired character.
A space is selected like a character.

▷ 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.

5.2.7 Clear Data

PATH: SETPOINTS ▷ S1 489 SETUP ▷▽ CLEAR DATA

■ CLEAR DATA [▷]	CLEAR LAST TRIP DATA: No	*Range: No, Yes*
MESSAGE	RESET MWh and Mvarh METERS: No	*Range: No, Yes*
MESSAGE	CLEAR PEAK DEMAND DATA: No	*Range: No, Yes*
MESSAGE	CLEAR RTD MAXIMUMS: No	*Range: No, Yes*
MESSAGE	CLEAR ANALOG I/P MIN/MAX: No	*Range: No, Yes*
MESSAGE	CLEAR TRIP COUNTERS: No	*Range: No, Yes*
MESSAGE	CLEAR EVENT RECORD: No	*Range: No, Yes*
MESSAGE	CLEAR GENERATOR INFORMATION: No	*Range: No, Yes*

MESSAGE	CLEAR BREAKER INFORMATION: No	*Range: No, Yes*

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 256 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:** The number of thermal resets and the total generator running hours can be viewed in actual values. On a new installation, or if new equipment is installed, this information is cleared through 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.

5.3 S2 System Setup

5.3.1 Current Sensing

PATH: SETPOINTS ▷▽ S2 SYSTEM SETUP ▷ CURRENT SENSING

■ CURRENT [▷]	PHASE CT PRIMARY: -------------	*Range: 1 to 5000 in steps of 1, Not Programmed*
MESSAGE	GROUND CT: 50:0.025	*Range: None, 1A Secondary, 5A Secondary, 50:0.025*
MESSAGE	GROUND CT RATIO: 100: 1	*Range: 10 to 10000 in steps of 1. Seen only if Ground CT Type is 1 A*
MESSAGE	GROUND CT RATIO: 100: 5	*Range: 10 to 10000 in steps of 1. Seen only if Ground CT Type is 5 A*

As a safeguard, the **PHASE CT PRIMARY** and **GENERATOR PARAMETERS** setpoints are defaulted to "--------" when shipped, indicating that the 489 was never programmed. Once these values are entered, the 489 will be in service. Select the Phase CT so that the maximum fault current does not exceed 20 times the primary rating. When relaying class CTs are purchased, this precaution helps prevent CT saturation under fault conditions. The secondary value of 1 or 5 A **must** be specified when ordering so 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 CT input, set **GROUND CT** to "50:0.025". No additional ground CT messages will appear. On solid or low resistance grounded systems, where fault currents may be quite large, the 489 1 A/5 A secondary Ground CT input should be used. Select the Ground CT primary so 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.

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

5.3.2 Voltage Sensing

PATH: SETPOINTS ▷ S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING

■ VOLTAGE [▷]	VT CONNECTION TYPE: None	*Range: Open Delta, Wye, None*
MESSAGE	VOLTAGE TRANSFORMER RATIO: 5.00:1	*Range: 1.00:1 to 300.00:1 in steps of 0.01*
MESSAGE	NEUTRAL VOLTAGE TRANSFORMER: No	*Range: No, Yes*
MESSAGE	NEUTRAL VT RATIO: 5.00:1	*Range: 1.00:1 to 240.00:1 in steps of 0.01.*

NOTE

The **NEUTRAL VT RATIO** setpoint is seen only if **NEUTRAL VOLTAGE TRANSFORMER** setpoint is "Yes".

The voltage transformer connections and turns ratio are entered here. 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 VT ratio must be entered here for voltage measurement across the neutral grounding device. Note that the neutral VT input is not intended to be used at continuous voltages greater than 240 V. If the voltage across the neutral input is less than 240 V during fault conditions, an auxiliary voltage transformer is not required. If this is not the case, use an auxiliary VT to drop the fault voltage below 240 V. The **NEUTRAL VT RATIO** entered must be the total effective ratio of the grounding transformer and any auxiliary step up or step down VT.

For example, if the distribution transformer ratio is 13200:480 and the auxiliary VT ratio is 600:120, the **NEUTRAL VT RATIO** setpoint is calculated as:

$$\begin{aligned}\textbf{NEUTRAL VT RATIO} &= \text{Distribution Transformer Ratio} \times \text{Auxiliary VT Ratio} : 1 \\ &= \frac{13200}{480} \times \frac{600}{120} : 1 = 137.50 : 1\end{aligned} \quad \textbf{(EQ 0.1)}$$

Therefore, set **NEUTRAL VT RATIO** to 137.50:1

5.3.3 Generator Parameters

PATH: SETPOINTS ▷▽ S2 SYSTEM SETUP ▷▽ GENERATOR PARAMETERS

■ GENERATOR [▷]		GENERATOR RATED MVA: ----------------	*Range: 0.050 to 2000.000 MVA or Not Programmed*
	MESSAGE	GENERATOR RATED POWER FACTOR: -------	*Range: 0.05 to 0.99 or Not Programmed*
	MESSAGE	GENERATOR VOLTAGE PHASE-PHASE: --------	*Range: 100 to 30000 V in steps of 1 or Not Programmed*
	MESSAGE	GENERATOR NOMINAL FREQUENCY: ----------	*Range: 25 Hz, 50 Hz, 60 Hz, or Not Programmed*
	MESSAGE	GENERATOR PHASE SEQUENCE: -----------	*Range: ABC, ACB, or Not Programmed*

As a safeguard, when a unit is received from the factory, the **PHASE CT PRIMARY** and Generator Parameters setpoints will be defaulted to "--------", indicating they are not programmed. The 489 indicates that it was never programmed. Once these values are entered, the 489 will be in service. All elements associated with power quantities are programmed in per unit values calculated from the rated MVA and power factor. The generator full load amps (FLA) is calculated as

$$\text{Generator FLA} = \frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Generator Rated Phase-Phase Voltage}} \quad \textbf{(EQ 0.2)}$$

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.

5.3.4 Serial Start/Stop Initiation

PATH: SETPOINTS ▷▽ S2 SYSTEM SETUP ▷▽ SERIAL START/STOP

■ SERIAL [▷]		SERIAL START/STOP INITIATION: Off	*Range: On, Off*
	MESSAGE	STARTUP INITIATION RELAYS (2-5): ----	*Range: Any Combination of Relays 2 to 5*
	MESSAGE	SHUTDOWN INITIATION RELAYS (1-4): ----	*Range: Any Combination of Relays 1 to 4*
	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 GE publication number GEK-106495: *489 Communications Guide* 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.

5.4 S3 Digital Inputs

5.4.1 Description

The 489 has nine (9) 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.

WARNING

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 (see the **S1 489 SETUP ▷ PASSCODE** menu). The access switch has no effect on setpoint programming from the RS232 and RS485 serial communications ports.

5.4.2 Breaker Status

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷ BREAKER STATUS

```
■
BREAKER                [▷]
```

```
BREAKER STATUS:
Breaker Auxiliary b
```

Range: Breaker Auxiliary a, Breaker Auxiliary b

WARNING

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.

5.4.3 General Input A to G

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ GENERAL INPUT A(G)

■ GENERAL [▷]	ASSIGN DIGITAL INPUT: None	*Range: None, Input 1 to Input 7. See note below.*
MESSAGE	ASSERTED DIGITAL INPUT STATE: Closed	*Range: Closed, Open*
MESSAGE	INPUT NAME: Input A	*Range: 12 alphanumeric characters*
MESSAGE	BLOCK INPUT FROM ONLINE: 0 s	*Range: 0 to 5000 s in steps of 1.*
MESSAGE	GENERAL INPUT A CONTROL: Off	*Range: Off, On*
MESSAGE	PULSED CONTROL RELAY DWELL TIME: 0.0 s	*Range: 0.0 to 25.0 s in steps of 0.1*
MESSAGE	ASSIGN CONTROL RELAYS (1-5): -----	*Range: Any combination of Relays 1 to 5*
MESSAGE	GENERAL INPUT A CONTROL EVENTS: Off	*Range: Off, On*
MESSAGE	GENERAL INPUT A ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	GENERAL INPUT A ALARM DELAY: 0.5 s	*Range: 0.1 to 5000.0 s in steps of 0.1*
MESSAGE	GENERAL INPUT A ALARM EVENTS: Off	*Range: Off, On*
MESSAGE	GENERAL INPUT A TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	GENERAL INPUT A TRIP DELAY: 5.0 s	*Range: 0.1 to 5000.0 in steps of 0.1*

NOTE

If an input is assigned to the Tachometer function, it may not be assigned via the **ASSIGN DIGITAL INPUT** setpoint.

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 inputs are programmable. To disable the input functions when the generator is offline, until some 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 "0 s" for the **BLOCK INPUT FROM ONLINE** block time indicates that the input functions are always enabled while the generator is offline as well as online.

Inputs may be configured for control, alarm, or trip. If the control feature is enabled, the assigned output relay(s) operate when the input is asserted. If the **PULSED CONTROL RELAY DWELL TIME** is set to “0”, the output relay(s) operate only while the input is asserted. However, if a dwell time is assigned, the output relay(s) 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, an alarm or trip will occur after the specified delay.

5.4.4 Remote Reset

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ REMOTE RESET

```
■ REMOTE RESET      [▷]        ASSIGN DIGITAL
                               INPUT: None
```

Range: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7

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.

If an input is assigned to the tachometer function, it may not be used here.

5.4.5 Test Input

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ TEST INPUT

```
■ TEST INPUT        [▷]        ASSIGN DIGITAL
                               INPUT: None
```

Range: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7

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.

If an input is assigned to the tachometer function, it may not be used here.

5.4.6 Thermal Reset

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ THERMAL RESET

```
■ THERMAL RESET     [▷]        ASSIGN DIGITAL
                               INPUT: None
```

Range: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7

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.

If an input is assigned to the tachometer function, it may not be used here.

5.4.7 Dual Setpoints

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ DUAL SETPOINTS

■ DUAL [▷]		ASSIGN DIGITAL INPUT: None	*Range: None, Input 1, Input 2, Input 3, Input 4, Input 5, Input 6, Input 7*
	MESSAGE	ACTIVATE SETPOINT GROUP: Group 1	*Range: Group 1, Group 2*
	MESSAGE	EDIT SETPOINT GROUP: Group 1	*Range: Group 1, Group 2*

If an input is assigned to the tachometer function, it may not be used here.

This feature allows for dual settings for the current, voltage, power, RTD, and thermal model protection elements (setpoint pages S5 to 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.

When accessing the Group 2 setpoints, the block character (■) for the setpoints menu header will be replaced by the number two (**2**) as indicated below.

The following chart illustrates the available Group 2 (alternate group) setpoints

2 SETPOINTS [▷] S5 CURRENT ELEM.	2 SETPOINTS [▷] S6 VOLTAGE ELEM.	2 SETPOINTS [▷] S7 POWER ELEMENTS	2 SETPOINTS [▷] S8 RTD TEMPERA-TURE	2 SETPOINTS [▷] S9 THERMAL MODEL
2 OVERCURRENT [▷] ALARM	2 UNDERVOLTAGE [▷]	2 REACTIVE [▷] POWER	2 RTD [▷] TYPES	2 MODEL [▷] SETUP
2 OFFLINE [▷] OVERCURRENT	2 OVERVOLTAGE [▷]	2 REVERSE [▷] POWER	2 RTD #1 [▷]	2 THERMAL [▷] ELEMENTS
2 INADVERTENT [▷] ENERGIZATION	2 VOLTS/HERTZ [▷]	2 LOW [▷] FORWARD POWER	↓	
2 PHASE [▷] OVERCURRENT	2 PHASE [▷] REVERSAL		2 RTD #12 [▷]	
2 NEGATIVE [▷] SEQUENCE	2 UNDERFREQUENCY [▷]		2 OPEN [▷] RTD SENSOR	
2 GROUND [▷] OVERCURRENT	2 OVERFREQUENCY [▷]		2 RTD [▷] SHORT/LOW TEMP	
2 PHASE [▷] DIFFERENTIAL	2 NEUTRAL [▷] OVERVOLTAGE (Fund)			
2 GROUND [▷] DIRECTIONAL	2 NEUTRAL U/V [▷] (3rd HARMONIC)			
2 HIGH-SET [▷] PHASE OVERCURRENT	2 LOSS [▷] OF EXCITATION			
	2 DISTANCE [▷] ELEMENT			

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.

5.4.8 Sequential Trip

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ SEQUENTIAL TRIP

■ SEQUENTIAL [▷]		ASSIGN DIGITAL INPUT: None	*Range: None, Input 1 to Input 7.*
	MESSAGE	SEQUENTIAL TRIP TYPE Low Forward Power	*Range: Low Forward Power, Reverse Power*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	SEQUENTIAL TRIP LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
	MESSAGE	SEQUENTIAL TRIP DELAY: 1.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*

If an input is assigned to the tachometer function, it may not be used here.

During routine shutdown and for some 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-phase 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 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.

5.4.9 Field-Breaker

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ FIELD-BREAKER DISCREPANCY

■ FIELD-BREAKER [▷]		ASSIGN DIGITAL INPUT: None	Range: None, Input 1 to Input 7
	MESSAGE	FIELD STATUS CONTACT: Auxiliary a	Range: Auxiliary a, Auxiliary b
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
	MESSAGE	FIELD-BKR DISCREP. TRIP DELAY: 1.0 s	Range: 0.1 to 500.0 s in steps of 0.1

If an input is assigned to the tachometer function, it may not be used here.

The field-breaker discrepancy function is intended for use with synchronous generators. If a digital input is assigned to this function, any time the field status contact indicates the field is not applied and 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 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 it is closed.

5.4.10 Tachometer

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ TACHOMETER

■ TACHOMETER [▷]		ASSIGN DIGITAL INPUT: None	Range: None, Inputs 4 to 7.
	MESSAGE	RATED SPEED: 3600 RPM	Range: 100 to 3600 RPM in steps of 1
	MESSAGE	TACHOMETER ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	TACHOMETER ALARM SPEED: 110% Rated	Range: 101 to 175% in steps of 1
	MESSAGE	TACHOMETER ALARM DELAY: 1 s	Range: 1 to 250 s in steps of 1
	MESSAGE	TACHOMETER ALARM EVENTS: Off	Range: On, Off
	MESSAGE	TACHOMETER TRIP: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4

MESSAGE	TACHOMETER TRIP SPEED: 110% Rated	*Range: 101 to 175% in steps of 1*
MESSAGE	TACHOMETER TRIP DELAY: 1 s	*Range: 1 to 250 s in steps of 1*

One of assignable digital inputs 4 to 7 may be assigned to the tachometer function to measure mechanical speed. The 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 measured RPM exceeds the threshold setpoint for the time specified by the delay, a trip or alarm will occur. The RPM value can be viewed with the **A2 METERING DATA ▷▽ SPEED ▷▽ TACHOMETER** actual value.

For 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.

5.4.11 Waveform Capture

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ WAVEFORM CAPTURE

■ WAVEFORM [▷]	ASSIGN DIGITAL INPUT: None	*Range: None, Input 1 to Input 7.*

If an input is assigned to the tachometer function, it may not be used here.

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.

5.4.12 Ground Switch Status

PATH: SETPOINTS ▷▽ S3 DIGITAL INPUTS ▷▽ GND SWITCH STATUS

■ GROUND [▷]	ASSIGN DIGITAL INPUT: None	*Range: None, Input 1 to Input 7*
MESSAGE	GROUND SWITCH CONTACT: Auxiliary a	*Range: Auxiliary a, Auxiliary b*

If an input is assigned to the tachometer function, it may not be used here.

This function is used to detect the status of a grounding switch for the generator for which the relay is installed. Refer to *Stator Ground Fault* on page A–1 for additional details.

5.5 S4 Output Relays

5.5.1 Description

Five of the six output relays are always non-failsafe; the 6 Service relay is always failsafe. As a failsafe, the 6 Service 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 6 Service output will however indicate that the 489 has been drawn out.

5.5.2 Relay Reset Mode

PATH: SETPOINTS ▷▽ S4 OUTPUT RELAYS ▷ RELAY RESET MODE

■ RELAY [▷]		1 TRIP: All Resets	*Range: All Resets, Remote Reset Only*
	MESSAGE	2 AUXILIARY: All Resets	*Range: All Resets, Remote Reset Only*
	MESSAGE	3 AUXILIARY: All Resets	*Range: All Resets, Remote Reset Only*
	MESSAGE	4 AUXILIARY: All Resets	*Range: All Resets, Remote Reset Only*
	MESSAGE	5 ALARM: All Resets	*Range: All Resets, Remote Reset Only*
	MESSAGE	6 SERVICE: All Resets	*Range: All Resets, Remote Reset Only*

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).

For example, selected trips such as Instantaneous Overcurrent and Ground Fault may be assigned to output relay 2 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 relay 2.

▷ Program relay 2 to Remote Reset Only.

5.6 S5 Current Elements

5.6.1 Inverse Time Overcurrent Curve Characteristics

Description

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 5–1: 489 Overcurrent Curve Types

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

$$T_{RESET} = \frac{E \times M \times C_R}{100} \quad \textbf{(EQ 0.3)}$$

where: T_{RESET} = reset time in seconds
E = energy capacity reached (in %)
M = curve multiplier
C_R= characteristic constant (5 for ANSI, IAC, Definite Time and FlexCurves™, 8 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:

$$T = M \times \left(A + \frac{B}{(I/I_{pickup}) - C} + \frac{D}{((I/I_{pickup}) - C)^2} + \frac{E}{((I/I_{pickup}) - C)^3} \right) \qquad \textbf{(EQ 0.4)}$$

where: T = Trip Time in seconds
M = Multiplier setpoint
I = Input Current
I_{pickup} = Pickup Current setpoint
A, B, C, D, E = Constants

Table 5–2: 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

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:

$$T = M \times \left(\frac{K}{(I/I_{pickup})^E - 1} \right) \qquad \textbf{(EQ 0.5)}$$

where: T = Trip Time in seconds
M = Multiplier setpoint
I = Input Current
I_{pickup} = Pickup Current setpoint
K, E = Constants

Table 5–3: 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:

$$T = M \times \left(A + \frac{B}{(I/I_{pickup}) - C} + \frac{D}{((I/I_{pickup}) - C)^2} + \frac{E}{((I/I_{pickup}) - C)^3} \right) \qquad \textbf{(EQ 0.6)}$$

where: T = Trip Time in seconds
M = Multiplier setpoint
I = Input Current
I_{pickup} = Pickup Current setpoint
A, B, C, D, E = Constants

Table 5–4: IAC Inverse Time Curve Constants

IAC Curve Shape	Constants				
	A	B	C	D	E
Extreme Inverse	0.0040	0.6379	0.6200	1.7872	0.2461
Very Inverse	0.0900	0.7955	0.1000	–1.2885	7.9586
Inverse	0.2078	0.8630	0.8000	–0.4180	0.1947
Short Inverse	0.0428	0.0609	0.6200	–0.0010	0.0221

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 EnerVista 489 Setup software or the front panel keys and display.

Table 5–5: FlexCurve™ Trip Times

Pickup I/I_{pkp}	Trip Time (ms)	Pickup I/I_{pkp}	Trip Time (ms)	Pickup I/I_{pkp}	Trip Time (ms)	Pickup I/I_{pkp}	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 to 1000.00 makes this delay adjustable from instantaneous to 100.00 seconds in steps of 1 ms.

$$T = M \times 100 \text{ ms}, \text{ when } I > I_{pickup} \qquad \textbf{(EQ 0.7)}$$

where: T = Trip Time in seconds
M = Multiplier Setpoint
I = Input Current
I_{pickup} = Pickup Current Setpoint

5.6.2 Overcurrent Alarm

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷ OVERCURRENT ALARM

1 OVERCURRENT ALARM [▷]		OVERCURRENT ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	OVERCURRENT ALARM LEVEL: 1.01 x FLA	Range: 0.10 to 1.50 × FLA in steps of 0.01
	MESSAGE	OVERCURRENT ALARM DELAY: 0.1 s	Range: 0.1 to 250.0 s in steps of 0.1
	MESSAGE	OVERCURRENT ALARM EVENTS: Off	Range: On, Off

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:

$$\text{Generator FLA} = \frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Generator Rated Phase-Phase Voltage}} \qquad \textbf{(EQ 0.8)}$$

5.6.3 Offline Overcurrent

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ OFFLINE OVERCURRENT

1 OFFLINE OVERCURRENT [▷]		OFFLINE OVERCURRENT TRIP: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
	MESSAGE	OFFLINE OVERCURRENT PICKUP: 0.05 x CT	Range: 0.05 to 1.00 × CT in steps of 0.01
	MESSAGE	OFFLINE OVERCURRENT TRIP DELAY: 5 cycles	Range: 3 to 99 cycles in steps of 1

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.

5.6.4 Inadvertent Energization

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ INADVERTENT ENERG.

`1 INADVERTENT [▷]` `ENERGIZATION`	`INADVERTENT ENERGIZE` `TRIP: Off`	*Range: Off, Latched, Unlatched*
MESSAGE	`ASSIGN TRIP` `RELAYS (1-4): 1---`	*Range: Any combination of Relays 1 to 4*
MESSAGE	`ARMING SIGNAL:` `U/V and Offline`	*Range: U/V and Offline, U/V or Offline*
MESSAGE	`INADVERTENT ENERGIZE` `O/C PICKUP: 0.05 x CT`	*Range: 0.05 to 3.00 × CT in steps of 0.01*
MESSAGE	`INADVERTENT ENERGIZE` `PICKUP: 0.50 x Rated`	*Range: 0.50 to 0.99 × Rated Voltage in steps of 0.01*

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

This feature requires 5 seconds to arm, 250 ms 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.

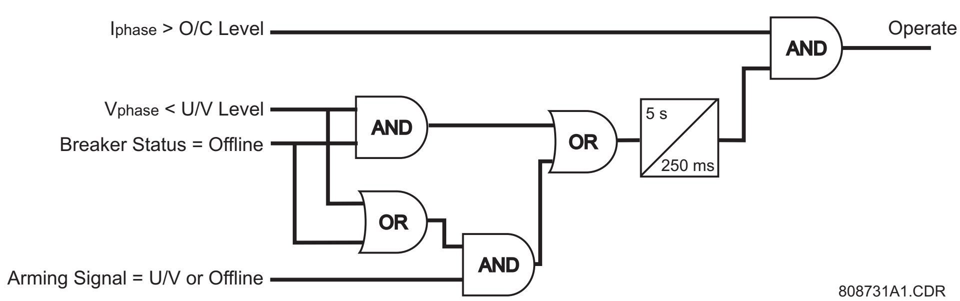


FIGURE 5–1: Inadvertent Energization Logic

5.6.5 Phase Overcurrent

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ PHASE OVERCURRENT

1 PHASE OVERCURRENT [▷]		PHASE OVERCURRENT TRIP: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
	MESSAGE	ENABLE VOLTAGE RESTRAINT: No	Range: No, Yes
	MESSAGE	VOLTAGE LOWER LIMIT: 10%	Range: 10 to 60%. Seen only if **ENABLE VOLTAGE RESTRAINT** is "Yes"
	MESSAGE	PHASE OVERCURRENT PICKUP: 10.00 x CT	Range: 0.15 to 20.00 × CT in steps of 0.01
	MESSAGE	CURVE SHAPE: ANSI Extremely Inv.	Range: See Table 5–1: 489 Overcurrent Curve Types on page –29.
	MESSAGE	FLEXCURVE TRIP TIME AT 1.03 x PU: 65535 ms	Range: 0 to 65535 ms Seen only if **CURVE SHAPE** is "Flexcurve"
		↓	
	MESSAGE	FLEXCURVE TRIP TIME AT 20.0 x PU: 65535 ms	Range: 0 to 65535 ms. Seen only if **CURVE SHAPE** is "Flexcurve"
	MESSAGE	OVERCURRENT CURVE MULTIPLIER: 1.00	Range: 0.00 to 1000.00 in steps of 0.01
	MESSAGE	OVERCURRENT CURVE RESET: Instantaneous	Range: Instantaneous, Linear

If the primary system protection 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 these curve shapes are not adequate, FlexCurves™ may be used to customize the inverse time curve characteristics.

The voltage restraint feature lowers the pickup value of each phase time overcurrent element in a fixed relationship (see figure below) with the corresponding input voltage to a minimum pickup of 0.15 × CT. The **VOLTAGE LOWER LIMIT** setpoint prevents 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 99 ms; therefore, any voltage restrained overcurrent trip should have a time delay of 100 ms or more or nuisance tripping on fuse loss could occur.

For example, to determine the voltage restrained phase overcurrent pickup level under the following situation:

- **PHASE OVERCURRENT PICKUP:** "2.00 × CT"

- **ENABLE VOLTAGE RESTRAINT:** "Yes"
- **VOLTAGE LOWER LIMIT**: 10%
- Phase-Phase Voltage / Rated Phase-Phase Voltage = 0.4 p.u. V

The voltage restrained phase overcurrent pickup level is calculated as follows:

$$\begin{aligned} \text{Pickup}_{\text{vrest}} &= \text{Phase OC Pickup} \times \text{Voltage Rest. Pickup Multiplier} \times \text{CT} \\ &= (2 \times 0.4) \times \text{CT} = 0.8 \times \text{CT} \end{aligned} \quad \textbf{(EQ 5.9)}$$

The 489 phase overcurrent restraint voltages and restraint characteristic are shown below.

Phase Overcurrent Restraint Voltages:

CURRENT	VOLTAGE
IA	Vab
IB	Vbc
IC	Vca

808792A4.CDR

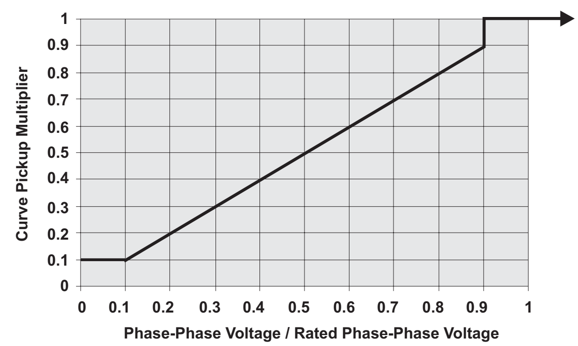


FIGURE 5–2: Voltage Restraint Characteristic

5.6.6 Negative Sequence

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ NEGATIVE SEQUENCE

1 NEGATIVE SEQUENCE [▷]	NEGATIVE SEQUENCE ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	NEG. SEQUENCE ALARM PICKUP: 3% FLA	*Range: 3 to 100% FLA in steps of 1*
MESSAGE	NEGATIVE SEQUENCE ALARM DELAY: 0.5 s	*Range: 0.1 to 100.0 s in steps of 0.1*
MESSAGE	NEGATIVE SEQUENCE ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	NEGATIVE SEQUENCE O/C TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	NEG. SEQUENCE O/C TRIP PICKUP: 8% FLA	*Range: 3 to 100% FLA in steps of 1*
MESSAGE	NEG. SEQUENCE O/C CONSTANT K: 1	*Range: 1 to 100 in steps of 1*
MESSAGE	NEG. SEQUENCE O/C MAX. TIME: 1000 s	*Range: 10 to 1000 s in steps of 1*

MESSAGE

```
NEG. SEQUENCE O/C
RESET RATE: 227.0 s
```

Range: 0.0 to 999.9 s in steps of 0.01

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 short time negative-sequence capability of the generator is defined as follows:

$$K = I_2^2 T \qquad \textbf{(EQ 5.10)}$$

where: K = constant from generator manufacturer depending on size and design;
I_2 = negative sequence current as a percentage of generator rated FLA as measured at the output CTs;
t = time in seconds when I_2 > pickup (minimum 250 ms, maximum defined by setpoint).

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:

$$\text{Generator FLA} = \frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Rated Generator Phase-Phase Voltage}} \qquad \textbf{(EQ 5.11)}$$

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.

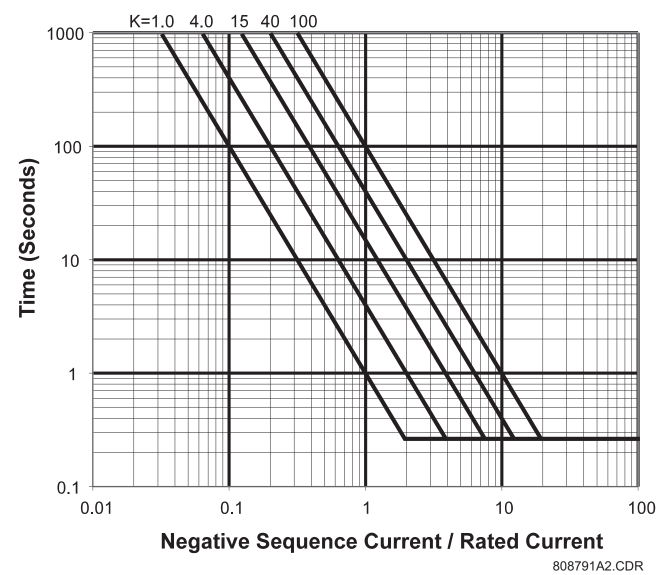


FIGURE 5–3: Negative-Sequence Inverse Time Curves

5.6.7 Ground Overcurrent

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ GROUND OVERCURRENT

1 GROUND OVERCURRENT [▷]	GROUND OVERCURRENT ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	GROUND O/C ALARM PICKUP: 0.20 x CT	*Range: 0.05 to 20.00 × CT in steps of 0.01*
MESSAGE	GROUND O/C ALARM DELAY: 0 cycles	*Range: 0 to 100 cycles in steps of 1*
MESSAGE	GROUND OVERCURRENT ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	GROUND OVERCURRENT TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	GROUND O/C TRIP PICKUP: 0.20 x CT	*Range: 0.05 to 20.00 × CT in steps of 0.01*
MESSAGE	CURVE SHAPE: ANSI Extremely Inv.	*Range: see Table 5–1: 489 Overcurrent Curve Types on page –29.*
MESSAGE	FLEXCURVE TRIP TIME AT 1.03 x PU: 65535 ms	*Range: 0 to 65535 ms. Seen only if* CURVE SHAPE *is Flexcurve*
MESSAGE	FLEXCURVE TRIP TIME AT 1.05 x PU: 65535 ms	*Range: 0 to 65535 ms. Seen only if* CURVE SHAPE *is Flexcurve*
	↓	
MESSAGE	FLEXCURVE TRIP TIME AT 20.0 x PU: 65535 ms	*Range: 0 to 65535 ms. Seen only if* CURVE SHAPE *is Flexcurve*
MESSAGE	OVERCURRENT CURVE MULTIPLIER: 1.00	*Range: 0.00 to 1000.00 in steps of 0.01*
MESSAGE	OVERCURRENT CURVE RESET: Instantaneous	*Range: Instantaneous, Linear*

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 CT rating for the 489 is 50:0.025.

For example, if the ground CT is 50:0.025, a pickup of 0.20 would be 0.20 × 50 = 10 A primary. If the ground CT is 50:0.025, a pickup of 0.05 would be 0.05 × 50 = 2.5 A primary.

5.6.8 Phase Differential

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ PHASE DIFFERENTIAL

`1 PHASE [▷]` `DIFFERENTIAL`		`PHASE DIFFERENTIAL` `TRIP: Off`	*Range: Off, Latched, Unlatched*
	MESSAGE	`ASSIGN TRIP` `RELAYS (1-4): 1---`	*Range: Any combination of Relays 1 to 4*
	MESSAGE	`DIFFERENTIAL TRIP` `MIN. PICKUP: 0.10 x`	*Range: 0.05 to 1.00 × CT in steps of 0.01*
	MESSAGE	`DIFFERENTIAL TRIP` `SLOPE 1: 10%`	*Range: 1 to 100% in steps of 1*
	MESSAGE	`DIFFERENTIAL TRIP` `SLOPE 2: 20%`	*Range: 1 to 100% in steps of 1*
	MESSAGE	`DIFFERENTIAL TRIP` `DELAY: 0 cycles`	*Range: 0 to 100 cycles in steps of 1*

The 489 differential element consists of the well known, dual slope, percent restraint characteristic. A differential signal is derived from the phasor sum of the currents on either side of the machine. A restraint signal is derived from the average of the magnitudes of these two currents. An internal flag (DIFF) is asserted when the differential signal crosses the operating characteristic as defined by the magnitude of the restraint signal. The DIFF flag produces a relay operation.

External faults near generators typically result in very large time constants of dc components in the fault currents. This creates a real danger of CT saturation.

The external fault currents will be large and the CTs will initially reproduce the fault current without distortion. Consequently the relay will see a large restraint signal coupled with a small differential signal. This condition is used as an indication of the possible onset of ac saturation of the CTs.

Magnetizing Inrush current due to the energizing of a step-up transformer or a sudden change of load, could cause a large dc offset on even very small currents that would saturate poor quality or mismatched CTs within a few power system cycles.

In order to provide additional security against maloperations during these events, an internal flag, SC, is set when either an ac or a dc saturation condition is indicated. Once the SC flag has been set, a comparison of the phase angles of the currents on either side of the generator is carried out. An external fault is inferred if the phase comparison indicates both currents are flowing in the same direction. An internal fault is inferred if the phase comparison indicates that the currents are flowing in opposite directions. In this case an internal flag, DIR, is set.

If the SC flag is not set, then the relay will operate for a DIFF flag alone. If the SC flag is set then the directional flag supervises the differential flag. The requirement for both the DIFF flag and the DIR flag during the period where CT saturation is likely therefore enhances the security of the scheme.

The differential element for phase A will operate when:

$$I_{operate} > k \times I_{restraint} \quad \textbf{(EQ 5.12)}$$

where the following hold:

$$I_{operate} = \overline{I_A} + \overline{I_a} = \text{operate current} \quad \textbf{(EQ 5.13)}$$

$$I_{restraint} = \frac{|I_A| + |I_a|}{2} = \text{restraint current} \quad \textbf{(EQ 5.14)}$$

$$\begin{gathered} k = \text{characteristic slope of the differential element in percent} \\ k = Slope1 \text{ if } I_R < 2 \times \text{CT}; \quad k = Slope2 \text{ if } I_R \geq 2 \times \text{CT} \end{gathered} \quad \textbf{(EQ 5.15)}$$

$$I_A = \text{phase current measured at the output CT} \quad \textbf{(EQ 5.16)}$$

$$I_a = \text{phase current measured at the neutral end CT} \quad \textbf{(EQ 5.17)}$$

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

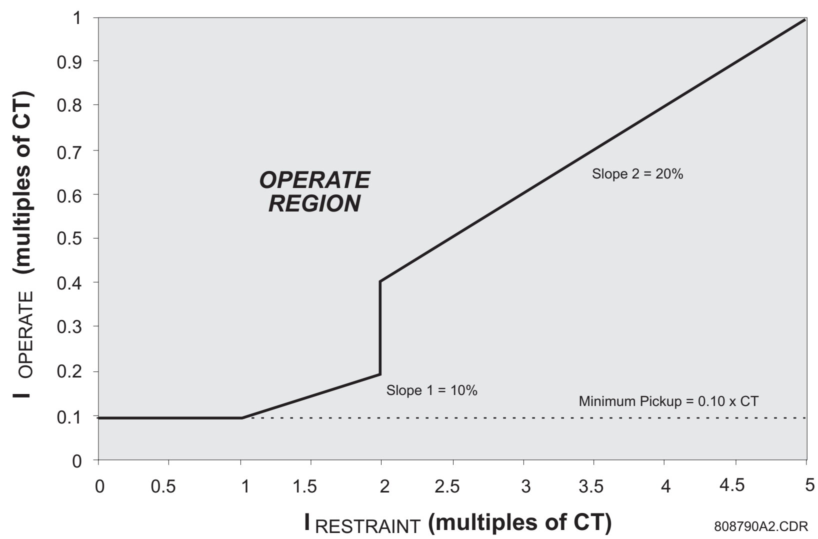


FIGURE 5–4: Differential Elements

5.6.9 Ground Directional

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ GROUND DIRECTIONAL

1 GROUND DIRECTIONAL [▷]		SUPERVISE WITH DIGITAL INPUTS: Yes	*Range: Yes, No.*
	MESSAGE	GROUND DIRECTIONAL MTA: 0°	*Range: 0°, 90°, 180°, 270°* *MTA = Maximum Torque Angle*
	MESSAGE	GROUND DIRECTIONAL ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	GROUND DIR. ALARM PICKUP: 0.05 x CT	*Range: 0.05 to 20.00 × CT in steps of 0.01*

MESSAGE	GROUND DIR. ALARM DELAY: 3.0 sec.	*Range: 0.1 to 120.0 sec. in steps of 0.1*
MESSAGE	GROUND DIR. ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	GROUND DIRECTIONAL TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	GROUND DIR. TRIP PICKUP: 0.05 x CT	*Range: 0.05 to 20.00 × CT in steps of 0.01*
MESSAGE	GROUND DIR. TRIP DELAY: 3.0 sec.	*Range: 0.1 to 120.0 sec. in steps of 0.1*

NOTE

The **SUPERVISE WITH DIGITAL INPUTS** setpoint is seen only if a digital input assigned to Ground Switch Status.

The 489 detects ground directional by using two measurement quantities: V_0 and I_0. The angle between these quantities determines 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, V_0, below 2.0 V secondary.

NOTE

The pickup level for the ground current elements is programmed as a multiple of ground CT. The 50:0.025 CT is intended for measuring very small ground fault currents when connected to a sensitive ground CT having the same ratio.
For example, a pickup to 0.2xCT translates into 0.2x0.0025A = 0.5mA secondary on the terminals of the sensitive ground CT, with a relay measuring 0.2x5A = 1 A primary. A pickup setting of 0.05xCT would lead to 0.05x0.0025A = 0.125mA secondary, or 0.05x5A =0. 25A primary current.

It is strongly recommended not to exceed the CT continuous rating of 150mA for long periods of time during tests.

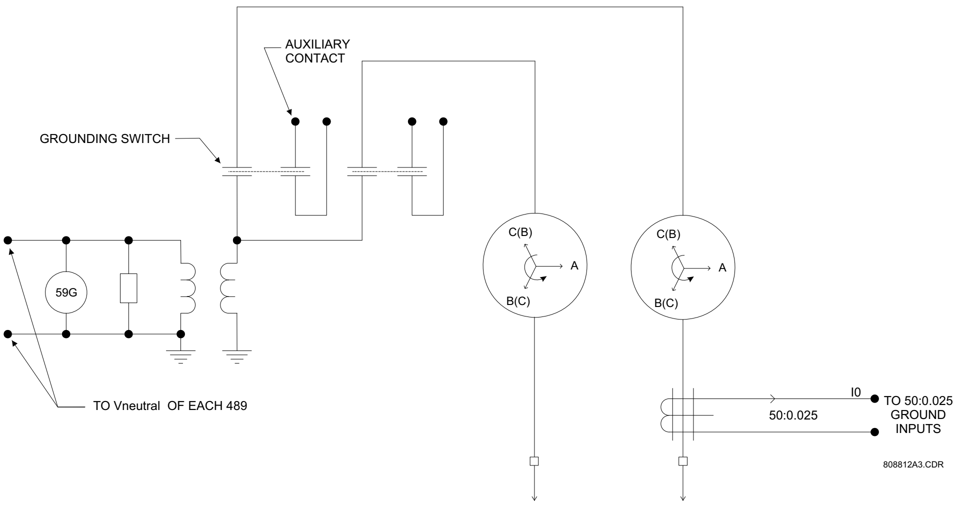


FIGURE 5–5: Ground Directional Detection

5.6.10 High-Set Phase OC

PATH: SETPOINTS ▷▽ S5 CURRENT ELEM. ▷▽ HIGH-SET PHASE OVERCURRENT

1 HIGH-SET [▷] PHASE OVERCURRENT		HIGH-SET PHASE O/C TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	HIGH-SET PHASE O/C PICKUP: 5.00 x CT	*Range: 0.15 to 20.00 x CT in steps of 0.01*
	MESSAGE	HIGH-SET PHASE O/C DELAY: 1.00 s	*Range: 0.00 to 100.00 s in steps of 0.01*

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 at 50/60 Hz.

5.7 S6 Voltage Elements

5.7.1 Undervoltage

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷ UNDERVOLTAGE

1 UNDERVOLTAGE [▷]	◁ ▷	UNDERVOLTAGE ALARM: Off	Range: Off, Latched, Unlatched
MESSAGE	△ ▽	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
MESSAGE	△ ▽	UNDERVOLTAGE ALARM PICKUP: 0.85 x Rated	Range: 0.50 to 0.99 × Rated in steps of 0.01
MESSAGE	△ ▽	UNDERVOLTAGE ALARM DELAY: 3.0 s	Range: 0.2 to 120.0 s in steps of 0.1
MESSAGE	△ ▽	UNDERVOLTAGE ALARM EVENTS: Off	Range: On, Off
MESSAGE	△ ▽	UNDERVOLTAGE TRIP: Off	Range: Off, Latched, Unlatched
MESSAGE	△ ▽	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
MESSAGE	△ ▽	UNDERVOLTAGE TRIP PICKUP: 0.80 x Rated	Range: 0.50 to 0.99 × Rated in steps of 0.01
MESSAGE	△ ▽	UNDERVOLTAGE TRIP DELAY: 1.0 s	Range: 0.2 to 10.0 s in steps of 0.1
MESSAGE	△ ▽	UNDERVOLTAGE CURVE RESET RATE: 1.4 s	Range: 0.0 to 999.9 s in steps of 0.1
MESSAGE	△	UNDERVOLTAGE CURVE ELEMENT: Curve	Range: Curve, Definite Time

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 definite time or a curve. When the magnitude of the average phase-phase voltage is less than the pickup × 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 undervoltage curve is:

$$T = \frac{D}{1 - V/V_{pickup}}, \quad \text{when } V < V_{pickup} \qquad \textbf{(EQ 5.18)}$$

where: *T* = trip time in seconds
D = **UNDERVOLTAGE TRIP DELAY** setpoint
V = actual average phase-phase voltage
V_{pickup} = **UNDERVOLTAGE TRIP PICKUP** setpoint

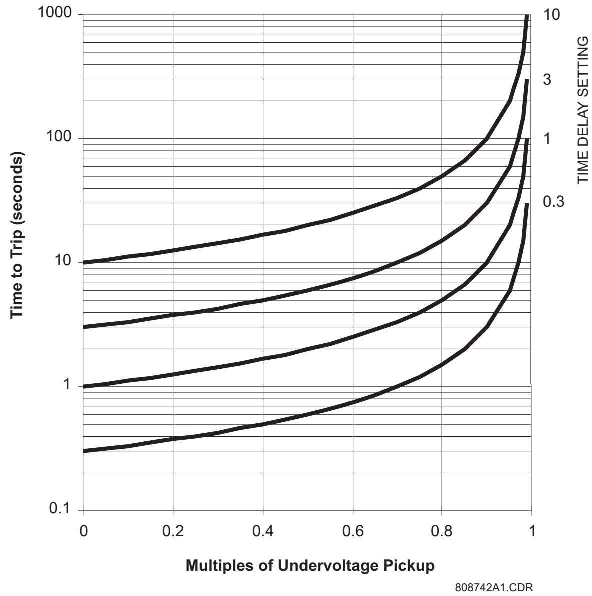


FIGURE 5–6: Undervoltage Curves

5.7.2 Overvoltage

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ OVERVOLTAGE

1 OVERVOLTAGE [▷]	OVERVOLTAGE ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	OVERVOLTAGE ALARM PICKUP: 1.15 x Rated	*Range: 1.01 to 1.50 × Rated in steps of 0.01*
MESSAGE	OVERVOLTAGE ALARM DELAY: 3.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*
MESSAGE	OVERVOLTAGE ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	OVERVOLTAGE TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	OVERVOLTAGE TRIP PICKUP: 1.20 x Rated	*Range: 1.01 to 1.50 × Rated in steps of 0.01*
MESSAGE	OVERVOLTAGE TRIP DELAY: 1.0 s	*Range: 0.1 to 10.0 s in steps of 0.1*

MESSAGE	OVERVOLTAGE CURVE RESET RATE: 1.4 s	*Range: 0.0 to 999.9 s in steps of 0.1*
MESSAGE	OVERVOLTAGE CURVE ELEMENT: Curve	*Range: Curve, Definite Time*

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:

$$T = \frac{D}{(V/V_{pickup}) - 1}, \quad \text{when } V > V_{pickup} \qquad \textbf{(EQ 5.19)}$$

where: T = trip time in seconds
D = **OVERVOLTAGE TRIP DELAY** setpoint
V = actual average phase-phase voltage
V_{pickup}= **OVERVOLTAGE TRIP PICKUP** setpoint

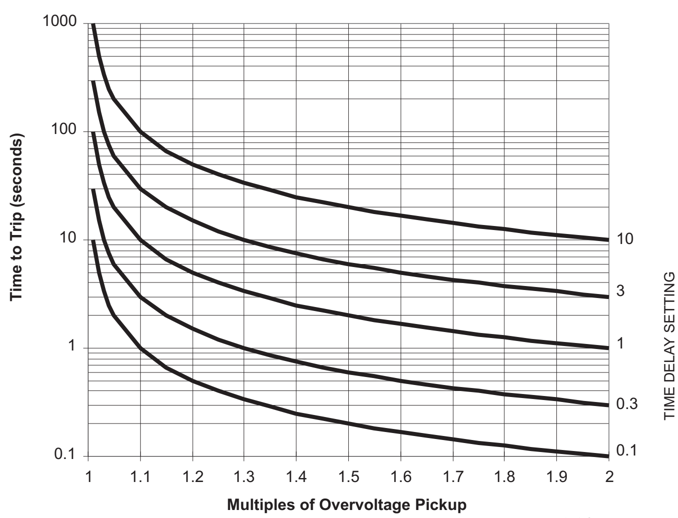


FIGURE 5–7: Overvoltage Curves

5.7.3 Volts/Hertz

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ VOLTS/HERTZ

1 VOLTS/HERTZ [▷]	VOLTS/HERTZ ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*

MESSAGE	▲▼	VOLTS/HERTZ ALARM PICKUP: 1.00 xNominal	*Range: 0.50 to 1.99 ×Nominal in steps of 0.01*
MESSAGE	▲▼	VOLTS/HERTZ ALARM DELAY: 3.0 s	*Range: 0.1 to 150.0 s in steps of 0.1*
MESSAGE	▲▼	VOLTS/HERTZ ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	▲▼	VOLTS/HERTZ TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	▲▼	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	▲▼	VOLTS/HERTZ TRIP PICKUP: 1.00 xNominal	*Range: 0.50 to 1.99 ×Nominal in steps of 0.01*
MESSAGE	▲▼	VOLTS/HERTZ TRIP DELAY: 1.0 s	*Range: 0.1 to 150.0 s in steps of 0.1*
MESSAGE	▲▼	VOLTS/HERTZ CURVE RESET RATE: 1.4 s	*Range: 0.0 to 999.9 s in steps of 0.1*
MESSAGE	▲	VOLTS/HERTZ TRIP ELEMENT: Curve #1	*Range: Curve #1, Curve #2, Curve #3, Definite Time*

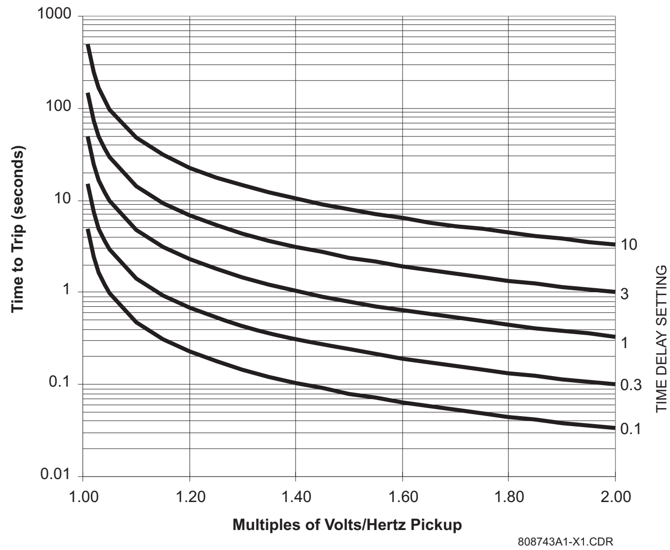
The Volts Per Hertz elements may be used generator and unit transformer protection. They are active as soon as the magnitude and frequency of V_{ab} is measurable. The alarm element is definite time; the trip element can be definite time or a curve. Once the V/Hz measurement V_{ab} exceeds the pickup level for the specified time, 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 V/Hz will be accurate through a frequency range of 5 to 90 Hz. Settings less than 1.00 only apply for special generators such as short circuit testing machines.

The formula for Volts/Hertz Curve 1 is:

$$T = \frac{D}{\left(\frac{V/F}{(V_{nom}/F_s) \times \text{Pickup}}\right)^2 - 1}, \quad \text{when } \frac{V}{F} > \text{Pickup} \qquad \textbf{(EQ 5.20)}$$

where: T = trip time in seconds
D = **VOLTS/HERTZ TRIP DELAY** setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = **VOLTS/HERTZ TRIP PICKUP** setpoint

The V/Hz Curve 1 trip curves are shown below for delay settings of 0.1, 0.3, 1, 3, and 10 seconds.

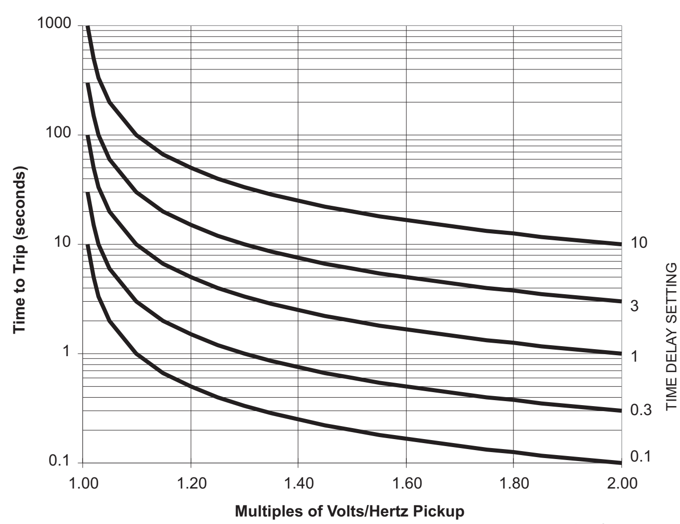


The formula for Volts/Hertz Curve 2 is:

$$T = \frac{D}{\dfrac{V/F}{(V_{nom}/F_s) \times \text{Pickup}} - 1}, \quad \text{when } \frac{V}{F} > \text{Pickup} \qquad \textbf{(EQ 5.21)}$$

where: T = trip time in seconds
D = **VOLTS/HERTZ TRIP DELAY** setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = **VOLTS/HERTZ TRIP PICKUP** setpoint

The V/Hz Curve 2 trip curves are shown below for delay settings of 0.1, 0.3, 1, 3, and 10 seconds.

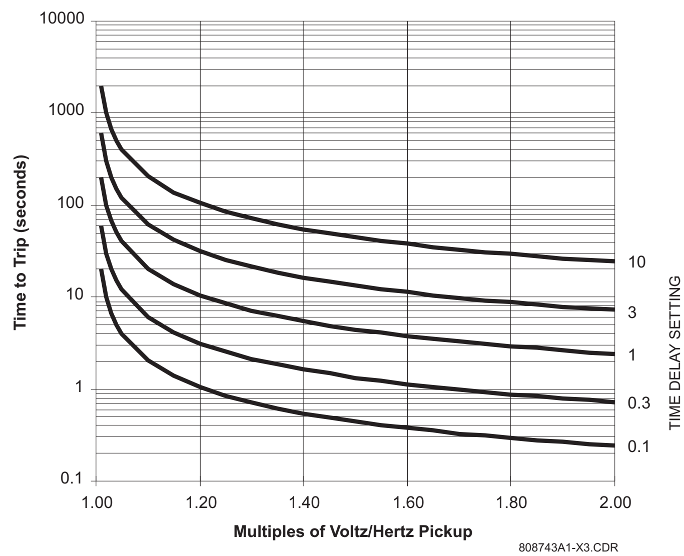


The formula for Volts/Hertz Curve 3 is:

$$T = \frac{D}{\left(\frac{V/F}{(V_{nom}/F_s) \times \text{Pickup}}\right)^{0.5} - 1}, \quad \text{when } \frac{V}{F} > \text{Pickup} \qquad \textbf{(EQ 5.22)}$$

where: T = trip time in seconds
D = **VOLTS/HERTZ TRIP DELAY** setpoint
V = RMS measurement of Vab
F = frequency of Vab
V_{NOM} = generator voltage setpoint
F_S = generator frequency setpoint
Pickup = **VOLTS/HERTZ TRIP PICKUP** setpoint

The V/Hz Curve 3 trip curves are shown below for delay settings of 0.1, 0.3, 1, 3, and 10 seconds.



NOTE

Volts/Hertz is calculated per unit as follows:

$$\text{Volts/Hertz} = \frac{\text{phase-phase voltage / rated phase-phase voltage}}{\text{frequency / rated frequency}}$$

5.7.4 Phase Reversal

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ PHASE REVERSAL

```
1 PHASE            [▷]
  REVERSAL
```

```
PHASE REVERSAL
TRIP: Off
```

Range: Off, Latched, Unlatched

MESSAGE

```
ASSIGN TRIP
RELAYS (1-4): 1---
```

Range: Any combination of Relays 1 to 4

The 489 can detect the phase rotation of the three phase voltages. A trip will occur within 200 ms 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.

5.7.5 Underfrequency

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ UNDERFREQUENCY

1 UNDERFREQUENCY [▷]	BLOCK UNDERFREQUENCY FROM ONLINE: 1 s	*Range: 0 to 5 s in steps of 1*
MESSAGE	VOLTAGE LEVEL CUTOFF: 0.50 x Rated	*Range: 0.50 to 0.99 × Rated in steps of 0.01*
MESSAGE	UNDERFREQUENCY ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	UNDERFREQUENCY ALARM LEVEL: 59.50 Hz	*Range: 20.00 to 60.00 Hz in steps of 0.01*
MESSAGE	UNDERFREQUENCY ALARM DELAY: 5.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*
MESSAGE	UNDERFREQUENCY ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	UNDERFREQUENCY TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	UNDERFREQUENCY TRIP LEVEL1: 59.50 Hz	*Range: 20.00 to 60.00 Hz in steps of 0.01*
MESSAGE	UNDERFREQUENCY TRIP DELAY1: 60.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*
MESSAGE	UNDERFREQUENCY TRIP LEVEL2: 58.00 Hz	*Range: 20.00 to 60.00 Hz in steps of 0.01*
MESSAGE	UNDERFREQUENCY TRIP DELAY2: 30.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*

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.

5.7.6 Overfrequency

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ OVERFREQUENCY

1 OVERFREQUENCY [▷]	BLOCK OVERFREQUENCY FROM ONLINE: 1 s	*Range: 0 to 5 s in steps of 1*
MESSAGE	VOLTAGE LEVEL CUTOFF: 0.50 x Rated	*Range: 0.50 to 0.99 × Rated in steps of 0.01*
MESSAGE	OVERFREQUENCY ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	OVERFREQUENCY ALARM LEVEL: 60.50 Hz	*Range: 25.01 to 70.00 Hz in steps of 0.01*
MESSAGE	OVERFREQUENCY ALARM DELAY: 5.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*
MESSAGE	OVERFREQUENCY ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	OVERFREQUENCY TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	OVERFREQUENCY TRIP LEVEL1: 60.50 Hz	*Range: 25.01 to 70.00 Hz in steps of 0.01*
MESSAGE	OVERFREQUENCY TRIP DELAY1: 60.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*
MESSAGE	OVERFREQUENCY TRIP LEVEL2: 62.00 Hz	*Range: 25.01 to 70.00 Hz in steps of 0.01*
MESSAGE	OVERFREQUENCY TRIP DELAY2: 30.0 s	*Range: 0.1 to 5000.0 s in steps of 0.1*

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.

5.7.7 Neutral Overvoltage

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ NEUTRAL O/V (FUNDAMENTAL)

1 NEUTRAL O/V [▷] (FUNDAMENTAL)		SUPERVISE WITH DIGITAL INPUT: No	*Range: Yes, No*
	MESSAGE	NEUTRAL OVERVOLTAGE ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	NEUTRAL O/V ALARM LEVEL: 3.0 Vsec	*Range: 2.0 to 100.0 Vsec in steps of 0.1*
	MESSAGE	NEUTRAL OVERVOLTAGE ALARM DELAY: 1.0 s	*Range: 0.1 to 120.0 s in steps of 0.1*
	MESSAGE	NEUTRAL OVERVOLTAGE ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	NEUTRAL OVERVOLTAGE TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	NEUTRAL O/V TRIP LEVEL: 5.0 Vsec	*Range: 2.0 to 100.0 Vsec in steps of 0.1*
	MESSAGE	NEUTRAL OVERVOLTAGE TRIP DELAY: 1.0 s	*Range: 0.1 to 120.0 s in steps of 0.1*
	MESSAGE	NEUTRAL O/V CURVE RESET RATE: 0.0	*Range: 0.0 to 999.9 in steps of 0.1*
	MESSAGE	NEUTRAL O/V TRIP ELEM.: Time	*Range: Curve, Definite Time*

NOTE

The **SUPERVISE WITH DIGITAL INPUT** setpoint is seen only if a digital input assigned to Ground Switch Status.

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.

The formula for the curve is:

$$T = \frac{D}{(V/V_{pickup}) - 1} \quad \text{when } V > V_{pickup} \qquad \textbf{(EQ 5.23)}$$

where T = trip time in seconds
D = **NEUTRAL OVERVOLTAGE TRIP DELAY** setpoint
V = neutral voltage
V_{pickup} = **NEUTRAL O/V TRIP LEVEL** setpoint

The neutral overvoltage curves are shown below. Refer to Appendix B for Application Notes.

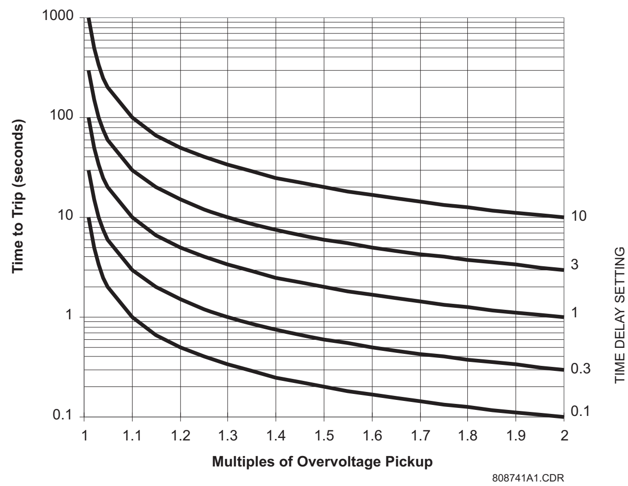


FIGURE 5–8: Neutral Overvoltage Curves

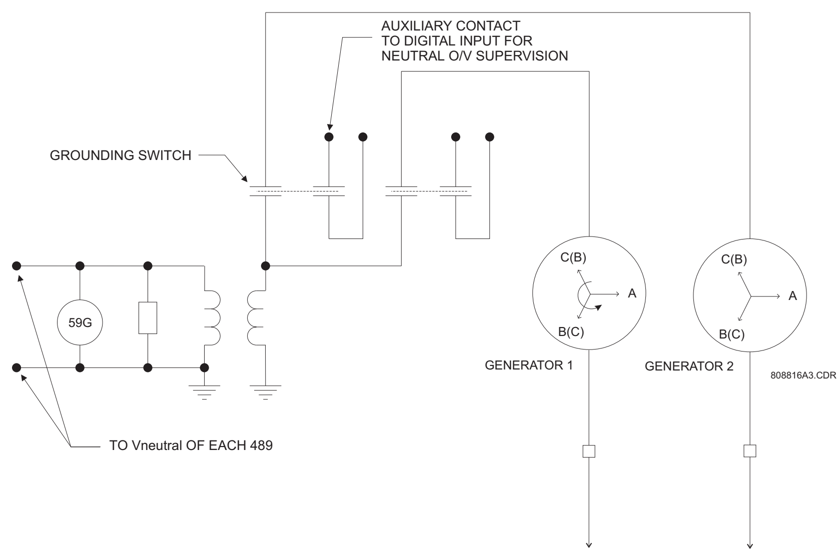


FIGURE 5–9: Neutral Overvoltage Detection

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.

5.7.8 Neutral Undervoltage

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ NEUTRAL U/V (3RD HARMONIC)

1 NEUTRAL U/V [▷] (3rd HARMONIC)	
LOW POWER BLOCKING LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
MESSAGE: LOW VOLTAGE BLOCKING LEVEL: 0.75 x Rated	*Range: 0.50 to 1.00 × Rated in steps of 0.01*
MESSAGE: NEUTRAL UNDERVOLTAGE ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE: ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE: NEUTRAL U/V ALARM LEVEL: 0.5 Vsec	*Range: 0.5 to 20.0 Vsec in steps of 0.1*
MESSAGE: NEUTRAL UNDERVOLTAGE ALARM DELAY: 30 s	*Range: 5 to 120 s in steps of 1*
MESSAGE: NEUTRAL UNDERVOLTAGE ALARM EVENTS: Off	*Range: On, Off*
MESSAGE: NEUTRAL UNDERVOLTAGE TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE: ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE: NEUTRAL U/V TRIP LEVEL: 1.0 Vsec	*Range: 0.5 to 20.0 Vsec in steps of 0.1*
MESSAGE: NEUTRAL UNDERVOLTAGE TRIP DELAY: 30 s	*Range: 5 to 120 s in steps of 1*

NOTE

The **LOW POWER BLOCKING LEVEL**, **NEUTRAL U/V ALARM LEVEL**, and **NEUTRAL U/V TRIP LEVEL** setpoints are seen only if the **S2 SYSTEM SETUP ▷▽ VOLTAGE ▷▽ VT CONNECTION** setpoint is “Delta”

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.

For 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.

$$\frac{V_{N3}}{(V_{P3}/3) + V_{N3}} \le 0.15 \quad \text{which simplifies to} \quad V_{P3} \ge 17V_{N3} \qquad \textbf{(EQ 5.24)}$$

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:

$$V_{P3}' > 0.25\text{ V} \text{ and } V_{P3}' \geq \text{Threshold} \times 17 \times \frac{\text{Neutral VT Ratio}}{\text{Phase VT Ratio}} \quad \textbf{(EQ 5.25)}$$

where: V_{N3} = magnitude of the third harmonic voltage at generator neutral;
V_{P3} = magnitude of the third harmonic voltage at the generator terminals
V_{P3}' = VT secondary magnitude of the third harmonic voltage measured at the generator terminals;
V_{N3}' = VT sec. magnitude of 3^{rd} harmonic voltage at generator neutral;
Threshold = 0.15 V for the alarm element and 0.1875 V for the trip element

For 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.

5.7.9 Loss of Excitation

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ LOSS OF EXCITATION

1 LOSS OF EXCITATION [▷]		ENABLE VOLTAGE SUPERVISION: Yes	*Range: Yes, No*
	MESSAGE	VOLTAGE LEVEL: 0.70 x Rated	*Range: 0.70 to 1.00 × Rated in steps of 0.01*
	MESSAGE	CIRCLE 1 TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN CIRCLE 1 TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	CIRCLE 1 DIAMETER: 25.0 Ωsec	*Range: 2.5 to 300.0 Ωsec in steps of 0.1*
	MESSAGE	CIRCLE 1 OFFSET: 2.5 Ωsec	*Range: 1.0 to 300.0 Ωsec in steps of 0.1*
	MESSAGE	CIRCLE 1 TRIP DELAY: 5.0 s	*Range: 0.1 to 10.0 s in steps of 0.1*
	MESSAGE	CIRCLE 2 TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN CIRCLE 2 TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	CIRCLE 2 DIAMETER: 35.0 Ωsec	*Range: 2.5 to 300.0 Ωsec in steps of 0.1*
	MESSAGE	CIRCLE 2 OFFSET: 2.5 Ωsec	*Range: 1.0 to 300.0 Ωsec in steps of 0.1*
	MESSAGE	CIRCLE 2 TRIP DELAY: 5.0 s	*Range: 0.1 to 10.0 s in steps of 0.1*

NOTE

The **VOLTAGE LEVEL** setpoint is seen only if **ENABLE VOLTAGE SUPERVISION** is set to "Yes".

Loss of excitation is detected with an impedance element. When the impedance falls within the impedance circle for the specified delay time, a trip will occur if it is enabled. Circles 1 and/or 2 can be tuned to a particular system. The larger circle diameter should be set to the synchronous reactance of the generator, x_d, and the circle offset to the generator transient reactance $x'_d / 2$. Typically the smaller circle (if used) is set to minimum time with a diameter set to $0.7x_d$ and an offset of $x'_d / 2$. This feature is blocked if voltage supervision is enabled and the generator voltage is above the **VOLTAGE LEVEL** setpoint. The trip feature is supervised by minimum current of 0.05 × CT. Note that the Loss of Excitation element will be blocked if there is a VT fuse failure or if the generator is offline. Also, it uses output CT inputs.

The secondary phase-phase loss of excitation impedance is defined as:

$$Z_{loe} = \frac{V_{AB}}{I_A - I_B} = M_{loe} \angle \theta_{loe} \quad \textbf{(EQ 5.26)}$$

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.

$$Z_{secondary} = \frac{Z_{primary} \times \text{CT Ratio}}{\text{VT Ratio}} \qquad \textbf{(EQ 5.27)}$$

where: $Z_{primary}$ = 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

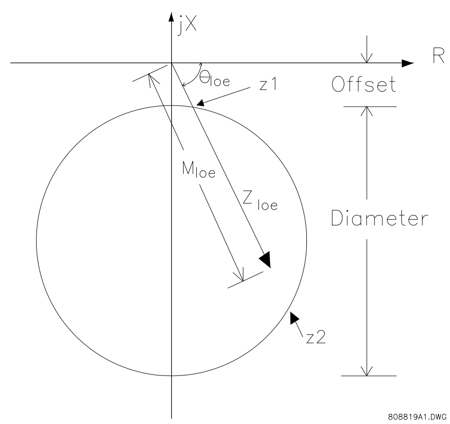


FIGURE 5–10: Loss of Excitation R-X Diagram

5.7.10 Distance Element

PATH: SETPOINTS ▷▽ S6 VOLTAGE ELEM. ▷▽ DISTANCE ELEMENT

1 DISTANCE ELEMENT [▷]	STEP UP TRANSFORMER SETUP: None	*Range: None, Delta/Wye*
MESSAGE	FUSE FAILURE SUPERVISION: On	*Range: On, Off*
MESSAGE	ZONE #1 TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ZONE #1 TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	ZONE #1 REACH: 10.0 Ωsec	*Range: 0.1 to 500.0 Ωsec in steps of 0.1*
MESSAGE	ZONE #1 ANGLE: 75°	*Range: 50 to 85° in steps of 1*
MESSAGE	ZONE #1 TRIP DELAY: 0.4 s	*Range: 0.0 to 150.0 s in steps of 0.1*
MESSAGE	ZONE #2 TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ZONE #2 TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*

MESSAGE	ZONE #2 REACH: 15.0 Ωsec	*Range: 0.1 to 500.0 Ωsec in steps of 0.1*
MESSAGE	ZONE #2 ANGLE: 75°	*Range: 50 to 85° in steps of 1*
MESSAGE	ZONE #2 TRIP DELAY: 2.0 s	*Range: 0.0 to 150.0 s in steps of 0.1*

The distance protection function (ANSI device 21) implements two zones of mho phase-to-phase distance protection (six elements total) 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 (see figure below), thus providing some protection for internal and unit transformer faults. In systems with a delta-wye transformer (DY330°), 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 ms. A VT fuse failure could cause a maloperation of a distance element unless the element is supervised by the VTFF element. In order to prevent nuisance tripping the elements require a minimum phase current of 0.05 x CT.

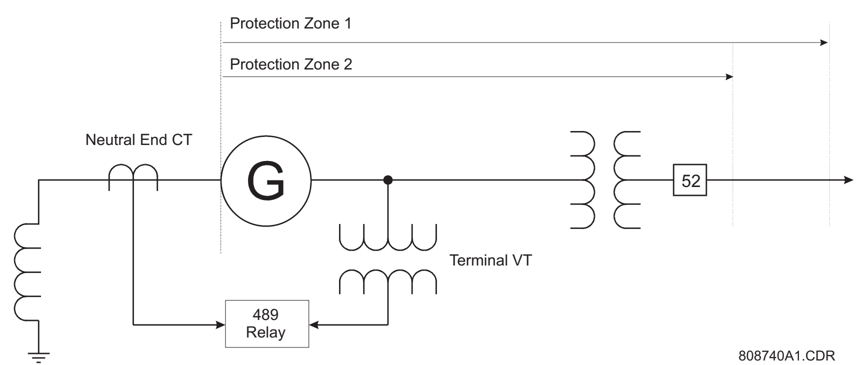


FIGURE 5–11: Distance Element Setup

The 489 phase distance element is intended to provide backup protection for phase-to-phase faults on the electric power system. This element uses the phase-to-phase voltage measured at the generator terminals and phase currents measured at the neutral side of the generator. As such this element will provide coverage for the generator step-up transformer and will also provide a degree of protection for stator phase-to-phase faults.

The element has a offset mho characteristic as shown in FIGURE 5–12: Distance Element Characteristics on page –59. Offset in the third quadrant is 1/8th of the forward reach to provide better resistive fault coverage for close-in faults. The element provides a separate measurement in three loops for AB, BC, and CA faults. There is a setting for specification of the step-up transformer connection. If this setting is chosen as "None", then it is assumed that the transformer is Wye-Wye connected or that there is no step-up transformer. In this case the element will use the following operating quantities.

Element	Voltage	Current
AB	Va – Vb	Ia – Ib
BC	Vb – Vc	Ib – Ic
CA	Vc – Va	Ic – Ia

If this setting is chosen as "Delta/Wye" then it is assumed that the transformer is Yd1 or Yd11. In this case the following operating quantities are used.

Element	Voltage	Current
AB	(Vab – Vca) / $\sqrt{3}$	$\sqrt{3} \times$ Ia
BC	(Vbc – Vab) / $\sqrt{3}$	$\sqrt{3} \times$ Ib
CA	(Vca – Vbc) / $\sqrt{3}$	$\sqrt{3} \times$ Ic

The first zone is typically used to provide a backup protection for a step-up transformer and generator system bus protection (generator impedance should not be included into reach setting). The reach is set to cover the step-up transformer impedance with some margin, say 25%. The time delay should be coordinated with step up transformer and bus backup protection.

The second zone reach is typically set to cover the longest transmission line or feeder leaving the generating station. Care must be taken for possible under-reaching effects due to the fault contribution from other lines or generators. The element is intended for backup protection and therefore time delay should always be included. This element is typically set to coordinate with the longest operating time of the system distance relays protecting lines leaving station.

The measuring point of the element is defined by the location of the VT and CT as shown in FIGURE 5–11: Distance Element Setup on page –57. Therefore, the impedance of the step-up transformer should be included and the impedance of the generator should not be included. Care should also be taken to ensure the apparent impedance seen by the element when the machine is operating at worst-case load and power factor does not encroach into the operating characteristic. The reach setting is in secondary ohms. The minimum operating time of the element is 150 ms to coordinate with VTFF operating time (99 ms).

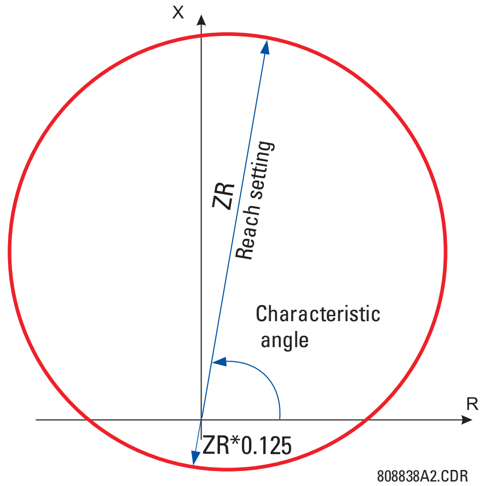


FIGURE 5–12: Distance Element Characteristics

5.8 S7 Power Elements

5.8.1 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. All power quantities are measured from the phase-phase voltage and the currents measured at the output CTs.

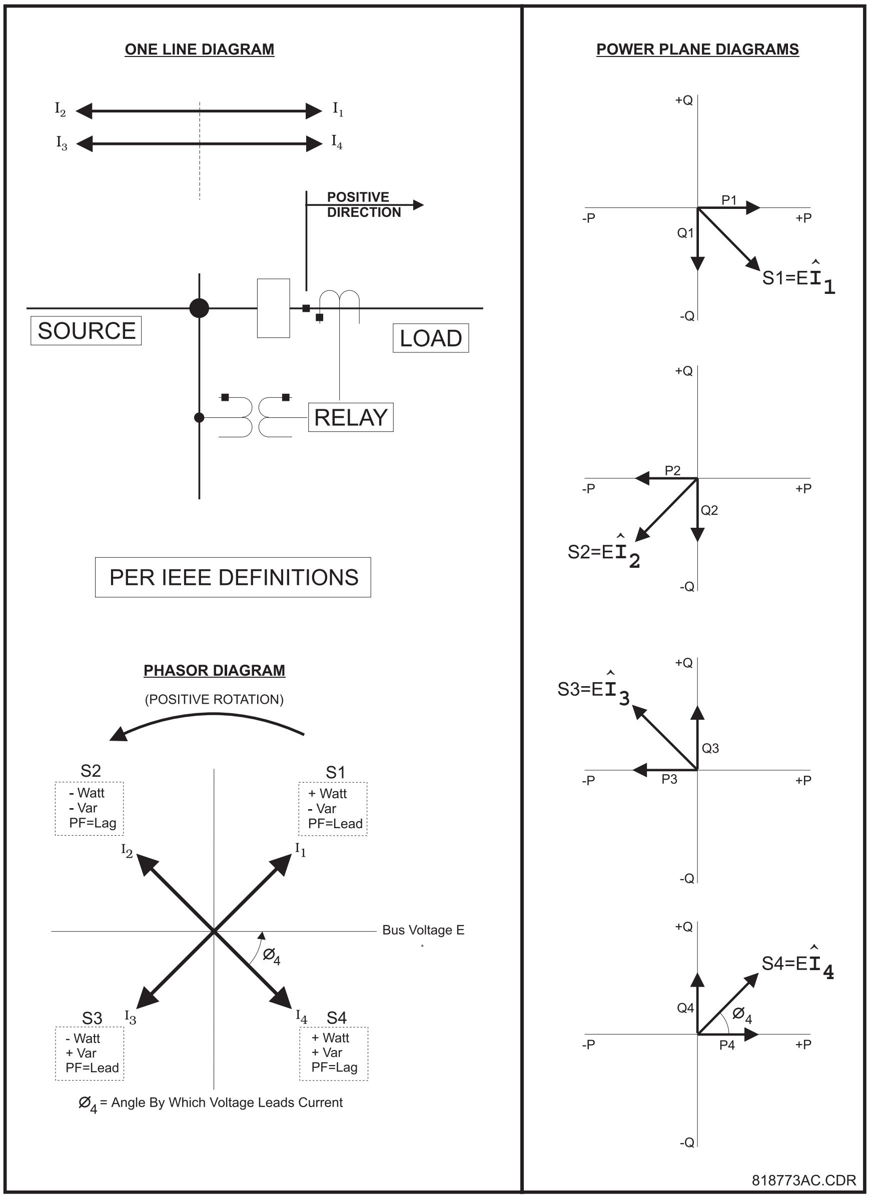


FIGURE 5–13: Power Measurement Conventions

5.8.2 Reactive Power

PATH: SETPOINTS ▷▽ S7 POWER ELEMENTS ▷ REACTIVE POWER

1 REACTIVE POWER [▷]		BLOCK Mvar ELEMENT FROM ONLINE: 1 s	Range: 0 to 5000 s in steps of 1
	MESSAGE	REACTIVE POWER ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	POSITIVE Mvar ALARM LEVEL: 0.85 x Rated	Range: 0.02 to 2.01 × Rated in steps of 0.01
	MESSAGE	NEGATIVE Mvar ALARM LEVEL: 0.85 x Rated	Range: 0.02 to 2.01 × Rated in steps of 0.01
	MESSAGE	POSITIVE Mvar ALARM DELAY: 10.0 s	Range: 0.2 to 120.0 s in steps of 0.1 (lagging vars, overexcited)
	MESSAGE	NEGATIVE Mvar ALARM DELAY: 1.0 s	Range: 0.2 to 120.0 s in steps of 0.1 (leading vars, underexcited)
	MESSAGE	REACTIVE POWER ALARM EVENTS: Off	Range: On, Off
	MESSAGE	REACTIVE POWER TRIP: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
	MESSAGE	POSITIVE Mvar TRIP LEVEL: 0.80 x Rated	Range: 0.02 to 2.01 × Rated in steps of 0.01
	MESSAGE	NEGATIVE Mvar TRIP LEVEL: 0.80 x Rated	Range: 0.02 to 2.01 × Rated in steps of 0.01
	MESSAGE	POSITIVE Mvar TRIP DELAY: 20.0 s	Range: 0.2 to 120.0 s in steps of 0.1 (lagging vars, overexcited)
	MESSAGE	NEGATIVE Mvar TRIP DELAY: 20.0 s	Range: 0.2 to 120.0 s in steps of 0.1 (leading vars, underexcited)

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-phase 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:

For example, given Rated MVA = 100 MVA and Rated Power Factor = 0.85, we have

$$\begin{aligned}\text{Rated Mvars} &= \text{Rated MVA} \times \sin(\cos^{-1}(\text{Rated PF})) \\ &= 100 \times \sin(\cos^{-1}0.85) \\ &= 52.67\ \text{Mvars}\end{aligned} \quad \textbf{(EQ 5.28)}$$

5.8.3 Reverse Power

PATH: SETPOINTS ▷▽ S7 POWER ELEMENTS ▷▽ REVERSE POWER

1 REVERSE POWER [▷]		BLOCK REVERSE POWER FROM ONLINE: 1 s	*Range: 0 to 5000 s in steps of 1*
	MESSAGE	REVERSE POWER ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	REVERSE POWER ALARM LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
	MESSAGE	REVERSE POWER ALARM DELAY: 10.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*
	MESSAGE	REVERSE POWER ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	REVERSE POWER TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	REVERSE POWER TRIP LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
	MESSAGE	REVERSE POWER TRIP DELAY: 20.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*

If enabled, once the magnitude of 3-phase 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.

5.8.4 Low Forward Power

PATH: SETPOINTS ▷▽ S7 POWER ELEMENTS ▷▽ LOW FORWARD POWER

1 LOW FORWARD POWER [▷]		BLOCK LOW FWD POWER FROM ONLINE: 0 s	*Range: 0 to 15000 s in steps of 1*
	MESSAGE	LOW FORWARD POWER ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	LOW FWD POWER ALARM LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
	MESSAGE	LOW FWD POWER ALARM DELAY: 10.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*
	MESSAGE	LOW FWD POWER ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	LOW FORWARD POWER TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	LOW FWD POWER TRIP LEVEL: 0.05 x Rated	*Range: 0.02 to 0.99 × Rated MW in steps of 0.01*
	MESSAGE	LOW FWD POWER TRIP DELAY: 20.0 s	*Range: 0.2 to 120.0 s in steps of 0.1*

If enabled, once the magnitude of 3-phase 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.

5.9 S8 RTD Temperature

5.9.1 RTD Types

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷ RTD TYPES

1 RTD TYPES [▷]		STATOR RTD TYPE: 100 Ohm Platinum	*Range: 100 Ohm Platinum, 120 Ohm Nickel, 100 Ohm Nickel, 10 Ohm Copper*
	MESSAGE	BEARING RTD TYPE: 100 Ohm Platinum	*Range: as above*
	MESSAGE	AMBIENT RTD TYPE: 100 Ohm Platinum	*Range: as above*
	MESSAGE	OTHER RTD TYPE: 100 Ohm Platinum	*Range: as above*

Each of the twelve RTDs 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.

Table 5–6: RTD Temperature vs. Resistance

Temperature		100 Ω Pt (DIN 43760)	120 Ω Ni	100 Ω Ni	10 Ω Cu
° C	° F				
–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

Table 5–6: RTD Temperature vs. Resistance

Temperature °C	Temperature °F	100 Ω Pt (DIN 43760)	120 Ω Ni	100 Ω Ni	10 Ω Cu
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

5.9.2 RTDs 1 to 6

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ RTD #1(6)

1 RTD #1 [▷]		RTD #1 APPLICATION: Stator	*Range: Stator, Bearing, Ambient, Other, None*
	MESSAGE	RTD #1 NAME:	*Range: 8 alphanumeric characters*
	MESSAGE	RTD #1 ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5.*
	MESSAGE	RTD #1 ALARM TEMPERATURE: 130°C	*Range: 1 to 250°C in steps of 1*
	MESSAGE	RTD #1 ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	RTD #1 TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	RTD #1 TRIP VOTING: RTD #1	*Range: RTD #1 to RTD #12*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	RTD #1 TRIP TEMPERATURE: 155°C	*Range: 1 to 250°C in steps of 1*

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.

5.9.3 RTDs 7 to 10

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ RTD #7(10)

1 RTD #7 [▷]		RTD #7 APPLICATION: Bearing	*Range: Stator, Bearing, Ambient, Other, None*
	MESSAGE	RTD #7 NAME:	*Range: 8 alphanumeric characters*
	MESSAGE	RTD #7 ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5.*
	MESSAGE	RTD #7 ALARM TEMPERATURE: 80°C	*Range: 1 to 250°C in steps of 1*
	MESSAGE	RTD #7 ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	RTD #7 TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	RTD #7 TRIP VOTING: RTD #7	*Range: RTD #1 to RTD #12*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
	MESSAGE	RTD #7 TRIP TEMPERATURE: 90°C	*Range: 1 to 250°C in steps of 1*

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.

5.9.4 RTD 11

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ RTD #11

1 RTD #11 [▷]	RTD #11 APPLICATION: Other	Range: Stator, Bearing, Ambient, Other, None
MESSAGE	RTD #11 NAME:	Range: 8 alphanumeric characters
MESSAGE	RTD #11 ALARM: Off	Range: Off, Latched, Unlatched
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5.
MESSAGE	RTD #11 ALARM TEMPERATURE: 80°C	Range: 1 to 250°C in steps of 1
MESSAGE	RTD #11 ALARM EVENTS: Off	Range: On, Off
MESSAGE	RTD #11 TRIP: Off	Range: Off, Latched, Unlatched
MESSAGE	RTD #11 TRIP VOTING: RTD #11	Range: RTD #1 to RTD #12
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
MESSAGE	RTD #11 TRIP TEMPERATURE: 90°C	Range: 1 to 250°C in steps of 1

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.

5.9.5 RTD 12

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ RTD #12

1 RTD #12 [▷]	RTD #12 APPLICATION: Ambient	Range: Stator, Bearing, Ambient, Other, None
MESSAGE	RTD #12 NAME:	Range: 8 alphanumeric characters
MESSAGE	RTD #12 ALARM: Off	Range: Off, Latched, Unlatched
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5.

MESSAGE	RTD #12 ALARM TEMPERATURE: 60°C	*Range: 1 to 250°C in steps of 1*
MESSAGE	RTD #12 ALARM EVENTS: Off	*Range: On, Off*
MESSAGE	RTD #12 TRIP: Off	*Range: Off, Latched, Unlatched*
MESSAGE	RTD #12 TRIP VOTING: RTD #12	*Range: RTD #1 to RTD #12*
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*
MESSAGE	RTD #12 TRIP TEMPERATURE: 80°C	*Range: 1 to 250°C in steps of 1*

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.

5.9.6 Open RTD Sensor

SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ OPEN RTD SENSOR

1 OPEN RTD [▷] SENSOR	OPEN RTD SENSOR: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	OPEN RTD SENSOR ALARM EVENTS: Off	*Range: On, Off*

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.

5.9.7 RTD Short/Low Temp

PATH: SETPOINTS ▷▽ S8 RTD TEMPERATURE ▷▽ RTD SHORT/LOW TEMP

Display		Setpoint	Range
1 RTD SHORT/LOW TEMP [▷]		RTD SHORT/LOW TEMP ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	RTD SHORT/LOW TEMP ALARM EVENTS: Off	Range: On, Off

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.

5.10 S9 Thermal Model

5.10.1 489 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.

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 (approximately 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.

The figure below illustrates typical thermal limit curves for induction motors. The starting characteristic is shown for a high inertia load at 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.

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.

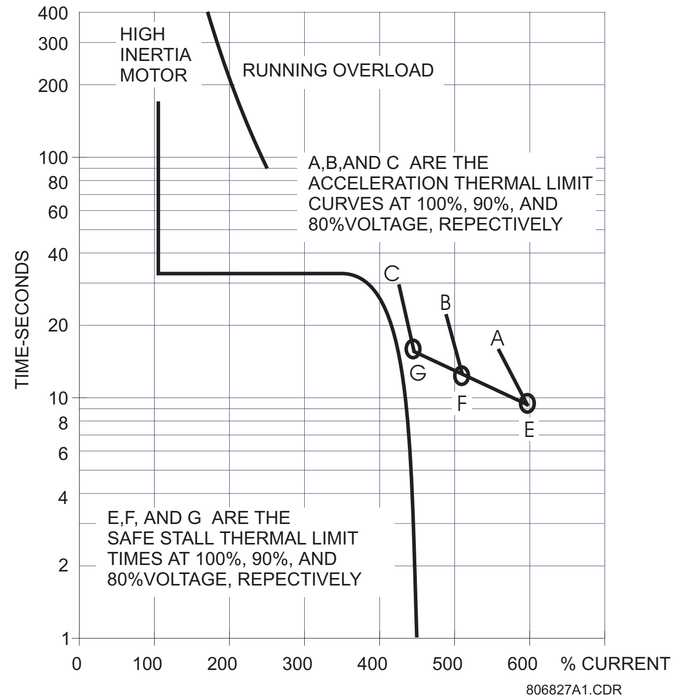


FIGURE 5–14: Typical Time-Current and Thermal Limit Curves (ANSI/IEEE C37.96)

5.10.2 Model Setup

Setpoints

PATH: SETPOINTS ▷▽ S9 THERMAL MODEL ▷ MODEL SETUP

1 MODEL SETUP [▷]		ENABLE THERMAL MODEL: No	*Range: No, Yes*
	MESSAGE	OVERLOAD PICKUP LEVEL: 1.01 x FLA	*Range: 1.01 to 1.25 × FLA in steps of 0.01*
	MESSAGE	UNBALANCE BIAS K FACTOR: 0	*Range: 0 to 12 in steps of 1. A value of "0" disables this feature*
	MESSAGE	COOL TIME CONSTANT ONLINE: 15 min.	*Range: 0 to 500 min. in steps of 1*
	MESSAGE	COOL TIME CONSTANT OFFLINE: 30 min.	*Range: 0 to 500 min. in steps of 1*
	MESSAGE	HOT/COLD SAFE STALL RATIO: 1.00	*Range: 0.01 to 1.00 in steps of 0.01*
	MESSAGE	ENABLE RTD BIASING: No	*Range: No, Yes*
	MESSAGE	RTD BIAS MINIMUM: 40°C	*Range: 0 to 250°C in steps of 1*

MESSAGE	RTD BIAS CENTER POINT: 130°C	*Range: 0 to 250°C in steps of 1*
MESSAGE	RTD BIAS MAXIMUM: 155°C	*Range: 0 to 250°C in steps of 1*
MESSAGE	SELECT CURVE STYLE: Standard	*Range: Standard, Custom, Voltage Dependent*
MESSAGE	STANDARD OVERLOAD CURVE NUMBER: 4	*Range: 1 to 15 in steps of 1. See Note below.*
MESSAGE	TIME TO TRIP AT 1.01 x FLA: 17414.5 s	*Range: 0.5 to 99999.9 in steps of 0.1. See Notes below.*
	↓	
MESSAGE	TIME TO TRIP AT 20.0 x FLA: 5.6 s	*Range: 0.5 to 99999.9 in steps of 0.1. See Notes below.*
MESSAGE	MINIMUM ALLOWABLE VOLTAGE: 80%	*Range: 70 to 95% in steps of 1. See Notes below.*
MESSAGE	STALL CURRENT @ MIN VOLTAGE: 4.80 x FLA	*Range: 2.00 to 15.00 × FLA in steps of 0.01. See Notes below.*
MESSAGE	SAFE STALL TIME @ MIN VOLTAGE: 20.0 s	*Range: 0.5 to 999.9 in steps of 0.1. See Notes below.*
MESSAGE	ACCEL. INTERSECT @ MIN VOLT: 3.80 x FLA	*Range: 2.00 to* **STALL CURRENT @ MIN VOLTAGE** *in steps of 0.01. See Notes below.*
MESSAGE	STALL CURRENT @ 100% VOLTAGE: 6.00 x FLA	*Range: 2.00 to 15.00 × FLA in steps of 0.01. See Note below.*
MESSAGE	SAFE STALL TIME @ 100% VOLTAGE: 10.0 s	*Range: 0.5 to 999.9 in steps of 0.1. See Notes below.*
MESSAGE	ACCEL. INTERSECT @ 100% VOLT: 5.00 x FLA	*Range: 2.00 to* **STALL CURRENT @ 100% VOLTAGE** *in steps of 0.01. See Notes below.*

NOTE

The **RTD BIAS MINIMUM**, **RTD BIAS CENTER**, and **RTD BIAS MAXIMUM** setpoints is are seen only if **ENABLE RTD BIASING** is set to "Yes".

NOTE

The **STANDARD OVERLOAD CURVE NUMBER** is seen only if **SELECT CURVE STYLE** is set to "Standard". If the **SELECT CURVE STYLE** is set to "Voltage Dependent", all setpoints shown after the **STANDARD OVERLOAD CURVE NUMBER** are displayed. If the **SELECT CURVE STYLE** is set to "Custom", the setpoints shown after **TIME TO TRIP AT 20.0 X FLA** are not displayed.

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:

$$\frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Rated Generator Phase-Phase Voltage}} \quad \textbf{(EQ 5.29)}$$

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 50 ms using the following equation:

$$TC_{\text{used } t} = TC_{\text{used } t-50\text{ms}} + \frac{50\text{ ms}}{\text{time to trip}} \times 100\% \quad \textbf{(EQ 5.30)}$$

where time to trip = time taken from the overload curve at I_{eq} 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 the following figure and table).

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

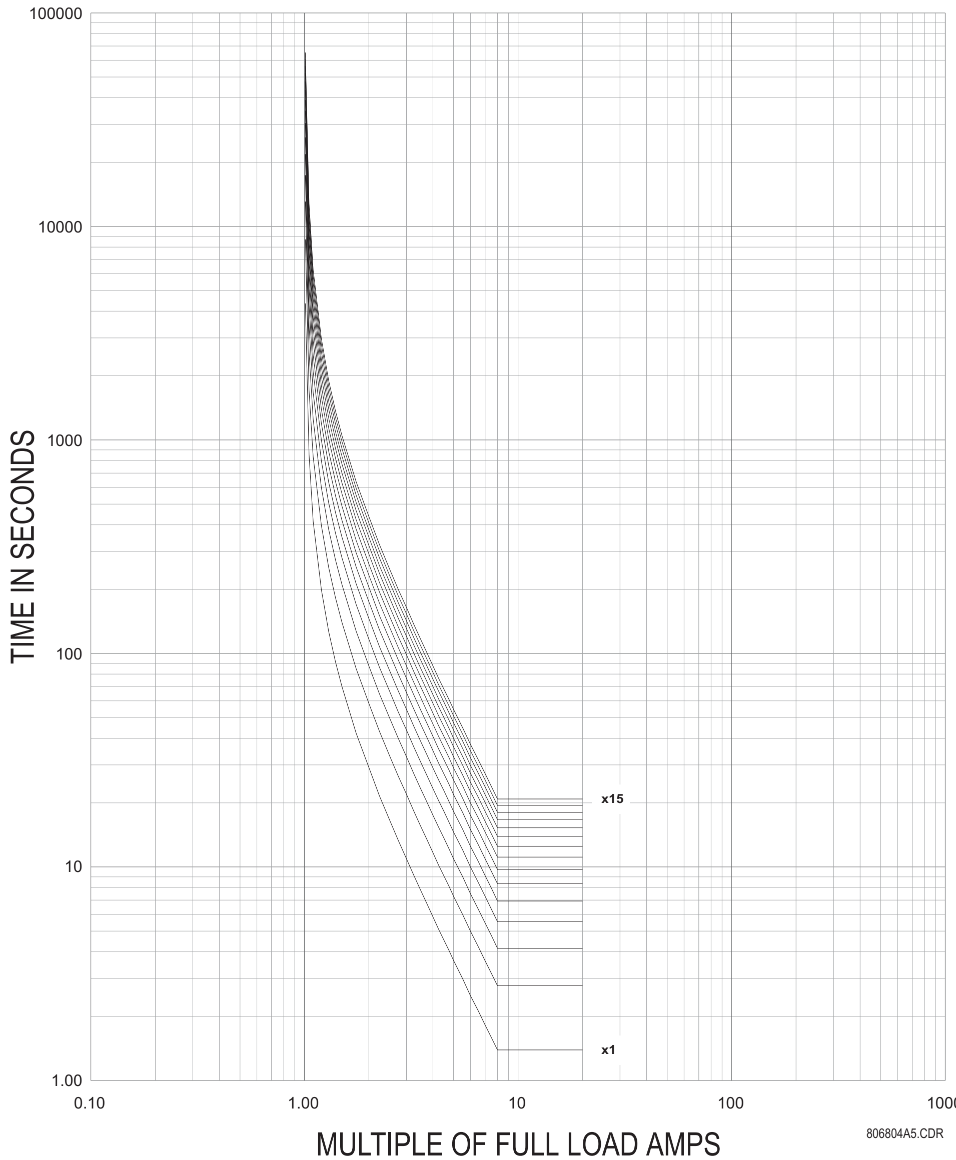


FIGURE 5–15: 489 Standard Overload Curves

NOTE

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

The standard overload curves equation is:

$$\text{Time to Trip} = \frac{\text{Curve Multiplier} \times 2.2116623}{0.02530337 \times (\text{Pickup} - 1)^2 + 0.05054758 \times (\text{Pickup} - 1)} \qquad \textbf{(EQ 5.31)}$$

Table 5–7: 489 Standard Overload Curve Multipliers

PICKUP (× FLA)	STANDARD CURVE MULTIPLIERS														
	× 1	× 2	× 3	× 4	× 5	× 6	× 7	× 8	× 9	× 10	× 11	× 12	× 13	× 14	× 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

Table 5–7: 489 Standard Overload Curve Multipliers

PICKUP (× FLA)	STANDARD CURVE MULTIPLIERS														
	× 1	× 2	× 3	× 4	× 5	× 6	× 7	× 8	× 9	× 10	× 11	× 12	× 13	× 14	× 15
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

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 generator protection so successful starting may be possible without compromising protection. Furthermore, the characteristics of the starting thermal (locked rotor and acceleration) and the running thermal damage curves may not fit together very smoothly. In this instance, it may be necessary to use a custom curve to tailor protection to the thermal limits to allow the generator to be started successfully and 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 allows users to program their own curves by entering trip times for 30 pre-determined current levels.

The curves below show 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.

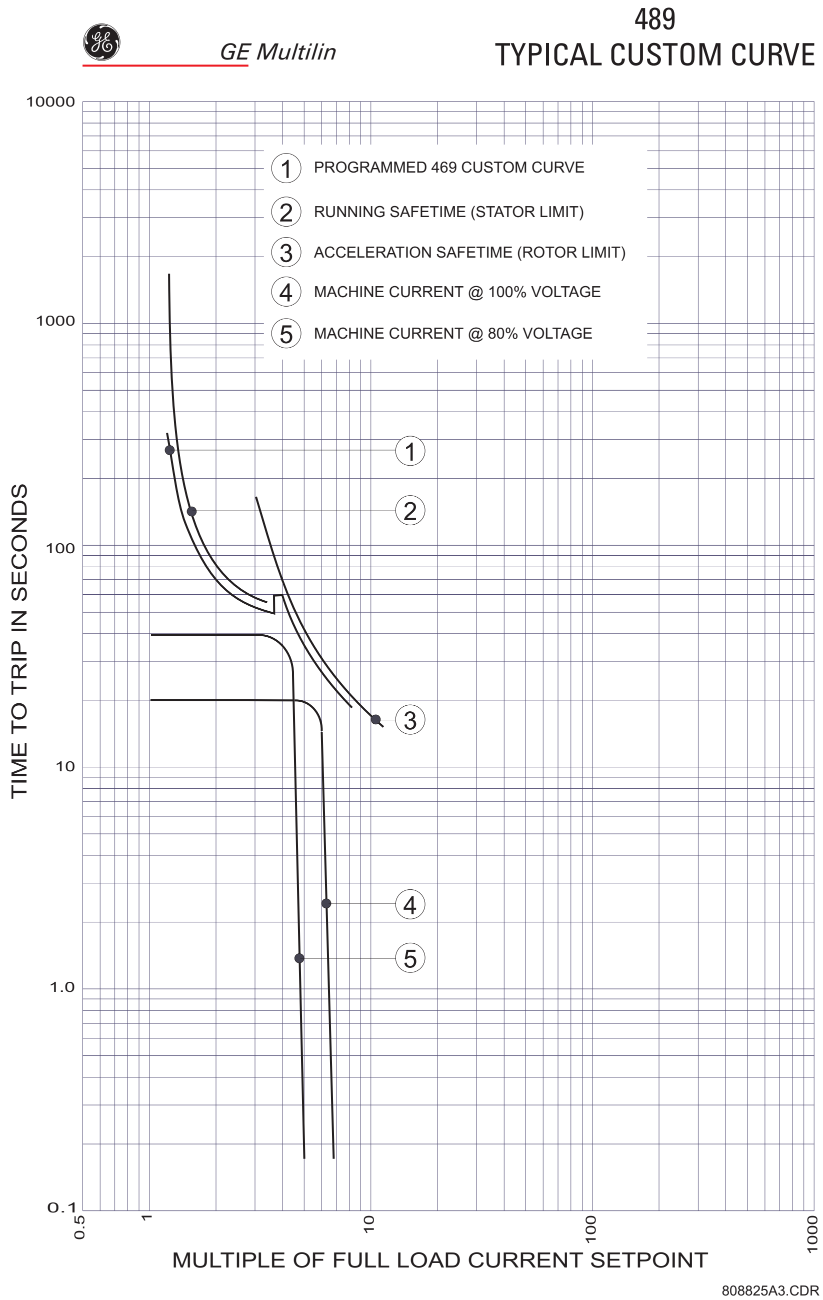


FIGURE 5–16: Custom Curve Example

Voltage Dependent Overload Curve

It is 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 coordinated against that curve. The protection relay 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 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 thermal limit curve shapes 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.

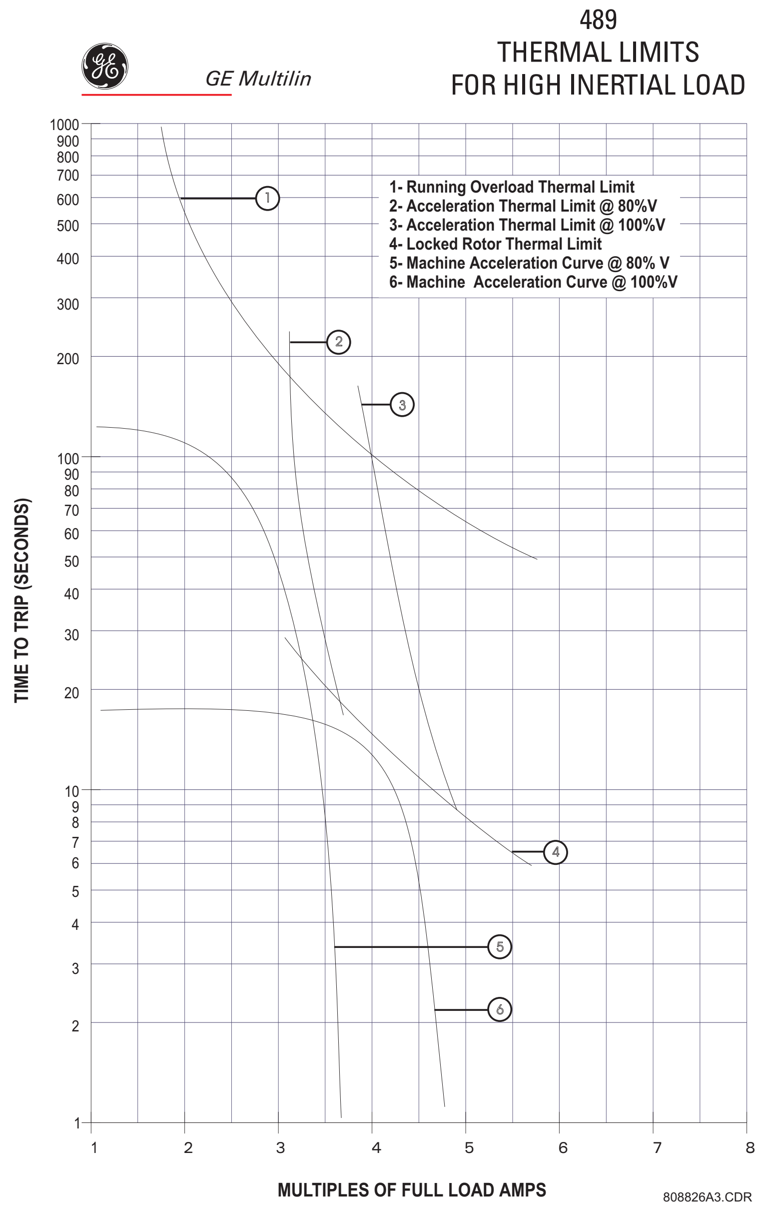


FIGURE 5–17: Thermal Limits for High Inertial Load

To illustrate the Voltage Dependent Overload Curve feature, the thermal limits shown in *Thermal Limits for High Inertial Load* on page 5–79 will be used.

▷ 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 the custom curve below).

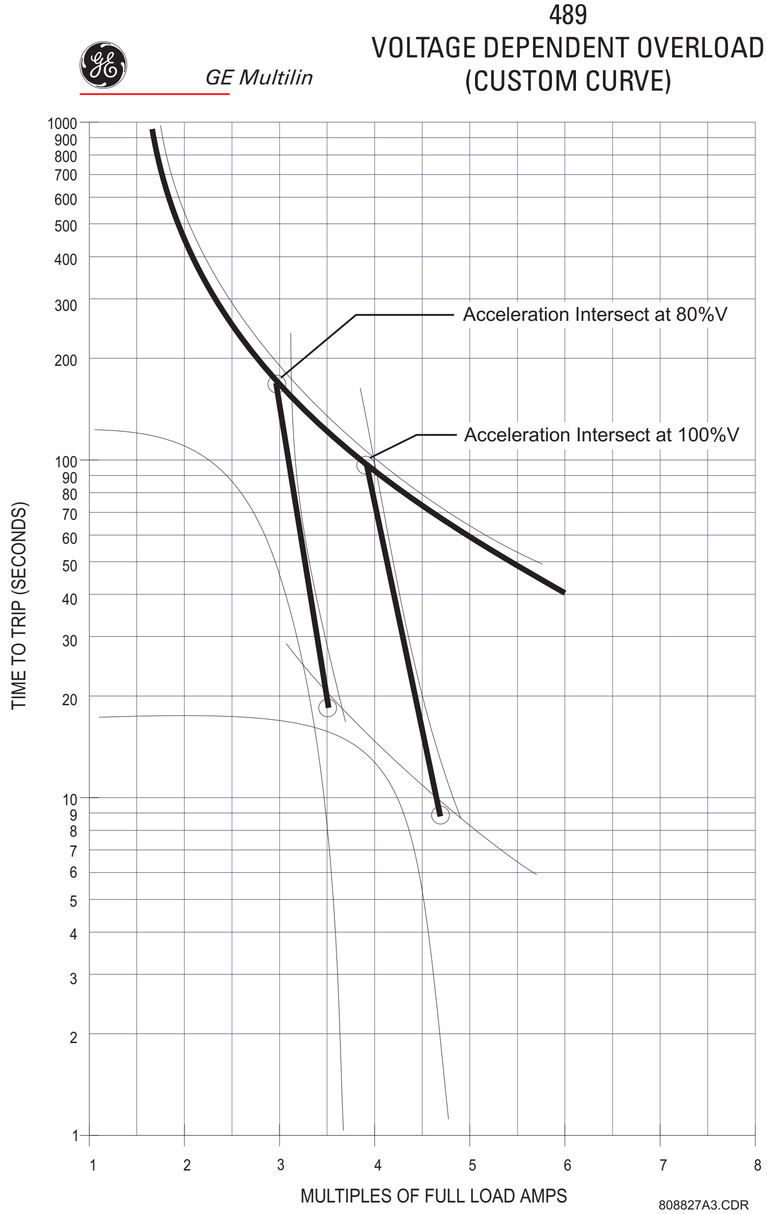


FIGURE 5–18: Voltage Dependent Overload Curve (Custom)

- ▷ Enter the per unit current value for the acceleration overload curve intersect with the custom curve for 80% voltage.
- ▷ Enter the per unit current and safe stall protection time for 80% voltage (see the acceleration curves below).
- ▷ Enter the per unit current value for the acceleration overload curve intersect with the custom curve for 100% voltage.
- ▷ Enter the per unit current and safe stall protection time for 100% voltage (see the acceleration curves below).

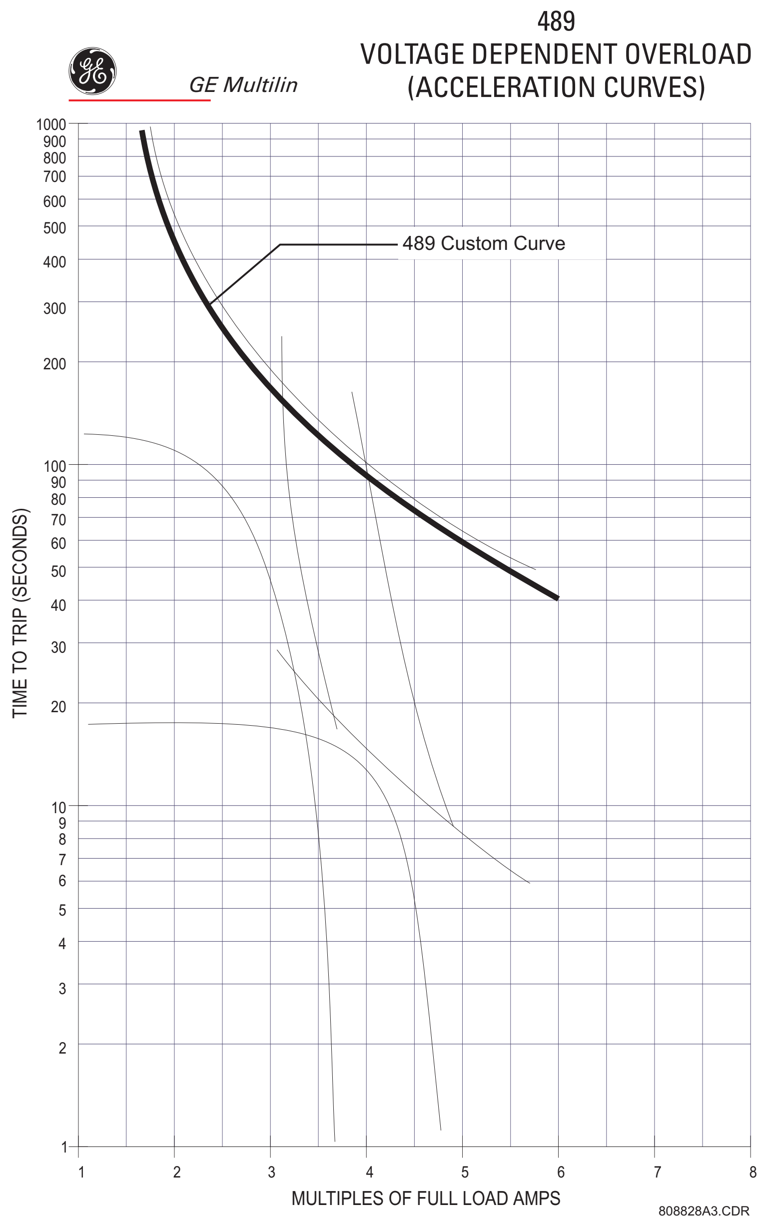


FIGURE 5–19: Voltage Dependent Overload Curve (Acceleration Curves)

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

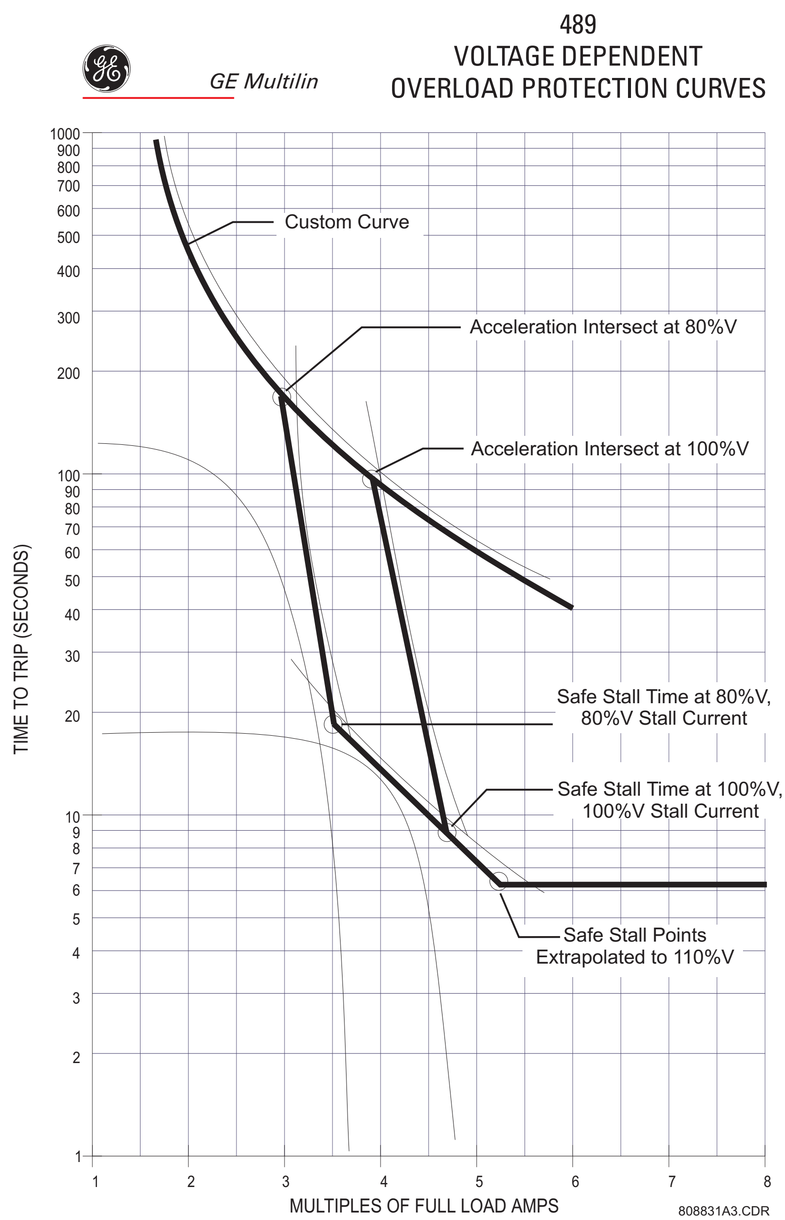


FIGURE 5–20: Voltage Dependent Overload Protection Curves

NOTE

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

The following curves illustrate the resultant overload protection for 80% and 100% voltage, respectively. For voltages between these levels, the 489 shifts the acceleration curve linearly and constantly based upon the measured voltage during generator start.

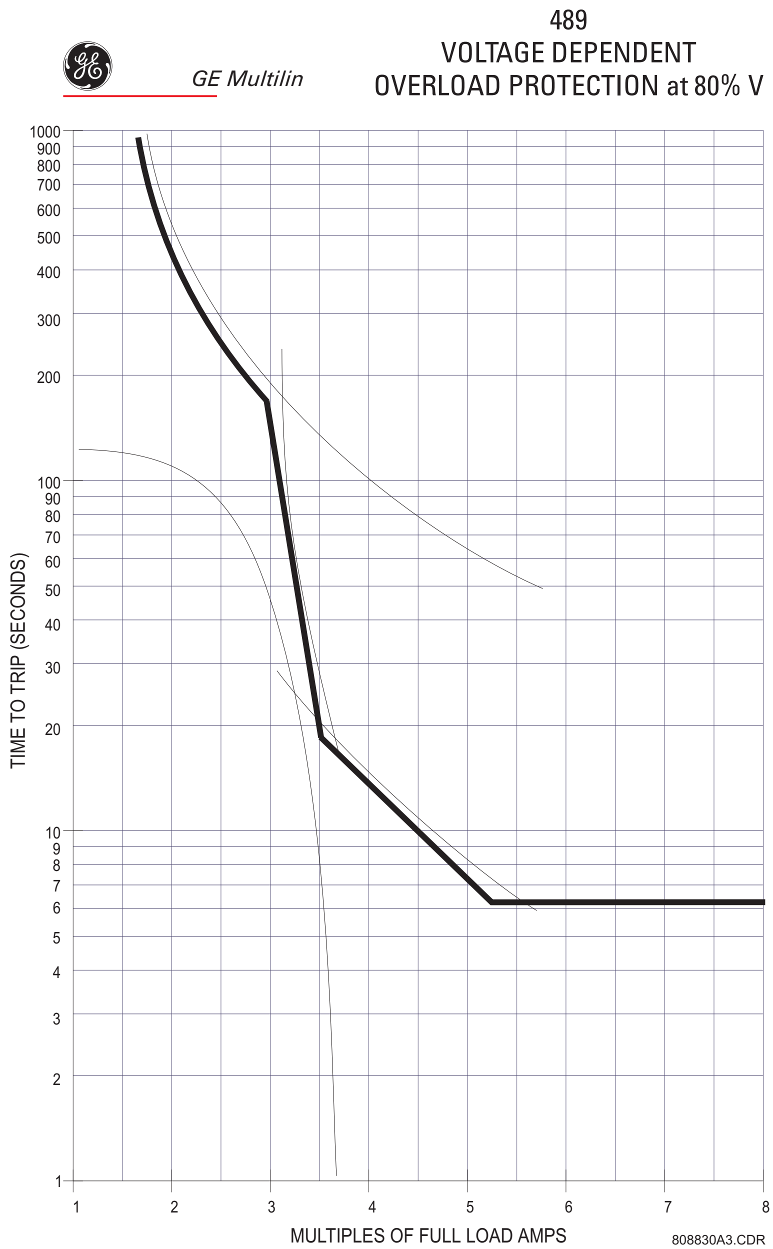


FIGURE 5–21: Voltage Dependent Overload Protection at 80% Voltage

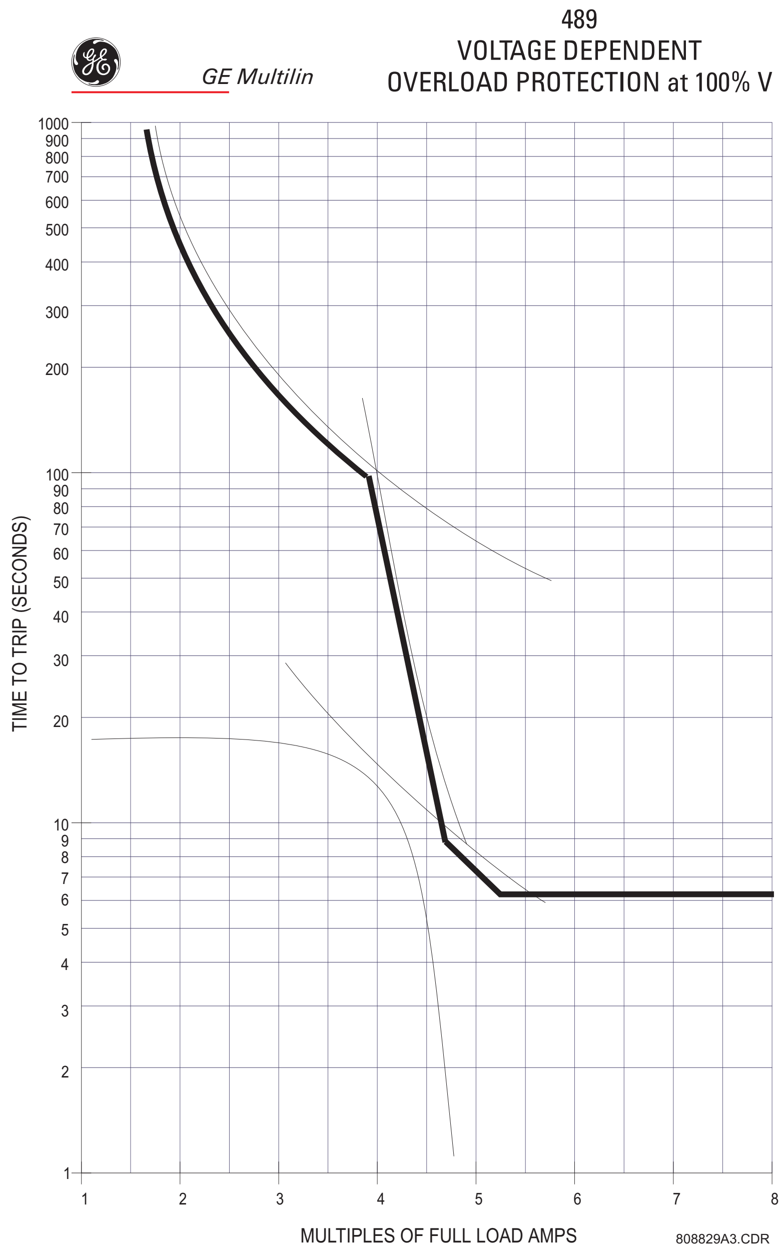


FIGURE 5–22: Voltage Dependent Overload Protection at 100% Voltage

Unbalance Bias

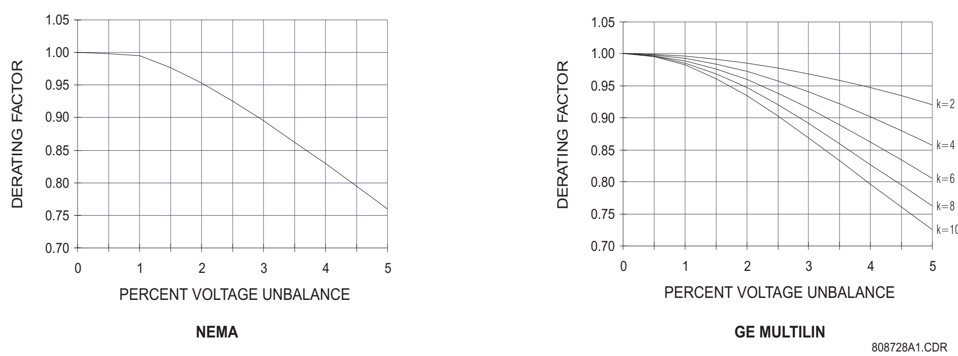
Unbalanced phase currents will cause additional rotor heating that will not be accounted for by electromechanical relays and may not be accounted for in some electronic protective relays. When the generator is running, the rotor will rotate in the direction of the positive sequence current at near synchronous 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 twice 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 (I_{per_unit}). This equivalent current is calculated using the equation shown below.

$$I_{eq} = \sqrt{I_1^{\ 2} + kI_2^{\ 2}} \qquad \textbf{(EQ 5.32)}$$

where: I_{eq} = equivalent motor 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 relating negative-sequence rotor resistance to positive-sequence rotor resistance, not to be confused with the k indicating generator negative-sequence capability for an inverse time curve.

The figure below shows induction machine derating as a function of voltage unbalance as recommended by NEMA (National Electrical Manufacturers Association). Assuming a typical inrush of 6 × FLA and a negative sequence impedance of 0.167, voltage unbalances of 1, 2, 3, 4, and 5% equal current unbalances of 6, 12, 18, 24, and 30%, respectively. Based on this assumption, the GE curve illustrates the amount of machine derating for different values of k entered for the **UNBALANCE BIAS K FACTOR** setpoint. Note that the curve created when k = 8 is almost identical to the NEMA derating curve.



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 motor current. k may be calculated conservatively as:

$$k = \frac{175}{I_{LR}^2} \text{ (typical estimate); } k = \frac{230}{I_{LR}^2} \text{ (conservative estimate)} \qquad \textbf{(EQ 5.33)}$$

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

Machine Cooling

The 489 thermal capacity used value is reduced exponentially when the motor current is below the **OVERLOAD PICKUP** setpoint. This reduction simulates machine cooling. The cooling time constants should be entered for both stopped and running cases (the generator is assumed to be running if current is measured or the generator is online). A machine with a stopped rotor normally cools significantly slower than one with a turning rotor. Machine cooling is calculated using the following formulae:

$$TC_{used} = (TC_{used\_start} - TC_{used\_end})(e^{-t/\tau}) + TC_{used\_end} \quad \textbf{(EQ 5.34)}$$

$$TC_{used\_end} = \left(\frac{I_{eq}}{\text{overload\_pickup}}\right)\left(1 - \frac{\text{hot}}{\text{cold}}\right) \times 100\% \quad \textbf{(EQ 5.35)}$$

where: TC_{used} = thermal capacity used
TC_{used_start} = TC_{used} value caused by overload condition
TC_{used_end} = TC_{used} value dictated by the hot/cold safe stall ratio when the machine is running (= 0 when the machine is stopped)
t = time in minutes
τ = Cool Time Constant (running or stopped)
I_{eq} = equivalent heating current
overload_pickup = overload pickup setpoint as a multiple of FLA
hot / cold = hot/cold safe stall ratio

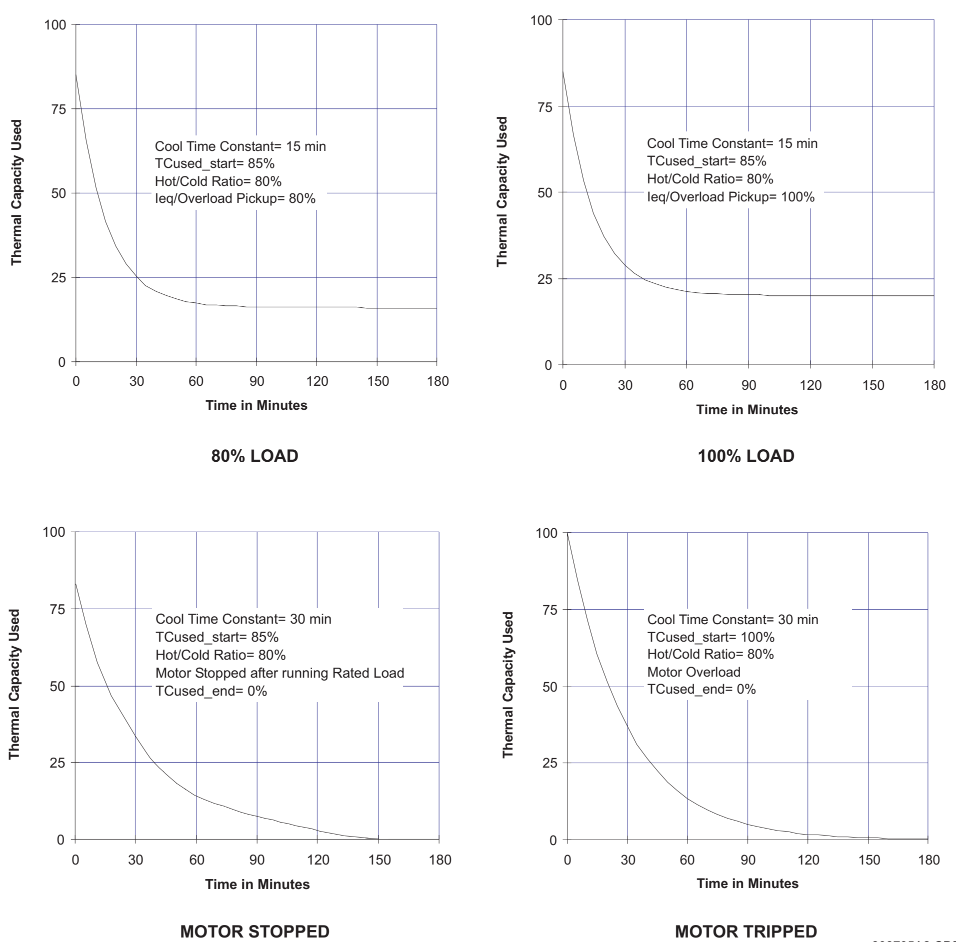


FIGURE 5–23: Thermal Model Cooling

Hot/Cold Safe Stall 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 SAFE STALL 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 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 SAFE STALL 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.

$$TC_{used\_end} = I_{eq} \times \left(1 - \frac{hot}{cold}\right) \times 100\% \qquad \textbf{(EQ 5.36)}$$

where: TC_{used_end} = Thermal Capacity Used if I_{per_unit} remains steady state
I_{eq} = equivalent generator heating current
hot/cold = **HOT/COLD SAFE STALL RATIO** setpoint

The hot/cold safe stall 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 SAFE STALL RATIO** should be entered as “1.00”.

RTD Bias

The thermal replica created by the features described in the sections above operates as a complete and independent model. However, the thermal overload curves 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 automatically determines the thermal capacity used value for the center point using the **HOT/COLD SAFE STALL RATIO** setpoint.

$$TC_{used\ at\ RBC} = \left(1 - \frac{hot}{cold}\right) \times 100\% \qquad \textbf{(EQ 5.37)}$$

At temperatures less that the RTD Bias Center temperature,

$$RTD\_Bias\_TC_{used} = \frac{Temp_{actual} - Temp_{min}}{Temp_{center} - Temp_{min}} \times TC_{used\ at\ RBC} \qquad \textbf{(EQ 5.38)}$$

At temperatures greater than the RTD Bias Center temperature,

$$RTD\_Bias\_TC_{used} = \frac{Temp_{actual} - Temp_{center}}{Temp_{max} - Temp_{center}} \times (100 - TC_{used\ at\ RBC}) + TC_{used\ at\ RBC} \qquad \textbf{(EQ 5.39)}$$

where: $RTD\_Bias\_TC_{used}$ = TC used due to hottest stator RTD
$Temp_{actual}$ = current temperature of the hottest stator RTD
$Temp_{min}$ = RTD Bias minimum setpoint
$Temp_{center}$ = RTD Bias center setpoint
$Temp_{max}$ = RTD Bias maximum setpoint
$TC_{used\ at\ RBC}$ = TC used defined by the **HOT/COLD SAFE STALL RATIO** setpoint

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 over-load pickup before an overload trip occurs. Presumably, the machine would trip on stator RTD temperature at that time.

NOTE

No biasing occurs if the hottest stator RTD is open or short.

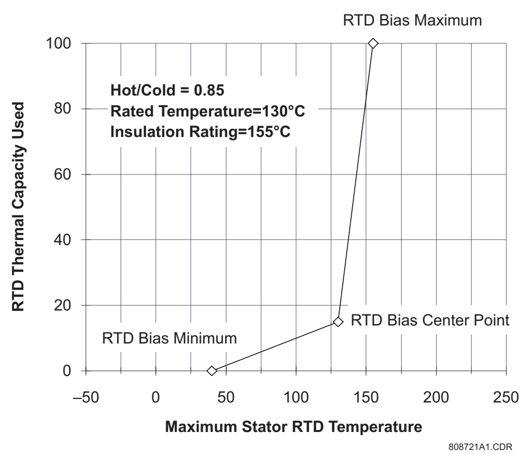


FIGURE 5–24: RTD Bias Curve

5.10.3 Thermal Elements

SETPOINTS ▷▽ S9 THERMAL MODEL ▷▽ THERMAL ELEMENTS

1 THERMAL [▷] ELEMENTS		THERMAL MODEL ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	THERMAL ALARM LEVEL: 75% Used	*Range: 10 to 100% Used in steps of 1*
	MESSAGE	THERMAL MODEL ALARM EVENTS: Off	*Range: On, Off*
	MESSAGE	THERMAL MODEL TRIP: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	*Range: Any combination of Relays 1 to 4*

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 offline cooling time constant. The thermal capacity used alarm may be used as a warning indication of an impending overload trip.

5.11 S10 Monitoring

5.11.1 Trip Counter

PATH: SETPOINTS ▷▽ S10 MONITORING ▷ TRIP COUNTER

■ TRIP [▷]		TRIP COUNTER ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	TRIP COUNTER ALARM LEVEL: 25 Trips	*Range: 1 to 50000 Trips in steps of 1*
	MESSAGE	TRIP COUNTER ALARM EVENTS: Off	*Range: On, Off*

When enabled, a trip counter alarm will occur when the **TRIP COUNTER ALARM LEVEL** is reached. 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.

For example, it might be useful to set a Trip Counter alarm at 100 trips, prompting the operator or supervisor to investigate the type of trips that have occurred. A breakdown of trips by type may be found in the **A4 MAINTENANCE ▷▽ TRIP COUNTERS** actual values page. If a trend is detected, it would warrant further investigation.

5.11.2 Breaker Failure

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ BREAKER FAILURE

■ BREAKER [▷]		BREAKER FAILURE ALARM: Off	*Range: Off, Latched, Unlatched*
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
	MESSAGE	BREAKER FAILURE LEVEL: 1.00 x CT	*Range: 0.05 to 20.00 × CT in steps of 0.01*
	MESSAGE	BREAKER FAILURE DELAY: 100 ms	*Range: 10 to 1000 ms in steps of 10*
	MESSAGE	BREAKER FAILURE ALARM EVENTS: Off	*Range: On, Off*

If the breaker failure alarm feature may be enabled as latched or unlatched. If the 1 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.

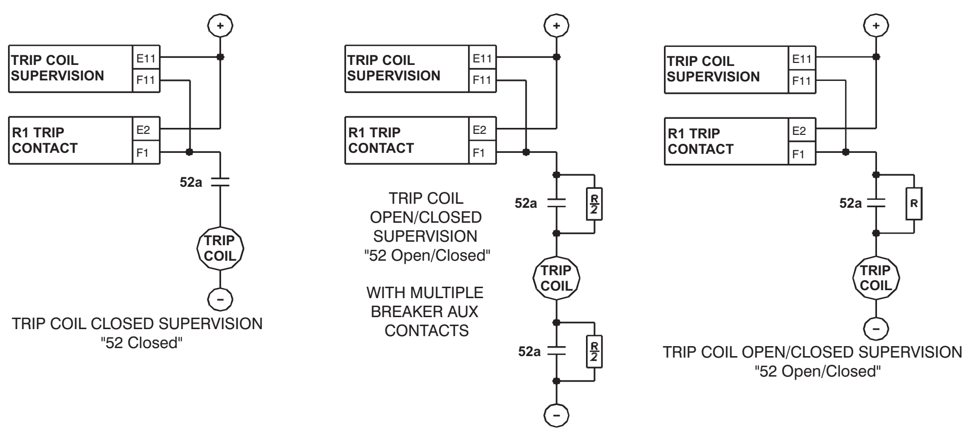
5.11.3 Trip Coil Monitor

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ TRIP COIL MONITOR

■ TRIP COIL MONITOR [▷]	TRIP COIL MONITOR ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	SUPERVISION OF TRIP COIL: 52 Closed	*Range: 52 Closed, 52 Open/Closed*
MESSAGE	TRIP COIL MONITOR ALARM EVENTS: Off	*Range: On, Off*

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 300 ms.

If 52 Open/Closed is selected, the trip coil supervision circuitry monitors 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 figure below for modifications to the wiring and proper resistor selection. If that continuity is broken, a Starter Failure alarm will indicate Trip Coil Supervision.



VALUE OF RESISTOR 'R'

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

808727A1.CDR

FIGURE 5–25: Trip Coil Supervision

5.11.4 VT Fuse Failure

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ VT FUSE FAILURE

■ VT FUSE FAILURE [▷]	VT FUSE FAILURE ALARM: Off	*Range: Off, Latched, Unlatched*
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	*Range: Any combination of Relays 2 to 5*
MESSAGE	VT FUSE FAILURE ALARM EVENTS: Off	*Range: On, Off*

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

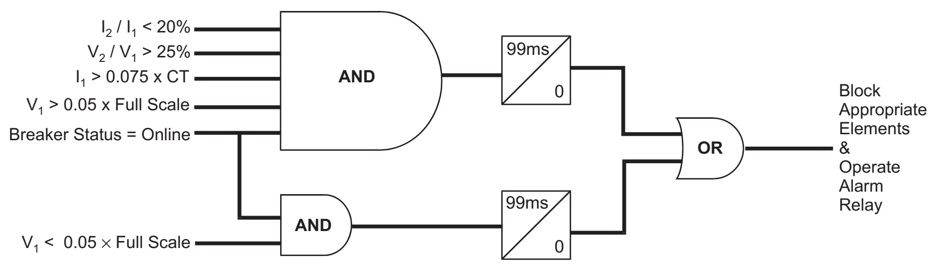


FIGURE 5–26: VT Fuse Failure Logic

5.11.5 Demand

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ CURRENT DEMAND...

■ CURRENT [▷]		CURRENT DEMAND PERIOD: 15 min.	Range: 5 to 90 min. in steps of 1
	MESSAGE	CURRENT DEMAND ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	CURRENT DEMAND LIMIT: 1.25 x FLA	Range: 0.10 to 20.00 × FLA in steps of 0.01
	MESSAGE	CURRENT DEMAND ALARM EVENTS: Off	Range: On, Off
■ MW DEMAND [▷]		MW DEMAND PERIOD: 15 min.	Range: 5 to 90 min. in steps of 1
	MESSAGE	MW DEMAND ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	MW DEMAND LIMIT: 1.25 x Rated	Range: 0.10 to 2.00 × Rated in steps of 0.01
	MESSAGE	MW DEMAND ALARM EVENTS: Off	Range: On, Off
■ Mvar DEMAND [▷]		Mvar DEMAND PERIOD: 15 min.	Range: 5 to 90 min. in steps of 1
	MESSAGE	Mvar DEMAND ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	Mvar DEMAND LIMIT: 1.25 x Rated	Range: 0.10 to 2.00 × Rated in steps of 0.01
	MESSAGE	Mvar DEMAND ALARM EVENTS: Off	Range: On, Off
■ MVA DEMAND [▷]		MVA DEMAND PERIOD: 15 min.	Range: 5 to 90 min. in steps of 1
	MESSAGE	MVA DEMAND ALARM: Off	Range: Off, Latched, Unlatched
	MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
	MESSAGE	MVA DEMAND LIMIT: 1.25 x Rated	Range: 0.10 to 2.00 × Rated in steps of 0.01

MESSAGE

```
MVA DEMAND
ALARM EVENTS: Off
```

Range: On, Off

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:

$$\text{Generator FLA} = \frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Generator Rated Phase-Phase Voltage}} \qquad \textbf{(EQ 5.40)}$$

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).

$$\text{Demand} = \frac{1}{N}\sum_{n=1}^{N} |\text{Average}_N| \qquad \textbf{(EQ 5.41)}$$

where: N = programmed Demand Period in minutes,
n = time in minutes

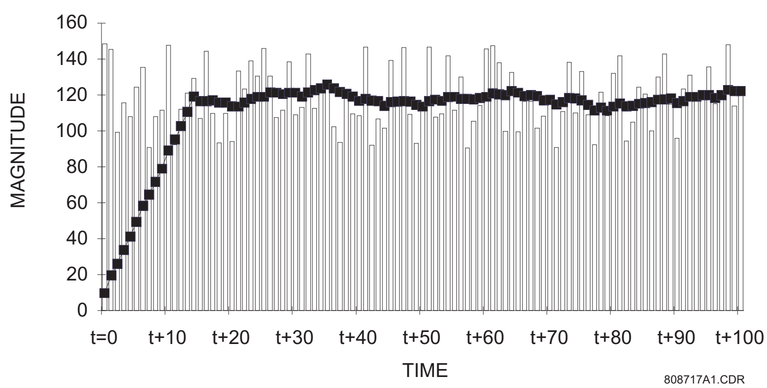


FIGURE 5–27: Rolling Demand (15 Minute Window)

5.11.6 Pulse Output

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ PULSE OUTPUT

```
■
PULSE              [▷]
```

```
POS. kWh PULSE OUT
RELAYS (2-5): ----
```

Range: Any combination of Relays 2 to 5

MESSAGE

```
POS. kWh PULSE OUT
INTERVAL: 10 kWh
```

Range: 1 to 50000 kWh in steps of 1

MESSAGE

```
POS. kvarh PULSE OUT
RELAYS (2-5): ----
```

Range: Any combination of Relays 2 to 5

MESSAGE	POS. kvarh PULSE OUT INTERVAL: 10 kvarh	Range: 1 to 50000 kvarh in steps of 1
MESSAGE	NEG. kvarh PULSE OUT RELAYS (2-5): ----	Range: Any combination of Relays 2 to 5
MESSAGE	NEG. kvarh PULSE OUT INTERVAL: 10 kvarh	Range: 1 to 50000 kvarh in steps of 1
MESSAGE	PULSE WIDTH: 200 ms	Range: 200 to 1000 ms in steps of 1

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 auxiliary 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 so 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.

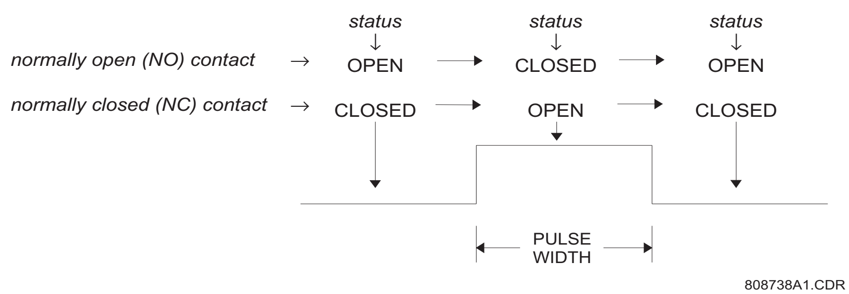


FIGURE 5–28: Pulse Output

5.11.7 Running Hour Setup

PATH: SETPOINTS ▷▽ S10 MONITORING ▷▽ RUNNING HOUR SETUP

■ RUNNING [▷]	INITIAL GEN. RUNNING HOURS: 0 h	Range: 0 to 999999 h in steps of 1
MESSAGE	GEN. RUNNING HOURS ALARM: Off	Range: Off, Latched, Unlatched
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
MESSAGE	GEN. RUNNING HOURS LIMIT: 1000 h	Range: 1 to 1000000 h in steps of 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 switching 489 relays without losing previous generator running hour values.

5.12 S11 Analog Inputs/Outputs

5.12.1 Analog Outputs 1 to 4

PATH: SETPOINTS ▷▽ S11 ANALOG I/O ▷ ANALOG OUTPUT 1(4)

■ ANALOG [▷]		ANALOG OUTPUT 1: Real Power (MW)	*Range: See Table 5–8: Analog Output Parameters on page –97.*
	MESSAGE	REAL POWER (MW) MIN: 0.00 x Rated	*Range: 0.00 to 2.00 × Rated in steps of 0.01*
	MESSAGE	REAL POWER (MW) MAX: 1.25 x Rated	*Range: 0.00 to 2.00 × Rated in steps of 0.01*
■ ANALOG [▷]		ANALOG OUTPUT 2: Apparent Power (MVA)	*Range: See Table 5–8: Analog Output Parameters on page –97.*
	MESSAGE	APPARENT POWER (MVA) MIN: 0.00 x Rated	*Range: 0.00 to 2.00 × Rated in steps of 0.01*
	MESSAGE	APPARENT POWER (MVA) MAX: 1.25 x Rated	*Range: 0.00 to 2.00 × Rated in steps of 0.01*
■ ANALOG [▷]		ANALOG OUTPUT 3: Avg. Output Current	*Range: See Table 5–8: Analog Output Parameters on page –97.*
	MESSAGE	AVG. OUTPUT CURRENT MIN: 0.00 x FLA	*Range: 0.00 to 20.00 × Rated in steps of 0.01*
	MESSAGE	AVG. OUTPUT CURRENT MAX: 1.25 x FLA	*Range: 0.00 to 20.00 × Rated in steps of 0.01*
■ ANALOG [▷]		ANALOG OUTPUT 4: Average Voltage	*Range: See Table 5–8: Analog Output Parameters on page –97.*
	MESSAGE	AVERAGE VOLTAGE MIN: 0.00 x Rated	*Range: 0.00 to 1.50 × Rated in steps of 0.01*
	MESSAGE	AVERAGE VOLTAGE MAX: 1.25 x Rated	*Range: 0.00 to 1.50 × Rated in steps of 0.01*

The 489 has four analog output channels (4 to 20 mA or 0 to 1 mA 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 4 mA output. The maximum value programmed represents the 20 mA output. All four of the outputs are updated once every 50 ms. Each parameter may only be used once.

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

Table 5–8: Analog Output Parameters

Parameter Name	Range / Units	Step	Default	
			Min.	Max
IA Output Current	0.00 to 20.00 × FLA	0.01	0.00	1.25
IB Output Current	0.00 to 20.00 × FLA	0.01	0.00	1.25
IC Output Current	0.00 to 20.00 × FLA	0.01	0.00	1.25
Avg. Output Current	0.00 to 20.00 × FLA	0.01	0.00	1.25
Neg. Seq. Current	0 to 2000% FLA	1	0	100
Averaged Gen. Load	0.00 to 20.00 × 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
RTDs 1 to 12	–50 to +250°C or –58 to +482°F	1	0	200
AB Voltage	0.00 to 1.50 × Rated	0.01	0.00	1.25
BC Voltage	0.00 to 1.50 × Rated	0.01	0.00	1.25
CA Voltage	0.00 to 1.50 × Rated	0.01	0.00	1.25
Volts/Hertz	0.00 to 2.00 × Rated	0.01	0.00	1.50
Frequency	0.00 to 90.00 Hz	0.01	59.00	61.00
Neutral Volt. (3rd)	0 to 25000 V	0.1	0.0	45.0
Average Voltage	0.00 to 1.50 × Rated	0.01	0.00	1.25
Power Factor	0.01 to 1.00 lead/lag	0.01	0.8 lag	0.8 lead
Reactive Power (Mvar)	–2.00 to 2.00 × Rated	0.01	0.00	1.25
Real Power	–2.00 to 2.00 × Rated	0.01	0.00	1.25
Apparent Power	0.00 to 2.00 × Rated	0.01	0.00	1.25
Analog Inputs 1 to 4	–50000 to +50000	1	0	50000
Tachometer	0 to 7200 RPM	1	3500	3700
Thermal Capacity Used	0 to 100%	1	0	100
Current Demand	0.00 to 20.00 × FLA	0.01	0.00	1.25
Mvar Demand	0.00 to 2.00 × Rated	0.01	0.00	1.25
MW Demand	0.00 to 2.00 × Rated	0.01	0.00	1.25
MVA Demand	0.00 to 2.00 × Rated	0.01	0.00	1.25

5.12.2 Analog Inputs 1 to 4

PATH: SETPOINTS ▷▽ S11 ANALOG I/O ▷▽ ANALOG INPUT 1(4)

■ ANALOG [▷]	ANALOG INPUT1: Disabled	Range: Disabled, 4-20 mA, 0-20 mA, 0-1 mA
MESSAGE	ANALOG INPUT1 NAME: Analog I/P 1	Range: 12 alphanumeric characters
MESSAGE	ANALOG INPUT1 UNITS: Units	Range: 6 alphanumeric characters
MESSAGE	ANALOG INPUT1 MINIMUM: 0	Range: –50000 to 50000 in steps of 1
MESSAGE	ANALOG INPUT1 MAXIMUM: 100	Range: –50000 to 50000 in steps of 1
MESSAGE	BLOCK ANALOG INPUT1 FROM ONLINE: 0 s	Range: 0 to 5000 sec. in steps of 1
MESSAGE	ANALOG INPUT1 ALARM: Off	Range: Off, Latched, Unlatched
MESSAGE	ASSIGN ALARM RELAYS (2-5): ---5	Range: Any combination of Relays 2 to 5
MESSAGE	ANALOG INPUT1 ALARM LEVEL: 10 Units	Range: –50000 to 50000 in steps of 1 Units reflect ANALOG INPUT 1 UNITS above
MESSAGE	ANALOG INPUT1 ALARM PICKUP: Over	Range: Over, Under
MESSAGE	ANALOG INPUT1 ALARM DELAY: 0.1 s	Range: 0.1 to 300.0 s in steps of 0.1
MESSAGE	ANALOG INPUT1 ALARM EVENTS: Off	Range: On, Off
MESSAGE	ANALOG INPUT1 TRIP: Off	Range: Off, Latched, Unlatched
MESSAGE	ASSIGN TRIP RELAYS (1-4): 1---	Range: Any combination of Relays 1 to 4
MESSAGE	ANALOG INPUT1 TRIP LEVEL: 20 Units	Range: –50000 to 50000 in steps of 1 Units reflect ANALOG INPUT 1 UNITS above
MESSAGE	ANALOG INPUT1 TRIP PICKUP: Over	Range: Over, Under
MESSAGE	ANALOG INPUT1 TRIP DELAY: 0.1 s	Range: 0.1 to 300.0 s in steps of 0.1

There are 4 analog inputs (4 to 20 mA, 0 to 20 mA, or 0 to 1 mA) that 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 EnerVista 489 Setup 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 maxi-mum 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 seconds, 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 seconds, 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.

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

5.13 S12 Testing

5.13.1 Simulation Mode

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷ SIMULATION MODE

■ SIMULATION [▷]		SIMULATION MODE: Off	*Range: Off, Simulate Pre-Fault, Simulate Fault, Pre-Fault to Fault*
	MESSAGE	PRE-FAULT TO FAULT TIME DELAY: 15 s	*Range: 0 to 300 s in steps of 1*

The 489 may be placed in several simulation modes. This simulation may be useful for several purposes. First, it may be used to under-stand 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.

The **SIMULATION MODE** setpoint 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** is set to "Pre-Fault to Fault", 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, the **SIMULATION MODE** reverts to "Off". Selecting "Off" for the **SIMULATION MODE** places the 489 back in service. If the 489 measures current or control power is cycled, the **SIMULATION MODE** automatically reverts 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.

5.13.2 Pre-Fault Setup

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ PRE-FAULT SETUP

■ PRE-FAULT [▷]	PRE-FAULT Iphase OUTPUT: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01*
MESSAGE	PRE-FAULT VOLTAGES PHASE-N: 1.00 x Rated	*Range: 0.00 to 1.50 × Rated in steps of 0.01. Enter as a phase-to-neutral quantity.*
MESSAGE	PRE-FAULT CURRENT LAGS VOLTAGE: 0°	*Range: 0 to 359° in steps of 1*
MESSAGE	PRE-FAULT Iphase NEUTRAL: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01 180° phase shift with respect to Iphase OUTPUT*
MESSAGE	PRE-FAULT CURRENT GROUND: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01. CT is either XXX:1 or 50:0.025*
MESSAGE	PRE-FAULT VOLTAGE NEUTRAL: 0 Vsec	*Range 0.0 to 100.0 Vsec in steps of 0.1 Fundamental value only in secondary units*
MESSAGE	PRE-FAULT STATOR RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
MESSAGE	PRE-FAULT BEARING RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
MESSAGE	PRE-FAULT OTHER RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
MESSAGE	PRE-FAULT AMBIENT RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
MESSAGE	PRE-FAULT SYSTEM FREQUENCY: 60.0 Hz	*Range: 5.0 to 90.0 Hz in steps of 0.1*
MESSAGE	PRE-FAULT ANALOG INPUT 1: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	PRE-FAULT ANALOG INPUT 2: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	PRE-FAULT ANALOG INPUT 3: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	PRE-FAULT ANALOG INPUT 4: 0%	*Range: 0 to 100% in steps of 1*

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”.

5.13.3 Fault Setup

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ FAULT SETUP

■ FAULT [▷]	◁ ▷	FAULT Iphase OUTPUT: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01*
	MESSAGE	FAULT VOLTAGES PHASE-N: 1.00 x Rated	*Range: 0.00 to 1.50 × Rated in steps of 0.01. Enter as a phase-to-neutral quantity.*
	MESSAGE	FAULT CURRENT LAGS VOLTAGE: 0°	*Range: 0 to 359° in steps of 1*
	MESSAGE	FAULT Iphase NEUTRAL: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01. (180° phase shift with respect to Iphase OUTPUT)*
	MESSAGE	FAULT CURRENT GROUND: 0.00 x CT	*Range: 0.00 to 20.00 × CT in steps of 0.01. CT is either XXX:1 or 50:0.025*
	MESSAGE	FAULT VOLTAGE NEUTRAL: 0 Vsec	*Range: 0.0 to 100.0 Vsec in steps of 0.1 Fundamental value only in secondary volts*
	MESSAGE	FAULT STATOR RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
	MESSAGE	FAULT BEARING RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
	MESSAGE	FAULT OTHER RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
	MESSAGE	FAULT AMBIENT RTD TEMP: 40°C	*Range: –50 to 250°C in steps of 1*
	MESSAGE	FAULT SYSTEM FREQUENCY: 60.0 Hz	*Range: 5.0 to 90.0 Hz in steps of 0.1*
	MESSAGE	FAULT ANALOG INPUT 1: 0%	*Range: 0 to 100% in steps of 1*
	MESSAGE	FAULT ANALOG INPUT 2: 0%	*Range: 0 to 100% in steps of 1*
	MESSAGE	FAULT ANALOG INPUT 3: 0%	*Range: 0 to 100% in steps of 1*
	MESSAGE	FAULT ANALOG INPUT 4: 0%	*Range: 0 to 100% in steps of 1*

The values entered here are substituted for the measured values in the 489 when the **SIMULATION MODE** is “Simulate Fault”.

5.13.4 Test Output Relays

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ TEST OUTPUT RELAYS

■ TEST [▷]	◁ ▷	FORCE OPERATION OF RELAYS: Disabled	*Range: Disabled, 1 Trip, 2 Auxiliary, 3 Auxiliary, 4 Auxiliary, 5 Alarm, 6 Service, All Relays, No Relays*

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. The appropriate relay indicator will illuminate at that time. Selecting “Disabled” places 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.

5.13.5 Test Analog Output

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ TEST ANALOG OUTPUT

■ TEST [▷]	FORCE ANALOG OUTPUTS FUNCTION: Disabled	*Range: Enabled, Disabled*
MESSAGE	ANALOG OUTPUT 1 FORCED VALUE: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	ANALOG OUTPUT 2 FORCED VALUE: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	ANALOG OUTPUT 3 FORCED VALUE: 0%	*Range: 0 to 100% in steps of 1*
MESSAGE	ANALOG OUTPUT 4 FORCED VALUE: 0%	*Range: 0 to 100% in steps of 1*

These 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 reflects the forced value as a percentage of the range 4 to 20 mA or 0 to 1 mA. Selecting “Disabled” places all four analog output channels back in service, reflecting their programmed parameters. 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 In Service indicator will flash, indicating that the 489 is not in protection mode.

5.13.6 Comm Port Monitor

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ COMMUNICATION PORT MONITOR

■ COMMUNICATION [▷]		MONITOR COMM. PORT: Computer RS485	*Range:* *Computer RS485, Auxiliary RS485, Front Panel RS232*
	MESSAGE	CLEAR COMM. BUFFERS: No	*Range:* *No, Yes*
	MESSAGE	LAST Rx BUFFER: Received OK	*Range:* *Buffer Cleared, Received OK, Wrong Slave Addr., Illegal Function, Illegal Count, Illegal Reg. Addr., CRC Error, Illegal Data*
	MESSAGE	Rx1: 02,03,00,67,00, 03,B4,27	*Range:* *received data in HEX*
	MESSAGE	Rx2:	*Range:* *received data in HEX*
	MESSAGE	Tx1: 02,03,06,00,64, 00,0A,00,0F	*Range:* *transmit data in HEX*
	MESSAGE	Tx2:	*Range:* *transmit data in HEX*

During communications troubleshooting, it can be useful to see the data being transmitted to the 489 from some master device, as well as the data transmitted back to that master device. The messages shown here make it possible to view that data. Any of the three communications ports may be monitored. After the communications buffers are cleared, any data received from the monitored communications port is stored in Rx1 and Rx2. If the 489 transmits a message, it appears in the Tx1 and Tx2 buffers. In addition to these buffers, there is a message indicating the status of the last received message.

5.13.7 Factory Service

PATH: SETPOINTS ▷▽ S12 489 TESTING ▷▽ FACTORY SERVICE

■ FACTORY [▷]	ENTER FACTORY PASSCODE: 0	*Range:* *N/A*

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

Digital Energy
Multilin

489 Generator Management Relay

Chapter 6: Actual Values

6.1 Overview

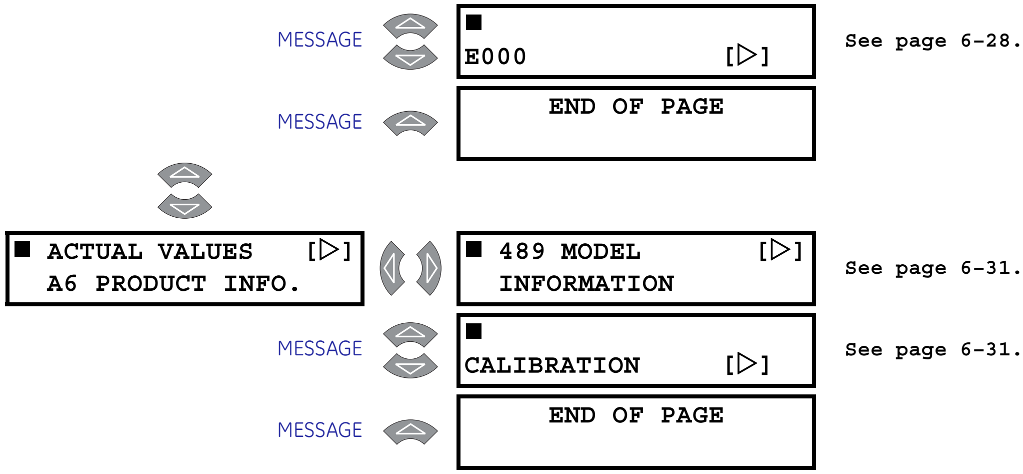
6.1.1 Actual Values Main Menu

The actual values message map is shown below.

■ ACTUAL VALUES [▷] A1 STATUS	■ NETWORK STATUS [▷]	See page 6-4.
MESSAGE	■ GENERATOR [▷]	See page 6-4.
MESSAGE	■ LAST TRIP DATA [▷]	See page 6-5.
MESSAGE	■ ALARM STATUS [▷]	See page 6-6.
MESSAGE	■ TRIP PICKUPS [▷]	See page 6-9.
MESSAGE	■ ALARM PICKUPS [▷]	See page 6-12.
MESSAGE	■ DIGITAL [▷]	See page 6-15.
MESSAGE	■ REAL TIME CLOCK [▷]	See page 6-15.
MESSAGE	END OF PAGE	

■ ACTUAL VALUES [▷] A2 METERING DATA		■ CURRENT [▷]	See page 6-16.
	MESSAGE	■ VOLTAGE [▷]	See page 6-17.
	MESSAGE	■ POWER [▷]	See page 6-18.
	MESSAGE	■ TEMPERATURE [▷]	See page 6-19.
	MESSAGE	■ DEMAND [▷]	See page 6-20.
	MESSAGE	■ ANALOG [▷]	See page 6-20.
	MESSAGE	■ SPEED [▷]	See page 6-21.
	MESSAGE	END OF PAGE	
■ ACTUAL VALUES [▷] A3 LEARNED DATA		■ PARAMETER [▷]	See page 6-22.
	MESSAGE	■ RTD [▷]	See page 6-22.
	MESSAGE	■ ANALOG INPUT [▷] MIN/MAX	See page 6-23.
	MESSAGE	END OF PAGE	
■ ACTUAL VALUES [▷] A4 MAINTENANCE		■ TRIP [▷]	See page 6-25.
	MESSAGE	■ GENERAL [▷]	See page 6-27.
	MESSAGE	■ TIMERS [▷]	See page 6-27.
	MESSAGE	END OF PAGE	
■ ACTUAL VALUES [▷] A5 EVENT RECORD		■ E255 [▷]	See page 6-28.
	MESSAGE	■ E254 [▷]	See page 6-28.

↓



6.1.2 Description

Measured values, maintenance and fault analysis information are accessed in the actual values. 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 EnerVista 489 Setup software 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. However, a computer makes viewing much more convenient since many variables may be viewed simultaneously.

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.

In addition to the actual values, there are also diagnostic and flash messages that appear only when certain conditions occur. They are described later in this chapter.

6.2 A1 Status

6.2.1 Network Status

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ NETWORK STATUS

■ NETWORK STATUS [▷]	◁ ▷	Ethernet Lnk Con Dia Status [■] [■] [ ]	*Range: see description below*

This actual value appears when the relay is ordered with the Ethernet (T) option.

The **ETHERNET STATUS** actual value message indicates the status of the Ethernet link, connection, and diagnostic via three indicators. The [■] symbol indicates on, and the [ ] symbol indicates off. There is also a blinking indication.

The box under **LNK** column indicates the Ethernet link status. If it is on, the Ethernet port is connected to the network; if it is off, the port is disconnected. This indicator is normally on.

The box under the **CON** column indicates the connection status. If on, the Ethernet port is configured and ready to transmit and receive data. If blinking, the Ethernet port is either active (transmitting or receiving data) or indicating an error if the diagnostic status is also on or blinking.

The box under the **DIA** column indicates the diagnostic status. If it is on, then either a fatal Ethernet port error has occurred or there is a duplicate IP address on the network. If blinking, then there is a non-fatal network error. Off indicates no errors.

6.2.2 Generator Status

PATH: ACTUAL VALUES ▷ A1 STATUS ▷ GENERATOR STATUS

■ GENERATOR [▷]	◁ ▷	GENERATOR STATUS: Offline	*Range: Online, Offline, Tripped*
MESSAGE	△ ▽	GENERATOR THERMAL CAPACITY USED: 0%	*Range: 0 to 100%. Seen only if the Thermal Model is enabled*
MESSAGE	△	ESTIMATED TRIP TIME ON OVERLOAD: Never	*Range: 0 to 10000 sec., Never. Seen only if the Thermal Model is enabled*

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 **GENERATOR THERMAL CAPACITY USED** value 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.

6.2.3 Last Trip Data

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ LAST TRIP DATA

■ LAST TRIP DATA [▷]	CAUSE OF LAST TRIP: No Trip to Date	*Range: see Note below.*
MESSAGE	TIME OF LAST TRIP: 09:00:00.00	*Range: hour:min:sec*
MESSAGE	DATE OF LAST TRIP: Jan 01 1995	*Range: Month Day Year*
MESSAGE	TACHOMETER PRETRIP: 3600 RPM	*Range: 0 to 3600 RPM. Seen only if Tachometer is assigned.*
MESSAGE	A: 0 B: 0 C: 0 A PreTrip	*Range: 0 to 999999 A. Represents current measured from output CTs. Seen only if a trip has occurred.*
MESSAGE	a: 0 b: 0 c: 0 A PreTrip	*Range: 0 to 999999 A. Represents differential current. Seen only if differential element is enabled.*
MESSAGE	NEG. SEQ. CURRENT PRETRIP: 0% FLA	*Range: 0 to 2000% FLA. Seen only if there has been a trip.*
MESSAGE	GROUND CURRENT PRETRIP: 0.00 A	*Range: 0.00 to 200000.00 A. Not seen if* **GROUND CT** *is "None"*
MESSAGE	GROUND CURRENT PRETRIP: 0.00 Amps	*Range: 0.0 to 5000.0 A*
MESSAGE	Vab: 0 Vbc: 0 Vca: 0 V PreTrip	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "None"*
MESSAGE	FREQUENCY PRETRIP: 0.00 Hz	*Range: 0.00 to 90.00 Hz. Not seen if* **VT CONNECTION** *is "None"*
MESSAGE	NEUTRAL VOLT (FUND) PRETRIP: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*
MESSAGE	NEUTRAL VOLT (3rd) PRETRIP: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*
MESSAGE	REAL POWER (MW) PRETRIP: 0.000	*Range: 0.000 to ±2000.000 MW. Not seen if* **VT CONNECTION** *is "None"*
MESSAGE	REACTIVE POWER Mvar PRETRIP: 0.00 Hz	*Range: 0.000 to ±2000.000 Mvar. Not seen if* **VT CONNECTION** *is "None"*
MESSAGE	APPARENT POWER MVA PRETRIP: 0.00 Hz	*Range: 0.000 to ±2000.000 MVA. Not seen if* **VT CONNECTION** *is "None"*
MESSAGE	HOTTEST STATOR RTD RTD #1: 0°C PreTrip	*Range: –50 to 250°C. Seen only if at least one RTD is "Stator"*
MESSAGE	HOTTEST BEARING RTD RTD #7: 0°C PreTrip	*Range: –50 to 250°C. Seen only if at least one RTD is "Bearing"*
MESSAGE	HOTTEST OTHER RTD RTD #11: 0°C PreTrip	*Range: –50 to 250°C. Seen only if at least one RTD is "Other"*

MESSAGE	AMBIENT RTD RTD#12: 0°C PreTrip	Range: –50 to 250°C. Seen only if at least one RTD is Ambient
MESSAGE	ANALOG INPUT 1 PreTrip: 0 Units	Range: –50000 to 50000. Not seen if **ANALOG INPUT 1** is "Disabled"
MESSAGE	ANALOG INPUT 2 PreTrip: 0 Units	Range: –50000 to 50000. Not seen if **ANALOG INPUT 2** is "Disabled"
MESSAGE	ANALOG INPUT 3 PreTrip: 0 Units	Range: –50000 to 50000. Not seen if **ANALOG INPUT 3** is "Disabled"
MESSAGE	ANALOG INPUT 4 PreTrip: 0 Units	Range: –50000 to 50000. Not seen if **ANALOG INPUT 4** is "Disabled"
MESSAGE	Vab/Iab PreTrip: 0.0 Ωsec. 0°	Range: 0 to 65535 Ωsec.; 0 to 359°. Seen only if Loss of Excitation is enabled

NOTE

The range for the **CAUSE OF LAST TRIP** setpoint is: No Trip to Date, General Inputs A to G, Sequential Trip, Field-Bkr Discrep., Tachometer, Thermal Model, Offline Overcurrent, Phase Overcurrent, Neg. Seq. Overcurrent, Ground Overcurrent, Phase Differential, RTDs 1 to 12, Overvoltage, Undervoltage, Volts/Hertz, Phase Reversal, Underfrequency, Overfrequency, Neutral O/V, Neutral U/V (3rd), Reactive Power, Reverse Power, Low Forward Power, Inadvertent Energ., and Analog Inputs 1 to 4.

Immediately prior to issuing a trip, the 489 takes a snapshot of generator parameters and stores them as pre-trip values; this allows 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 **S1 489 SETUP** ▷▽ **CLEAR DATA** ▷▽ **CLEAR LAST TRIP DATA** setpoint. 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.

6.2.4 Alarm Status

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ ALARM STATUS

■ ALARM STATUS [▷]	NO ALARMS	Range: N/A. Message seen when no alarms are active
MESSAGE	Input A ALARM STATUS: Active	Range: Active, Latched. See Note below.
MESSAGE	Input B ALARM STATUS: Active	Range: Active, Latched. See Note below.
MESSAGE	Input C ALARM STATUS: Active	Range: Active, Latched. See Note below.
MESSAGE	Input D ALARM STATUS: Active	Range: Active, Latched. See Note below.
MESSAGE	Input E ALARM STATUS: Active	Range: Active, Latched. See Note below.

MESSAGE	Input F ALARM STATUS: Active	*Range: Active, Latched. See Note below.*
MESSAGE	Input G ALARM STATUS: Active	*Range: Active, Latched. See Note below.*
MESSAGE	TACHOMETER ALARM: 3000 RPM	*Range: 0 to 3600 RPM*
MESSAGE	OVERCURRENT ALARM: 10.00 x FLA	*Range: 0.00 to 20.00 × FLA*
MESSAGE	NEG. SEQ. CURRENT ALARM: 15% FLA	*Range: 0 to 100% FLA*
MESSAGE	GROUND OVERCURRENT ALARM: 5.00 A	*Range: 0.00 to 200000.00 A. Seen only if the GE 50:0.025 CT is used.*
MESSAGE	GROUND DIRECTIONAL ALARM: 5.00 A	*Range: 0.00 to 200000.00 A*
MESSAGE	UNDERVOLTAGE ALARM Vab= 3245 V 78%	*Range: 0 to 20000 V; 50 to 99% of Rated*
MESSAGE	OVERVOLTAGE ALARM Vab= 4992 V 120%	*Range: 0 to 20000 V; 101 to 150% of Rated*
MESSAGE	VOLTS/HERTZ ALARM PER UNIT V/Hz: 1.15	*Range: 0.00 to 2.00. Not seen if* **VT CONNECTION** *is None.*
MESSAGE	UNDERFREQUENCY ALARM: 59.4 Hz	*Range: 0.00 to 90.00 Hz*
MESSAGE	OVERFREQUENCY ALARM: 60.6 Hz	*Range: 0.00 to 90.00 Hz*
MESSAGE	NEUTRAL O/V (FUND) ALARM: 0.0 V	*Range: 0.0 to 25000.0 V*
MESSAGE	NEUTRAL U/V (3rd) ALARM: 0.0 V	*Range: 0.0 to 25000.0 V*
MESSAGE	REACTIVE POWER Mvar ALARM: +20.000	*Range: –2000.000 to +2000.000 Mvar*
MESSAGE	REVERSE POWER ALARM: -20.000 MW	*Range: –2000.000 to +2000.000 MW*
MESSAGE	LOW FORWARD POWER ALARM: -20.000 MW	*Range: –2000.000 to +2000.000 MW*
MESSAGE	RTD #1 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #2 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #3 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #4 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*

MESSAGE	RTD #5 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #6 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #7 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #8 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #9 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #10 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #11 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	RTD #12 ALARM: 135°C	*Range: –50 to +250°C. Top line displays the RTD name as programmed.*
MESSAGE	OPEN SENSOR ALARM: RTD # 1 2 3 4 5 6 ...	*Range: RTDs 1 to 12*
MESSAGE	SHORT/LOW TEMP ALARM RTD # 7 8 9 10 11 ...	*Range: RTDs 1 to 12*
MESSAGE	THERMAL MODEL ALARM: 100% TC USED	*Range: 1 to 100%*
MESSAGE	TRIP COUNTER ALARM: 25 Trips	*Range: 1 to 10000*
MESSAGE	BREAKER FAILURE ALARM: Active	*Range: Active, Latched*
MESSAGE	TRIP COIL MONITOR ALARM: Active	*Range: Active, Latched*
MESSAGE	VT FUSE FAILURE ALARM: Active	*Range: Active, Latched*
MESSAGE	CURRENT DEMAND ALARM: 1053 A	*Range: 1 to 999999 A*
MESSAGE	MW DEMAND ALARM: 50.500	*Range: –2000.000 to +2000.000 MW*
MESSAGE	Mvar DEMAND ALARM: -20.000	*Range: –2000.000 to +2000.000 Mvar*
MESSAGE	MVA DEMAND ALARM: 20.000	*Range: 0 to 2000.000 MVA*
MESSAGE	GEN. RUNNING HOURS ALARM: 1000 h	*Range: 0 to 1000000 hrs. Seen only if Running Hr. Alarm is enabled.*
MESSAGE	ANALOG I/P 1 ALARM: 201 Units	*Range: –50000 to +50000*

MESSAGE	ANALOG I/P 2 ALARM: 201 Units	*Range: –50000 to +50000*
MESSAGE	ANALOG I/P 3 ALARM: 201 Units	*Range: –50000 to +50000*
MESSAGE	ANALOG I/P 4 ALARM: 201 Units	*Range: –50000 to +50000*
MESSAGE	ALARM, 489 NOT INSERTED PROPERLY	*Range: N/A*
MESSAGE	489 NOT IN SERVICE Simulation Mode	*Range: Not Programmed, Simulation Mode, Output Relays Forced, Analog Output Forced, Test Switch Shorted*
MESSAGE	IRIG-B FAILURE ALARM: Active	*Range: Active. Seen only if IRIG-B is enabled and the associated signal input is lost.*

Any active or latched alarms may be viewed here.

The various alarm and alarm status actual values reflect the Input Name as programmed in the first line of the message. The status is “Active” if the condition that caused the alarm is still present.

If the 489 chassis is only partially engaged with the case, the **ALARM, 489 NOT INSERTED PROPERLY** service alarm appears after 1 sec. Secure the chassis handle to ensure that all contacts mate properly.

6.2.5 Trip Pickups

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ TRIP PICKUPS

■ TRIP PICKUPS [▷]	Input A PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input B PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input C PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input D PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input E PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input F PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	Input G PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	SEQUENTIAL TRIP PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	FIELD-BKR DISCREP. PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*

MESSAGE	TACHOMETER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	OFFLINE OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	INADVERTENT ENERG. PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	PHASE OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	NEG. SEQ. OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	GROUND OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	PHASE DIFFERENTIAL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	GROUND DIRECTIONAL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	HIGH-SET PHASE O/C PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	UNDERVOLTAGE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	OVERVOLTAGE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	VOLTS/HERTZ PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	PHASE REVERSAL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	UNDERFREQUENCY PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	OVERFREQUENCY PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	NEUTRAL O/V (FUND) PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	NEUTRAL U/V (3rd) PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	LOSS OF EXCITATION 1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	LOSS OF EXCITATION 2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	DISTANCE ZONE 1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	DISTANCE ZONE 2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*

MESSAGE	⇕	REACTIVE POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	REVERSE POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	LOW FORWARD POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #3 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #4 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #5 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #6 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #7 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #8 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #9 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #10 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #11 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	RTD #12 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	THERMAL MODEL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip.*
MESSAGE	⇕	ANALOG I/P 1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	⇕	ANALOG I/P 2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	⇕	ANALOG I/P 3 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*
MESSAGE	⇑	ANALOG I/P 4 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Trip, Latched Trip*

NOTE

The various trip pickup actual values reflect the Input Name as programmed in the first line of the message. The various digital and analog input functions are shown only if the function has been assigned as an input.

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.

6.2.6 Alarm Pickups

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ ALARM PICKUPS

■ ALARM PICKUPS [▷]	Input A PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input B PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input C PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input D PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input E PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input F PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Input G PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	TACHOMETER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	NEG. SEQ. OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	GROUND OVERCURRENT PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	GROUND DIRECTIONAL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	UNDERVOLTAGE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	OVERVOLTAGE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	VOLTS/HERTZ PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*

MESSAGE	UNDERFREQUENCY PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	OVERFREQUENCY PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	NEUTRAL O/V (FUND) PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	NEUTRAL U/V (3rd) PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	REACTIVE POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	REVERSE POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	LOW FORWARD POWER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #3 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #4 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #5 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #6 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #7 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #8 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #9 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #10 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #11 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	RTD #12 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	OPEN SENSOR PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	SHORT/LOW TEMP PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*

MESSAGE	THERMAL MODEL PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	TRIP COUNTER PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	BREAKER FAILURE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	TRIP COIL MONITOR PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	VT FUSE FAILURE PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	CURRENT DEMAND PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	MW DEMAND PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	Mvar DEMAND PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	MVA DEMAND PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	GEN. RUNNING HOURS PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	ANALOG I/P 1 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	ANALOG I/P 2 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	ANALOG I/P 3 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*
MESSAGE	ANALOG I/P 4 PICKUP: Not Enabled	*Range: Not Enabled, Inactive, Timing Out, Active Alarm, Latched Alarm.*

NOTE

The various alarm pickup actual values reflect the Input Name as programmed in the first line of the message. The various digital and analog input functions are shown only if the function has been assigned as an input.

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.

6.2.7 Digital Inputs

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ DIGITAL INPUTS

■ DIGITAL [▷] INPUTS		ACCESS SWITCH STATE: Open	*Range: Open, Shorted*
	MESSAGE	BREAKER STATUS SWITCH STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT1 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT2 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT3 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT4 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT5 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT6 STATE: Open	*Range: Open, Shorted*
	MESSAGE	ASSIGNABLE DIGITAL INPUT7 STATE: Open	*Range: Open, Shorted*
	MESSAGE	TRIP COIL SUPERVISION: No Coil	*Range: Open, Shorted*

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

6.2.8 Real Time Clock

PATH: ACTUAL VALUES ▷ A1 STATUS ▷▽ REAL TIME CLOCK

■ REAL TIME [▷] CLOCK	DATE: 01/01/1995 TIME: 12:00:00	*Range: 01/01/1995 to 12/31/2094,* *00:00:00 to 23:59:59*

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

6.3 A2 Metering Data

6.3.1 Current Metering

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷ CURRENT METERING

■ CURRENT [▷]	A: 0 B: 0 C: 0 Amps	*Range: 0 to 999999 A*
MESSAGE	a: 0 b: 0 c: 0 Neut.Amps	*Range: 0 to 999999 A*
MESSAGE	a: 0 b: 0 c: 0 Diff.Amps	*Range: 0 to 999999 A*
MESSAGE	AVERAGE PHASE CURRENT: 0 Amps	*Range: 0 to 999999 A*
MESSAGE	GENERATOR LOAD: 0% FLA	*Range: 0 to 2000% FLA*
MESSAGE	NEGATIVE SEQUENCE CURRENT: 0% FLA	*Range: 0 to 2000% FLA*
MESSAGE	PHASE A CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	PHASE B CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	PHASE C CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	NEUT. END A CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	NEUT. END B CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	NEUT. END C CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	DIFF. A CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	DIFF. B CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	DIFF. C CURRENT: 0 A 0° Lag	*Range: 0 to 999999 A, 0 to 359°*
MESSAGE	GROUND CURRENT: 0.0 A 0° Lag	*Range: 0.0 to 200000.0 A, 0 to 359°. Seen only if 1 A or 5 A Ground CT is used*
MESSAGE	GROUND CURRENT: 0.00 A 0° Lag	*Range: 0.00 to 100.00 A, 0 to 359°. Seen only if 50:0.025 CT is used*

All measured current values are displayed here. **A, B, C AMPS** represent the output side CT measurements: **A, B, C NEUT. AMPS** the neutral end CT measurements, and **A, B, C DIFF. AMPS** the differential operating current calculated as the vector difference between the output side and the neutral end CT measurements on a per phase basis. The 489 negative-sequence current is defined as the ratio of negative-sequence current to generator rated FLA, I_2 / FLA $\times$ 100%. The generator full load amps is calculated as: generator rated MVA / ($\sqrt{3}$ $\times$ generator phase-to-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), the IA output current is used as the zero angle reference vector.

6.3.2 Voltage Metering

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ VOLTAGE METERING

■ VOLTAGE [▷]	Vab: 0 Vbc: 0 Vca: 0 Volts	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "None".*
MESSAGE	AVERAGE LINE VOLTAGE: 0 Volts	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "None".*
MESSAGE	Van: 0 Vbn: 0 Vcn: 0 Volts	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "Wye".*
MESSAGE	AVERAGE PHASE VOLTAGE: 0 Volts	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "Wye".*
MESSAGE	LINE A-B VOLTAGE: 0 V 0° Lag	*Range: 0 to 50000 V, 0 to 359°. Not seen if* **VT CONNECTION** *is "None".*
MESSAGE	LINE B-C VOLTAGE: 0 V 0° Lag	*Range: as above*
MESSAGE	LINE C-A VOLTAGE: 0 V 0° Lag	*Range: as above*
MESSAGE	PHASE A-N VOLTAGE: 0 V 0° Lag	*Range: 0 to 50000 V, 0 to 359°. Not seen if* **VT CONNECTION** *is "Wye".*
MESSAGE	PHASE B-N VOLTAGE: 0 V 0° Lag	*Range: as above*
MESSAGE	PHASE C-N VOLTAGE: 0 V 0° Lag	*Range: as above*
MESSAGE	PER UNIT MEASUREMENT OF V/Hz: 0.00	*Range: 0.00 to 2.00. Not seen if* **VT CONNECTION** *is "None".*
MESSAGE	FREQUENCY: 0.00 Hz	*Range: 0.00 to 90.00 Hz. Not seen if* **VT CONNECTION** *is "None".*
MESSAGE	NEUTRAL VOLTAGE FUND: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*

	MESSAGE	NEUTRAL VOLTAGE 3rd HARM: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*
	MESSAGE	TERMINAL VOLTAGE 3rd HARM: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if* **VT CONNECTION** *is "Wye".*
	MESSAGE	IMPEDANCE Vab / Iab 0.0 Ω sec. 0°	*Range: 0.0 to 6553.5 Ωsec., 0 to 359°*

Measured voltage parameters will be displayed here. The V/Hz measurement is a per unit value based on Vab voltage/measured frequency divided by generator phase-to-phase nominal voltage/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 **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.3.3 Power Metering

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ POWER METERING

■ POWER [▷] METERING		POWER FACTOR: 0.00	*Range: 0.01 to 0.99 Lead or Lag, 0.00, 1.00*
	MESSAGE	REAL POWER: 0.000 MW	*Range: 0.000 to ±2000.000 MW*
	MESSAGE	REACTIVE POWER: 0.000 Mvar	*Range: 0.000 to ±2000.000 Mvar*
	MESSAGE	APPARENT POWER: 0.000 MVA	*Range: 0.000 to 2000.000 MVA*
	MESSAGE	POSITIVE WATTHOURS: 0.000 MWh	*Range: 0.000 to 4000000.000 MWh*
	MESSAGE	POSITIVE VARHOURS: 0.000 Mvarh	*Range: 0.000 to 4000000.000 Mvarh*
	MESSAGE	NEGATIVE VARHOURS: 0.000 Mvarh	*Range: 0.000 to 4000000.000 Mvarh*

The values for power metering appear here. Three-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 (+W and –vars). A synchronous generator can also generate vars (+vars).

If the **VT CONNECTION TYPE** is programmed as "None", the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.3.4 Temperature

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ TEMPERATURE

■ TEMPERATURE [▷]	HOTTEST STATOR RTD RTD#1: 40°C	*Range: –50 to 250°C, No RTD Seen only if at least 1 RTD programmed as Stator*
MESSAGE	RTD #1 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #2 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #3 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #4 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #5 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #6 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #7 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #8 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #9 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #10 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #11 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*
MESSAGE	RTD #12 TEMPERATURE: 40°C	*Range: –50 to 250°C, No RTD (open) --- (shorted)*

NOTE

These messages are seen only if the corresponding RTDs are programmed. The actual messages reflect the RTD Names as programmed.

The current level of the 12 RTDs will be displayed here. If the RTD is not connected, the value will be "No RTD". If the RTD is shorted, then "---" will be displayed. If no RTDs are programmed in the S7 RTD TEMPERATURE setpoints menu, the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.3.5 Demand Metering

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ DEMAND METERING

■ DEMAND METERING [▷]		CURRENT DEMAND: 0 Amps	Range: 0 to 999999 A
	MESSAGE	MW DEMAND: 0.000 MW	Range: 0 to 2000.000 MW. Not seen if VT CONNECTION TYPE is None
	MESSAGE	Mvar DEMAND: 0.000 Mvar	Range: 0 to 2000.000 Mvar. Not seen if VT CONNECTION TYPE is None
	MESSAGE	MVA DEMAND: 0.000 MVA	Range: 0 to 2000.000 MVA. Not seen if VT CONNECTION TYPE is None
	MESSAGE	PEAK CURRENT DEMAND: 0 Amps	Range: 0 to 999999 A
	MESSAGE	PEAK MW DEMAND: 0.000 MW	Range: 0 to 2000.000 MW. Not seen if VT CONNECTION TYPE is None
	MESSAGE	PEAK Mvar DEMAND: 0.000 Mvar	Range: 0 to 2000.000 Mvar. Not seen if VT CONNECTION TYPE is None
	MESSAGE	PEAK MVA DEMAND: 0.000 MVA	Range: 0 to 2000.000 MVA. Not seen if VT CONNECTION TYPE is None

The values for current and power demand are shown here. This peak demand information can be cleared using the S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR PEAK DEMAND setpoint. 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.

6.3.6 Analog Inputs

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ ANALOG INPUTS

■ ANALOG INPUTS [▷]		ANALOG I/P 1 0 Units	Range: –50000 to 50000.
	MESSAGE	ANALOG I/P 2 0 Units	Range: –50000 to 50000.
	MESSAGE	ANALOG I/P 3 0 Units	Range: –50000 to 50000.
	MESSAGE	ANALOG I/P 4 0 Units	Range: –50000 to 50000.

NOTE

These messages are seen only if the corresponding Analog Inputs are programmed. The actual messages reflect the Analog Input Names as programmed.

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 the S11 ANALOG I/O setpoints page, the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.3.7 Speed

PATH: ACTUAL VALUES ▷▽ A2 METERING DATA ▷▽ SPEED

■ SPEED [▷]	TACHOMETER: 0 RPM	*Range: 0 to 7200 RPM*

If the Tachometer function is assigned to one of the digital inputs, its speed be viewed here. If no digital input is configured for tachometer, the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.4 A3 Learned Data

6.4.1 Parameter Averages

PATH: ACTUAL VALUES ▷▽ A3 LEARNED DATA ▷ PARAMETER AVERAGES

■ PARAMETER AVERAGES [▷]	AVERAGE GENERATOR LOAD: 100% FLA	*Range: 0 to 2000% FLA*
MESSAGE	AVERAGE NEG. SEQ. CURRENT: 0% FLA	*Range: 0 to 2000% FLA*
MESSAGE	AVERAGE PHASE-PHASE VOLTAGE: 0 V	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "None"*

The 489 calculates the average magnitude of several parameters over a period of time. This time is specified by **S1 489 SETUP ▷▽ PREFERENCES ▷▽ PARAMETER AVERAGES CALC. PERIOD** setpoint (default 15 minutes). The calculation is a sliding window and is ignored when the generator is offline (that is, 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.

6.4.2 RTD Maximums

PATH: ACTUAL VALUES ▷▽ A3 LEARNED DATA ▷▽ RTD MAXIMUMS

■ RTD [▷]	RTD #1 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #2 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #3 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #4 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #5 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #6 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #7 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #8 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #9 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #10 MAX. TEMP.: 40°C	*Range: –50 to 250°C*

MESSAGE	RTD #11 MAX. TEMP.: 40°C	*Range: –50 to 250°C*
MESSAGE	RTD #12 MAX. TEMP.: 40°C	*Range: –50 to 250°C*

NOTE

These messages are seen only if the corresponding RTDs are programmed. The actual messages reflect the RTD Names as programmed.

The 489 will learn the maximum temperature for each RTD. This information can be cleared using the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR RTD MAXIMUMS** setpoint. The RTD maximums will not update if a digital input programmed as Test Input is shorted. If no RTDs are programmed in the **S7 RTD TEMPERATURE** setpoints page, the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.4.3 Analog Input Min/Max

PATH: ACTUAL VALUES ▷▽ A3 LEARNED DATA ▷▽ ANALOG INPUT MIN/MAX

■ ANALOG INPUT [▷] MIN/MAX	ANALOG I/P 1 MIN: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 1 MAX: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 2 MIN: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 2 MAX: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 3 MIN: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 3 MAX: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 4 MIN: 0 Units	*Range: –50000 to 50000*
MESSAGE	ANALOG I/P 4 MAX: 0 Units	*Range: –50000 to 50000*

NOTE

These messages are seen only if the corresponding Analog Inputs are programmed. The actual messages reflect the Analog Input Names as programmed.

The 489 learns the minimum and maximum values of the analog inputs since they were last cleared. This information can be cleared using the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR ANALOG I/P MIN/MAX** setpoint. 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 the **S11 ANALOG I/O** setpoints menu, the **THIS FEATURE NOT PROGRAMMED** flash message will appear when an attempt is made to enter this group of messages.

6.5 A4 Maintenance

6.5.1 Trip Counters

PATH: ACTUAL VALUES ▷▽ A4 MAINTENANCE ▷ TRIP COUNTERS

■ TRIP [▷]		TOTAL NUMBER OF TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	DIGITAL INPUT TRIPS: 0	*Range: 0 to 50000. Caused by the General Input Trip feature*
	MESSAGE	SEQUENTIAL TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	FIELD-BKR DISCREP. TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	TACHOMETER TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	OFFLINE OVERCURRENT TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	PHASE OVERCURRENT TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	NEG. SEQ. OVERCURRENT TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	GROUND OVERCURRENT TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	PHASE DIFFERENTIAL TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	GROUND DIRECTIONAL TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	HIGH-SET PHASE O/C TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	UNDERVOLTAGE TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	OVERVOLTAGE TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	VOLTS/HERTZ TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	PHASE REVERSAL TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	UNDERFREQUENCY TRIPS: 0	*Range: 0 to 50000*
	MESSAGE	OVERFREQUENCY TRIPS: 0	*Range: 0 to 50000*

MESSAGE	NEUTRAL O/V (Fund) TRIPS: 0	*Range: 0 to 50000*
MESSAGE	NEUTRAL U/V (3rd) TRIPS: 0	*Range: 0 to 50000*
MESSAGE	LOSS OF EXCITATION 1 TRIPS: 0	*Range: 0 to 50000*
MESSAGE	LOSS OF EXCITATION 2 TRIPS: 0	*Range: 0 to 50000*
MESSAGE	DISTANCE ZONE 1 TRIPS: 0	*Range: 0 to 50000*
MESSAGE	DISTANCE ZONE 2 TRIPS: 0	*Range: 0 to 50000*
MESSAGE	REACTIVE POWER TRIPS: 0	*Range: 0 to 50000*
MESSAGE	REVERSE POWER TRIPS: 0	*Range: 0 to 50000*
MESSAGE	LOW FORWARD POWER TRIPS: 0	*Range: 0 to 50000*
MESSAGE	STATOR RTD TRIPS: 0	*Range: 0 to 50000*
MESSAGE	BEARING RTD TRIPS: 0	*Range: 0 to 50000*
MESSAGE	OTHER RTD TRIPS: 0	*Range: 0 to 50000*
MESSAGE	AMBIENT RTD TRIPS: 0	*Range: 0 to 50000*
MESSAGE	THERMAL MODEL TRIPS: 0	*Range: 0 to 50000*
MESSAGE	INADVERTENT ENERG. TRIPS: 0	*Range: 0 to 50000*
MESSAGE	ANALOG I/P 1 TRIPS: 0	*Range: 0 to 50000. Reflects Analog In Name/units as programmed*
MESSAGE	ANALOG I/P 2 TRIPS: 0	*Range: 0 to 50000. Reflects Analog In Name/units as programmed*
MESSAGE	ANALOG I/P 3 TRIPS: 0	*Range: 0 to 50000. Reflects Analog In Name/units as programmed*
MESSAGE	ANALOG I/P 4 TRIPS: 0	*Range: 0 to 50000. Reflects Analog In Name/units as programmed*
MESSAGE	COUNTERS CLEARED: Jan 1, 1995	*Range: Date in format shown*

The number of trips by type is displayed here. When the total reaches 50000, all counters reset. This information can be cleared with the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR TRIP COUNTERS** setpoint. 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.

6.5.2 General Counters

PATH: ACTUAL VALUES ▷▽ A4 MAINTENANCE ▷▽ GENERAL COUNTERS

■ GENERAL [▷] COUNTERS	NUMBER OF BREAKER OPERATIONS: 0	*Range: 0 to 50000*
MESSAGE	NUMBER OF THERMAL RESETS: 0	*Range: 0 to 50000. Seen only if a Digital Input is assigned to Thermal Reset.*

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 exceeds 50000, that counter will reset to 0.

The **NUMBER OF BREAKER OPERATIONS** counter can also be cleared using the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR BREAKER INFORMATION** setpoint. The **NUMBER OF THERMAL RESETS** counter can be cleared using the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR GENERATOR INFORMATION** setpoint.

The number of breaker operations will not update if a digital input programmed as Test Input is shorted.

6.5.3 Timers

PATH: ACTUAL VALUES ▷▽ A4 MAINTENANCE ▷▽ TIMERS

■ TIMERS [▷]	GENERATOR HOURS ONLINE: 0 h	*Range: 1 to 1000000 hrs.*

The 489 accumulates the total online time for the generator. This may be useful for scheduling routine maintenance. When this timer exceeds 1000000, it resets to 0. This timer can be cleared using the **S1 489 SETUP ▷▽ CLEAR DATA ▷▽ CLEAR GENERATOR INFORMATION** setpoint. The generator hours online will not update if a digital input programmed as Test Input is shorted.

6.6 A5 Event Recorder

6.6.1 Event Recorder

PATH: ACTUAL VALUES ▷▽ A5 EVENT RECORDER ▷▽ E001(E256)

■ E001 [▷] <Cause>		TIME OF E001: 00:00:00.0	*Range: hour: minutes: seconds*
	MESSAGE	DATE OF E001: Jan. 01, 1992	*Range: month day, year*
	MESSAGE	ACTIVE GROUP E001: 1	*Range: 1, 2*
	MESSAGE	TACHOMETER E001: 3600 RPM	*Range: 0 to 3600 RPM. Seen only if a Digital Input set as Tachometer*
	MESSAGE	A: 0 B: 0 C: 0 A E001	*Range: 0 to 999999 A*
	MESSAGE	a: 0 b: 0 c: 0 NA E001	*Range: 0 to 999999 NA. Represents neutral end current.*
	MESSAGE	NEG. SEQ. CURRENT E001: 0% FLA	*Range: 0 to 2000% FLA*
	MESSAGE	GROUND CURRENT E001: 0.00 A	*Range: 0 to 20000.0 A. Not seen if* **GROUND CT TYPE** *is "None".*
	MESSAGE	Vab: 0 Vbc: 0 Vca: 0 V E001	*Range: 0 to 50000 V. Not seen if* **VT CONNECTION** *is "None".*
	MESSAGE	FREQUENCY E001: 0.00 Hz	*Range: 0.00 to 90.00 Hz. Not seen if* **VT CONNECTION** *is "None".*
	MESSAGE	NEUTRAL VOLT (FUND) E001: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*
	MESSAGE	NEUTRAL VOLT (3rd) E001: 0.0 V	*Range: 0.0 to 25000.0 V. Seen only if there is a neutral VT.*
	MESSAGE	Vab/Iab E001: 0.0 Ωsec. 0°	*Range: 0.0 to 6553.5 Ωsec., 0 to 359°. Seen only if the Loss of Excitation element is Enabled.*
	MESSAGE	REAL POWER (MW) E001: 0.000	*Range: 0 to ±2000.000 MW. Not seen if* **VT CONNECTION** *is "None"*
	MESSAGE	REACTIVE POWER Mvar E001: 0.000	*Range: 0 to ±2000.000 Mvar. Not seen if* **VT CONNECTION** *is "None"*
	MESSAGE	APPARENT POWER MVA E001: 0.000	*Range: 0 to 2000.000 MVA. Not seen if* **VT CONNECTION** *is "None"*
	MESSAGE	HOTTEST STATOR RTD#1: 0°C E001	*Range: –50 to +250°C. Seen only if 1 or more RTDs are set as Stator.*
	MESSAGE	HOTTEST BEARING RTD#7: 0°C E001	*Range: –50 to +250°C. Seen only if 1 or more RTDs are set as Bearing.*

MESSAGE	HOTTEST OTHER RTD#11: 0°C E001	*Range: –50 to +250°C. Seen only if 1 or more RTDs are set as Other.*
MESSAGE	AMBIENT RTD#12 0°C E001	*Range: –50 to +250°C. Seen only if 1 or more RTDs are set as Ambient.*
MESSAGE	ANALOG INPUT 1 E001: 0.0 Units	*Range: –50000 to 50000. Reflects the Analog Input name. Not seen if Analog Input 1 is disabled.*
MESSAGE	ANALOG INPUT 2 E001: 0.0 Units	*Range: –50000 to 50000. Reflects the Analog Input name. Not seen if Analog Input 2 is disabled.*
MESSAGE	ANALOG INPUT 3 E001: 0.0 Units	*Range: –50000 to 50000. Reflects the Analog Input name. Not seen if Analog Input 3 is disabled.*
MESSAGE	ANALOG INPUT 4 E001: 0.0 Units	*Range: –50000 to 50000. Reflects the Analog Input name. Not seen if Analog Input 4 is disabled.*

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.

NOTE

The event recorder data may be inaccurate if 489 relay power-on time is less than 2 seconds.

The date and time stamping feature 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.

E001 is the most recent event and **E256** is the oldest event. Each new event bumps the other event records down until the 256th event is reached. The 256th event record is lost when the next event occurs. This information can be cleared using **S1 489 SETUP** ▷▽ **CLEAR DATA** ▷▽ **CLEAR EVENT RECORD** setpoint. The event record will not update if a digital input programmed as Test Input is shorted.

Table 6–1: Cause of Events (Sheet 1 of 2)

TRIPS			
Ambient RTD12 Trip *	Analog I/P 1 to 4 Trip *	Bearing RTD 7 Trip *	Bearing RTD 8 Trip *
Bearing RTD 9 Trip *	Bearing RTD 10 Trip *	Differential Trip	Distance Zone 1 Trip
Distance Zone 2 Trip	Field-Bkr Discr. Trip	Gnd Directional Trip	Ground O/C Trip
Hiset Phase O/C Trip	Inadvertent Energization Trip	Input A to G Trip *	Loss of Excitation 1
Loss of Excitation 2	Low Fwd Power Trip	Neg Seq O/C Trip	Neutral O/V Trip
Neut. U/V (3rd) Trip	Offline O/C Trip	Overfrequency Trip	Overvoltage Trip

* reflects the name as programmed

Table 6–1: Cause of Events (Sheet 2 of 2)

TRIPS			
Phase O/C Trip	Phase Reversal Trip	Reactive Power Trip	Reverse Power Trip
RTD11 Trip *	Sequential Trip	Stator RTD 1 Trip *	Stator RTD 2 Trip *
Stator RTD 3 Trip *	Stator RTD 4 Trip *	Stator RTD 5 Trip *	Stator RTD 6 Trip *
Tachometer Trip	Thermal Model Trip	Underfrequency Trip	Undervoltage Trip
Volts/Hertz Trip			

ALARMS (OPTIONAL EVENTS)			
489 Not Inserted	Ambient RTD12 Alarm *	Analog I/P 1 to 4 Alarm *	Bearing RTD 7 Alarm *
Bearing RTD 8 Alarm *	Bearing RTD 9 Alarm *	Bearing RTD 10 Alarm *	Breaker Failure
Current Demand Alarm	Gnd Directional Alarm	Ground O/C Alarm	Input A to G Alarm *
Low Fwd Power Alarm	MVA Demand Alarm	Mvar Demand Alarm	MW Demand Alarm
NegSeq Current Alarm	Neut. U/V 3rd Alarm	Neutral O/V Alarm	Open RTD Alarm
Overcurrent Alarm	Overfrequency Alarm	Overvoltage Alarm	Reactive Power Alarm
Reverse Power Alarm	RTD11 Alarm *	Service Alarm	Short/Low RTD Alarm
Stator RTD 1 Alarm	Stator RTD 2 Alarm	Stator RTD 3 Alarm	Stator RTD 4 Alarm
Stator RTD 5 Alarm	Stator RTD 6 Alarm	Tachometer Alarm	Thermal Model Alarm
Trip Coil Monitor	Trip Counter Alarm	Underfrequency Alarm	Undervoltage Alarm
Volts Per Hertz Alarm	VT Fuse Fail Alarm		

OTHER			
Control Power Applied	Control Power Lost	Dig I/P Waveform Trig	Input A to G Control *
Serial Comm. Start	Serial Comm. Stop	Serial Waveform Trip	Setpoint 1 Active
Setpoint 2 Active	Simulation Started	Simulation Stopped	Thermal Reset Close

* reflects the name as programmed

6.7 A6 Product Information

6.7.1 489 Model Info

PATH: ACTUAL VALUES ▷▽ A6 PRODUCT INFO ▷ 489 MODEL INFO

■ 489 MODEL [▷] INFORMATION		ORDER CODE: 489-P5-HI-A20	*Range: N/A*
	MESSAGE	489 SERIAL NO: A3260001	*Range: N/A*
	MESSAGE	489 REVISION: 32E100A4.000	*Range: N/A*
	MESSAGE	489 BOOT REVISION: 30K401A0.000	*Range: N/A*

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.

6.7.2 Calibration Info

PATH: ACTUAL VALUES ▷▽ A6 PRODUCT INFO ▷▽ CALIBRATION INFO

■ CALIBRATION [▷] INFORMATION		ORIGINAL CALIBRATION DATE: Jan 01 1996	*Range: month day year*
	MESSAGE	LAST CALIBRATION DATE: Jan 01 1996	*Range: month day year*

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

6.8 Diagnostics

6.8.1 Diagnostic Messages

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 MESSAGE ▶ key. When the MESSAGE ▶ 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 MESSAGE ▶ key will cause the 489 to revert back to the normal default messages. When normal default messages are being displayed, pressing the MESSAGE ▶ key 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 **A1 STATUS** ▷▽ **LAST TRIP DATA** queue and the Message LED would flash. Pressing the MESSAGE ▶ key cycles 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 MESSAGE ▶ 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 **A1 STATUS** ▷▽ **ALARM STATUS** queue. Finally, another press of the MESSAGE ▶ key will cause the 489 to return to the original **CAUSE OF LAST TRIP** message, and the cycle could be repeated.

LAST TRIP DATA:

```
CAUSE OF LAST TRIP:
Overload
```

```
TIME OF LAST TRIP:
12:00:00.0
```

```
DATE OF LAST TRIP
Jan 01 2002
```

↓
↓
↓

```
ANALOG INPUT 4
PreTrip: 0 Units
```

ACTIVE ALARMS:	STATOR RTD #1 ALARM: 135°C
START BLOCK LOCKOUTS:	OVERLOAD LOCKOUT BLOCK: 25 min

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.

6.8.2 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 6–2: Flash Messages

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

- **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, an entered setpoint value may fall between valid setpoint values. The 489 detects this condition and store a value rounded to the nearest valid setpoint value. To find the valid range and step for a given setpoint, press the HELP key while the setpoint is being displayed.
- **OUT OF RANGE! ENTER: #### TO ##### BY #:** If a setpoint value outside the acceptable range of values is entered, the 489 displays this message and substitutes proper values for that setpoint. An appropriate value may then be entered.

- **ACCESS DENIED, SHORT ACCESS SWITCH:** The Access Switch must be shorted to store any setpoint values. If this message appears and it is necessary to change a setpoint, short the Access terminals C1 and C2.
- **ACCESS DENIED, ENTER PASSCODE:** The 489 has a passcode security feature. If this feature is enabled, not only must the Access Switch terminals be shorted, but a valid 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 the S1 489 SETUP ▷ PASSCODE setpoints menu.
- **INVALID PASSCODE ENTERED:** This flash message appears if an invalid passcode is entered for the passcode security feature.
- **NEW PASSCODE HAS BEEN ACCEPTED:** This message will appear as an acknowledge that the new passcode has been accepted when changing the passcode for the passcode security feature.
- **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 results in this flash message, prompting the user to enter "0" as the passcode. When this has been done, the feature may be enabled by entering a non-zero passcode.
- **ENTER A NEW PASSCODE FOR ACCESS:** The passcode security feature is disabled if the passcode is zero. If the CHANGE PASSCODE SETPOINT is entered as yes, this flash message appears prompting the user to enter a non-zero passcode and enable the passcode security feature.
- **SETPOINT ACCESS IS NOW PERMITTED:** Any time the passcode security feature is enabled and a valid passcode is entered, this flash message appears to notify that setpoints may now be altered and stored.
- **SETPOINT ACCESS IS NOW RESTRICTED:** If the passcode security feature is enabled and a valid passcode entered, this message appears when the S1 489 SETUP ▷ PASSCODE ▷▽ SETPOINT ACCESS setpoint is altered to "Restricted". This message also appears any time that setpoint access is permitted and the access jumper is removed.
- **DATE ENTRY WAS NOT COMPLETE:** Since the DATE setpoint has a special format (entered as MM/DD/YYYY), this message appears and the new value will not be stored if the ENTER key is pressed before *all* of the information has been entered. Another attempt will have to be made with the complete information.
- **DATE ENTRY WAS OUT OF RANGE:** Appears if an invalid entry is made for the DATE (for example, 15 entered for the month).
- **TIME ENTRY WAS NOT COMPLETE:** Since the TIME setpoint has a special format (entered as HH/MM/SS.s), this message appears and the new value will not be stored if the ENTER key is pressed before *all* of the information has been entered. Another attempt will have to be made with the complete information.
- **TIME ENTRY WAS OUT OF RANGE:** Appears if an invalid entry is made for the TIME (for example, 35 entered for the hour).
- **NO TRIPS OR ALARMS TO RESET:** Appears if the RESET key is pressed when there are no trips or alarms present.
- **RESET PERFORMED SUCCESSFULLY:** If all trip and alarm features that are active can be cleared (that is, the conditions that caused these trips and/or alarms are no longer

present), then this message appears 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 (that is, the conditions that caused some of these trips and/or alarms are still present), then this message appears when a reset is performed, indicating that only trips and alarms that could be reset have been reset.
- **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 appears to verify the operation. If RESET is pressed again while this message is displayed, the reset will be performed.
- **PRESS [ENTER] TO ADD DEFAULT MESSAGE:** Appears if the decimal [.] key, immediately followed by the ENTER key, is entered anywhere in the actual value message structure. This message prompts 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:** Appears anytime a new default message is added to the default message list.
- **DEFAULT MESSAGE LIST IS FULL:** Appears if an attempt is made to add a new default message to the default message list when 20 messages are already assigned. To add a new message, one of the existing messages must be removed.
- **PRESS [ENTER] TO REMOVE MESSAGE:** Appears if the decimal [.] key, immediately followed by the ENTER key, is entered in the S1 489 SETUP ▷▽ DEFAULT MESSAGES setpoint page. This message prompts 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:** Appears anytime a default message is removed from the default message list.
- **DEFAULT MESSAGES 6 of 20 ARE ASSIGNED:** Appears anytime the S1 489 SETUP ▷▽ DEFAULT MESSAGES setpoint page is entered, notifying the user of the number of default messages assigned.
- **INVALID SERVICE CODE ENTERED:** Appears if an invalid code is entered in the S12 489 TESTING ▷▽ FACTORY SERVICE setpoints page.
- **KEY PRESSED HERE IS INVALID:** Under certain situations, certain keys have no function (for example, any number key while viewing actual values). This message appears if a keypress has no current function.
- **DATA CLEARED SUCCESSFULLY:** Confirms that data is reset in the S1 489 SETUP ▷▽ CLEAR DATA setpoints page.
- **[.] KEY IS USED TO ADVANCE THE CURSOR:** Appears immediately to prompt the use of the [.] key for cursor control anytime a setpoint requiring text editing is viewed. If the setpoint is not altered for 1 minute, this message flashes 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.

- **END 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.

Digital Energy
Multilin

489 Generator Management Relay

Chapter 7: Testing

7.1 Test Setup

7.1.1 Description

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 the 489 may be mounted) may be useful for creating a portable test set with a wiring harness for all of the inputs and outputs. Testing of the relay during commissioning using a primary injection test set will ensure that CTs and wiring are correct and complete.

The 489 tests are listed below. For the following tests refer to *Secondary Current Injection Testing* on page 7–3:

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 Accuracy 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
14. For the following tests refer to *Secondary Injection Setup #2* on page 7–15:
15. GE Multilin (HGF) Ground Current Accuracy Test
16. Neutral Voltage (3rd Harmonic) Accuracy Test
17. Phase Differential Trip Test
18. For the following test refer to *Secondary Injection Test Setup #3* on page 7–19:
19. Voltage Restrained Overcurrent Test

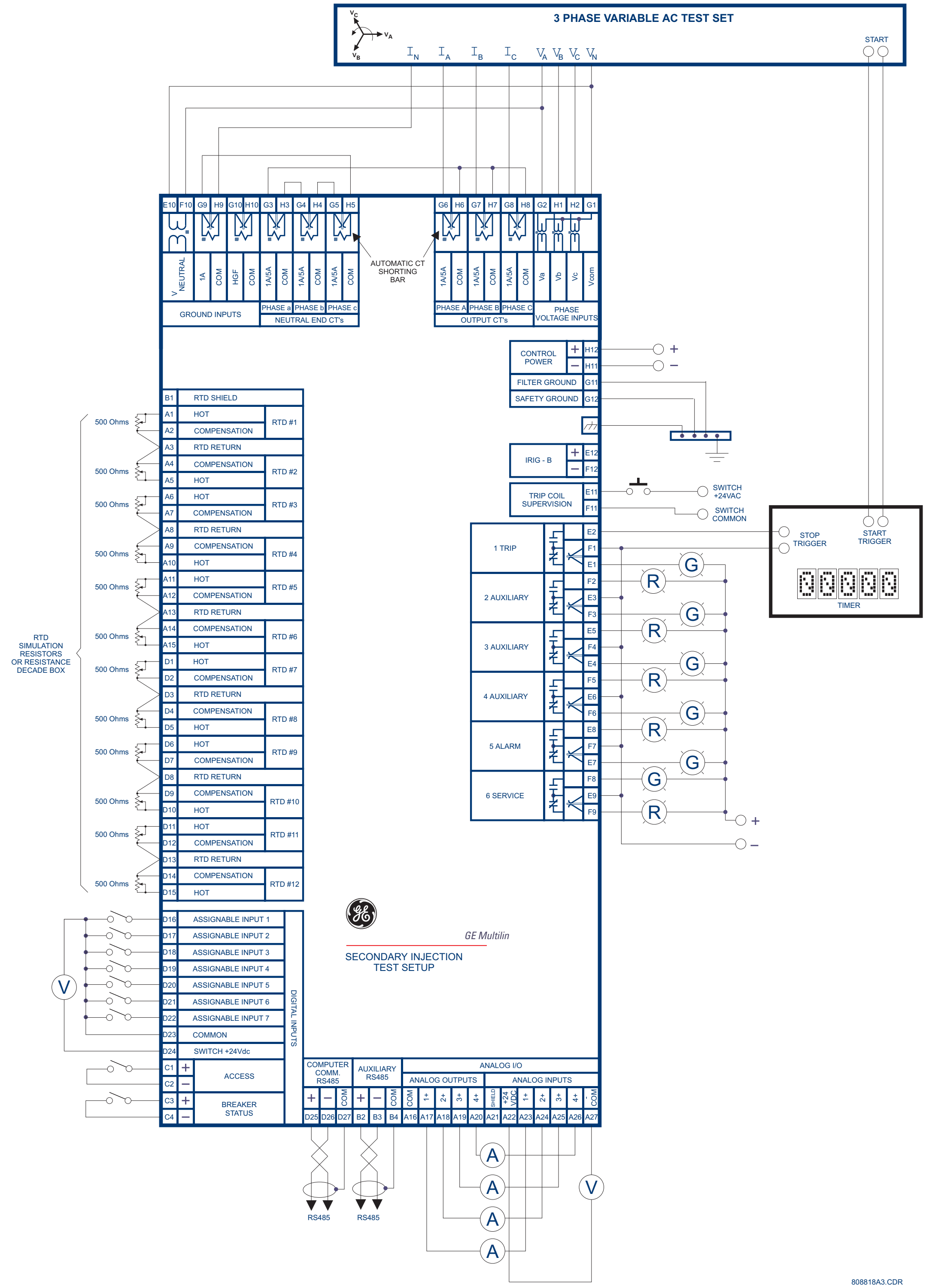


FIGURE 7–1: Secondary Current Injection Testing

7.2 Hardware Functional Tests

7.2.1 Output Current Accuracy

The specification for output and neutral end current input is ±0.5% of 2 × CT when the injected current is less than 2 × CT. Perform the steps below to verify accuracy.

▷ Alter the following setpoint:

S2 SYSTEM SETUP ▷ CURRENT SENSING ▷▽ PHASE CT PRIMARY: "1000 A"

Measured values should be ±10 A.

▷ Inject the values shown in the table below and verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA ▷▽ CURRENT METERING** menu.

Injected Current		Expected Current	Measured Current		
1 A Unit	5 A Unit		Phase A	Phase B	Phase C
0.1 A	0.5 A	100 A			
0.2 A	1.0 A	200 A			
0.5 A	2.5 A	500 A			
1 A	5 A	1000 A			
1.5 A	7.5 A	1500 A			
2 A	10 A	2000 A			

7.2.2 Phase Voltage Input Accuracy

The specification for phase voltage input accuracy is ±0.5% of full scale (200 V). Perform the steps below to verify accuracy.

▷ Alter the following setpoints in the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu:

VT CONNECTION TYPE: "Wye"
VOLTAGE TRANSFORMER RATIO: "10.00:1"

Measured values should be ±1.0 V.

▷ Apply the voltage values shown in the table and verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA ▷▽ VOLTAGE METERING** menu.

Applied Line-Neutral Voltage	Expected Voltage Reading	Measured Voltage		
		A-N	B-N	C-N
30 V	300 V			
50 V	500 V			
100 V	1000 V			
150 V	1500 V			

Applied Line-Neutral Voltage	Expected Voltage Reading	Measured Voltage		
		A-N	B-N	C-N
200 V	2000 V			

7.2.3 Ground (1 A), Neutral, and Differential Current Accuracy

The specification for neutral, differential and 1 A ground current input accuracy is ±0.5% of 2 × CT. Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP** ▷ **CURRENT SENSING** menu, set:

GROUND CT: "1A Secondary"
GROUND CT RATIO: "1000:1"
PHASE CT PRIMARY: "1000 A"

▷ In the **S5 CURRENT ELEMENTS** ▷▽ **PHASE DIFFERENTIAL** menu, set:

PHASE DIFFERENTIAL TRIP: "Unlatched"
DIFFERENTIAL TRIP MIN. PICKUP: "0.1 x CT"

The last two setpoints are needed to view the neutral and the differential current. The trip element will operate when differential current exceeds 100 A.

Measured values should be ±10 A.

▷ 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 the **A2 METERING DATA** ▷ **CURRENT METERING** menu or press the NEXT key to view the current values when differential trip element is active.

Table 7–1: Neutral and Ground Current Test Results

Injected Current 1 A Unit	Expected Current	Measured Ground Current	Measured Neutral Current		
			Phase A	Phase B	Phase C
0.1 A	100 A				
0.2 A	200 A				
0.5 A	500 A				
1 A	1000 A				

Table 7–2: Differential Current Test Results

Injected Current	Expected Current Reading		Measured Differential Current		
	Differential Phase A	Differential Phase B,C	Phase A	Phase B	Phase C
0.1 A	200 A	100 A			
0.2 A	400 A	200 A			
0.5 A	1000 A	500 A			
1 A	2000 A	1000 A			

7.2.4 Neutral Voltage (Fundamental) Accuracy

The specification for neutral voltage (fundamental) accuracy is ±0.5% of full scale (100 V). Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP** ▷▽ **VOLTAGE SENSING** menu, set:

NEUTRAL VOLTAGE TRANSFORMER: "Yes"
NEUTRAL V.T. RATIO: "10.00:1"

▷ In the **S2 SYSTEM SETUP** ▷▽ **GEN. PARAMETERS** menu, set:

GENERATOR NOMINAL FREQUENCY: "60 Hz"

Measured values should be ±5.0 V.

▷ Apply the voltage values shown in the table and verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA** ▷▽ **VOLTAGE METERING** menu.

Applied Neutral Voltage at 60 Hz	Expected Neutral Voltage	Measured Neutral Voltage
10 V	100 V	
30 V	300 V	
50 V	500 V	

7.2.5 Negative Sequence Current Accuracy

The 489 measures negative sequence current as a percent of Full Load Amperes (FLA). A sample calculation of negative sequence current is shown below. Given the following generator parameters:

Rated MVA (P_A) = 1.04
Voltage Phase to Phase (V_{pp}): 600 V

We have:

$$\text{FLA} = \frac{P_A}{\sqrt{3} \times V_{pp}} = \frac{1.04 \times 10^6}{\sqrt{3} \times 600} = 1000\ \text{A} \qquad \textbf{(EQ 7.1)}$$

With the following output currents:

$$I_a = 780\angle 0°, \quad I_b = 1000\angle 113°\ \text{lag}, \quad I_c = 1000\angle 247°\ \text{lag} \qquad \textbf{(EQ 7.2)}$$

The negative-sequence current Ins is calculated as:

$$\begin{aligned} I_{ns} &= \frac{1}{3}(I_a + a^2 I_b + aI_c) \quad \text{where } a = 1\angle 120° = -0.5 + j0.866 \\ &= \frac{1}{3}(780\angle 0° + (1\angle 120°)^2(1000\angle -113°) + (1\angle 120°)(1000\angle 113°)) \\ &= \frac{1}{3}(780\angle 0° + 1000\angle 127° + 1000\angle 233°) \\ &= \frac{1}{3}(780 - 601.8 + j798.6 - 601.8 - j798.6) \\ &= -141.2 \\ \Rightarrow \%I_{ns} &= \frac{I_{ns}}{\text{FLA}} \times 100 = 14\% \end{aligned} \tag{EQ 7.3}$$

Therefore, the negative sequence current is 14% of FLA. The specification for negative-sequence current accuracy is per output current inputs. Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP ▷▽ GEN. PARAMETERS** menu, set:

GENERATOR RATED MVA: "1.04"
VOLTAGE PHASE-PHASE: "600"

Note that setting **VOLTAGE PHASE-PHASE** to "600" is equivalent to setting FLA = 1000 A. This is for testing purposes only!

▷ In the **S2 SYSTEM SETUP ▷ CURRENT SENSING** menu, set:

PHASE CT PRIMARY: "1000 A"

▷ Inject the values shown in the table below and verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA ▷ CURRENT METERING** menu.

Injected Current		Expected Negative Sequence Current	Measured Negative Sequence Current
1 A Unit	5 A Unit		
Ia = 0.78 A ∠0° Ib = 1 A ∠113° lag Ic = 1 A ∠247° lag	Ia = 3.9 A ∠0° Ib = 5 A ∠113° lag Ic = 5 A ∠247° lag	14% FLA	
Ia = 1.56 A ∠0° Ib = 2 A ∠113° lag Ic = 2 A ∠247° lag	Ia = 7.8 A ∠0° Ib = 10 A ∠113° lag Ic = 10 A ∠247° lag	28% FLA	
Ia = 0.39 A ∠0° Ib = 0.5 A ∠113° lag Ic = 0.5 A ∠247° lag	Ia = 1.95 A ∠0° Ib = 2.5 A ∠113° lag Ic = 2.5 A ∠247° lag	7% FLA	

7.2.6 RTD Accuracy

The specification for RTD input accuracy is ±2° for Platinum/Nickel and ±5° for Copper. Perform the steps below.

▷ In the **S8 RTD TEMPERATURE MENU**, set:

RTD TYPE ▷ STATOR RTD TYPE: "100 Ohm Platinum" (select desired type)
RTD #1 ▷ RTD #1 APPLICATION: "Stator" (repeat for RTDs 2 to 12)

Measured values should be ±2°C / ±4°F for platinum/nickel and ±5°C / ±9°F for copper.

▷ Alter the resistance applied to the RTD inputs as shown below to simulate RTDs and verify accuracy.

▷ View the measured values in **A2 METERING DATA ▷▽ TEMPERATURE**.

Applied Resistance 100 Ω Platinum	Expected RTD Temperature Reading		Measured RTD Temperature Select One: ____°C ____°F											
	°C	°F	1	2	3	4	5	6	7	8	9	10	11	12
84.27 Ω	–40°C	–40°F												
100.00 Ω	0°C	32°F												
119.39 Ω	50°C	122°F												
138.50 Ω	100°C	212°F												
157.32 Ω	150°C	302°F												
175.84 Ω	200°C	392°F												
194.08 Ω	250°C	482°F												

Applied Resistance 120 Ω Nickel	Expected RTD Temperature Reading		Measured RTD Temperature Select One: ____°C ____°F											
	°C	°F	1	2	3	4	5	6	7	8	9	10	11	12
92.76 Ω	–40°C	–40°F												
120.00 Ω	0°C	32°F												
157.74 Ω	50°C	122°F												
200.64 Ω	100°C	212°F												
248.95 Ω	150°C	302°F												
303.46 Ω	200°C	392°F												
366.53 Ω	250°C	482°F												

Applied Resistance 100 Ω Nickel	Expected RTD Temperature Reading		Measured RTD Temperature Select One: ____°C ____°F											
	°C	°F	1	2	3	4	5	6	7	8	9	10	11	12
77.30 Ω	–40°C	–40°F												
100.00 Ω	0°C	32°F												
131.45 Ω	50°C	122°F												
167.20 Ω	100°C	212°F												
207.45 Ω	150°C	302°F												
252.88 Ω	200°C	392°F												
305.44 Ω	250°C	482°F												

Applied Resistance 10 Ω Copper	Expected RTD Temperature Reading		Measured RTD Tempeature Select One: ____°C ____°F											
	°C	°F	1	2	3	4	5	6	7	8	9	10	11	12
7.49 Ω	–40°C	–40°F												
9.04 Ω	0°C	32°F												
10.97 Ω	50°C	122°F												
12.90 Ω	100°C	212°F												
14.83 Ω	150°C	302°F												
16.78 Ω	200°C	392°F												

Applied Resistance 10 Ω Copper	Expected RTD Temperature Reading		Measured RTD Tempeature Select One: ____°C ____°F											
	°C	°F	1	2	3	4	5	6	7	8	9	10	11	12
18.73 Ω	250°C	482°F												

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 +24 V DC with a voltmeter. Perform the steps below to verify functionality of the digital inputs.

▷ Open switches of all of the digital inputs and the trip coil supervision circuit.

▷ View the status of the digital inputs and trip coil supervision in the **A1 STATUS ▷▽ DIGITAL INPUTS** menu.

▷ Close switches of all of the digital inputs and the trip coil supervision circuit.

▷ View the status of the digital inputs and trip coil supervision in the **A1 STATUS ▷▽ DIGITAL INPUTS** menu.

Input	Expected Status (Switch Open)	4 Pass 8 Fail	Expected Status (Switch Closed)	4 Pass 8 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	

7.2.8 Analog Inputs and Outputs

The specification for analog input and analog output accuracy is ±1% of full scale. Perform the steps below to verify accuracy. Verify the Analog Input +24 V DC with a voltmeter.

4 to 20 mA Inputs:

▷ In the **S11 ANALOG I/O ▷▽ ANALOG INPUT 1** menu, set:

ANALOG INPUT 1: "4-20 mA"
ANALOG INPUT 1 MINIMUM: "0"
ANALOG INPUT 1 MAXIMUM: "1000" (repeat all for Analog Inputs 2 to 4)

Analog output values should be ±0.2 mA on the ammeter. Measured analog input values should be ±10 units.

▷ Force the analog outputs using the following setpoints from the **S12 TESTING ▷▽ TEST ANALOG OUTPUT** menu:

FORCE ANALOG OUTPUTS FUNCTION: "Enabled"
ANALOG OUTPUT 1 FORCED VALUE: "0%" (enter %, repeat for Outputs 2 to 4)

▷ Verify the ammeter readings and the measured analog input readings.
For the purposes of testing, the analog input is fed in from the analog output (see *Secondary Current Injection Testing* on page 7–3).

▷ View the measured values in the **A2 METERING DATA ▷ ANALOG INPUTS** menu.

Analog Output Force Value	Expected Ammeter Reading	Measured Ammeter Reading (ma)				Expected Analog Input Reading	Measured Analog Input Reading (units)			
		1	2	3	4		1	2	3	4
0%	4 mA					0 units				
25%	8 mA					250 units				
50%	12 mA					500 units				
75%	16 mA					750 units				
100%	20 mA					1000 units				

0 to 1 mA Analog Inputs:

▷ In the **S11 ANALOG I/O ▷▽ ANALOG INPUT 1** menu, set:

ANALOG INPUT 1: "0-1 mA"
ANALOG INPUT 1 MINIMUM: "0"
ANALOG INPUT 1 MAXIMUM: "1000" (repeat for Analog Inputs 2 to 4)

Analog output values should be ±0.01 mA on the ammeter. Measured analog input values should be ±10 units.

▷ Force the analog outputs using the following setpoints in the **S12 TESTING ▷▽ TEST ANALOG OUTPUT** menu:

FORCE ANALOG OUTPUTS FUNCTION: "Enabled"
ANALOG OUTPUT 1 FORCED VALUE: "0%" (enter %, repeat for Outputs 2 to 4)

▷ Verify the ammeter readings as well as the measured analog input readings.

▷ View the measured values in the **A2 METERING DATA ▷▽ ANALOG INPUTS** menu.

Analog Output Force Value	Expected Ammeter Reading	Measured Ammeter Reading (mA)				Expected Analog Input Reading	Measured Analog Input Reading (units)			
		1	2	3	4		1	2	3	4
0%	0 mA					0 units				
25%	0.25 mA					250 units				
50%	0.50 mA					500 units				
75%	0.75 mA					750 units				
100%	1.00 mA					1000 units				

7.2.9 Output Relays

To verify the functionality of the output relays, perform the following steps:

Using the setpoint:

S12 TESTING ▷▽ TEST OUTPUT RELAYS ▷▽ FORCE OPERATION OF RELAYS: "1 Trip"

▷ Select and store values as per the table below, verifying operation

Force Operation Setpoint	Expected Measurement (4 for short)												Actual Measurement (4 for short)											
	1		2		3		4		5		6		1		2		3		4		5		6	
	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc	no	nc
1 Trip	4			4		4		4		4	4													
2 Auxiliary		4	4			4		4		4	4													
3 Auxiliary		4		4	4			4		4	4													
4 Auxiliary		4		4		4	4			4	4													
5 Alarm		4		4		4		4	4		4													
6 Service		4		4		4		4		4		4												
All Relays	4		4		4		4		4			4												
No Relays		4		4		4		4		4	4													

NOTE

The 6 Service relay is failsafe or energized normally. Operating output relay 6 causes it to de-energize.

7.3 Additional Functional Tests

7.3.1 Overload Curve Accuracy

The specification for overload curve timing accuracy is ±100 ms or ±2% of time to trip. Pickup accuracy is as per the current inputs (±0.5% of 2 × CT when the injected current is less than 2 × CT and ±1% of 20 × CT when the injected current is equal to or greater than 2 × CT). Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP** ▷▽ **GEN. PARAMETERS** menu, set:

GENERATOR RATED MVA: "1.04"
GENERATOR VOLTAGE PHASE-PHASE: "600"

Note that setting **GENERATOR VOLTAGE PHASE-PHASE** to "600" is equivalent to setting FLA = 1000 A. For testing purposes ONLY!

▷ In the **S2 SYSTEM SETUP** ▷ **CURRENT SENSING** menu, set:

PHASE CT PRIMARY: "1000"

▷ In the **S9 THERMAL MODEL** ▷ **MODEL SETUP** menu, set:

SELECT CURVE STYLE: "Standard"
OVERLOAD PICKUP LEVEL: "1.10 x FLA"
UNBALANCE BIAS K FACTOR: "0"
HOT/COLD SAFE STALL RATIO: "1.00"
ENABLE RTD BIASING: "No"
STANDARD OVERLOAD CURVE NUMBER: "4"
ENABLE THERMAL MODEL: "Yes"

▷ In the **S9 THERMAL MODEL** ▷ **THERMAL ELEMENTS** menu, set:

THERMAL MODEL TRIP: "Latched" or "Unlatched"

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 the **A2 METERING DATA** ▷ **CURRENT METERING** menu.

The thermal capacity used and estimated time to trip may be viewed in the **A1 STATUS** ▷▽ **GENERATOR STATUS** menu.

Average Phase Current Displayed	Pickup Level	Expected Time to Trip	Tolerance Range	Measured Time to Trip (sec.)
1050 A	1.05 × FLA	never	n/a	
1200 A	1.20 × FLA	795.44 s	779.53 to 811.35 s	
1750 A	1.75 × FLA	169.66 s	166.27 to 173.05 s	
3000 A	3.00 × FLA	43.73 s	42.86 to 44.60 s	
6000 A	6.00 × FLA	9.99 s	9.79 to 10.19 s	
10000 A	10.00 × FLA	5.55 s	5.44 to 5.66 s	

NOTE

$$\text{FLA} = \frac{\text{Generator Rated MVA}}{\sqrt{3} \times \text{Generator Phase-to-Phase Voltage}} \quad \textbf{(EQ 7.4)}$$

7.3.2 Power Measurement Test

The specification for reactive and apparent power is ± 1% of $\sqrt{3} \times 2 \times CT \times VT_{ratio} \times VT_{full\text{-}scale}$ at $I_{avg} < 2 \times CT$. Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP ▷ CURRENT SENSING** menu, set:

PHASE CT PRIMARY: “1000”

▷ In the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu, set:

VT CONNECTION TYPE: “Wye”
VOLTAGE TRANSFORMER RATIO: “10.00:1”

▷ Inject current and apply voltage as per the table below.

▷ Verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA ▷▽ POWER METERING** menu:

Injected Current / Applied Voltage (Ia is the reference vector)		Power Quantity			Power Factor	
1 A UNIT	**5 A UNIT**	**Expected**	**Tolerance**	**Measured**	**Expected**	**Measured**
Ia = 1 A∠0° Ib = 1 A∠120° lag Ic = 1 A∠240° lag Va = 120 V∠342° lag Vb = 120 V∠102° lag Vc = 120 V∠222° lag	Ia = 5 A∠0° Ib = 5 A∠120° lag Ic = 5 A∠240° lag Ia = 120 V∠342° lag Vb = 120 V∠102° lag Vc = 120 V∠222° lag	+3424 kW	3355 to 3493 kW		0.95 lag	
Ia = 1 A∠0° Ib = 1 A∠120° lag Ic = 1 A∠240° lag Va = 120 V∠288° lag Vb = 120 V∠48° lag Vc = 120 V∠168° lag	Ia = 5 A∠0° Ib = 5 A∠120° lag Ic = 5 A∠240° lag Va = 120 V∠288° lag Vb = 120 V∠48° lag Vc = 120 V∠168° lag	+3424 kvar	3355 to 3493 kvar		0.31 lag	

7.3.3 Reactive Power Accuracy

The specification for reactive power is ±1% of $\sqrt{3} \times 2 \times CT \times VT_{ratio} \times VT_{full\ scale}$ at $I_{avg} < 2 \times CT$. Perform the steps below to verify accuracy and trip element.

▷ In the **S2 SYSTEM SETUP ▷ CURRENT SENSING** menu, set:

PHASE CT PRIMARY: “5000”

▷ In the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu, set:

VT CONNECTION TYPE: “Wye”
VOLTAGE TRANSFORMER RATIO: “100:1”

▷ In the **S2 SYSTEM SETUP ▷▽ GEN. PARAMETERS** menu, set

GENERATOR RATED MVA: “100”
GENERATOR RATED POWER FACTOR: “0.85”
GENERATOR VOLTAGE PHASE-PHASE: “12000”

The rated reactive power is $100\sin(\cos^{-1}(0.85)) = \pm 52.7$ Mvar.

▷ Alter the following reactive power setpoints in the **S7 POWER ELEMENTS ▷ REACTIVE POWER** menu:

REACTIVE POWER ALARM: “Unlatched”
ASSIGN ALARM RELAYS(2-5): “---5”
POSTIVE MVAR ALARM LEVEL: “0.6 x Rated”
NEGATIVE MVAR ALARM LEVEL: “0.6 x Rated”
REACTIVE POWER ALARM DELAY: “5 s”
REACTIVE POWER ALARM EVENT: “On”
REACTIVE POWER TRIP: “Unlatched”
ASSIGN TRIP RELAYS(1-4): “1---”
POSTIVE MVAR TRIP LEVEL: “0.75 x Rated”
NEGATIVE MVAR TRIP LEVEL: “0.75 x Rated”
REACTIVE POWER TRIP DELAY: “10 s”

▷ 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 the **A2 METERING DATA ▷ POWER METERING** page.

▷ View the Event Records in the **A5 EVENT RECORD** menu.

Current/Voltage	Mvar			Alarm			Trip		
	Expected	Tolerance	Measured	Expected	Observed	Delay	Expected	Observed	Delay
Vab=120V∠0° Vbc=120V∠120°lag Vca=120V∠240°lag Ian=5 A∠10°lag Ibn=5 A∠130°lag Icn=5 A∠250°lag	18	13 to 23		4		N/A	**8**		N/A
Vab=120V∠0° Vbc=120V∠120°lag Vca=120V∠240°lag Ian=5 A∠340°lag Ibn=5 A∠100°lag Icn=5 A∠220°lag	–35	–40 to –30		4			**8**		N/A
Vab=120V∠0° Vbc=120V∠120°lag Vca=120V∠240°lag Ian=5 A∠330°lag Ibn=5 A∠90°lag Icn=5 A∠210°lag	–52	–57 to –47		4			4		
Vab=120V∠0° Vbc=120V∠120°lag Vca=120V∠240°lag Ian=5 A∠30°lag Ibn=5 A∠150°lag Icn=5 A∠270°lag	52	47 to 57		4			4		

4: Activated, **8**: Not Activated

7.3.4 Voltage Phase Reversal Accuracy

The relay can detect voltage phase rotation and protect against phase reversal. To test the phase reversal element, perform the following steps:

▷ In the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu, set:

VT CONNECTION TYPE: “Wye”

▷ In the **S2 SYSTEM SETUP ▷▽ GEN. PARAMETERS** menu, set:

GENERATOR PHASE SEQUENCE: "ABC"

▷ In the **S3 DIGITAL INPUTS ▷ BREAKER STATUS** menu, set:

BREAKER STATUS: "Breaker Auxiliary a"

▷ In the **S6 VOLTAGE ELEMENTS ▷▽ PHASE REVERSAL** menu, set:

PHASE REVERSAL TRIP: "Unlatched"
ASSIGN TRIP RELAYS: "1---"

▷ Apply voltages as per the table below. Verify the operation on voltage phase reversal

Applied Voltage	Expected Result	Observed Result
Va = 120 V∠0° Vb = 120 V∠120° lag Vc = 120 V∠240° lag	No Trip	
Va = 120 V∠0° Vb = 120 V∠240° lag Vc = 120 V∠120° lag	Phase Reversal Trip	

7.3.5 Injection Test Setup #2

Set up the 489 device as follows for the GE Multilin HGF Ground Accuracy Test, Neutral Voltage (3rd Harmonic) Accuracy Test, and the Phase Differential Trip Test.

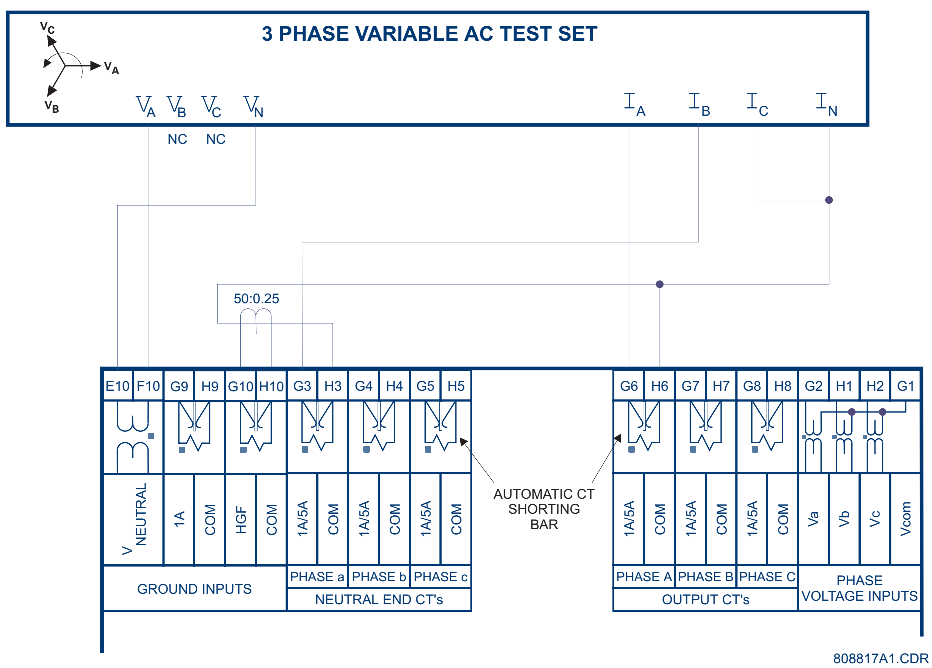


FIGURE 7–2: Secondary Injection Setup #2

7.3.6 GE Multilin 50:0.025 Ground Accuracy

The specification for GE Multilin HGF 50:0.025 ground current input accuracy is ±0.5% of 2 × CT rated primary (25 A). Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP ▷ CURRENT SENSING** menu, set:

GROUND CT: “50:0.025 CT”

Measured values should be ±0.25 A.

▷ Inject the values shown in the table below either as primary values into a GE Multilin 50:0.025 Core Balance CT or as secondary values that simulate the core balance CT.

▷ Verify accuracy of the measured values in the **A2 METERING DATA ▷ CURRENT METERING** menu.

Injected Current		Current Reading	
Primary 50:0.025 CT	**Secondary**	**Expected**	**Measured**
0.25 A	0.125 mA	0.25 A	
1 A	0.5 mA	1.00 A	
5 A	2.5 mA	5.00 A	
10 A	5 mA	10.00 A	

7.3.7 Neutral Voltage (3rd Harmonic) Accuracy

The 489 specification for neutral voltage (3rd harmonic) accuracy is ±0.5% of full scale (100 V). Perform the steps below to verify accuracy.

▷ In the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu, set

NEUTRAL VOLTAGE TRANSFORMER: “Yes”
NEUTRAL V.T. RATIO: “10.00:1”

▷ In the **S2 SYSTEM SETUP ▷▽ GEN. PARAMETERS** menu, set:

GENERATOR NOMINAL FREQUENCY: “60 Hz”

Measured values should be ±5.0 V.

▷ Apply the voltage values shown in the table and verify accuracy of the measured values.

▷ View the measured values in the **A2 METERING DATA ▷▽ VOLTAGE METERING** menu.

Applied Neutral Voltage at 180 Hz	Expected Neutral Voltage	Measured Neutral Voltage
10 V	100 V	
30 V	300 V	
50 V	500 V	

7.3.8 Phase Differential Trip Accuracy

NOTE

These tests will require a dual channel current source. The unit must be capable of injecting prefault currents and fault currents of a different value. Application of excessive currents (greater than 3 × CT) for extended periods will cause damage to the relay.

Minimum Pickup Check

- ▷ Connect the relay test set to inject Channel X current (I_X) into the G3 terminal and out of H3 terminal (Phase A). Increase I_X until the differential element picks up.
- ▷ Record this value as pickup.
- ▷ Switch off the current.

The theoretical pickup can be computed as follows:

$$I_{XPU} = \text{Pickup setting} \times \text{CT} \qquad \textbf{(EQ 7.5)}$$

Single Infeed Fault

- ▷ Set the I_X prefault current equal to 0.
- ▷ Set the fault current equal to CT.
- ▷ Apply the fault.
- ▷ Switch off the current.
- ▷ Record the operating time.
- ▷ Set the I_X prefault current equal to 0.
- ▷ Set the fault current equal to 5 × CT.
- ▷ Apply the fault.
- ▷ Switch off the current.
- ▷ Record the operating time.

Slope 1 Check

- ▷ Connect the relay test set to inject Channel Y current (I_Y) into the G6 terminal and out of H6 terminal.
  The angle between I_X and I_Y will be 180°.
- ▷ Set pre-fault current, I_X and I_Y equal to zero.
- ▷ Set fault current, I_Y equal to 1½ CT.

At this value the relay should operate according to the following formula:

$$I_{XOP1} = \frac{2 - \text{Slope 1 setting}}{2 + \text{Slope 1 setting}} \times \frac{3 \times \text{CT}}{2} \qquad \textbf{(EQ 7.6)}$$

- ▷ Set fault current, I_X equal to 0.95 × I_{XOP1}.
- ▷ Apply the fault.
  The relay should operate.
- ▷ Switch off the current.
- ▷ Set fault current, I_X equal to 1.05 × I_{XOP1}.
- ▷ Apply the fault.
  The relay should restrain.
- ▷ Switch off the current.

Slope 2 Check

▷ Set fault current, I_Y equal to 2.5 × CT.

At this value the relay should operate according to the following formula.

$$I_{XOP2} = \frac{2 - \text{Slope 2 setting}}{2 + \text{Slope 2 setting}} \times 2.5 \times \text{CT} \qquad \textbf{(EQ 7.7)}$$

▷ Set fault current, I_X equal to $0.95 \times I_{XOP2}$.

▷ Switch on the test set.
The relay should operate.

▷ Switch off the current.

▷ Set fault current, I_X equal to $1.05 \times I_{XOP2}$.

▷ Switch on the test set.
The relay should restrain.

▷ Switch off the current.

Directional Check

▷ Set pre-fault current, I_X and I_Y equal to 3.5 × CT.
At this value the conditions for CT saturation detection are set and the relay will enable the directional check.

▷ Set fault current, I_X equal to $0.95 \times I_{XOP2}$.

▷ Switch on the test set.
The relay should restrain.

▷ Switch off the current.

▷ **Repeat steps from Minimum Pickup Check onward for phases B and C.**

Test Results

Test	Phase A		Phase B		Phase C	
	Calculated	Measured	Calculated	Measured	Calculated	Measured
Minimum Pickup						

Test	Phase A		Phase B		Phase C	
	CT	5 × CT	CT	5 × CT	CT	5 × CT
Single Infeed Fault						

Test		Phase A		Phase B		Phase C	
		operate	restrain	operate	restrain	operate	restrain
Slope 1	I_x						
	I_y						
	Operation (OK/not OK)						
Slope 2	I_x						
	I_y						
	Operation (OK/not OK)						
Directional Check	I_x	N/A		N/A		N/A	
	I_y	N/A		N/A		N/A	
	Operation (OK/not OK)	N/A		N/A		N/A	

7.3.9 Injection Test Setup #3

Setup the 489 device as follows for the Voltage Restrained Overcurrent test.

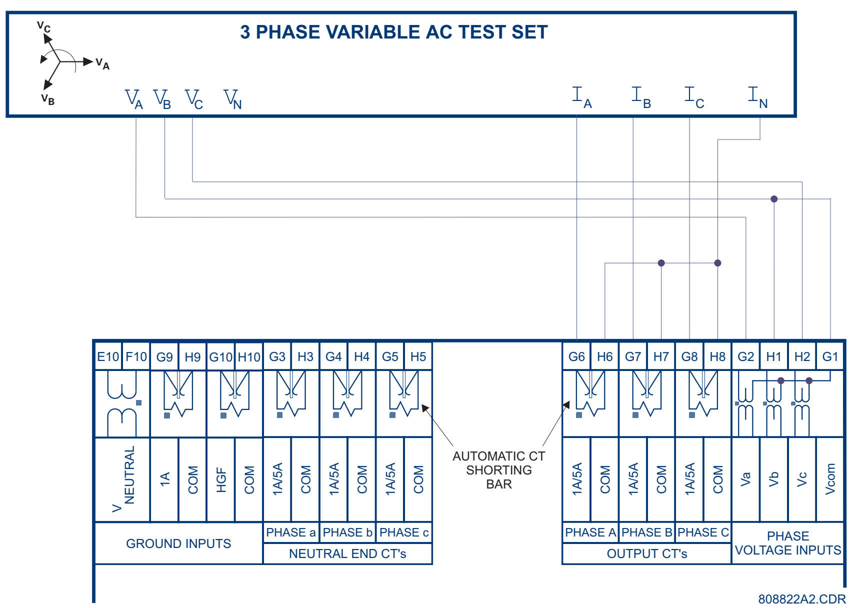


FIGURE 7–3: Secondary Injection Test Setup #3

7.3.10 Voltage Restrained Overcurrent Accuracy

Setup the relay as shown in FIGURE 7–3: *Secondary Injection Test Setup #3* on page 7–19.

▷ In the **S2 SYSTEM SETUP ▷▽ GEN. PARAMETERS** menu, set:

GENERATOR RATED MVA: "100 MVA"
GENERATOR VOLTAGE PHASE-PHASE: "12000"

▷ In the **S2 SYSTEM SETUP ▷▽ VOLTAGE SENSING** menu, set:

VT CONNECTION TYPE: "Open Delta"
VOLTAGE TRANSFORMER RATIO: "100:1"

▷ In the **S5 CURRENT ELEMENTS ▷ OVERCURRENT ALARM** menu, set:

OVERCURRENT ALARM: "Unlatched"
O/C ALARM LEVEL: "1.10 x FLA"
OVERCURRENT ALARM DELAY: "2 s"
O/C ALARM EVENTS: "On"

▷ In the **S5 CURRENT ELEMENTS ▷▽ PHASE OVERCURRENT** menu, set:

PHASE OVERCURRENT TRIP: "Latched"
ENABLE VOLTAGE RESTRAINT: "Yes"
PHASE O/C PICKUP: "1.5 x CT"
CURVE SHAPE: "ANSI Extremely Inv."
O/C CURVE MULTIPLIER: "2.00"
O/C CURVE RESET: "Instantaneous"

The trip time for the extremely inverse ANSI curve is given as:

$$\text{Time to Trip} = M \times \left(A + \frac{B}{\frac{I}{\langle K \rangle \times I_p} - C} + \frac{D}{\left(\frac{I}{\langle K \rangle \times I_p} - C\right)^2} + \frac{E}{\left(\frac{I}{\langle K \rangle \times I_p} - C\right)^3} \right) \quad \textbf{(EQ 7.8)}$$

where: M = **O/C CURVE MULTIPLIER** setpoint

I = input current
I_p = **PHASE O/C PICKUP** setpoint
A, B, C, D, E = curve constants, where A = 0.0399, B = 0.2294, C = 0.5000, D = 3.0094, and E = 0.7222
K = voltage restrained multiplier <optional>

The voltage restrained multiplier is calculated as:

$$K = \frac{\text{phase-to-phase voltage}}{\text{rated phase-to-phase voltage}} \quad \textbf{(EQ 7.9)}$$

and has a range of 0.1 to 0.9.

▷ Using *Secondary Injection Test Setup #3* on page 7–19, inject current and apply voltage as per the table below.

▷ Verify the alarm/trip elements and view the event records in the **A5 EVENT RECORD** menu.

Current/voltage (5 A unit)		Alarm			Trip		Trip Delay	
Current	Voltage	expected	observed	delay	expected	observed	expected	observed
Ian = 5 A∠0° Ibn = 5 A∠120° lag Icn = 5 A∠240° lag	Vab = 120 V∠0° lag Vbc = 120 V∠120° lag Vca = 120 V∠240° lag	8		N/A	8		N/A	N/A
Ian = 6 A∠0° Ibn = 6 A∠120° lag Icn = 6 A∠240° lag	Vab = 120 V∠0° Vbc = 120 V∠120° lag Vca = 120 V∠240° lag	4			8		N/A	N/A
Ian = 10 A∠0° Ibn = 10 A∠120° lag Icn = 10 A∠240° lag	Vab = 120 V∠0° Vbc = 120 V∠120° lag Vca = 120 V∠240° lag	4			4		11.8 s	
Ian = 10 A∠0° Ibn = 10 A∠120° lag Icn = 10 A∠240° lag	Vab = 100 V∠0° Vbc = 100 V∠120° lag Vca = 100 V∠240° lag	4			4		6.6 s	
Ian = 10 A∠0° Ibn = 10 A∠120° lag Icn = 10 A∠240° lag	Vab = 60 V∠0° Vbc = 60 V∠120° lag Vca = 60 V∠240° lag	4			4		1.7 s	

4 activated; 8 Not Activated

7.3.11 Distance Element Accuracy

The theoretical impedance on the R-X plane can be calculated as:

$$Z_i = \frac{0.875 \times Z_d \times \cos(\theta_d - \theta_i) + \sqrt{(0.875 \times Z_d \times \cos(\theta_d - \theta_i))^2 + 4 \times Z_d^2 \times 0.125}}{2} \quad \textbf{(EQ 7.10)}$$

where: Z_d = programmed distance impedance
θ_d = programmed distance characteristic angle
θ_i = variable angle on the R-X plane at point *i* for which boundary impedance is to be calculated

It is recommended that voltage is kept constant while increasing the current magnitude at certain angles referenced to voltage phase A until element operates.

Then the expected operating current (assuming that current in the two phases are 180° apart) can be calculated as:

$$\vec{I}_i = \frac{\vec{V}_a - \vec{V}_b}{2\vec{Z}_i} \quad \textbf{(EQ 7.11)}$$

where $\vec{Z}_i = Z_i \times e^{j\theta_i}$.

Digital Energy
Multilin

489 Generator Management Relay

Appendix

A.1 Stator Ground Fault

A.1.1 Description

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 into a nominal 1 A secondary circuit or an input reserved for a special GE Multilin type HGF ground CT for very sensitive ground current detection. Using the HGF CT allows measurement of ground current values as low as 0.25 A primary. With impedance-grounded generators, a single ground fault on the stator does not require that the unit be quickly removed from service. 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. 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.

A.1.2 Neutral Overvoltage Element

The simplest, and one of the oldest methods to detect stator ground faults on high-impedance-grounded generators, is to sense the voltage across the stator grounding resistor (See References [1, 2] at the end of this section). This is illustrated, in a simplified form in the figure below. 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 489 neutral overvoltage protection element. This element has an alarm and a trip function, with separately adjustable operate levels and time delays. The trip function offers a choice of timing curves as well as 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 V.

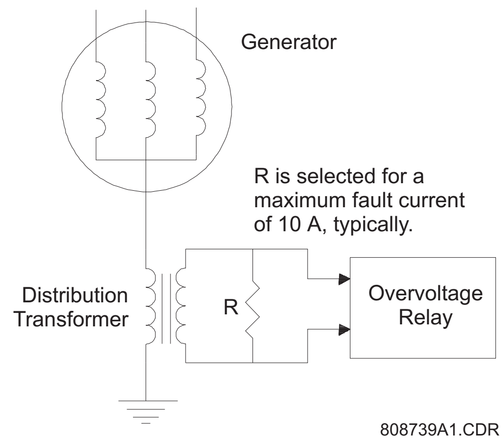


FIGURE A–1: Stator Ground Fault Protection

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.

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.

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 normally consists of a distribution transformer and a properly sized resistor). It is possible that only one generator is grounded while the others have a floating neutral point when connected to the power grid (see the figure below). 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.

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.

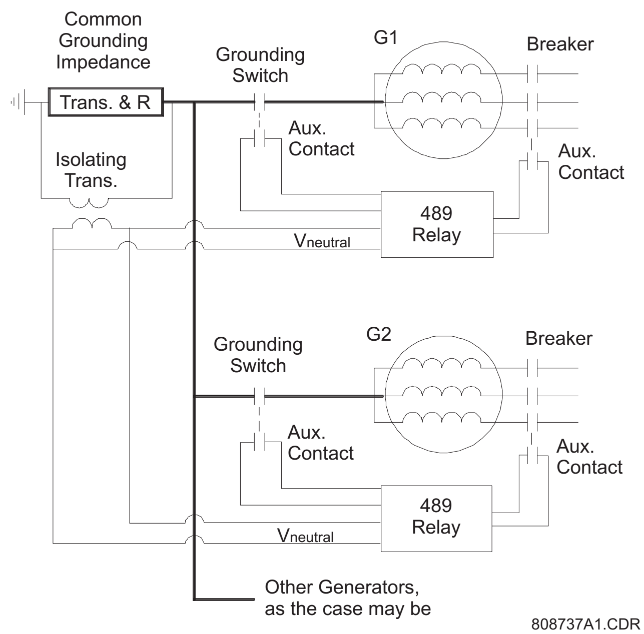


FIGURE A–2: Parallel Generators with Common Grounding Impedance

A.1.3 Ground Overcurrent Element

The ground overcurrent element can be used as a direct replacement or 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 below. 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.

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 A. 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 the figure below, 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 *Ground Directional* on page 5–40 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.

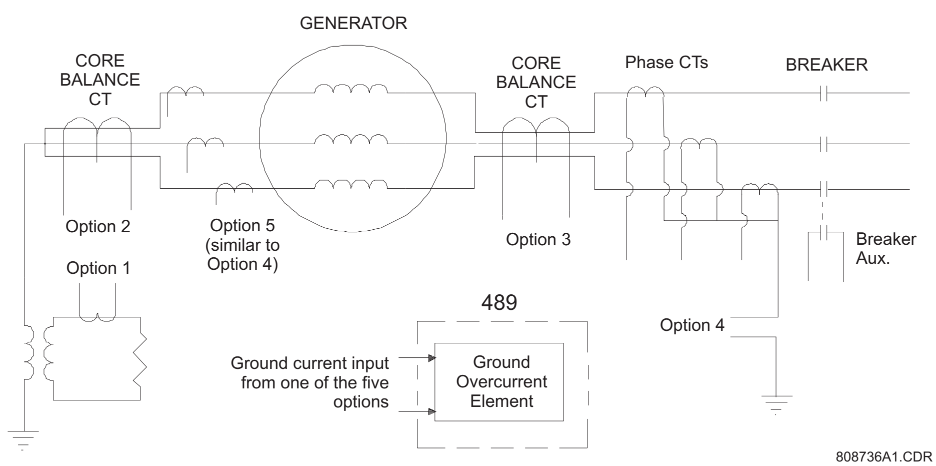


FIGURE A–3: Ground Overcurrent Element with Different Current Source Signals

A.1.4 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 shown below (due to CT inaccuracies, it is generally 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).

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.

This element's normal 'plane of operation' for a resistor-grounded generator is the 180° plane, as shown in FIGURE A–4: *Ground Directional Element Polarities and Plane of Operation*, for an internal ground fault. That is, for an internal stator-to-ground fault, the V_o signal is 180° away from the I_o signal, if the polarity convention is observed. If the grounding impedance is inductive, the plane of operation will be the 270° plane, again, with the polarity convention shown below. If the polarity convention is reversed on one input, the user will need to change the plane of operation by 180°.

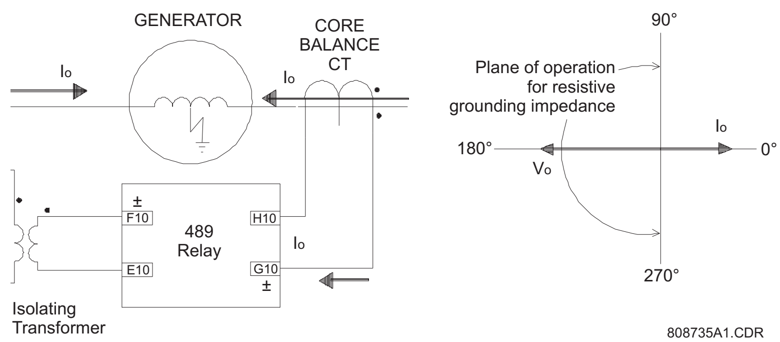


FIGURE A–4: Ground Directional Element Polarities and Plane of Operation

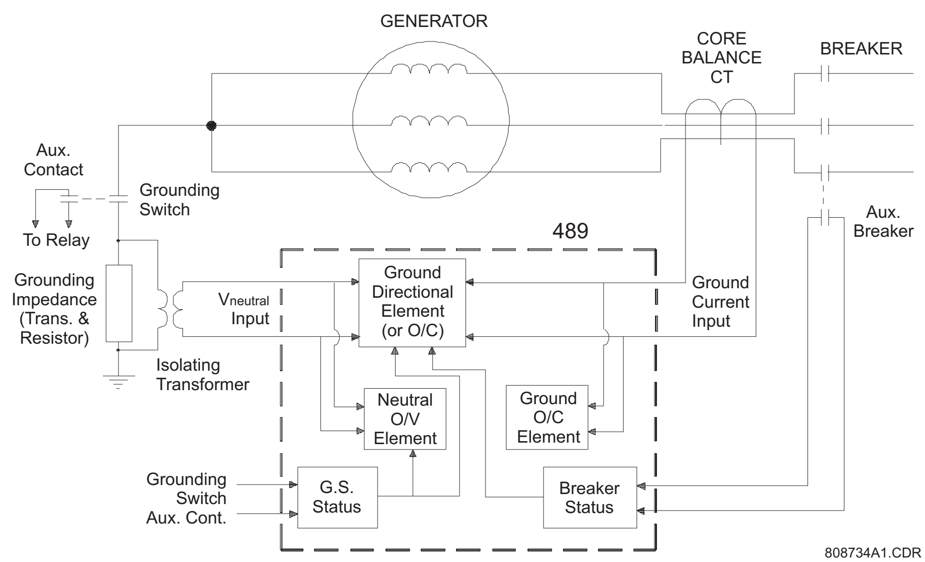


FIGURE A–5: Ground Directional Element Conceptual Arrangement

The operating principle of this element is quite simple: for internal ground faults the two signals will be 180° 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.

The current pickup level of the element can be adjusted down to 0.05 × CT primary, allowing an operate level of 0.25 A 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 V.

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. The table below illustrates the status of different elements under various operating conditions.

Table A–1: Detection Element Status

Generator Condition	Unit Breaker	Ground Switch	Element		
			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 I_0)	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

A.1.5 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 (see Reference 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:

$$\frac{V_{N3}}{V_{P3}/3 + V_{N3}} \le 0.15 \quad \text{which simplifies to} \quad V_{P3} \ge 17V_{N3} \qquad \textbf{(EQ 1.1)}$$

The 489 tests the following conditions prior to testing the basic operating equation to ensure that V_{N3} is of a measurable magnitude:

$$V_{P3'} > 0.25\ \text{V} \quad \text{and} \quad V_{P3'} \geq \text{Permissive\_Threshold} \times 17 \times \frac{\text{Neutral CT Ratio}}{\text{Phase CT Ratio}} \qquad \textbf{(EQ 1.2)}$$

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}' and V_{N3}' are the corresponding voltage transformer secondary values
Permissive_Threshold is 0.15 V for the alarm element and 0.1875 V 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.

A.1.6 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 Multilin, “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.

A.2 Stator Differential Protection Special Application

A.2.1 Background

The 489 relay is applied in a dual breaker arrangement as shown in the figure below. In this configuration one breaker is closed at a time eliminating a danger of through fault conditions. However, the customer prefers not to sum up the two breaker currents to obtain effectively the terminal-side current of the generator, nor to install an extra CT at the generator to measure the terminal-side current explicitly. Instead, the customer applies two 489 relays each spanning its differential zone between the neutral-side CT of the generator and the CT at the corresponding breaker.

In this application, when a breaker is closed, the other (opposite) relay would measure the neutral-side current without the matching terminal-side current, as the latter flows via the other (closed) breaker and it not visible to the opposite relay.

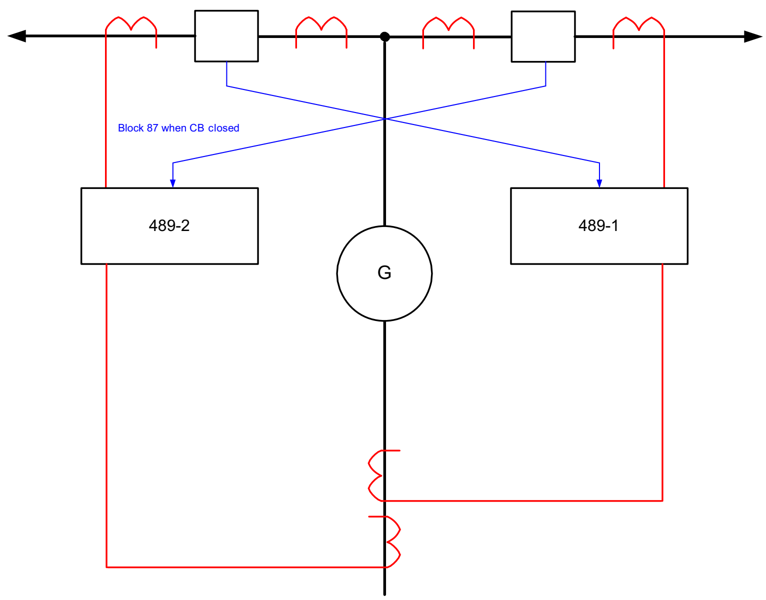


FIGURE A–6: Considered application of two 489s protecting a dual-breaker generator configuration

When both breakers are opened both relays be operational with the differential function enabled. The application is based on blocking the differential function using the position of the opposite breaker via the multiple setting group mechanism of the relay.

When both breakers are opened, both relays are in their setting group 1 with the differential functions operational. When a breaker is closed, its relay remains in group 1 so that no setting group switching takes place and therefore continuous uninterrupted protection is provided for the generator. At the same time the opposite relay is blocked by switching to group 2 in which the differential function is disabled. This prevents mis-operation. There is no provision for an "advanced close" signal, and the breaker position signal is used instead.

In addition, enhanced differential protection algorithm takes care the timing offset between the main and auxiliary contacts of the breaker. As a result, maximum of 50ms timing offset between the main and auxiliary contacts of the breaker will block the differential function.

A.2.2 Stator Differential Logic

The differential function uses an internal timer of 130ms as shown in the figure below. This timer is a common timer for all three phases of the differential function. Normally, the timer is not engaged ensuring instantaneous operation and backward compatibility with the previous firmware revisions of the product.

The timer is engaged only when the terminal-side currents in all three phases are zero. If any of the terminal currents is above 5% of CT nominal, the timer is by-passed. Also, if any of the neutral-side current is above 5 times CT nominal, the timer is by-passed as well.

In this logic the current magnitudes are filtered fundamental frequency components (T stands for terminal-side currents, and N stands for neutral-side currents); PKP denotes the pickup state of the element prior to any user set delay that may or may not be used in a particular application; A, B and C designate phases.

The differential element works as follows:

With the machine under load, the terminal currents are above 5% of CT nominal and no delay is applied to the differential function.

With the machine on-line but with no load (below 5%) the delay is applied. However, should a fault occur at that time, at least one of the terminal current would get elevated cancelling the delay and resulting in an instantaneous trip.

With the opposite breaker being closed as in the considered dual-breaker application, a current is drawn (either transformer inrush or load or both). This will activate the differential characteristic. However, the timer remains engaged because all the terminal currents (ABC) are zero, and all the neutral-side currents (ABC) are below 5 times CT nominal. The timer keeps timing out. However, before it expires the relay switches to group 2 and blocks the differential function. This prevents misoperation.

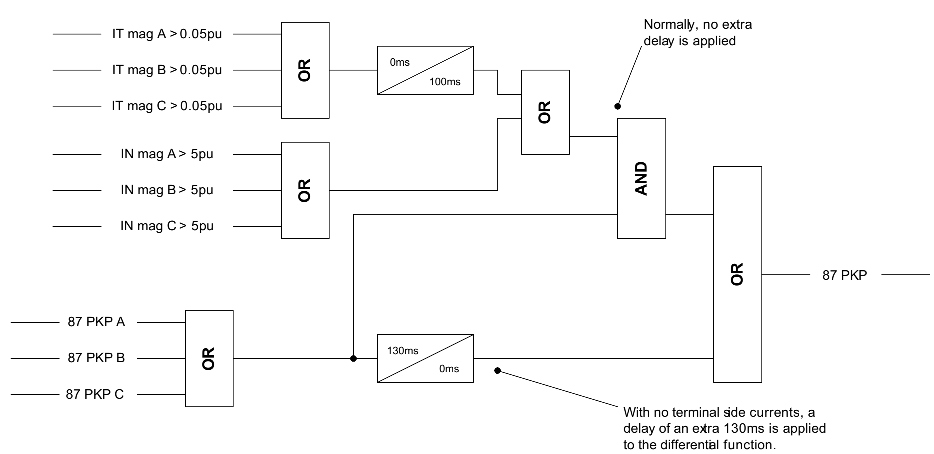


FIGURE A–7: Enhancements to the stator differential logic

Should a fault occur during the first 50-60ms after closing the breaker, the corresponding relay would trip instantly. Before closing the breaker the corresponding relay too applies a delay. However, once the load/inrush current exceeds 5% of CT nominal, its timer is by-passed and instantaneous protection is provided.

Should a fault occur during generator start-up with both breakers opened, both relays would operate after the extra time delay of 130ms. This delay is acceptable under such conditions. Even this delay will be eliminated if the fault is heavy enough to draw more than 5 times CT nominal from the neutral-side of the generator.

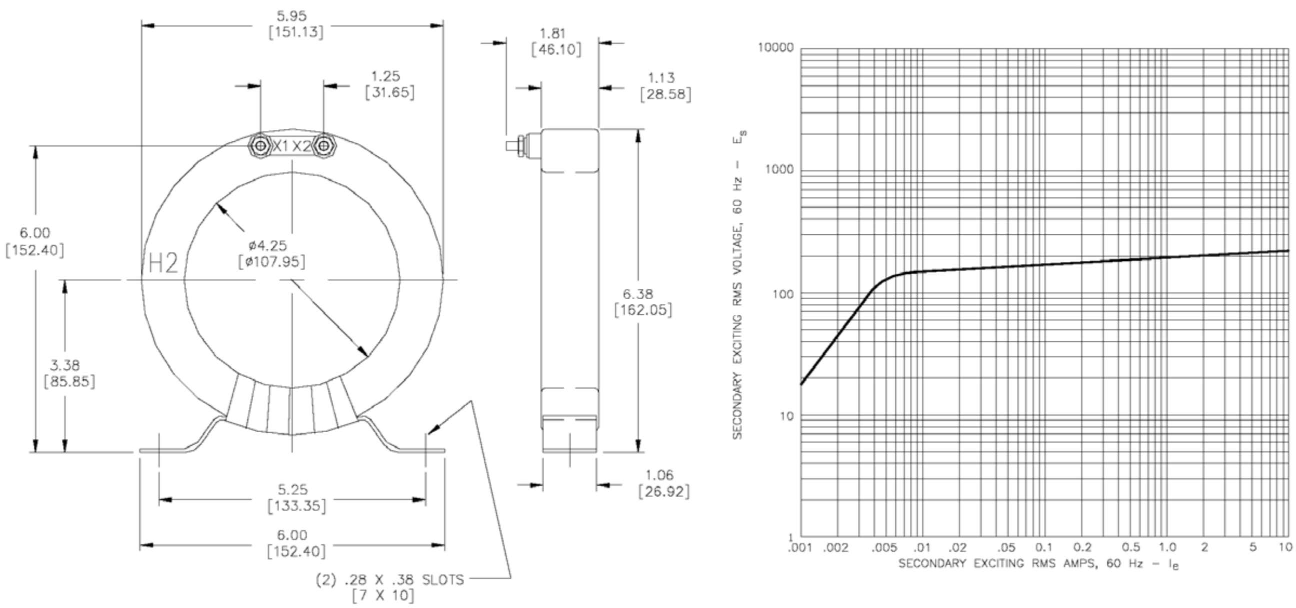
For proper implementation, the internal timer is cleared each time the 87 function becomes enabled (so that a partial time out from the previous “enabled” period does not affect the intended operation).

A.3 Current Transformers

A.3.1 Ground Fault CTs for 50:0.025 A CT

CTs that are specially designed to match the ground fault input of GE Multilin 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-inch, 5½-inch, or 8-inch diameter windows.

HGF3C



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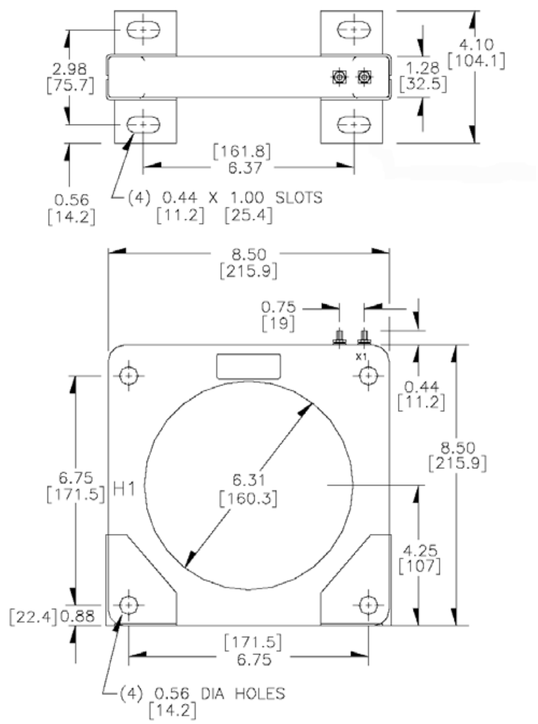
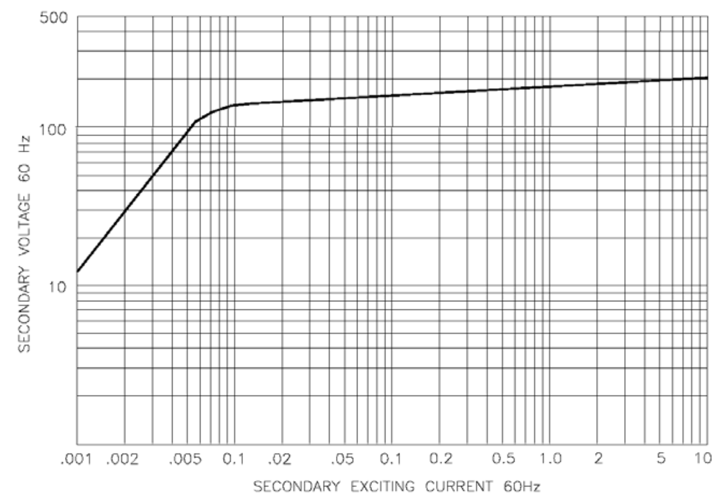
HGF5C





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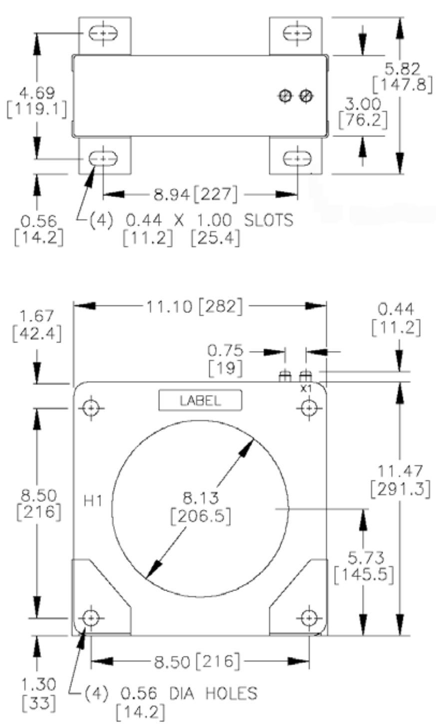
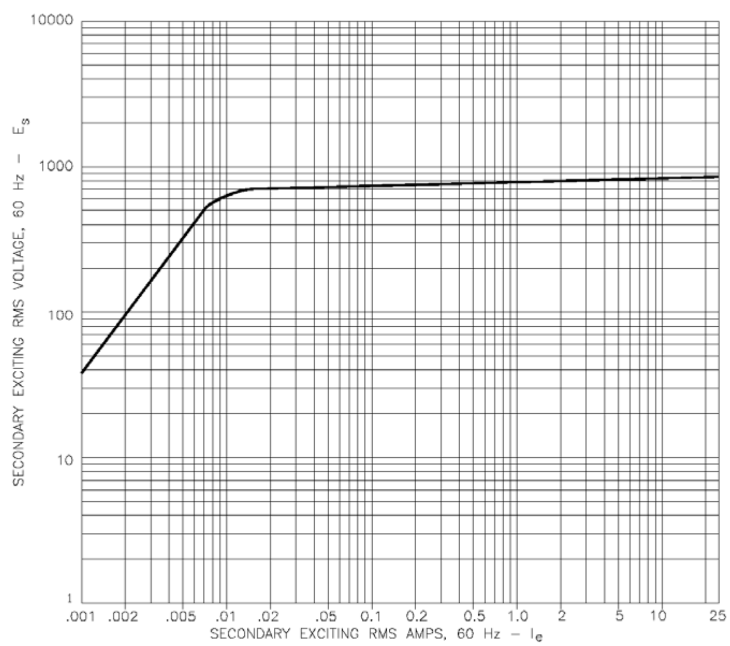
HGF8





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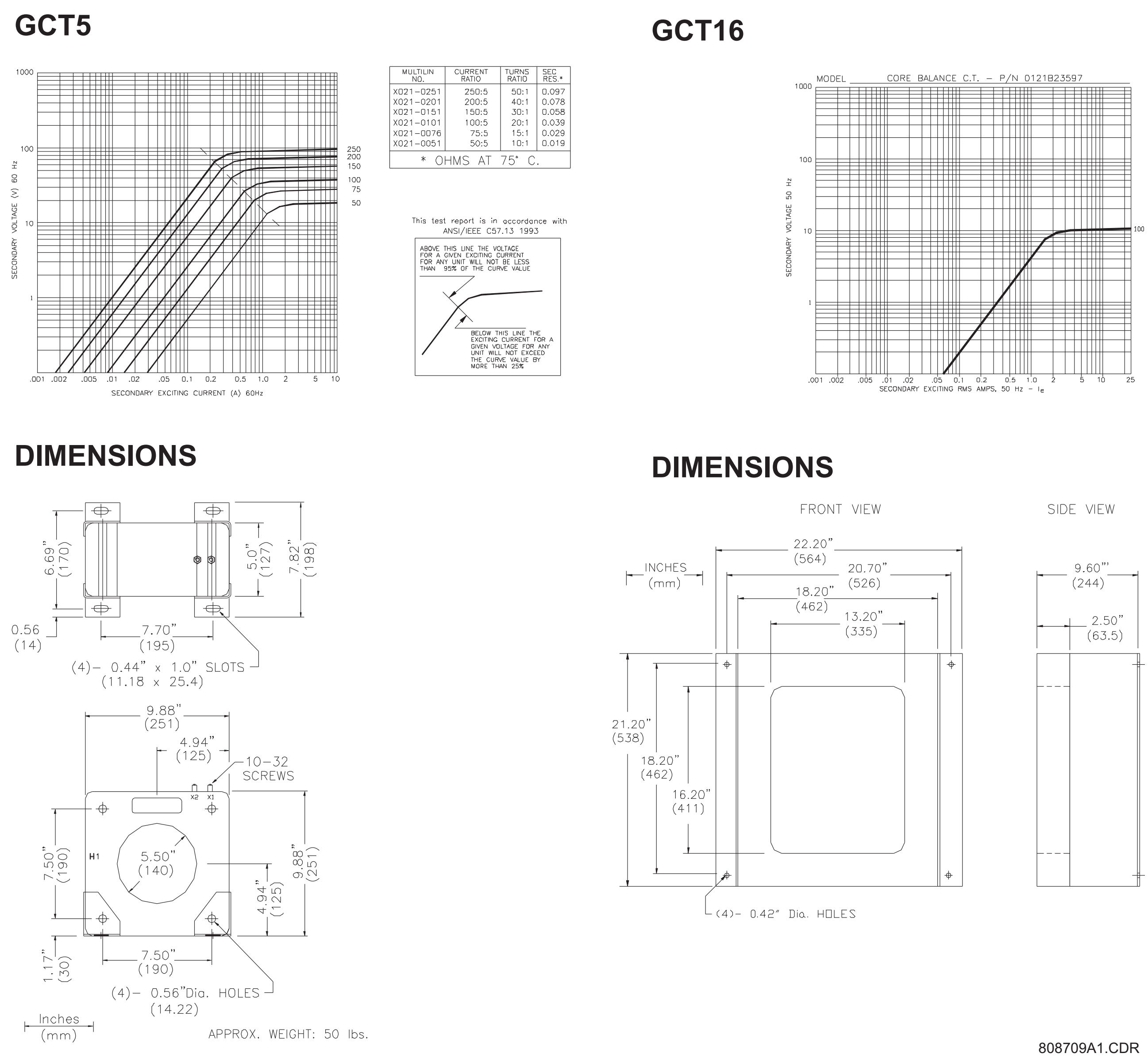
A.3.2 Ground Fault CTs for 5 A Secondary CT

For low resistance or solidly grounded systems, a 5 A secondary CT should be used. Two sizes are available with 5½" or 13" × 16" windows. Various Primary amp CTs can be chosen (50 to 250).



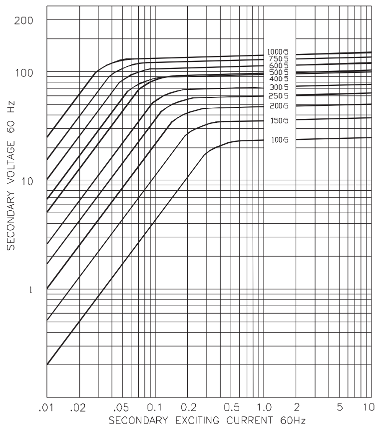
MULTILIN NO.	CURRENT RATIO	TURNS RATIO	SEC RES.*
X021–0251	250:5	50:1	0.097
X021–0201	200:5	40:1	0.078
X021–0151	150:5	30:1	0.058
X021–0101	100:5	20:1	0.039
X021–0076	75:5	15:1	0.029
X021–0051	50:5	10:1	0.019

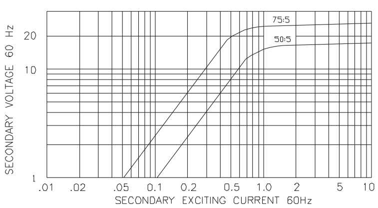
* OHMS AT 75° C.

A.3.3 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: 600 V BIL, 10 KV.

EXCITATION CURVE

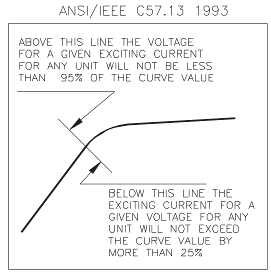


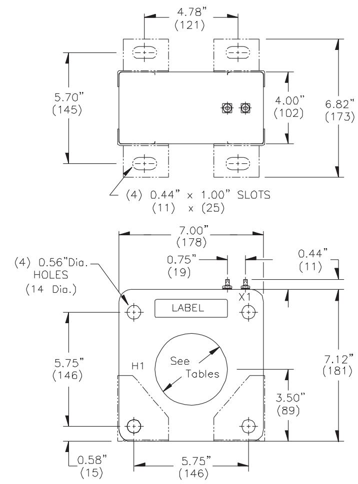


CURRENT TRANSFORMER SPECIFICATIONS				
CURRENT RATIO	WINDOW SIZE	CT CLASS	MULTILIN No.	CT Dims.
50:5	2.75"	C10	X911-0010	A
75:5	2.75"	C10	X911-0011	A
100:5	3.00"	C10	X911-0012	B
150:5	3.00"	C10	X911-0013	B
200:5	3.00"	C20	X911-0014	B
250:5	3.00"	C20	X911-0015	B
300:5	3.00"	C20	X911-0016	B
400:5	3.00"	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

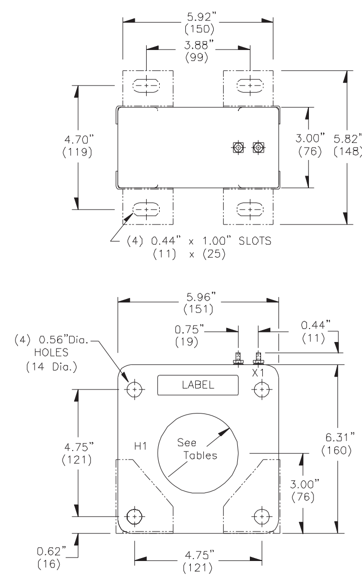
90906BA1.DWG

This test report is in accordance with ANSI/IEEE C57.13 1993





CT DIMENSIONS "A"



CT DIMENSIONS "B"

808712A1.CDR

A.4 Time Overcurrent Curves

A.4.1 ANSI Curves

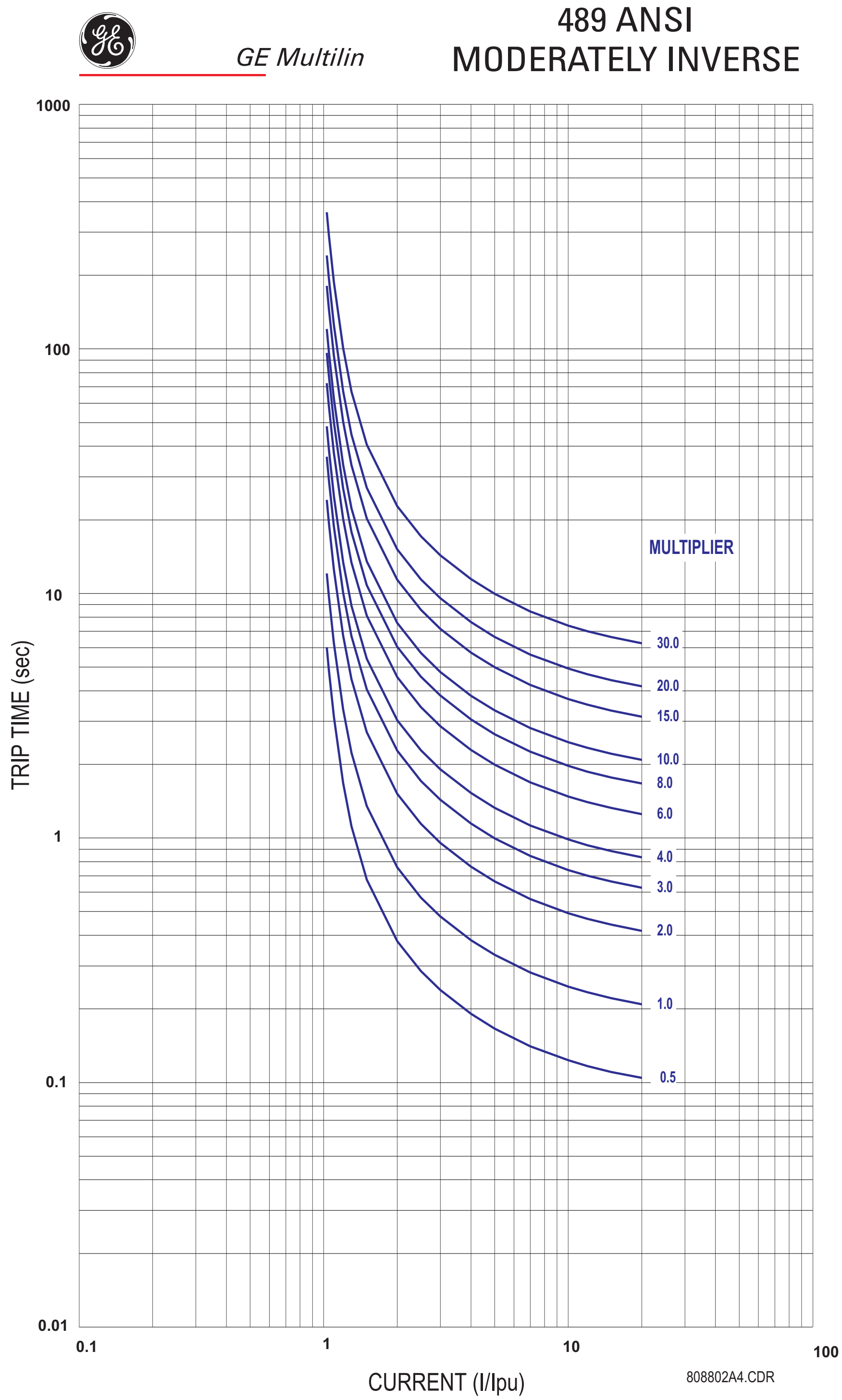


FIGURE A–8: ANSI Moderately Inverse Curves

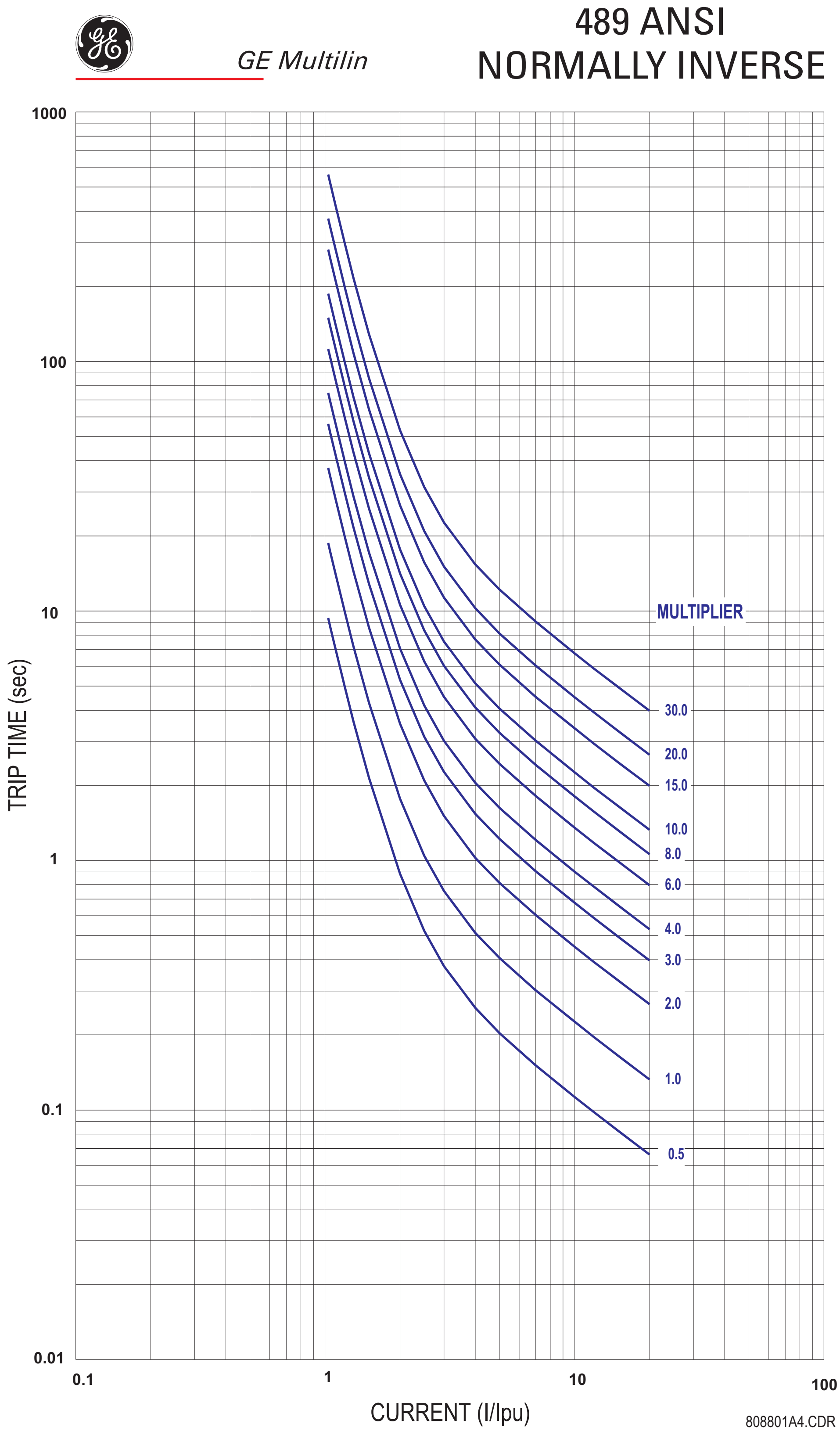


FIGURE A–9: ANSI Normally Inverse Curves

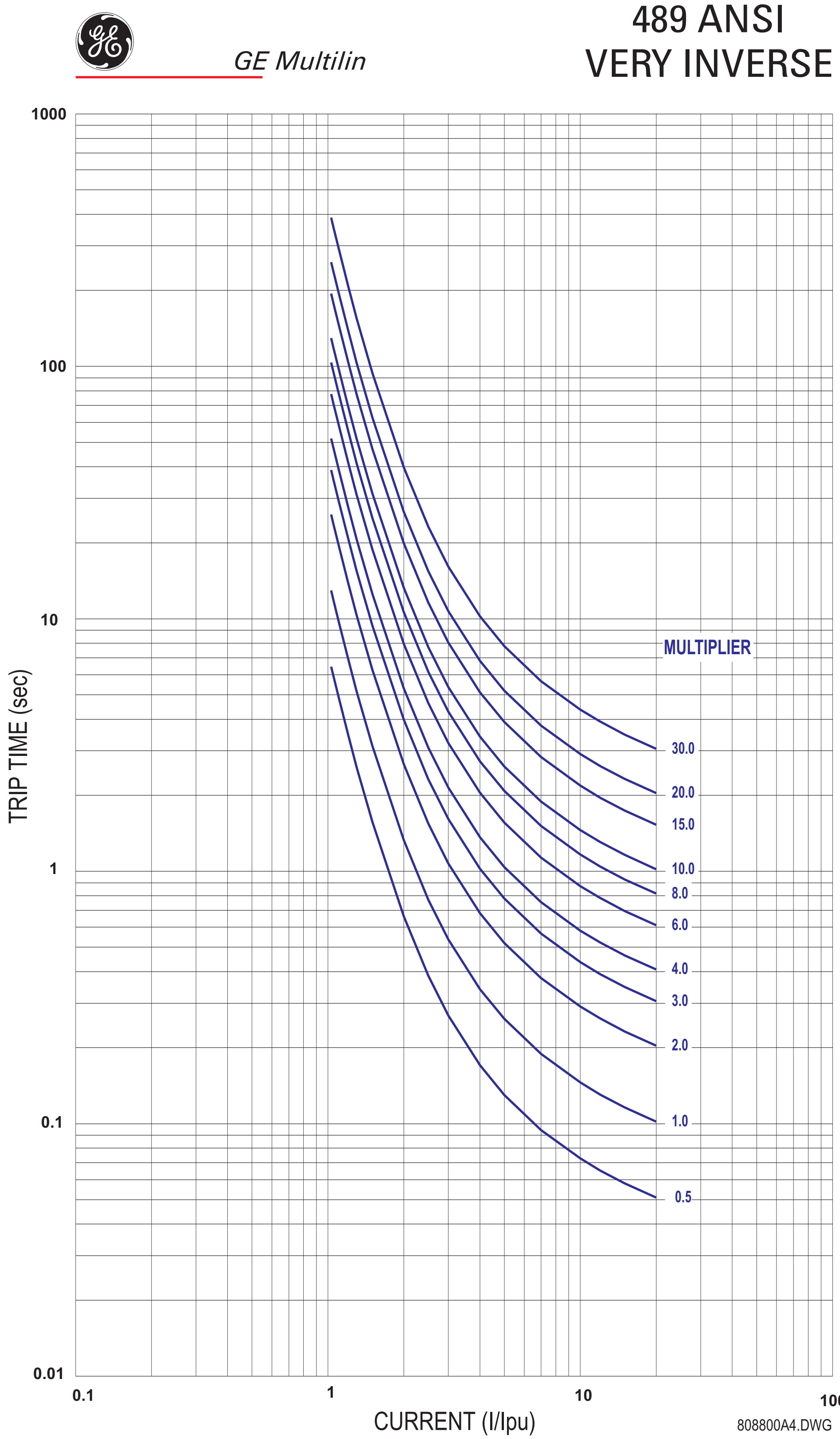


FIGURE A–10: ANSI Very Inverse Curves

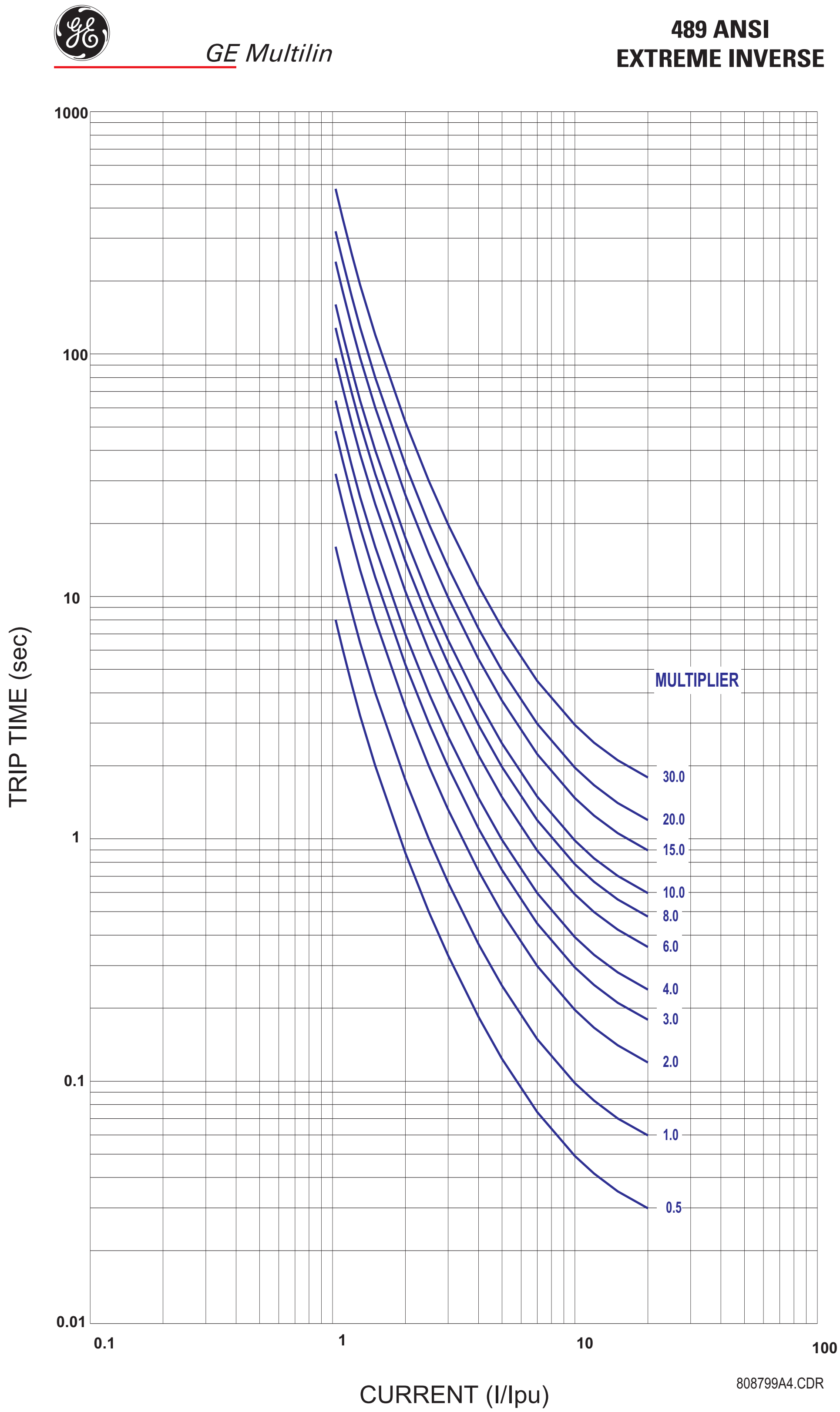


FIGURE A–11: ANSI Extremely Inverse Curves

A.4.2 Definite Time Curves

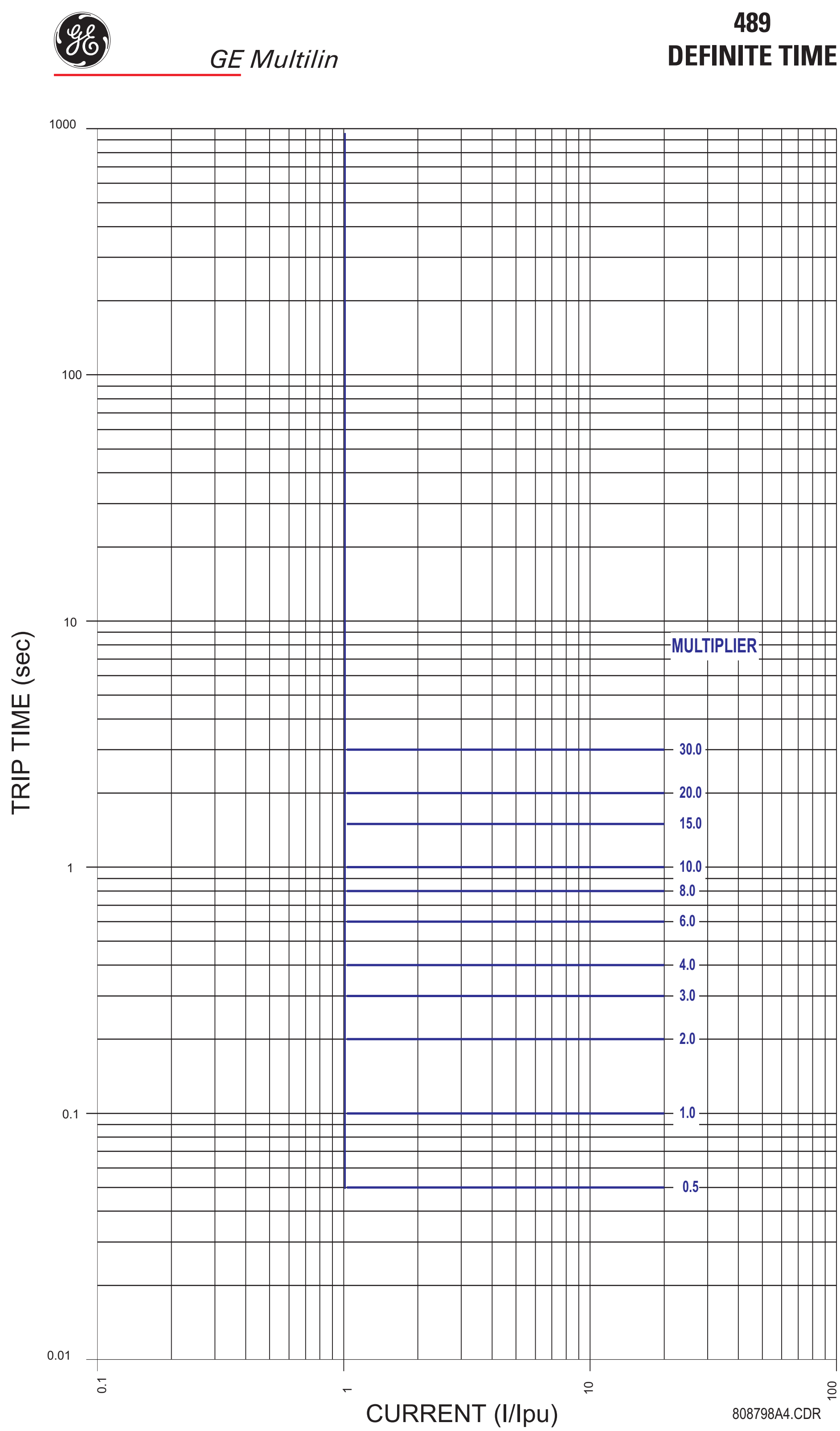


FIGURE A–12: Definite Time Curves

A.4.3 IAC Curves

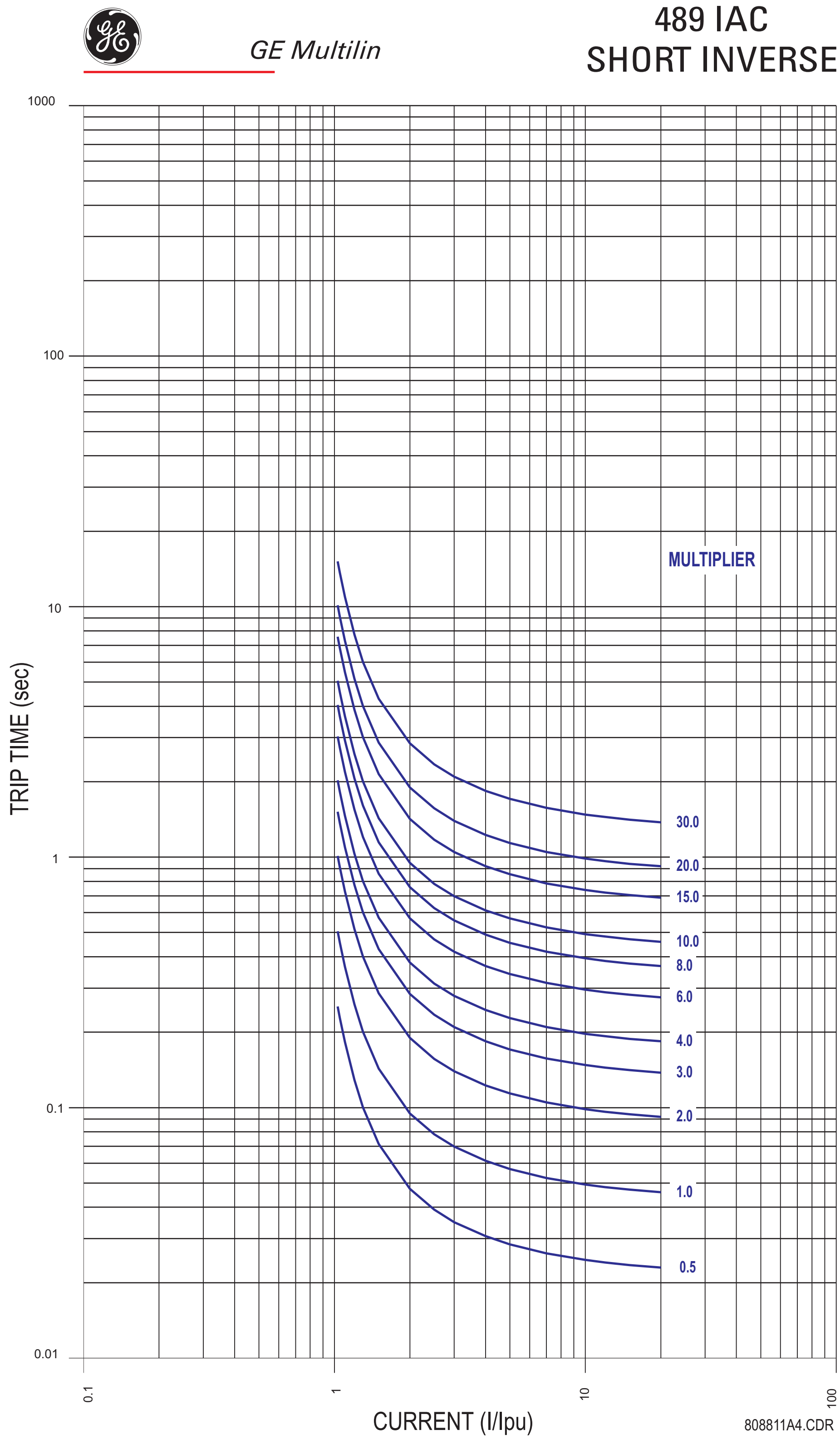


FIGURE A–13: IAC Short Inverse Curves

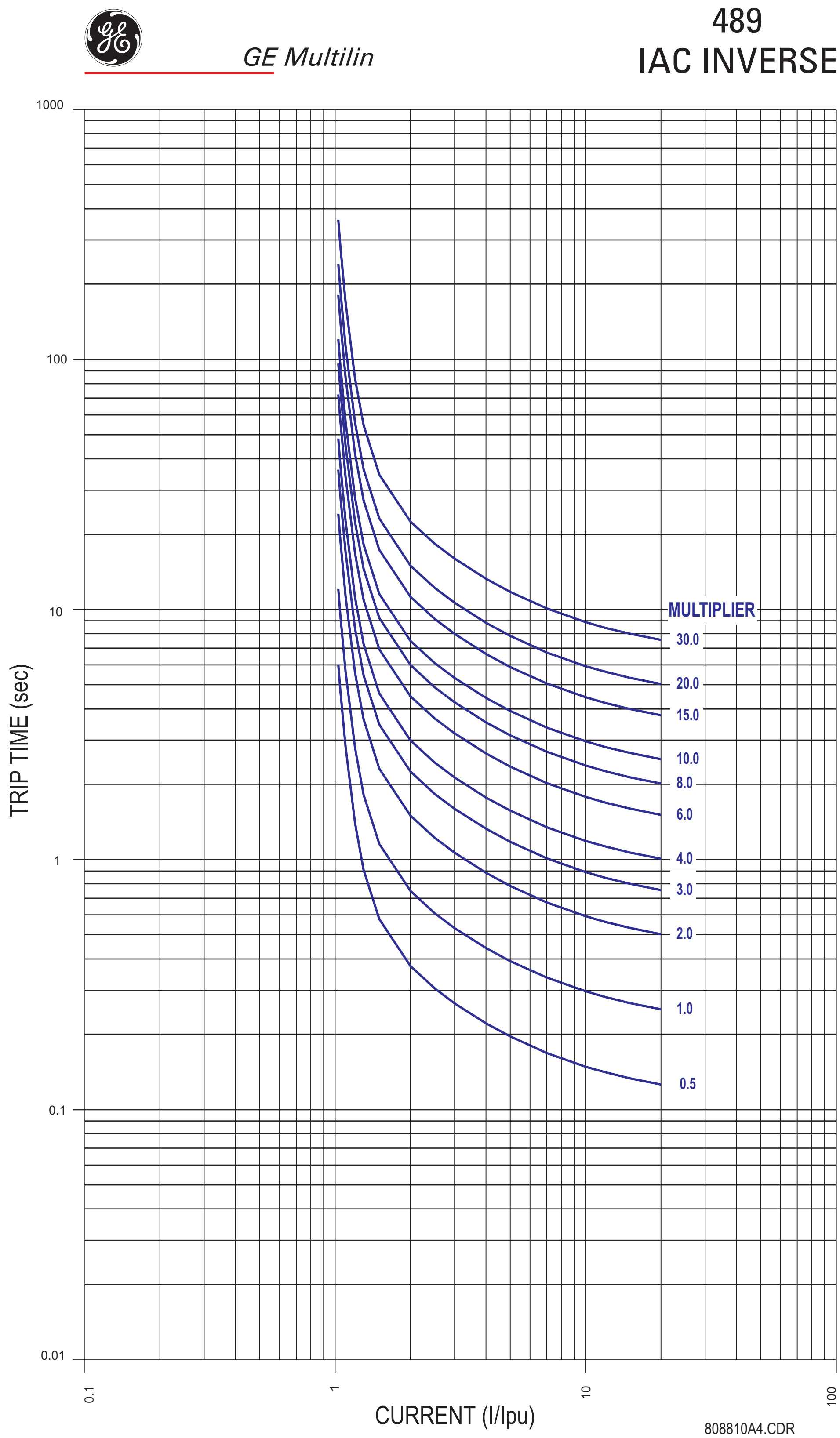


FIGURE A–14: IAC Inverse Curves

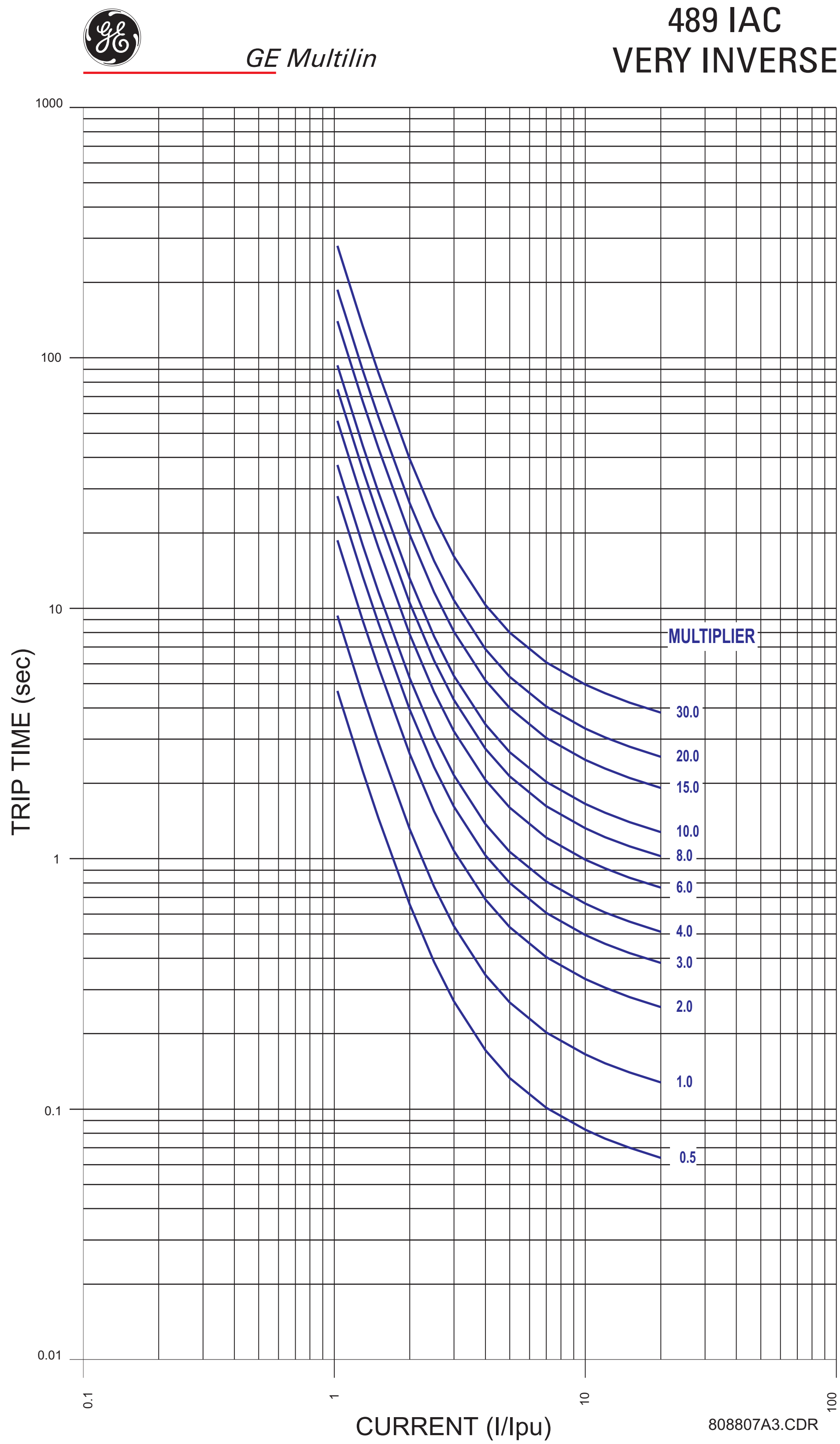


FIGURE A–15: IAC Very Inverse Curves

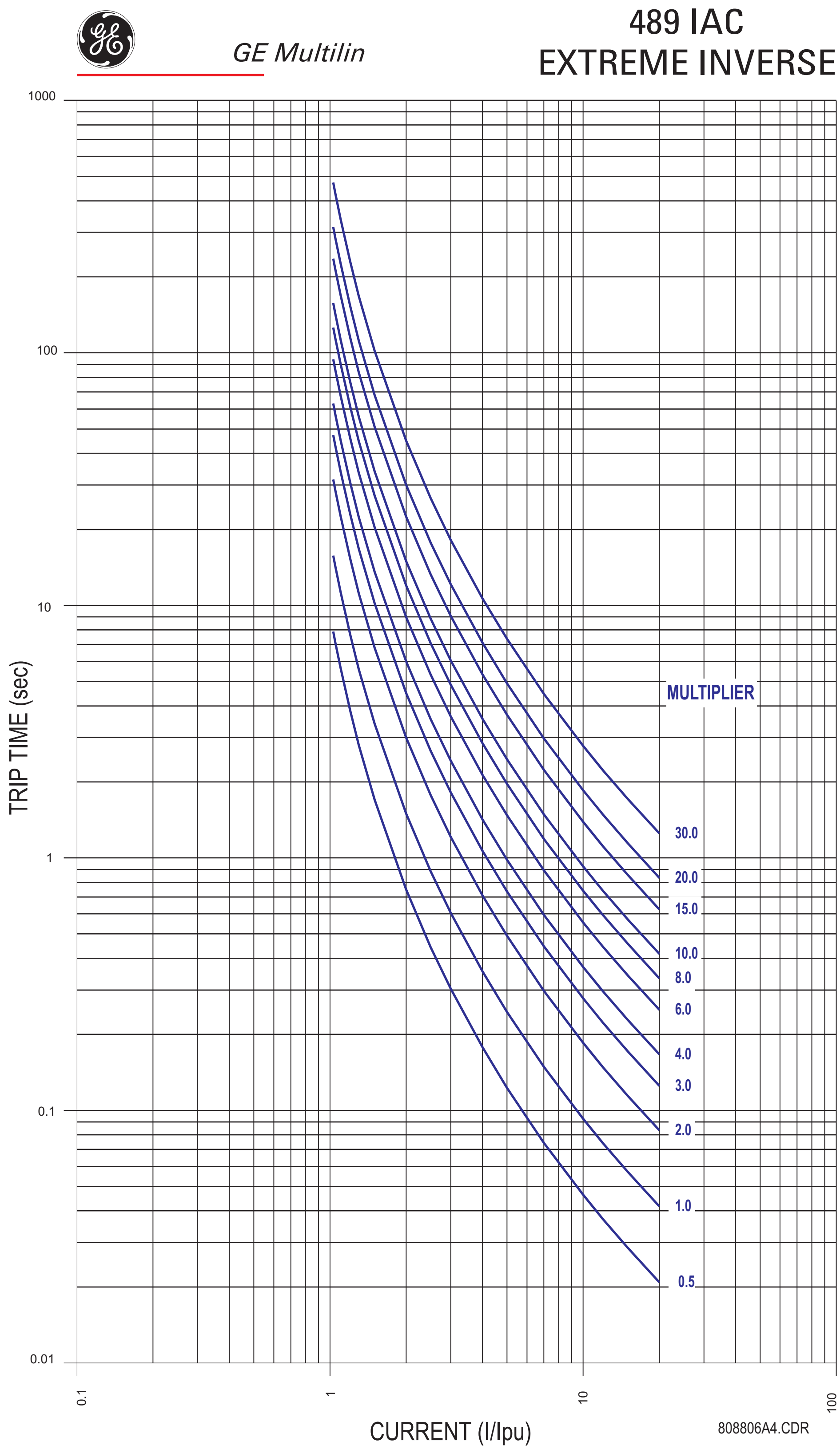


FIGURE A–16: IAC Extreme Inverse Curves

A.4.4 IEC Curves

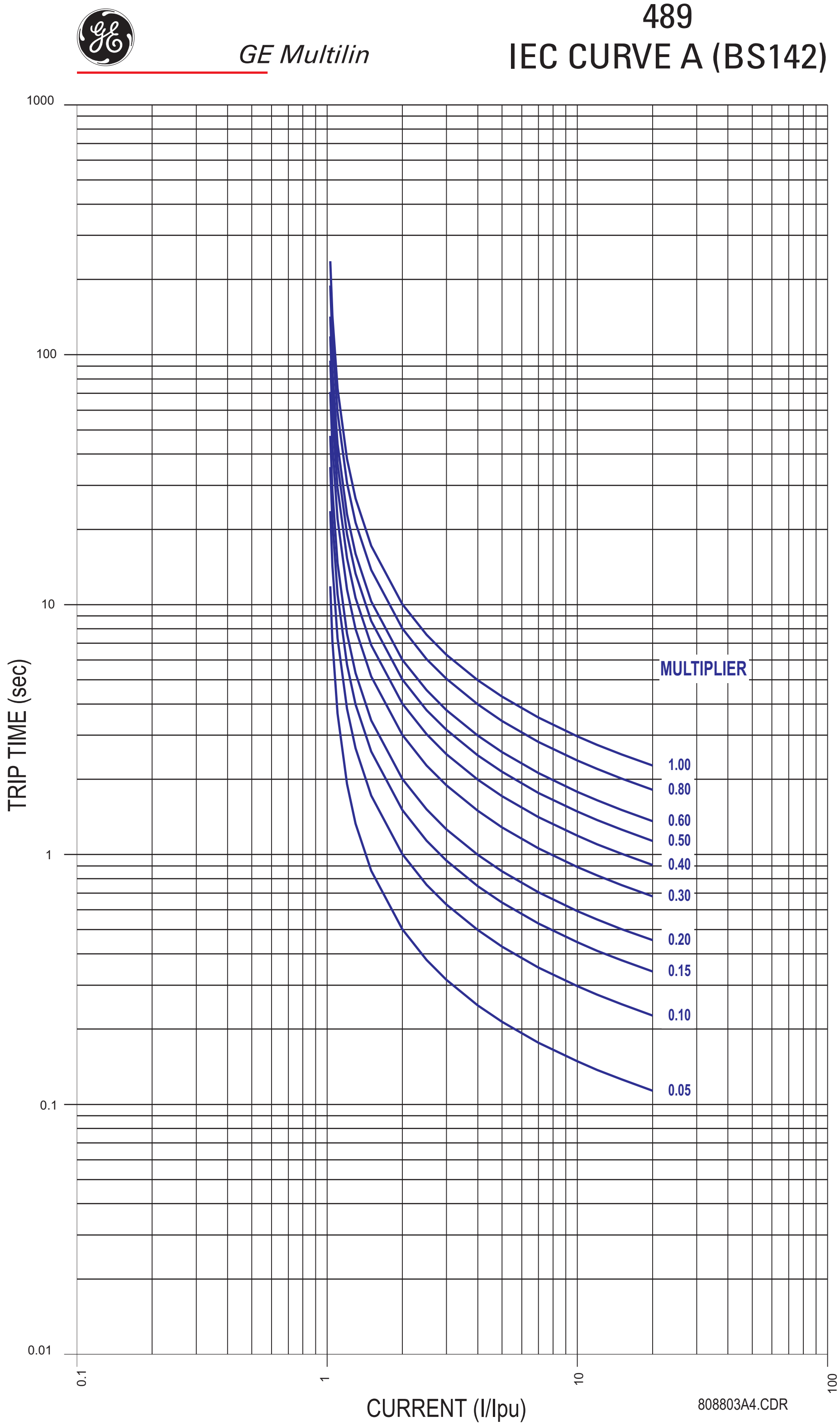


FIGURE A–17: IEC Curves A (BS142)

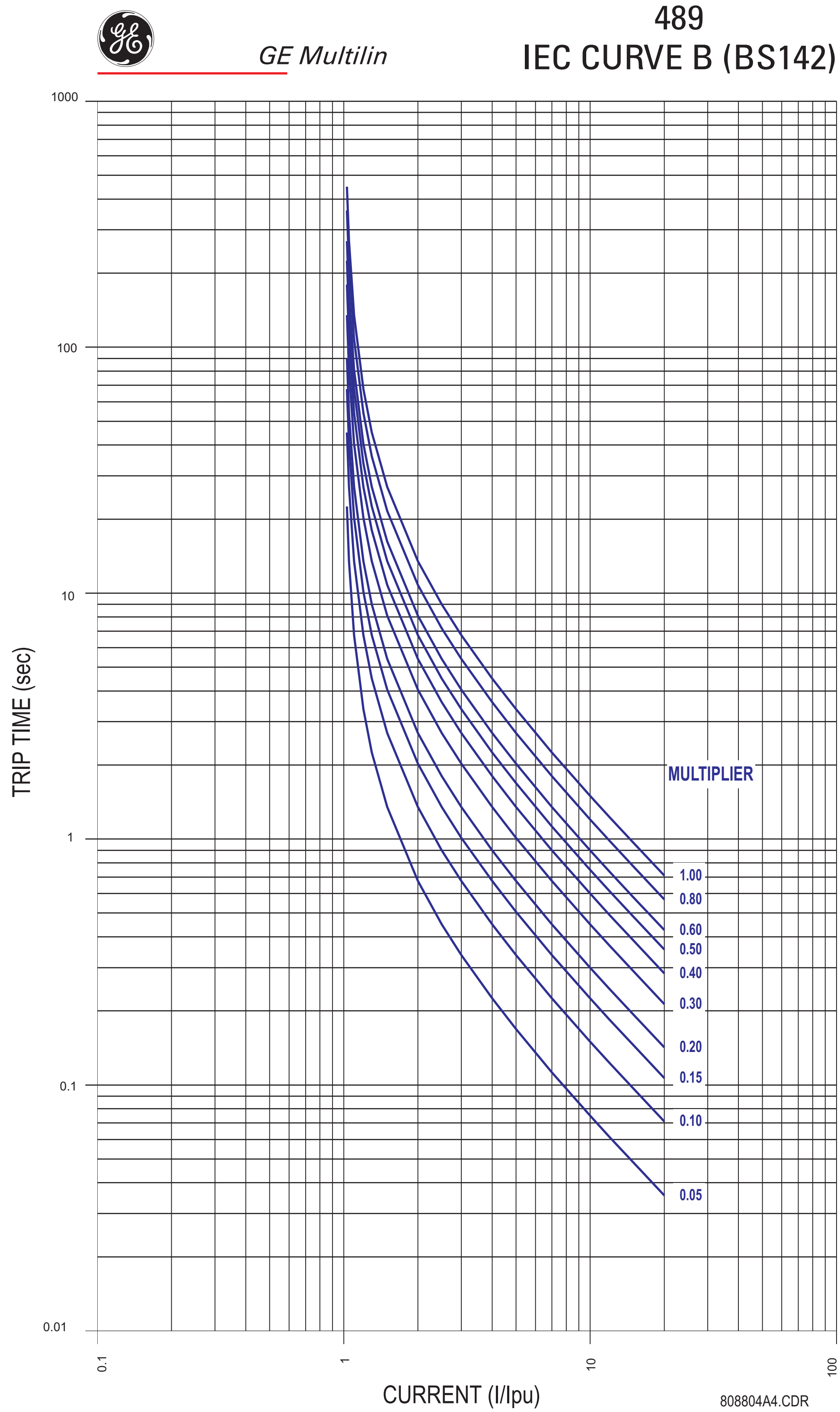


FIGURE A–18: IEC Curves B (BS142)

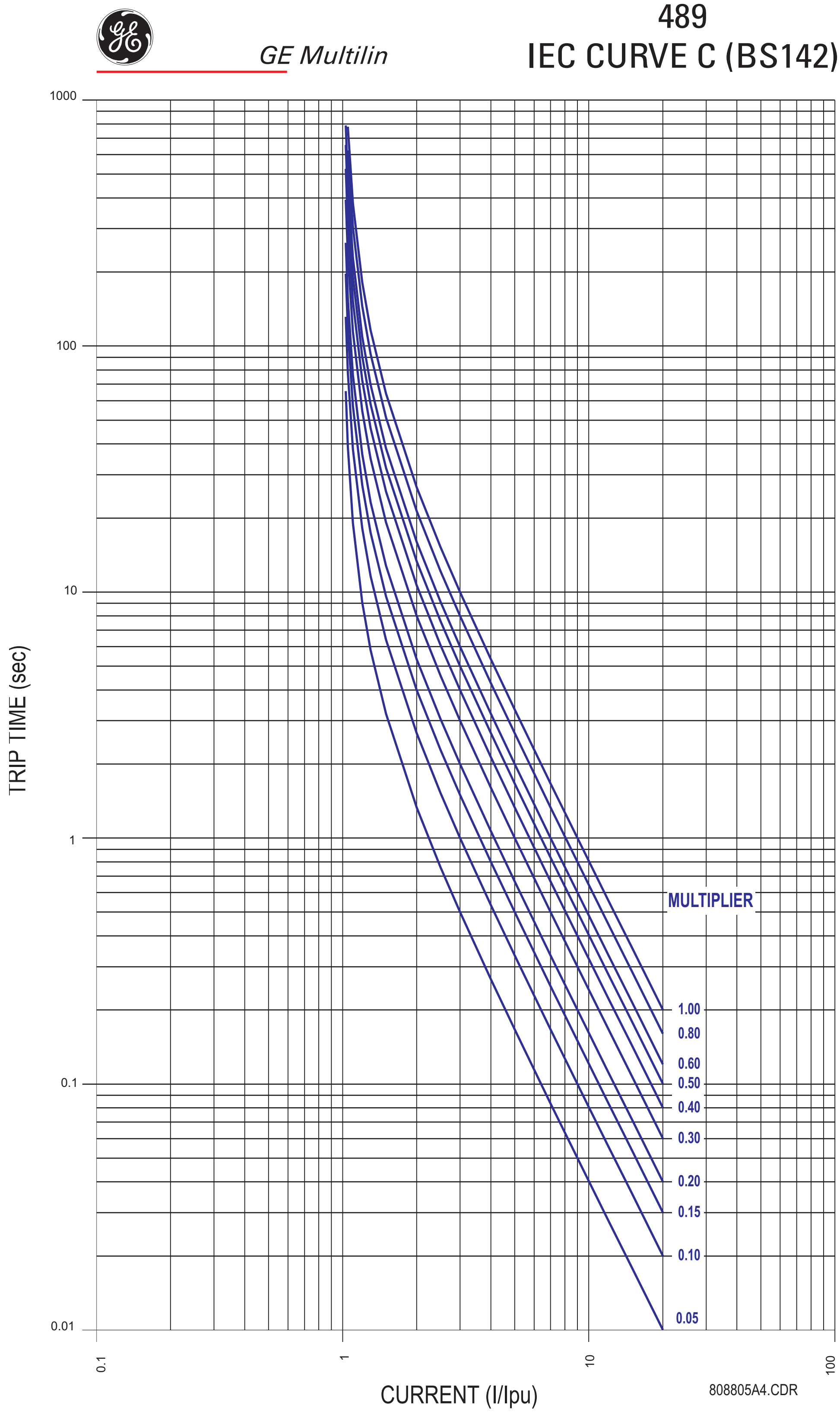


FIGURE A–19: IEC Curves C (BS142)

A.5 Revision History

A.5.1 Change Notes

Table A–2: Revision History

MANUAL P/N	REVISION	RELEASE DATE	ECO
1601-0150-A1	3.00	26 April 2004	489-249
1601-0150-A2	3.00	21 May 2004	---
1601-0150-A3	3.00	22 July 2004	---
1601-0150-A4			
1601-0150-A5	4.0x	21 July 2006	
1601-0150-A6	4.0x	9 February, 2007	
1601-0150-A7	4.0x	31 March, 2007	
1601-0150-A8	4.0x	3 April, 2008	
1601-0150-A9	4.0x	12 June, 2008	
1601-0150-AA	4.0x	10 September, 2008	
1601-0150-AB	4.0x	2 December, 2008	
1601-0150-AC	4.0x	23 April, 2009	
1601-0150-AD	4.0x	21 July, 2009	

A.5.2 Changes to the 489 Manual

Table A–3: Major Updates for 489 Manual Revision AD

SECT (AC)	SECT (AD)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-AD
3.1.6	3.1.6	Revision	Figure 3-9 revised.
3.2.1	3.2.1	Revision	Figure 3-10 revised.

Table A–4: Major Updates for 489 Manual Revision AC

SECT (AB)	SECT (AC)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-AC

Table A–4: Major Updates for 489 Manual Revision AC

SECT (AB)	SECT (AC)	CHANGE	DESCRIPTION
4.1.7	4.1.7	Revision	Self-test Warnings table: Relay Not Configured revised.

Table A–5: Major Updates for 489 Manual Revision AB

SECT (AA)	SECT (AB)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-AB
2.2.5	2.2.5	Revision	Power Metering - changes to spec.
7.3.2	7.3.2	Revision	Changes to specs.

Table A–6: Major Updates for 489 Manual Revision AA

SECT (A9)	SECT (AA)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-AA
5.6.9	5.6.9		Change Note (Pickup Level)

Table A–7: Major Updates for 489 Manual Revision A9

SECT (A8)	SECT (A9)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A9
5.6.5	5.6.5		Fig 5-2: Change graph

Table A–8: Major Updates for 489 Manual Revision A8

SECT (A7)	SECT (A8)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A8
2.1.2 2.2.5	2.1.2 2.2.5	Update	Changes to DC Power Supply range
fig 5-2	fig 5-2		Change graph
	8.2.1	Add	New Section: Stator Differential Protection

Table A–8: Major Updates for 489 Manual Revision A8

SECT (A7)	SECT (A8)	CHANGE	DESCRIPTION
8.2.1	8.3.1	Update	Drawings changed
Equn 7.7	Equn 7.7	Update	Change equation

Table A–9: Major Updates for 489 Manual Revision A7

PAGE (A5)	SECT (A6)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A6
5-31	5.6.8	Correction	Changes to step value - Differential Trip Delay
2-9	2.2.6	Correction	Changes to Littelfuse SLO-BLO data
2-7,8 5-39,40	2.2.3 5.7.5,6	Update	Changes to OverFrequency and Underfrequency parameters

Table A–10: Major Updates for 489 Manual Revision A6

PAGE (A5)	PAGE (A6)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A6
2-14	2-14	Update	Changes to ELECTROSTATIC DISCHARGE value

Table A–11: Major Updates for 489 Manual Revision A4

PAGE (A3)	PAGE (A4)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A4
2-	2-	Update	Updated ORDERING section
2-	2-	Update	Updated SPECIFICATIONS section
---	3-4	Add	Added ETHERNET COMMUNICATION section
5-	---	Remove	Removed SERIAL PORTS section
---	5-	Add	Added COMMUNICATIONS section
5-44	5-44	Update	Updated DISTANCE ELEMENT section

Table A–11: Major Updates for 489 Manual Revision A4

PAGE (A3)	PAGE (A4)	CHANGE	DESCRIPTION
---	6-3	Add	Added NETWORK STATUS section
---	7-16	Add	Added DISTANCE ELEMENT ACCURACY section

Table A–12: Major Updates for 489 Manual Revision A3

PAGE (A2)	PAGE (A3)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A3
5-67	5-67	Update	Updated THERMAL MODEL COOLING diagram to 808705A2

Table A–13: Major Updates for 489 Manual Revision A2

PAGE (A1)	PAGE (A2)	CHANGE	DESCRIPTION
Title	Title	Update	Manual part number to 1601-0150-A2
Additional changes for revision A2 were cosmetic. There was no change to content.			

A.6 EU Declaration of Conformity

A.6.1 EU Declaration of Conformity

General Electric Multilin
215 Anderson Ave. Markham, Ontario Canada. L6E 1B3
Tel: (905) 294-6222 Fax: (905) 294-8512

EU DECLARATION OF CONFORMITY

Applicable Council Directive(s): **1)** 73/23/EEC The Low Voltage Directive
2) 89/336/EEC The EMC Directive

Standard(s) to Which Conformity is Declared:

1)

EN 60947-1 : 1999	Low-voltage switchgear and control gear
EN 1010-1:1990+ A 1:1992+ A 2:1995	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

2)

EN 50263: 1999	EMC Product Standard for Measuring Relays and Protection Equipment

Manufacturer's Name: General Electric Multilin

Manufacturer's Address: 215 Anderson Ave.
Markham, Ontario, Canada
L6E 1B3

Manufacturer's Representative in the EU: Jokin Galletero
GE Multilin
Avenida Pinoa 10
48170 Zamudio, Spain
Tel.: 34-94-4858817 Fax: 34-94-4858838

Type of Equipment: Protection & Control Relay

Model Number: SR489

First Year of Manufacture: 1999

I the undersigned, hereby declare that the equipment specified above conforms to the above Directives and Standards.

Full Name: Jeff Mazereeuw

Position: Technology Manager

Signature: Jeff M

Place: GE Multilin

Date: February 13, 2006

A.7 Warranty

A.7.1 GE Multilin Warranty

General Electric Multilin Inc. (GE Multilin) 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 Multilin 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 Multilin authorized factory outlet.

GE Multilin 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 Multilin Standard Conditions of Sale.

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