Digital Energy
Multilin

489 Generator Management Relay
Instruction Manual

Firmware Revision: 4.0X

Manual Part Number: 1601-0150-AF
Manual Order Code: GEK-106494P

GE Multilin

215 Anderson Avenue, Markham, Ontario

Canada L6E 1B3

Tel: (905) 294-6222 Fax: (905) 201-2098

Internet: http://www.GEindustrial.com/multilin

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

Part number: 1601-0150-AF (July 2011)

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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
```

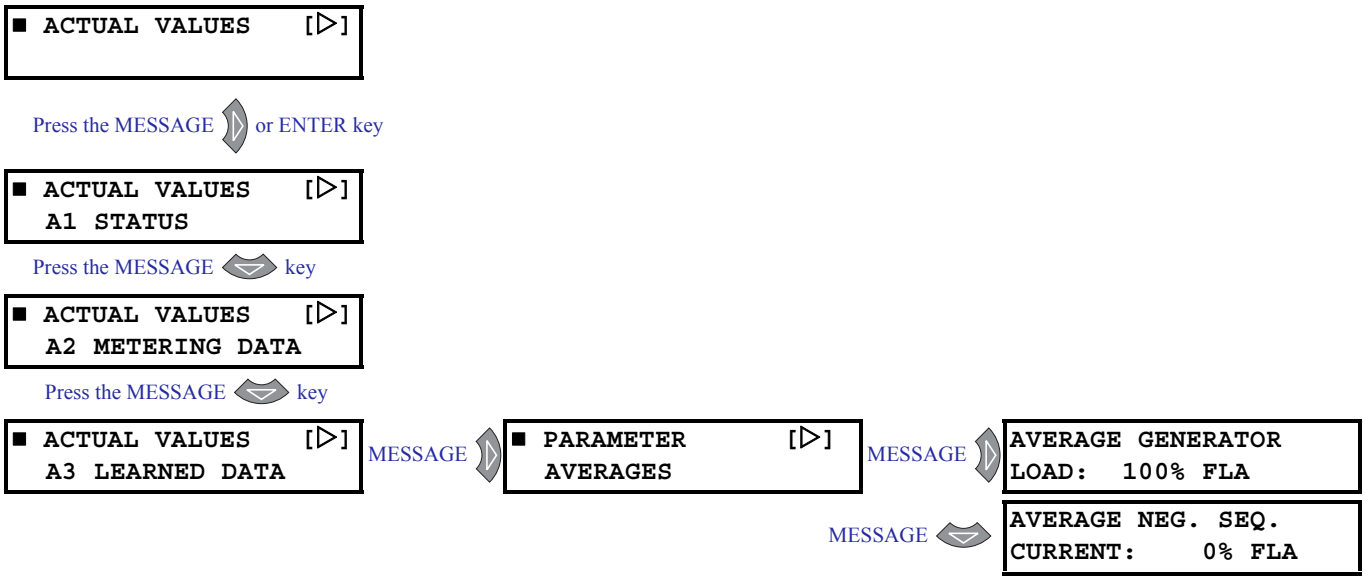
▷ Press the ◀ MESSAGE key twice to return to the **A4 MAINTENANCE** page header.

```
■ 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.

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.

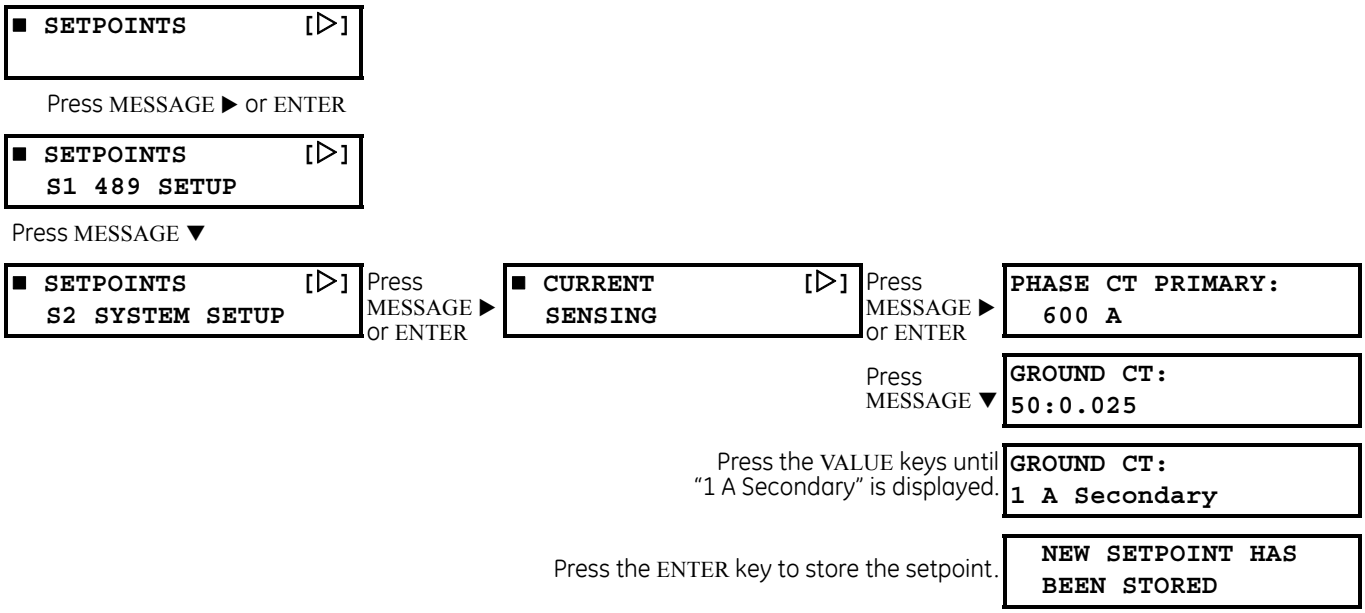
```
PHASE CT PRIMARY:
 600 A
```

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	●	●

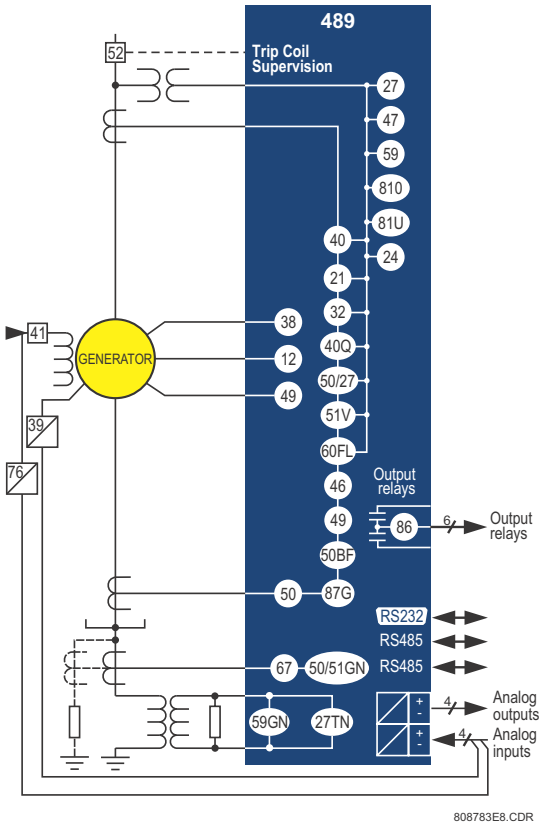

FIGURE 2–1: Single Line Diagram

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

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	Additional Features
Voltage (phasors)	Drawout Case (maintenance and testing)
Current (phasors) and Amps Demand	Breaker Failure
Real Power, MW Demand, MWh	Trip Coil Supervision
Apparent Power and MVA demand	VT Fuse Failure
MW, Mvar, and ±MVarh demand	Simulation
Frequency	Flash Memory for easy firmware upgrades
Power Factor	
RTD	
Speed in RPM with a Key Phasor Input	
User-Programmable Analog Inputs	

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

Ground CT	Input	Burden	
		VA	Ω
1 A / 5 A	1 A	0.024	0.024
	5 A	0.605	0.024
	20 A	9.809	0.024
50:0.025 HGF	0.025 A	0.057	90.7
	0.1 A	0.634	90.7
	0.5 A	18.9	75.6

GROUND CT CURRENT WITHSTAND (SECONDARY)

Ground CT	Withstand Time		
	1 sec.	2 sec.	continuous
1 A / 5 A	80 × CT	40 × CT	3 × CT
50:0.025 HGF	N/A	N/A	150 mA

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

IRIG-B

Amplitude Modulated:	2.5 to 6.0 Vpk-pk at 3:1 signal ratio
DC shift:	TTL
Input impedance:	50 kΩ ±10%

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

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