GE
Grid Solutions

# GPM

## Field and Stator Ground Fault Protection Modules


# Instruction Manual

Product version: 2.0x

GE publication code: 1601-0256-AH1 (GEK-113231F)

imagination at work

GPM Field and Stator Ground Fault Protection Modules Instruction Manual for version 2.0x.



Part number: 1601-0256-AH1 (October 2018)

# GPM Field and Stator Ground Fault Protection Modules

# Table of contents

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 1: Introduction

This chapter outlines safety and technical support information.

## Safety symbols and definitions

Before attempting to install or use the device, review all safety indicators in this document to help prevent injury, equipment damage, or downtime.

The following safety and equipment symbols are used in this document.

**DANGER** **Indicates a hazardous situation which, if not avoided, will result in death or serious injury.**

**WARNING** **Indicates a hazardous situation which, if not avoided, could result in death or serious injury.**

**CAUTION** **Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.**

**NOTICE** Indicates practices not related to personal injury.

### General cautions and warnings

The following general safety precautions and warnings apply.

**DANGER** **Ensure that all connections to the product are correct so as to avoid accidental risk of shock and/or fire, for example such as can arise from high voltage connected to low voltage terminals.**

**Follow the requirements of this manual, including adequate wiring size and type, terminal torque settings, voltage, current magnitudes applied, and adequate isolation/ clearance in external wiring from high to low voltage circuits.**

**Use the device only for its intended purpose and application.**

**Ensure that all ground paths are uncompromised for safety purposes during device**

**operation and service.**

**Ensure that the control power applied to the device, the AC current, and voltage input match the ratings specified on the relay nameplate. Do not apply current or voltage in excess of the specified limits.**

**Only qualified personnel are to operate the device. Such personnel must be thoroughly familiar with all safety cautions and warnings in this manual and with applicable country, regional, utility, and plant safety regulations.**

**Hazardous voltages can exist in the power supply and at the device connection to current transformers, voltage transformers, control, and test circuit terminals. Make sure all sources of such voltages are isolated prior to attempting work on the device.**

**Hazardous voltages can exist when opening the secondary circuits of live current transformers. Make sure that current transformer secondary circuits are shorted out before making or removing any connection to the current transformer (CT) input terminals of the device.**

**For tests with secondary test equipment, ensure that no other sources of voltages or currents are connected to such equipment and that trip and close commands to the circuit breakers or other switching apparatus are isolated, unless this is required by the test procedure and is specified by appropriate utility/plant procedure.**

**When the device is used to control primary equipment, such as circuit breakers, isolators, and other switching apparatus, all control circuits from the device to the primary equipment must be isolated while personnel are working on or around this primary equipment to prevent any inadvertent command from this device.**

**Use an external disconnect to isolate the mains voltage supply.**

**Personal safety can be affected if the product is physically modified by the end user. Modifications to the product outside of recommended wiring configuration, hardware, or programming boundaries is not recommended end-use practice. Product disassembly and repairs are not permitted. All service needs to be conducted by the factory.**

## For further assistance

For product support, contact the information and call center as follows.

GE Grid Solutions
650 Markland Street
Markham, Ontario
Canada L6C 0M1
Worldwide telephone: +1 905 927 7070
Europe/Middle East/Africa telephone: +34 94 485 88 54
North America toll-free: 1 877 547 8629
Fax: +1 905 927 5098
Worldwide e-mail: multilin.tech@ge.com
Europe e-mail: multilin.tech.euro@ge.com
Website: http://www.gegridsolutions.com/multilin

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 2: Product description

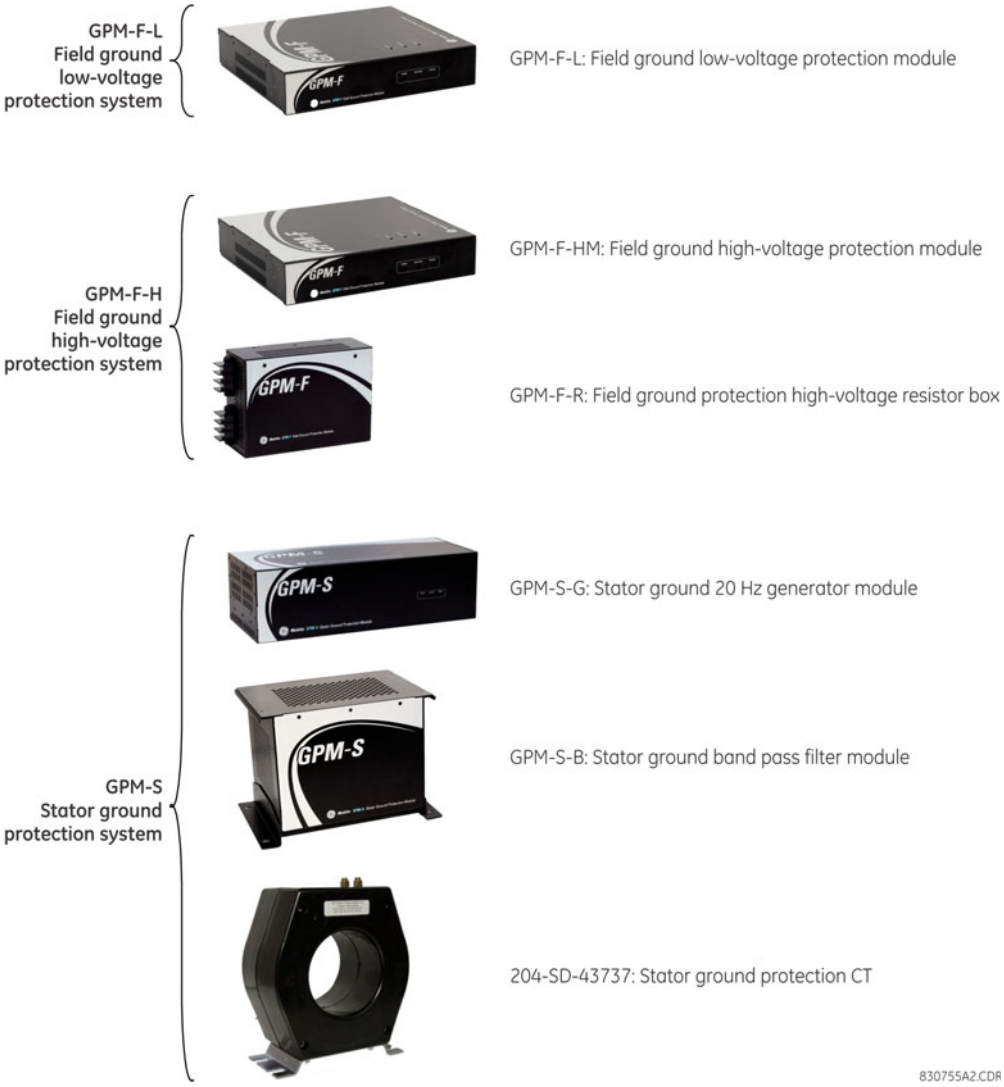
## Overview

A ground protection module (GPM) is used with the G60 Generator Protection System and MiCOM Agile P345 Generator Protection System in the following configurations:

- Field low voltage protection system for voltages up to 600 V DC, order code GPM-F-L
- Field high voltage protection system for voltages greater than 600 V DC, order code GPM-F-H
- Stator protection system for G60 or MiCOM Agile P345, order code GPM-S

The following figure compares these systems.

**Figure 1: Generator ground protection components**



The following figures show placement of GPM-F and GPM-S units.

**Figure 2: GPM-F placement**

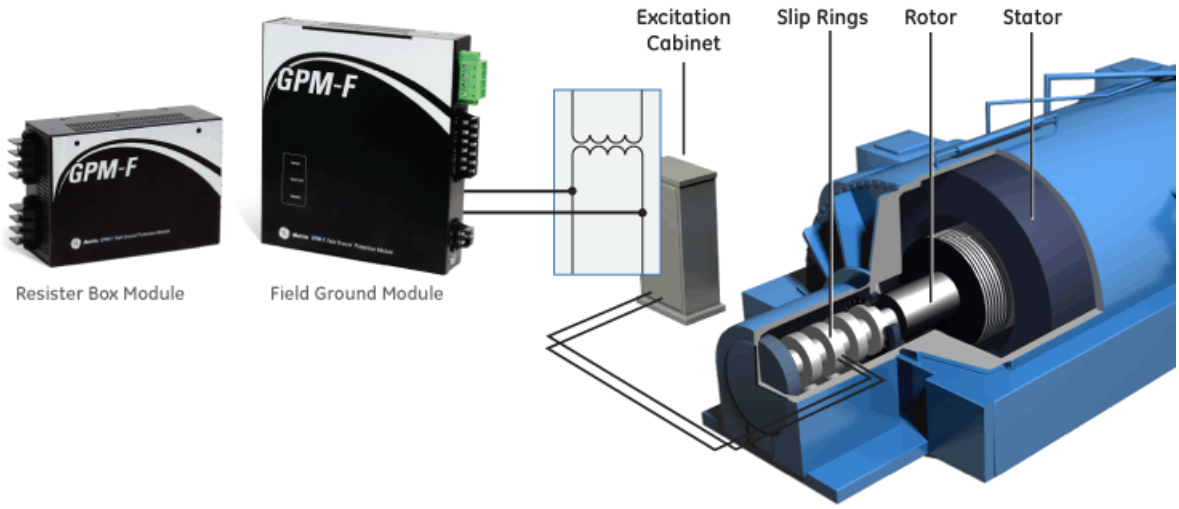
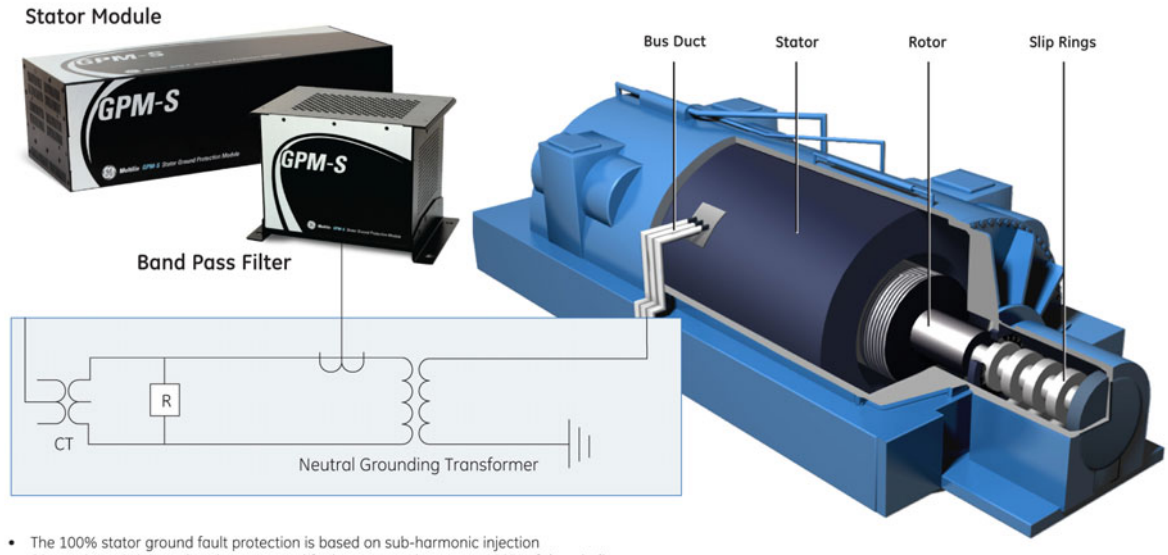



**Figure 3: GPM-S placement**

## 100% Stator Ground Fault Detection




- The 100% stator ground fault protection is based on sub-harmonic injection
- 20Hz voltage is injected to detect ground faults at any point across 100% of the winding
- The stator ground module works in combination with the G60 to provide 100% stator ground fault protection
- Operational during generator start-up, running and stopped conditions

The GPM units are set up and run from the G60 or MiCOM Agile P345.

# Specifications

### GPM-F CONTACT INPUTS

| | |
|---|---|
| Internal wetting: | 24 V DC, terminals (B6 I/P#3, B7 I/P#2, B8 I/P#1, B9 I/P common) |
| Input comparator threshold: | 6 V DC |
| External contact: | dry |
| Current when energized: | < 10 mA |
| Debounce time: | 10 ms |

### GPM-F CRITICAL FAILURE RELAY

| | |
|---|---|
| Make and carry: | 30 A for 0.2 s as per ANSI C37.90, terminals (B10 NC, B12 NO, B11 common) |
| Continuous carry: | 8 A |
| Break (DC inductive, L/R = 40 ms): | 1 A at 24 V, 0.5 A at 48 V, 0.3 A at 125 V, 0.2 A at 250 V |
| Operate time: | < 8 ms |
| Contact material: | silver alloy |

### GPM-F POWER SUPPLY

| | |
|---|---|
| GPM-F-L: | 100 to 240 V AC at 50/60 Hz and 10 VA<br>125 to 250 V DC at 10 W<br>terminals (A1 Line or Positive DC, A2 Neutral or Negative DC, A3 Earth Ground) |
| GPM-F-HM: | 100 to 240 V AC at 50/60 Hz and 10 VA<br>125 to 250 V DC at 10 W |

### GPM-F-R

| | |
|---|---|
| Current limiting resistor: | 12.5 Ω × 4 |
| Voltage divider resistor: | 5 Ω × 3 |
| Field voltage outputs: | 600 V DC rated field voltage. terminals (A3 F1, A5 F(-), A7 F(+)) |
| Field voltage inputs: | 800 V DC rated field voltage. terminals (B1 F2+, B3 F2, C1 F-) |

### GPM-S-G CONTACT INPUTS

| | |
|---|---|
| Field voltage: | 600 V DC rated field voltage. terminals (C1 FGND, C2 F1, C3 F(-), C4 F(+)) |
| Internal wetting: | 24 V DC, terminals (A1 I/P#1, A2 I/P #2, A6 I/P common) |
| Input comparator threshold: | 6 V DC |
| External contact: | dry |
| Current when energized: | < 10 mA |
| Debounce time: | 10 ms |
| Field voltage: | 600 V DC rated field voltage |

### GPM-S-G CRITICAL FAILURE RELAY

| | |
|---|---|
| Terminals: | A3 NC, A7 NO, A8 common |
| Make and carry: | 30 A for 0.2 s as per ANSI C37.90 |
| Continuous carry: | 8 A |
| Break (DC inductive, L/R = 40 ms): | 1 A at 24 V<br>0.5 A at 48 V<br>0.3 A at 125 V<br>0.2 A at 250 V |
| Operate time: | < 8 ms |
| Contact material: | silver alloy |

### GPM-S-G POWER SUPPLY

| | |
|---|---|
| Power supply: | 100 to 240 V AC at 50/60 Hz and 110 VA<br>125 to 250 V DC at 110 W<br>terminals (B8 Earth Ground, B9 Neutral or Negative DC, B10 Line or Positive DC) |

Output ratings: 26 V rectangular at 20 Hz, load capability 80 VA

**GPM-S-B**

Power rating: 80 VA
Input ratings: maximum 30 V rectangular at 20 Hz, terminals (A1 Input1, A3 Input2)
Output rating: maximum 30 V rectangular at 20 Hz (field load dependent), terminals (B1 Output1, B3 Output2)
Divider Input: maximum 480 V AC 50/60Hz. terminals (B6 Divider high, B7 Divider low)
Divider Output: maximum 240 V AC 50/60Hz. terminals (A6 Divider out, A7 Divider Low)

**STATOR GROUND PROTECTION CT**

Part number: 204-SD-43737
Turns ratio: 400:5A
Rating factor (RF): 3.0
Frequency: 20 Hz
Voltage insulation: 600 V
Basic impulse level (BIL): 10 kV
Calculated relay class at 20 Hz: C20
Approximate weight: 35 lbs (15.9 kg)

| Test | Reference standard | Test level | |
|---|---|---|---|
| | | GPM-F types | GPM-S types |
| Dielectric voltage withstand | EN 60255-5 | 2.3 kV AC / 4.6 kV DC | 2.3 kV AC / 3.3 kV DC |
| Impulse voltage withstand | EN 60255-5 | 5 kV | 5 kV |
| Insulation | EN 60255-5 | 500 V DC | 500 V DC |
| Damped oscillatory | IEC 61000-4-18 IEC 60255-22-1 | 2.5 kV CM, 1 kV DM | 2.5 kV CM, 1 kV DM |
| Electrostatic discharge | EN 61000-4-2 IEC 60255-22-2 | Level 4 | Level 4 |
| RF immunity | EN 61000-4-3 IEC 60255-22-3 | 20 V/m | 20 V/m |
| Fast transient disturbance | EN 61000-4-4 IEC 60255-22-4 | Class A and B | Class A and B |
| Surge immunity | EN 61000-4-5 IEC 60255-22-5 | Level 4 | Level 4 |
| Conducted RF immunity | EN 61000-4-6 IEC 60255-22-6 | Level 3 | Level 3 |
| Voltage interruption and ripple DC | IEC 60255-11 | 15% ripple, 1 ms to 5 s interrupts | 15% ripple, 1 ms to 5 s interrupts |
| Radiated and conducted emissions | CISPR11 / CISPR22 / IEC 60255-25 | Class A | Class A |
| Sinusoidal vibration | IEC 60255-21-1 | Class 2 | Class 1 |
| Shock and Bump | IEC 60255-21-2 | Class 2 | Class 1 |
| Seismic | IEC 60255-21-3 | Class 2 | Class 1 |
| Power magnetic immunity | IEC 61000-4-8 | Level 5 | Level 5 |
| Pulse magnetic immunity | IEC 61000-4-9 | Level 4 | Level 4 |
| Damped magnetic immunity | IEC 61000-4-10 | Level 4 | Level 4 |

| Test | Reference standard | Test level | |
|---|---|---|---|
| | | GPM-F types | GPM-S types |
| Voltage dip and interruption | IEC 61000-4-11 | 0%, 40%, 70%, 80% dips; 250/300 cycle interrupts | 0%, 40%, 70%, 80% dips; 250/300 cycle interrupts |
| Voltage ripple | IEC 61000-4-17 | 15% ripple | 15% ripple |
| Ingress protection | IEC 60529 | IP10 | IP10 |
| Environmental (cold) | IEC 60068-2-1 | –40°C, 16 hrs | –40°C, 16 hrs |
| Environmental (dry heat) | IEC 60068-2-2 | 85°C, 16hrs | 85°C, 16hrs |
| Relative humidity cyclic | IEC 60068-2-30 | 6 day, variant 1 | 6 day, variant 1 |
| SWC oscillatory | IEEE/ANSI C37.90.1 | 2.5 kV,1 MHz | 2.5 kV,1 MHz |
| SWC transients | IEEE/ANSI C37.90.1 | 4 kV 2.5 kHz | 4 kV 2.5 kHz |
| RF immunity | IEEE/ANSI C37.90.2 | 20 V/m | 20 V/m |
| ESD | IEEE/ANSI C37.90.3 | 15 kV air / 8 kV contact | 15 kV air / 8 kV contact |
| Safety | UL 508 | e83849 NKCR2 | e83849 NKCR2 |
| | UL C22.2-14 | e83849 NKCR8 | e83849 NKCR8 |

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 3: Field ground module

## Field ground low-voltage module

### Mechanical installation

The field ground low-voltage protection system consists of one module: the field ground protection low-voltage module (GPM-F-L). The figures show dimensions and mounting.

**Figure 4: Dimensions for panel-mounted GPM-F-L**

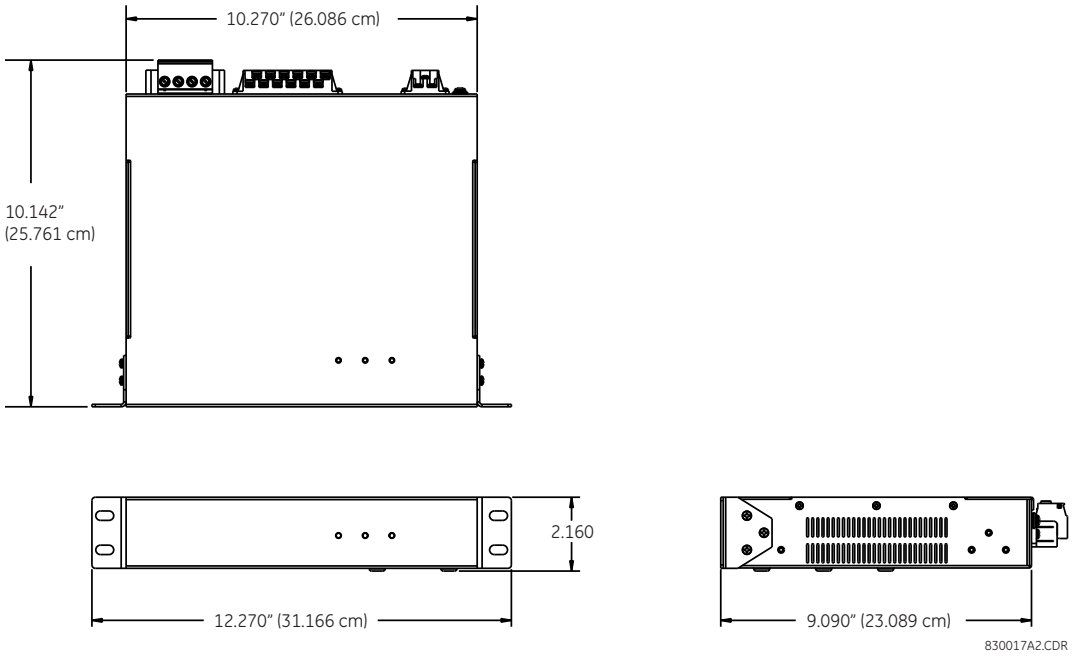


**Figure 5: Dimensions for wall-mounted GPM-F-L**

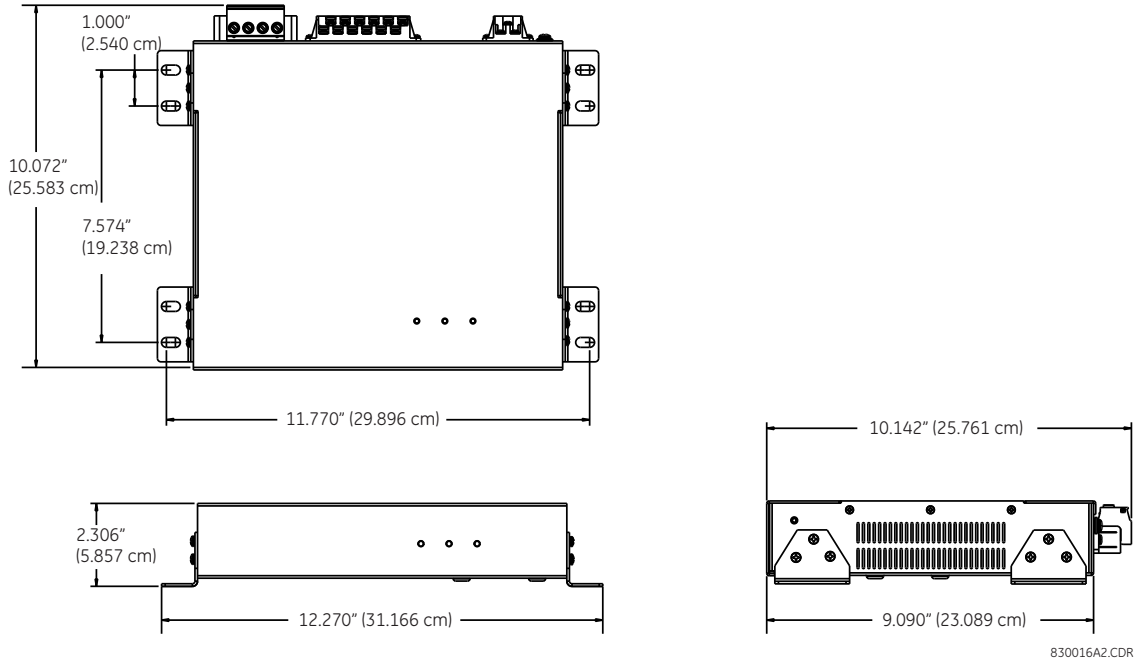


**Figure 6: Mounting for panel-mounted GPM-F-L**

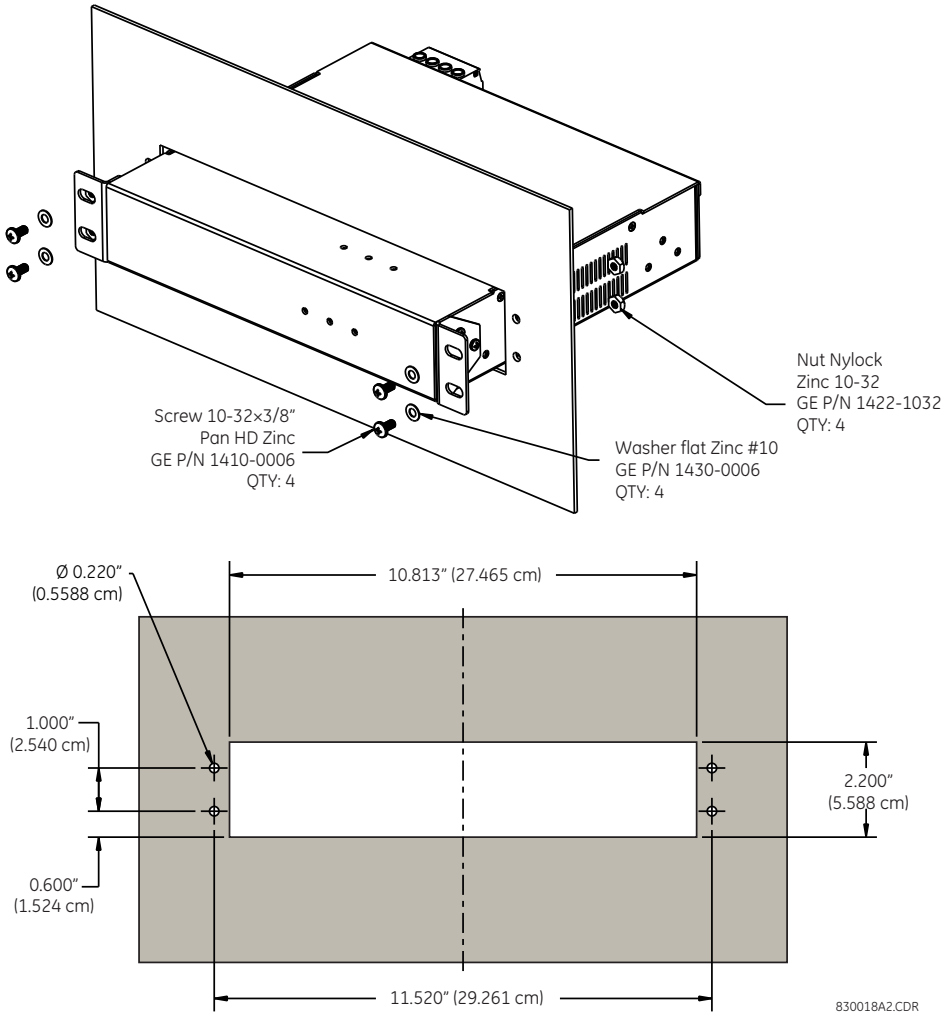
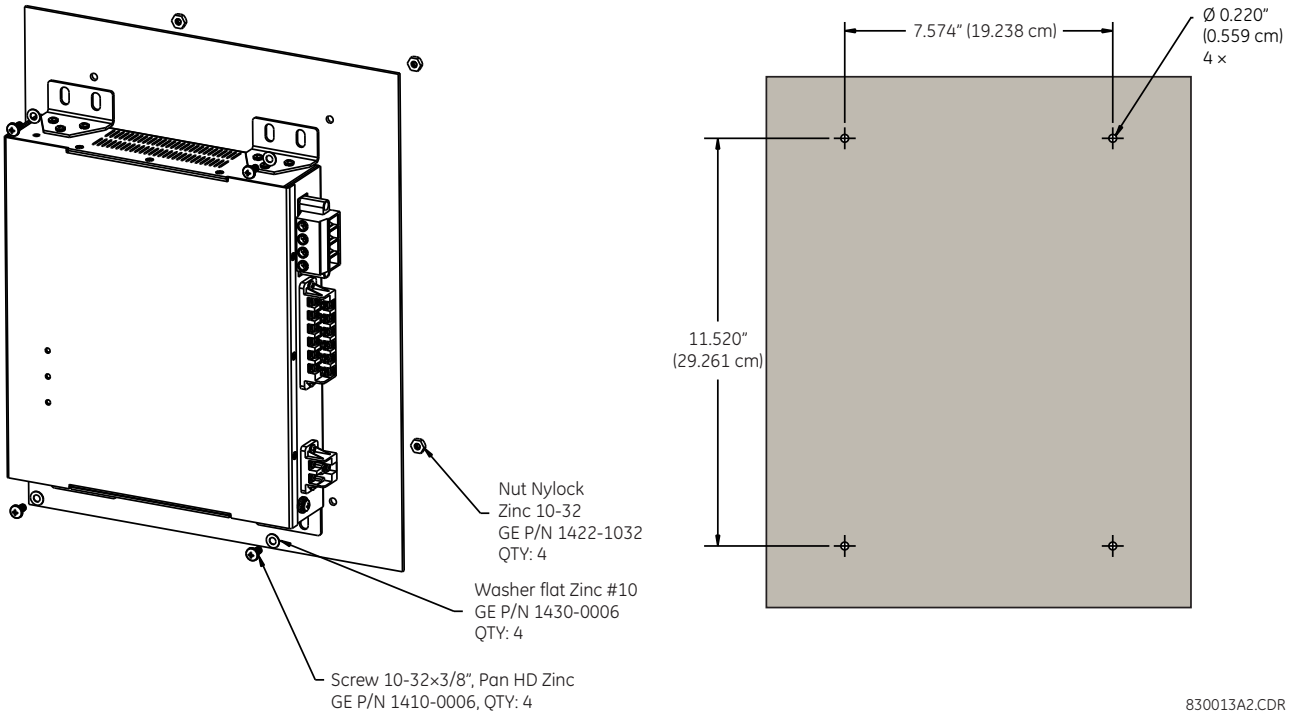


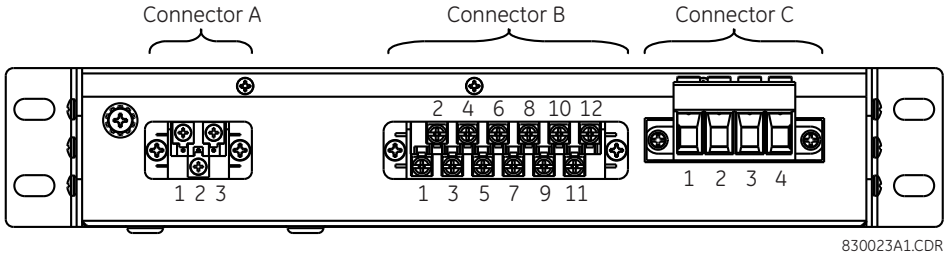
**Figure 7: Mounting for wall-mounted GPM-F-L**




## Electrical installation

There are three connectors on the field protection low-voltage module, as shown in the following figure.

**Figure 8: Rear view of GPM-F-L showing terminal blocks**



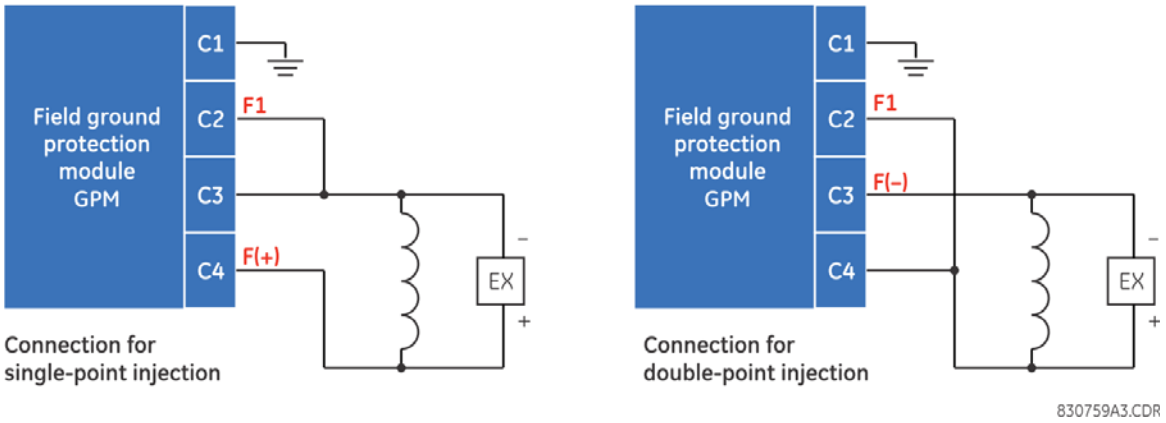
The table outlines the pin assignments. Three contact inputs are provided. Upon closure of any of the contact inputs, low frequency injection stops.

**Table 1: Pin assignments for GPM-F-L**

| Pin | Label | Definition |
|---|---|---|
| **Connector A** | | |
| 1 | L(+) | AC-L (DC+) |
| 2 | N(–) | AC-N (DC–) |
| 3 | GND | Ground |
| **Connector B** | | |
| 1 | CH1(+) | RS485 channel 1 positive |
| 2 | CH1(–) | RS485 channel 1 negative |
| 3 | COM | RS485 common |
| 4 | CH2(+) | RS485 channel 2 positive |
| 5 | CH2(–) | RS485 channel 2 negative |
| 6 | IN3 | Contact input 3 |
| 7 | IN2 | Contact input 2 |
| 8 | IN1 | Contact input 1 |
| 9 | COM | Contact input common |
| 10 | NC | Relay NC (normally closed) |
| 11 | COM | Relay common |
| 12 | NO | Relay NO (normally open) |
| **Connector C** | | |
| 1 | FGND | Field ground |
| 2 | F1 | Injection to excitation positive (single point) / excitation positive (double point) |
| 3 | F(–) | Injection to excitation negative |
| 4 | F(+) | Excitation positive for fault location (optional connection) |

The figure illustrates how to wire the GPM-F-L module for single and double point injections.

**Figure 9: Connecting a field ground protection module**



# Field ground high-voltage module

## Mechanical installation

The field ground high-voltage protection system consists of two modules: the field ground protection high-voltage module (GPM-F-HM) and the field ground protection high-voltage resistor box (GPM-F-R). Both are required. The figures show dimensions and mounting.

**Figure 10: Dimensions for panel-mounted GPM-F-HM**

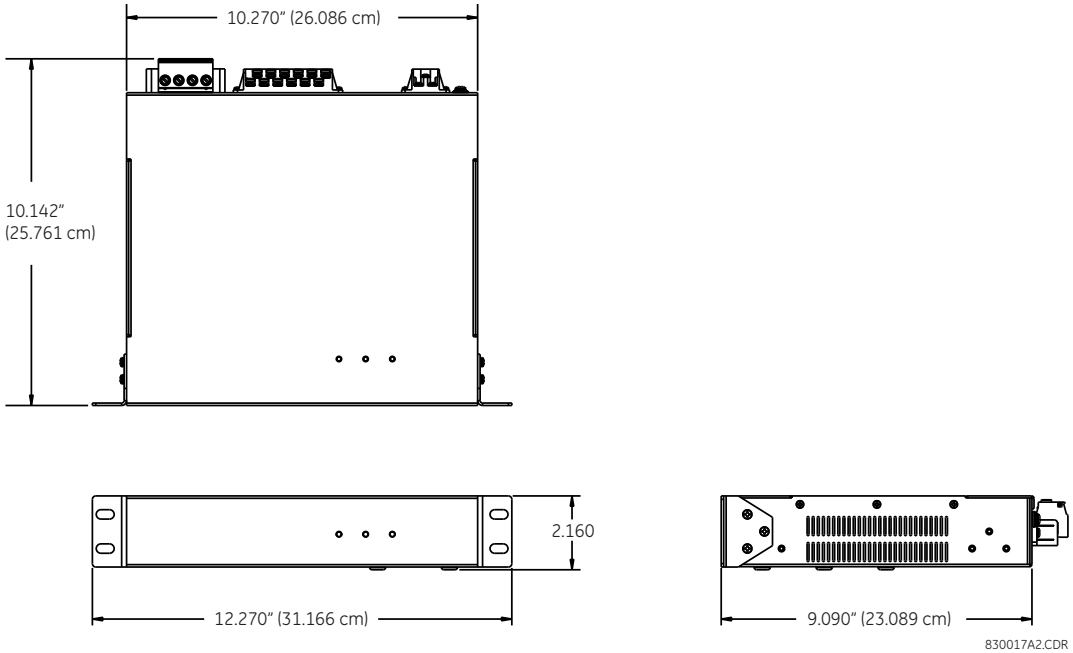



**Figure 11: Dimensions for wall-mounted GPM-F-HM**

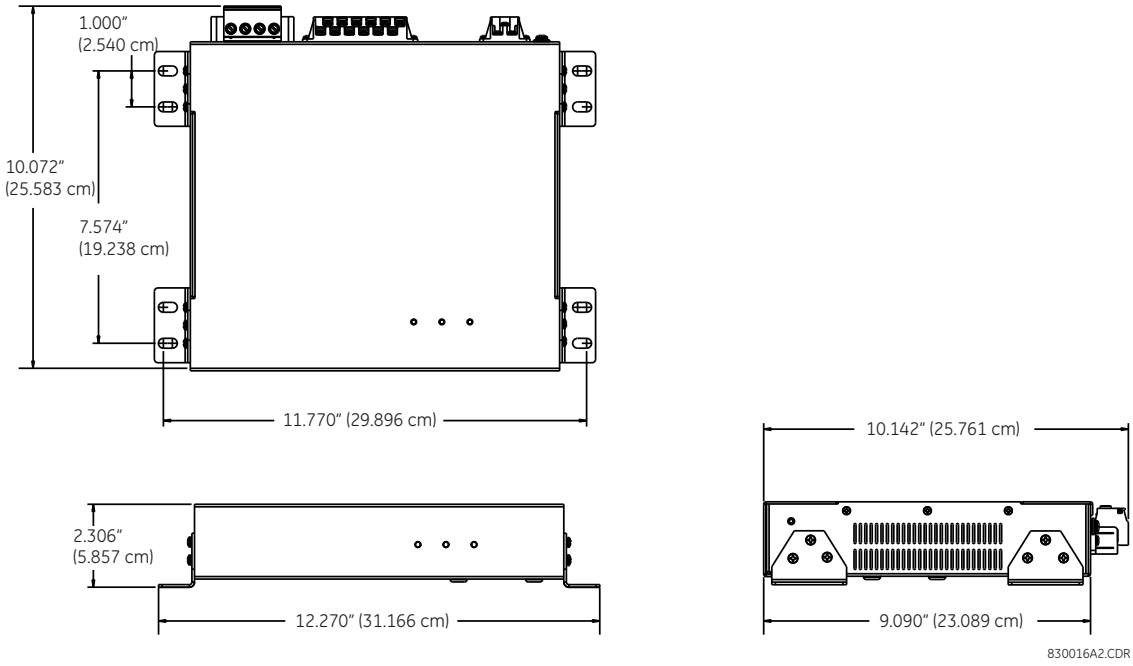


**Figure 12: Dimensions for GPM-F-R high-voltage resistor box**

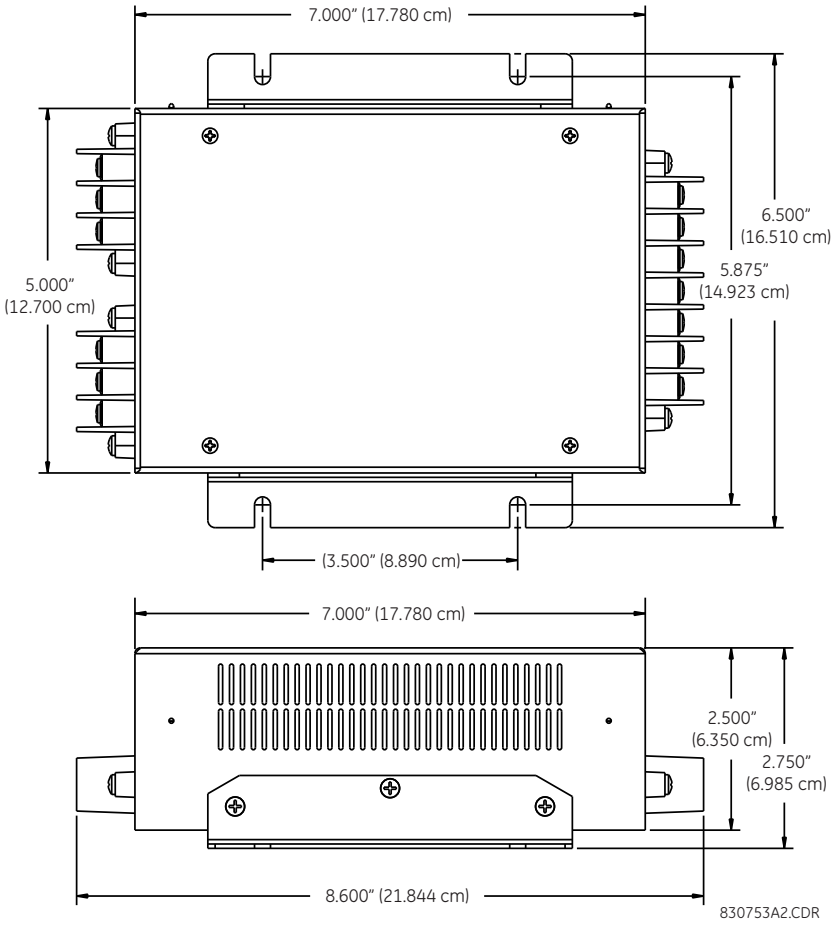


**Figure 13: Mounting for panel-mounted GPM-F-HM**

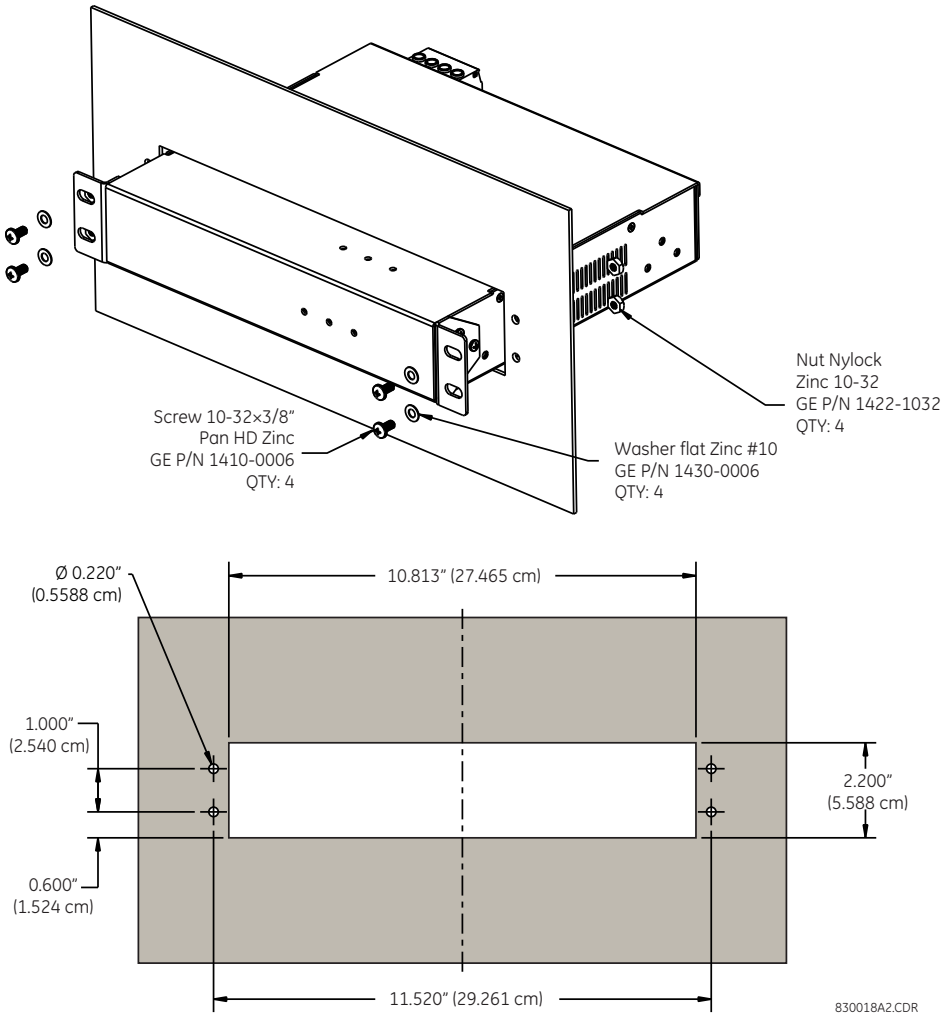


**Figure 14: Mounting for wall-mounted GPM-F-HM**

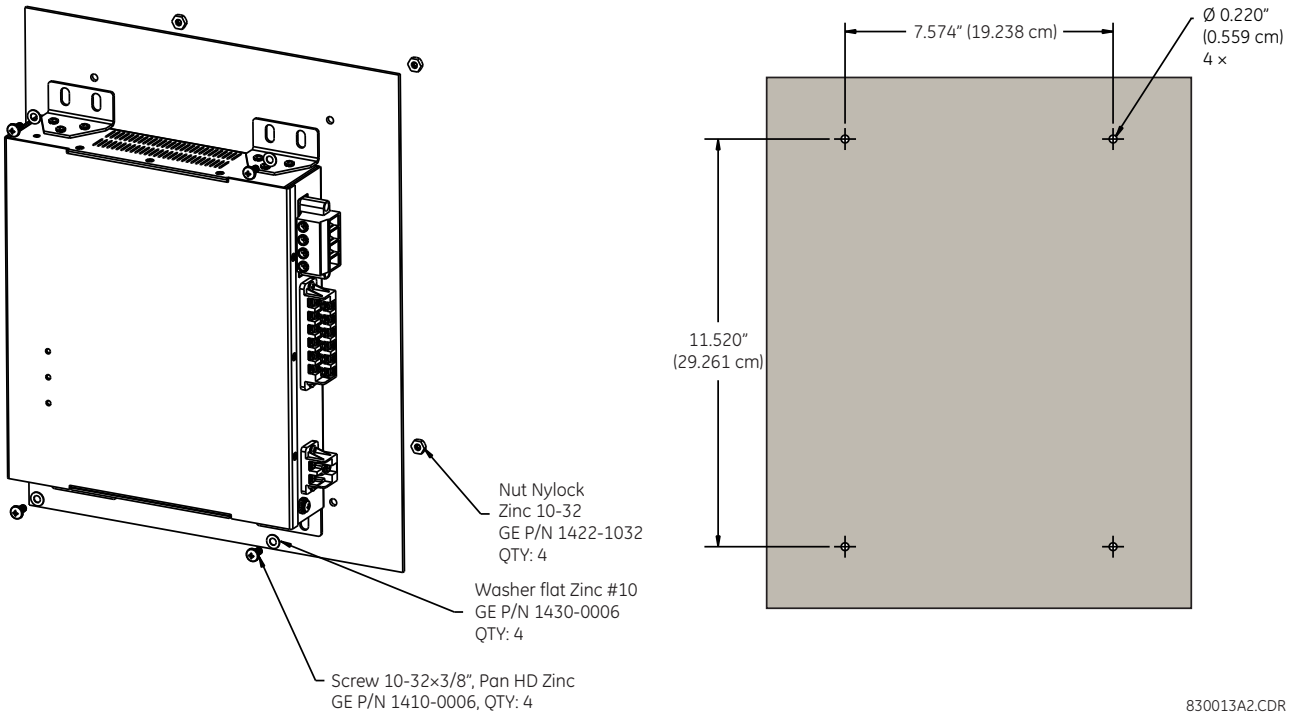
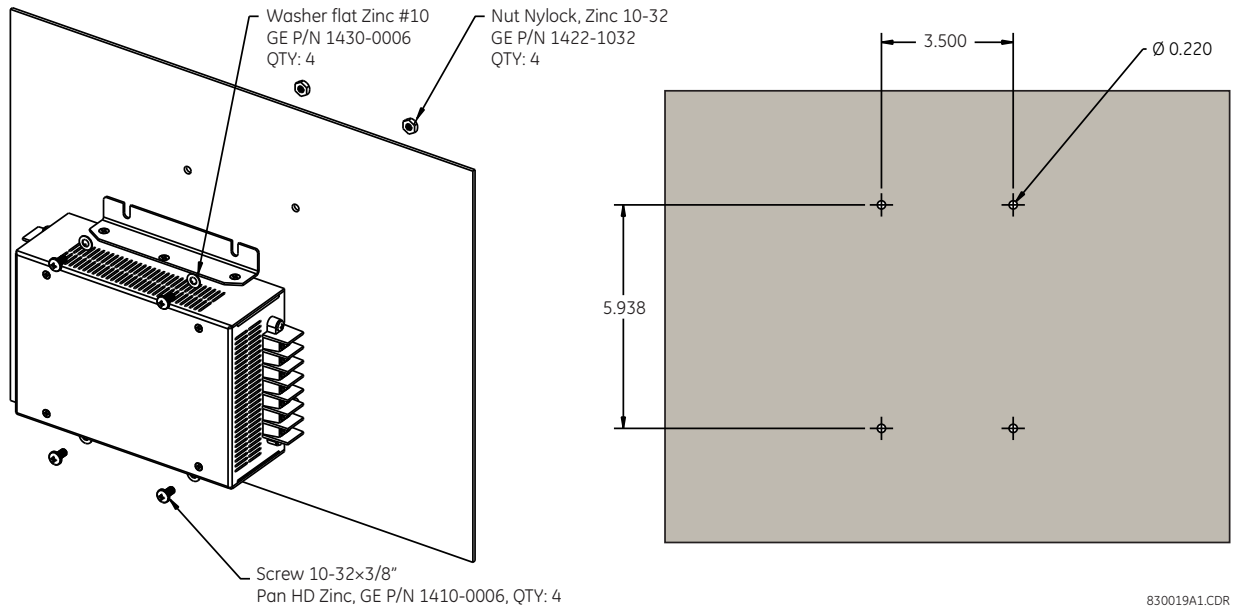


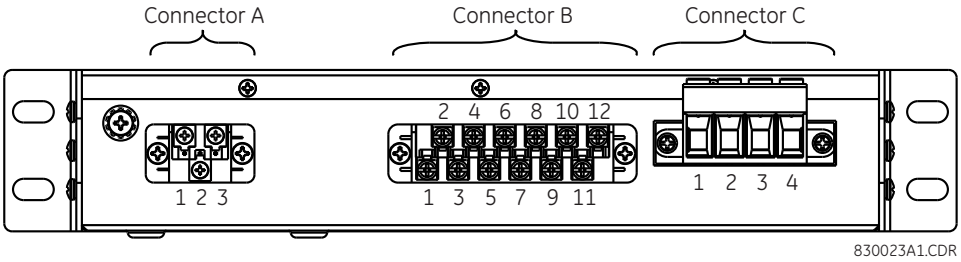

**Figure 15: Mounting for GPM-F-R high-voltage resistor box (inches)**



## Electrical installation

There are three connectors on the field ground protection high-voltage module, as shown in the following figure.

**Figure 16: Rear view of GPM-F-HM module showing terminal blocks**



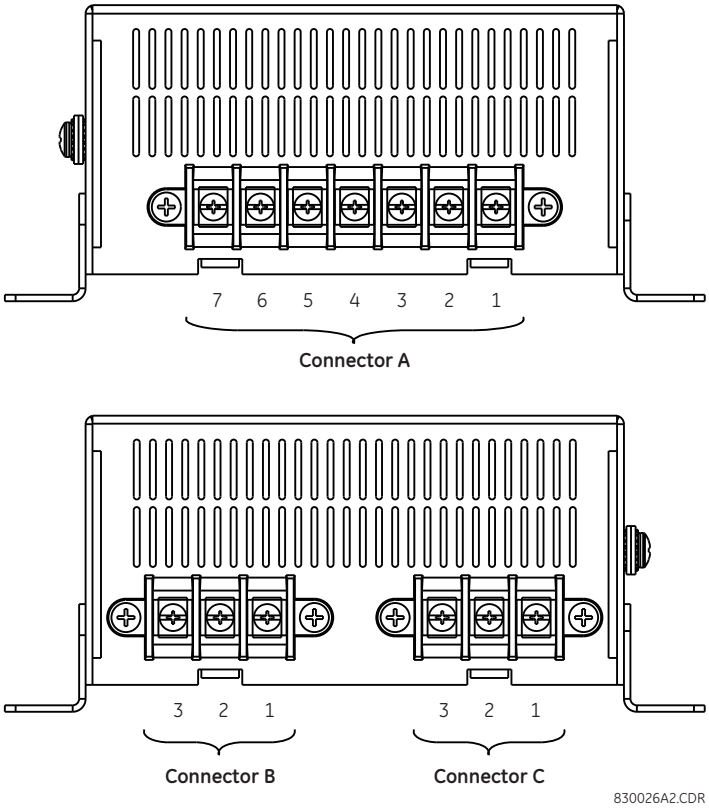

The table outlines the pin assignments. Three contact inputs are provided. Upon closure of any of the contact inputs, low frequency injection stops.

**Table 2: Pin assignments for GPM-F-HM**

| Pin | Label | Definition |
|---|---|---|
| **Connector A** | | |
| 1 | L(+) | AC-L (DC+) |
| 2 | N(–) | AC-N (DC–) |
| 3 | GND | Ground |
| **Connector B** | | |
| 1 | CH1(+) | RS485 channel 1 positive |
| 2 | CH1(–) | RS485 channel 1 negative |
| 3 | COM | RS485 common |
| 4 | CH2(+) | RS485 channel 2 positive |
| 5 | CH2(–) | RS485 channel 2 negative |
| 6 | IN3 | Contact input 3 |
| 7 | IN2 | Contact input 2 |
| 8 | IN1 | Contact input 1 |
| 9 | COM | Contact input common |
| 10 | NC | Relay NC (normally closed) |
| 11 | COM | Relay common |
| 12 | NO | Relay NO (normally open) |
| **Connector C** | | |
| 1 | FGND | Field ground |
| 2 | F1 | Injection to excitation negative (single point) /excitation positive (double point) |
| 3 | F(–) | Injection to excitation negative |
| 4 | F(+) | Excitation positive for fault location (optional connection) |

There are three connectors on the field ground protection high-voltage resistor box, as shown in the following figure.

**Figure 17: GPM-F-R module showing terminal blocks**




The table outlines the pin assignments.

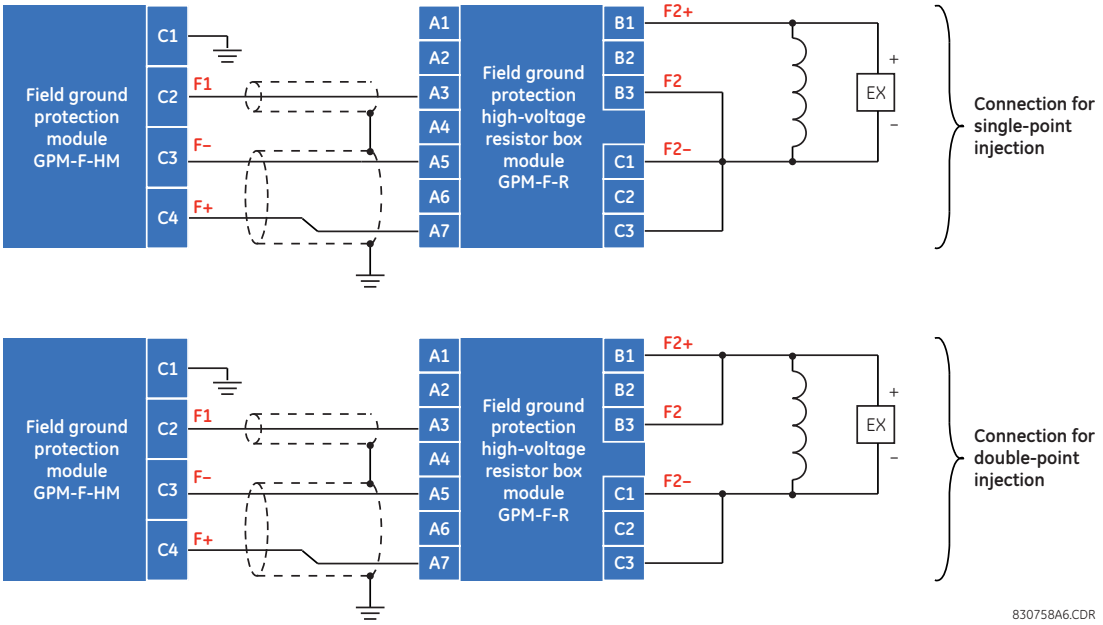
**Table 3: Pin assignments for GPM-F-R**

| Pin | Label | Definition |
|---|---|---|
| **Connector A** | | |
| 1 | A1 | Not used |
| 2 | A2 | Not used |
| 3 | A3 | Injection secondary (F1) |
| 4 | A4 | Not used |
| 5 | A5 | Excitation secondary negative (F–) |
| 6 | A6 | Not used |
| 7 | A7 | Excitation secondary positive (F+) |
| **Connector B** | | |
| 1 | B1 | Excitation primary positive (F2+) |
| 2 | B2 | Not used |
| 3 | B3 | Injection to excitation positive (F2) |
| **Connector C** | | |
| 1 | C1 | Injection to excitation negative / excitation primary negative (F2–) |
| 2 | C2 | Not used |
| 3 | C3 | Not used |

The following figure illustrates how to wire the GPM-F-HM module with the GPM-F-R resistor box for both single-point injection and double-point injection. To connect the units:

1. Externally short terminals C1 and C3 of the GPM-F-R high-voltage resistor box for both single-point injection and double-point injection.
2. Shield the connection between F1 (terminal C2) on the GPM-F-HM field ground protection module and terminal A3 on the GPM-F-R high-voltage resistor box module. Keep the connection length as short as possible, and do not exceed 10 meters.
3. Shield the connection between the F+ and F– pair (terminals C3 and C4) on the GPM-F-HM field ground protection module and terminals A5 and A7 on the GPM-F-R high-voltage resistor box module. Keep the length as short as possible, and do not exceed 10 meters.

**Figure 18: Connecting high-voltage module to high-voltage resistor box**



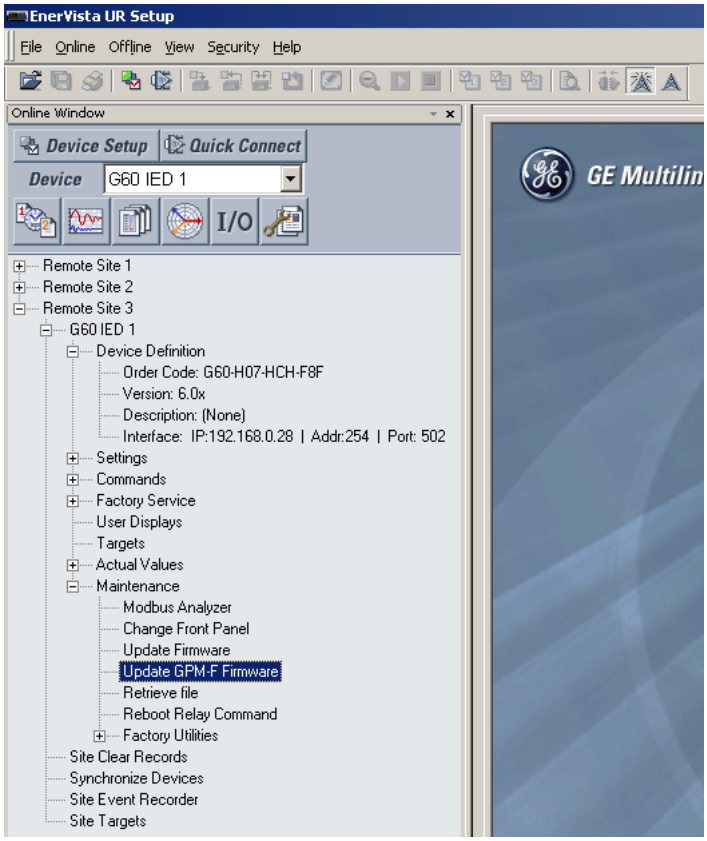

# Upgrade the GPM-F firmware

Perform the upgrade using the front port and one of the computer COM ports 1 to 4. The process also works for a serial port device, taking longer to complete (approximately 5 minutes).

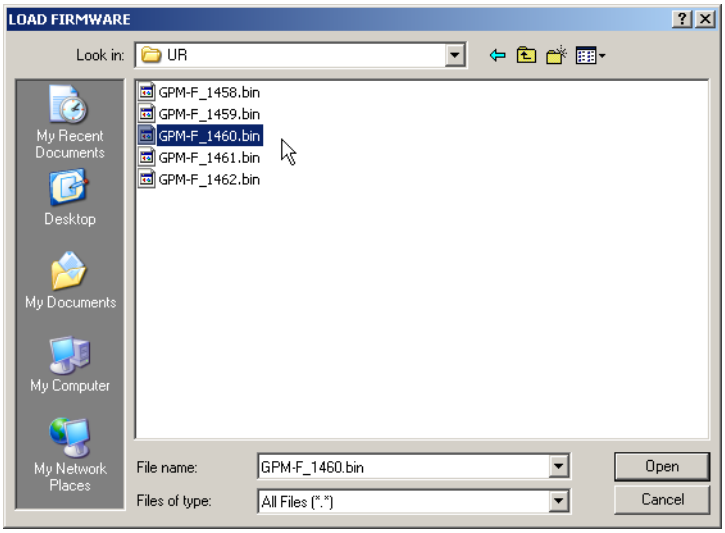
To upgrade the firmware for the GPM-F modules:

1. Start the EnerVista UR Setup software.
2. Open the G60 device so that it appears in the online window.

3. Navigate to **Maintenance > Update GPM Firmware**.




4. Select the appropriate firmware file.




5. Click the **Open** button to start the firmware upgrade.

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 4: Stator ground module

## Overview

Using 100% stator ground fault protection based on sub-harmonic injection, a 20 Hz voltage is injected to detect ground faults at any point across 100% of the winding. The stator ground module works in combination with the G60 or MiCOM Agile P345 to provide 100% stator ground fault protection that is operational during generator start-up, running, and stopped conditions.

## Mechanical installation

The stator ground protection system consists of three modules: the stator ground protection 20 Hz generator module (GPM-S-G), the stator ground band pass filter module (GPM-S-B), and the stator ground protection CT (204-SD-43737). All three are required. The following figures show dimensions and mounting.

With GPM-S, use a CT/VT module with Sensitive Ground capability (for example 8G, 8J, 8M, 8R) to connect stator ground protection CT (204-SD-43737) input to the G60 device.

Figure 19: Dimensions for panel-mounted GPM-S-G (second generation) (inches)

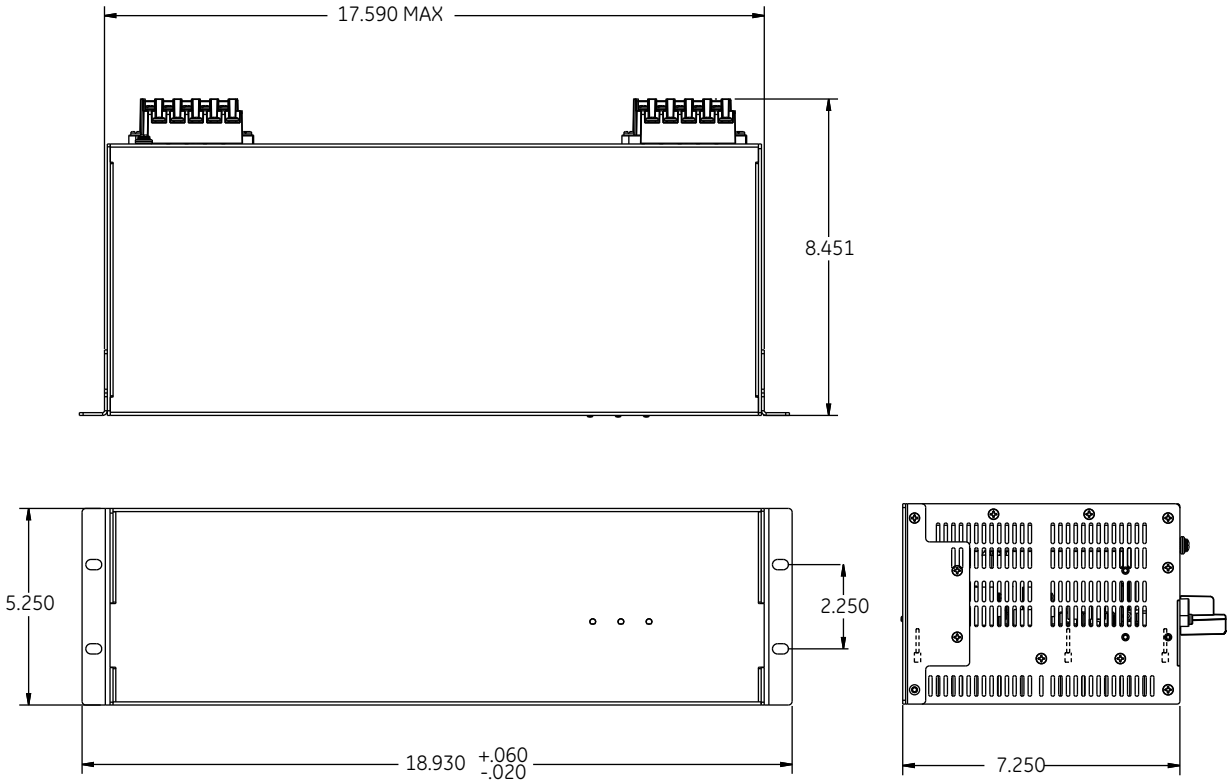



Figure 20: Dimensions for panel-mounted GPM-S-G (discontinued) (inches)

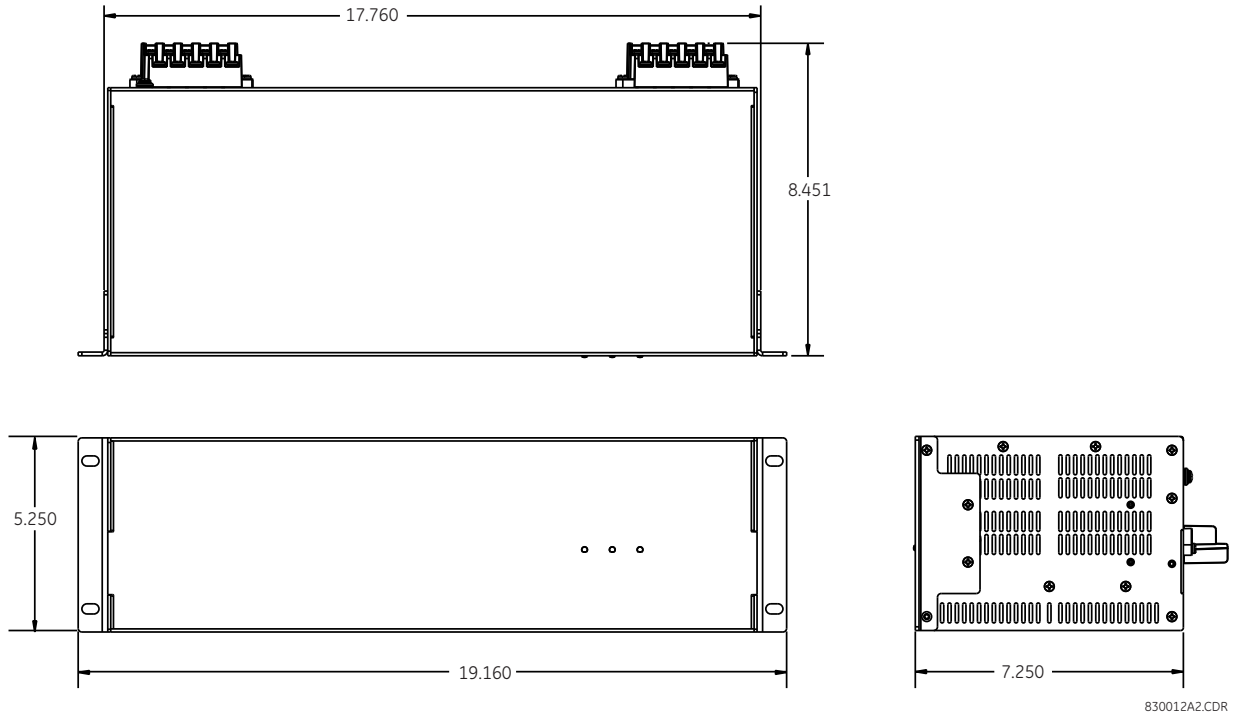


Figure 21: Dimensions for wall-mounted GPM-S-G (inches)

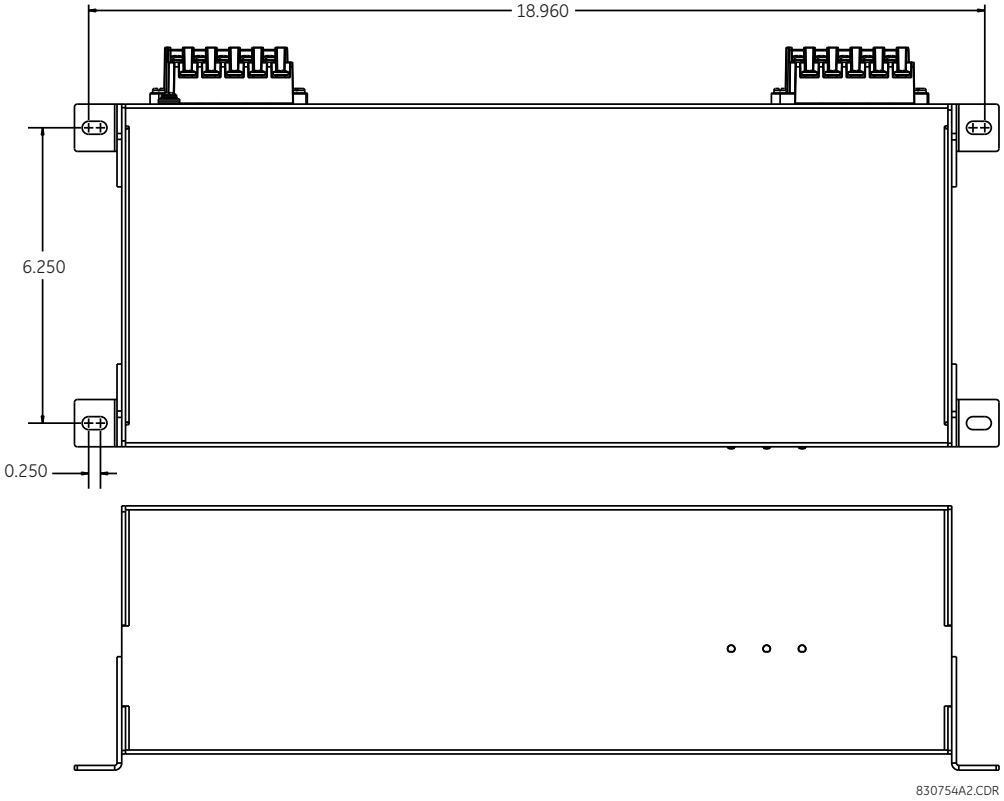



Figure 22: Dimensions for GPM-S-B band pass filter (inches)

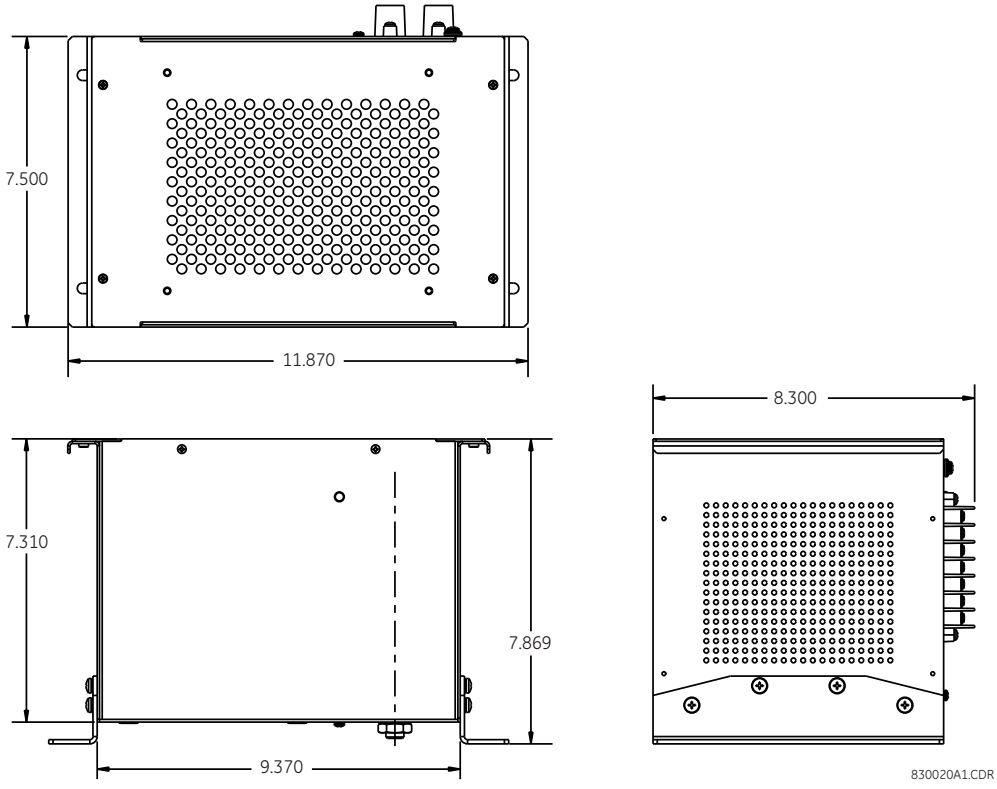
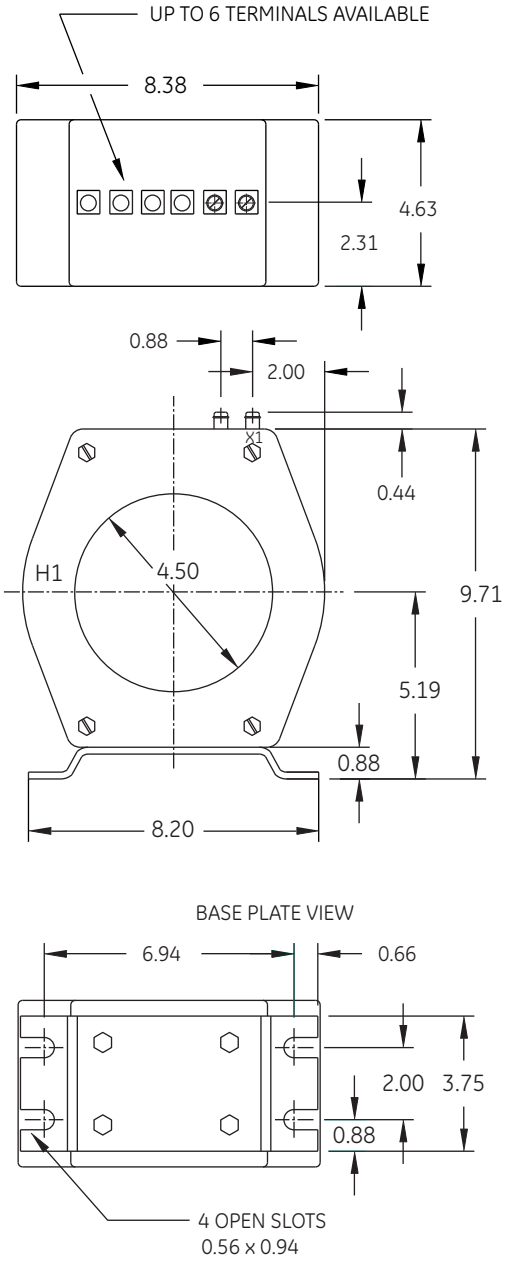


**Figure 23: Dimensions for stator ground protection CT (204-SD-43737) (inches)**




Terminals are brass No. 10-32 female with one screw, flat washer, and lock washer

830027A1.cdr

**Figure 24: Mounting for panel-mounted GPM-S-G (second generation) (inches)**

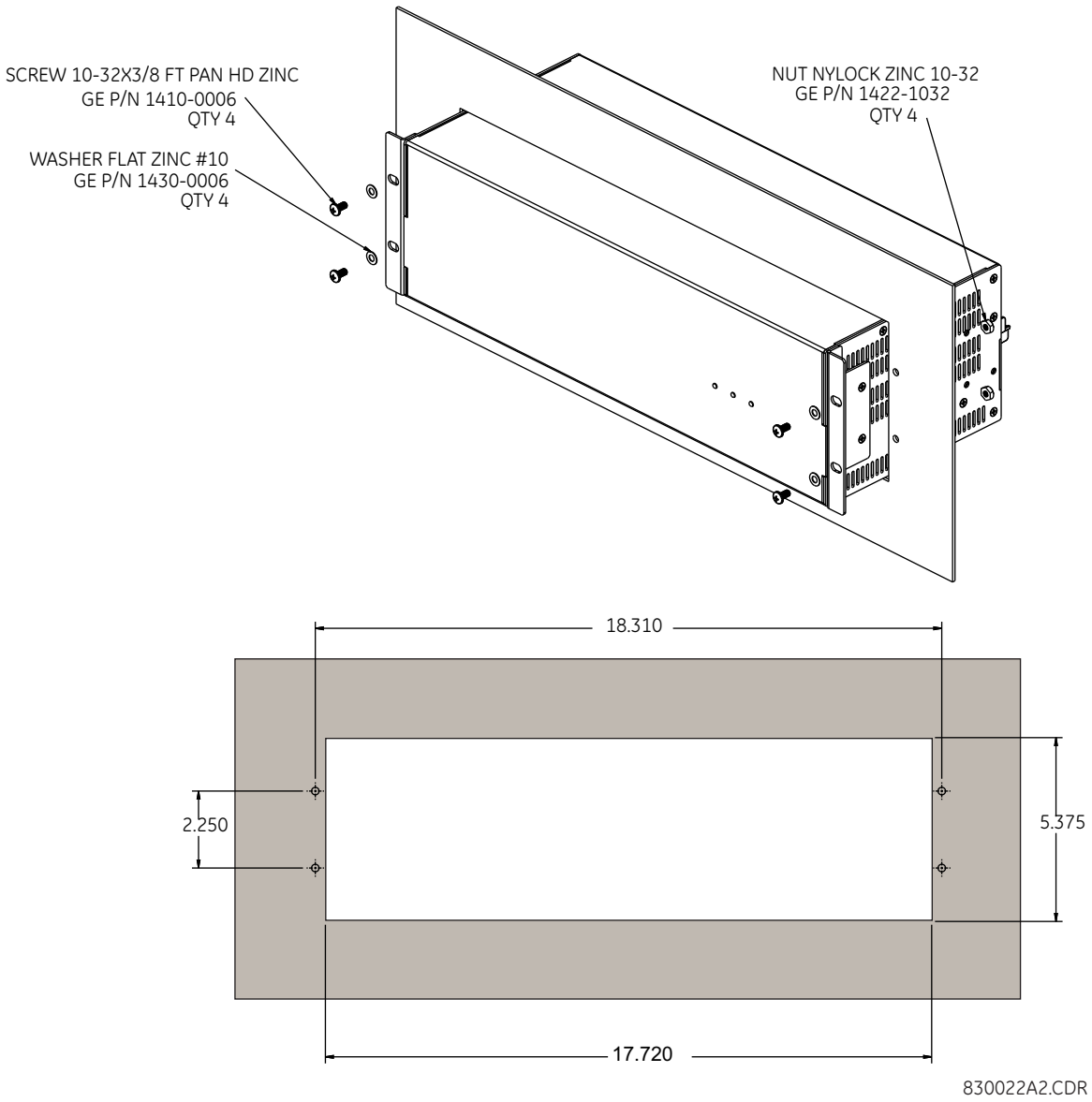


**Figure 25: Mounting for panel-mounted GPM-S-G (discontinued) (inches)**

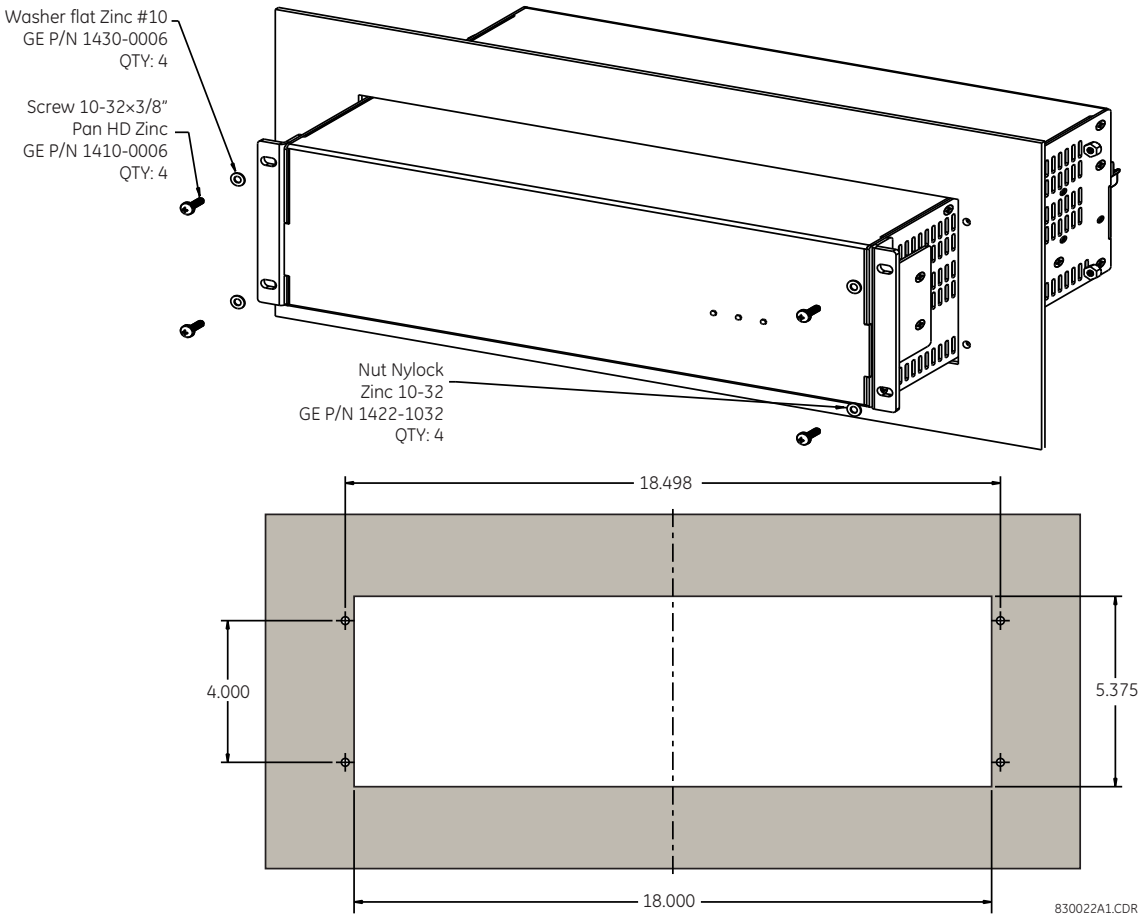


**Figure 26: Mounting for wall-mounted GPM-S-G (inches)**

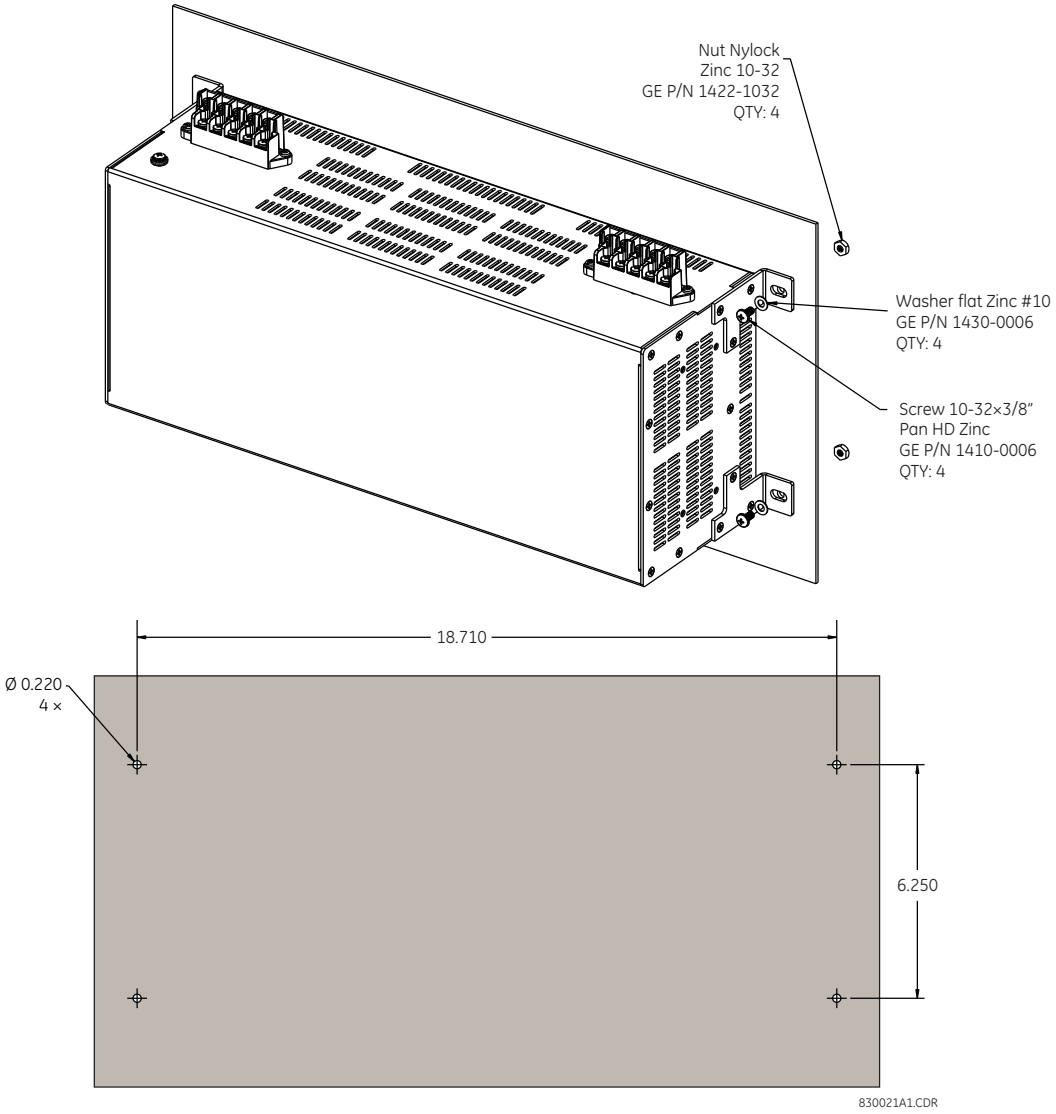
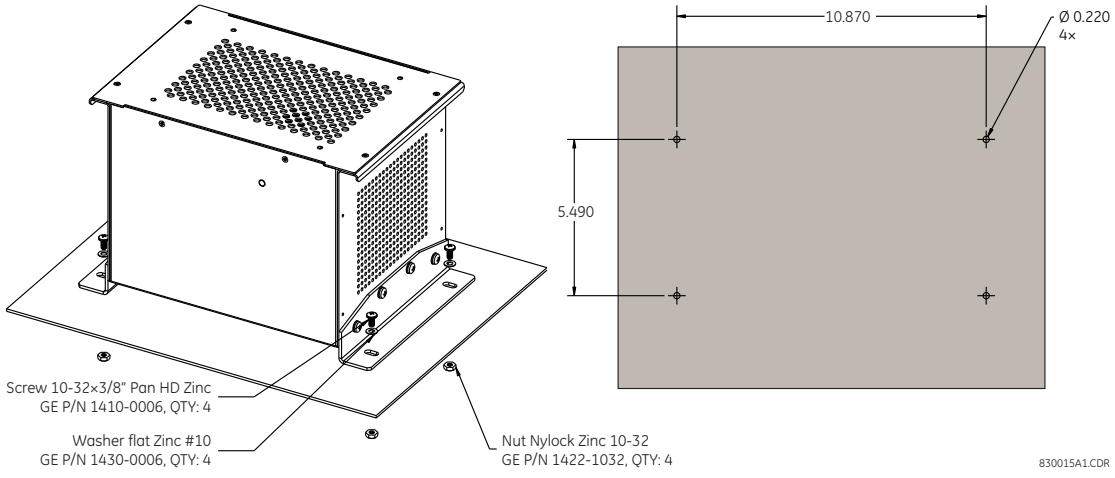


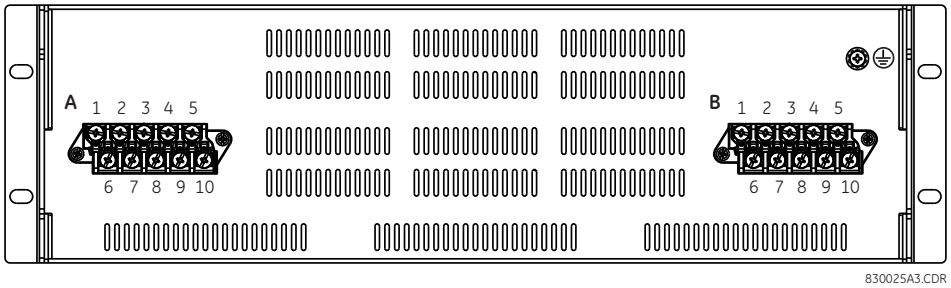

**Figure 27: Mounting for GPM-S-B band pass filter (inches)**



# Electrical installation

There are two connectors on the stator ground protection 20 Hz generator module, as shown in the following figure.

**Figure 28: Rear view of GPM-S-G showing terminal blocks**




The table outlines the pin assignments. Two contact inputs are provided. Upon closure of any of the contact inputs, 20 Hz injection stops.

**Table 4: Pin assignments for GPM-S-G**

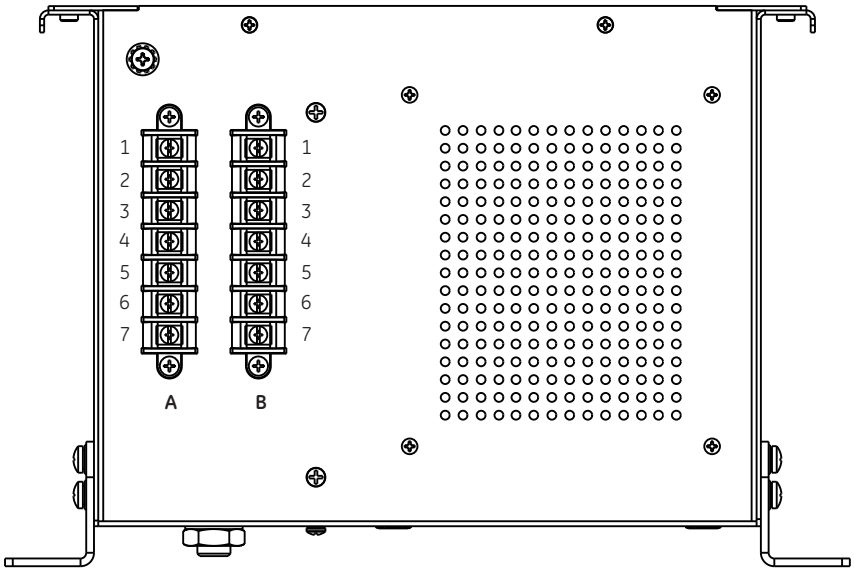
| Pin | Label | Definition |
|---|---|---|
| **Connector A** | | |
| 1 | A1 | Contact input 1 |
| 2 | A2 | Contact input 2 |
| 3 | A3 | Alarm relay NC (normally closed) |
| 4 | A4 | Not used |
| 5 | A5 | Output 1 |
| 6 | A6 | Contact input common |
| 7 | A7 | Alarm relay NO (normally open) |
| 8 | A8 | Alarm relay common |
| 9 | A9 | Not used |
| 10 | A10 | Output 2 |
| **Connector B** | | |
| 1 | B1 | Not used |
| 2 | B2 | Not used |
| 3 | B3 | Not used |
| 4 | B4 | Not used |
| 5 | B5 | Not used |
| 6 | B6 | Not used |
| 7 | B7 | Not used |
| 8 | B8 | Ground |
| 9 | B9 | Power neutral / DC negative |
| 10 | B10 | Power line / DC positive |

There are two connectors on the stator ground protection band pass filter module, as shown in the following figure.

**⚠WARNING**

**Electrical shock hazard.**
**INTERNALLY CHARGED CAPACITORS**
**A high voltage potential exists across terminals A1/B5 and terminals B1/A5 after power is removed (up to 500 V). Take extra care to avoid accidental short circuit with terminals A1/B5 and B1/A5.**
**HOW TO REMOVE CHARGE FROM TERMINALS**
**Discharge the GPM-S-B through terminal A1 and B1 before installation or maintenance as follows. Temporarily connect one wire (minimum 18 AWG) between terminals A1 and A7 and another wire (minimum 18 AWG) between B1 and B6 for two seconds. Remove these connections after the capacitor discharge routine.**

Figure 29: GPM-S-B showing terminal blocks




The table outlines the pin assignments.

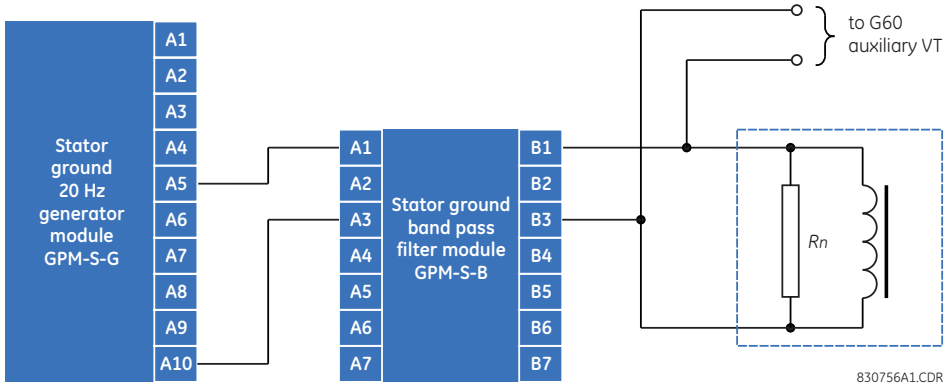
Table 5: Pin assignments for GPM-S-B

| Pin | Label | Definition |
|---|---|---|
| **Connector A** | | |
| 1 | A1 | Input 1 |
| 2 | A2 | Not used |
| 3 | A3 | Input 2 |
| 4 | A4 | Not used |
| 5 | A5 | Reserved |
| 6 | A6 | Divider out |
| 7 | A7 | Divider low |
| **Connector B** | | |

| Pin | Label | Definition |
|---|---|---|
| 1 | B1 | Output 1 |
| 2 | B2 | Not used |
| 3 | B3 | Output 2 |
| 4 | B4 | Not used |
| 5 | B5 | Reserved |
| 6 | B6 | Divider high |
| 7 | B7 | Divider low |

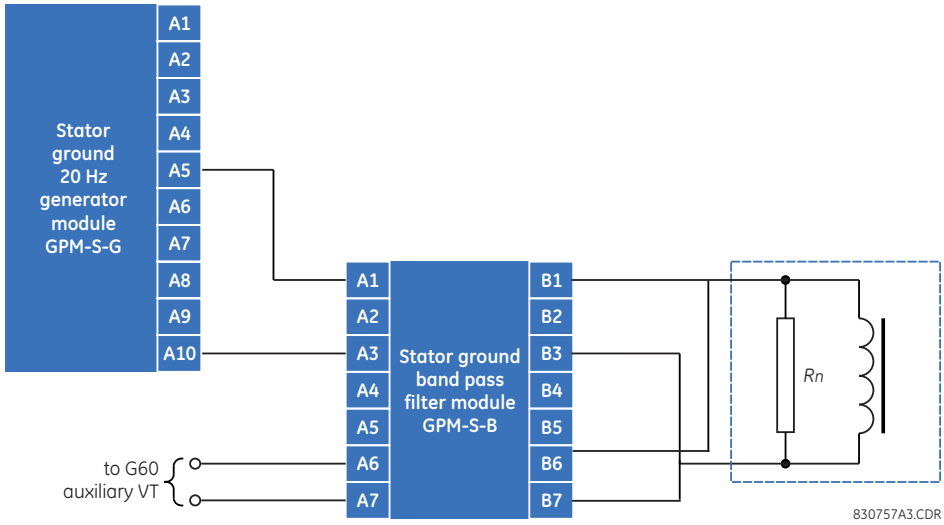
The following figure illustrates how to connect the stator ground 20 Hz generator module with the band pass filter module where the neutral grounding transformer (NGT) secondary voltage is less than or equal to 240 V.

**Figure 30: Stator ground protection system connections (NGT secondary ≤ 240 V)**




The following figure illustrates how to connect the stator ground 20 Hz generator module with the band pass filter module where the NGT secondary voltage is greater than 240 V.

**Figure 31: Stator ground protection system connections (NGT secondary > 240 V)**



## Upgrade the GPM-S firmware

Perform the upgrade using the front port and one of the computer COM ports 1 to 4. The process also works for a serial port device, taking longer to complete (approximately 5 minutes).

To upgrade the firmware for the GPM-S modules:

1. Start the EnerVista UR Setup software.
2. Open the G60 device so that it appears in the online window.
3. Navigate to **Maintenance > Update Firmware**.
4. Select the appropriate firmware file.
5. Click the **Open** button to start the firmware upgrade.

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 5: Settings

## Stator ground protection

### Overview

For the sub-harmonic injection based 100% stator ground protection, configure the stator ground source as follows:

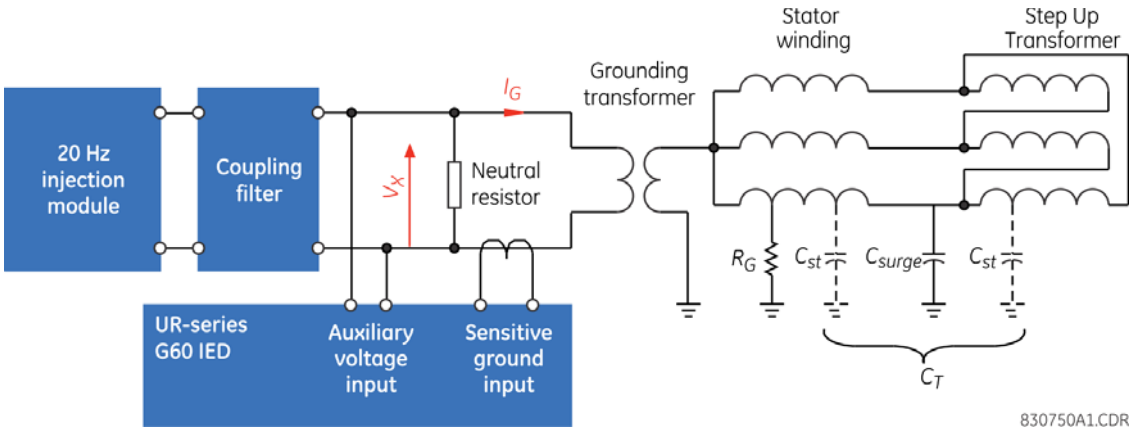
- Configure the voltage measured at the neutral of the machine as the auxiliary VT bank. The element extracts the 20 Hz component of the auxiliary voltage from the source in order to calculate resistance. The fundamental frequency component from the same input is extracted when the same source is configured for auxiliary overvoltage protection element to provide 95% stator ground fault protection. Select the auxiliary VT connection setting as "Vn" for this element.
- Configure current measured at the secondary of the neutral grounding transformer of the machine as the sensitive ground CT bank. The element extracts the 20 Hz component of the ground current from the source in order to calculate resistance.
- This source can be independent of any of the other inputs from the generator, such as neutral end CTs, terminal end CTs, and terminal VTs. Or combine these auxiliary VT and sensitive ground CT with either neutral side or terminal side inputs within the same source settings.
- In addition, set the relay with frequency tracking enabled and, for the source used as the G60 **Frequency And Phase Reference** setting, use the one connected to generator terminal VTs. The tracking frequency, which is essentially the generator frequency, blocks the sub-harmonic stator ground protection and auxiliary over-voltage protection in the frequency range of 15 to 25 Hz.

### Sub-harmonic stator ground fault settings

A voltage source placed at the neutral of the generator produces a current for ground faults anywhere on the stator winding. This source is coupled to the primary circuit using the existing neutral grounding transformer. The following figure shows a typical high-impedance grounded generator that is protected against ground faults using the sub-harmonic injection method. The neutral resistor is chosen to limit the ground fault current to a low value (less than 25 A) in order to minimize damage. A sub-harmonic frequency

voltage signal is injected into the neutral of the generator. Under normal conditions, a resulting current flows through the surge capacitors ($C_s$) and through the stray capacitance of the stator and step-up transformer windings. When a ground fault develops on the stator winding, an additional current flows through the resistance $R_G$. The value of $R_G$ is derived from the measurement of the injected voltage and the resulting current.

**Figure 32: Stator ground fault detection by sub-harmonic injection**




An AC signal is injected so that it can be coupled through an injection transformer to the primary circuit. The signal is of a low frequency in order to minimize the effects of the capacitance of the primary circuit. A frequency of 20 Hz is chosen.

Referring to the figure, the admittance seen looking into the grounding transformer is

$$Y = \frac{1}{N^2} \times \frac{I_G}{V_X} = \frac{1}{R_G} + j\omega C_T \qquad \textbf{Eq. 1}$$

where

$R_G$ is the ground fault resistance

$C_T$ is the total capacitance to ground

$N$ is the neutral grounding transformer ratio

$V_X$ is the measured sub-harmonic voltage

$I_G$ is the measured sub-harmonic current

The ground fault resistance can be calculated by measuring the 20 Hz voltage and current phasors at the secondary of the grounding transformer. This is done by the G60. An overcurrent element responding to the sub-harmonic provides backup protection.

For machines that can operate at sub-synchronous frequencies (for instance a gas turbine that employs static starting), the function is blocked at frequencies between 15 and 25 Hz. This ensures that the voltage and current produced by the generator does not leak into the sub-harmonic ground fault measurements.

In addition, a check for minimum values of injected voltage and current guards against a failure of the injection unit or a short or open circuit in the external circuit. In addition, the critical-fail relay contact of the 20 Hz generator can also be connected to one of the contact inputs of G60 and the sub-harmonic stator ground element can be blocked.

The stator ground source settings determine the signals that are applied for $V_X$, $I_G$, and frequency. The resistance is reported in primary ohms. Therefore, the VT ratio setting of the auxiliary VT input must match the turns ratio of the neutral grounding transformer and the CT primary setting of the ground CT input must match that of the CT used to measure ground current.

When the magnitude of $R_G$ is large, the resulting current $I_G$ is very small and the G60 sensitive ground input is used to make this measurement. Thus, a CT/VT module with sensitive ground current input needs to be present in a G60 when used for sub-harmonic stator ground protection.

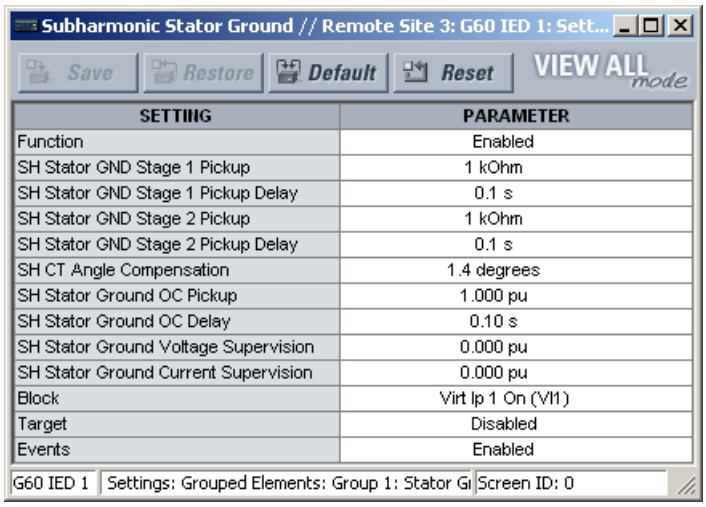
The following accessory modules are required for sub-harmonic injection based stator ground protection:

- 20 Hz injection module (GE Multilin order code): GPM-S-G
- Coupling filter (GE Multilin order code): GPM-S-B
- Current transformer (GE order code): 204-SD-43737

To configure the settings:

1. Select the **Settings > Grouped Elements > Group 1(6) > Stator Ground > Subharmonic Stator Ground** item to open the sub-harmonic stator ground fault settings window.

**Figure 33: Sub-harmonic stator ground fault settings window**




The following settings are available.

**Function**

*Range: Enabled, Disabled*
*Default: Disabled*

This setting enables and disables the sub-harmonic stator ground fault element.

**SH Stator Ground Stage 1 Pickup**

*Range: 1 to 20 kOhm in steps of 1*
*Default: 10 kOhm*

If the measured stator ground primary resistance is less than the value specified by this setting, the stage 1 element picks up. Normally stage 1 is used to raise alarms and typical settings fall in the range of 5 to 10 kΩ. This setting is given in primary ohms.

**SH Stator Ground Stage 1 Pickup Delay**

*Range: 0.1 to 600.0 seconds in steps of 0.1*
*Default: 10.0 seconds*

This setting specifies a time delay for stage 1. Typical values are in the range of 5 to 10 seconds. This delay needs to be added to the operating time of the element to obtain the overall delay.

**SH Stator Ground Stage 2 Pickup**

*Range: 1 to 20 kOhm in steps of 1*
*Default: 3 kOhm*

If the measured stator ground primary resistance is less than the value specified by this setting, stage 2 element picks up. Normally stage 2 is used to raise trip signals and typical settings fall in the range of 1 to 5 kΩ. This setting is given in primary ohms.

**SH Stator Ground Stage 2 Pickup Delay**

*Range: 0.1 to 600.0 seconds in steps of 0.1*
*Default: 1.0 seconds*

This setting specifies a time delay for stage 2. Typical values are 1 to 2 seconds. This delay needs to be added to the operating time of the element to obtain the overall delay.

**SH CT Angle Compensation**

*Range: –30.00 to 30.00 degrees in steps of 0.01*
*Default: 0.0 degrees*

The CT used can introduce phase shifts. This setting compensates for the phase shifts to obtain accurate fault resistance calculations. Perform a test during commissioning at no fault condition by measuring the **SH Current Angle** reported by the G60. In a healthy machine, the sub-harmonic impedance is purely capacitive and the angle is 90°. The difference in angle can be used as the **SH CT Angle Compensation** setting. The preferred method of doing this is by inserting a resistance equal to the **SH Stator Ground Stage 2 Pickup** setting at the neutral of the generator and compensating the angle at this setting.

**SH Stator Ground OC Pickup**

*Range: 0.001 to 1.000 pu in steps of 0.001*
*Default: 0.010 pu*

This setting specifies the backup overcurrent pickup level based on sub-harmonic current. This protection can be used in addition to the sub-harmonic injection based 100% ground fault and fundamental phasor over voltage based 95% ground fault protection. One per-unit value of current is the sensitive ground CT secondary rating setting, which is always 5 A since the CT used is rated for 5 A secondary.

**SH Stator Ground OC Delay**

*Range: 0.10 to 600.00 seconds in steps of 0.01*
*Default: 1.00 seconds*

This setting specifies a time delay for sub-harmonic current based backup over current protection. Consider thermal capabilities of the loading resistor or neutral grounding transformer when setting this delay.

**SH Stator Ground Voltage Supervision**

*Range: 0.000 to 0.100 pu in steps of 0.001*
*Default: 0.000 pu*

The 20 Hz source can be monitored using this voltage supervision. This setting in per-unit values (pu) provides the voltage level below which if the sub-harmonic voltage phasor magnitude remains for a period of 10 seconds, the SH STAT GND TRB OP operand is asserted. One per-unit value of voltage is the auxiliary VT nominal secondary voltage setting or the equivalent primary voltage if used in primary. A typical setting of 1 V is suggested. However, when the neutral grounding transformer's load resistance is less than 0.5 ohms, the use of voltage supervision is not recommended.

**SH Stator Ground Current Supervision**

*Range: 0.000 to 0.100 pu in steps of 0.001*

*Default: 0.000 pu*

The 20 Hz source can be monitored using this current supervision. This setting in per-unit values provides the current level below which if the sub-harmonic current phasor magnitude remains for a period of 10 seconds, the SH STAT GND TRB OP operand is asserted. One per-unit current is the sensitive ground CT secondary rating setting or the primary rating if used in primary. A typical setting of 0.002 pu (=10 mA in secondary) is recommended with the provided 5 A secondary CT.

**Block**

*Range: any FlexLogic™ operand*

*Default: OFF*

Assertion of the FlexLogic operand assigned to this setting blocks operation of the sub-harmonic stator ground element.

**Target**

*Range: Disabled, Self-Reset, Latched*

*Default: Self-Reset*

This setting defines the operation of the sub-harmonic stator ground target message. When set to "Disabled", no target message or illumination of a faceplate LED indicator is issued upon operation of the element. When set to "Self-Reset", the target message and LED indication follow the operate state of the element, and self-resets once the operate element condition clears. When set to "Latched", the target message and LED indication remain visible after the element output returns to logic 0 until a reset command is received by the relay.

**Events**

*Range: Enabled, Disabled*

*Default: Disabled*

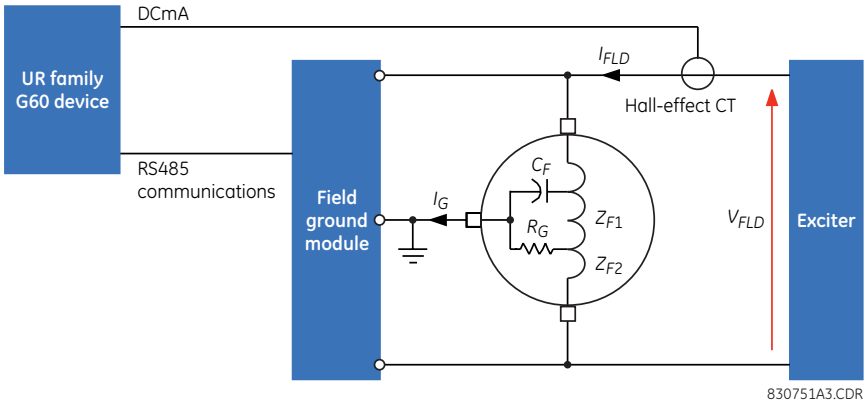
This setting enables and disables the logging of sub-harmonic stator ground events in the sequence of events recorder.

# Field ground fault protection

## Overview

The following figure shows a field ground detection scheme using the G60 and the GPM-F. The field winding of a synchronous generator is represented electrically by the impedance $Z_F = Z_{F1} + Z_{F2}$. Under normal conditions, the field circuit is ungrounded. The capacitance $C_F$ is the stray capacitance of the field, distributed along the field winding. This capacitance represents the only path for current to flow to ground under normal conditions.

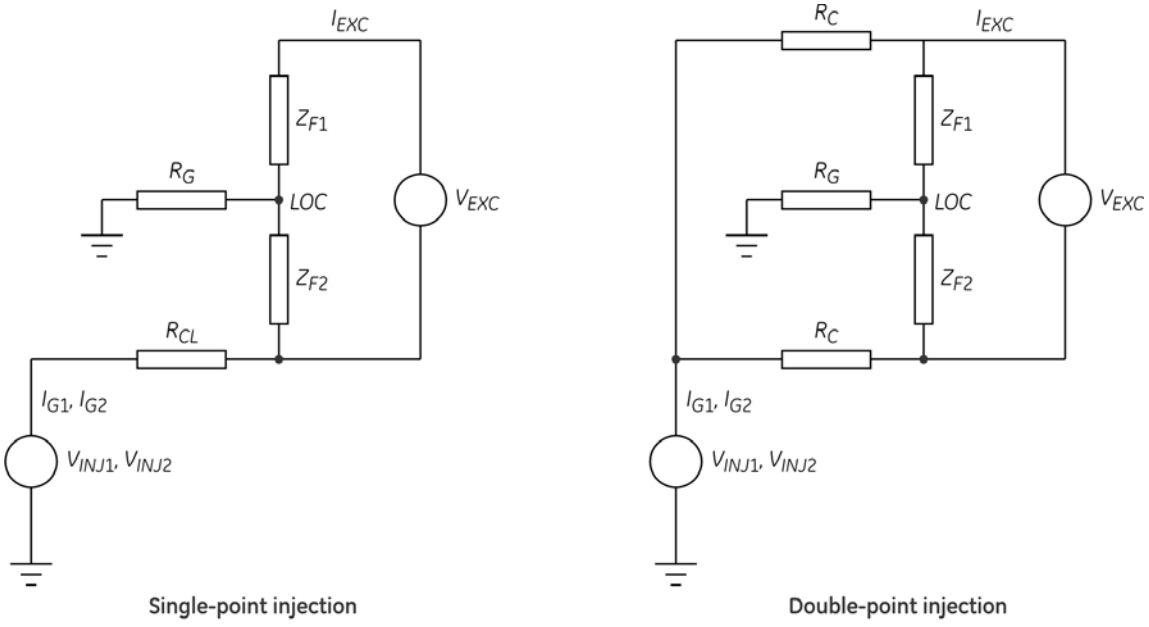
Figure 34: Field ground fault detection




The resistance $R_G$ represents a breakdown of the field winding insulation providing a resistive path to ground through the field grounding brush. The insulation failure can occur anywhere, so the impedances $Z_{F1}$ and $Z_{F2}$ are unknown. The fault impedance $R_G$ is also unknown. The purpose of the field ground detector is to measure this resistance.

Measurement of $R_G$ is accomplished by injecting a voltage, $V_{INJ}$ and measuring the resulting current, $I_G$. The measurement algorithm must be capable of discriminating between capacitive current due to $C_F$ (which can be significant) and resistive current due to a fault. The exciter voltage, $V_{FLD}$ is a DC value with a small ripple such that the impedance of the field is essentially resistive. The current $I_{FLD}$ is a DC current with a range of tens, hundreds, or thousands of amps.

Figure 35: Equivalent circuit, single-point and double-point injection



Referring to the single-point injection circuit, the magnitude of $I_{FLD}$ makes it evident that $V_{INJ}$ cannot have a significant impact on the voltage drop across $Z_{F2}$. Therefore if two values ($V_{INJ1}$ and $V_{INJ2}$) are injected, the following equations can be written:

$$V_{INJ1} = I_{G1}R_G + I_{G1}R_{CL}V_{F2}$$
$$V_{INJ2} = I_{G2}R_G + I_{G2}R_{CL}V_{F2} \quad \textbf{Eq. 2}$$

where

$I_{G1}$ is the current flowing due to $V_{INJ1}$

$I_{G2}$ is the current flowing due to $V_{INJ2}$

Solving for $R_G$ we get:

$$R_G = \frac{(V_{INJ1} - V_{INJ2}) - (I_{G1} - I_{G2}) \times R_{CL}}{I_{G1} - I_{G2}} \quad \textbf{Eq. 3}$$

For the double-point injection circuit, $R_{CL}$ is defined as:

$$R_{CL} = \frac{R_C}{2} \quad \textbf{Eq. 4}$$

The $V_{INJ}$ voltage is therefore composed of a square wave to create two levels of injection. Once the value of $R_G$ is known it can be substituted into the $V_{INJ}$ equation above to determine $V_{F2}$. If the $V_{FLD}$ voltage (refer to the single-point injection circuit) is known through measurement then the location of the fault is simply $V_{F2}$ / $V_{FLD}$. This gives the location of the fault as a percentage of field winding from negative terminal in case of single point injection. If double point injection is used, fault location cannot be determined. The relay displays an invalid fault location for approximately 10% for such conditions. The fault location cannot be determined if the field voltage is zero (that is, when the generator is not running). The fault location is displayed only when the measured field ground resistance is less than 500 KΩ.

### Ground undercurrent

A brush lift-off condition prevents the field ground detector from operating. This is detected by calculating the RMS value of the ground current. It normally has a non-zero value due to the capacitance of the field winding. A drop in this signal indicates an open circuit in the injection path and the field ground under current feature detects this condition.

### Field current monitoring

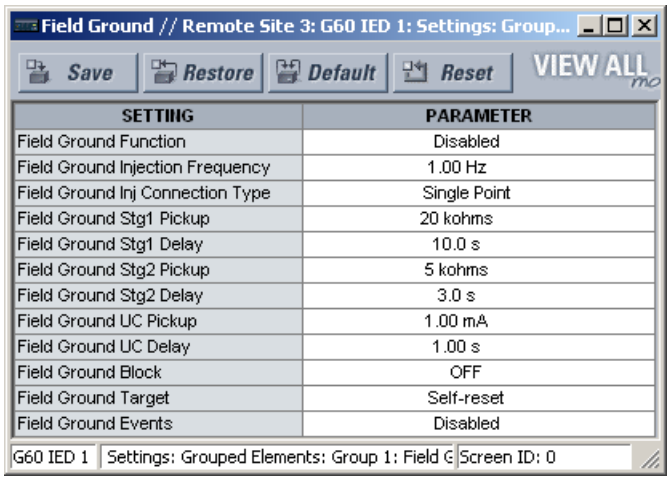
The G60 can monitor the field current via a Hall effect transducer that produces a 4 to 20 mA output. This device must be wired to a DCmA input of the G60 or a HardFiber Brick. Note that the relay must be configured with a transducer input card for the former case. Assignment of this signal to the field ground function allows the user to detect a field overcurrent or undercurrent condition. The maximum and minimum settings configured for scaling of this DCmA input is used to get the per-unit values of field current.

## Field ground settings

To configure field ground settings:

1. Navigate to **Settings > Grouped Elements > Group 1(6) > Field Ground Protection > Field Ground** to open the field ground fault settings window.

Figure 36: Field ground fault settings




The following settings are available.

**Field Ground Function**

*Range: Enabled, Disabled*

*Default: Disabled*

This setting enables and disables the field ground fault element.

**Field Ground Injection Frequency**

*Range: 0.1 to 3.0 Hz in steps of 0.1*

*Default: 1.00 Hz*

This setting specifies the frequency of the signal to be injected into the field winding for detecting ground faults. The injection frequency selection depends on the value of field winding capacitance to ground. Use the following formula to set the injection frequency when the field winding capacitance is known in µF.

$$F_{inj} = \frac{2.5}{C_F} \qquad \textbf{Eq. 5}$$

The $C_F$ value is in microfarads.

The table provides examples of injection frequency settings for various field winding capacitance values. For field winding capacitances greater than 10 µF, resistance measurements are less accurate.

Table 6: Examples of injection frequency settings

| $C_F$ | $F_{INJ}$ |
|---|---|
| 1 µF | 2.50 Hz |
| 2 µF | 1.50 Hz |
| 3 µF | 0.83 Hz |
| 4 µF | 0.63 Hz |
| 5 µF | 0.50 Hz |
| 6 µF | 0.42 Hz |
| 7 µF | 0.36 Hz |
| 8 µF | 0.31 Hz |
| 9 µF | 0.28 Hz |
| 10 µF | 0.25 Hz |

**Field Ground Inj Connection Type**

*Range: Single Point, Double Point*

*Default: Single Point*

Field ground protection can be implemented by injecting a low frequency signal either into both positive and negative terminals of the field winding or only into the negative terminal of the field winding. For single point injection, the G60 provides the feature of fault location. In case of a field ground fault, the G60 displays the location of the fault in the field winding as a percentage of the winding from the negative terminal. If the preference is to keep the injection symmetrical into the field winding, then double point injection has to be done but the fault location feature is not available. This setting has to match the type of connection on the field ground module.

**Field Ground Stg1 Pickup**

*Range: 1 to 500 kOhms in steps of 1*

*Default: 20 kOhms*

If the measured ground resistance is less than the value specified by this setting, then the stage 1 element picks up. Normally stage 1 is used to raise alarms and typical settings fall in the range of 10 to 40 kΩ.

**Field Ground Stg1 Delay**

*Range: 0.1 to 600.0 seconds in steps of 0.1*

*Default: 10.0 seconds*

This setting specifies a time delay for stage 1. Typical settings are in the range of 10 to 15 seconds. This delay needs to be added to the operating time of the element to obtain the overall delay.

**Field Ground Stg2 Pickup**

*Range: 1 to 500 kOhms in steps of 1*

*Default: 5 kOhms*

If the measured ground resistance is less than the value specified by this setting, then the stage 2 element picks up. Normally stage 2 is used to raise trip signals and typical settings fall in the range of 2 to 5 kΩ.

**Field Ground Stg2 Delay**

*Range: 0.1 to 600.0 seconds in steps of 0.1*

*Default: 3.0 seconds*

This setting specifies a time delay for stage 2. Typical settings are in the range of 3 to 5 seconds. This delay needs to be added to the operating time of the element to obtain the overall delay.

**Field Ground UC Pickup**

*Range: 0.05 to 100.00 mA in steps of 0.1*

*Default: 1.00 mA*

This setting specifies the ground undercurrent level below which a brush open condition is detected. A brush lift-off condition prevents the field ground detector from operating. This is detected by calculating the RMS value of the ground current. It normally has a non-zero value due to the capacitance of the field winding. A drop in this signal indicates an open circuit in the injection path. To set this value, the ground current in a healthy operating condition preferably with zero field voltage needs to be recorded from G60 actual values (performed during commissioning). Configure this setting to be 60 to 70% of that normal value.

**Field Ground UC Delay**

*Range: 0.10 to 600.00 s in steps of 0.1*

*Default: 1.0 seconds*

This setting specifies a time delay for the field ground undercurrent element. Typical settings are in the range of 20 to 30 seconds. This delay needs to be added to the operating time of the element to obtain the overall delay.

**Field Ground Block**

*Range: any FlexLogic operand*

*Default: OFF*

Assertion of the FlexLogic operand assigned to this setting blocks operation of the field ground element.

**Field Ground Target**

*Range: Disabled, Self-Reset, Latched*

*Default: Self-Reset*

This setting defines the operation of the field ground target message. When set to "Disabled", no target message or illumination of a faceplate LED indicator is issued upon operation of the element. When set to "Self-Reset", the target message and LED indication follow the operate state of the element, and self-resets once the operate element condition clears. When set to "Latched", the target message and LED indication remains visible after the element output returns to logic 0 until a reset command is received by the relay.

**Field Ground Events**

*Range: Enabled, Disabled*

*Default: Disabled*

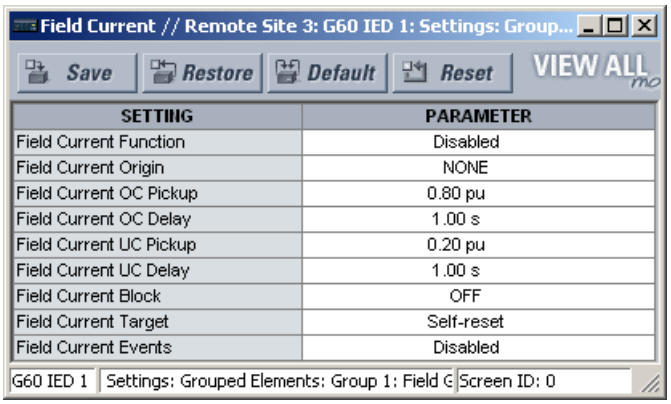
This setting enables and disables the logging of field ground events in the sequence of events recorder.

## Field current settings

To configure field current fault detector settings:

1. Navigate to **Settings > Grouped Elements > Group 1(6) > Field Ground Protection > Field Current** to open the field current fault settings window.

Figure 37: Field current fault settings




The following settings are available.

**Field Current Function**

*Range: Enabled, Disabled*
*Default: Disabled*

This setting enables and disables the field current fault element.

**Field Current Origin**

*Range: None, dcmA 1, dcmA 2,..., dcmA 24, RTD1,RTD2,..., RTD8*
*Default: None*

This setting selects the DCmA input to be used for the field current protection element. A DCmA input can be selected from up to 24 possible inputs, depending on the number of installed transducer modules. In a HardFiber Brick / G60 system, this setting can point to one of the Resistance Temperature Detector (RTD) inputs mapped to a Brick DCmA input. In both cases, the minimum and maximum scaling settings of that transducer input are used to perform the per-unit conversion. The unit setting are configured as “Amps” if the transducer input is used.

These minimum and maximum settings are set as per the Hall sensor current rating. The per-unit computation is scaled to a base equal to the maximum value setting, with a zero per-unit value corresponding to zero in the unit system used by the maximum value setting. For example, in the case where the maximum value setting is 100 A, a trip level of 75 A is achieved by setting the operate level at 0.75 pu, regardless of the range (for example, 4 to 20 mA, 0 to 20 mA, and so on) and regardless of the minimum value setting.

**Field Current OC Pickup**

*Range: 0.05 to 1.00 pu in steps of 0.01*
*Default: 0.80 pu*

This setting specifies the field current level (in per-unit values) above which the overcurrent element picks up.

**Field Current OC Delay**

*Range: 0.00 to 600.00 seconds in steps of 0.01*
*Default: 1.00 seconds*

This setting specifies a time delay for the overcurrent element. This delay is added to the operating time of the element to obtain the overall delay.

**Field Current UC Pickup**

*Range: 0.05 to 1.00 pu in steps of 0.01*
*Default: 0.20 pu*

This setting specifies the field current level above which the undercurrent element picks up.

**Field Current UC Delay**

*Range: 0.00 to 600.00 seconds in steps of 0.01*
*Default: 1.00 seconds*

This setting specifies a time delay for the undercurrent element. This delay is added to the operating time of the element to obtain the overall delay.

**Field Current Block**

*Range: any FlexLogic operand*
*Default: OFF*

Assertion of the FlexLogic operand assigned to this setting blocks operation of the field current ground element.

**Field Current Target**

*Range: Disabled, Self-Reset, Latched*

*Default: Self-Reset*

This setting defines the operation of the field current ground target message. When set to “Disabled”, no target message or illumination of a faceplate LED indicator is issued upon operation of the element. When set to “Self-Reset”, the target message and LED indication follow the operate state of the element, and self-resets once the operate element condition clears. When set to “Latched”, the target message and LED indication remains visible after the element output returns to logic 0 until a reset command is received by the relay.

**Field Current Events**

*Range: Enabled, Disabled*

*Default: Disabled*

This setting enables and disables the logging of field current ground events in the sequence of events recorder.

# GPM Field and Stator Ground Fault Protection Modules

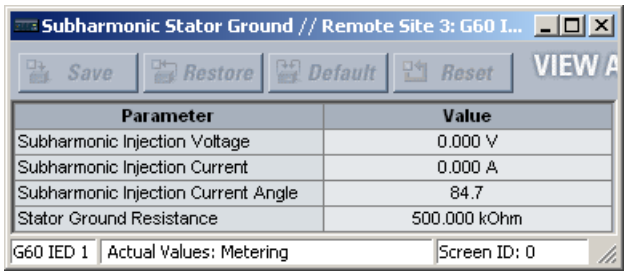
# Chapter 6: Actual values and messages

## Sub-harmonic stator ground actual values

To view actual values:

1. Navigate to **Actual Values > Metering > Subharmonic Stator Ground** to open the sub-harmonic stator ground fault actual values window.

Figure 38: Sub-harmonic stator ground fault actual values

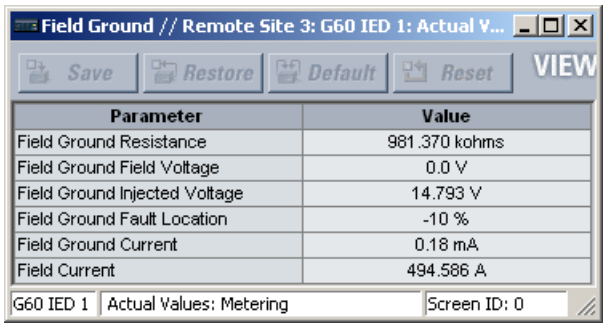



## Field ground actual values

To view actual values:

1. Navigate to **Actual Values > Metering > Field Ground** to open the sub-harmonic stator ground fault actual values window.

Figure 39: Field ground fault actual values




# GPM-F module messages

This section outlines self-test error messages that can display for the GPM-F modules.

**GPM-F FAILURE: TROUBLE 01**

*Latched target message*: No

*Description of problem*: The G60 detects loss of communication with the field ground module on the RS485 link

*Frequency of this test*: Every five seconds

*What to do*: Check the field ground module and its RS485 connection to the G60

**GPM-F FAILURE: TROUBLE 02**

*Latched target message*: No

*Description of problem*: The field ground module reports trouble with injected low frequency signal voltage level or frequency

*Frequency of this test*: Every second

*What to do*: Verify that the injection voltage actual value in the G60 is around 15 V. If the message remains, cycle power to the field ground module. If the problem persists, contact the factory.

**GPM-F FAILURE: TROUBLE 03**

*Latched target message*: No

*Description of problem*: Field ground module reports trouble with its circuitry

*Frequency of this test*: Every second

*What to do*: Verify that the actual values in the G60 are within accepted values. Cycle power to the field ground module. If the problem remains, contact the factory.

**GPM-F FAILURE: TROUBLE 04**

*Latched target message*: No

*Description of problem*: The setting for field ground module injection frequency does not match the injection frequency reported by the module

*Frequency of this test*: Every second

*What to do*: The field ground module is possibly connected to another G60 through its alternate RS485 port and possibly receiving another frequency setting. Ensure that both G60 devices connected to the same field ground module have the same injection frequency setting.

**GPM-F FAILURE: TROUBLE 05**

*Latched target message*: No

*Description of problem*: The hardware revision of the field ground module is not supported by the present revision of the G60

*Frequency of this test*: Every second

*What to do*: Check the hardware revision of the field ground module in the G60 actual values and contact the factory.

**GPM-F FAILURE: TROUBLE 06**

*Latched target message*: No

*Description of problem*: The firmware revision of the field ground module is not supported by the present revision of the G60

*Frequency of this test*: Every second

*What to do*: Check the firmware revision of the field ground module in the G60 actual values and contact the factory.

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 7: Additional parameters

This chapter lists FlexLogic operands and Modbus memory map registers that are available when the field and stator ground modules are installed.

## FlexLogic operands

The following FlexLogic operands are available to the G60 when the field and stator ground modules are installed.

**FIELD GROUND FAULT PROTECTION OPERANDS**

| | |
|---|---|
| FIELD CURRENT OC DPO | Asserted when the field current overcurrent element drops out |
| FIELD CURRENT OC OP | Asserted when the field current overcurrent element operates |
| FIELD CURRENT OC PKP | Asserted when the field current overcurrent element picks up |
| FIELD CURRENT UC DPO | Asserted when the field current undercurrent element drops out |
| FIELD CURRENT UC OP | Asserted when the field current undercurrent element operates |
| FIELD CURRENT UC PKP | Asserted when the field current undercurrent element picks up |
| FIELD GND INJ UC DPO | Asserted when the field ground injection undercurrent element drops out |
| FIELD GND INJ UC OP | Asserted when the field ground injection undercurrent element operates |
| FIELD GND INJ UC PKP | Asserted when the field ground injection undercurrent element picks up |
| FIELD GND STG1 DPO | Asserted when stage 1 of the field ground fault element drops out |
| FIELD GND STG1 OP | Asserted when stage 1 of the field ground fault element operates |
| FIELD GND STG1 PKP | Asserted when stage 1 of the field ground fault element picks up |
| FIELD GND STG2 DPO | Asserted when stage 2 of the field ground fault element drops out |

| | |
|---|---|
| FIELD GND STG2 OP | Asserted when stage 2 of the field ground fault element operates |
| FIELD GND STG2 PKP | Asserted when stage 2 of the field ground fault element picks up |
| GPM-F FAILURE | Asserted when a GPM-F self-test error has been detected |

**SUB-HARMONIC STATOR GROUND FAULT DETECTOR OPERANDS**

| | |
|---|---|
| SH STAT GND OC DPO | Asserted when the sub-harmonic stator ground fault overcurrent element drops out |
| SH STAT GND OC OP | Asserted when the sub-harmonic stator ground fault overcurrent element operates |
| SH STAT GND OC PKP | Asserted when the sub-harmonic stator ground fault overcurrent element picks up |
| SH STAT GND STG1 DPO | Asserted when stage 1 of the sub-harmonic stator ground fault element drops out |
| SH STAT GND STG1 OP | Asserted when stage 1 of the sub-harmonic stator ground fault element operates |
| SH STAT GND STG1 PKP | Asserted when stage 1 of the sub-harmonic stator ground fault element picks up |
| SH STAT GND STG2 DPO | Asserted when stage 2 of the sub-harmonic stator ground fault element drops out |
| SH STAT GND STG2 OP | Asserted when stage 2 of the sub-harmonic stator ground fault element operates |
| SH STAT GND STG2 PKP | Asserted when stage 2 of the sub-harmonic stator ground fault element picks up |
| SH STAT GND TRB OP | Asserted when the sub-harmonic voltage phasor magnitude remains lower than the programmed voltage supervision value for 10 seconds |

# Modbus memory map

The following Modbus memory map registers are available to the G60 when the field and stator ground modules are installed. The particular registers actually present depend on the G60 firmware version, order codes, and module options.

The map is also viewable in a web browser. In the browser, enter the IP address of the G60 and click the option.

### Table 7: Memory map

| Address | Description | Range | Units | Step | Format | Default |
|---|---|---|---|---|---|---|
| **Sub-harmonic stator ground fault protection actual values (read only)** | | | | | | |
| 1678 | Subharmonic Injection Voltage | 0 to 999999.999 | V | 0.001 | F060 | 0 |
| 167A | Subharmonic Injection Current | 0 to 999999.999 | A | 0.001 | F060 | 0 |
| 167C | Stator Ground Resistance | 0 to 500 | kOhm | 0.001 | F003 | 500000 |
| 167E | Stator Ground Resistance Exceeded | 0 to 0.1 | --- | 0.1 | F208 | (none) |
| 167F | Subharmonic Injection Current Angle | -360 to 360 | --- | 0.1 | F002 | 0 |
| **Field ground fault protection actual values (read only)** | | | | | | |
| 6640 | Field Ground Resistance | 0 to 20000 | kOhm | 0.001 | F003 | 20000000 |
| 6642 | Field Ground Current | 0 to 655.35 | mA | 0.01 | F001 | 0 |
| 6643 | Field Ground Injected Voltage | -32.767 to 32.767 | V | 0.001 | F002 | 0 |

| Address | Description | Range | Units | Step | Format | Default |
|---|---|---|---|---|---|---|
| 6644 | Field Ground Fault Location | -30000 to 30000 | % | 1 | F002 | -10 |
| 6645 | Field Ground Field Voltage | -3276.8 to 3276.7 | V | 0.1 | F002 | 0 |
| 6646 | Field Current | -9999.999 to 9999.999 | --- | 0.001 | F004 | 0 |
| 6648 | Field Current Units | --- | --- | --- | F206 | "A" |
| **Sub-harmonic stator ground fault settings (read/write)** | | | | | | |
| 6710 | Subharmonic Stator Ground Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 6711 | Subharmonic Stator Ground Stage 1 Pickup | 1 to 20 | kOhm | 1 | F001 | 10 |
| 6712 | Subharmonic Stator Ground Stage 1 Pickup Delay | 0.1 to 600 | s | 0.1 | F001 | 100 |
| 6713 | Subharmonic Stator Ground Stage 2 Pickup | 1 to 20 | kOhm | 1 | F001 | 3 |
| 6714 | Subharmonic Stator Ground Stage 2 Pickup Delay | 0.1 to 600 | s | 0.1 | F001 | 10 |
| 6715 | Subharmonic CT Angle Compensation | -30 to 30 | degrees | 0.1 | F002 | 0 |
| 6718 | Subharmonic Stator Ground OC Pickup | 0.001 to 1 | pu | 0.001 | F001 | 10 |
| 6719 | Subharmonic Stator Ground OC Delay | 0.1 to 600 | s | 0.01 | F001 | 100 |
| 671A | Subharmonic Stator Ground Volt Supv | 0 to 0.1 | pu | 0.001 | F001 | 0 |
| 671B | Subharmonic Stator Ground Curr Supv | 0 to 0.1 | pu | 0.001 | F001 | 0 |
| 671C | Subharmonic Stator Ground Block | 0 to 4294967295 | --- | --- | F300 | 0 |
| 671E | Subharmonic Stator Ground Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 671F | Subharmonic Stator Ground Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| **Field current settings (read/write)** | | | | | | |
| 7E74 | Field Current Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7E75 | Field Current Origin | 0 to 48 | --- | 1 | F151 | 0 (NONE) |
| 7E76 | Field Current Over Current (OC) Pickup | 0.05 to 1 | pu | 0.01 | F001 | 80 |
| 7E77 | Field Current Over Current (OC) Delay | 0 to 600 | seconds | 0.01 | F001 | 100 |
| 7E78 | Field Current Under Current (UC) Pickup | 0.05 to 1 | pu | 0.01 | F001 | 20 |
| 7E79 | Field Current Under Current (UC) Delay | 0 to 600 | seconds | 0.01 | F001 | 100 |
| 7E7A | Field Current Block | 0 to 4294967295 | --- | 1 | F300 | 0 |
| 7E7C | Field Current Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 7E7D | Field Current Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| **Field ground settings (read/write)** | | | | | | |

| Address | Description | Range | Units | Step | Format | Default |
|---|---|---|---|---|---|---|
| 7E7E | Field Ground Function | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |
| 7E7F | Field Ground Injection Frequency | 0.1 to 3 | Hz | 0.01 | F001 | 100 |
| 7E80 | Field Ground Injection Connection Type | 0 to 1 | --- | 1 | F613 | 0 (Single Point) |
| 7E81 | Field Ground STG1 Pickup | 1 to 500 | kOhm | 1 | F001 | 20 |
| 7E82 | Field Ground STG1 Delay | 0.1 to 600 | seconds | 0.1 | F001 | 100 |
| 7E83 | Field Ground STG2 Pickup | 1 to 500 | kOhm | 1 | F001 | 5 |
| 7E84 | Field Ground STG2 Delay | 0.1 to 600 | seconds | 0.1 | F001 | 30 |
| 7E85 | Field Ground UC Pickup | 0.05 to 100 | mA | 0.01 | F001 | 100 |
| 7E86 | Field Ground UC Delay | 0.1 to 600 | seconds | 0.01 | F001 | 100 |
| 7E87 | Field Ground Block | 0 to 4294967295 | --- | 1 | F300 | 0 |
| 7E89 | Field Ground Target | 0 to 2 | --- | 1 | F109 | 0 (Self-reset) |
| 7E8A | Field Ground Events | 0 to 1 | --- | 1 | F102 | 0 (Disabled) |

## Modbus memory map data formats

**F001: UNSIGNED 16 BIT INTEGER**

Unsigned 16-bit integer numerical data.

**F002: SIGNED 16 BIT INTEGER**

Singed 16-bit integer numerical data.

**F003: UNSIGNED 32 BIT INTEGER**

Unsigned 32-bit integer (two registers) numerical data.

The high-order word is stored in the first register, and the low-order word is stored in the second register.

**F004: SIGNED 32 BIT INTEGER**

Signed 32-bit integer (two registers) numerical data. The high-order word is stored in the first register, and the low-order word is stored in the second register.

**F060: IEEE 32-BIT FLOATING POINT NUMBER**

IEEE 32-bit floating point number numerical data.

**F102: ENABLE AND DISABLE FUNCTION**

| Enumeration | Function |
|---|---|
| 0 | Disabled |
| 1 | Enabled |

**F109: CONTACT OUTPUT OPERATION**

| Enumeration | Operation |
|---|---|
| 0 | Self-reset |
| 1 | Latched |
| 2 | Disabled |

**F141: SELF TEST ERRORS**

| Products | Bitmask | Error |
|---|---|---|
| All | 0 | Any Self Tests |
| " | 1 | IRIG-B Failure |
| " | 2 | Port 1 Offline |
| " | 3 | Port 2 Offline |
| " | 4 | Port 3 Offline |
| " | 5 | Port 4 Offline |
| " | 6 | Port 5 Offline |
| " | 7 | Port 6 Offline |
| " | 8 | RRTD Communications Failure |
| " | 9 | Voltage Monitor |
| " | 10 | FlexLogic Error Token |
| " | 11 | Equipment Mismatch |
| " | 12 | Process Bus Failure |
| " | 13 | Unit Not Programmed |
| " | 14 | System Exception |
| " | 15 | Latching Output Discrepancy |
| " | 17 | Maintenance Alert 01 |
| " | 18 | SNTP Failure |
| " | 19 | Maintenance Alert |
| " | 20 | Maintenance Alert |
| " | 21 | Maintenance Alert |
| " | 22 | Temperature Monitor |
| All except B90, L60 | 23 | Process Bus Trouble |
| All except B90, L60 | 24 | Brick Trouble |
| All | 25 | Field RTD Trouble |
| " | 26 | Field TDR Trouble |
| " | 27 | RxGOOSE Offline |
| " | 28 | Direct Device Offline |
| " | 29 | Maintenance Alert |
| " | 30 | Any Minor Error |
| " | 31 | Any Major Error |
| " | 33 | Maintenance Alert |
| " | 64 | Maintenance Alert |
| " | 65 | IEC 61850 Data Set |
| " | 66 | Aggregator Error |
| " | 67 | Unit Not Calibrated |
| " | 68 | Settings Save Error |
| " | 69 | SRAM Data Error |
| " | 70 | Program Memory |

| Products | Bitmask | Error |
|---|---|---|
| " | 71 | Watchdog Error |
| " | 72 | Low on Memory |
| " | 73 | Prototype Firmware |
| " | 74 | Module Failure 01 |
| " | 75 | Module Failure 02 |
| " | 76 | Module Failure 03 |
| " | 77 | Module Failure 04 |
| " | 78 | Module Failure 05 |
| " | 79 | Module Failure 06 |
| " | 80 | Module Failure 07 |
| " | 81 | Module Failure 08 |
| " | 82 | Module Failure 09 |
| " | 83 | Incompatible H/W |
| " | 84 | Module Failure 10 |
| " | 85 | Module Failure 11 |
| " | 86 | Module Failure 12 |
| " | 87 | High ENET Traffic |
| " | 89 | Relay Restart |
| " | 90 | FGM Failure |
| " | 91 | FGM Failure |
| " | 92 | FGM Failure |
| " | 93 | FGM Failure |
| " | 94 | FGM Failure |
| " | 95 | FGM Error |
| " | 96 | Maintenance Alert |
| " | 97 | PHY Monitor |
| " | 98 | Storage Media Alarm |
| " | 99 | Wrong Transceiver |
| " | 100 | Power Supply Warning |
| " | 101 | RAM Filesystem Fail |
| " | 102 | Backup CID Imported |
| " | 103 | Defaulted to ICD |
| " | 104 | TO Install Settings |

**F146: MISCELLANEOUS EVENT CAUSES**

| Products | Bitmask | Definition |
|---|---|---|
| All | 0 | Events Cleared |
| " | 1 | Oscillography Triggered |
| " | 2 | Date/time Changed |
| " | 3 | Default Settings Loaded |
| " | 4 | Test Mode Forcing On |
| " | 5 | Test Mode Forcing Off |
| " | 6 | Power On |
| " | 7 | Power Off |
| " | 8 | Relay In Service |
| " | 9 | Relay Out of Service |
| " | 10 | Watchdog Reset |
| " | 11 | Oscillography Clear |
| " | 12 | Reboot Command |
| " | 13 | LED Test Initiated |
| " | 14 | Flash Programming |
| " | 15 | Fault Report Trigger |
| " | 16 | User-Programmable Fault Report Trigger |
| " | 17 | --- |
| " | 18 | Reload CT/VT module (DSP) Settings |
| " | 19 | --- |
| " | 20 | Ethernet Port 1 Offline |
| " | 21 | Ethernet Port 2 Offline |
| " | 22 | Ethernet Port 3 Offline |
| " | 23 | Ethernet Port 4 Offline |
| " | 24 | Ethernet Port 5 Offline |
| " | 25 | Ethernet Port 6 Offline |
| " | 26 | Test Mode Isolated |
| " | 27 | Test Mode Forcible |
| " | 28 | Test Mode Disabled |
| " | 29 | Temperature Warning On |
| " | 30 | Temperature Warning Off |
| " | 31 | Unauthorized Access |
| " | 32 | System Integrity Recovery |
| " | 33 | System Integrity Recovery 06 |
| " | 34 | System Integrity Recovery 07 |
| N60 | 35 | Slot B Module |
| " | 36 | Slot D Module |
| " | 37 | Slot F Module |
| " | 38 | Slot G Module |
| " | 39 | Slot H Module |
| " | 40 | Slot J Module |
| " | 41 | Slot K Module |
| " | 42 | Slot L Module |
| " | 43 | Slot M Module |
| " | 44 | Slot N Module |

| Products | Bitmask | Definition |
|---|---|---|
| " | 45 | Slot P Module |
| " | 46 | Slot R Module |
| " | 47 | Slot S Module |
| " | 48 | Slot T Module |
| " | 49 | Slot U Module |
| " | 50 | Slot V Module |
| " | 51 | Slot W Module |
| " | 52 | Slot X Module |
| All | 53 | CID Imported |
| " | 54 | Backup CID Imported |
| " | 55 | ICD Applied |
| " | 56 | SYS INTEGR RECOV 08 |
| C60 D60 F60 G60 L30 L90 N60 T60 | 57 | PMU 1 Record Triggered |
| C60 N60 | 58 | PMU 2 Record Triggered |
| N60 | 59 | PMU 3 Record Triggered |
| " | 60 | PMU 4 Record Triggered |
| " | 61 | PMU 5 Record Triggered |
| " | 62 | PMU 6 Record Triggered |

**F151: RTD SELECTION**

| Bitmask | Selected RTD |
|---|---|
| 0 | No RTD selected |
| 1 | RTD 1 |
| 2 | RTD 2 |
| 3 | RTD 3 |
| 4 | RTD 4 |
| 5 | RTD 5 |
| 6 | RTD 6 |
| 7 | RTD 7 |
| 8 | RTD 8 |
| 9 | RTD 9 |
| 10 | RTD 10 |
| 11 | RTD 11 |
| 12 | RTD 12 |
| 13 | RTD 13 |
| 14 | RTD 14 |
| 15 | RTD 15 |
| 16 | RTD 16 |
| 17 | RTD 17 |
| 18 | RTD 18 |
| 19 | RTD 19 |
| 20 | RTD 20 |
| 21 | RTD 21 |
| 22 | RTD 22 |
| 23 | RTD 23 |

| Bitmask | Selected RTD |
|---|---|
| 24 | RTD 24 |
| 25 | RTD 25 |
| 26 | RTD 26 |
| 27 | RTD 27 |
| 28 | RTD 28 |
| 29 | RTD 29 |
| 30 | RTD 30 |
| 31 | RTD 31 |
| 32 | RTD 32 |
| 33 | RTD 33 |
| 34 | RTD 34 |
| 35 | RTD 35 |
| 36 | RTD 36 |
| 37 | RTD 37 |
| 38 | RTD 38 |
| 39 | RTD 39 |
| 40 | RTD 40 |
| 41 | RTD 41 |
| 42 | RTD 42 |
| 43 | RTD 43 |
| 44 | RTD 44 |
| 45 | RTD 45 |
| 46 | RTD 46 |
| 47 | RTD 47 |
| 48 | RTD 48 |

**F206: 6-CHARACTER ASCII TEXT**

Unsigned 48-bit integer (three registers) numerical data. For every 16-bit register (two characters), the most-significant byte represents the first character, and the least-significant byte represents the second character.

**F208: 2-CHARACTER ASCII TEXT**

**F300: FLEXLOGIC BASE TYPE (15-bit type)**

The FlexLogic BASE type is 14 bits and is combined with a 17-bit descriptor and 1 bit for the protection element to form a 32-bit value. The combined bits are of the form: PTTTTTTTTTTTTTTDDDDDDDDDDDDDDDDD, where P bit if set indicates that the FlexLogic type is associated with a protection element state and D represents bits for the type in F124 format. If P bit is not set, then the T represents bits for the type and D represents range.

The values in square brackets indicate the base type with P prefix [PTTTTTTTTTTTTTT] and the values in round brackets indicate the descriptor range. The left-most D bit indicates whether the type is an ON or OFF type. There can be a total 65535 BASE type elements, 131071 protection element IDs, and 16383 element states. There can be a total of 65535 descriptors of each type.

[0] Off (0) – This is boolean FALSE value

[1] On (1) – This is boolean TRUE value

[2] CONTACT INPUTS (1 to 96)

[3] CONTACT INPUTS OFF (1 to 96)
[4] VIRTUAL INPUTS (1 to 32)
[6] VIRTUAL OUTPUTS (1 to 64)
[8] CONTACT OUTPUTS
[10] CONTACT OUTPUTS VOLTAGE DETECTED (1 to 64)
[11] CONTACT OUTPUTS VOLTAGE OFF DETECTED (1 to 64)
[12] CONTACT OUTPUTS CURRENT DETECTED (1 to 64)
[13] CONTACT OUTPUTS CURRENT OFF DETECTED (1 to 64)
[14] REMOTE INPUTS (1 to 32)
[16] DIRECT INPUTS (1 to 96)
[18] REMOTE OUTPUT DNA BIT PAIRS (1 to 32)
[20] REMOTE OUTPUT UserSt BIT PAIRS (1 to 32)
[22] REMOTE DEVICE ONLINE (1 to 16)
[24] MISCELLANEOUS EQUATION
[26] TELEPROTECTION INPUTS
[28] INSERT (via keypad only)
[30] DELETE (via keypad only)
[32] END
[34] NOT (1 INPUT)
[36] 2 INPUT XOR (0)
[38] LATCH SET/RESET (2 inputs)
[40] OR (2 to 16 inputs)
[42] AND (2 to 16 inputs)
[44] NOR (2 to 16 inputs)
[46] NAND (2 to 16 inputs)
[48] TIMER (1 to 32)
[50] ASSIGN VIRTUAL OUTPUT (1 to 64)
[52] ONE SHOT
[54] SELF-TEST ERROR (see F141 for range)
[56] PLATFORM DIRECT INPUT (1 to 96)
[58] PLATFORM DIRECT OUTPUT (1 to 96)
[60] PLATFORM DIRECT DEVICE (1 to 8)
[62] MISCELLANEOUS EVENTS (see F146 for range)
[64] PDC NETWORK CONTROL
[66] PMU RECORDER OUT OF MEMORY
[68] PMU RECORDER STOPPED
[128 to 255] ELEMENT STATES (see the Element States section in the G60 Modbus memory map)

**F613: FIELD GROUND MODULE (FGM) INJECTION CONNECTION TYPE**

| Enumeration | Connection type |
|---|---|
| 0 | Single-point |
| 1 | Double-point |

# GPM Field and Stator Ground Fault Protection Modules

# Chapter 8: Maintenance

This chapter outlines repair, storage, and disposal.

## Repairs

There are no parts that can be replaced in the field by the end user. The firmware and software can be upgraded without return of the device to the factory.

For issues not solved by troubleshooting, the process to return the device to the factory for repair is as follows:

- Contact a GE Grid Solutions Technical Support Center. Contact information is found in the first chapter.
- Obtain a Return Materials Authorization (RMA) number from the Technical Support Center.
- Verify that the RMA and Commercial Invoice received have the correct information.
- Tightly pack the unit in a box with bubble wrap, foam material, or styrofoam inserts or packaging peanuts to cushion the item(s). You may also use double boxing whereby you place the box in a larger box that contains at least 5 cm of cushioning material.
- Ship the unit by courier or freight forwarder, along with the Commercial Invoice and RMA, to the factory.

  GE GRID SOLUTIONS
  650 MARKLAND STREET
  MARKHAM, ONTARIO
  CANADA  L6C 0M1
  ATTN: SERVICE DEPT.
  RMA# : _____

  Customers are responsible for shipping costs to the factory, regardless of whether the unit is under warranty.
- Fax a copy of the shipping information to the GE Grid Solutions service department in Canada at +1 905 927 5098.

Use the detailed return procedure outlined at
https://www.gegridsolutions.com/multilin/support/ret_proc.htm
The current warranty and return information are outlined at
https://www.gegridsolutions.com/multilin/warranty.htm

## Storage

Store the unit indoors in a cool, dry place. If possible, store in the original packaging.

## Disposal

There are no special requirements for disposal of the unit at the end its service life. To prevent non-intended use of the unit, dismantle the unit, and recycle the metal when possible.

# GPM Field and Stator Ground Fault Protection Modules

# Appendix A: Miscellaneous

This chapter provides the warranty and the document revision history.

## Warranty

For products shipped as of 1 October 2013, GE Grid Solutions warrants most of its GE manufactured products for 10 years. For warranty details including any limitations and disclaimers, see the Terms and Conditions at

https://www.gegridsolutions.com/multilin/warranty.htm

For products shipped before 1 October 2013, the standard 24-month warranty applies.

## Revision history

The table outlines the releases and revision history of this document. The suffix on the 1601 part number follows the UR Family release cycle.

**Table 8: Revision history (English)**

| Publication number | Part number | Firmware | Release date | ECO |
|---|---|---|---|---|
| GEK-113231 | 1601-0256-V1 | 1.0x | 1 September 2010 | 10-1812 |
| GEK-113231A | 1601-0256-V2 | 1.0x | 7 February 2011 | 10-1966 |
| GEK-113231B | 1601-0256-Z1 | 1.0x | 15 February 2013 | 13-0126 |
| GEK-113231C | 1601-0256-AC1 | 1.0x | 1 May 2016 | 16-2703 |
| GEK-113231D | 1601-0256-AF1 | 1.0x | 1 May 2017 | 17-3647 |
| GEK-113231E | 1601-0256-AG1 | 1.0x | 31 March 2018 | 18-4430 |
| GEK-113231F | 1601-0256-AH1 | 1.0x | 9 October 2018 | 18-4790 |

### Table 9: Major changes to GPM manual version AH1 (English)

| Page | Description |
|---|---|
| --- | Updated several figures, increasing size and improving line widths |
| 7 | Added to Stator Ground Protection CT specifications, specifically relay class and weight |
| 26 | Added Figure 23 Dimensions for Stator Ground Protection CT (204-SD-43737) |

### Table 10: Major changes to GPM manual version AG1 (English)

| Page | Description |
|---|---|
| 12 | Updated Table 1 Pin Assignments for GPM-F-L, specifically C2 to C4 entries |
| 17 | Updated Table 2 Pin Assignments for GPM-F-HM specifically C2 to C4 entries |
| 22 | Updated Figure 20 title to "Dimensions for panel-mounted GPM-S-G (discontinued)" instead of "first generation" |
| 25 | Updated Figure 24 title to "Mounting for panel-mounted GPM-S-G (discontinued)" instead of "first generation" |
| 32 | Updated equation 1 in Sub-harmonic Stator Ground Fault Settings section |

### Table 11: Major changes to GPM manual version AF1 (English)

| Page | Description |
|---|---|
| --- | General revision |
| --- | Updated template to 8.5 x 11 inch format instead of small format 5.5 x 7.25 inch size to reflect current printing process |
| --- | Updated title from Quick Reference Guide to Instruction Manual for consistency with Universal Relay (UR) products |
| 5 | Updated several specifications, including Terminals |
| 28 | Added warning before Figure 28 GPM-S-B Module Showing Terminal Blocks |
| 31 | Updated Settings chapter to be consistent with G60 instruction manual |
| 47 | Updated Modbus memory map and F codes |

### Table 12: Major changes to GPM manual version AC1 (English)

| Page | Description |
|---|---|
| --- | Updated branding from GE Digital Energy to GE Grid Solutions and refreshed template |
| 25, 39 | Updated introductory sentences for firmware upgrade |
| 29 | Added sentence regarding use of 8G, 8J, 8M, 8R modules to connect to G60 |
| 30 | Updated Figure 19 Dimensions for GPM-S-G Panel-Mounted Unit for dimensions and screw locations |
| 34 | Updated Figure 23 Mounting Diagram for GPM-S-G Wall-Mounted Unit to reflect change in screw locations |
| 35 | Updated Figure 25 Rear View of GPM-S-G Module Showing Terminal Blocks to reflect change in screw locations |
| 73 | Added Maintenance chapter with repair, storage, and disposal information |
| 75 | Revised warranty to 10 years |

### Table 13: Major changes to GPM manual version Z1 (English)

| Page | Description |
|---|---|
| --- | Updated with general editing |
| 4 | Added GPM-S-G Module Contact Input specifications |
| 11 | Added content that three contact inputs provided for GPM-F-L pin assignments for connectors and that low frequency injection stops upon closure of any of the contact inputs. |
| 17 | Added content that three contact inputs provided for GPM-F-HM pin assignments for connectors and that low frequency injection stops upon closure of any of the contact inputs. |
| 30 | Added content that two contact inputs are provided for GPM-S-G pin assignments for connectors and that 20 Hz injection stops upon closure of any of the contact inputs. |