SEL-2664

Field Ground Module

Instruction Manual

20240529

SCHWEITZER ENGINEERING LABORATORIES, INC.

PM2664-01

PM2664-01

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Preface

Manual Overview

The SEL-2664 Field Ground Module Instruction Manual contains specifications and describes the installation, operation, settings, application, and troubleshooting of the module.

An overview of each manual section and topics follows:

Preface: Describes the manual organization and conventions used to present information; lists important safety information.

Section 1: Introduction and Specifications. Specifies the basic features and functions of the SEL-2664; lists the specifications.

Section 2: Hardware and Installation. Explains how to mount and wire the SEL-2664; illustrates wiring connections for various applications.

Section 3: Insulation Resistance Measurement. Details how the SEL-2664 calculates the insulation resistance of the generator field winding to ground and provides guidance to select the appropriate settings.

Section 4: Applications. Discusses how to connect the SEL-2664 to the SEL-300G, SEL-700G, SEL-2664S, or to an SEL communications processor. Also provides an example of programming an SEL communications processor to work with the SEL-2664 for monitoring and indication.

Section 5: Testing and Troubleshooting. Lists self-tests and troubleshooting instructions.

Appendix A: Firmware and Manual Versions. Provides a record of changes made to the firmware and manual since the initial release.

Appendix B: Firmware Upgrade Instructions. Describes the procedure to upgrade the firmware stored in Flash memory.

Safety Information

⚠CAUTION

To ensure proper safety and operation, the equipment ratings, installation instructions, and operating instructions must be checked before commissioning or maintenance of the equipment. The integrity of any protective conductor connection must be checked before carrying out any other actions. It is the responsibility of the user to ensure that the equipment is installed, operated, and used for its intended function in the manner specified in this manual. If misused, any safety protection provided by the equipment may be impaired.

Dangers, Warnings, and Cautions

This manual uses three kinds of hazard statements, defined as follows:

⚠DANGER
Indicates an imminently hazardous situation that, if not avoided, **will** result in death or serious injury.

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

⚠CAUTION
Indicates a potentially hazardous situation that, if not avoided, **may** result in minor or moderate injury or equipment damage.

Safety Symbols

The following symbols are often marked on SEL products.

	**⚠CAUTION** Refer to accompanying documents.	**⚠ATTENTION** Se reporter à la documentation.
	Earth (ground)	Terre
	Protective earth (ground)	Terre de protection
	Direct current	Courant continu
	Alternating current	Courant alternatif
	Both direct and alternating current	Courant continu et alternatif
	Instruction manual	Manuel d'instructions

Safety Marks

The following statements apply to this device.

General Safety Marks (Sheet 1 of 2)

⚠CAUTION For use in a controlled environment.	**⚠ATTENTION** Pour utilisation dans un milieu controle.
Connectors for power supply must have overcurrent protection of 20 A, 300 V maximum. Provide a 14 AWG–16 AWG copper ground conductor.	Connecteurs pour l'entrée et l'offre doivent avoir protection de surintensité du circuit de dérivation rated un maximum de 20 A, 300 V. Fournir une AWG 14–AWG 16 de terre en cuivre.
For use in Pollution Degree 2 environment.	Pour l'utilisation dans un environnement de Degré de Pollution 2.
Ambient air temperature shall not exceed 40°C (104°F).	La température de l'air ambiante ne doit pas dépasser 40°C (104°F).
For use on a flat surface of a Type 12 enclosure.	Destiné à l'utilisation sur une surface plane d'un boîtier de Type 12.

General Safety Marks (Sheet 2 of 2)

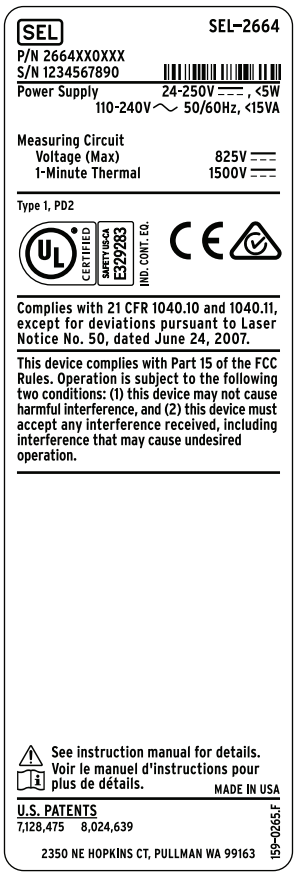
Terminal Ratings Wire Material Use copper supply wires suitable for 105°C (221°F). Wire Size Power Connections: 14–16 AWG Field Connections: 14–18 AWG Tightening Torque Compression Plug: 0.5–1.0 Nm (4.4–8.8 in-lb)	Spécifications des bornes Type de filage Utiliser seulement conducteurs en cuivre 105°C (221°F). Calibre de fil Connexions d'alimentation : 14–16 AWG Connexions de champ : 14–18 AWG Couple de serrage Fiche à compression : 0,5–1,0 Nm (4,4–8,8 livres-pouce)
Constructed of minimum 1 mm thick non-painted aluminum, measuring approximately 235 mm by 215 mm by 95 mm.	Construit d'un minimum de 1 mm d'épaisseur en aluminium non peinte, mesurant environ 235 mm par 215 mm par 95 mm.
When protected by an external circuit breaker, the breaker must be rated 20 A, 300 V maximum.	Lorsque protégé par un disjoncteur externe, le disjoncteur doit avoir une valeur nominale de 20 A, 300 V maximal.

Other Safety Marks

⚠DANGER Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.	**⚠DANGER** Débrancher tous les raccordements externes avant d'ouvrir cet appareil. Tout contact avec des tensions ou courants internes à l'appareil peut causer un choc électrique pouvant entraîner des blessures ou la mort.
⚠DANGER Field connection terminals are connected to the generator field winding, which usually carries very high dc voltage. Disconnect the wires from the generator field winding before working on the unit. Never come into contact with live wires.	**⚠DANGER** Les bornes de raccordement à l'enroulement du champ du générateur sont directement connectées à l'alimentation du champ dont la tension peut s'élever à plusieurs centaines de volts CC. Débrancher les fils en provenance de l'enroulement du champ avant de travailler sur l'unité. Ne jamais toucher des filssous tension.
⚠WARNING Use of this equipment in a manner other than specified in this manual can impair operator safety safeguards provided by this equipment.	**⚠AVERTISSEMENT** L'utilisation de cet appareil suivant des procédures différentes de celles indiquées dans ce manuel peut désarmer les dispositifs de protection d'opérateur normalement actifs sur cet équipement.
⚠WARNING Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.	**⚠AVERTISSEMENT** Seules des personnes qualifiées peuvent travailler sur cet appareil. Si vous n'êtes pas qualifiés pour ce travail, vous pourriez vous blesser avec d'autres personnes ou endommager l'équipement.
⚠CAUTION Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.	**⚠ATTENTION** Les composants de cet équipement sont sensibles aux décharges électrostatiques (DES). Des dommages permanents non-décelables peuvent résulter de l'absence de précautions contre les DES. Raccordez-vous correctement à la terre, ainsi que la surface de travail et l'appareil avant d'en retirer un panneau. Si vous n'êtes pas équipés pour travailler avec ce type de composants, contacter SEL afin de retourner l'appareil pour un service en usine.
⚠CAUTION Class 1 LASER Product. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.	**⚠ATTENTION** Produit LASER de Classe 1. Regarder vers les connecteurs optiques, les extrémités des fibres ou les connecteurs de cloison peut entraîner une exposition à des rayonnements dangereux.
⚠CAUTION Use of controls or adjustments, or performance of procedures other than those specified herein, may result in hazardous radiation exposure.	**⚠ATTENTION** L'utilisation de commandes ou de réglages, ou l'application de tests de fonctionnement différents de ceux décrits ci-après peuvent entraîner l'exposition à des radiations dangereuses.

Product and Compliance Label

The label is affixed to the top of the product. Refer to *Figure 2.1*.



Laser

The SEL-2664 is a Class 1 Laser Product and complies with IEC 60825-1:2007 and with 21 CFR 1040.10. The following table shows laser information specific to the SEL-2664.

Item	Detail
Mode	Transmit (No Receive) multimode
Wavelength	850 nm
Source	LASER
Connector type	ST
Output power	–14 to –3 dBm

Laser/LED Safety Warnings and Precautions (Sheet 1 of 2)

⚠CAUTION
Use of controls, adjustments, or performance of procedures other than those specified herein may result in hazardous radiation exposure.

⚠CAUTION
Class 1 LASER Product. Looking into optical connections, fiber ends, or bulkhead connections can result in hazardous radiation exposure.

- ➤ Do not look into the end of an optical cable connected to an optical output.
- ➤ Do not look into the fiber-optic ports/connectors.
- ➤ Do not perform any procedures or adjustments that are not described in this manual.

Laser/LED Safety Warnings and Precautions (Sheet 2 of 2)

- ➤ During installation, maintenance, or testing of the optical ports, only use test equipment classified as Class 1 laser products.
- ➤ Incorporated components such as transceivers and laser/LED emitters are not user serviceable. Units must be returned to SEL for repair or replacement.

Environmental Conditions and Voltage Information

The following table lists important environmental and voltage information.

Condition	Range/Description
Indoor/outdoor use	Indoor/Outdoor
Altitude[a]	As high as 2000 m
Temperature	–40° to +85°C
Relative Humidity	5% to 95% noncondensing
Main Supply Voltage Fluctuations	±10% of nominal voltage
Overvoltage	Category II
Pollution	Degree 2
Atmospheric pressure	80 to 110 kPa

[a] Consult with the factory for derating specifications for higher altitude applications.

Instructions for Cleaning and Decontamination

Disconnect all power sources from the module before cleaning. Clean the surface with a mild soap solution and a damp cloth. Do not use abrasive materials, polishing compounds, or harsh chemical solvents (such as xylene or acetone) on any surface.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

Schweitzer Engineering Laboratories, Inc.
2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A
Tel: +1.509.338.3838
Fax: +1.509.332.7990
Internet: selinc.com/support
Email: info@selinc.com

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Section 1
Introduction and Specifications

Introduction

NOTE: The rotor iron of the generator must be grounded to ensure accurate measurement of the insulation resistance between the field winding and ground. Follow the machine manufacturer's guidelines for grounding practices of the rotor iron.

The SEL-2664 Field Ground Module calculates the insulation resistance of a synchronous generator field winding to ground. The measurement can be performed on an energized or de-energized generator. The module transmits the insulation resistance value to an SEL-300G, SEL-400G, SEL-700G, or SEL-2664S Relay, which then compares this value with pickup settings for alarm or trip.

The SEL-300G, SEL-400G, SEL-700G, and SEL-2664S use the insulation resistance value to detect a ground fault in an ungrounded field winding of a generator. Avoid significant damage to the generator by taking corrective actions before a second ground path occurs.

The SEL-2664 uses inexpensive fiber-optic cable to transmit the field insulation resistance value as far as 1000 meters.

The SEL-2664 works with continuous field voltages as high as 750 Vdc and can withstand 1500 Vdc for one minute.

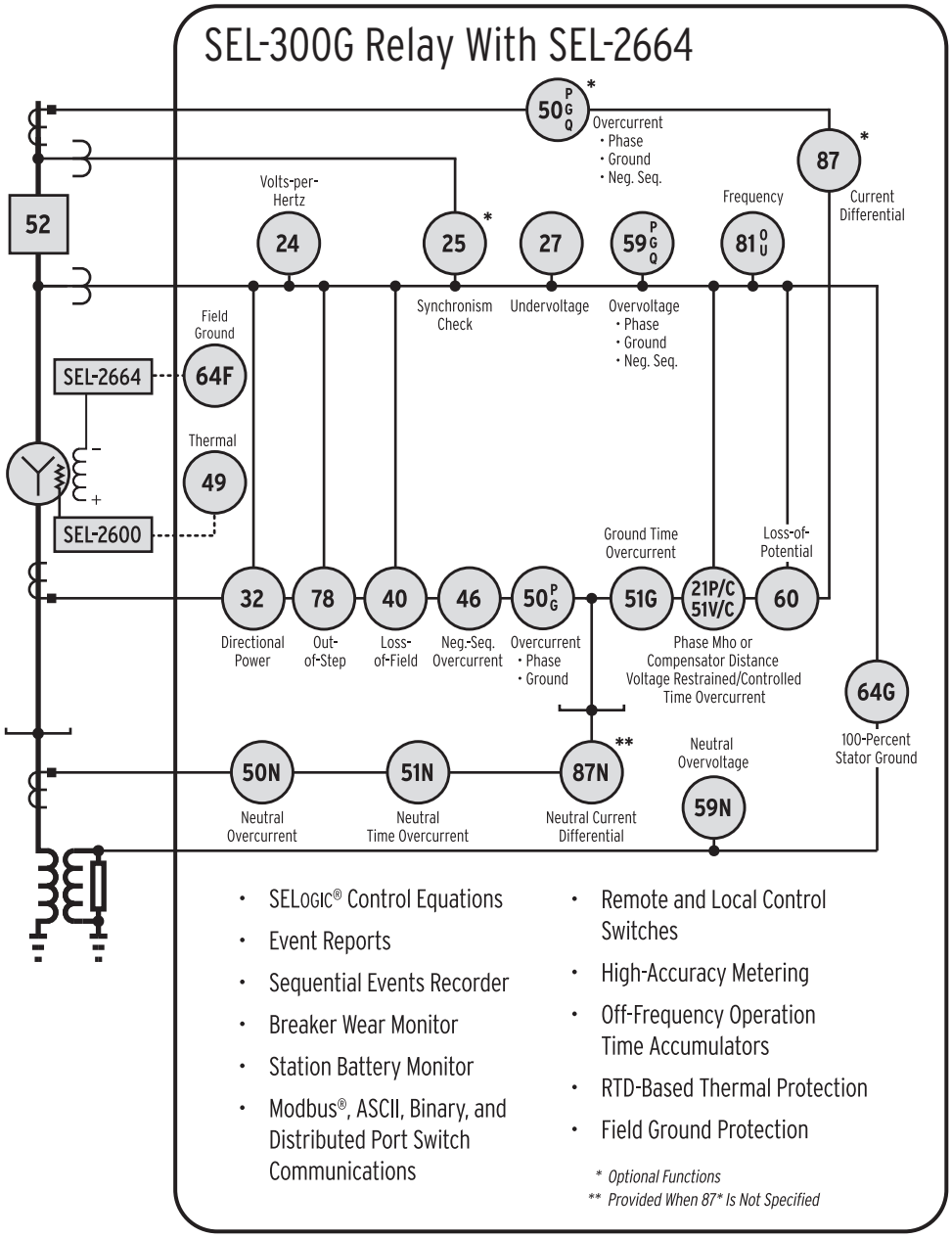


Figure 1.1 SEL-2664 Functional Overview (an SEL-400G, SEL-700G or SEL-2664S Application Is Similar)

Specifications

Compliance

Designed and manufactured under an ISO 9001 certified quality management system

UL Listed to U.S. and Canadian safety standards (File E329283; NMTR, NMTR7)

CE Mark

RCM Mark

General

Power Supply

Nominal Input Voltage: 24–250 Vdc
110–240 Vac (50/60 Hz)

Input Voltage Range: 18–300 Vdc
85–264 Vac

Power Consumption: <5 W or 5 VA

Fuse Ratings

Ratings: 1.6 A

Maximum Rated Voltage: 300 Vdc, 250 Vac

Breaking Capacity: 1500 A at 250 Vac

Type: Time-lag T

Operating Temperature

–40° to +85°C (–40° to +185°F)

Relative Humidity

5% to 95% noncondensing

Maximum Altitude

2000 m

Atmospheric Pressure

80–110 kPa

Pollution Degree

Degree 2

Overvoltage Category

Category II

Dimensions

See *Figure 2.2*, *Figure 2.3*, and *Figure 2.4* for device dimensions.

Weight

1.36–1.81 kg (3–4 lb)

Power Terminal Connections

Compression Plug Tightening Torque

Minimum: 0.5 Nm (4.4 in-lb)
Maximum: 1.0 Nm (8.8 in-lb)

Frequency

50, 60 Hz

DC Voltage Input

Nominal Operating Voltage (U_e): 60–750 Vdc continuous

Maximum Rated Voltage Range: 48–825 Vdc continuous

Rated Insulation Voltage: 825 Vdc

1-Minute Thermal Rating: 1500 Vdc

Common Mode Voltage for Accuracy: ≤50 Vdc

Rated Impulse Voltage (U_{imp}): 5000 V

Continuous Current Rating: 0.5 A

Measurement Category II

Fiber-Optic Port

One port consisting of a transmit (no receive) multimode fiber-optic interface with ST connections

Location: Rear Panel

Transmission Distance: ≤1000 meters

Fiber-Optic Cable: 50, 62.5, and 200 µm fiber

Wavelength: 850 nm

Data Rate: 9600 bps

Optical Source: 850 nm VCSEL transmitter

Typical Transmit Level: –12 dBm

Maximum Output Level: –3.0 dBm

Communication Protocols

SEL ASCII

Xmodem file transfer

SEL Fast Message Unsolicited Block Transmit

Element Accuracies

Insulation Resistance Measurement

Measurement Range: 500 Ω–20 MΩ

Measurement Accuracy,
Steady State (only applicable to 500 Ω–200 kΩ): ±5% ±500 Ω for 48 ≤ VF ≤ 825 Vdc
±5% ±20 kΩ for 825 ≤ VF ≤ 1500 Vdc

Note: VF = Field Voltage

Wire Sizes

Use 105°C-rated wiring. Wire sizes for grounding (earthing) and power connections are dictated by the terminal blocks and expected load currents. You can use the following table as a guide in selecting wire sizes:

Connection Type	Minimum Wire Size	Maximum Wire Size	Insulation Voltage
Grounding (Earthing) Connection	16 AWG (1.3 mm^2)	14 AWG (2.1 mm^2)	300 V min
Power Connection	16 AWG (1.3 mm^2)	14 AWG (2.1 mm^2)	300 V min
Field Terminal Connections	18AWG (0.8 mm^2)	14 AWG (2.1 mm^2)	825 V min

Type Tests

Electromagnetic Compatibility

General: EN 60255-26:2013 ed. 3.0

Electromagnetic Compatibility Emissions

Radiated Emissions:
IEC 60255-26:2013 Class A
FCC 47 CFR Part 15.109 Class A
ICES-003 Issue 6
EN 55011:2009 + A1:2010 Class A
EN 55022:2010 + AC:2011 Class A
EN 55032:2012 + AC:2013 Class A
CISPR 11:2009 + A1:2010 Class A
CISPR 22:2008 Class A
CISPR 32:2015 Class A

Conducted Emissions:
IEC 60255-26:2013 Class A
FCC 47 CFR Part 15.107 Class A
ICES-003 Issue 6
EN 55011:2009 + A1:2010 Class A
EN 55022:2010 + AC:2011 Class A
EN 55032:2012 + AC:2013 Class A
CISPR 11:2009 + A1:2010 Class A
CISPR 22:2008 Class A
CISPR 32:2015 Class A

Electromagnetic Compatibility Immunity

Conducted RF Immunity:
IEC 61000-4-6:2004
IEC 60255-26:2013; Section 7.2.9
Severity Level: 10 Vrms

Electrostatic Discharge Immunity:
IEC 61000-4-2:2008
IEC 60255-26:2013; Section 7.2.3
IEEE C37.90.3-2001
Severity Level 4
8 kV contact discharge
15 kV air discharge

Fast Transient/Burst Immunity:
IEC 61000-4-4:2012
IEC 60255-26:2013; Section 7.2.5
4 kV at 5.0 kHz

Magnetic Field Immunity:
IEC 61000-4-8:2009
IEC 60225-26:2013; Section 7.2.10
Severity Level: 1000 A/m for 3 seconds, 100 A/m for 1 minute; 50/60 Hz
IEC 61000-4-9:2001
Severity Level: 1000 A/m
IEC 61000-4-10:2001
Severity Level: 100 A/m (100 kHz and 1 MHz)

Power Supply Immunity:
IEC 61000-4-11:2004
IEC 61000-4-17:1999
IEC 61000-4-29:2000
IEC 60255-26:2013; Section 7.2.11, 7.2.12, 7.2.13

Radiated Radio Frequency Immunity:
IEC 61000-4-3:2010
IEC 60255-26:2013; Section 7.2.4
10 V/m

Surge Immunity:
IEC 61000-4-5:1995 + A1:2001
IEC 60255-26:2013; Section 7.2.7
1 kV line-to-line
2 kV line-to-earth

Surge Withstand Capability Immunity:
IEC 61000-4-18:2010
IEC 60255-26:2013; Section 7.2.6
2.5 kV common mode
1 kV differential mode
IEEE C37.90.1-2002
2.5 kV oscillatory
4 kV fast transient

Environmental

Cold:
IEC 60255-27:2013; Section 10.6.1.2
IEC 60255-27:2013; Section 10.6.1.4
IEC 60068-2-1:2007
–40°C, 16 hours

Damp Heat, Cyclic:
IEC 60068-2-30:2005
Severity Level: 25°C to 55°C, 6 cycles
Relative Humidity: 95%

Damp Heat, Steady State:
IEC 60068-2-78:2012
Severity Level: 93% RHMin, 40°C; 10 days

Dry Heat:
IEC 60255-27:2013; Section 10.6.1.1
IEC 60255-27:2013; Section 10.6.1.3
IEC 60068-2-2:2007
85°C, 16 hours

Object Penetration and Dust Ingress:
IEC 60529:1989 + A1:1991 + A2:2013
IEC 60255-27:2013; Section 10.6.2.6
Severity Level: IP20

Vibration Resistance:
IEC 60255-21-1:1998
IEC 60255-27:2013; Section 10.6.2.1

Endurance: Class 2
Response: Class 1

Shock Resistance:
IEC 60255-21-2:1998
IEC 60255-27:2013; Section 10.6.2.2
IEC 60255-27:2013; Section 10.6.2.3

Withstand: Class 1
Response: Class 2
Bump: Class 1

Seismic Resistance:
IEC 60255-21-3:1993
IEC 60255-27:2013; Section 10.6.2.4

Quake Response: Class 2

Safety

Dielectric Strength:
IEC 60255-27:2013; Section 10.6.4.3
IEEE C37.90-2005
3.1 kVdc on power supply terminals
4.2 kVdc on field terminals

Impulse:
IEC 60255-27:2013, Section 10.6.4.2
Severity Level: 0.5 J, 5 kV
IEEE C37.90-2005
Severity Level: 0.5 J, 5 kV

Laser Safety:
21 CFR 1040.10
Product Class: Class 1
IEC 60825-1:2007 Class 1

Product Safety:
EN 60255-27:2013 ed 2.0
IEC 61010-1:2001
[BS EN 61010-1:2001]
UL 508
CAN/CSA C22.2 No. 14-10

Section 2
Hardware and Installation

Overview

Design your installation by using the mounting and connection information in this section. Options include wall, panel, or rack mounting. This section also includes information on configuring the SEL-2664 Field Ground Module for your application.

Device Placement

Proper placement of the SEL-2664 ensures that you receive trouble-free service. Follow the stated guidelines for proper physical installation of the module.

Physical Location

The SEL-2664 shall be installed in an indoor or outdoor environment in a suitable overall enclosure. In either environment, the module shall be protected from direct sunlight, precipitation, and full wind pressure, while also restricting personnel from access to hazardous parts. If installed outdoors, it shall be enclosed in a water-tight cabinet. See *Specifications on page 1.3* for environmental guidelines. See *Making Rear-Panel Connections on page 2.6* for protective guidelines against accidental contact to hazardous terminals.

Device Mounting

The SEL-2664 is available in three mounting options: wall mount, rack mount, and panel mount. The wall-mount option is provided standard with the SEL-2664. The panel-mount and rack-mount options do not come standard and must be ordered separately.

The SEL-2664 comes with two faceplates located on the front and the top sides (see *Figure 2.1*). On a wall mount, the top faceplate will face you. On rack and panel mounts, the front faceplate will face you.

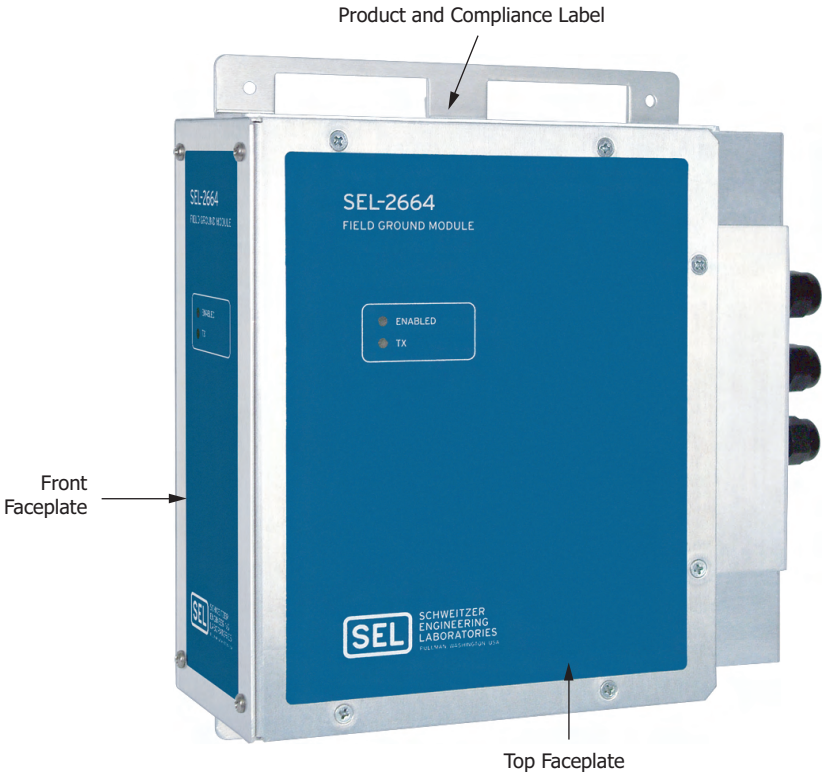


Figure 2.1 SEL-2664 Module Front and Top Faceplates

Wall Mount

SEL offers the SEL-2664 in a wall-mount version for convenient mounting. Refer to the MOT (Model Option Table) to order the SEL-2664 in a wall-mount version. SEL ships a wall-mount bracket with the SEL-2664 for a wall-mount version order. The wall-mount bracket can be screwed directly into a wall with four #10 screws. *Figure 2.1* shows the SEL-2664 with a wall-mount bracket.

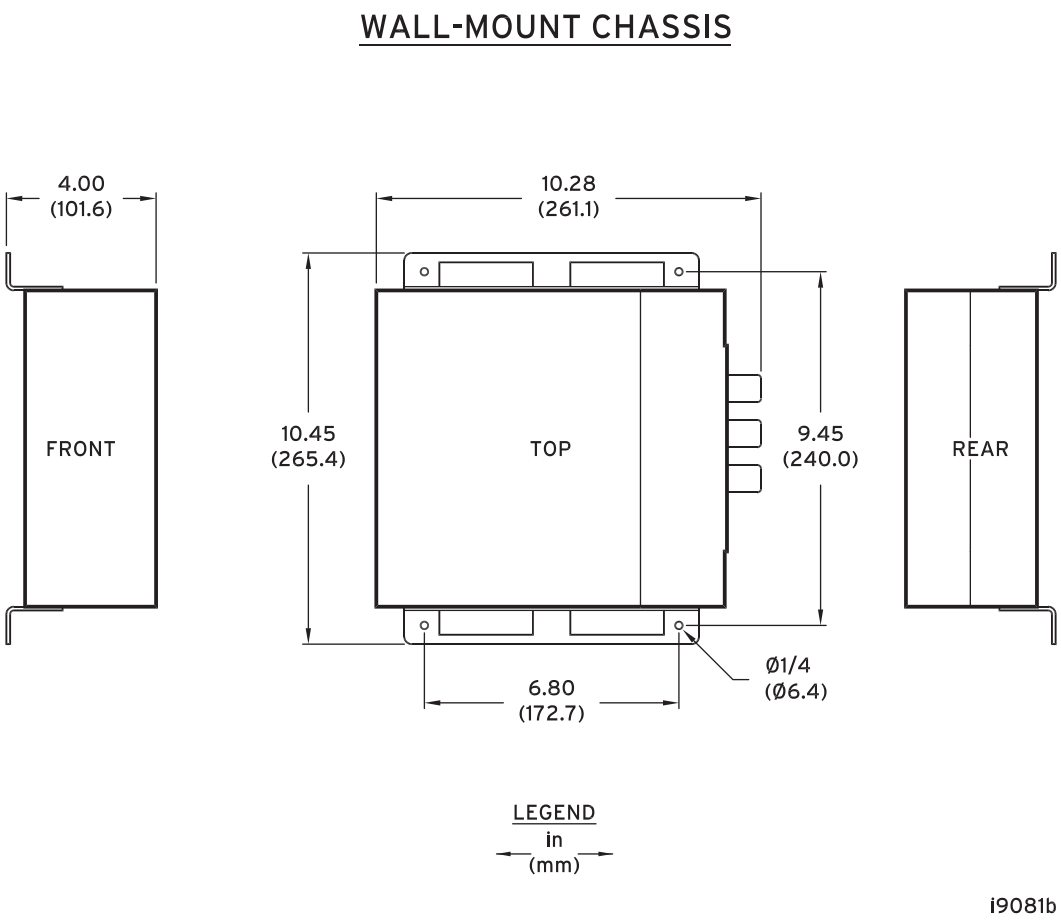


Figure 2.2 SEL-2664 Wall-Mount Dimensions

Panel Mount

SEL also offers the SEL-2664 in a panel-mount version. Refer to the Model Option Table to order the SEL-2664 in a panel-mount version. Follow the steps below to install the module onto a panel.

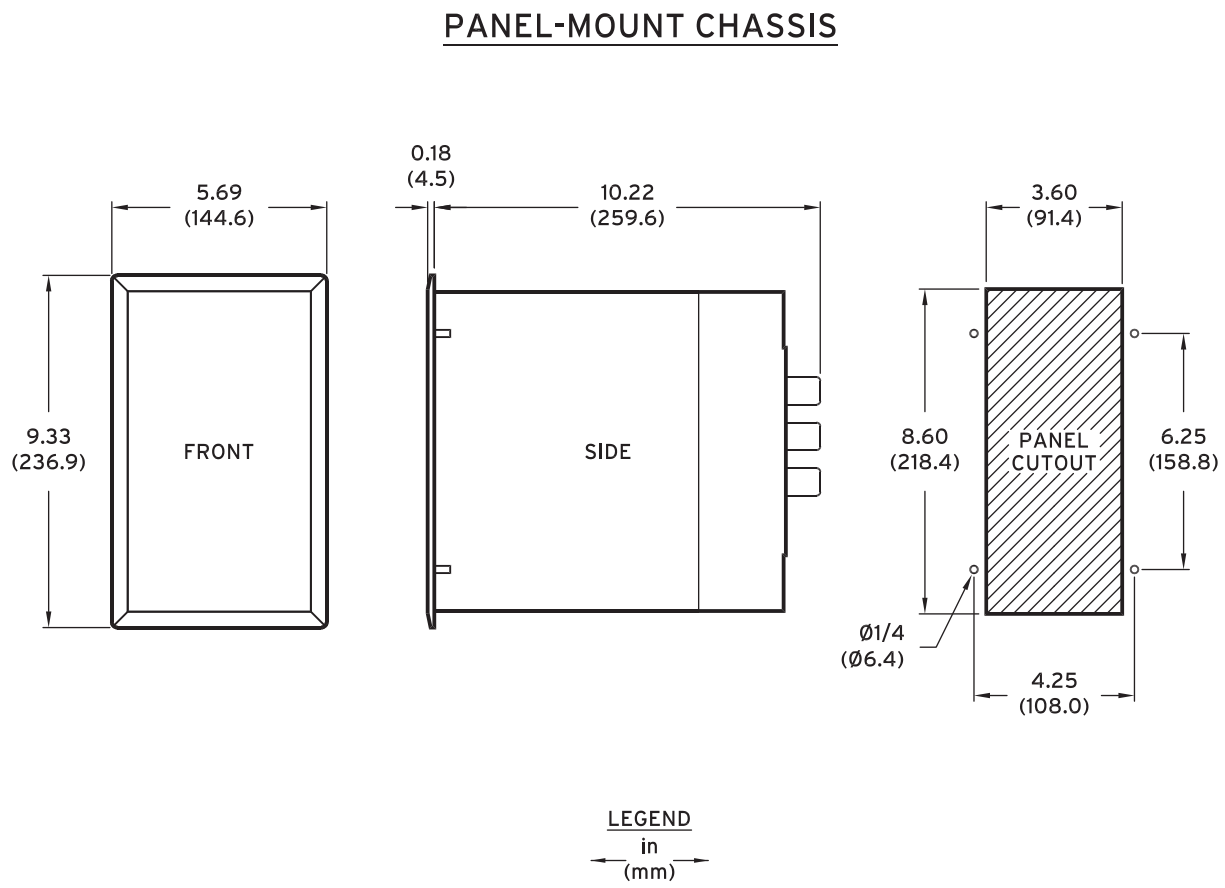


Figure 2.3 SEL-2664 Panel-Mount Dimensions

Step 1. Cut a hole 3.60 inches x 8.60 inches (width x height) on the panel (see *Figure 2.3* for panel cutout dimensions).

Step 2. Carefully mark the panel with the locations for the four holes shown in *Figure 2.3*.

Step 3. Drill out the four holes in *Step 2* with a 0.22-inch drill bit.

Step 4. Insert the SEL-2664 through the cutout, and align the four studs through the holes.

Step 5. Secure the SEL-2664 to the panel with the four #10 nuts provided.

Rack Mount

The SEL-2664 can be mounted in a standard 19-inch rack. Refer to the Model Option Table to order the SEL-2664 in a rack-mount version. SEL ships a rack-mount panel with the SEL-2664 for a rack-mount version order (see *Figure 2.4*). Follow the steps below to install the SEL-2664 in a 19-inch rack.

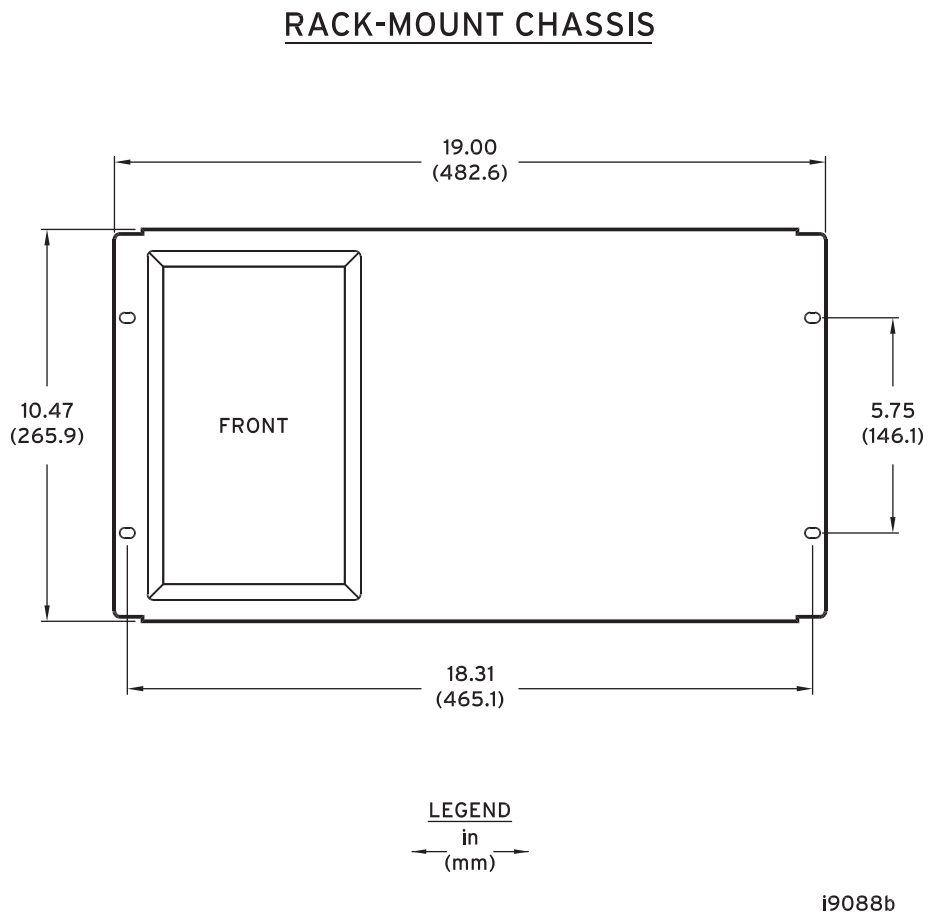


Figure 2.4 SEL-2664 Rack-Mount Dimensions

Step 1. Install the supplied rack-mount panel in the rack (see *Figure 2.4* for the rack-mount panel dimensions).

Step 2. Insert the SEL-2664 through the cutout, and align the four studs through the holes.

Step 3. Secure the SEL-2664 to the rack-mount panel with the four #10 nuts provided.

Status and Target Indicators

The SEL-2664 has two LEDs that serve as status and target indicators. View these LEDs from the front and the top faceplates.

The **ENABLED** LED is a green indicator that illuminates when the power supply is healthy and all self-tests pass. Refer to *Section 5: Testing and Troubleshooting* for a list of self-tests. The SEL-2664 start-up time from energization is less than 5 seconds.

The TX LED is the red indicator that illuminates when each data packet is transmitting. The TX LED is off during the interpacket period.

I/O Configuration

Injection Frequency Jumper Selection

NOTE: The SEL-2664 uses Jumper 1A only; the three jumpers 1B, 1C, and 1D shown in the figure do not serve any purpose.

Use Jumper 1A (see *Figure 2.5*) to set the frequency of the square-wave injection voltage. *Figure 2.5* also illustrates the OPEN/CLOSE position of Jumper 1A. When Jumper 1A is set at the OPEN position, the injection frequency is 0.25 Hz. The SEL-2664 ships with Jumper 1A at the OPEN position as default. When Jumper 1A is set at the CLOSE position, the injection frequency is 1.0 Hz.

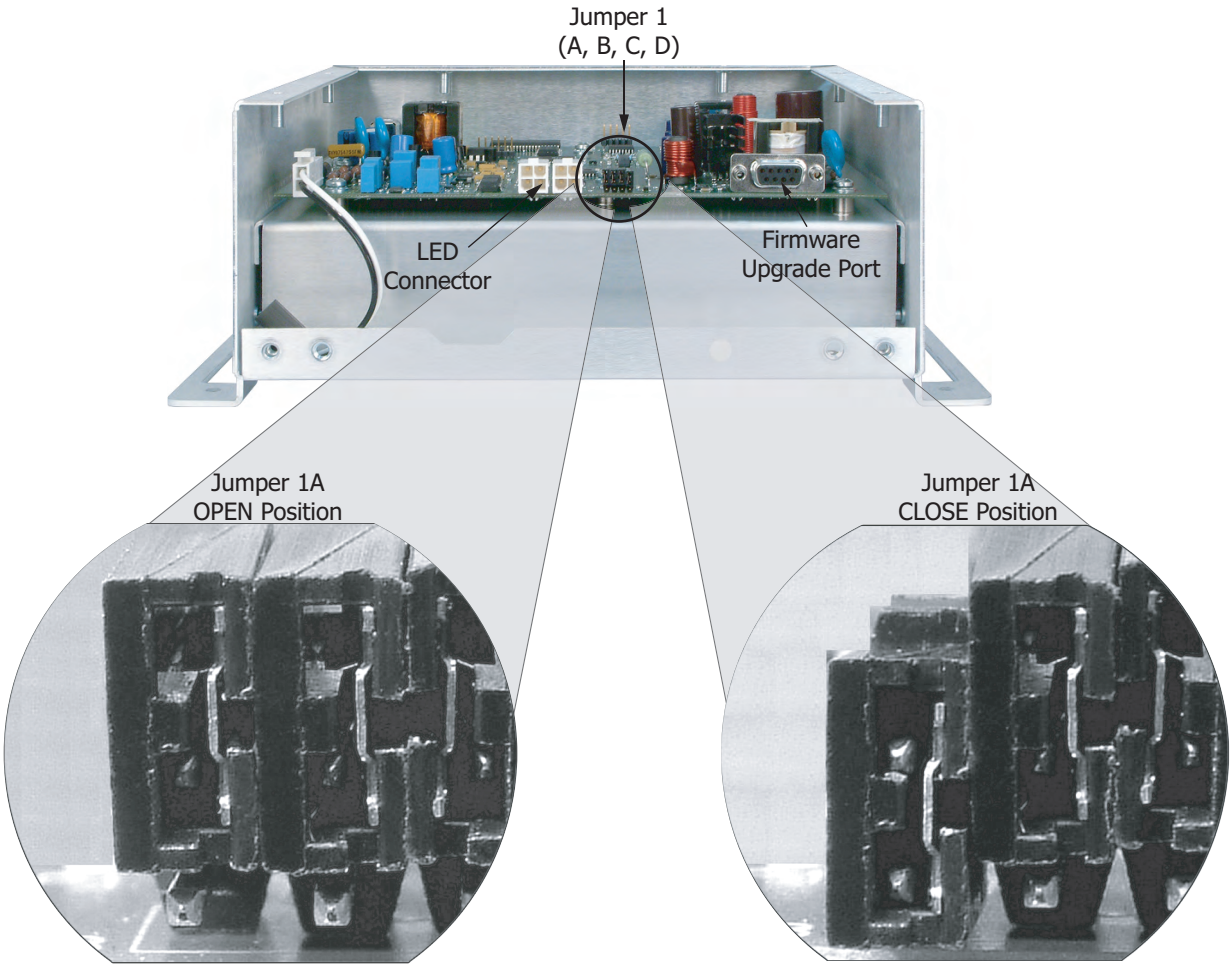


Figure 2.5 Jumper 1A Location and OPEN/CLOSE Illustration

Making Rear-Panel Connections

Refer to *Figure 2.6* for an illustration of the rear panel.

Field connection terminals connect to the generator field winding, which usually carries very high dc voltage. The cable can be a 14 AWG–18 AWG wire as long as 91.4 m (300 ft). The outer diameter range that is recommended for the strain relief on the field connection terminals is 4.6–7.9 mm (0.181–0.312 inch). Use 105°C-rated wiring.

Guard against accidental contact with field connection terminals by using approved enclosures or either of the following methods:

- Location of equipment in a room, vault, or similar enclosure that is accessible only to qualified persons.
- Suitable permanent, substantial partitions or screens arranged so that only qualified persons can access the space within reach of live circuitry. Any openings in partitions or screens should be located and sized to prevent personnel or conducting objects from coming in contact with live circuitry.

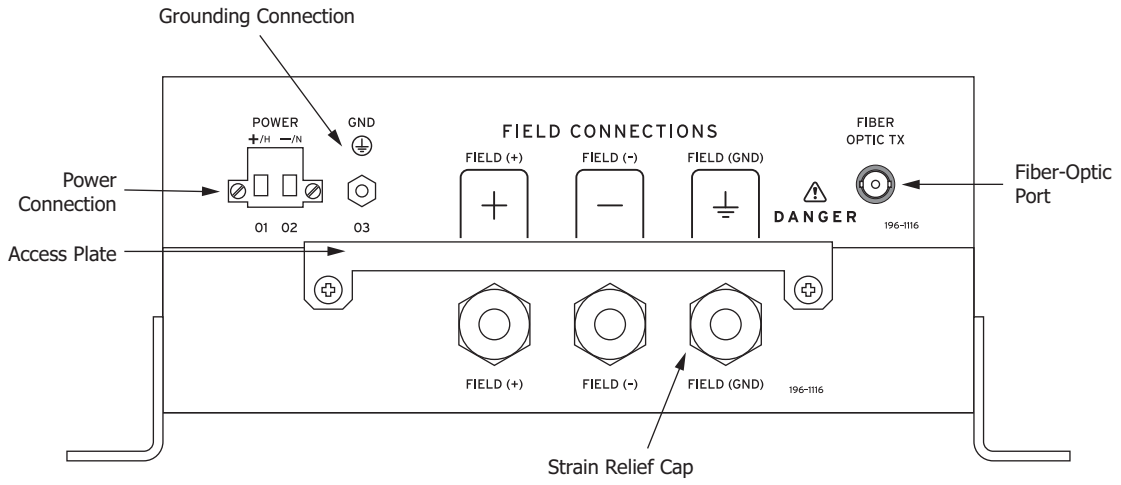


Figure 2.6 SEL-2664 Rear Panel

DANGER
Field connection terminals are connected to the generator field winding, which usually carries very high dc voltage. Disconnect the wires from the generator field winding before working on the unit. Never come into contact with live wires.

Follow the steps below to connect to the field connection terminals.

Step 1. Consult with the manufacturer of your generator for the proper wires (size, rating, insulation, etc.) to connect between the generator field winding and the SEL-2664.

Step 2. Ensure that no wire is presently connected from the generator field winding to the SEL-2664 field connection terminals.

If there are wires connected from the generator field winding to SEL-2664 field connection terminals, follow the generator manufacturer's guidelines to disconnect the wires from the generator field winding before removing the wires from SEL-2664 field connection terminals.

NOTE: Field connections requirements:
- 14–18 AWG wire size
- 750 Vdc continuous (terminal-to-terminal and terminal-to-ground)
- 1500 Vdc for 1 minute
- 0.5 A continuous
- Maximum length of 300 ft
- Termination of wires with connected ring terminals
- Use copper conductors only

Step 3. Remove the two screws on the access plate (see *Figure 2.6*).

Step 4. Lift off the access plate. You should see three metal screw holes labeled as **FIELD (+)**, **FIELD (−)**, and **FIELD (GND)**.

Step 5. Loosen the strain relief caps (see *Figure 2.6*).

Step 6. Insert a wire through the **FIELD (+)** strain relief cap into the **FIELD (+)** metal screw hole.

Step 7. Secure the wire with the supplied screw.

Step 8. Tighten the **FIELD (+)** strain relief cap.

Step 9. Insert a second wire through the **FIELD (−)** strain relief cap into the **FIELD (−)** metal screw hole.

Step 10. Secure the wire with the supplied screw.

Step 11. Tighten the **FIELD (−)** strain relief cap.

Step 12. Insert a third wire through the **FIELD (GND)** strain relief cap into the **FIELD (GND)** metal screw hole.

Step 13. Secure the wire with the supplied screw.

Step 14. Tighten the **FIELD (GND)** strain relief cap.

Step 15. Replace the access plate.

Step 16. Tighten the two screws on the access plate.

Step 17. Connect two wires from the **FIELD (+)** and **FIELD (–)** terminals to two ends of the generator field winding (see *Figure 2.7*).

Follow your generator manufacturer's guidelines in making this connection.

Step 18. Connect the wire from **FIELD (GND)** to the ground brush on the rotor iron (see *Figure 2.7*).

Follow your generator manufacturer's guidelines in making this connection.

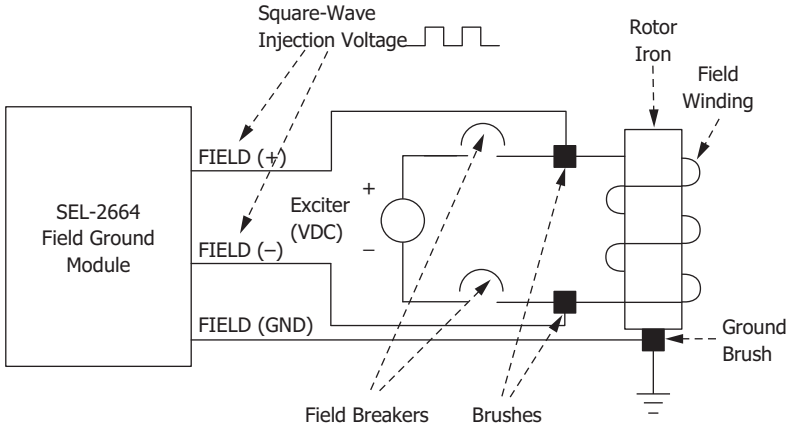


Figure 2.7 Making Connections from SEL-2664 Rear Terminals to the Generator

Power Connection

The **POWER** terminals on the module rear panel must connect to 18–300 Vdc or 85–264 Vac (see *Specifications on page 1.3* for complete power input specifications). The **POWER** terminals are isolated from chassis ground. Use 14–16 AWG (2.1–1.3 mm^2) size wire to connect to the **POWER** terminals.

For compliance with IEC 60947-1 and IEC 60947-3, place a suitable external switch or circuit breaker in the power leads for the SEL-2664; this device should interrupt both the hot (+/H) and neutral (–/N) power leads. The maximum current rating for the power disconnect circuit breaker or optional overcurrent device (fuse) should be 20 A, 300 V. Be sure to locate this device within 3.0 m (9.8 ft) of the relay.

The maximum current rating for the power disconnect circuit breaker or overcurrent device (fuse) must be 20 A. An internal power supply fuse, with a 5 x 20 mm, time-lag, high-breaking capacity 1.6 A–250 V rating, protects the operational power supply. Be sure to use fuses that comply with IEC 60127-2.

Grounding Connection

Connect the protective (safety) grounding conductor terminal labeled **GND** on the rear panel to a rack frame or switchgear ground for proper safety and performance. Use 14 AWG (2.1 mm^2) to 16 AWG (1.3 mm^2) wire for the ground connection.

Figure 2.8 Protective (Safety) Grounding Conductor Terminal Symbol

Field Serviceability

The SEL-2664 firmware can be upgraded in the field. Refer to *Appendix B: Firmware Upgrade Instructions*. The only component that can be replaced in the field is the power supply fuse, F1.

Fuse Replacement

To replace the power supply fuse, perform the following steps:

Step 1. De-energize the device.

Step 2. Disconnect all connections to the generator field winding.

Step 3. Remove the front faceplate by removing the four screws.

Step 4. Remove the top faceplate by removing the six screws.

Step 5. Remove the main board tray.

Step 6. Locate the fuse labeled F1 on the board (see *Figure 2.9*).

Step 7. Remove the fuse from the fuse holder.

Step 8. Ensure fuse holder has not been damaged, bent, or deformed.

Step 9. Reform the fuse holder to ensure proper contact with the new fuse.

Step 10. Replace the fuse with a 5 x 20 mm, time-lag, high-breaking capacity 1.6 A–250 V rating, or equivalent fuse.

Step 11. Reinstall the main board tray into the chassis.

Step 12. Replace the top and front faceplate, reinstall all screws, and energize the unit.

⚠DANGER
Disconnect or de-energize all external connections before opening this device. Contact with hazardous voltages and currents inside this device can cause electrical shock resulting in injury or death.

⚠CAUTION
Equipment components are sensitive to electrostatic discharge (ESD). Undetectable permanent damage can result if you do not use proper ESD procedures. Ground yourself, your work surface, and this equipment before removing any cover from this equipment. If your facility is not equipped to work with these components, contact SEL about returning this device and related SEL equipment for service.

⚠WARNING
Have only qualified personnel service this equipment. If you are not qualified to service this equipment, you can injure yourself or others, or cause equipment damage.

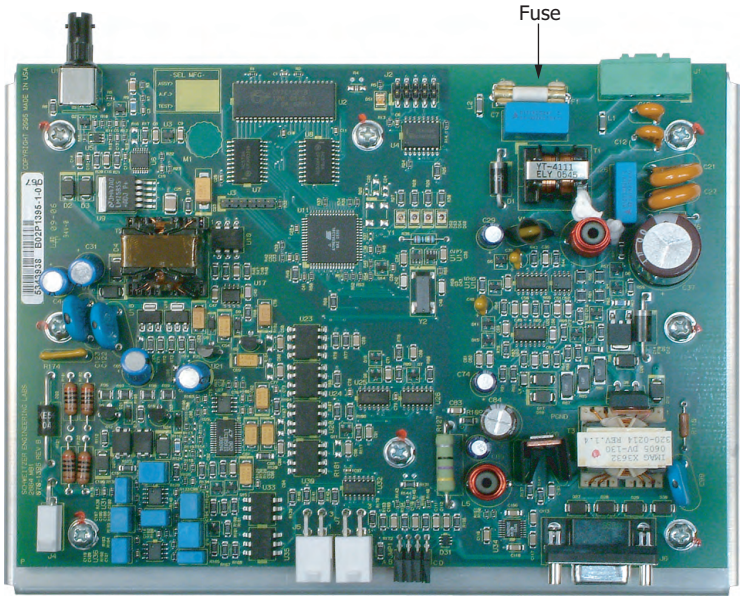


Figure 2.9 Location of Fuse on Main Board

Section 3

Insulation Resistance Measurement

Overview

The field of a generator is an ungrounded single-circuit winding that is wound on the rotor (*Figure 3.1*). To produce the required magnetic field, a dc source is connected to the field winding. This exciter dc voltage source typically ranges from 48 to 825 V.

Insulation deterioration or breakdown can cause the field winding to contact the rotor iron. This first ground will not generally affect the operation of the generator. A second ground will cause a portion of the field winding to be shorted, resulting in unbalanced air gap fluxes in the generator. This in turn can cause rotor vibration that can damage the generator.

It is best to detect the first ground and take corrective action. Following detection of a field ground, the generator owner can decide to trip or alarm.

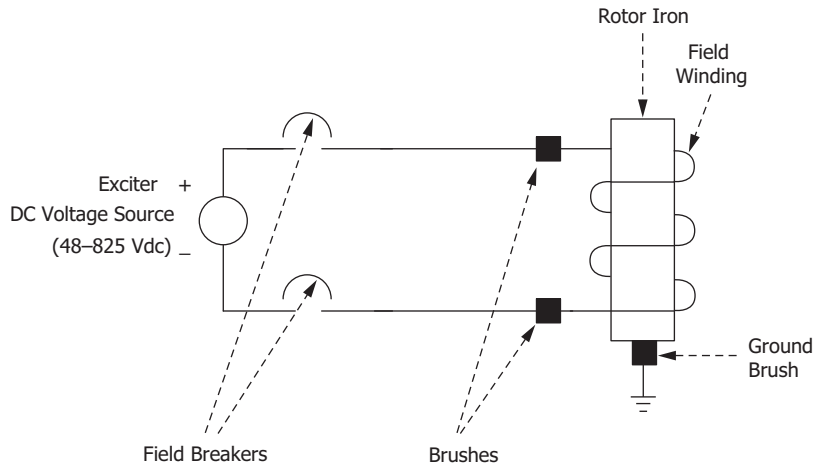


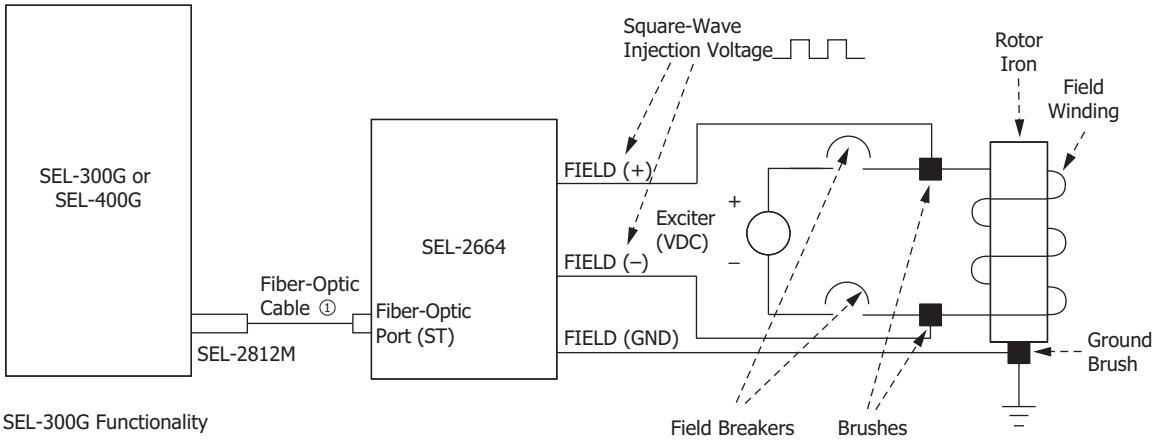
Figure 3.1 Typical Generator Field Circuit

Insulation Resistance Measurement

NOTE: SEL-2812MT or SEL-2812MR Fiber-Optic Transceiver can be used because this application does not use the IRIG connection.

The SEL-2664 Field Ground Module calculates the insulation resistance between the field winding and ground and transmits this insulation resistance value to the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S Relay.

Figure 3.2 shows the connection from the module to the generator field winding and to the SEL-300G.



SEL-300G Functionality

- 64F elements and settings
- Metering
- Reporting
- Receive from SEL-2664:
  - Insulation resistance
  - Self-test results
- Decision making (Trip/No Trip)

- Injection dc signal (square wave)
- Calculate insulation resistance
- Transmit to SEL-300G:
  - Insulation resistance
  - Self-test results

① Refer to the Model Option Table for cable choices.

Figure 3.2 Connection from the SEL-2664 to the Generator Field Winding and the SEL-300G

(An SEL-400G, SEL-700G, or SEL-2664S application is similar)

The SEL-2664 employs an internal sense resistor. If there is a ground in the field winding, a voltage appears across this internal sense resistor. Using the sense resistor voltage value, the module calculates the insulation resistance between the field winding and ground. If there is no connection between the field winding and ground, the voltage across the sense resistor is zero, and the calculated insulation resistance approaches infinity. The SEL-2664, however, is limited to 20 megohms.

NOTE: The rotor iron of the generator must be grounded to ensure accurate measurement of the insulation resistance between the field winding and ground. Follow the machine manufacturer's guidelines for grounding practices of the rotor iron.

The module transmits the insulation resistance value to the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S through a fiber-optic cable. Users can enable and set the 64F element in the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S to alarm or trip for certain insulation resistance values.

Table 4.2 lists requirements necessary for applying the SEL-2664 with an SEL-300G.

Injection Frequency Selection

The SEL-2664 injects a square-wave voltage at a fixed injection frequency (Fg) to the generator field winding. Use a jumper on the device main board (see *Figure 2.5*) to select between 0.25 Hz or 1 Hz for Fg. If jumper 1A is at the OPEN position, the frequency of the square-wave voltage injection is 0.25 Hz. If jumper 1A is at the CLOSE position, the frequency of the square-wave voltage injection is 1 Hz.

For generators with an overall field-to-ground capacitance (Cfg) less than 2.5 microfarads, Fg can be set to 1 Hz and still meet the stated accuracy for 64F elements. For generators with Cfg from 2.5 microfarads to 10 microfarads, Fg should be set at 0.25 Hz to ensure the stated accuracy for 64F elements. The SEL-2664 works with other generators that have an overall field-to-ground capacitance of more than 10 microfarads, but the accuracy is not within the stated specification.

When Fg is set at 0.25 Hz, the SEL-2664 measures insulation resistance every 2 seconds. When Fg is set at 1 Hz, the SEL-2664 measures insulation resistance every 0.5 seconds. If operating time is important to your applications, follow the guideline below to select the frequency for the square-wave dc signal injection. Otherwise, leave the module at its default jumper setting of 0.25 Hz.

Table 3.1 Jumper Selection

Field-to-Ground Capacitance (Cfg)	Jumper Position (Jumper 1A)	Injected Signal Frequency (Fg)	Time Between Each Insulation Resistance Calculation	Accuracy
Cfg < 2.5 µF	Close	1 Hz	0.5 seconds	Within Specification
2.5 µF ≤ Cfg ≤ 10 µF	Open	0.25 Hz	2 seconds	Within Specification
Cfg >10 µF	Open	0.25 Hz	2 seconds	Not Within Specification

The philosophy behind the dual frequency principle (for Fg) is that the user does not have to know or measure the capacitance between the field winding and ground. Follow the steps below to select the correct fixed injection frequency for the SEL-2664.

Step 1. Disconnect the relay trip and alarm contact.

Step 2. Remove the module from service.

Step 3. Remove the module main board.

Step 4. Verify that Jumper 1A is at the OPEN position.

Step 5. Put the module back in service.

Step 6. Display and take note of the measured insulation resistance in the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S.

Step 7. Remove the module from service.

Step 8. Remove the module main board.

Step 9. Set Jumper 1A at the CLOSE position.

Step 10. Put the module back in service.

Step 11. Display and take note of the measured insulation resistance in the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S.

Step 12. Set the final injection frequency to the frequency with the highest measured insulation resistance.

Step 13. If the measured insulation resistances are the same, choose 1 Hz as the injection frequency.

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Section 4
Applications

Overview

This section describes the SEL-2664 Field Ground Module communication data packet and contains detailed instructions for using the SEL-2664 with an SEL-300G, SEL-400G, SEL-700G, SEL-2664S Relay, or an SEL communications processor to provide field ground protection in the generator field winding.

Data Packet Definition

The SEL-2664 sends a binary data packet approximately every half period of the square-wave injection voltage. When the injection frequency is 0.25 Hz, the module transmits the packet every 2 seconds. When the injection frequency is 1.0 Hz, the module transmits the packet every 500 milliseconds. The packet contains data for insulation resistance and self-test status. The SEL-2664 requires no software setting. The fiber-optic port in the SEL-2664 has a built-in SEL-2812 Fiber-Optic Transceiver transmit circuit. SEL recommends using an SEL-2812 transceiver and any EIA-232 device to process the binary packet contents shown in *Table 4.1*. The SEL-700G and SEL-2664S have a fiber-optic serial port that supports the SEL-2664 fiber-optic port directly.

Table 4.1 SEL-2664 Data Packet Definitions (Sheet 1 of 2)

Data Value	Data Size	Description of Data
A546h	2 bytes	Beginning of message code
1Eh	1 byte	Message length (30 bytes)
0000000000h	5 bytes	Routing value (0)
0	1 byte	Status byte
12h	1 byte	Function code
C0h	1 byte	Sequence byte
01h	1 byte	Field ground module identifier byte
xxxx	2 bytes	Field ground module status
xxxx	2 bytes	Counter that is incremented when an insulation resistance measurement occurs
xxxxxxxx	4 bytes	Insulation resistance, scaled at 1 bit = 1 ohm
xxxx	2 bytes	Future use
xxxx	2 bytes	Injection waveform period, scaled at 1 bit = 1 millisecond

Table 4.1 SEL-2664 Data Packet Definitions (Sheet 2 of 2)

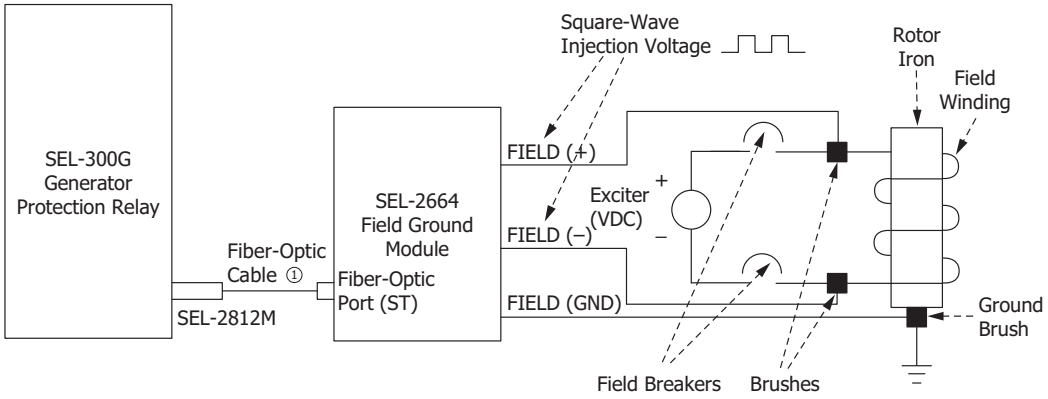
Data Value	Data Size	Description of Data
xxxxxxxx	4 bytes	Firmware release version (first character is an ASCII alphabetic character and the remaining three characters are ASCII numeric characters)
yyyy	2 bytes	CRC-16 block check code

SEL-300G Generator Relay Application

NOTE: SEL-2812MT or SEL-2812MR Fiber-Optic Transceiver can be used because this application does not use the IRIG connection.

The SEL-300G Generator Relay has an optional field ground protection feature that uses the SEL-2664 to acquire insulation resistance value for alarm and trip functions.

Connect the SEL-2664 to the SEL-300G as shown in *Figure 4.1*. Use a fiber-optic cable and a transceiver to transmit the insulation resistance data to the SEL-300G. The EIA-232 port must be set for SEL protocol and a data rate of 9600 bps, 8 data bits, no parity, and 1 stop bit to start receiving the insulation resistance value from the SEL-2664. Set and test the SEL-300G as directed in the *SEL-300G Multifunction Generator Relay Instruction Manual*.



① Refer to the Model Option Table for cable choices.

Figure 4.1 Field Ground Protection With an SEL-300G Relay

SEL-300G Requirements for SEL-2664 Application

If you want to add field ground protection functionality to an existing SEL-300G installation, use the checklist shown in *Table 4.2* to determine the requirements.

Table 4.2 SEL-300G Requirements for Field Ground Protection Functionality (Sheet 1 of 2)

Existing SEL-300G	Recommended Actions for SEL-2664 Application
Firmware version R1*xx*	Consult the factory for a replacement SEL-300G
Firmware version R2*xx*	Consult the factory for hardware upgrade or replacement SEL-300G

Table 4.2 SEL-300G Requirements for Field Ground Protection Functionality (Sheet 2 of 2)

Existing SEL-300G	Recommended Actions for SEL-2664 Application
Firmware version R3*xx*	Order a firmware conversion kit from the factory to field-upgrade firmware to version R323 or later
EIA-232 Serial Port 2 or Port 3 availability	EIA-232 Port 2 or Port 3 availability is required to connect an SEL-2664 to an SEL-300G, using a fiber-optic cable and an SEL-2812M Transceiver

SEL-400G Generator Relay Application

The SEL-400G relay works with the SEL-2664 Field Ground Module to provide field ground protection for the generator field winding. Two different pickup levels of the insulation resistance are available for configuration. The field ground protection elements (64F) Relay Word bits can be programmed into an output contact for alarm or into the trip equation for tripping. The protection covers a range of high-resistance as well as low-resistance ground faults (0.5–200.0 kilohms).

Connect the SEL-2664 directly to two ends of the generator field winding and the rotor ground brush. When the SEL-2664 calculates the insulation resistance value between the field winding and ground, it uses a fiber-optic cable with ST connectors and a transceiver (SEL-2812MR or MT) to transmit the insulation resistance value to the SEL-400G. Consult the *SEL-400G Advanced Generator Protection System Instruction Manual* for detailed instructions on setting up the SEL-2664. Set the EIA-232 port in the SEL-400G to SEL protocol and change the port settings to 9600 bps, 8 data bits, no parity, and 1 stop bit to start receiving the insulation resistance value from the SEL-2664.

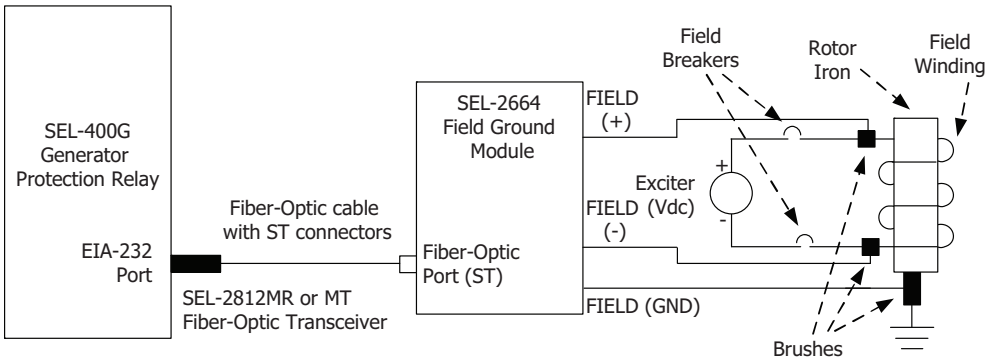


Figure 4.2 Field Ground Protection With an SEL-400G Relay

SEL-700G Generator Relay Application

The SEL-700G relay works with the SEL-2664 Field Ground Module to provide field ground protection for the generator field winding. Two different pickup levels of the insulation resistance are available for configuration. The field ground protection elements (64F) Relay Word bits can be programmed

into an output contact for alarm or into the trip equation for tripping. The protection covers a range of high-resistance as well as low-resistance ground faults (0.5–200.0 kilohms).

Connect the SEL-2664 directly to two ends of the generator field winding and the rotor ground brush. When the SEL-2664 calculates the insulation resistance value between the field winding and ground, it uses a fiber-optic cable with ST connectors and a transceiver (SEL-2812MR or MT) to transmit the insulation resistance value to the SEL-700G. Consult the *SEL-700G Instruction Manual* for detailed instructions on setting up the SEL-2664. Set the EIA-232 port in the SEL-700G to SEL protocol and change the port settings to 9600 bps, 8 data bits, no parity, and 1 stop bit to start receiving the insulation resistance value from the SEL-2664. For applications without the SEL-2600 RTD Module, the SEL-700G has the fiber-optic serial port Port 2 available that supports the SEL-2664 fiber-optic port directly by using a fiber-optic cable with ST connectors.

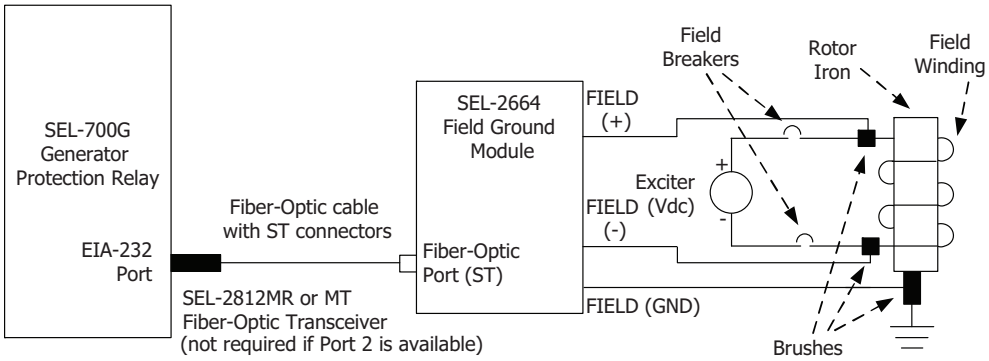


Figure 4.3 Field Ground Protection With an SEL-700G Relay

SEL-2664S Stator Ground Protection Relay Application

The SEL-2664S works with the SEL-2664 Field Ground Module to protect the generator field winding. Connect the SEL-2664 directly to two ends of the generator field winding and the rotor ground brush. When the SEL-2664 calculates the insulation resistance value between the field winding and ground, it uses a fiber-optic cable with ST connectors to transmit the insulation resistance value to fiber-optic Port 2 of the SEL-2664S. Consult the *SEL-2664S Instruction Manual* for detailed instructions on setting up the SEL-2664S.

See *Figure 4.4* for a typical example of the dc connections for 100 percent stator ground protection using the SEL-2664S Relay (stator-to-ground insulation resistance measurement) and the SEL-2664 Field Ground Module (dc field-to-ground insulation resistance measurement).

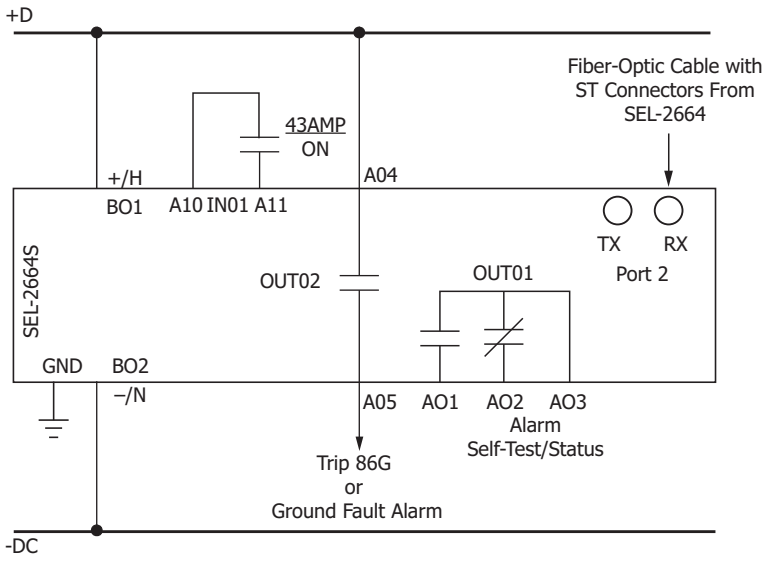


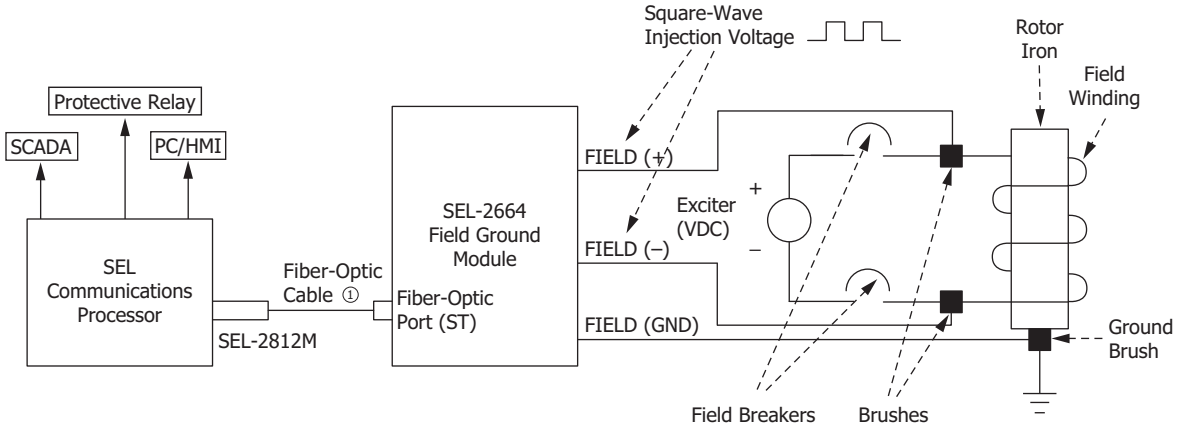
Figure 4.4 Typical DC Connections for an SEL-2664S Application

SEL Communications Processor Applications

NOTE: SEL-2812MT or SEL-2812MR Fiber-Optic Transceiver can be used because the IRIG connection is not used in this application.

The SEL-2664 communicates with an SEL-2032 or SEL-2030 Communications Processor to enhance many protection and monitoring applications. The communications processor monitors insulation resistance data from the SEL-2664, performs threshold comparisons, and sends control commands to a protective relay.

The application shown in *Figure 4.5* represents a possible configuration using the SEL-2664 and an SEL communications processor. Contact SEL for help in applying these products in other configurations.



① Refer to the Model Option Table for cable choices.

Figure 4.5 Field Ground Protection With an SEL Communications Processor

Program an SEL communications processor to perform five automated steps:

Step 1. Receive insulation resistance data packet from the SEL-2664

Step 2. Store the insulation resistance data packet in SEL communications processor memory

Step 3. Convert the insulation resistance raw data into the insulation resistance value

Step 4. Perform insulation resistance threshold comparisons

Step 5. Issue control commands to a protective relay (based on the insulation resistance comparisons)

The next few pages describe how to configure an SEL communications processor to perform the five automated steps shown above. This description assumes that the SEL-2664 is connected to Serial Port 4 of an SEL communications processor. Refer to the instruction manual of your SEL communications processor for further information on programming concepts.

Receive the Insulation Resistance Data Packet from the SEL-2664

Connect the SEL-2664 to an SEL communications processor through the use of an SEL-2812M Fiber-Optic Transceiver and an SEL-C805 200-µm fiber-optic cable (or equivalent). Verify that the port settings of an SEL communications processor are as shown in the following screen capture.

```
*>>SET P 4 <Enter>

DEVICE = S <Enter>
CONFIG = N <Enter>
PORTID = SEL-2664 Insulation Resistance <Enter>
BAUD = 9600 <Enter>
DATABIT = 8 <Enter>
STOPBIT = 1 <Enter>
PARITY = N <Enter>
RTS_CTS = N <Enter>
XON_XOFF = N <Enter>
TIMEOUT = OFF <Enter>

*>>
```

Store the Insulation Resistance Data Packet in SEL Communications Processor Memory

Use the **SET A** command to reserve memory.

```
*>>SET A 4 <Enter>

AUTOBUF = N <Enter>
STARTUP = "" <Enter>
SEND_OPER = N <Enter>
REC_SER = N <Enter>
MSG_CNT = 0 <Enter>
ARCH_EN = N <Enter>
USER = 22 <Enter>

*>>
```

The USER setting reserves a data region with 22 registers. Each register is 2 bytes, for a total length of 44 bytes. This data region holds the received data packet and mathematical equations for data conversion and threshold comparisons.

An SEL communications processor automatically moves the data section of each received data packet (see *Table 4.1*) into the reserved USER data region of Port 4 at the addresses shown in *Table 4.3*.

Table 4.3 SEL-2032/SEL-2030 Communications Processor Memory Map

Address (hex)	Offset	Data Description
F800h	0h	Module Status
F801h	01h	Counter
F802h–F803h	02h–03h	Insulation Resistance Raw Data
F804h	04h	Future Use
F805h	05h	Injection Waveform Period
F806h–F807h	06h–07h	Firmware Version
F808h–F815h	08h–15h	Storage for Mathematical Functions

The SEL-2664 data packet includes insulation resistance information for the generator field winding. To access the insulation resistance, use the memory map location associated with the insulation resistance raw data, then convert to the insulation resistance value.

Access data from the USER region through the use of an absolute address or the form *n*:USER:offset, where *n* is the port number and offset is the value shown in the offset column of *Table 4.3*. For example, access the SEL-2664 module status through the use of the absolute address F800h or the offset form 4:USER:0h. The examples in the remainder of this section use the offset form.

Convert the Insulation Resistance Raw Data Into the Insulation Resistance Value

You need to convert the Insulation Resistance raw *data* from the USER region to the Insulation Resistance *value* for your applications. Although the SEL-2664 transmits the Insulation Resistance value as high as 20 megohms, an SEL communications processor limits the value to 8,388,352 ohms through the use of signed 16-bit integers. The insulation resistance data consist of 4 bytes contained in two registers (02h and 03h). Assuming they are labeled *byte3*, *byte2*, *byte1*, *byte0*, the pseudocode for the conversion is as follows:

IF (*byte3* is greater than 0 or MSBit of *byte2* equals 1)

THEN Insulation_Resistance = 8,388,352 ohms

ELSE Insulation_Resistance = (*byte2*:*byte1*) • 256 ohms

The SEL-2664 sends the MSByte (*byte3*) first, and LSByte (*byte0*) last. Therefore, register 02h stores *byte3* and *byte2*; register 03h stores *byte1* and *byte0*.

Follow the settings below to obtain Insulation Resistance value from the data stored in registers 02h and 03h. Serial Port 4 is assumed.

```
*>>SET M 4 <Enter>

 1  08h=4:USER:02h*256     #shift byte2 in 02h eight places to the left <Enter>
 2  09h=4:USER:03h/256     #shift byte1 in 03h eight places to the right <Enter>
 3  0Ah=4:USER:09h         #transfer the number in 09h to register 0Ah <Enter>
 4  0Ah+=4:USER:08h        #add the number in 08h to register 0Ah <Enter>
 5  0Bh,f=4:USER:0Ah       #assign raw resistance value to 0Bh <Enter>
 6  0Bh,f*=256             #multiply 0Bh by 256 to obtain possible resistance value
     <Enter>
 7  0Dh=4:USER:02h/256     #shift byte3 in 02h eight places to the right <Enter>
 8  0Eh=0                  #assign 0 to 0Eh <Enter>
 9  0Eh-=4:USER:0Dh        #subtract byte3 from 0Eh and put result back into 0Eh
     <Enter>
10 IF 4:USER:0Eh:15       #if bit 15 of 0Eh is one <Enter>
11 0Fh,f;;OHMS=8388352    #assign 8388352 to 0Fh <Enter>
12 ELSE                   #otherwise if bit 15 of 0Eh is zero <Enter>
13 IF 4:USER:0Ah:15       #check if bit 15 of register 0Ah is one <Enter>
14 0Fh,f;;OHMS=8388352    #assign 8388352 to 0Fh <Enter>
15 ELSE                   #otherwise if bit 15 of register 0Ah is zero <Enter>
16 0Fh,f;;OHMS=4:USER:0Bh #assign the value stored in 0Bh <Enter>
17 ENDIF <Enter>
18 ENDIF <Enter>
```

Following the # symbols are text comments that are not required to set the SEL communications processor.

The insulation resistance value is either 8,388,352 ohms or (*byte2*:*byte1*) • 256 ohms.

Lines 1, 2, 3, and 4: Retrieve *byte2* and *byte1* from two registers 02h and 03h, then put *byte2* and *byte1* into register 0Ah to obtain the number (*byte2*:*byte1*).

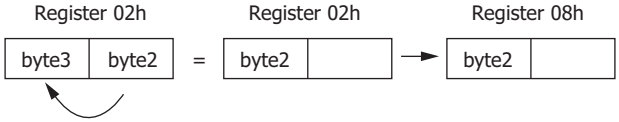
Lines 5 and 6: Transfer the number in register 0Ah to register 0Bh and multiply it by 256 to obtain a possible insulation resistance value (*byte2*:*byte1*) • 256 ohms.

Lines 7, 8, and 9: Retrieve *byte3* into register 0Dh. Subtract *byte3* from zero and put the result into register 0Eh. *Byte3* is either a zero or a positive number. Therefore, the result in register 0Eh is a negative number if *byte3* is greater than zero. The result in register 0Eh is a zero if *byte3* is zero.

Lines 10 to 18: First, look at the sign bit of register 0Eh. If the sign bit (Bit 15) of register 0Eh is set, that means the number in 0Eh is negative. Assign the value 8,388,352 to register 0Fh. Second, if the sign bit of register 0Eh is not set, proceed to check the sign bit of register 0Ah. The sign bit of register 0Ah is indeed the MSBit of *byte2*. If the MSBit of *byte2* equals one, assign the value 8,388,352 to register 0Fh. If the MSBit of *byte2* is zero, assign the result of (*byte2*:*byte1*) • 256, which is stored as a floating-point number in register 0Bh, to register 0Fh.

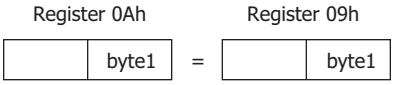
The following graphic illustration provides further explanation of SET M equations from Line 1 to Line 18.

Line 1: Shift *byte2* in register 02h eight positions to the left and store the result in register 08h.

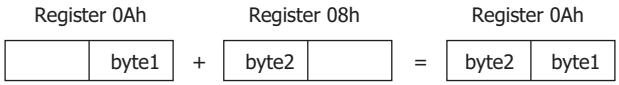


Line 2: Shift *byte1* in register 03h eight positions to the right and store the result in register 09h.

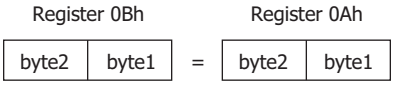
Line 3: Transfer the number in register 09h to register 0Ah.



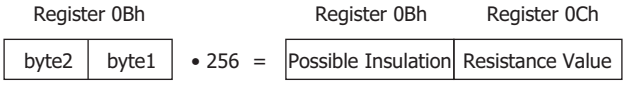
Line 4: Add the number in register 0Ah to the number in register 08h, and put the result back in register 0Ah. This gives you the insulation resistance data represented by (*byte2*:*byte1*).



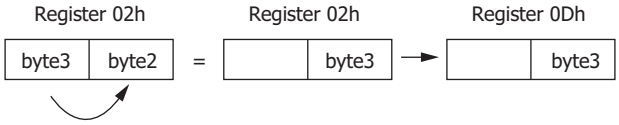
Line 5: Assign the number in register 0Ah to register 0Bh.



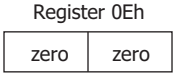
Line 6: Multiply 0Bh by 256 to obtain the possible insulation resistance value. Save the result back in register 0Bh as a floating-point number. A float-point number takes up two registers. The next register available for use is 0Dh.



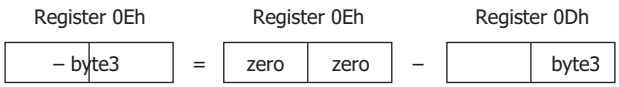
Line 7: Shift *byte3* in register 02h eight positions to the right, and store *byte3* in register 0Dh.



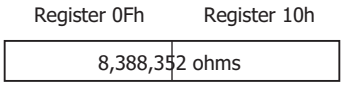
Line 8: Store number zero into register 0Eh.



Line 9: Subtract register 0Dh from register 0Eh, and put the result back into register 0Eh.

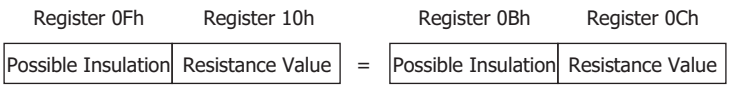


Lines 10 and 11: If Bit 15 of register 0Eh is one, register 0Eh is a negative number. That means *byte3* is a positive number (greater than zero). The insulation resistance is 8,388,352 ohms and stored in register 0Fh as a floating-point number.



Lines 12, 13, and 14: If Bit 15 of register 0Eh is zero, proceed to check Bit 15 of register 0Ah. If bit 15 of register 0Ah is set, that means the MSBit of *byte2* equals one. Then assign 8,388,352 to register 0Fh.

Lines 15 and 16: If Bit 15 of register 0Ah is zero, assign to register 0Fh the value of (*byte2*:*byte1*) • 256 that is stored in register 0Bh.



Use command **VIEW 4 USER OHMS** to view the insulation resistance value.

Perform Insulation Resistance Threshold Comparisons

The example communications processor settings shown below compare the measured insulation resistance value against a threshold of 2000 ohms. If the insulation resistance value is less than the threshold, Bit 0 of register 15h is set equal to 1. The example again assumes use of Serial Port 4.

```
*>>SET M 4 <Enter>

19 11h,f=2000            #Store the resistance threshold <Enter>
20 13h,f=4:USER:0Fh,f    #Get the measured insulation resistance value <Enter>
21 13h,f-=4:USER:11h,f   #Subtract the threshold <Enter>
22 15h:0=4:USER:13h:15   #Get the sign bit of result <Enter>
```

Line 19: Store the insulation resistance threshold in register 11h.

Line 20: Put the measured insulation resistance value in register 13h.

Line 21: Subtract the threshold from the measured insulation resistance value, and store the result in register 13h. If the result is negative, the measured insulation resistance is less than the threshold, and Bit 15 (the sign bit) of register 13h is set.

Line 22: Copy the sign bit (Bit 15) of register 13h into Bit 0 of 15h.

Issue Control Commands to a Protective Relay

Connect an SEL communications processor to the protective relay. Establish communications as outlined in the SEL communications processor and the protective relay instruction manuals.

Use the **SET P** command to set AUTO_CONFIG equal to Y. This enables automatic control capabilities for the serial port connected to the relay. Use the **SET A** command to set SEND_OPER equal to Y. This enables Fast Operate commands based on logic bit transitions. Use the **SET L** command to control four breakers through Fast Operate commands based on the result of a single insulation resistance comparison.

The following example settings assume that the relay is connected to an SEL communications processor Serial Port 10, and that the SEL-2664 is connected to Serial Port 4.

When SBR1 logic is true (logical 1), the SEL communications processor sends a Fast Operate open command to the relay.

```
*>>SET L 10 <Enter>

SBR1=4:USER:15h:0 <Enter>
CBR1=0 <Enter>

*>>
```

Refer to the specific device instruction manual for more information on Fast Operate commands, wiring, and configuration.

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Section 5
Testing and Troubleshooting

Overview

This section provides a list of self-test routines that the SEL-2664 Field Ground Module runs periodically. If a problem occurs, please refer to *Table 5.2* for a guide to isolating and correcting the problem.

Self-Test

The SEL-2664 runs a variety of self-tests. When there is a failure and the module is disabled, the module extinguishes the **ENABLED** LED.

Table 5.1 lists hardware self-tests, test methods, and actions taken.

Table 5.1 SEL-2664 Self-Tests

Test	Alarm	Disable ENABLED LED (Y/N)	Test Method
Internal RAM (Turn On)	LATCH	Y	Performs a read/write test on system CPU RAM
Internal RAM (Run Time)	LATCH	Y	Performs a read/write test on system CPU RAM
External RAM (Turn On)	LATCH	Y	Performs a read/write test on system RAM
External RAM (Run Time)	LATCH	Y	Performs a read/write test on system RAM
Code Flash (Turn On)	LATCH	Y	SELBOOT qualifies code with a checksum
Code Flash (Run Time)	LATCH	Y	Checksum is computed on the entire code base
Internal EEPROM (Turn On)	N/A	N	Verifies the checksum for all the settings stored in the EEPROM
Isolated A/D Converter	LATCH	Y	Verifies if all readings from the isolated A/D converter are zero
A/D Converter Gain Stages	LATCH	Y	Verifies if primary input readings acquired via the three gain stages do not match
Injection Signal	LATCH	Y	Isolated A/D converter monitors if the injection signal is out-of-tolerance
Isolated Power Supplies	LATCH	Y	Isolated A/D converter monitors if any internal isolated power supply is out-of-tolerance
Nonisolated Power Supplies	LATCH	Y	A/D converter monitors if any internal nonisolated power supply is out-of-tolerance in three consecutive processing cycles

Troubleshooting

Refer to *Table 5.2* for troubleshooting instructions for particular situations.

Table 5.2 Troubleshooting

Symptoms	Possible Cause	Diagnosis/Solution
The module **ENABLED** faceplate LED is dark.	➤ Input power is not present or a fuse is blown. ➤ Self-test failure.	➤ Verify that input power is present, or replace Fuse F1.
The module **TX** faceplate LED is dark.	➤ The fiber-optic cable is not connected. ➤ The fiber-optic cable is the incorrect type.	➤ Verify the cable connection. ➤ Use the Model Option Table to verify the correct cable type.
The module does not respond to commands from a device connected to the internal firmware upgrade port.	➤ Cable is not connected. ➤ Cable is the incorrect type. ➤ The module or communicating device has communication mismatch(es). ➤ The module firmware upgrade port has received an XOFF, halting communications.	➤ Verify the cable connection. ➤ Verify the cable pinout. ➤ Verify module communications parameters. ➤ Type **<Ctrl+Q>** to send the module XON and restart communications.

Technical Support

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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Pullman, WA 99163-5603 U.S.A
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Internet: selinc.com/support
Email: info@selinc.com

Appendix A
Firmware and Manual Versions

Firmware

Determining the Firmware Version in Your SEL-2664

To find the firmware revision number in your SEL-2664 Field Ground Module, use the internal firmware upgrade port **STATUS** command to view the status report. The status report displays the Firmware Identification (FID) label:

FID=SEL-2664-R101-V0-Z000000-D20060717

The firmware revision number follows the R, and the release date follows the D.

Table A.1 lists the firmware versions, a description of modifications, and the instruction manual date code that corresponds to firmware versions. The most recent firmware version is listed first.

Starting with revisions published after March 1, 2022, changes that address security vulnerabilities are marked with "[Cybersecurity]". Other improvements to cybersecurity functionality that should be evaluated for potential cybersecurity importance are marked with "[Cybersecurity Enhancement]".

Table A.1 Firmware Revision History

Firmware Identification (FID) Number	Summary of Revisions	Manual Date Code
SEL-2664-R201-V0-Z000000-D20170428	➤ Improved the self-test for nonisolated power supplies by revising the tolerance levels and adding security requiring three consecutive processing cycles with out-of-tolerance measurements before declaring a self-test diagnostic failure. Units with R1xx firmware cannot be upgraded to R200 or higher in the field. Such an upgrade, because it involves calibration changes, requires that the unit be returned to the factory.	20170428
SEL-2664-R200-V0-Z000000-D20100120	➤ Improved calibration of the measurement channels. Units with R1xx firmware cannot be upgraded to R200 or higher in the field. Such an upgrade, because it involves calibration changes, requires that the unit be returned to the factory.	20100120
SEL-2664-R101-V0-Z000000-D20060717	➤ Initial version.	20060717

Instruction Manual

The date code at the bottom of each page of this manual reflects the creation or revision date.

Table A.2 lists the reference manual release dates and a description of modifications. The most recent reference manual revisions are listed at the top.

Table A.2 Instruction Manual Revision History (Sheet 1 of 2)

Revision Date	Summary of Revisions
20240529	**Section 1** ➤ Updated *Introduction*. **Section 3** ➤ Updated *Insulation Resistance Measurement* and *Injection Frequency Selection*. **Section 4** ➤ Updated *Overview*. ➤ Added *SEL-400G Generator Relay Application*.
20180216	**Preface** ➤ Updated *Safety Information.* ➤ Updated *Product and Compliance Label.* **Section 1** ➤ Updated *Specifications.* **Section 2** ➤ Updated *Physical Location* under *Device Placement.* ➤ Updated *Figure 2.1: SEL-2664 Module Front and Top Faceplates.* ➤ Updated *Figure 2.6: SEL-2664 Rear Panel.* ➤ Updated *Fuse Replacement* under *Field Serviceability*.
20170428	**Preface** ➤ Updated the *General Safety Marks* table. **Section 1** ➤ Updated *Compliance* in *Specifications*. **Section 5** ➤ Updated *Table 5.1: SEL-2664 Self-Tests* for the test method of the nonisolated power supplies. **Appendix A** ➤ Updated for firmware version R201. **Appendix B** ➤ Updated *Firmware (Flash) Upgrade Overview* and *Upgrade Firmware Using a Terminal Emulator*. ➤ Added *Technical Assistance*.
20150925	**Preface** ➤ Updated *Product and Compliance Labels*. ➤ Updated *Laser*. **Section 1** ➤ Updated *Compliance* in *Specifications*. ➤ Updated Laser Safety and Product Safety under *Safety* in *Specifications*.
20150123	**Preface** ➤ Added *Safety Information* and *General Information*. ➤ Updated the UL label. **Section 1** ➤ Changed the *Certifications* section title to *Compliance* and relocated the section to the beginning of the *Specifications*.

Table A.2 Instruction Manual Revision History (Sheet 2 of 2)

Revision Date	Summary of Revisions
	Section 4 ➤ Updated the SEL-300G Generator Protection Relay application for the EIA-232 port settings. ➤ Added applications with SEL-700G and SEL-2664S relays.
20121012	Preface ➤ Moved *Safety Information* to the *Preface* from *Section 1*. ➤ Updated the UL label. Section 1 ➤ Added continuous current rating and field terminal connections wire sizes in *Specifications*. Section 2 ➤ Added new bullets in the Field Terminal Connection note that wire connections are terminated in ring terminals and that only copper conductors must be used for field connections.
20100120	Section 2 ➤ Added note on field connections wire size requirements in *Making Rear-Panel Connections*. Section 3 ➤ Added note to *Insulation Resistance Measurement* that SEL-2812MT or SEL-2812MR can be used because the example application does not use IRIG-B. Section 4 ➤ Added note to *SEL-300G Generator Protection Relay Application* that SEL-2812MT or SEL-2812MR can be used because the example application does not use IRIG-B. Appendix A ➤ Updated for firmware version R200.
20061110	Section 1 ➤ Added Measurement Category II in *Specifications*. Section 2 ➤ Added wire temperature rating in *Making Rear-Panel Connections*. ➤ Updated compliance label in *Figure 1.2: Class 1 LASER Product Compliance Label and Serial Label*.
20060717	➤ Initial version.

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Appendix B
Firmware Upgrade Instructions

Firmware (Flash) Upgrade Overview

SEL occasionally offers firmware upgrades to improve the performance of your SEL-2664 Field Ground Module. Changing physical components is unnecessary because the module stores firmware in Flash memory. Upgrade the module firmware by downloading a file from a personal computer to the module via the firmware upgrade port using a terminal emulator as outlined in the following sections.

Required Equipment

Gather the following equipment before starting this firmware upgrade.

- Personal computer
- Terminal emulation software that supports Xmodem or 1k Xmodem protocol
- A serial communications cable (SEL-C234A cable or equivalent) or a null-modem cable
- Disc containing the firmware upgrade (.hex) file

NOTE: SEL strongly recommends that you upgrade firmware at the location of the module and with a direct connection from the personal computer to the module firmware upgrade port. Do not load firmware from a remote location; problems can arise that you will not be able to address from a distance. When upgrading at the substation, do not attempt to load the firmware into the module through an SEL communications processor.

Upgrade Firmware Using a Terminal Emulator

The following instructions assume you have a working knowledge of your personal computer terminal emulation software. In particular, you must be able to modify your serial communications parameters (data rate, data bits, parity, etc.), select transfer protocol (Xmodem or 1k Xmodem), and transfer files.

NOTE: Make sure the firmware version is compatible with the module. Refer to Appendix A: Firmware and Manual Versions for more information.

Step 1. If the SEL-2664 is in use, follow your company practices for removing the module from service. Typically, these include disconnecting external voltage sources to disable module functions.

Step 2. Apply power to the module.

Step 3. Remove the front faceplate of the module to access the firmware upgrade port.

Step 4. Connect the PC to the SEL-2664 internal firmware upgrade port using an SEL-C234A cable (or equivalent serial communications cable).

NOTE: For a list of commands available in SELBOOT, type **HEL <Enter>**.

Step 5. Start upgrading the firmware.

a. Issue the **L_D** command to the module.

b. Type **Y <Enter>** at the following prompt:

```
Disable device to receive firmware (Y/N)?
```

c. Type **Y <Enter>** at the following prompt:

```
Are you sure (Y,N)?
```

The module sends the `!>` prompt.

Step 6. Change the data rate, if necessary.

a. Type **BAU 3 <Enter>** at the SELBOOT `!>` prompt. This command changes the data rate of the communications port to 38400 bps.

b. Change the data rate of the PC to 38400 bps to match the module.

The data rate command works as follows:

- **BAU 1 <Enter>** sets the data rate to 9600 bps.
- **BAU 2 <Enter>** sets the data rate to 19200 bps.
- **BAU 3 <Enter>** sets the data rate to 38400 bps.
- **BAU 4 <Enter>** sets the data rate to 57600 bps.
- **BAU 5 <Enter>** sets the data rate to 115200 bps.

Step 7. Begin the transfer of the new firmware to the module by issuing the **REC** command.

Step 8. Type **Y** to erase the existing firmware and load new firmware. (to abort, type **N** or press **<Enter>**).

Step 9. Press any key (e.g., **<Enter>**) when the relay sends a prompt.

Step 10. Start the file transfer.

Select the **Send file** option in your communications software. Use the Xmodem protocol and send the file that contains the new firmware (e.g., r2012664.hex).

The file transfer typically takes one minute at 38400 bps, depending on the module. If you see no indication of a transfer in progress within a few minutes after clicking **Send**, use the **REC** command again and reattempt the transfer.

Figure B.1 shows the entire firmware upgrade process.

NOTE: A successful restart sequence can take as long as two minutes, after which time the SEL-2664 leaves SELBOOT. You will see no display on your PC to indicate a successful restart.

```
==>>L_D <Enter>
Disable device to receive firmware (Y,N)? Y <Enter>

Are you sure (Y/N)? Y <Enter>
Device disabled

!>BAU 3 <Enter>
!>REC <Enter>
Caution! - This erases the Application firmware.
Are you sure? (Y/N) Y <Enter>
Erasing
OK
Waiting for data from the PC <Enter>
```

Figure B.1 Firmware File Transfer Process

NOTE: The module restarts in SELBOOT if the power fails while receiving new firmware. Upon power up, the module firmware upgrade port will be at the default 9600 bps. Change the data rate of the PC to 9600 bps to re-establish a connection with the device and then resume the firmware upgrade process.

Step 11. The module illuminates the **ENABLED** front faceplate LED if the firmware upgrade was successful.

Step 12. Change the data rate of the PC to 9600 bps. Press **<Enter>** and confirm that the ==>> prompt appears on the computer screen.

Step 13. Enter the **STATUS** command (**STA <Enter>**) to view the module status messages.

If necessary, contact the factory for assistance in achieving a successful firmware upgrade.

Technical Assistance

We appreciate your interest in SEL products and services. If you have questions or comments, please contact us at:

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2350 NE Hopkins Court
Pullman, WA 99163-5603 U.S.A.
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Glossary

A	Abbreviation for amperes; unit of electrical current flow.
ac	Abbreviation for alternating current.
ASCII	Abbreviation for American Standard Code for Information Interchange. Defines a standard set of text characters. The SEL-2664 uses ASCII text characters to communicate through the use of a firmware upgrade port.
Cfg	The capacitance value between the generator field winding and ground.
dc	Abbreviation for direct current.
EIA-232	Electrical definition for point-to-point serial data communications interfaces, based on the standard EIA/TIA-232. Formerly known as RS-232.
ESD	Electrostatic discharge. The sudden transfer of charge between objects at different potentials caused by direct contact or induced by an electrostatic field.
Fg	The frequency of the square-wave injection voltage.
Firmware	The nonvolatile program stored in the IED that defines relay operation.
GND	Ground.
HMI	Human-machine interface.
LCD	Liquid Crystal Display.
LED	Light-Emitting Diode. Used as indicators on the SEL-2664 front and top panels.
PC	Personal Computer.
Protocol	A language for communication between devices.
RAM	Random-Access Memory.
Rf	The insulation resistance value that the SEL-2664 calculates and transmits to the SEL-300G, the SEL-700G, or the SEL-2664S.
SCADA	Supervisory Control and Data Acquisition.
Square-Wave Injection Voltage	The SEL-2664 injects a square-wave dc voltage. The output of this square-wave injection voltage is connected to the generator field winding through terminals **FIELD (+)** and **FIELD (–)**.
V	Abbreviation for volts; unit of electromotive force.
W	Abbreviation for watts; unit of electrical power.

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Index

Page numbers appearing in bold mark the location of the topic's primary discussion.

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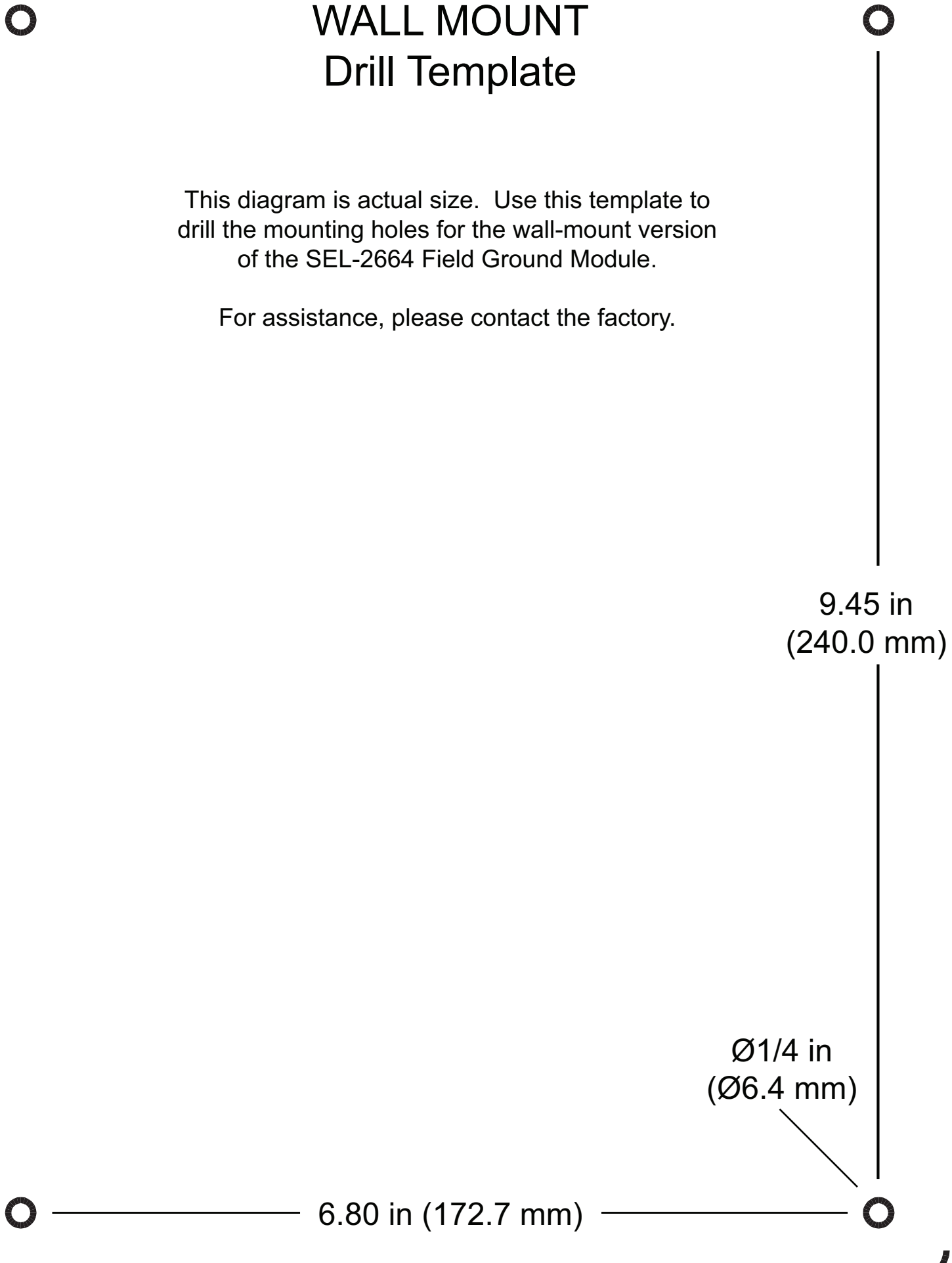
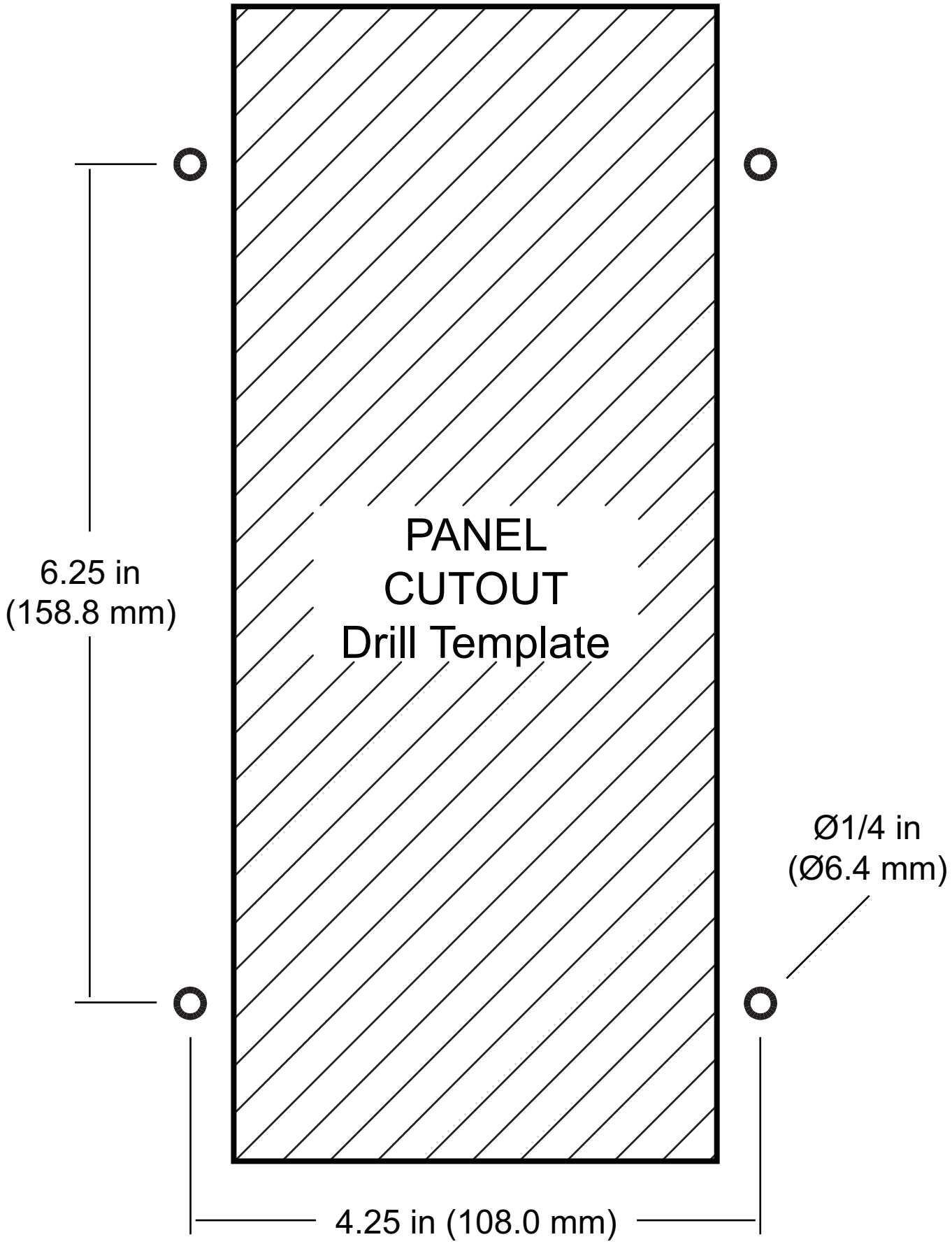
WALL MOUNT
Drill Template

This diagram is actual size. Use this template to drill the mounting holes for the wall-mount version of the SEL-2664 Field Ground Module.

For assistance, please contact the factory.



This diagram is actual size. Use this template to drill the mounting holes for the panel-mount version of the SEL-2664 Field Ground Module.



For assistance, please contact the factory.

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