SEL-2664 Field Ground Module

Protect Against Major Damage by Adding Field Ground Protection to the SEL-300G, SEL-700G, and SEL-2664S Relays With the SEL-2664

High Reliability, Low Price
➤ Ten-Year, Worldwide Warranty
➤ −40° to +85°C Operating Temperature
➤ Ruggedized to Meet Industrial and Utility Standards
➤ Wall, Panel, or Rack Mounting

Field Insulation Resistance Measurement
➤ Superior Switched DC Voltage Injection Method
➤ Measurement Range to Approximately 20 MΩ
➤ Fault Detection Range from 500 Ω to 200 kΩ
➤ Detect Faults With Generator in Energized or De-Energized State

Plug-In Compatibility With the SEL-300G, SEL-700G, and SEL-2664S
➤ Fiber-Optic Serial Connection from an SEL-2664 Field Ground Module to an SEL-300G, SEL-700G, or SEL-2664S Relay
➤ No Settings in the SEL-2664
➤ Simple Programming With ACSELERATOR Quick-Set® SEL-5030 Software for the SEL-300G, SEL-700G, or SEL-2664S Settings
➤ Local LCD Display of Settings, Measured Values (Including Insulation Resistance Rf), and Statuses in the SEL-300G or SEL-700G Relays

Fiber-Optic Connection to the SEL-300G, SEL-700G, or SEL-2664S
➤ Noise-Free Monitoring and Protection
➤ Reliable Digital Communications of Field Insulation Resistance and Self-Test Diagnostics
➤ As Far as 1000 meters Transmission Distance
➤ Improved Personnel Safety (Elimination of Copper Connection)
Functional Overview

The SEL-2664 Field Ground Module calculates field winding insulation resistance in the rotor of a synchronous generator. The measurement can be obtained from an energized or de-energized generator. Insulation resistance values are transmitted to an SEL-300G, SEL-700G, or SEL-2664S relay for the field ground protection element (64F) alarm and/or trip functions.

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

The SEL-300G, SEL-700G, and SEL-2664S relays use the field insulation resistance value to detect a ground fault in an ungrounded field winding of a generator. By detecting a ground fault in the field winding, users are alerted to a possible short-circuited field winding. Avoid significant damage to the generator by taking corrective actions before a second ground path occurs.

The SEL-2664 transmits the field insulation resistance value as far as 1000 meters using inexpensive fiber-optic cable. The SEL-2664 works with continuous field voltages as high as 750 Vdc, and is able to withstand 1500 Vdc for one minute.

![SEL-300G Relay With SEL-2664](image)

\[\text{SEL-300G Relay With SEL-2664}\]

Figure 1  Functional Diagram of an SEL-300G With the SEL-2664 for the 64F Element (An SEL-700G or SEL-2664S application is similar)
An SEL-300G, SEL-700G, or SEL-2664S Protective Relay Application

The SEL-300G, SEL-700G, and SEL-2664S Protective Relays have a selectable field ground protection element (64F) that uses the SEL-2664 Field Ground Module to acquire insulation resistance data for alarm and trip functions. Connect the SEL-2664 to the SEL-300G as shown in Figure 2. On the SEL-700G and SEL-2664S relays, the fiber-optic PORT 2 connects directly to the SEL-2664.

Use a fiber-optic cable and an SEL-2812M Transceiver to transmit the insulation resistance data to the SEL-300G. The EIA-232 port used must be set for an 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. Refer to the SEL-700G Instruction Manual for similar settings and application details.

Figure 2 Field Ground Protection Using an SEL-300G Relay and an SEL-2664 Field Ground Module (An SEL-700G application is similar)

The SEL-2664S Stator Ground Protection Relay supports a similar application. 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 the fiber-optic port (PORT 2) of the SEL-2664S. Consult the SEL-2664S Instruction Manual for detailed instructions on setting up the SEL-2664. You need to set the fiber-optic serial port (PORT 2) in the SEL-2664S to SEL protocol and 9600 bps, 8 data bits, no parity, and 1 stop bit to start receiving the insulation resistance value from the SEL-2664.

SEL-300G and SEL-700G Requirements for an SEL-2664 Application

If the field ground protection functionality is to be added to an existing SEL-300G installation, use the following checklist to determine the requirements. All SEL-700G models, except the SEL-700GT model, support field ground protection using the SEL-2664.

<table>
<thead>
<tr>
<th>Existing SEL-300G</th>
<th>Recommended Actions for an SEL-2664 Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firmware version R1xx</td>
<td>Contact the factory for a replacement SEL-300G.</td>
</tr>
<tr>
<td>Firmware version R2xx</td>
<td>Consult with the factory about a hardware upgrade or a replacement SEL-300G.</td>
</tr>
<tr>
<td>Firmware version R3xx</td>
<td>Order a firmware conversion kit from the factory to field upgrade firmware to R323 or later.</td>
</tr>
<tr>
<td>EIA-232 Serial Port 2 or Port 3 availability</td>
<td>EIA-232 Port 2 or Port 3 availability is required to connect the SEL-2664 using a fiber-optic cable and an SEL-2812M Transceiver. Visit the SEL website or call the factory for cable selection and ordering information.</td>
</tr>
</tbody>
</table>
The 64F element requires that the SEL-2664 provide an insulation resistance measurement.

Add 64F-element Relay Word bits to the appropriate SELOGIC control equation settings to generate the front-panel messages, alarm, trip, event report, and SER report.

### Settings for the 64F Element

- **Insulation Resistance Element:** 0.5–200.0 kΩ
- **Pickup Accuracy:** ±5% ± 500 Ω for 48 Vdc ≤ VF ≤ 825 Vdc  
  ±5% ± 20 kΩ for 825 Vdc ≤ VF ≤ 1500 Vdc  
  (VF is the generator field winding excitation dc voltage)
- **Pickup Time:** ≤ 2 s if the injection frequency in the SEL-2664 is selected at 1 Hz  
  ≤ 8 s if the injection frequency in the SEL-2664 is selected at 0.25 Hz
- **Definite-Time Delay:** 0.0–99.0 s
- **Maximum Definite-Time Delay Accuracy:** ±0.5% ±5 ms

### SEL-300G METER Command Report With Field Insulation Resistance Rf

**Table 1 Field Ground Protection (64F) (Requires SEL-2664 Field Ground Module)**

<table>
<thead>
<tr>
<th>Insulation Resistance Element</th>
<th>0.5–200.0 kΩ</th>
</tr>
</thead>
</table>
| Pickup Accuracy             | ±5% ± 500 Ω for 48 Vdc ≤ VF ≤ 825 Vdc  
  ±5% ± 20 kΩ for 825 Vdc ≤ VF ≤ 1500 Vdc  
  (VF is the generator field winding excitation dc voltage) |
| Pickup Time                 | ≤ 2 s if the injection frequency in the SEL-2664 is selected at 1 Hz  
  ≤ 8 s if the injection frequency in the SEL-2664 is selected at 0.25 Hz |
| Definite-Time Delay         | 0.0–99.0 s  
  Maximum Definite-Time Delay Accuracy | ±0.5% ±5 ms |

**SEL-700G and SEL-2664S also support similar settings, and MET and STA reports. Please refer to the SEL-700G and SEL-2664S instruction manuals for details.**

### SEL-300G STATUS Command Report With Field Ground Module (FGM) Status

**Table 2 Field Insulation**

<table>
<thead>
<tr>
<th>Rf (kΩ)</th>
<th>Generator field winding insulation resistance.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>If 64FOPT = EXT and the 64FFLT Relay Word bit equals zero, the insulation resistance value is displayed.</td>
</tr>
<tr>
<td></td>
<td>If 64FOPT = EXT and the 64FFLT Relay Word bit equals one, the message FIELD INSULATION Rf (k ohms) Fail is displayed.</td>
</tr>
<tr>
<td></td>
<td>If 64FOPT = NONE, nothing is displayed.</td>
</tr>
</tbody>
</table>

**SEL-300G STATUS Command Report With Field Ground Module (FGM) Status**

**Table 3 Field Insulation**

| FGMA  | SEL-300G Field Ground Module Data Sheet Schweitzer Engineering Laboratories, Inc. |
The SEL-2664 sends a binary data packet approximately every half period of the square-wave injection voltage. When the injection frequency is selected at 0.25 Hz, the packet transmits every 2 seconds. When the injection frequency is selected at 1.0 Hz, the packet transmits every 500 milliseconds. The packet contains data for insulation resistance and self-test status; therefore no software setting is necessary in the SEL-2664. The SEL-2812M Fiber-Optic Transceiver (with ST connectors) plus any EIA-232 device can be configured to process the binary packet contents shown in Table 4.

SEL-2664 Self-Tests

The SEL-2664 runs a variety of self-tests. When there is a failure and the device is disabled, the module will extinguish the ENABLED LED. Table 5.1 in the SEL-2664 Field Ground Module Instruction Manual lists hardware self-tests, test methods, and actions taken.

SEL-2664 Injection Voltage Frequency Selection Criteria

The SEL-2664 injects a square-wave voltage at a fixed injection frequency (Fg) to the generator field winding. The fixed frequency Fg can be selected between two values, 0.25 Hz or 1 Hz, using a jumper located on the main board of the SEL-2664. 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 0.25 Hz to ensure the stated accuracy for the 64F element. For generators with CfG less than 10 microfarads, Fg should be set at 0.25 Hz to ensure the stated accuracy for the 64F element. The SEL-2664 works with other generators that have overall field-to-ground capacitance more than 10 microfarads, but the actual error may not be within the stated accuracy.

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 guidelines in Table 5 to select the frequency for the square-wave dc signal injection. Otherwise, leave the module at its default jumper setting of 0.25 Hz.
SEL Communications Processor Applications

The SEL-2664 Field Ground Module communicates with an SEL 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.

You can program an SEL communications processor to perform five automated steps.

- Receive an insulation resistance data packet from the SEL-2664.
- Store the insulation resistance data packet in memory.
- Convert the insulation resistance raw data into the insulation resistance value.
- Perform insulation resistance threshold comparisons.
- Issue control commands to a protective relay based on the insulation resistance comparisons.

Figure 3 shows a possible configuration using the SEL-2664 and an SEL communications processor. Contact SEL for help in applying these products in other configurations.

Refer to the SEL-2664 Field Ground Module Instruction Manual for more details, including configuration of the SEL communications processor.

Table 5 Jumper Settings

<table>
<thead>
<tr>
<th>Field-to-Ground Capacitance (CFG)</th>
<th>Jumper Position (Jumper 1A)</th>
<th>Injected Signal Frequency (FG)</th>
<th>Time Between Each Insulation Resistance Calculation</th>
<th>Accuracy</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt; 2.5 \mu F$</td>
<td>Close</td>
<td>1 Hz</td>
<td>0.5 seconds</td>
<td>Within Spec.</td>
<td>Operating time is faster</td>
</tr>
<tr>
<td>$2.5 \mu F \leq CFG \leq 10 \mu F$</td>
<td>Open</td>
<td>0.25 Hz</td>
<td>2 seconds</td>
<td>Within Spec.</td>
<td>Shipped default position</td>
</tr>
<tr>
<td>$&gt; 10 \mu F$</td>
<td>Open</td>
<td>0.25 Hz</td>
<td>2 seconds</td>
<td>Not Within Spec.</td>
<td>Recommended setting for generators with CFG &gt; 10 µF</td>
</tr>
</tbody>
</table>

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

Figure 3 Field Ground Protection With an SEL Communications Processor

1 Refer to the Model Option Table for cable choices.
Wiring Diagrams

Figure 4  Typical SEL-2664 Connection Diagram

Front- and Rear-Faceplate Diagrams

Figure 5  SEL-2664 Front Faceplate
Product Dimensions

**WALL-MOUNT CHASSIS**

Figure 6  SEL-2664 Side- or Rear-Faceplate Diagram

Figure 7  Wall-Mount Chassis
PANEL-MOUNT CHASSIS

Figure 8  Panel-Mount Chassis

RACK-MOUNT CHASSIS

Figure 9  Rack-Mount Chassis
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 15 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)

Operating Environment
Insulation Class: I
Pollution Degree: 2
Overvoltage Category: II
Atmospheric Pressure: 80–110 kPa
Relative Humidity: 5%–95%, noncondensing
Maximum Altitude Without Derating: 2000 m
(Consult the Factory for Higher Altitude Derating):

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 (Ue):
60–750 Vdc continuous
Maximum Rated Voltage Range:
48–825 Vdc continuous
Rated Insulation Voltage: 825 Vdc

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:

<table>
<thead>
<tr>
<th>Connection Type</th>
<th>Minimum Wire Size</th>
<th>Maximum Wire Size</th>
<th>Insulation Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grounding (Earthing)</td>
<td>16 AWG (1.3 mm²)</td>
<td>14 AWG (2.1 mm²)</td>
<td>300 V min</td>
</tr>
<tr>
<td>Power Connection</td>
<td>16 AWG (1.3 mm²)</td>
<td>14 AWG (2.1 mm²)</td>
<td>300 V min</td>
</tr>
<tr>
<td>Field Terminal Connections</td>
<td>18 AWG (0.8 mm²)</td>
<td>14 AWG (2.1 mm²)</td>
<td>825 V min</td>
</tr>
</tbody>
</table>
### Product Standards

**Electromagnetic Compatibility:**
- IEC 60255-26:2013
- IEC 60255-27:2013

**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

### Type Tests

#### Environmental

**Object Penetration and Dust Ingress:**
- 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
- Class 1

**Shock Resistance:**
- IEC 60255-27:2013; Section 10.6.2.2
- IEC 60255-27:2013; Section 10.6.2.3

**Withstand:**
- Class 2
- Class 1

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

**Seismic Response:**
- Class 2

**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

**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

**Damp Heat, Steady State:**
- IEC 60068-2-7:2012
  - Severity Level: 93% RHMin, 40°C; 10 days

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

#### Dielectric Strength and Impulse Tests

**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

#### RFI and Interference Tests

**EMC Immunity:**
- IEC 61000-4-2:2008
- IEC 60255-26:2013; Section 7.2.3
- IEEE C37.90-2001
  - Severity Level: 4
  - 8 kV contact discharge
  - 15 kV air discharge

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

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

**Surge Immunity:**
- IEC 61000-4-5:2005
- 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 C37.90-2002
  - 2.5 kV oscillatory
  - 4 kV fast transient

**Conducted RF Immunity:**
- IEC 61000-4-6:2004

**Magnetic Field Immunity:**
- IEC 60255-26:2013; 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

#### EMC Emissions

**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

**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

### Safety

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