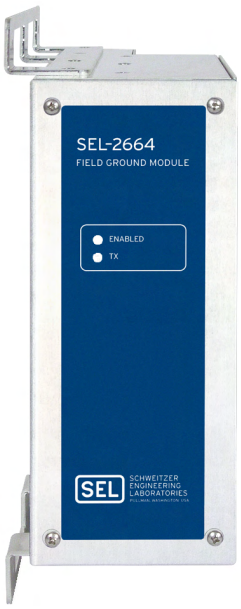
SEL-2664 Field Ground Module

Protect Against Major Damage by Adding Field Ground Protection to the SEL-300G, SEL-400G, 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

Plug-In Compatibility With the SEL-300G, SEL-400G, SEL-700G, and SEL-2664S

- Fiber-Optic Serial Connection From an SEL-2664 Field Ground Module to an SEL-300G, SEL-400G, SEL-700G, or SEL-2664S Relay
- No Settings in the SEL-2664
- Simple Programming With ACSELERATOR QuickSet® SEL-5030 Software for the SEL-300G, SEL-400G, SEL-700G, or SEL-2664S Settings
- Local LCD of Settings, Measured Values (Including Insulation Resistance Rf), and Statuses in the SEL-300G, SEL-400G, or SEL-700G Relays

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

Fiber-Optic Connection to the SEL-300G, SEL-400G, 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 m Transmission Distance
- Improved Personnel Safety (Elimination of Copper Connection)

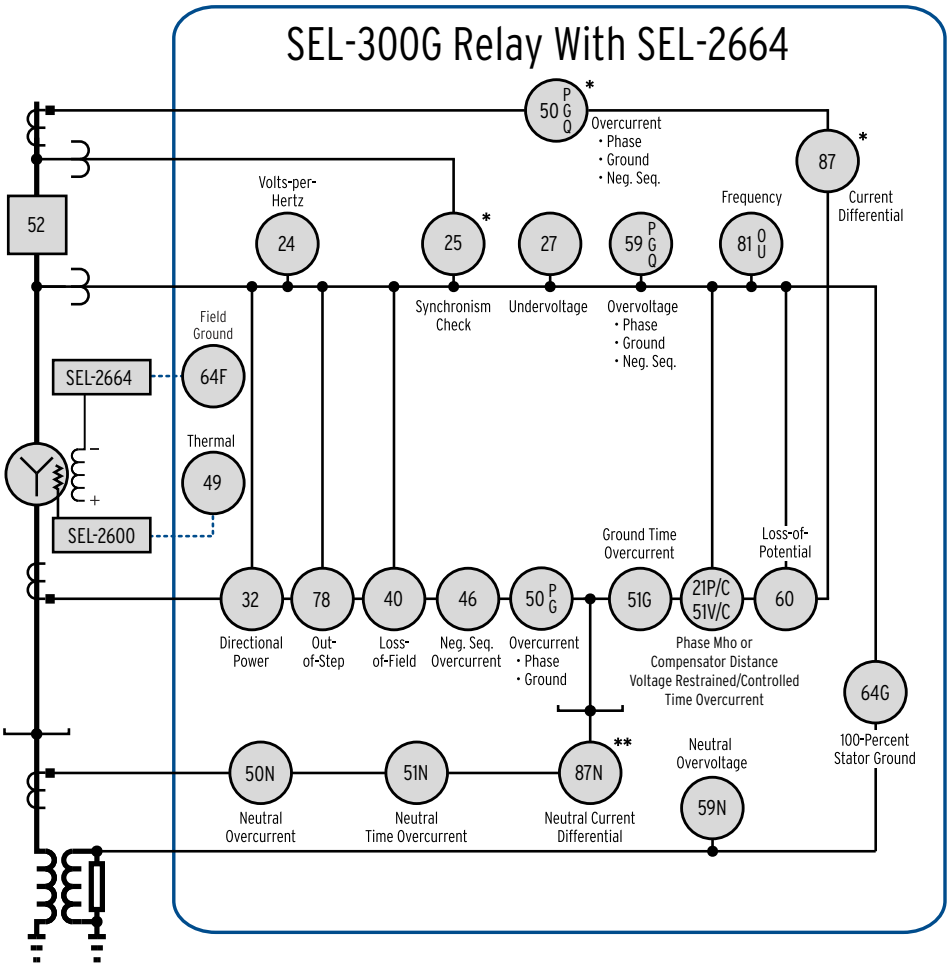
Functional Overview

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-400G, SEL-700G, or SEL-2664S 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-400G, 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 1 minute.



- SELogic® Control Equations
- Event Reports
- Sequential Events Recorder
- Breaker Wear Monitor
- Station Battery Monitor
- Modbus®, ASCII, Binary, and Distributed Port Switch Communications
- Remote and Local Control Switches
- High-Accuracy Metering
- Off-Frequency Operation Time Accumulators
- RTD-Based Thermal Protection
- Field Ground Detection

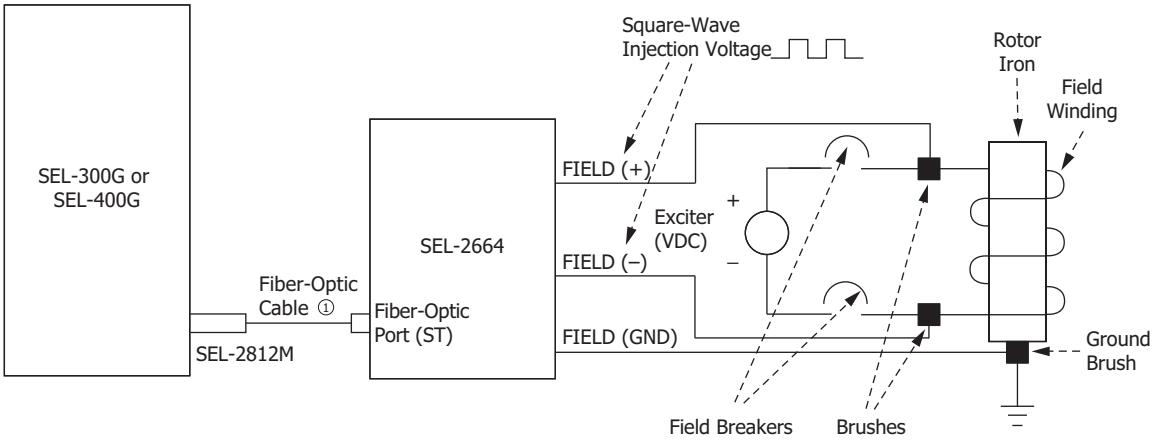
* Optional Functions
** Provided When 87* Is Not Specified

Figure 1 Functional Diagram of an SEL-300G With the SEL-2664 for the 64F Element (An SEL-400G, SEL-700G or SEL-2664S Application Is Similar)

An SEL-300G, SEL-400G, SEL-700G, or SEL-2664S Protective Relay Application

The SEL-300G, SEL-400G, SEL-700G, and SEL-2664S relays have a selectable field ground protection element (64F) that uses the SEL-2664 to acquire insulation resistance data for alarm and trip functions. Connect the SEL-2664 to the SEL-300G or SEL-400G 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 Fiber-Optic Transceiver With IRIG-B 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-400G Advanced Generator Protection System Instruction Manual* and the *SEL-700G Generator and Intertie Protection Relays Instruction Manual* for similar settings and application details.



① Refer to the Model Option Table for cable choices.

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

Figure 2 Field Ground Protection Using an SEL-300G or SEL-400G and an SEL-2664 (An SEL-700G Application Is Similar)

The SEL-2664S 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 Stator Ground Protection Relay Instruction Manual* for detailed instructions on setting up the SEL-2664. You must 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 by using the SEL-2664.

Existing SEL-300G	Recommended Actions for an SEL-2664 Application
Firmware version R1*xx*	Contact the factory for a replacement SEL-300G.
Firmware version R2*xx*	Consult with the factory about a hardware upgrade or a replacement SEL-300G.
Firmware version R3*xx*	Order a firmware conversion kit from the factory to field upgrade firmware to R323 or later.
EIA-232 Serial Port 2 or Port 3 availability	EIA-232 Port 2 or Port 3 availability is required to connect the SEL-2664 by using a fiber-optic cable and an SEL-2812M. Visit the SEL website or call the factory for cable selection and ordering information.

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

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

Settings for the 64F Element

The 64F element requires that the SEL-2664 provide an insulation resistance measurement.

64F Input Option (EXT, NONE) 64FOPT = _____

Level 1 Pickup (OFF, 0.5-200.0 kΩ) *(hidden when 64FOPT = NONE)* 64F1P = _____

Level 1 Delay (0.0-99.0 sec) *(hidden when 64FOPT = NONE or when 64F1D = OFF)* 64F1D = _____

Level 2 Pickup (OFF, 0.5-200.0 kΩ) *(hidden when 64FOPT = NONE)* 64F1P = _____

Level 2 Delay (0.0-99.0 sec) *(hidden when 64FOPT = NONE or when 64F1D = OFF)* 64F2D = _____

64F Element Torque Control (SELOGIC control equation) *(hidden when 64FOPT = NONE)* 64FTC = _____

Add the 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.

SEL-300G METER Command Report With Field Insulation Resistance Rf (Available on Front-Panel LCD or Serial Port)

```
=>MET <Enter>
GENERATOR                          Date: 02/20/04    Time: 07:58:54.990
TERMINAL
                    A         B         C         N         G
I MAG (A)       904.052   903.011   908.535     0.034     4.286
I ANG (DEG)      -4.96   -124.88    115.02     56.40     90.93
                    A         B         C         N
V MAG (KV)        7.910     7.905     7.917     0.000
V ANG (DEG)       0.00   -119.89    120.09     8.22
                  VP3       VN3       VN1
V MAG (sV)        0.003     0.001     0.001
                    A         B         C        3P
MW                7.125     7.111     7.165    21.401
MVAR              0.619     0.622     0.635     1.875
PF                0.996     0.996     0.996     0.996
                  LAG       LAG       LAG       LAG
                   I1        3I2       3I0        V1        V2        3V0
MAG             905.199     6.096     4.286     7.911     0.008     0.004
ANG   (DEG)      -4.94   -124.45     90.93     0.07    -99.02    -48.37
FREQ (Hz)         60.01                VDC (V) 122.5
V/Hz (percent)  99.60
FIELD INSULATION Rf (k ohms)   16666.6
=>
```

Table 2 Field Insulation

Rf (kΩ)	Generator field winding insulation resistance. If 64FOPT = EXT and the 64FFLT Relay Word bit equals zero, the insulation resistance value is displayed. If 64FOPT = EXT and the 64FFLT Relay Word bit equals one, the message `FIELD INSULATION Rf (k ohms) Fail` is displayed. If 64FOPT = NONE, nothing is displayed.

SEL-300G STATUS Command Report With Field Ground Module (FGM) Status (Available on Front-Panel LCD or Serial Port)

```
=>STA <Enter>

GENERATOR                          Date: 01/20/00    Time: 10:20:19.544
TERMINAL
FID=SEL 300G-X207-V31H425XX4X-Z001001-D20000217       CID=04B0
SELF TESTS
W=Warn    F=Fail
       IA      IB      IC      IN      VA      VB      VC      VN      MOF
OS     0       1       0       1       1       0       0       1       0
       +5V_PS  +5V_REG -5V_REG +12V_PS -12V_PS +15V_PS -15V_PS
PS      4.95    5.01   -4.99    11.96  -12.05   14.90  -14.93
       TEMP    RAM     ROM     A/D     CR_RAM  EEPROM  IO_BRD
        42.5   OK      OK      OK      OK      OK      OK
FGM    COMM    MODULE
       OK      OK
Relay Enabled
```

The SEL-700G and SEL-2664S also support similar settings, and **MET** and **STA** reports. Refer to the *SEL-700G Generator and Intertie Protection Relays Instruction Manual* and *SEL-2664S Stator Ground Protection Relay Instruction Manual* for details.

Table 3 Communication and Module (SEL-2664) Status Values

COMM	MODULE	Description
OK	OK	Receiving valid communications
OK	FAIL	Receiving communications from a device with a status word indicating a remote failure
FAIL	N/A	Lost communications
FAIL	FAIL	Lost communications, but the last communication from the device contains a status word indicating a remote failure

SEL-2664 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 selected at 0.25 Hz, the packet transmits every 2 s. When the injection frequency is selected at 1.0 Hz, the packet transmits every 500 ms. The packet contains data for insulation resistance and self-test status; therefore no software setting is necessary in the SEL-2664. The SEL-2812M transceiver (with ST connectors) plus any EIA-232 device can be configured to process the binary packet contents shown in *Table 4*.

Table 4 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 (28 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 Ω
xxxx	2 bytes	Future use
xxxx	2 bytes	Injection waveform period, scaled at 1 bit = 1 ms

Table 4 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. Remaining three characters are ASCII numeric characters.
yyyy	2 bytes	CRC-16 block check code

The SEL-2664 front faceplate **TX** LED is pulsed when it is transmitting data.

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, by 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 μF, Fg can be set to 1 Hz and ensure the stated accuracy for the 64F element. For generators with Cfg less than 10 μF, 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 μF, 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 s. 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.

Table 5 Jumper Settings

Field-to-Ground Capacitance (CFG)	Jumper Position (Jumper 1A)	Injected Signal Frequency (FG)	Time Between Each Insulation Resistance Calculation	Accuracy	Comment
Cfg < 2.5 µF	Close	1 Hz	0.5 s	Within specifications	Operating time is faster
2.5 µF ≤ Cfg ≤10 µF	Open	0.25 Hz	2 s	Within specifications	Shipped default position
Cfg > 10 µF	Open	0.25 Hz	2 s	Not within specifications	Recommended setting for generators with Cfg > 10 µF

SEL Communications Processor Applications

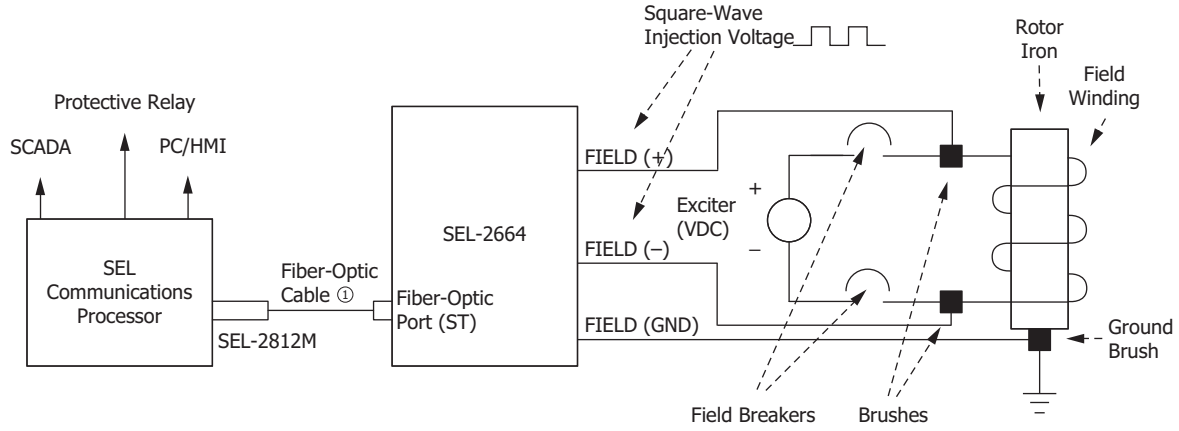
The SEL-2664 communicates with an SEL communications processor to enhance many protection and monitoring applications. The communications processor monitors insulation resistance data from the SEL-2664, performs threshold comparisons, and sends control commands to a protective relay.

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 that uses 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.



① Refer to the Model Option Table for cable choices.

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

Figure 3 Field Ground Protection With an SEL Communications Processor

Wiring Diagrams

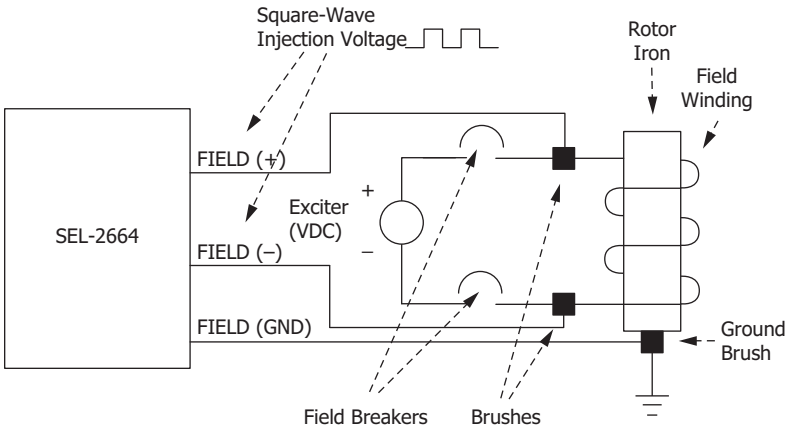


Figure 4 Typical SEL-2664 Connection Diagram

Front- and Rear-Faceplate Diagrams

Figure 5 SEL-2664 Front Faceplate

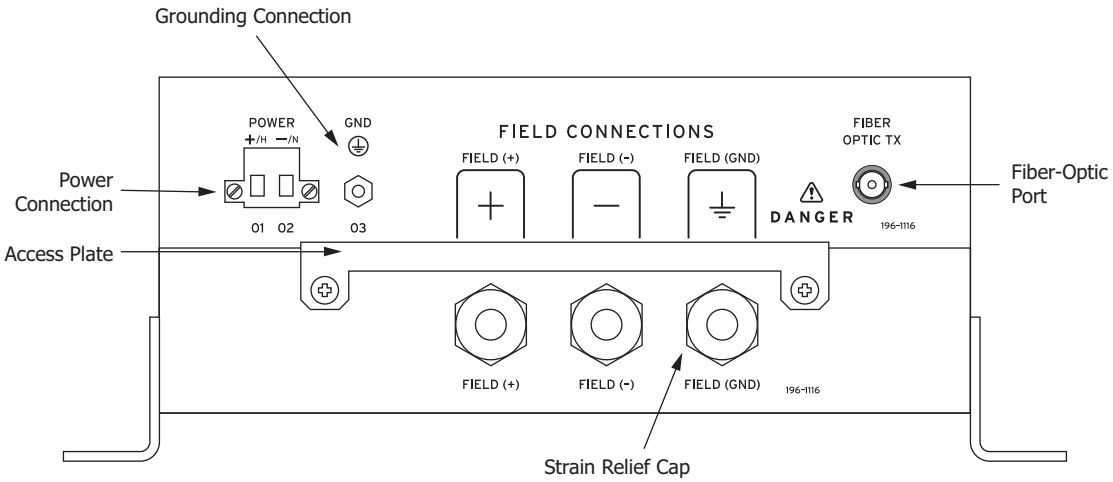


Figure 6 SEL-2664 Side- or Rear-Faceplate Diagram

Product Dimensions

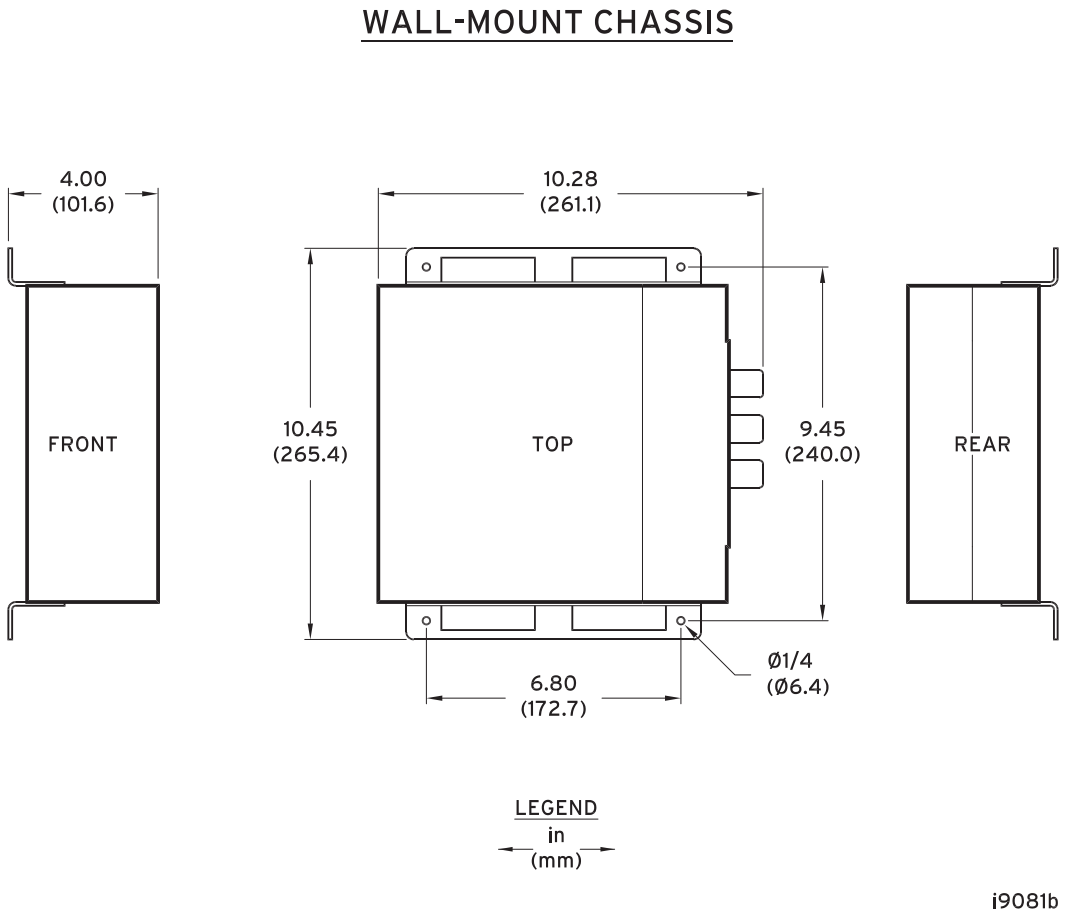


Figure 7 Wall-Mount Chassis

PANEL-MOUNT CHASSIS

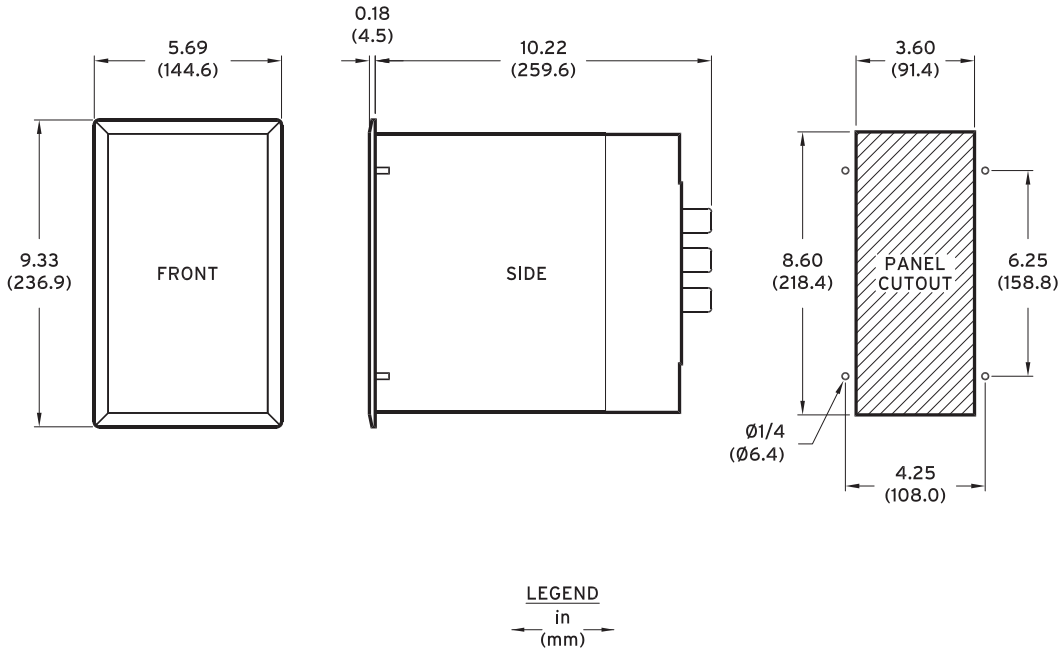


Figure 8 Panel-Mount Chassis

RACK-MOUNT CHASSIS

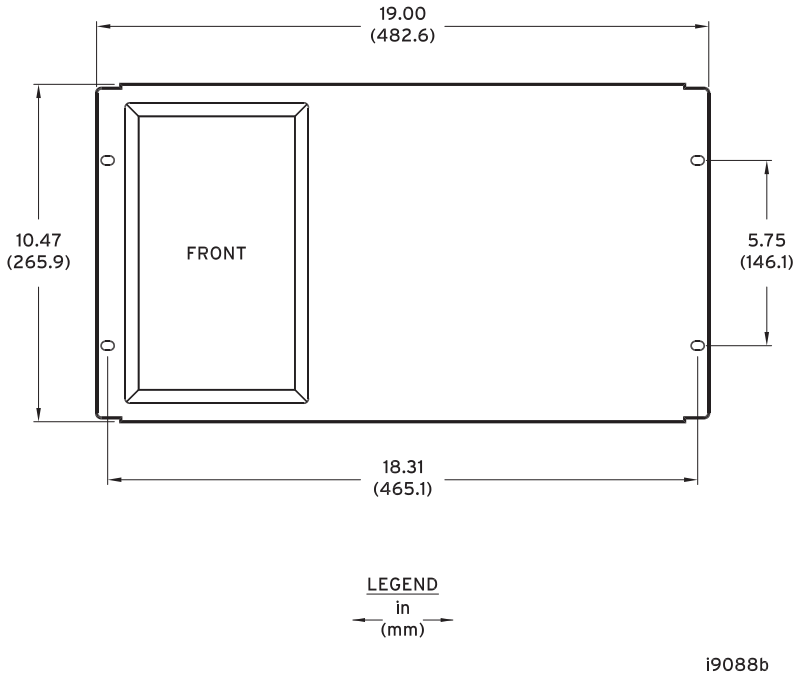


Figure 9 Rack-Mount Chassis

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 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 7*, *Figure 8*, and *Figure 9* 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	18 AWG (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: Response:	Class 2 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

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