Introduction

The FGD-2 Field Ground Detector Module is a transducer that continuously monitors the resistance of the field circuit of a synchronous machine with respect to ground. It applies a fixed voltage with respect to ground which causes a small leakage current to flow. The FGD-2 provides a low voltage output signal proportional to the leakage current. The voltage output is measured by a compatible product and used for field ground protection.

Two versions of the FGD-2 are available. A low-voltage version, rated for 800 Vdc maximum generator field voltage, is provided for brush or brushless exciter systems. A high-voltage version, rated for 1,750 Vdc generator field voltage, is provided for static exciter systems.

The metal enclosure of the FGD-2 offers electric shock protection from incidental contact. A compatible footprint and identical functionality make for simple replacement of a Field Ground Detector (FGD) with the FGD-2.

Specifications

Power Supply Requirements

Voltage: 100/120 Vac (nominal), 90-132 Vac (range)
Frequency: 50-60Hz

Pin Assignments
Power Input: 1 (L), 2 (N)

Enable Input

Voltage: 100/120 Vac (nominal), 90-132 Vac (range)
Frequency: 50-60 Hz

Pin Assignments
Enable: 3 (L), 4 (N)

Field Input

Low Voltage Version (9501000100)
Voltage: 800 Vdc maximum

High Voltage Version (9501000101)
Voltage: 1,750 Vdc maximum

Pin Assignments
Field Input: 9 (GND, Core), 12 (F+)

Analog Output

Voltage: 0–15 Vdc

Pin Assignments
Output: 5 (+), 6 (–), 7 (GND, chassis)

Environment

Temperature
Operating: –40 to 60°C (–40 to 140°F)
Storage: –40 to 65°C (–40 to 149°F)

Ingress Protection Class
IP20

Humidity
0 to 95%, non-condensing

Physical

Weight:	2.6 lb (1.2 kg)
Size (WxHxD):	7.82 x 6.93 x 2.82 inches (198.6 x 176.1 x 71.6 mm)

China RoHS

The following table serves as the declaration of hazardous substances for China in accordance with PRC standard SJ/T 11364-2014. The EFUP (Environment Friendly Use Period) for this product is 40 years.

PRODUCT:	FGD-2									
	有害物质 Hazardous Substances									
零件名称 Part Name	铅 Lead (Pb)	汞 Mercury (Hg)	镉 Cadmium (Cd)	六价铬 Hexavalent Chromium (Cr^{6+})	多溴联苯 Polybrominated Biphenyls (PBB)	多溴二苯醚 Polybrominated Diphenyl Ethers (PBDE)	邻苯二甲酸二丁酯 Dibutyl Phthalate (DBP)	邻苯二甲酸丁苄酯 Benzyl butyl phthalate (BBP)	邻苯二甲酸二酯 Bis(2-ethylhexyl) phthalate (BEHP)	邻苯二甲酸二异丁酯 Diisobutyl phthalate (DIBP)
金属零件 Metal parts	O	O	O	O	O	O	O	O	O	O
聚合物 Polymers	O	O	O	O	O	O	O	O	O	O
电子产品 Electronics	X	O	O	O	O	O	O	O	O	O
电缆和互连配件 Cables & interconnect accessories	X	O	O	O	O	O	O	O	O	O
绝缘材料 Insulation material	O	O	O	O	O	O	O	O	O	O

本表格依据 SJ/T11364 **的**规定编制。

O: **表示**该有害物质在该部件所有均质材料中的含量均在 GB/T 26572 规定的限量要求以下。

X: **表示**该有害物质至少在该部件的某一均质材料中的含量超出 GB/T 26572 规定的限量要求。

This form was prepared according to the provisions of standard SJ/T11364.

O: Indicates that the hazardous substance content in all homogenous materials of this part is below the limit specified in standard GB/T 26252.

X: Indicates that the hazardous substance content in at least one of the homogenous materials of this part exceeds the limit specified in standard GB/T 26572.

CE Compliance

This product has been evaluated and complies with the relevant essential requirements set forth by the EU legislation as part of a system, not as a stand-alone device.

EC Directives

- Low Voltage Devices (LVD) 2014/35/EU
- Electromagnetic Compatibility (EMC) 2014/30/EU
- Hazardous Substances (RoHS2) 2011/65/EU

Harmonized Standards used for Evaluation

- IEC 62103:2003 (pertinent EMC sections)
- EN 62477-1:2012
- EN 61000-6-2:2005
- EN 61000-6-4:2007; with AMD 1:2011
- EN 50581:2012, Ed 12

Installation

The FGD-2 is typically preinstalled in an excitation control system. If replacement is necessary, carefully label and document each of the connections to the FGD-2 in order to properly reconnect the new module. FGD-2 connectors and indicators are illustrated in Figure 1. Locator letters in Figure 1 correspond to the lettered descriptions in Table 1. When a replacement FGD-2 is installed in a DECS-2100 or ECS2100 system, the system calibration values may need to be updated.

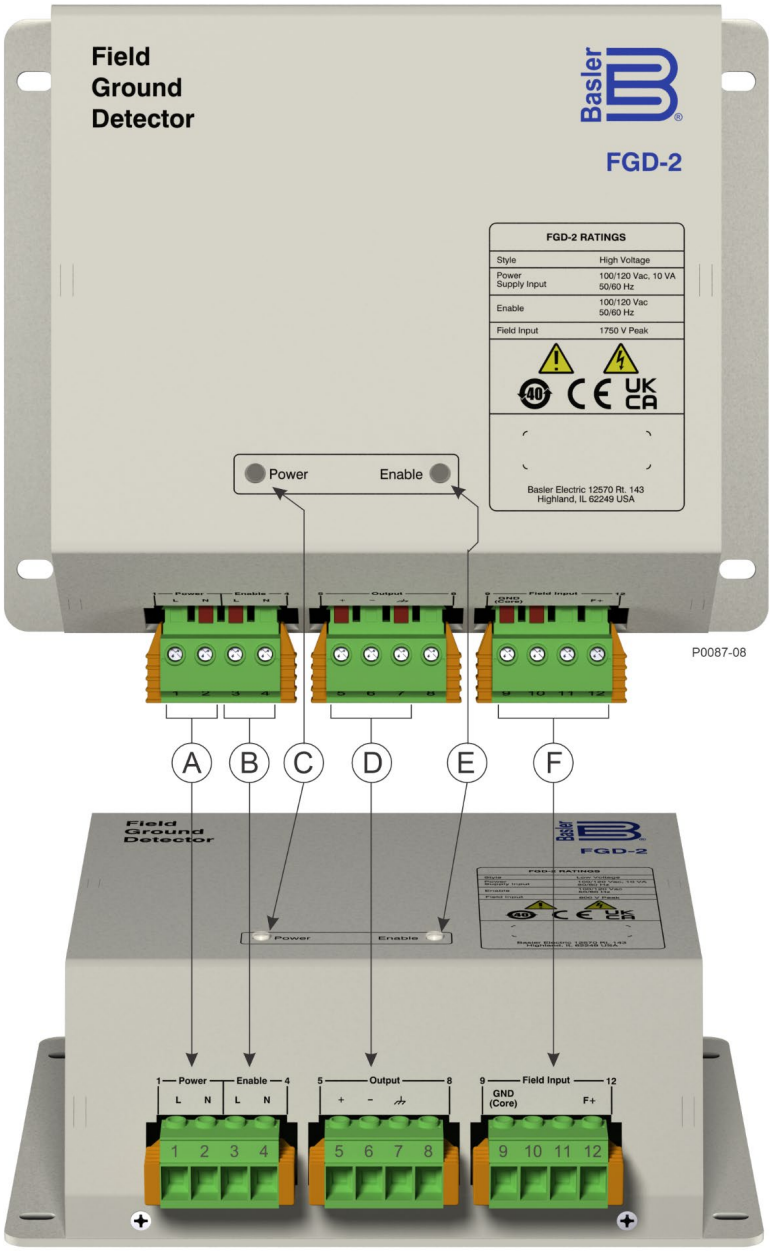

Figure 1. FGD-2 Connectors and Indicators

Table 1. FGD-2 Connector and Indicator Descriptions

Locator	Description
A	Power Supply. The Power Input terminals accept 120 Vac (90-132 Vac) 50/60 Hz.
B	64G Relay Enable. The Enable terminals accept 120 Vac (90-132 Vac) 50/60 Hz.
C	Power LED. This green Power LED lights to indicate the presence of FGD-2 operating power.
D	Output. Supplies a voltage signal that is proportional to the level of detected field leakage current.
E	Active Status LED. The green Active Status LED lights to indicate that the FGD-2 is enabled and supplying a voltage signal to the output.
F	Field Input. Supplies approximately –60 Vdc to the positive side of a machine field and measures the level of leakage current.

Retrofitting an FGD

Although the FGD-2 is smaller in size than the FGD, it may still be mounted in place of an FGD using only four of the six existing mounting holes. Either the upper four or the lower four mounting holes may be used.

FGD-2 Connections

Connectors with screw-down compression terminals are used for all FGD-2 connections. The connectors, and the headers that they plug into, have a dovetailed edge that ensures proper connector orientation. Similar-sized connectors and headers are uniquely keyed to ensure that a connector mates only with the correct header to prevent damage to the FGD-2. However, care must still be taken to ensure that the proper connector is inserted into the appropriate header. Connector screw terminals accept a maximum wire size of 8 AWG. The maximum screw torque is 7.1 in-lb or 0.8 N•m. Figure 2 illustrates typical FGD-2 connections.

The FGD-2 was designed to be connected between F+ and ground, but it is also compatible with applications where only F– is available. Figure 3 illustrates this alternate connection option.

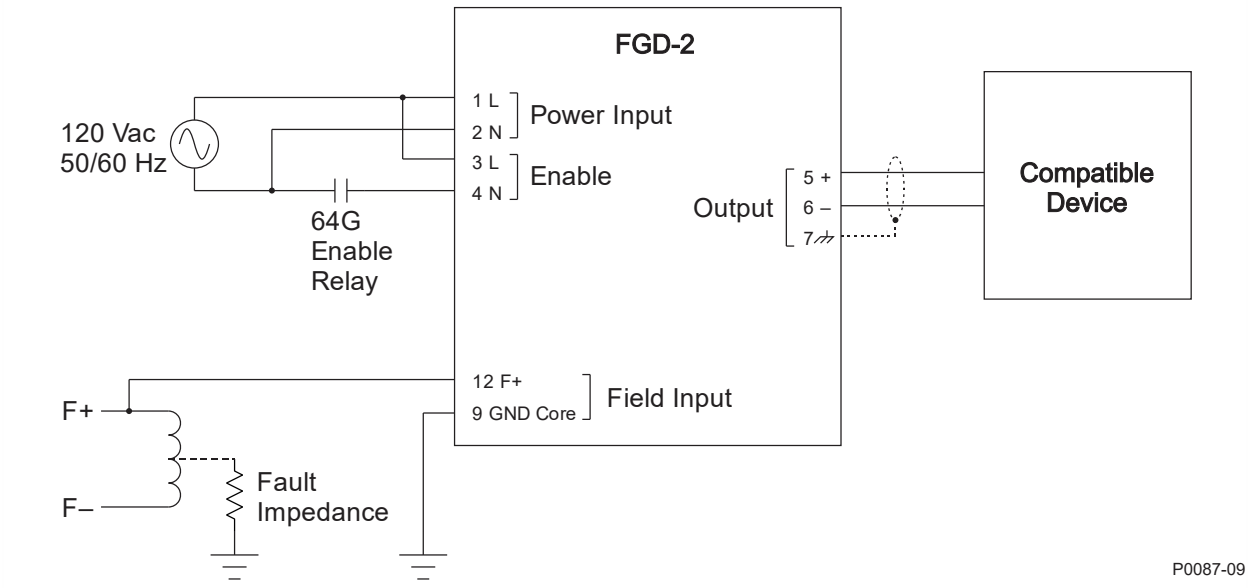

Figure 2. FGD-2 Connections

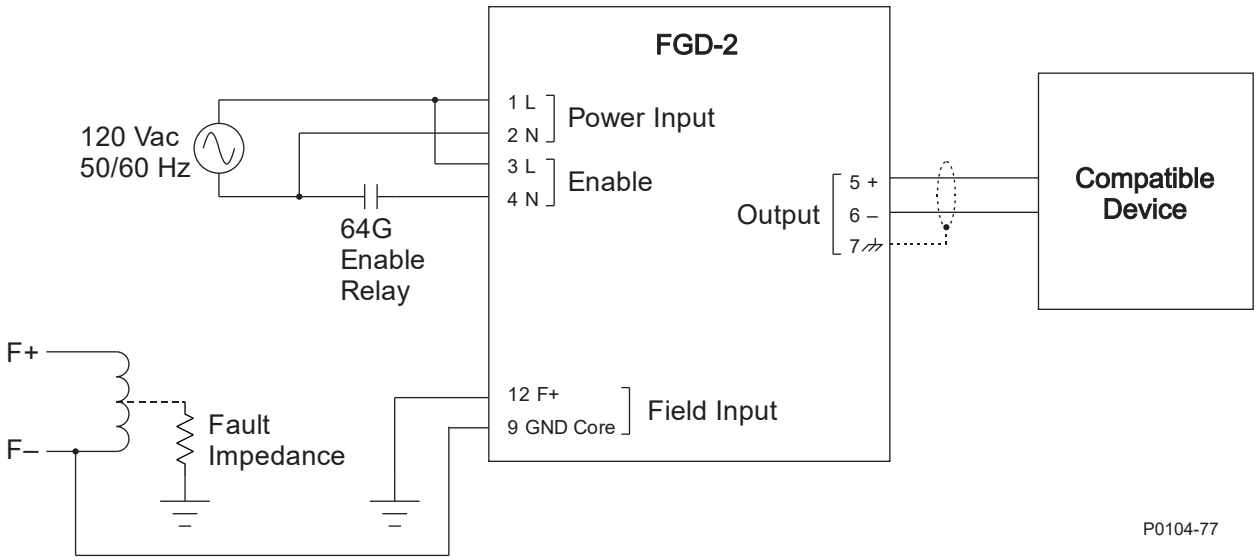

Figure 3. FGD-2 Alternate Connections

Operation

The FGD-2 continuously monitors the machine field circuit for ground faults. Ground faults are detected through the measurement of leakage current to ground which is determined by measuring the voltage drop across a shunt resistor within the ground detector source. The Basler device connected to the FGD-2 receives a voltage signal from the ground detection source that is proportional to the level of field leakage current. The excitation capabilities and analog input ranges of different Basler products will limit the maximum compatible field voltage for accurate field ground resistance measurements. Refer to Table 2 for more details.

Table 2. FGD-2 Maximum Field Input Ratings by Product

FGD-2 Version	AIOM-2	BE1-FLEX
Low Voltage (9501000100)	800 Vdc	625 Vdc
High Voltage (9501000101)	1,750 Vdc	1,475 Vdc

AIOM-2

In a DECS-2100 system, the AIOM-2/AIOM digitizes the signal and transmits it via fiber optic cables to the ECM-2. In an ECS2100 system, the digitized signal is received by the ECM/SIM. The value of leakage current appears as an input to the BESTCOMS™*Pro* FLDGND logic block. Within the FLDGND logic block, a value of resistance to ground is calculated from the voltage applied and the level of leakage current measured. Typically, this calculated resistance value is transmitted to a display panel via the PMOUT logic block. In the event of a low field ground resistance value, the FLDGND logic block issues a Low Field Ground Resistance alarm. During detection of low field ground resistance, an alarm issued by the DIGROUT logic block can be used to energize a relay within the system's Digital I/O Module (DIOM-2 or DIOM). This annunciation may be used to provide a dry relay contact for a remote alarm.

BE1-FLEX

The FGD-2 output can be connected to any analog input of the BE1-FLEX. Field ground protection settings can be configured in BESTCOMS*Plus*.

Ground Detection Source

The ground detection source supplies approximately –60 Vdc to the positive side of a machine field and measures the level of leakage current to ground. The positive side of the field bus is held negative with respect to ground.

Note
Application of the FGD-2 assumes that the field is isolated from ground everywhere except for the point where the ground detector source references the positive (+) bus to be approximately –60 Vdc to ground. If there are other sources or loads connected to the field circuit, they will cause the FGD-2 to operate improperly.

Current Measurement and Resistance Calculations

The level of leakage current to ground is determined by measuring the voltage drop across a shunt resistor within the ground detector source. The voltage drop across the resistor is amplified and sent to output terminals 5 (+) and 6 (–).

The amount of leakage current varies with the field voltage and the location of the fault. Therefore, the actual value of ground resistance falls within a defined range for any value of leakage current. The resistance range is calculated using two equations: one equation for minimum resistance (Equation 1) and one for maximum resistance (Equation 2).

$$Minimum\ Resistance = \frac{60\ \mathrm{V}}{\mathrm{I_G}} - 60\ \mathrm{k\Omega}$$

Equation 1. Minimum Resistance

$$Maximum\ Resistance = \frac{\mathrm{V_F} + 60\ \mathrm{V}}{\mathrm{I_G}} - 60\ \mathrm{k\Omega}$$

Equation 2. Maximum Resistance

In the equations above, 60 is used as a nominal value representing the ground detector source voltage and as a nominal value representing the current limiting resistance in the ground detector source.

For the minimum resistance calculation, it is assumed that a ground occurs at the positive (+) terminal of the machine field and the 60 Vdc is supplied solely from the ground detector source. For the maximum resistance calculation, it is assumed that the ground occurs at the negative (–) terminal of the machine field and the voltage is supplied from the 60 Vdc ground detector source in series with the dc voltage applied across the entire machine field. It is impossible for a ground to occur at a point in the excitation system where the level of machine field voltage to ground nullifies the ground detector source's 60 Vdc. This is because the ground detector source voltage value always adds to the value of any machine field voltage to ground.

Example of Ground Resistance Calculations

A machine operating with a field voltage of 325 Vdc (V_F) and a measured leakage current of 0.5 mAdc (I_G) would yield the resistance values shown in Equation 3 and Equation 4.

$$\frac{60\ V}{0.5\ mA} - 60\ k\Omega = 60\ k\Omega\ minimum$$

Equation 3. Minimum Resistance Value

$$\frac{325\ V + 60\ V}{0.5\ mA} - 60\ k\Omega = 710\ k\Omega\ maximum$$

Equation 4. Maximum Resistance Value

The calculated results indicate that the ground resistance could range between 60 kΩ and 710 kΩ.

Note
If a ground occurs on the PPT secondary or near the negative (–) terminal of the machine field when the field voltage is high enough to cause leakage current exceeding 1 mA, the calculated minimum resistance value will be negative.

Low- and High-Voltage Versions

When replacing an FGD-2, the voltage style must match the FGD-2 being replaced. For reference, the FGD-2 low voltage part number is 9501000100, and the FGD-2 high voltage part number is 9501000101.

Monitoring

FGD-2 monitoring consists of two LED indicators located on the front panel. The green Power LED illuminates to indicate the presence of FGD-2 operating power. The green Active Status LED illuminates to indicate that the FGD-2 is enabled and supplying a voltage signal.

Test Instructions

The following procedures are performed only when the FGD-2 is not functioning as described in this publication.

1. With the machine field disconnected from ground, measure the voltage across terminals 1 and 2. Also measure the voltage across terminals 3 and 4. If 120 Vac is not present, check for an open GDFU (or EXFU) fuse in DECS-2100 systems.
2. With the machine field disconnected from ground, verify that 60 Vdc is present between terminals 9 and 12.
3. For applications with a low-voltage ground detector source, perform step 3a. For applications with a high-voltage ground detector source, perform step 3b.
    a. Connect a 50 kΩ resistor across terminals 9 and 12. Measure the voltage across terminals 5 and 6. Approximately 0.55 Vdc should be present.
    b. Connect a 50 kΩ resistor across terminals 9 and 12. Measure the voltage across terminals 5 and 6. Approximately 0.25 Vdc should be present.
4. In DECS-2100 systems, close 64FU. Verify that the voltage from the positive (+) bus to ground on both sides of fuse 64FU is the same. The voltage should be approximately –60 Vdc with the meter common lead connected to ground.

MAINTENANCE

This device contains long-life aluminum electrolytic capacitors. For devices that are not in service (spares in storage), the life of these capacitors can be maximized by energizing the device for 30 minutes once per year.

SPARE PARTS

A reasonable stock of spare parts minimizes downtime in the event of malfunction. When ordering spare parts, care should be taken to specify the style numbers (or other identification) which are printed on the nameplate. Careful documentation of the original connections is essential any time the FGD-2 is removed. It is recommended that at least one FGD-2 is stocked.

SAFETY

As with all electrical equipment, appropriate safety measures must be taken when dealing with excitation equipment. High voltage is present within the excitation cubicles; their magnitudes depend upon the particular system. Opening the sources (e.g., disconnecting device 41) does not completely disconnect the high voltages. As long as the machine is still physically connected to the system, there is a possibility that a safety hazard exists.

Warning!

Bodily injury could result if contact is made with components in this apparatus which carry either line voltage or are subject to abnormally high voltages. References to the circuit diagrams, notably within other documentation, discloses hazardous areas.

Every precaution must be taken when working at the excitation control switchgear to ensure that all high voltages are isolated and avoided by test personnel. In addition to the machine terminal voltage (460 Vac or greater) at the excitation transformer, there may be other sources of power entering the cubicles, such as 125/250 Vdc and/or 120/240 Vac used to feed certain devices. A good rule to follow is to assume that all connections are live and dangerous until proven otherwise and to avoid all body contact with any of these voltages.

Glossary

AIOM-2, AIOM
Analog I/O Module. Provides additional analog inputs, RTD inputs, and analog outputs to an ECS2100 or DECS-2100.

BESTCOMS™*Pro*
A Windows®-based PC application which connects to an ECM-2, ECM, FCIM, BCM, or BCM-2 for user programming and monitoring of excitation system functions. This software presents table and block diagram representations of the controller logic configuration.

DIOM-2, DIOM
Digital I/O Module. Provides additional digital inputs and outputs to an ECS2100 or DECS-2100.

ECM
Exciter Control Module. This contains the excitation control, limiting, protection, and communication software. The ECM is used with the ECS2100.

ECM-2
Excitation Control Module. This contains the excitation control, firing control, limiting, protection, and communication software. The ECM-2 is used with the DECS-2100.

SIM
Sensor Input Module, used only in ECS2100 excitation systems. Provides isolated signals from PT, CT, AIOM, and DIOM to the ECM.