Littelfuse®

Expertise Applied | Answers Delivered

POWR-GARD® PROTECTION RELAY CATALOG

PROTECTION RELAYS

Ground Fault Protection • Motor Protection • Feeder Protection • Supplemental Monitoring

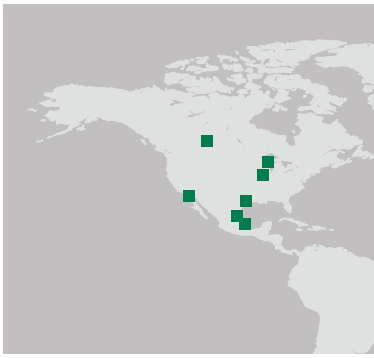
Littelfuse POWR-GARD®

Portfolio of Electrical Safety

Global Resources for A Global Market

From mining installations in Chile to semiconductor fabrication plants in Taiwan, customers trust Littelfuse POWR-GARD® electrical safety products and services to keep systems running and workers protected.

Our innovation, proven technical expertise, broad portfolio of products and services and global resources enable us to provide objective, comprehensive solutions for each unique application.



WE ARE THE EXPERTS IN ELECTRICAL

Fuses and Fuseholders

Product engineers and facility managers depend on Littelfuse POWR-GARD® circuit protection products to enhance the safety and productivity of electrical installations and OEM products.

Fuses and Fuseholders

Medium Voltage Fuses

Indicating Products

Up-LINK™ Remote Indication

OEM Custom Products

Electrical Safety Services

POWR-GARD's extensive package of safety services offered throughout North America helps customers reduce Arc-Flash incidents and comply with safety regulations.

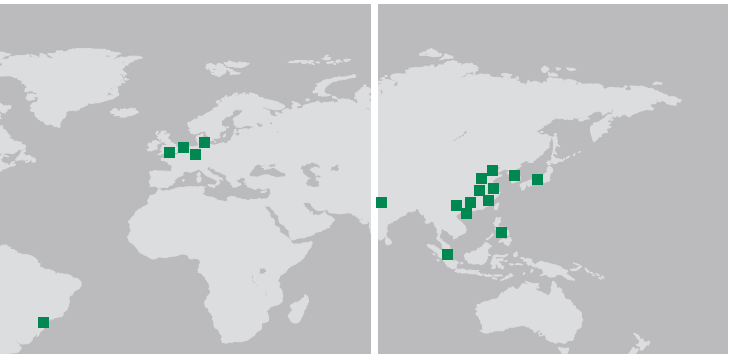
Electrical Safety Services

Safety Training

High Power Testing Lab

Products and Services

We Improve Electrical Safety and Increase Uptime



POWR-GARD® has a tradition of helping customers improve their electrical systems. Offering more than well designed products, our technical expertise brings years of experience and product design support to your application.

We can provide immediate access to specialized technical resources, online references or application support in the field. This catalog outlines the POWR-GARD® protection relay products and the technical capabilities we offer for your application.

SAFETY AND PRODUCTIVITY

Protection Relays

Our comprehensive line of electronic and microprocessor-based protection relays safeguard equipment and personnel in order to prevent expensive damage, downtime or injury due to electrical faults.

The features and flexibility within the products and the software allow you to select the appropriate protection for each part of your electrical system.

Ground Fault Relays

Resistance Grounding Systems

Motor Protection Relays

Feeder Protection Relays

Supplemental Monitors

Safeguard Critical Applications with POWR-GARD® Protection Relays

Petrochemical, Oil and Gas
Water and Waste Water
Pulp and Paper
Data Centers
Alternative Energy
Power Generators
Semiconductor Equipment
Transportation
Hospitals
Marine

Solve Expensive and Unsafe Problems in Your Facility

Critical Circuits Need Protection
A protection relay is an intelligent controller that can detect abnormal conditions in electrical equipment or power systems and initiate appropriate action.

Protection relays are designed to safeguard critical circuits and solve the most pressing problems faced by facility and safety managers — minimizing electrical safety hazards, saving cost, and reducing unnecessary downtime.

SAFETY

- Shock Hazard
- Injury to Personnel
- Arc-Flash Hazards
- Open CT Hazards
- Failed Resistors

COST

- Fault Damage
- Equipment Replacement
- Calibration Costs
- Compliance Citations
- Motor Rewinds

DOWNTIME

- Replacement Time
- Nuisance Tripping
- Intermittent Faults
- Unreliable Protection
- Calibration Time

Typical Applications for Protection Relays

Why are Protection Relays Necessary?
Protection relays safeguard critical components of an electrical circuit from damage. When the relay detects a damaging or unsafe condition, the relay will send an alarm or trip signal in order to notify or prevent the condition from continuing. Protection relays increase the uptime of critical systems and enhance the safety of people and equipment during fault situations.

Application	Common Problems	Product Category
GENERATORS	Insulation breakdown due to vibration and environment	GFP RG SM
TRANSFORMERS	Ground faults due to persistent overloading and age	GFP RG
SWITCHGEAR & MCCs	Highest average downtime per IEEE 493-1997	GFP RG MP SM
SWITCHBOARDS & PANELBOARDS	Low level leakage current undetected by typical OCPDs	GFP SM
DRIVES	Switching frequencies cause nuisance tripping	GFP MP SM
MOTORS & PUMPS	Winding faults due to overloading, water, dust and vibration	GFP MP SM
FEEDER CIRCUITS	Temperature and mechanical stress lead to severe damage	FP
PORTABLE EQUIPMENT	Constant movement leads to broken ground conductors	GFP SM
GROUNDING RESISTORS	Failed resistors due to corrosion or loose connections	RG SM

POWR-GARD® Product Categories

GFP
GROUND FAULT PROTECTION

Ground Fault Protection Relays
improve the safety of workers and reduce incidents of Arc-Flash without affecting the uptime of critical operations. Critical in manufacturing environments, sensitive ground-fault relays with advanced filtering will detect the breakdown in insulation resistance caused by moisture, vibration, chemicals and dust without the nuisance trips.

RG
RESISTANCE GROUNDING

Resistance Grounding
overcomes many of the issues experienced with solidly grounded and ungrounded electrical systems. High Resistance Grounding eliminates Arc-Flash Hazards associated with ground-faults and transient overvoltages, and allows for continuous operation during a ground fault.

MP
MOTOR PROTECTION

Motor Protection Relays
prevent expensive damage to motors caused by overloads, jams, phase loss or imbalance, heat from non-electric sources, heavy start-ups or excessive operational cycles. Dynamic thermal curves, integrated protection, metering, and data logging functions extend motor life and maximize process efficiency.

FP
FEEDER PROTECTION

Feeder Protection Relays
protect feeder circuits from overcurrents, earth faults, phase loss or other detrimental conditions in critical applications and processes. Feeder Protection Relays provide essential data for predictive and preventative maintenance — extending the life of equipment, enhancing safety and maximizing efficiency.

SM
SUPPLEMENTAL MONITORING

Supplemental Monitors
work together with existing protection to enhance your electrical system safety and performance by monitoring its components. These monitors are designed for application specific functionality such as insulation monitoring, ground continuity monitoring, and resistor monitoring.

Product Selection Guide

Use this Product Selection Guide to choose the appropriate protection relay or monitor for your application

STEP 1
Select product category

GFP RG MP FP SM

STEP 2
Select the needed features in each category

STEP 3
This is the recommended product for your application

This is the product catalog number and datasheet page number

GFP

GROUND FAULT PROTECTION

UNGROUNDED DC SYSTEM

Detect Ground Faults

PGR-2601
pg. 8

UNGROUNDED AC SYSTEM

Locate Ground Fault & Reduce Transient Overvoltage

YES

Convert System to Resistance Grounding
pgs. 24 & 25

NO

Detect Insulation Breakdown

YES

PGR-3200
pg. 10

NO

PGR-3100
pg. 9

SOLIDLY GROUNDED AC SYSTEM

Increase Up-Time & Reduce Potential for Arc Flash

YES

Convert System to Resistance Grounding
pgs. 24 & 25

NO

Ground Fault Protection for Generators

YES

PGR-4300
pg. 11

NO

Ground Fault Alarm Level

10mA- 3A

PGR-4700
pg. 12

> 3A

PGR-5701
pg. 13

Ground-Fault Protection Relays

RG

RESISTANCE GROUNDING

RESISTANCE-GROUNDED AC SYSTEM

Pulsing, Digital Filtering, Communications and Software

YES

Identify Faulted Feeder

YES

PGR-5330 & PGR-5701
use in combination
pg. 14 *pg. 13*

NO

PGR-5330
pg. 14

NO

PGM-8325
pg. 22

Ground-Fault Protection Relays

Implement Low Resistance Grounding

PGN-1000
pg. 24

Implement High Resistance Grounding

PGN-3000
pg. 25

Resistance Grounding Systems

Product Selection Guide

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MP
MOTOR PROTECTION

ADVANCED

Multi-Function Overload Protection

Typically > 100 hp

Voltage Protection and Starter Control

YES

PGR-6300
pg. 17

NO

PGR-6200
pg. 16

BASIC

Ground Fault Protection and Insulation Monitoring

Typically < 100 hp

PGR-6100
pg. 15

Motor Protection Relays

FP
FEEDER PROTECTION

ADVANCED

Multi-Function IEEE/IEC Overload Protection

PGR-7200
pg. 20

BASIC

Ground Fault Protection and Insulation Monitoring

PGR-6100
pg. 15

Feeder Protection Relays

SM
SUPPLEMENTAL MONITORING

MONITORS

Monitor Ground Conductor

PGM-8134
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Monitor Neutral to Ground

PGM-8325
pg. 22

Monitor Insulation

PGM-8600
pg. 23

Monitors

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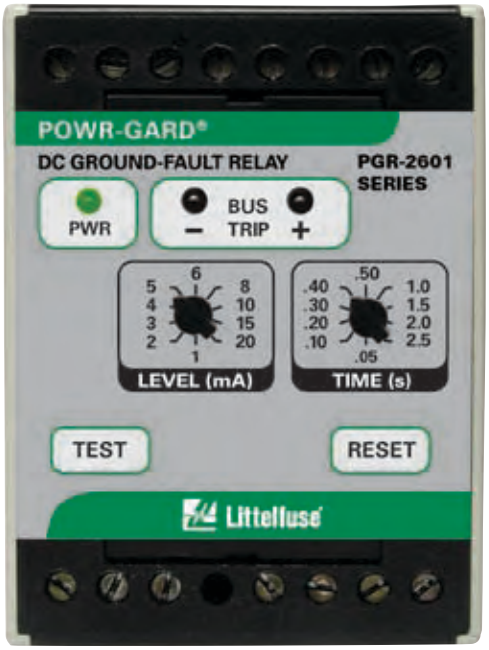
PROTECTION RELAYS, MONITORS AND SYSTEMS

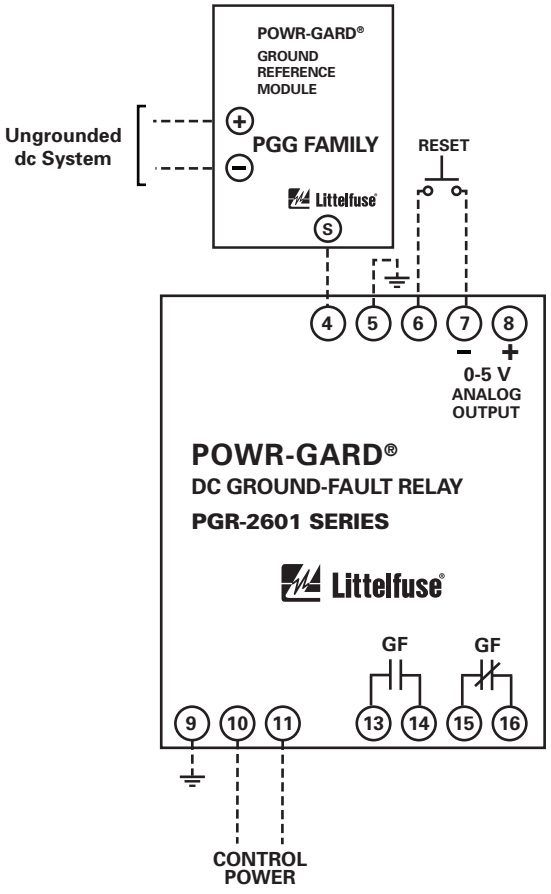
Wiring Diagrams Legend

- All relays are shown de-energized
- Dotted lines show field wiring
- Ground-Fault CT input is not polarity sensitive (Applies to PGR-5701, PGR-5330, PGM-8325, PGR-6200, PGR-6300, PGR-7200, PGM-8134)

PGR-2601 SERIES

DC Ground-Fault Relay





See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-2601 is a microprocessor-based ground-fault relay for ungrounded dc systems. It provides sensitive ground-fault protection without the problems associated with nuisance tripping.

Ground-fault current is sensed using a PGG Series Ground-Reference Module—a resistor network that limits ground-fault current to 25 mA.

Applications

The PGR-2601 is used on ungrounded dc systems ranging from industrial 24-Vdc control circuits to 800-Vdc automated transportation systems.

Features/Benefits

- Sensitive 1-to 20-mA trip setting provides a wide range of low-level protection and 50-ms to 2.5-s trip delay allows quick protection
- Form A and Form B ground-fault trip contacts
- Non-volatile trip memory retains trip state
- Analog output for external metering
- Selectable fail-safe or non-fail-safe operating modes
- No calibration required

Ordering Information

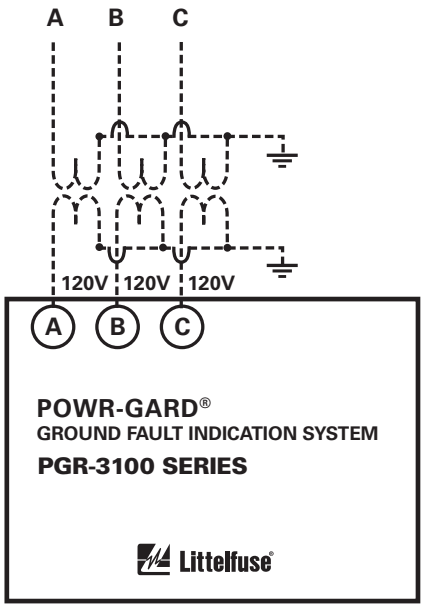
PGR-2601-OD	9-36 Vdc Control Power
PGR-2601-OT	32-70 Vdc Control Power
PGR-2601-OU	75-275 Vac/dc 50/60 Hz Control Power

Specifications

IEEE Device Numbers	76G
Input Voltage	See Ordering Information
Dimensions	**H** 75 mm (3.0"); **W** 55 mm (2.2"); **D** 115 mm (4.5")
Trip Level Settings	1 – 20 mA
Trip Time Settings	0.05 s – 2.5 s
Alarm Relay Contacts	Isolated N.O. and N.C.
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Test Button	Standard
Reset Button	Standard
Communications	Analog Output
Conformally Coated	Optional
Warranty	5 Year
Mounting	DIN, Surface, Panel (optional)

PGR-3100 SERIES

Ground-Fault Indication System



Description

The PGR-3100 indicates the presence of voltage on each phase of a three-phase system. The LEDs in the panel light up when voltage is present. When a ground-fault occurs, the voltage on the faulted phase reduces to ground potential, causing the LEDs for the faulted phase to dim and the LEDs for the unfaulted phases to become brighter.

Applications

Ungrounded ac systems are required by the National Electrical Code (NEC®) Article 250.21(B) to have ground detectors installed on the system. External potential transformers (PTs) can be used to step down system voltage, allowing the PGR-3100 to be applied to any system voltage. Voltage inputs do not require PTs for system voltages up to 240 Vac.

Features/Benefits

- Meets National Electrical Code (NEC®) Article 250.21(B) requirements for ungrounded systems
- Indicates presence of a ground fault and the faulted phase
- Lamp Test push button to verify proper operation
- Redundant long-life LEDs (two per phase) for reliability

Ordering Information

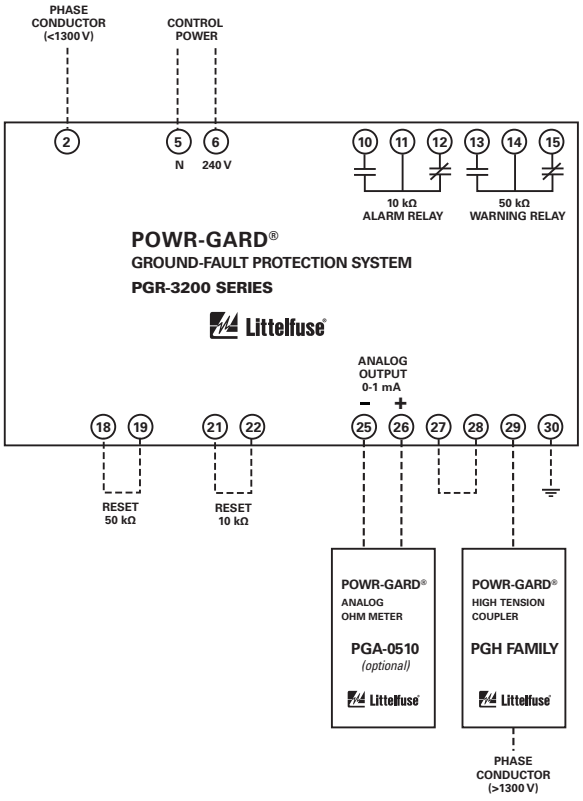
PGR-3100	Panel Mount

Specifications

IEEE Device Numbers	27, 64
Input Voltage	Up to 240 Vac 50/60 Hz
Indicator Off Voltage	< 30 Vac line to ground
Dimensions	**H** 108 mm (4.3"); **W** 88.9 mm (3.5"); **D** 54 mm (2.1")
Test Button	Standard
Conformally Coated	Optional
Warranty	5 Year
Mounting	Panel

PGR-3200 SERIES

Ground-Fault Protection System



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-3200 continuously monitors the insulation integrity of ungrounded electrical systems for ground faults. The relay provides two warnings for predictive purposes and one alarm.

When the power system is de-energized, the relay monitors the insulation for damage, providing predictive maintenance and troubleshooting for developing ground faults.

When the power system is energized, the relay monitors the system for ground faults and provides warnings as well as an alarm.

Applications

The units operate on ungrounded systems up to 6 kV, 1-phase or 3-phase, 50 or 60 Hz. The relay can be directly connected to power systems up to 1,300 V. Higher voltage requires a pre-calibrated high tension coupler (PGH) connected between the phase conductor and the relay.

Features/Benefits

- Meets National Electrical Code (NEC®) Article 250.21(B) requirements for ungrounded systems
- Provides 2 warnings at different levels (30 kΩ and 50 kΩ) and 1 alarm (10 kΩ)
- Analog output and optional meter (PGA-0510)
- DIN-rail or surface mount for ease of installation

Ordering Information

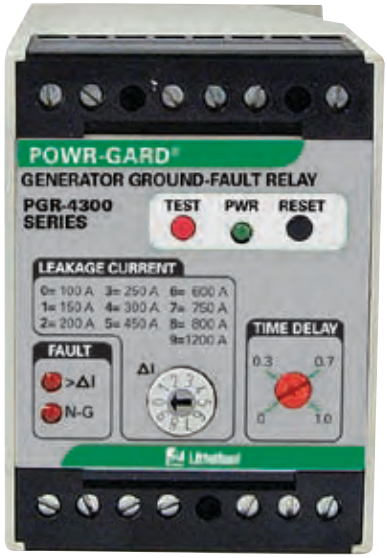
PGR-3200	240 Vac Control Power

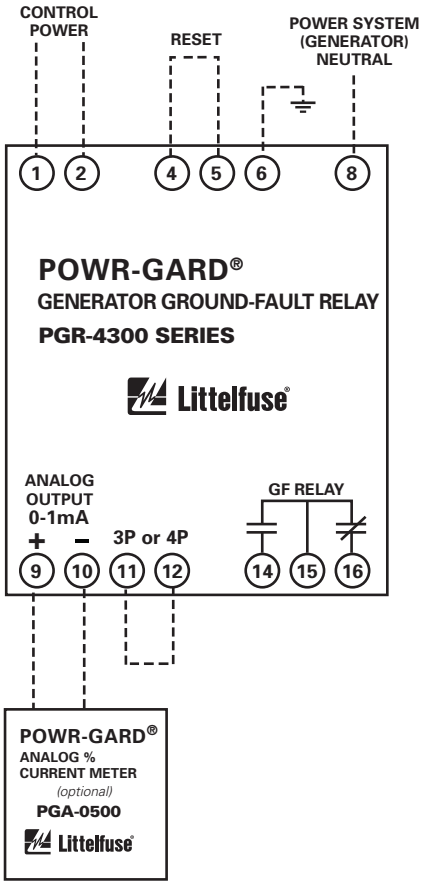
Specifications

IEEE Device Numbers	27, 64
Input Voltage	240 Vac, 50–60 Hz
Dimensions	**H** 99.7 mm (3.9"); **W** 75 mm (3"); **D** 110 mm (4.3")
Resistance Ratings	Insulation warning (30 kΩ and 50 kΩ) Insulation alarm (10 kΩ)
Contact Operating Mode	Non-fail-safe
Test Button	Standard
Reset Button	Standard
Relay Contacts	N.O and N.C. (warning and alarm)
Communications	Analog Output
Conformally Coated	Optional
Warranty	5 Year
Mounting	DIN, Surface

PGR-4300 SERIES (GFA300)

Generator Ground-Fault Relay





See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-4300 Generator Ground-Fault Relay provides a simple method for alarming a ground-fault condition on generators without the need for current transformers (CTs). This greatly simplifies the installation, and eliminates risks associated with 3-pole and 4-pole transfer switches. This relay also monitors the neutral-to-ground path for continuity.

Application

The PGR-4300 overcomes the complex CT configuration required for 3- or 4-pole transfer switch operations. Detecting ground-faults when a generator operates in conjunction with a 3-pole automatic transfer switch is very difficult. The PGR-4300 is ideal for any gen-set or application where there is not sufficient space to install CTs.

Features/Benefits

- Use with 3-pole or 4-pole transfer switches
- No CTs required
- Monitors neutral-to-ground integrity
- Simple 4-point connection
- Adjustable alarm level
- Adjustable time delay
- N.O. and N.C. alarm contacts
- Metering output

Ordering Information

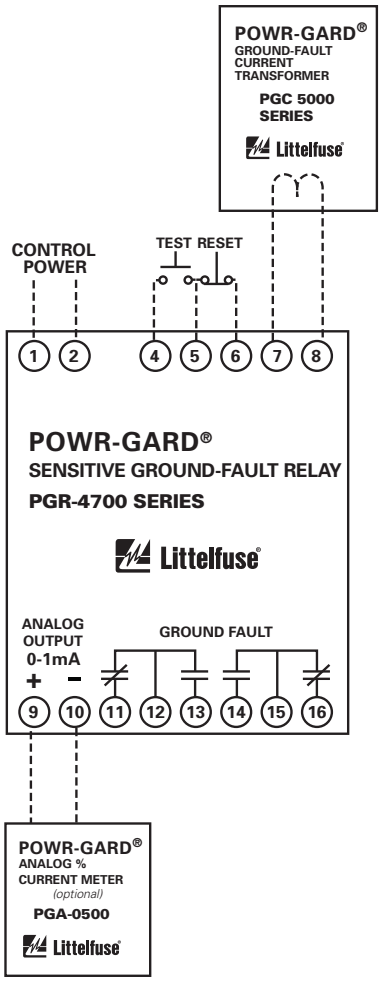
PGR-4300-12	12 Vdc Control Power
PGR-4300-24	24 Vdc Control Power
PGR-4300-120	120 Vac Control Power

Specifications

IEEE Device Numbers	50G, 50N, 51G, 51N
Input Voltage	See Ordering Information
Dimensions	**H** 75 mm (3.0"); **W** 55 mm (2.2"); **D** 115 mm (4.5")
Trip Level Settings	100–1200 A
Trip Time Delay Settings	0–1.0 s
Contact Operating Mode	Non-fail-safe
Test Button	Standard
Reset Button	Standard
Relay Contacts	N.O. and N.C.
Approvals	UL Listed
Communications	Analog Output
Conformally Coated	Optional
Warranty	5 Year
Mounting	DIN, Surface

PGR-4700 SERIES (RCD300M2)

Sensitive Ground-Fault Relay



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-4700 Sensitive Ground-Fault Relay provides sensitive ground-fault protection without nuisance tripping. It detects very low-level leakage current on large circuits to avoid or significantly reduce equipment damage. The leakages can be identified as they develop and ground faults can be detected before they become critical.

Applications

Ground-fault relays can be used for the protection of critical circuits in panel boards and switch boards, OEM power distribution panels and custom controls. They are typically used in critical load applications with costly downtime and hazards, such as high humidity, water, dust, chemicals, and vibration.

Features/Benefits

- Adjustable trip level settings from 10 mA to 3.0 A
- Advanced harmonic filtering
- Compatible with VFD applications
- Adjustable time delay
- Metering output with PLC interface for continuous monitoring of system
- CT loop monitoring

Ordering Information

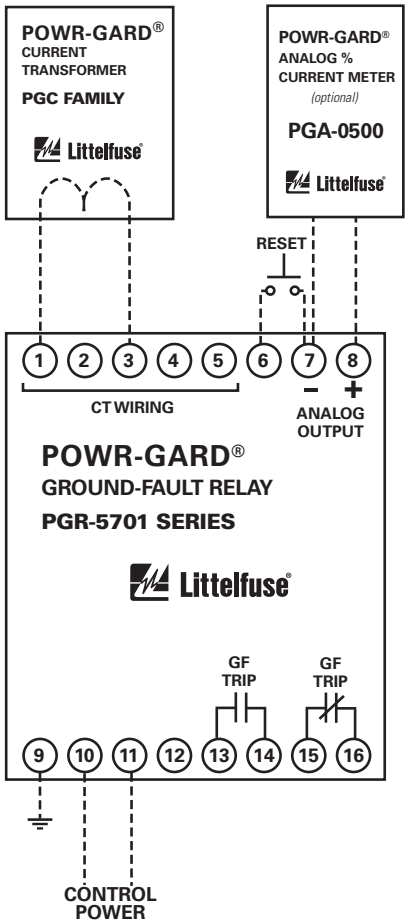
PGR-4700-24	24 Vdc Control Power
PGR-4700-120	120 Vac Control Power
PGR-4700-240	240 Vac Control Power

Specifications

IEEE Device Numbers	50G, 50N, 51G, 51N
Input Voltage	See Ordering Information
Dimensions	**H** 75 mm (3.0"); **W** 55 mm (2.2"); **D** 115 mm (4.5")
Trip Level Settings	10 mA – 3.0 A
Trip Time Delay Settings	0–1.5 s
Contact Operating Mode	Selectable fail-safe or non-fail-safe (Internal switch)
Harmonic Filtering	Standard
Test Button	Standard
Reset Button	Standard
CT Loop Monitoring	Standard
Relay Contacts	2 N.O. and N.C.
Approvals	UL listed
Communications	Analog Output
Conformally Coated	Optional
Warranty	5 Year
Mounting	DIN, Surface

PGR-5701 SERIES

Ground-Fault Relay



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-5701 is a microprocessor-based ground-fault relay for resistance-grounded and solidly grounded systems. It is uniquely suited for use on systems with significant harmonic content.

Applications

The PGR-5701 can provide main plant protection, feeder-level protection, or individual-load protection. Proper current transformer selection provides the desired pickup-setting range. The output contacts can be connected for use in protective tripping circuits or in alarming indication circuits. The analog output can be used with a PLC or a meter.

Features/Benefits

- Choice of input CT gives wide setting range (3 A and higher)
- Microprocessor-based unit with digital harmonic filter
- Compatible with adjustable-speed drives
- Analog output indicates ground-fault current, full scale is defined by CT rating
- Non-volatile trip memory retains trip state when power supply is cycled
- Selectable fail-safe or non-fail-safe operating mode

Ordering Information

PGR-5701-OD	9-36 Vdc Control Power
PGR-5701-OT	32-70 Vdc Control Power
PGR-5701-OU	75-275 Vac/dc Control Power

Specifications

IEEE Device Numbers	50G, 50N, 51G, 51N
Input Voltage	See Ordering Information
Dimensions	**H** 75 mm (3.0"); **W** 55 mm (2.2"); **D** 115 mm (4.5")
Trip Level Settings	1–99% CT-Primary Rating
Trip Time Settings	0.05–2.5 s
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard
Test Button	Standard
Reset Button	Standard
CT Loop Monitoring	Standard
Relay Contacts	Isolated N.O. and N.C.
Approvals	CSA certified to US and Canadian standards
Communications	Analog Output
Conformally coated	Optional
Warranty	5 Year
Mounting	DIN, Surface, Panel

PGR-5330 SERIES

Resistance Grounded Relay

Description

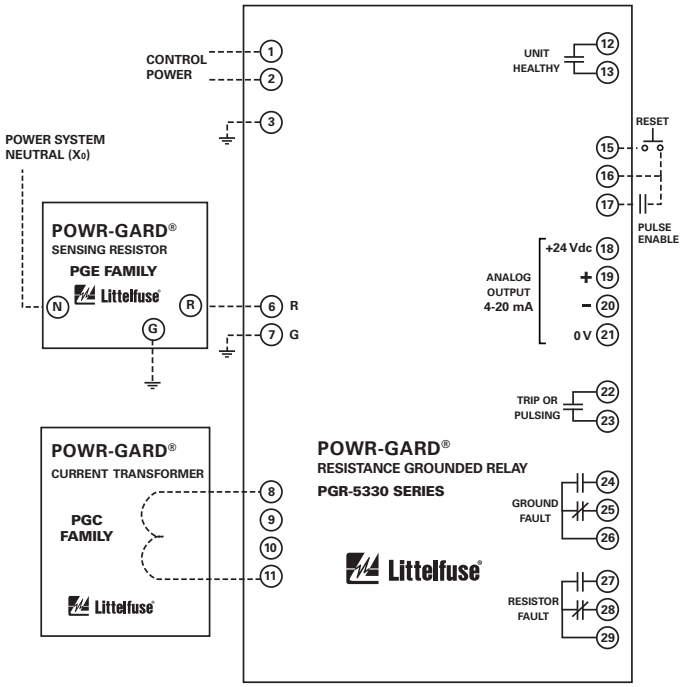
The PGR-5330 is an advanced ground-fault and resistor-monitoring relay. The PGR-5330 measures neutral current, neutral-to-ground voltage and neutral resistance. It provides continuous monitoring of the neutral-to-ground path to ensure the neutral-grounding resistor (NGR) is intact. This is of utmost importance on resistance-grounded systems because open NGRs render current-sensing ground-fault protection inoperative.

Applications

The PGR-5330 can be applied to high- and low-resistance-grounded transformers and generators in processing, manufacturing, chemical, forestry, petroleum, and water-treatment facilities.

Features/Benefits

- Detects ground faults
- Pulsing circuit and output contact for locating ground faults
- Continuously monitors neutral-ground-path continuity
- PGE sensing resistor eliminates hazardous voltage at relay
- Software for remote operation and data logging
- Standard RS-232 interface, optional network communications
- Wide set point ranges—compatible with any neutral connected NGR up to 35 kV system voltage
- DFT (harmonic) filter prevents nuisance tripping



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Ordering Information

PGR-5330-00-00	RS-232 Communications	80–265 Vac/dc
PGR-5330-01-00	RS-232 & DeviceNet™	80–265 Vac/dc
PGR-5330-02-00	RS-232 & Profibus®	80–265 Vac/dc
PGR-5330-03-00	RS-232 & Ethernet	80–265 Vac/dc

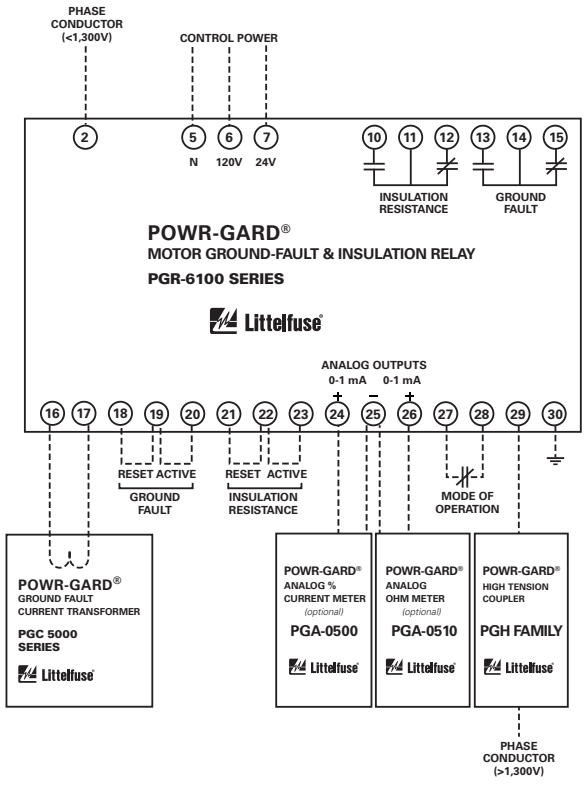
NOTE: For 36-72 Vdc Control Power use part numbers PGR-5330-20-00, PGR-5330-21-00, PGR-5330-22-00 or PGR-5330-23-00 respectively.

Specifications

IEEE Device Numbers	50G, 50N, 51G, 51N, 59N, 86
Input Voltage	See Ordering Information
Dimensions	**H** 150 mm (5.9"); **W** 109 mm (4.3"); **D** 100 mm (4.0")
GF Trip-Level Settings	2–100% of CT-Primary Rating
GF Trip-Time Settings	0.1–10 s
RF Trip-Level Settings	20–2000 Vac (≤5 kV systems) 100–10000 Vac (>5 kV systems)
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard
Reset Button	Standard
Relay Contacts	N.O. and N.C.
Pulsing Circuit	1.0–3.0 s in 0.2 s increments
Approvals	CSA certified to US and Canadian standards
Communications	RS-232; DeviceNet™, Profibus®, Ethernet
Analog Output	4–20 mA
Conformally Coated	Standard
Warranty	5 Year
Mounting	Panel, Surface

PGR-6100 SERIES (GFR4000)

Motor Ground-Fault & Insulation Relay



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-6100 Ground-Fault & Insulation Relay is designed to provide basic protection for a motor, including ground-fault protection and insulation monitoring. The fact that the PGR-6100 has predictive protective capabilities makes it unique. The ground-fault current and insulation resistance can be monitored using two separate meters. Two separate alarm contacts are also provided.

Applications

The PGR-6100 operates on grounded, resistance grounded and ungrounded systems. The unit can be directly connected to voltages up to 1,300 V, 1-phase or 3-phase, 50–60 Hz. For voltages from 1,300 V to 6,000 V, the PGR-6100 requires a pre-calibrated high tension coupler (PGH) connected between the phase connector and the relay.

Features/Benefits

- Adjustable sensitivity from 10 mA to 3.0 A (system energized)
- Insulation resistance from 250 kΩ to 2 MΩ (system de-energized)
- Adjustable time delay adapts to unique applications
- Selectable fail-safe or non-fail-safe operation
- Online monitoring to detect ground-fault current
- Offline monitoring of insulation resistance to alarm at unacceptable levels (mode of operation)
- CT loop monitoring
- Test button to verify proper operation
- Two alarm contacts (insulation and ground faults)
- Two analog outputs indicate insulation resistance and ground-fault current

Ordering Information

PGR-6100-120	24 Vdc / 120 Vac Control Power	50–60 Hz, 5 VA
PGR-6100-240	240 Vac Control Power	50–60 Hz, 5 VA

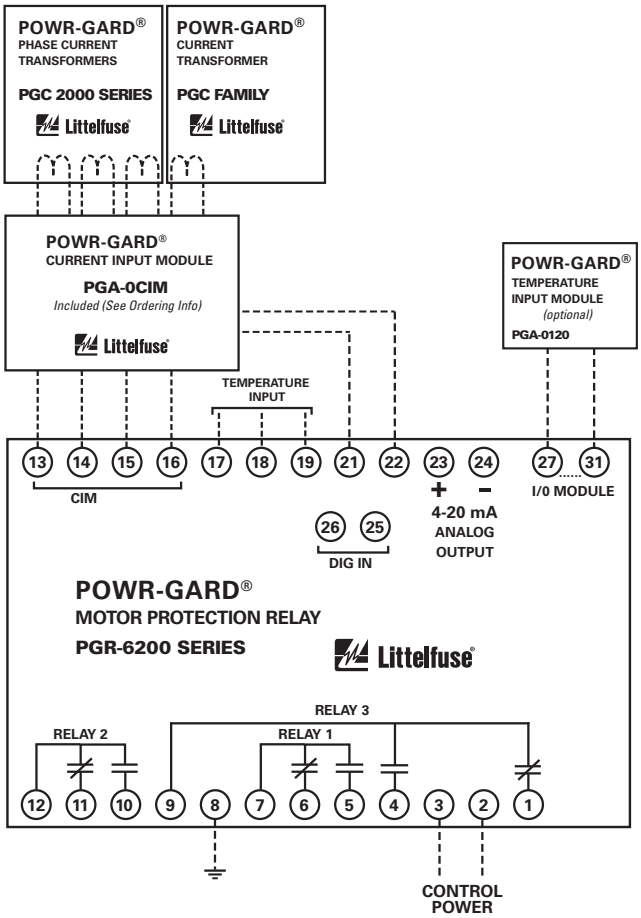
Specifications

IEEE Device Numbers	50, 50G, 50N, 51, 51G, 51N, 74
Input Voltage	See Ordering Information
Dimensions	**H** 99.7 mm (3.9"); **W** 75 mm (3"); **D** 110 mm (4.3")
GF Trip-Level Settings	10 mA–3.0 A
GF Trip-Time Delay Settings	0–1 s
RF Trip-Level Settings	250 kΩ /500 kΩ/1 MΩ /2 MΩ
Response delay	< 250 ms
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard
Test Button	Standard
Reset Button	Standard
CT Loop Monitoring	Standard
Relay Contacts	2 N.O and N.C.
Communications	2 Analog Outputs
Warranty	Limited lifetime
Mounting	DIN, Surface

PGR-6200 SERIES

Motor Protection Relay

NOTE: The PGR-6200 consists of the Motor Protection Relay (pictured above) and the PGA-0CIM Current Input Module (not pictured).



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-6200 Motor Protection Relay offers enhanced motor protection and metering to provide diagnostic and troubleshooting capabilities for critical process motors.

Applications

The PGR-6200 is ideal for retrofitting and upgrading motor protection using existing CTs. The PGR-6200 is used to provide current- and temperature-based protection, metering, and data logging for three-phase low-voltage medium-horsepower asynchronous motors. See the PGK Family of Panel Mount Adapter Kits to replace common obsolete relays.

Features/Benefits

- Eleven protective functions to extend the life of 3-phase motors and reduce downtime
- Reduced overcurrent feature can reduce Arc-Flash Hazards during maintenance
- Dynamic thermal model provides protection through starting, running, overload, and cooling cycles
- Standard TIA-232 interface with Modbus® RTU
- Optional TIA-485 with Modbus® RTU and Allen-Bradley® DF1, DeviceNet™, or Modbus® TCP communications
- Three programmable output relays, programmable analog output, programmable digital input
- Optional additional RTD temperature protection with PGA-0120 module
- Optional phase-differential protection with PGA-0140 module

Ordering Information

PGR-6200-00-00	RS-232 Communications
PGR-6200-01-00	RS-232 & RS-485 Communications
PGR-6200-02-00	RS-232 & DeviceNet™ Communications
PGR-6200-04-00	RS-232 & Ethernet Communications

NOTE: The PGR-6200 consists of the Motor Protection Relay and the PGA-0CIM Current Input Module (not pictured). To order the relay only, add (-MPU) to the part number listed above.

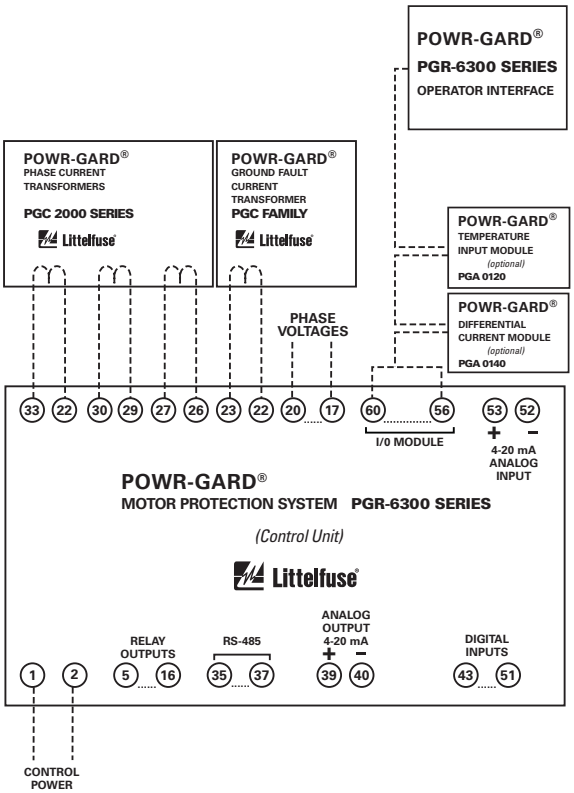
Specifications

IEEE Device Numbers	37,38,46,49,50,50G,50N,51,51G,51N,66,74,86,87
Input Voltage	65–265 Vac, 30 VA, 80–275 Vdc, 25 W
Power-Up Time	800 ms at 120 Vac
Ride-Through Time	100 ms minimum
24-Vdc Source	400 mA maximum
AC Measurements	True RMS and DFT, Peak, 32 samples/cycle and positive and negative sequence of fundamental
Frequency	50, 60Hz
Contacts	N.O. and N.C. (Form-C)
Approvals	CSA certified to US and Canadian standards
Communications	RS-232 (Standard); RS-485, DeviceNet™, Ethernet (Optional)
Analog Output	4-20 mA, programmable
Conformally Coated	Standard
Warranty	Limited lifetime
Mounting	Panel, Surface (optional)

PGR-6300 SERIES

Motor Protection System

NOTE: The PGR-6300 consists of the Operator Interface (pictured above) and the Control Unit (not pictured).



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Ordering Information

PGR-6300-01-00	RS-485 Communication
PGR-6300-02-00	RS-485 & DeviceNet™ Communication
PGR-6300-03-00	RS-485 & Profibus® Communication
PGR-6300-04-00	RS-485 & Ethernet Communication

NOTE: The PGR-6300 consists of the Operator Interface and the Control Unit (not pictured). To order the Control Unit only add (-CTU) to the part number listed above. To order the Operator Interface on its own, use part # PGR-6300-OPI-01-00.

Description

The PGR-6300 Motor Protection System monitors voltage, current, and temperature to provide a comprehensive package of 22 motor protection functions. The Motor Protection System is a modular system with integrated protection, motor control, metering, and data-logging functions. Motor starter control functionality is programmable for all common starter types.

Applications

The relay is used to provide current-, voltage-, and temperature-based protection, metering, and data logging for 3-phase low- or medium-voltage medium- to high-horsepower asynchronous motors. These motors are widely used in every industry including processing, manufacturing, petroleum, chemical, mining, forestry, water and wastewater treatment facilities.

Features/Benefits

- 22 protective functions to extend the life of 3-phase motors and reduce downtime
- Reduced overcurrent setting decreases Arc-Flash Hazard during maintenance
- Dynamic thermal model provides protection through starting, running, overload, and cooling cycles
- Meters current, voltage, power, temperature, and more
- Starter control—programmable for all common starter types
- 8 digital inputs, 5 relay outputs, 1 analog input and output
- Class 1 Zone 2 hazardous-location certified operator interface and temperature input module
- RS-485 Interface with Modbus® RTU and Allen-Bradley® DF1; Modbus® TCP and Ethernet/IP, DeviceNet™, or Profibus®
- Optional RTD temperature protection with PGA-0120 modules
- Optional phase-differential protection with PGA-0140 module

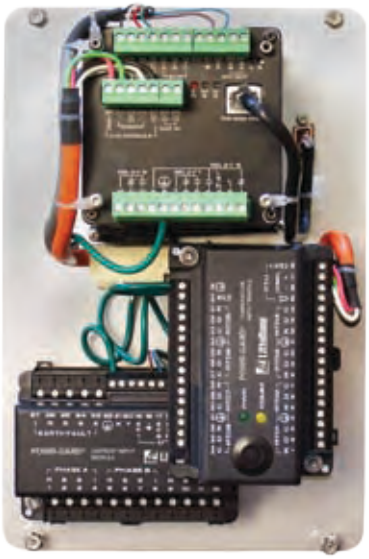
Specifications

IEEE Device Numbers	1,2,3,5,9,14,18,19,27,34,37,38,46,47,48,49,50, 50G,50N,51,51G,51N,55,59,66,74,81,86,87,94
Input Voltage	65 – 265 Vac, 25 VA
Power-Up Time	800 ms at 120 Vac
Ride-Through Time	100 ms minimum
24-Vdc Source	100 mA maximum
AC Measurements	True RMS and DFT, Peak, 16 Samples per cycle, and positive and negative sequence of fundamental
Frequency	50, 60 Hz, or ASD
Inputs	Phase-current, Earth-leakage current, Phase-voltage, PTC-thermistor, 4–20 mA, Tachometer
Relay Contacts	5 contacts— See Product Manual
Approvals	CSA certified to US and Canadian standards
Communications	Allen-Bradley® DFI and Modbus® RTU (Standard); DeviceNet™, Profibus®, Ethernet (Optional)
Analog Output	4 – 20 mA, programmable
Conformally Coated	Standard
Warranty	Limited lifetime
Mounting	Panel (operator interface) and Surface (control unit)

PGR-6210 SERIES

Motor Protection Retrofit Kit

Front



Back

Description

The PGR-6210 Motor Protection Retrofit Kit is designed to replace GE Multilin 169, 269, and 369 relays. It includes the PGR-6200 Motor Protection Relay, PGA-0CIM Current Input Module, and optional PGA-0120 Temperature Input Module pre-wired on a panel that can be installed in the existing space. The existing current transformers and wiring can be utilized, simplifying the upgrade procedure.

Applications

The PGR-6200 is an excellent choice for upgrading motor protection, providing current- and temperature-based protection, metering, and data logging.

Features/Benefits

- Direct replacement for GE Multilin 169, 269 and 369 relays
- Microprocessor-based protection
- Proven reliability
- Conformally coated circuit boards
- Additional protective functions, including reduced overcurrent and dynamic thermal model
- Minimal change-out time
- Use existing current transformers and RTD temperature sensors
- Ability to match existing overcurrent curves

Ordering Information

		PGA-0120 included
PGR-6210-00	RS-232 Communications	N
PGR-6210-01	RS-232 & RS-485 Communications	N
PGR-6210-02	RS-232 & DeviceNet™ Communications	N
PGR-6210-04	RS-232 & Ethernet Communications	N
PGR-6210-10	RS-232 Communications	Y
PGR-6210-11	RS-232 & RS-485 Communications	Y
PGR-6210-12	RS-232 & DeviceNet™ Communications	Y
PGR-6210-14	RS-232 & Ethernet Communications	Y

PGK FAMILY

Panel Mount Adapters

Relay is for illustrative purposes only and must be purchased separately.

Description

A variety of protection relay retrofit adapter plates are available for the products listed below. These adapter plates simplify the process of updating outdated or poorly functioning existing relays. Consult factory if you have a specific product to replace that is not featured. Panel mount adapters are available in either plate style for panel mounting or drawout style depending on the relay being replaced.

Applications

Motor (PGR-6200 or PGR-6300), feeder (PGR-7200) and ground-fault protection upgrades (PGR-4700 or PGR-5701) are available for electromechanical or solid state relays that are nearing the end of their life.

Features/Benefits

- Add communications capability to older switchgear and improve system performance
- Save cost by not calibrating older electromechanical devices
- Conformally coated circuit boards*
- Additional protective functions, including reduced overcurrent and dynamic thermal model*
- Minimal change-out time by using existing CTs
- Use existing RTD temperature sensors*
- Ability to match existing overcurrent curves*

*Included on PGR-6200, PGR-6300 and PGR-7200

Replacements

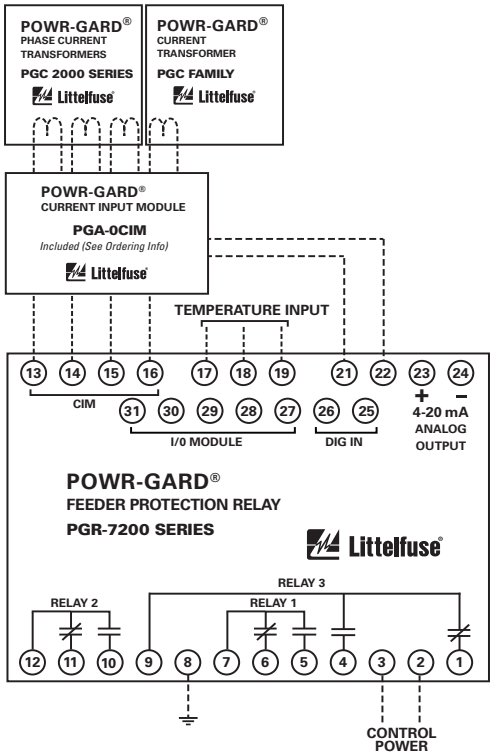
RELAY TO REPLACE:	PANEL MOUNT:	RELAY:
AB BULLETIN 1406	PGK-0014	PGR-6300
FPL-GFRM	PGK-0006	PGR-4700
FPL-GFRM	PGK-0006	PGR-5701
GE S1	PGK-0009	PGR-6200
GE S1	PGK-0009	PGR-7200
GE LODTRAK III	PGK-0010	PGR-6200
GE MULTILIN 169, 269, OR 369	PGK-0013	PGR-6300
	PGK-0016	PGR-6200
	PGK-0016	PGR-7200
GE MULTILIN P4A	PGK-0015	PGR-6200
GE MULTILIN P4A	PGK-0015	PGR-7200
GEC/MCGG	PGK-0003	PGR-4700
GEC/MCGG	PGK-0003	PGR-5701
GE & WESTINGHOUSE FT-11	PGK-0012	PGR-6200
P&B GOLDS	Contact Factory	PGR-7200
WESTINGHOUSE CO9 & CO11	Contact Factory	PGR-7200

For a complete list of the POWR-GARD Panel Mount Adapter Plates please see page 34.

PGR-7200 SERIES

Feeder Protection Relay

NOTE: The PGR-7200 consists of the Feeder Protection Relay (pictured above) and the PGA-0CIM Current Input Module (not pictured).



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGR-7200 Feeder Protection Relay provides integrated protection, metering, and data-logging functions. The relay can be programmed using the front-panel operator interface, the TIA-232 port, or an optional communications network.

Applications

The PGR-7200 is used to protect distribution feeders in processing, manufacturing, petroleum, chemical, mining, forestry, and water and waste treatment facilities.

Features/Benefits

- Eight functions to protect against overcurrent, ground faults, and phase loss
- IEC and IEEE overcurrent protection curves to coordinate with upstream and downstream devices
- CT saturation compensation
- Thermal element active below overcurrent pickup
- Definite- and inverse-time ground-fault protection
- Two set-point groups can be used for:
  - Maintenance setting to reduce Arc-Flash Hazards
  - Two different loads
- Standard TIA-232 interface with Modbus® RTU
- Optional TIA-485 with Modbus® RTU and Allen-Bradley®

Ordering Information

PGR-7200-00-00	RS-232 Communications
PGR-7200-01-00	RS-232 & RS-485 Communications
PGR-7200-02-00	RS-232 & DeviceNet™ Communications
PGR-7200-04-00	RS-232 & Ethernet Communications

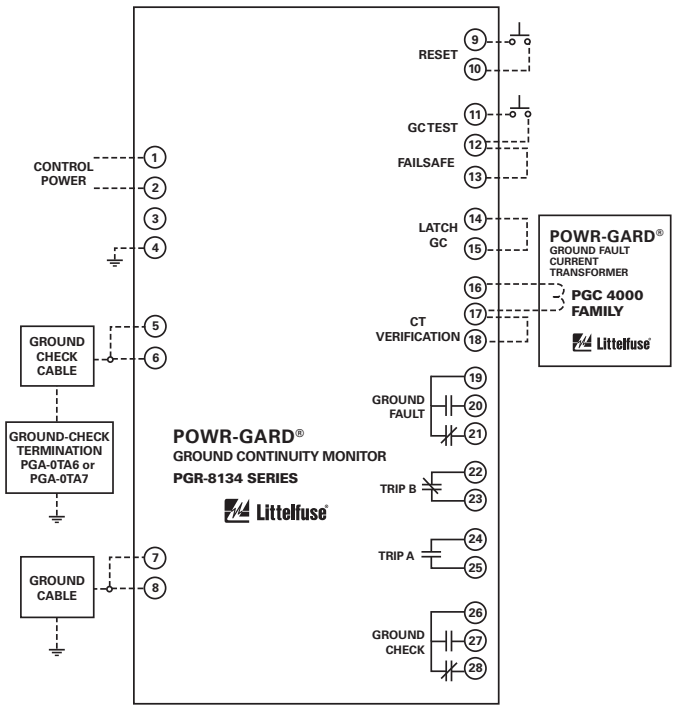
NOTE: The PGR-7200 consists of the Feeder Protection Relay and the PGA-0CIM Current Input Module (not pictured). To order the relay only, add (-FPU) to the part number listed above.

Specifications

IEEE Device Numbers	26, 46, 49, 50, 50G, 50N, 51, 51G, 51N, 74, 86
Input Voltage	65–265 Vac, 30 VA; 80–275 Vdc, 25 W
Power-Up Time	800 ms at 120 Vac
Ride-Through Time	100 ms minimum
24-Vdc Source	400 mA maximum
AC Measurements	True RMS and DFT, Peak 32 samples/cycle and positive and negative sequence of fundamental
Frequency	50 or 60 Hz
Relay Contacts	N.O. and N.C.
Approvals	CSA certified to US and Canadian standards
Communications	RS-232, RS-485, DeviceNet™, Ethernet
Analog Output	4–20 mA, programmable
Conformally Coated	Standard
Warranty	Limited lifetime
Mounting	Panel, Surface (optional)

PGM-8134 SERIES

Ground Continuity Monitor



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGM-8134 is a microprocessor-based, combination ground-wire monitor and ground-fault relay for resistance-grounded or solidly grounded systems. It continuously monitors the integrity of the ground wire to protect portable equipment from hazardous voltages caused by ground faults.

Applications

The PGM-8134 is field proven in monitoring trailing cables on large mobile equipment such as cranes, pumps, and shore-to-ship power. The PGM-8134 is used to monitor the ground wire and detect ground faults in portable power cables that incorporate a ground-check conductor (pilot wire). Applications include shore-to-ship power cables, dockside cranes, stacker-reclaimers, submersible pumps, and portable conveyors.

Features/Benefits

- Zener-characteristic termination assembly provides reliable ground-check loop verification
- Loop-resistance calibration not required
- High-induced-ac rejection makes unit suitable for applications with high voltages and long cables
- LED indication of ground-check and ground-fault circuit status, control power, current-sensor verification, and system health
- DFT (harmonic) filter prevents false operation
- Conformally coated circuit boards for circuit protection in corrosive atmospheres
- Fail-safe ground-check circuit

Ordering Information

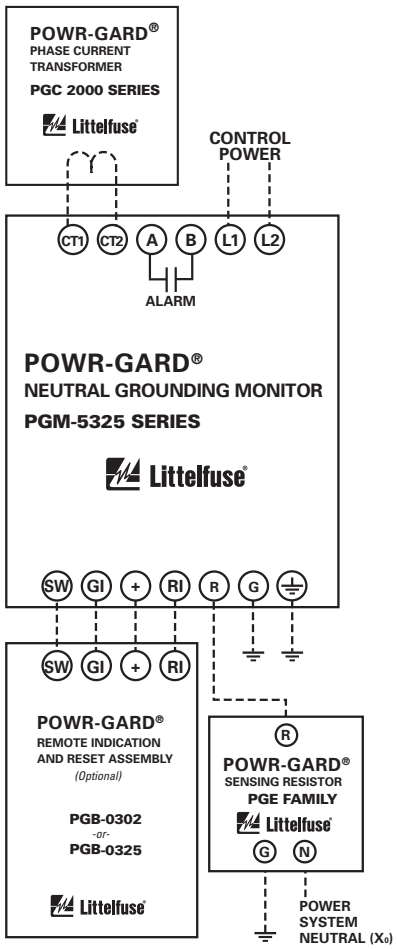
PGM-8134-00	60-265 Vac; 80-370 Vdc Control Power

Specifications

IEEE Device Numbers	3GC, 50G, 50N, 51G, 51N,
Input Voltage	60–265 Vac; 80–370 Vdc 15W
Dimensions	**H** 213 mm (8.4"); **W** 99 mm(3.9"); **D** 145 mm (5.7");
Trip Level Settings	0.5–12.5 A
Trip Time Settings	0.1–2.5 s
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard
Test Button	Standard
Reset Button	Standard
CT Loop Monitoring	Standard
Relay Contacts	Isolated N.O. and N.C. Contacts
Approvals	CSA certified to US and Canadian standards
Conformally Coated	Standard
Warranty	5 Year
Mounting	Panel, Surface (optional)

PGM-8325 SERIES

Neutral Grounding Monitor



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGM-8325 Neutral Grounding Monitor is used on resistance-grounded systems up to 25 kVac to monitor the integrity of the neutral-to-ground path. It measures current and voltage in a transformer or generator neutral-to-ground connection and continuity of the neutral-grounding resistor (NGR). The PGM-8325 coordinates these three measurements to detect a loose connection, corrosion, ground fault, or NGR failure, and provides one alarm or trip output contact.

Applications

The safety and reliability of a resistance grounded system depends on the neutral-to-ground connection. Corrosion, a loose connection, or resistor failure can cause an unsafe condition. The PGM-8325 Neutral Grounding Monitor is recommended for systems up to 25 kV with any size neutral grounding resistor (NGR). If the ground-fault relay feature is desired, the maximum NGR is 25 A. For resistor monitoring and ground-fault protection above 25 A, or to take advantage of additional features, refer to the PGR-5330.

Features/Benefits

- Continuous monitoring of neutral-to-ground path, including grounding resistor (any size NGR)
- Optional ground-fault detection (25 A max NGR)
- Selectable fail-safe or non-fail-safe operating modes
- Conformally coated circuit boards for circuit protection in corrosive atmospheres
- External PGE Sensing Resistor eliminates hazardous voltage at relay

Ordering Information

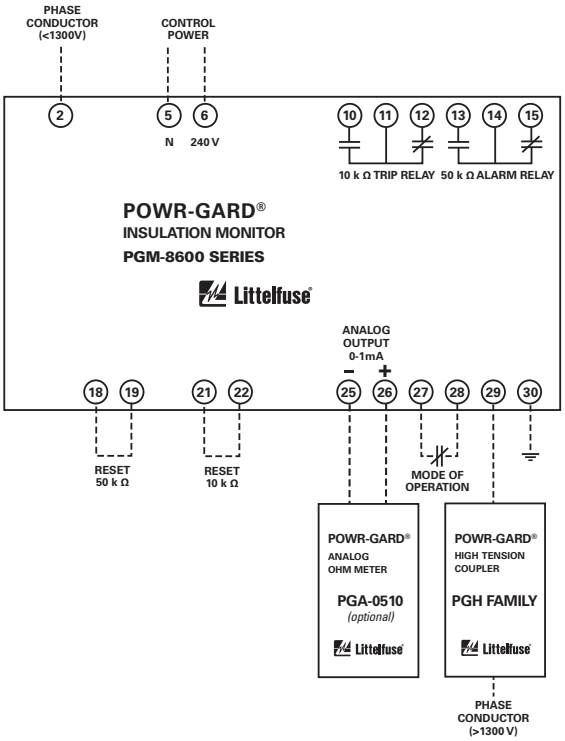
PGM-8325	120 Vac 50/60 Hz, 10 VA Control Power
PGM-8325-E	240 Vac 50/60 Hz, 10 VA Control Power

Specifications

IEEE Device Numbers	50G, 50N, 51G, 51N, 59N, 86
Input Voltage	See Ordering Information
Dimensions	**H** 150 mm (5.9"); **W** 109 mm (4.3"); **D** 100 mm (4.0")
GF Trip Level Settings	0.5–4.0 A
GF Trip Time Settings	0.1–2.0 s
RF Trip-Level Settings	20–400 Vac (≤ 5 kV systems) 100–2000 Vac (> 5 kV systems)
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Reset Button	Standard
Relay Contacts	N.O.
Approvals	CSA certified to US and Canadian standards
Conformally coated	Standard
Warranty	5 Year
Mounting	Surface

PGM-8600 SERIES (GFR4001-IM)

Insulation Monitor



See pg. 31-36 for Current Transformer Selection Guide and Accessory Information.

Description

The PGM-8600 relay monitors the insulation resistance to ground for failures. It provides two warnings, one alarm, and an analog output for predictive maintenance.

Applications

The relay can operate on grounded, resistance grounded or ungrounded systems up to 6 kV. It can be directly connected to supplies up to 1,300 kV, 1-phase or 3-phase, 50-60 Hz. A calibrated high-tension coupler (PGH) is required with 5 kV or 6 kV systems.

When the power system is de-energized, the relay monitors the insulation for damage, allowing for predictive maintenance and troubleshooting for developing ground faults.

When the power system is energized in ungrounded systems, the relay continues to monitor the insulation. In grounded systems, the relay switches off to prevent resistance tripping. The mode of operation (terminals 27-28) are connected to the circuit breaker or contactor auxiliary contacts to toggle the relay off when the contactor or breaker is closed.

Features/Benefits

- Continuously monitors insulation resistance for breakdowns
- Provides 2 warnings at different levels (30 kΩ and 50 kΩ) and 1 alarm (10 kΩ)
- Analog output and optional meter (PGA-0510)
- DIN-rail or surface mount for easy installation

Ordering Information

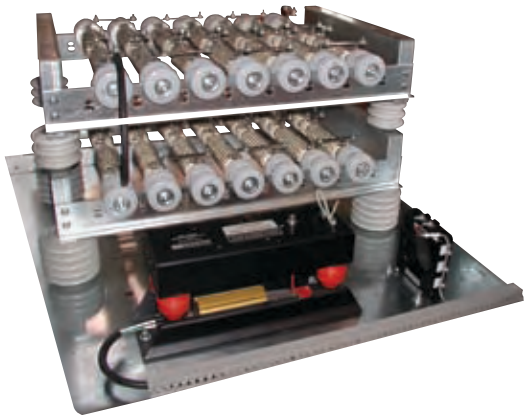
PGM-8600	240 Vac Control Power

Specifications

IEEE Device Numbers	86
Input Voltage	240 Vac, 50–60 Hz
Dimensions	**H** 99.7 mm (3.9"); **W** 75 mm (3"); **D** 110 mm (4.3")
Resistance Ratings	Insulation warning (30 kΩ and 50 kΩ) Alarm (10 kΩ)
Contact Operating Mode	Non-fail-safe
Test Button	Standard
Reset Button	Standard
Relay Contacts	2 N.O. or N.C.
Communications	Analog Output
Conformally Coated	Optional
Warranty	5 Year
Mounting	DIN, Surface

PGN-1000 SERIES

Low-Resistance Grounding System



Description

The PGN-1000 Series Resistance Grounding Systems are used to ground power systems by inserting a resistor between the system neutral and ground. This lowers the ground-fault current to a predetermined value.

Properly sized resistance grounding systems solve two problems of ungrounded systems — transient overvoltages and difficulty locating ground faults. The PGN-1000 Series Resistance Grounding System includes all necessary components to convert or design a resistance grounded system.

Low-Resistance Grounding also solves the problem of excessive ground-fault damage and Arc-Flash Hazards with solidly grounded systems. Properly sized resistors reduce ground-fault current to an acceptable level. Additional ground-fault relays (PGR-5701) can be installed on feeders to provide selective coordination as well as the ability to locate ground faults.

Applications

Low-Resistance grounding is typically applied on transformers and generators, and limits the ground-fault current to 25 A and above. Since ground-fault current is above 25 A, the faulted feeder must be de-energized. The reduced ground-fault current allows for an orderly shut-down procedure, typically within 10 seconds.

Features/Benefits

- Available from 480 V – 72 kV
- Available from 5 A – 800 A
- Can convert an existing ungrounded or a 3-wire solidly grounded system to a resistance grounded system. For more information on how to convert, see page 50.
- Resistance grounded relay or monitor (PGR-5330 or PGM-8325) is optional to provide ground-fault detection and resistor monitoring

Ordering Information

	SYS. VOLTAGE	RES. CURRENT	TIME		ENCLOSURE TYPE			FEATURES		CUSTOM
PGN – 1	X	X	X	–	X	–	0	X	–	XXX
	0 = Other	0 = Other	0 = Other		0 = Other			0 = Other		000 = Std
	2 = 480/277 V	1 = 5 A	1 = 10 s		N = No Enclosure			1 = Resistance Monitor		XXX = Dwg. #
	3 = 600/347 V	2 = 10 A	2 = 60 s		F = Outdoor FS			(PGM-8325)		
	4 = 2400/1390 V	3 = 25 A	3 = Ext.		W = Outdoor WM			2 = Resistance Mon. &		
	5 = 4160/2400 V	4 = 50 A	4 = Cont.					GF Relay (PGR-5330)		
	6 = 13800/8000 V	5 = 100 A								
		6 = 200 A								
		7 = 400 A								
		8 = 600 A								
		9 = 800 A								

PGN-3000 SERIES

High-Resistance Grounding System

Description

The PGN-3000 High-Resistance Grounding Systems are used to ground power systems by inserting a resistor between system neutral and ground to lower the ground-fault current to a predetermined value.

Properly sized resistance grounding systems solve two problems of ungrounded systems — transient overvoltages and difficulty locating ground faults. The PGN-3000 Series Resistance Grounding System includes all necessary components to convert or design a resistance grounded system.

The PGN-3000 includes a pulsing circuit and an optional PGR-5701 ground-fault relay to provide a method for locating ground faults. It also significantly reduces damage caused by ground-faults on solidly grounded systems, hence, eliminating the Arc-Flash Hazards associated with ground faults. The hazards associated with phase-to-phase electrical faults must still be mitigated by using current-limiting fuses and other methods.

Applications

High-Resistance grounding is typically applied on transformers and generators where safety and up-time are paramount. Since the ground-fault current is typically 5 A or less, there is no Arc-Flash Hazard associated with ground faults and the faulted feeder can remain in operation until it is safe to repair the fault. When ordering, the number of feeders to be monitored should be specified.

Features/Benefits

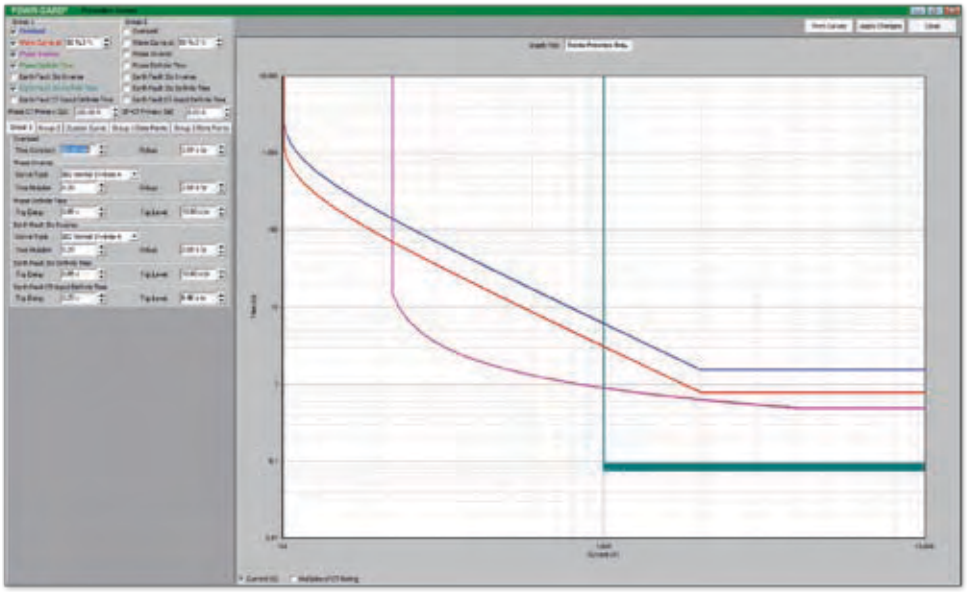
- All PGN-3000 Systems include resistor monitoring and ground-fault detection (using an additional PGR-5330 relay)
- Pulsing circuit to locate ground-faults (pulses 5 A up from the selected resistor current)
- Test circuit to simulate ground-fault
- Continuous rated resistors
- Stainless-steel elements prevent corrosion
- Available from 240 V – 4160 V and from 5 A – 25 A
- Can convert an existing ungrounded or a 3-wire solidly grounded system to a resistance grounded system. For more information on how to convert, see page 50.

Ordering Information

	CONFIGURATION	SYSTEM VOLTAGE	RES. CURRENT		ENCLOSURE TYPE	# OF FEEDERS		CUSTOM
PGN – 3	X	X	X	–	X	X	–	XXX
	0 = Other	0 = Other	0 = Other		0 = Other	0 = 0		000 = Std
	W = Wye	1 = 240 V	1 = 5 A		N = No Enclosure	1 = 1		XXX = Dwg. #
	D = Delta	2 = 480/277 V	2 = 10 A		F = Outdoor FS	2 = 2		
		3 = 600/347 V	3 = 15 A		W = Outdoor WM	3 = 3		
		4 = 2400/1390 V	4 = 20 A			4 = 4		
		5 = 4160/2400 V	5 = 25 A			5 = 5		
						6 = 6		
						7 = 7		
						8 = 8		
						9 = Other		

RELAY SOFTWARE

SOFTWARE



POWR-GARD protection relays are supplied with free software. The software simplifies programming and allows the user to save setpoint files and reuse them for similar applications.

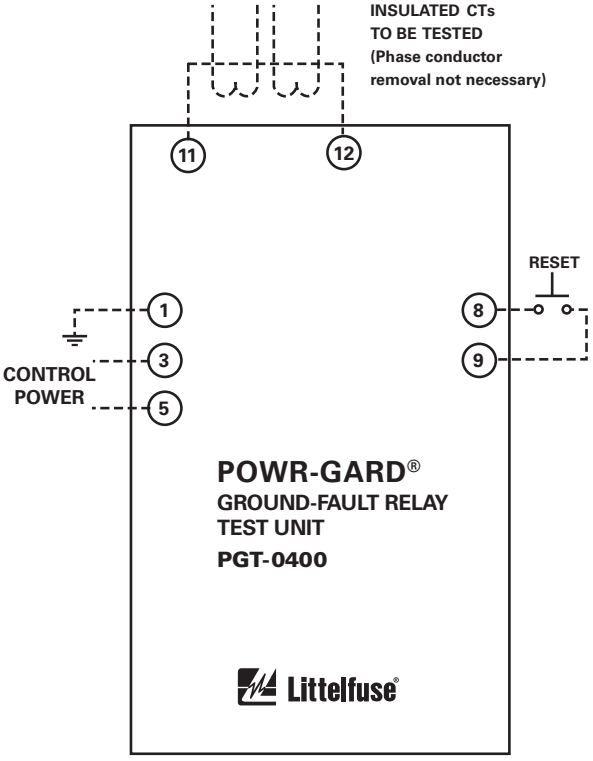
The software gives the ability to change parameters and see the impact on the protection time current curves. It allows another device curve to be entered to view simple coordination.

SOFTWARE		
Product	Features	Accessory For
PGW-COMM Relay Interface Software 	Provides remote access to metering, control, data logging, and programming features. Set points can be accessed individually, downloaded as a file, and protective curves can be plotted. Metered data can be observed or logged for later study.	**PGR-6200** **PGR-6300** **PGR-7200**
VPG-6200 Virtual Motor Protection Relay 	Allows the user to scroll through the PGR-6200 Motor Protection Relay menu.	**PGR-6200**
VPG-6300 Virtual Motor Protection System 	Allows the user to scroll through the PGR-6300 Motor Protection System menu.	**PGR-6300**
VPG-7200 Virtual Feeder Protection Relay 	Allows the user to scroll through the PGR-7200 Feeder Protection Relay menu.	**PGR-7200**
PGW-FLSH Firmware Update Utility 	Used to update relay firmware to add new features.	**PGR-5330** **PGR-6200** **PGR-6300** **PGR-7200**
PGW-5330 Relay Interface Software 	Used to receive data from the PGR-5330. It displays relay set points and measured values, and features data logging of information at a selectable interval.	**PGR-5330**
PGW-OSTT PGR-6200 Online Self-Training Tutorial 	Online Self-Training tutorial for PGR-6200 programming.	**PGR-6200**

RELAY TEST EQUIPMENT

PGT-0400 SERIES

Ground-Fault Relay Test Unit



Description

The PGT-0400 is a ground-fault-relay test unit designed to test current pickup level, time-delay and coordination of ground-fault protection.

The tester injects current through the window of installed ground-fault current transformers to verify the operation of ground-fault monitors and relays.

Applications

Used on substations, motor control centers (MCCs), central distribution panels, switchboards, and test benches to verify relay operation.

It is recommended to test every relay annually as well as its current interrupting device.

Features/Benefits

- The PGT-0400 tests the entire ground-fault circuit including current transformers, wiring, ground-fault relay and the operation of the interrupting device
- Current range is 0.5 to 9.9 A
- Duration range is 0.1 to 9.9 s or continuous output
- Light weight and compact for portability

Ordering Information

PGT-0400	120 Vac Control Power

Specifications

Input Voltage	84–134 Vac, 50/60 Hz, 80 VA
Dimensions	**H** 219 mm (8.6"); **W** 99 mm (3.9"); **D** 143 mm (5.6")
Output Current Settings	0.5–9.9 A
Output Duration Settings	0.1–9.9 s or continuous
Output Voltage	5.0 Vac maximum
Conformally Coated	Standard
Warranty	5 Year
Mounting	Surface, Panel

ACCESSORIES

CT SELECTION GUIDE

PRODUCT	GROUND-FAULT CT	TRIP LEVEL	PAGE #
PGR-2601	No CTs required	1 mA – 20 mA	–
PGR-3100	No CTs required	N/A	–
PGR-3200	No CTs required	Warnings at 30 kΩ & 50 kΩ, Alarm at 10 kΩ	–
PGR-4300	No CTs required	100 A – 1200 A	–
PGR-4700	PGC-5000 Series	10 mA – 3 A	32-33
PGR-5330	PGC-2000 Series (200 A Primary)	12 A – 200 A	32
	PGC-3000 Series - EFCT (5 A Primary)	100 mA – 5 A	32
	PGC-5000 Series (30-A Primary)	600 mA – 30 A	32-33
PGR-5701	PGC-2000 Series (200-A Primary)	10 A – 198 A	32
	PGC-3000 Series (5-A Primary)	50 mA – 4.95 A	32
	PGC-5000 Series (30-A Primary)	300 mA – 29.7 A	32-33
PGN-1000	CTs are included in system	N/A	–
PGN-3000	CTs are included in system	N/A	–
PGR-6100	PGC 5000 Series	10 mA – 3 A	32-33
PGR-6200*	PGC-2000 Series (200-A Primary)	10 A – 200 A	32
	PGC-3000 Series (5-A Primary)	50 mA – 5 A	32
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	32-33
PGR-6210*	Same as PGR-6200. Existing CT can be used in most cases.		
PGR-6300*	PGC-3000 Series (5-A Primary)	50 mA – 5 A	32
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	32-33
	Standard Iron core CTs (ie 50:5; 100:5, 200:5)	1 to 100% of CT Primary	–
PGR-7200*	PGC-2000 Series (200-A Primary)	10 A – 200 A	32
	PGC-3000 Series (5-A Primary)	50 mA – 5 A	32
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	32-33
PGM-8134	PGC-4000 Series	0.5 A – 12.5 A	32
PGM-8325	PGC-2000 Series	0.5 A – 4 A	32
PGM-8600	No CTs required	Warnings at 30 kΩ & 50 kΩ, Alarm at 10 kΩ	–

** Phase CTs should be selected with a primary rating of 100–300% of rated current to maintain specified accuracy. CTs with a 1-A or 5-A secondary are accepted.*

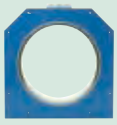
LEGEND: **GFP** (GROUND FAULT PROTECTION) **MP** (MOTOR PROTECTION) **FP** (FEEDER PROTECTION) **SM** (SUPPLEMENTAL MONITORING) **RG** (RESISTANCE GROUNDING)

PGC FAMILY

CURRENT TRANSFORMERS			
Product	Features	Inner Diameter	Accessory For
PGC-2056 Phase Current Transformer 	Detects phase current or ground-fault current. (200 A primary)	56 mm (2.20″)	**PGR-5330 PGR-5701 PGR-6200 PGR-6300 PGR-7200 PGM-8325**
PGC-2089 Phase Current Transformer 	Detects phase current or ground-fault current. (200 A primary)	89 mm (3.50″)	**PGR-5701 PGR-6200 PGR-6300 PGR-7200**
PGC-3026 Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5 A primary)	26 mm (1.02″)	**PGR-5330 PGR-5701 PGR-6200 PGR-6300 PGR-7200**
PGC-3082 Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5 A primary)	82 mm (3.23″)	**PGR-5330 PGR-5701 PGR-6200 PGR-6300 PGR-7200**
PGC-3140 Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5 A primary)	140 mm (5.50″)	**PGR-5701 PGR-6200 PGR-6300 PGR-7200**
PGC-31FC Flux Conditioner 	Fits in the PGC-3082 window to reduce saturation and prevent false operation due to large surge currents.	70 mm (2.75″)	**PGC-3082**
PGC-4064 Current Sensor 	Detects ground-fault current.	64 mm (2.50″)	**PGM-8134**
PGC-4108 Current Sensor 	Detects ground-fault current.	108 mm (4.25″)	**PGM-8134**
PGC-4160 Current Sensor 	Detects ground-fault current.	160 mm (6.31″)	**PGM-8134**
PGC-4210 Current Sensor 	Detects ground-fault current.	210 mm (8.25″)	**PGM-8134**
PGC-5025 Ground-Fault Current Transformer 	Current Transformer for low-level ground-fault situations, flux conditioner is standard. (30 A primary)	25 mm (0.98″)	**PGR-4700 PGR-5330 PGR-5701 PGR-6100 PGR-6200 PGR-6300 PGR-7200**
PGC-5060 Ground-Fault Current Transformer 	Current Transformer for low-level ground-fault situations, flux conditioner is standard. (30 A primary)	60 mm (2.36″)	**PGR-4700 PGR-5330 PGR-5701 PGR-6100 PGR-6200 PGR-6300 PGR-7200**

A ACCESSORIES

PGC FAMILY, PGG FAMILY

CURRENT TRANSFORMERS			
Product	Features	Inner Diameter	Accessory For
PGC-5095 Ground-Fault Current Transformer 	Current Transformer for low-level ground-fault situations, flux conditioner is standard. (30 A primary)	95 mm (3.74″)	**PGR-4700 PGR-5701 PGR-6100 PGR-6200 PGR-6300 PGR-7200**
PGC-5130 Ground-Fault Current Transformer 	Current Transformer for low-level ground-fault situations, flux conditioner is standard. (30 A primary)	130 mm (5.12″)	**PGR-4700 PGR-5701 PGR-6100 PGR-6200 PGR-6300 PGR-7200**
PGC-5200 Ground-Fault Current Transformer 	Current Transformer for low-level ground-fault situations, flux conditioner is standard. (30 A primary)	200 mm (7.87″)	**PGR-4700 PGR-5701 PGR-6100 PGR-6200 PGR-6300 PGR-7200**

NOTE: Contact factory for additional CT offerings.

GROUND-REFERENCE MODULES		
Product	Features	Accessory For
PGG-0024 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 24 Vdc bus.	**PGR-2601**
PGG-0048 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 48 Vdc bus.	**PGR-2601**
PGG-0125 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 125 Vdc bus.	**PGR-2601**
PGG-0250 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 250 Vdc bus.	**PGR-2601**
PGG-0500 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 500 Vdc bus.	**PGR-2601**
PGG-0780 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 780 Vdc bus.	**PGR-2601**

PGK FAMILY PANEL MOUNT ADAPTERS

PANEL MOUNT ADAPTERS			
Product		Features	Accessory For
PGK-0003		Used when replacing GEC/MCGG ground-fault relays.	**PGR-4700** **PGR-5701**
PGK-0006		Used when replacing FPL-GFRM ground-fault relays.	**PGR-5701**
PGK-0009		Used when replacing relays in the GE S1 Case.	**PGR-6200** **PGR-7200**
PGK-0010		Used when replacing the GE Lodtrak III.	**PGR-6200**
PGK-0012		Used when replacing GE and Westinghouse FT-11 relays.	**PGR-6200**
PGK-0013		Used when replacing the GE Multilin 169, 269, or 369.	**PGR-6300**
PGK-0014		Used for rough cutouts and when replacing the AB Bulletin 1406.	**PGR-6300**
PGK-0015		Used for rough cutouts and when replacing the GE Multilin P4A.	**PGR-6200** **PGR-7200**
PGK-0016 **PGK-0016-RTDB**		The PGK-0016 mounting plate is used when replacing the GE Multilin 169, 269, and 369 relays. The PGK-0016-RTDB is a mounting bracket for the optional PGA-0120 Temperature Input Module.	**PGR-6200** **PGR-7200**
PGK-0055		Used to panel mount the PGR-2601 and PGR-5701.	**PGR-2601** **PGR-6200** **PGR-5701** **PGR-4300**
PGK-0060		Used to panel mount the relay; IP 53 and NEMA 3 rating, tamper resistant.	**PGR-2601** **PGR-4300** **PGR-5701** **PGR-4700** **PGR-6200**
PGK-0SMK		A kit to convert panel mounted relays to surface mounted	**PGR-6200** **PGR-7200**

Note: The relays shown in the table above are for illustrative purposes only and are not included with the PGK Family Panel Mount Adapters.

PGA FAMILY, PGB FAMILY

INPUT MODULES			
Product		Features	Accessory For
PGA-0120 Temperature Input Module		Provides 8 programmable inputs to connect Pt100, Ni100, Ni120, and Cu10 RTDs.	**PGR-6200** **PGR-6300**
PGA-0140 Differential Current Module		Adds motor differential protection, compatible with core balance and summation current transformer connections.	**PGR-6200** **PGR-6300**

REMOTE INDICATION			
Product		Features	Accessory For
PGB-0302 Remote Indication and Reset Assembly		Panel-mounted remote indication and reset, standard 22 mm mounting with NEMA 4 and NEMA 13 rating.	**PGR-8325**
PGB-0325 Remote Indication and Reset Assembly		Panel-mounted remote indication and reset with NEMA 1 rating.	**PGR-8325**
PGA-016A Watertight Cover		Watertight cover for outdoor applications.	**PGR-6200** **PGR-7200**
PGA-0500 Analog % Current Meter		Panel-mounted analog meter displays ground-fault current as a percentage of the set-point.	**PGR-2601** **PGR-4300** **PGR-4700** **PGR-5701** **PGR-6100**
PGA-0510 Analog Ohm Meter		Panel-mounted analog ohmmeter displays insulation resistance from 0 Ω to infinity.	**PGR-3200** **PGR-6100** **PGR-8600**

PGE FAMILY, PGH FAMILY, PGA FAMILY

SENSING RESISTORS

Product	Features	Accessory For
PGE-600V Sensing Resistor 	Used on systems up to 1 kV.	**PGR-5330** **PGM-8325**
PGE-05KV Sensing Resistor 	Used on systems up to 5 kV.	**PGR-5330** **PGM-8325**
PGE-15KV Sensing Resistor 	Used on systems up to 15 kV.	**PGR-5330** **PGM-8325**
PGE-25KV Sensing Resistor 	Used on systems up to 25 kV.	**PGR-5330** **PGM-8325**
PGE-35KV Sensing Resistor 	Used on systems up to 35 kV.	**PGR-5330**

TERMINATIONS AND ADAPTERS

Product	Features	Accessory For
PGH-5000 High Tension Couplers 	Allows 5-kV lines to be connected to relay.	**PGR-3200** **PGR-6100** **PGR-8600**
PGH-6000 High Tension Couplers 	Allows 6-kV lines to be connected to relay.	**PGR-3200** **PGR-6100** **PGR-8600**
PGA-0TA6 Termination Assembly 	50 W ground-check termination with convenient mounting holes and screw terminals, temperature compensated.	**PGM-8134**
PGA-0TA7 Small-Format Termination Assembly with Wire Leads 	12 W ground-check termination, ideal for use in end caps and submersible pumps. Mounting holes and wire leads, temperature compensated.	**PGM-8134**
PGA-0400 Port-Powered Serial Converter 	Converts an RS-485 signal to an RS-232 signal, used for set-point programming and updating flash memory.	**PGR-6200** **PGR-6300** **PGR-7200**
PGA-0420 Serial Connector Adapter Kit 	Connects an RJ45 socket to a 9-pin serial connector, includes 1.5 m cable and plug-in adapter.	**PGR-6200** **PGR-7200**

PROTECTION OVERVIEW

Adjustable Alarm Level – A setting on a protection relay at which an LED or an output contact operates to activate a visual or audible alarm.

Adjustable Time Delay – A setting on a protection relay that determines the time between the fault detection and relay operation.

Alarm Relay Contact – The output of the relay that acts as a switch and is connected to a visual or audible alarm.

Analog Output– A 0–1 mA, 4–20 mA or 0–5 Vdc signal from a protection relay used to pass information to a device or controller.

Asynchronous Motor – A motor in which the speed of the rotor is not proportional to the frequency of the system to which it is connected.

Conformal Coating – Coating used to protect circuit boards from pollutants, corrosion, and mildew.

Continuous Output - On an PGT-0400 continuous output is defined as current that does not automatically stop.

Current Transformer (CT) – A transformer that produces a current in its secondary circuit in a known proportion to current in its primary circuit.

CT Loop – The electrical circuit between a current transformer and a protection relay or monitoring device.

CT Loop Monitoring - Continuous check of CT loop continuity to verify connection.

CT Saturation – A condition that occurs when a current transformer (CT) cannot maintain a secondary current proportional to a large primary current.

CT Local Saturation – Poorly installed phase conductors and large currents can cause an output from a zero-sequence (ground-fault) CT even though there is no fault.

CT Saturation Compensation - The fundamental current amplitude is compared to the peak-to-peak value. If the peak-to-peak value is much higher than the DFT value then the relay assumes the CT is into saturation and uses the peak-to-peak value.

Current-Based Protection – Protection parameters (Trip-levels/data collection etc.) derived from current levels in a circuit.

Current-Trip Setting - Selectable level of current at which a relay will operate.

Data Logging – Collecting and storing information in a format that can be reviewed for trending, troubleshooting and reporting.

DFT (Discrete Fourier Transform) Harmonic Filter – An algorithm used to measure the fundamental component of current and voltage and reject harmonics. This allows lower trip settings and eliminates nuisance trips due to harmonics.

Differential Module – An accessory for the PGR-6200 and PGR-6300 motor protection relays to add phase-differential protection.

Digital Harmonic Filter – The use of digital signal-processing (DSP) techniques such as the DFT to eliminate the measurement of harmonic components. In terms of ground-fault detection, use of a harmonic filter allows a setting below the background noise level.

Discrete Fourier Transform (DFT) – A mathematical algorithm used in a DSP to extract a single frequency, such as the fundamental frequency, from a signal.

Earth Leakage – See Leakage Current.

EFCT (Earth Fault Current Transformer) – A current transformer engineered to accurately detect low level ground-fault current.

Fail-Safe Mode (also known as Under Voltage or UV) – Output relay is energized during normal (not tripped) operation. If the protection relay loses supply voltage, the system will trip or alarm. (Also see: Non-fail-safe).

Fault Current - The current that flows when a phase conductor is faulted to another phase or ground.

Feeder – All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.

Feeder Protection – Overcurrent or overvoltage devices installed on a feeder circuit to supplement, compliment or replace downstream protective devices.

Flux Conditioner – A ring of magnetically conductive material inserted in a current-transformer window, used to reduce local saturation which can cause nuisance tripping.

Fundamental Frequency – In an alternating-current power system, the frequency of the generated voltage. In North America this is typically 60 Hz (60 cycles per second).

Ground Check Conductor – An insulated conductor in a trailing cable used to assist in monitoring continuity of the ground conductor. Typically designed to be the smallest conductor, it is the first to break when cable is mechanically stressed.

Ground Check Loop – The circuit that includes the ground-check conductor, ground-check termination device, ground-continuity monitor, and ground conductor.

Ground Check Termination – A device installed at the end of the ground-check loop to terminate the measuring signal from the ground continuity monitor.

Ground Continuity Monitor - A protection relay that continuously monitors a ground conductor and trips if this conductor opens or shorts to the ground-check conductor.

Ground-Fault – Unintentional contact between a phase conductor and ground or equipment frame. The words "ground" and "earth" are used interchangeably when it comes to electrical applications.

Ground-Fault Current – The current that returns to the supply neutral through the ground-fault and the ground-return path.

Ground-Fault Relay – A protection relay designed to detect a phase-to-ground-fault on a system and trip when current exceeds the pickup setting for greater than the trip time setting.

Ground-Fault Protection – A system that protects equipment from damaging ground-fault current by operating a disconnecting means to open all ungrounded conductors of a faulted circuit. This protection is at current levels less than those required to operate a supply circuit overcurrent device.

Ground Reference Module – A resistor network that limits ground-fault current to 25 mA and provides a signal to a dc ground-fault relay.

Harmonic Filter – A device or method to remove or ignore non-fundamental frequency components of a signal.

Harmonic Frequency - Harmonic-frequency components (voltage and current) are multiples of the fundamental frequency and, in a power system, can be considered noise. Harmonic-frequency components are often present because of the use of adjustable-speed motor drives.

High-Resistance Grounding – Using a neutral-ground resistor (NGR) to limit the current to a low level. Typically high-resistance grounding is 25 A and lower. (Also see: Low-Resistance Grounding).

High Tension Coupler - An accessory used to step down line voltage to a usable level for a relay.

I^2t (I squared t) – Thermal capacity, or used thermal capacity. In motor protection, thermal capacity is used to measure and describe motor heating in terms of current (I). This method is more accurate than temperature sensing because of temperature-sensor placement and the time delay inherent in temperature measurement.

IEEE Device Numbers – The devices in switching equipment are referred to by numbers, according to the functions they perform. These numbers are based on a system which has been adopted as standard for automatic switchgear by IEEE. This system is used on connection diagrams, in instruction books and in specifications.

Insulation Monitoring – Monitoring the resistance from phase to ground to detect insulation breakdown on a system.

Insulation Resistance – A measurement of the ability of an insulator, such as a cable jacket, to prevent current flow under the stress of a voltage; typically measured in mega-ohms. Insulation-resistance change can be monitored to predict impending failure.

Insulation Warning – A warning alarm triggered by a decrease in insulation resistance below a pre-determined value.

Integrated Motor Starter - A device, such as a motor-protection relay, with the built-in ability and a user interface to start and stop a motor.

Inverse-Time Ground-Fault Protection - A method by which time-to-trip of a protective device, such as an overcurrent relay or ground-fault-current relay, decreases as the magnitude of the fault increases.

Leakage Current – Very low level ground-fault current, typically measured in milliamperes (mA, thousandths of amperes).

Low-Resistance Grounding – A Resistance-Grounding System that allows high currents to flow during a ground-fault. Typically 100A and higher is considered Low-Resistance grounding. (Also see: High-Resistance Grounding)

LSIG Protection – An acronym for long-time, short-time, and instantaneous overcurrent, and ground-fault protection; a term often used to describe protection required for a power-distribution feeder, or a protection relay with these functions.

Motor Lockout - A condition where for safety reasons, the operator is prevented from starting the motor.

Motor Protection – Overload protection designed to protect the windings of a motor from high current levels. Modern motor protection relays add many additional features, such as metering, data logging and communications.

Neutral Grounding Resistor (NGR) – A current-limiting resistor connecting the power-system neutral to ground.

N.C. Contact (Normally Closed Contact) – Relay contact that is closed when the relay is not energized.

N.O. Contact (Normally Open Contact)– Relay contact that is open when the relay is not energized.

Non-Fail-Safe (also known as Shunt Trip or SH) – Output relay is energized and contacts change state when a trip occurs. If the protective device loses supply voltage, the system can continue to operate but will not be protected. (Also see: Fail-safe)

Non-Volatile Memory – Data is retained when power is removed.

Nuisance Trip – An undesired change in relay output due to misinterpreted readings.

Phase Current – Current present in a phase conductor.

Phase Current Transformer – A current transformer installed so that current from one phase conductor flows in its primary winding. For motor and feeder protection and metering in a three-phase system, three current transformers are typically used to measure phase currents.

Phase Differential Protection – Protection designed to detect winding-to-winding failures and winding-to-ground failures in an ac motor.

Phase Loss – Loss of power on a single phase.

Phase Voltage – The voltage measured between a phase conductor and ground.

Primary Rating (for CTs) – The current rating of the primary side of a current transformer. The first number in the ratio 500:5 is the primary rating. Under ideal conditions 500 A of primary current flow through the CT will produce 5 A of current out the secondary terminals.

Pulsing – Modulating the ground-fault current on a resistance grounded system using a contactor to short out part of the NGR elements (or to open one of two NGRs connected in parallel). Another version of pulsing is imposing a higher frequency signal on power lines and using a wand detector to locate the point of fault on a conductor

Pulsing Circuit – See Pulsing.

Online/Offline Monitoring – Insulation monitoring when the system is energized and de-energized.

Open CT Hazard – An open-circuited CT secondary can develop a dangerously high voltage when the primary is energized.

Relay – An electrical switch that opens and closes a contact (or contacts) under the control of another circuit. Typically an electromagnet.

Relay Operating Mode – Fail-safe or non-fail-safe methods of operation used for Undervoltage or Shunt trip breakers.

Resistance-Grounded System – An electrical system in which the transformer or generator neutral is connected to ground through a current-limiting resistor. (Also see: Solidly Grounded System, Ungrounded system).

Ride-Through Time – The amount of time a protection relay can maintain operation during a control-power dip.

RTD – Resistive Temperature Detector. A material that experiences a linear change in resistance with a change in temperature. Used to provide temperature metering. Common RTDs are 100 Ω platinum, 100 Ω nickel, 120 Ω nickel and 10 Ω copper.

Sensitive Ground-Fault Protection – Protection designed to accurately detect extremely low ground-fault current levels without nuisance tripping.

Solidly Grounded System – An electrical system in which the neutral point of a wye connected supply transformer is connected directly to ground.

Trailing Cables – Power cables used to supply electrical power to mobile equipment. They typically contain 3 phase conductors, 2 ground conductors and a pilot wire (or ground-check conductor).

Trip Level Settings (current) – Selectable current levels to define when a relay should operate.

Trip Time Settings - The time a fault is required to be present before trip action is taken.

Trip State – The state of the output contacts after a relay trip.

True RMS – "Root-Mean-Square" calculation used to derive true current or voltage value in electrical measurement when the waveform is non-sinusoidal.

Ungrounded System – An electrical system in which no point in the system is intentionally grounded. This was most common in process industries where continuity of service during a single-phase-to-ground-fault was required.

I. INTRODUCTION TO PROTECTION RELAYS AND APPLICATIONS

What is a Protection Relay?

A protection relay is a smart device that receives inputs, compares them to set points, and provides outputs. Inputs can be current, voltage, resistance, or temperature. Outputs can include visual feedback in the form of indicator lights and/or an alphanumeric display, communications, control warnings, alarms, and turning power off and on. A diagram is shown below.

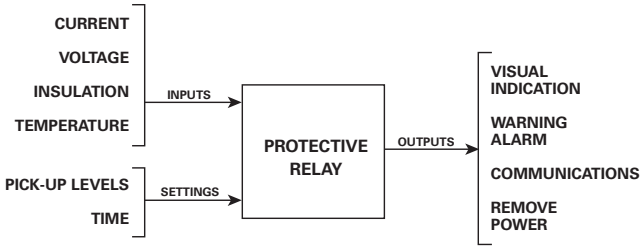


FIGURE 1

Protection relays can be either electromechanical or electronic/microprocessor-based. Electromechanical relays are an obsolete technology consisting of mechanical parts that require routine calibration to stay within intended tolerances. Microprocessor or electronic relays use digital technology to provide quick, reliable, accurate, and repeatable outputs. Using an electronic or microprocessor-based relay instead of an electromechanical design provides numerous advantages including improved accuracy, additional functions, reduced maintenance, smaller space requirements and lifecycle costs.

Inputs

A relay needs information from the system to make a decision. These inputs can be collected in a variety of ways. In some cases, the wires in the field can be connected directly to the relay. In other applications, additional devices are needed to convert the measured parameters to a format that the relay can process. These additional devices can be current transformers, potential transformers, tension couplers, RTDs or other devices.

Settings

Many protection relays have adjustable settings. The user programs settings (pick-up levels) that allow the relay to make a decision. The relay compares the inputs to these settings and responds accordingly.

Processes

Once the inputs are connected and the settings are programmed, the relay compares these values and makes a decision. Depending on the need, different types of relays are available for different functions.

Outputs

The relay has several ways of communicating that a decision has been made. Typically the relay will operate a switch (relay contact) to indicate that an input has surpassed a setting, or the relay can provide notification through visual feedback such as a meter or LED. One advantage of electronic or microprocessor relays is an ability to communicate with a network or a PLC.

As an example, a thermostat can be evaluated using the diagram in Figure 1. The input that is measured is temperature and the protection relay input device is the temperature sensor. The user sets the desired temperature setting (pick-up level). The relay measures the existing air temperature and compares it to the setting. The outputs can be used to provide controls (turning an air conditioner or furnace on or off) and visual indication on the thermostat display.

How Do Protection Relays Solve Electrical Problems?

Similar to how the thermostat solves the problem of automating the control of the air conditioner or furnace in a home, protection relays can solve electrical problems.

The purpose of the protection relay is to detect a problem, ideally during its initial stage, and to either eliminate or significantly reduce damage to personnel and/or equipment.

The following stages illustrate how an electrical problem develops:

Stage 1: When conductors with good insulation are exposed to fault initiators such as moisture, dust, chemicals, persistent overloading, vibration or just normal deterioration, the insulation will start to slowly deteriorate. Such small changes will not be immediately obvious until the damage is severe enough to cause an electrical fault. Relays can detect that a problem is developing by identifying slight deviations in current, voltage, resistance, or temperature. Due to the small magnitude in change, only a sophisticated device such as a sensitive protection relay or a monitor can detect these conditions and indicate that a problem may be developing, before any further damage has occurred.

Stage 2: As the problem becomes more severe, further changes take place such as insulation breakdown, overheating, or overvoltage. Since the change from normal to abnormal is great, traditional devices can be used to interrupt power. Protection relays can also be used to provide additional protection by detecting the fault contributors (overheating, overvoltage, etc.) not possible with fuses and circuit breakers.

Stage 3: At this point, the problem has occurred and caused damage. Different types of protective relays and monitors can reduce or eliminate damage because they detect problems in advance of traditional devices.

As an example, if a facility is continually resetting circuit breakers, replacing fuses, or repairing equipment and cannot locate the problem, they may be experiencing overcurrents. If this is the case, the user can install a protection relay that has an overcurrent feature. The relay measures the current (input) and allows the user to program limits (settings) into the relay. The settings typically are more sensitive than the fuses or circuit breakers. Once these limits are exceeded, the relay will operate an internal switch (relay contacts). The user has the option to use the switch to turn on a light (alarm indication) or remove power (shunt-trip) before greater problems occur. The user can use the alarm indication to help identify the faulty equipment prior to the traditional device clearing the fault.

II. RELAY APPLICATION

Ground-Fault Protection

The primary purpose of grounding electrical systems is to provide protection against electrical faults. However, this was not realized until the 1970's. Until then, most commercial and industrial systems were ungrounded. Although ungrounded systems do not cause significant damage during the first ground fault, the numerous disadvantages associated with ground faults resulted in a change to the grounding philosophy. There are other advantages for a grounded system, such as reduction of shock hazards and protection against lightning.

Electrical faults can be broken down into two categories: phase-to-phase faults and ground faults. Studies have shown that 98% of all electrical faults are ground faults (Source: Woodham, Jack, P.E. " The Basics of Grounding Systems" May 1, 2003 <http://www.ecmweb.com/mag/electric_basics_grounding_systems_2/index.html>). Where fuses can protect against phase-to-phase faults, additional protection, such as protection relays, are typically required to protect against ground faults.

Definition of Ground Fault

A ground fault is an inadvertent contact between an energized conductor and ground or equipment frame. The return path of the fault current is through the grounding system and any personnel or equipment that becomes part of that system. Ground faults are frequently the result of insulation breakdown. It's important to note that damp, wet, and dusty environments require extra diligence in design and maintenance. Since water is conductive it exposes degradation of insulation and increases the potential for hazards to develop.

Table 1 shows the leading initiators of electrical faults.

LEADING INITIATORS OF FAULTS	% OF ALL FAULTS
Exposure to moisture	22.5%
Shorting by tools, rodents, etc.	18.0%
Exposure to dust	14.5%
Other mechanical damage	12.1%
Exposure to chemicals	9.0%
Normal deterioration from age	7.0%

TABLE 1

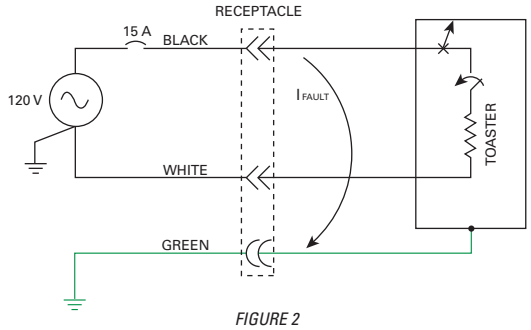


FIGURE 2

As as example, in the toaster circuit above, the black or hot wire is shorted to the metal casing of the toaster. When the circuit closes, all or part of the current is channeled through the toaster frame and then the green ground wire. When sufficient current flows (typically 6 x 15 A = 90 A), the circuit breaker will open. A protection relay could be installed to detect currents as low as 5 mA, which would open the circuit breaker at a significantly lower level, hence, much quicker than the traditional circuit breaker.

Although the example above shows a solidly grounded single-phase circuit, the philosophy is the same on three-phase circuits discussed later. Relays and monitors are specifically designed to look for the leading initiators shown in Table 1 by detecting low-level changes in current, voltage, resistance or temperature.

DC Systems

Direct current (dc) systems have positive and negative buses. If either bus is grounded, then it is referred to as a grounded system. If neither bus is grounded, then it is referred to as an ungrounded dc system. A ground fault on a dc system may cause damage to the source as well as in the field.

If the system is ungrounded, then it is possible to use a ground-fault relay by installing a ground-reference module between the two buses to establish a neutral point. The ground-fault relay uses this neutral point as a reference to detect low-level ground faults.

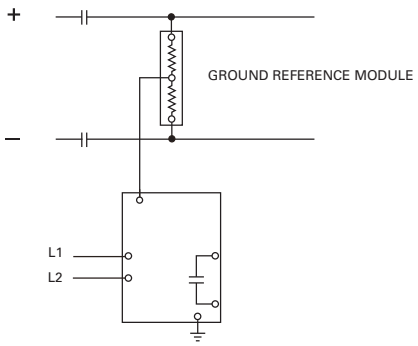


FIGURE 3

Ungrounded AC Systems

Ungrounded ac systems, shown below, were used where continuity of power was critical. For example, chemical plants or refineries involving processes that cannot be interrupted without extensive dollar or product loss may have an ungrounded system. However, experience has proven that these systems are problematic and are being replaced with resistance grounded systems. Two major problems with ungrounded systems are transient overvoltages and difficulty locating ground faults.

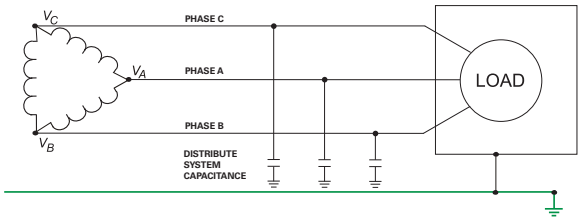


FIGURE 4

- An ungrounded system has no point in the system that is intentionally grounded (other than the normal bonding which is always present to connect the non-current-carrying metal parts to ground). Grounding occurs only through system capacitance to ground (as shown in Figure 4).
- Continuity of power occurs because the system can operate with one phase faulted to ground.
- An intermittent or arcing fault can produce high transient overvoltages to ground. These voltages are impressed on the phase conductors throughout the system until the insulation at the weakest point breaks down. This breakdown can occur at any point in the electrical system, causing a phase-to-ground-to-phase fault.
- Although a ground fault can be detected or alarmed on the system, there is no way to determine the location of the fault.

There are two methods used to detect ground faults in ungrounded systems. One method is to monitor the voltages between the phases and ground. As a ground fault develops, the faulted phase will collapse to ground potential, causing an indicator light to dim. The indicator lights on the unfaulted phases become brighter.

A better method to detect a ground fault is to measure the insulation resistance. As the insulation deteriorates, a relay continuously monitoring the insulation resistance can alarm at different levels for predictive maintenance. A visual indication or meter can also be used.

Solidly Grounded Systems

Due to the problem of ungrounded systems, a shift in philosophy occurred and designs moved from ungrounded to grounded systems. In most cases, the type of grounding system chosen was solidly grounded. A solidly grounded system is a system of conductors in which at least one conductor or point is intentionally grounded (usually the neutral point of transformer or generator windings). The problem with the direct connection is that ground fault current can be excessive, causing Arc-Flash hazards, extensive equipment damage, and possible injury to personnel.

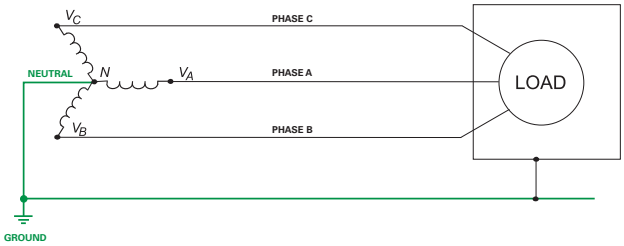


FIGURE 5

- In a solidly grounded system, the wye point (or neutral) of the power source is connected solidly to ground and offers a very stable system that maintains a fixed phase-to-ground voltage.
- The high ground-fault current is easy to detect with fuses, circuit breakers, or protection relays, allowing for selective tripping (tripping the faulted feeder and not the main feeder).
- When a ground fault occurs, high point-of-fault damage can quickly result since the energy available to the ground fault is only limited by the system impedance (which is typically very low).
- Due to excessive ground-fault current and Arc-Flash Hazards, the faulted feeder must be removed from service. This does not allow for continuous operation during a ground fault.

Figure 6 illustrates an example of the dangers associated with solidly grounded systems. In this example, a ground-fault occurs and the overcurrent protection is set at 600 A.

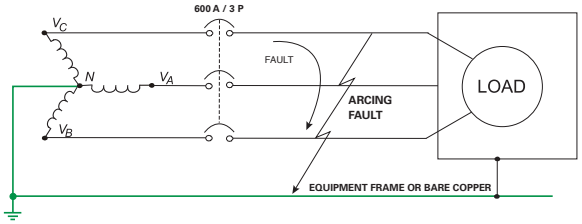


FIGURE 6

- Assume that this ground-fault is not a bolted fault, but an arcing fault due to an insulation breakdown or a partial reduction of clearances between the line and ground.
- Because of the arc resistance, the fault current may be reduced to as low as 38% of the bolted-fault level. The fault current can be in the range of a normal load or a slight overload.
- The fault current may be low enough that the overcurrent device (600-A circuit breaker) does not sense the fault current, or may pick it up but not trip for a long time.
- The energy being supplied by the source is concentrated at the arc and could cause severe equipment damage very quickly. This energy release could cause a fire that in turn, could damage the premises and present an extreme hazard to personnel.

Aside from converting this solidly grounded system to resistance grounding, the best way to prevent damage is to detect low-level ground leakage prior to it becoming a ground fault. In order to accomplish this, the protection relay must be able to sense a low-level ground leakage without nuisance tripping.

In modern facilities, equipment often generates noise or harmonics that may interfere with a protection relay's ability to function properly. For example, the noise or harmonics may be higher than the desired ground-fault relay settings, causing the relay to falsely operate when there is no fault on the system. The protection relay must be able to filter out noise or harmonics to provide reliable protection.

Resistance Grounded Systems

Resistance grounding is the only method of grounding that solves the problems commonly associated with both ungrounded systems and solidly grounded systems. The name is derived from the addition of a resistor between the system neutral and ground. The specifications of the resistor are user determined to achieve a desired ground fault current, which must be greater than the system capacitive charging current (explained later in this section).

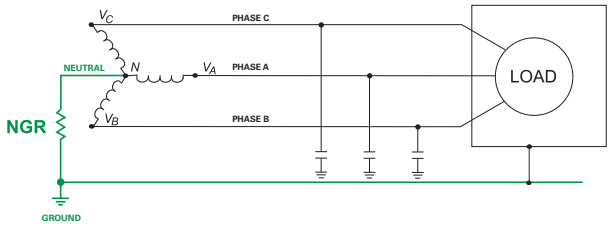


FIGURE 7

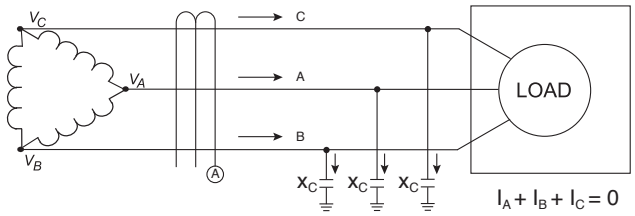


FIGURE 8

- The only disadvantage of resistance grounding is that if the resistor fails, the system will become ungrounded. Resistor monitoring is recommended to protect against this.
- Transient overvoltages can be eliminated by correctly sizing the neutral grounding resistor (NGR) to provide an adequate discharge path for the system capacitance.
- Continuity of operation with one ground fault is allowable in some applications when ground fault is ≤10 A.
- The NGR limits the available ground current. This eliminates or minimizes point-of-fault damage (Arc Flash Hazards) and controls the ground-fault voltage.
- Pulsing can be used to locate ground faults when ground fault is ≤ 10 A. Pulsing is created by using a shorting contactor to short out half of the resistance, causing the ground-fault current to double (usually one cycle per second). A hand-held zero-sequence meter is used to detect the fluctuating ground-fault current, and locate the ground fault.

A protection relay for resistance grounded systems is used to detect a ground fault and to monitor the neutral-to-ground connection. It can be used to provide alarms or to trip the faulted feeder from service during a ground fault. The relay can provide a pulsing circuit that can be used to locate the ground fault. The relay can also alarm or trip if the neutral-to-ground path fails. For systems 5 kV and less, high-resistance grounding can be used. High-resistance grounding typically limits the resistor current to 10 A or less. By doing so, the ground fault can remain on the system, given that the system is rated for the voltage shift.

For systems 2.4 kV and higher, low-resistance grounding systems can be used. Typically in those systems the ground fault current is 25 A or above and is cleared within 10 s.

System Capacitive Charging Current

Although not physically connected to ground, electrical conductors and the windings of all components are capacitively connected to ground. Consequently, a small current will flow to ground from each phase. This current does not occur at any particular location; rather, it is distributed throughout the system just as the capacitance to ground is distributed throughout the system. For analysis, it is convenient to consider the distributed capacitance as lumped capacitance, as shown in Figure 8.

Even if the distributed capacitance is not balanced, the ammeter will read zero because all the current flowing through the CT window must return through the CT window.

System charging current is the current that will flow into the grounding connection when one phase of an ungrounded system is faulted to ground. It can be measured as shown below if appropriate precautions are taken:

- If the fault occurs on the supply side of the CT, the sum of the currents in the CT window is not zero.
- Ammeter A will read the sum of the capacitive currents in the unfaulted phases. This value is the charging current of all the equipment on the load side of the CT.

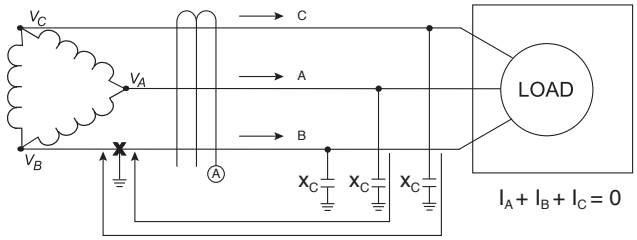


FIGURE 9

A single-line diagram of a three-feeder, resistance-grounded system with a fault on feeder 3 is shown in Figure 10.

- A CT (A1 and A2) on unfaulted feeders will detect the charging current of that feeder.
- A CT (A3) on a faulted feeder will detect the sum of the resistor current (I_R) and the charging currents ($I_1 + I_2$) of the unfaulted feeders.

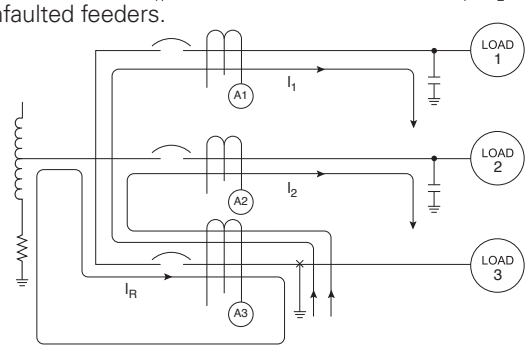


FIGURE 10

Selective coordination in a resistance-grounded system can be achieved if the pick-up setting of each ground-fault relay is greater than the charging current of the feeder it is protecting. If the pick-up setting of a ground-fault relay is less than the charging current of the feeder it is protecting, it will trip when a ground fault occurs elsewhere in the system. This is known as sympathetic tripping. If the relative size of the feeders can change, or if the advantage of using one operating value for all ground-fault relays in a system is recognized, then it is prudent to select an pick-up setting for all ground-fault relays that is larger than the system charging current.

In order to eliminate transient overvoltages associated with an ungrounded system, it is necessary to use a grounding resistor with a let-through current equal to or larger than the system charging current.

What is the minimum acceptable NGR current? Select a pick-up setting for the ground-fault relays that exceeds the system charging current and multiply the operating value by an acceptable tripping ratio. Use the next-largest available standard let-through current rating.

Motor Protection

Overview

Motors are a significant investment and often run critical processes. Motor protection relays are used to protect the windings in the stator from damage due to electrical faults and thermal overloads. Adequate motor protection not only prevents motor damage, but also ensures optimal process efficiency and minimal interruption. Cost recovery for protection is achieved by extending the life of the motor, preventing motor rewinds and reducing downtime.

Common Motor Problems

Overload and Overtemperature

Insulation breakdown is a common reason for motor failure. Windings in the motor are insulated with organic materials including epoxy and paper. Insulation degradation occurs when winding temperature exceeds its rating. The National Electrical Manufacturers Association (NEMA) states that the time-to-failure of organic insulation is halved for each 8 to 10°C rise above the motor insulation class rating. This point is illustrated in Figure 11.

Solution: An I^2t Thermal Model provides thermal-overload protection of motor windings during all phases of operation. By integrating the square of the current over time, a thermal model can predict motor temperature and react much quicker than embedded temperature devices. A thermal model takes into consideration the motor service factor, full-load current and class. A dynamic thermal model adjusts the time-to-trip depending on how much motor thermal capacity has been used. Figure 12 illustrates the adjustment in trip time for different current levels at different levels of used thermal capacity.

A dynamic thermal model allows conservative protection of a motor and allows operations to get the maximum work out of a motor without sacrificing available life. If the motor is hot (high % used thermal capacity) it will trip more rapidly during an overload than if the motor is cold (0% used thermal capacity). In the event of a stall condition, when available motor torque is lower than the torque required by the load, the motor can be de-energized before it overheats.

Many old-technology electronic thermal overloads do not take into consideration the values of load current below the full-load current (FLA) pick-up value. Modern overload relays should model currents above and below the FLA pick-up current to achieve maximum output of the motor and maximum life of insulation.

On larger induction motors, blockage or loss of ventilation can cause motor hot spots that current-based protection cannot detect without the use of temperature sensors. Resistance temperature detectors (RTDs) are an inexpensive device installed between the stator windings during manufacturing and may be included on motor-end bearings. An RTD has a linear change in resistance over its rated temperature range. Using information from an RTD, motor protection relays can provide protection for loss-of-ventilation, loss-of-cooling, or high-ambient-temperature.

The RTD temperature reading can also be used as input to the thermal model to improve protection.

When hot-motor compensation is enabled, the maximum stator-RTD temperature is used to bias the thermal model by increasing used I^2t when the RTD temperature is greater than the thermal-model temperature.

Overcurrent, Jam and Undercurrent

Overcurrent faults, also referred to as short circuits, can cause catastrophic motor failures and fires. Overcurrents can be caused by phase-to-phase and phase-to-ground-to-phase faults.

A mechanical jam, such as a failed bearing or load, can cause locked-rotor current to be drawn by the motor, resulting in overheating.

Undercurrent protection is required by some codes as a safety measure. A water pump that cavitates can be dangerous. The water typically provides pump cooling. Without the cooling water, case temperature can reach an extremely high value. If valves are opened under these conditions and cold water is allowed to reach red-hot metal parts, the resulting steam pressures can destroy the pump and pose a serious personnel hazard.

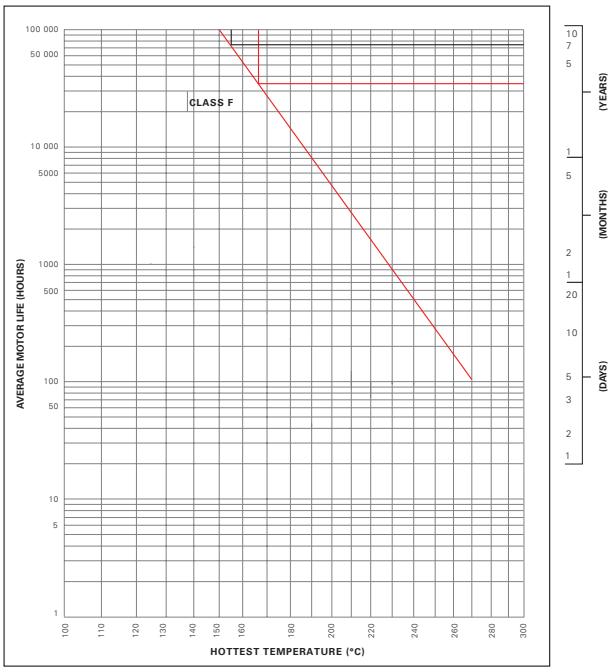


FIGURE 11

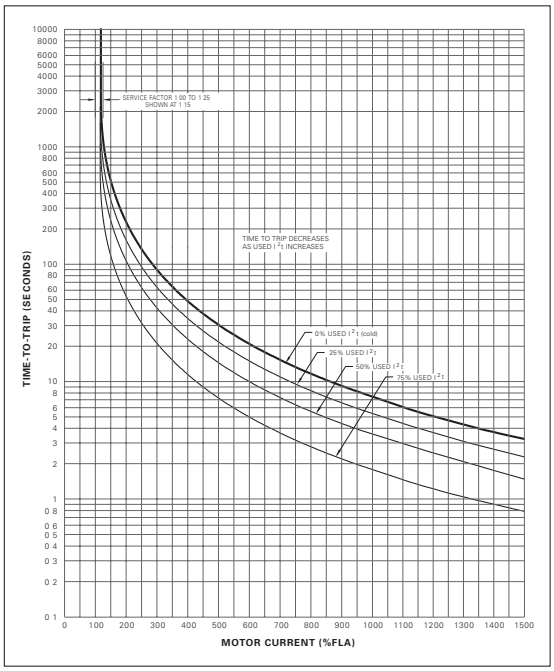


FIGURE 12

Solutions: A multifunction motor protection relay has multiple trip and alarm settings for current protection. Overcurrent protection is typically set above locked rotor current and has a minimal delay time. Overcurrent protection may be used to trip a breaker instead of a starter due to the high fault levels. Jam protection is set below overcurrent and has a slightly longer delay time. Jam protection prevents motor heating that would otherwise lead to an overload trip. Jam protection is enabled after the motor is running to avoid tripping on starting current. Undercurrent is set below full-load current to detect loss of load.

Under and Overvoltage

Overvoltages cause insulation stress and premature breakdown. Undervoltages, such as those caused by brownouts, can lead to increased motor heating. Torque developed by an electric motor changes as the square of the applied voltage. A 10% reduction in voltage results in a 19% reduction in torque. If the motor load is not reduced, the motor will be overloaded.

Solution: Under and overvoltage protection are features found in a higher-end motor-protection relays. Voltage protection can be used proactively to inhibit a start.

Ground Faults

Ground faults are the most common fault and can lead to more serious problems. Ground-fault protection, described elsewhere in this text, is an important consideration in motor loads.

Solution: The motor protection relay should be able to detect low-level ground-fault current when used on a resistance-grounded system.

High Resistance Winding Faults

Winding-to-winding and winding-to-ground failures inside the motor are difficult to detect using the phase and ground-fault CTs due to low magnitudes of current.

Solution: Differential protection in high-end motor protection relays use multiple CTs to compare the current entering and leaving the winding. If there is a difference in currents then leakage is occurring. This sensitive protection is used on very large motors.

Current and Voltage Unbalance, Phase Loss, Phase Reverse

Older motor protection did not consider current unbalance and today it is often overlooked. Unbalance increases negative-sequence current which causes additional rotor heating.

Phase loss is also referred to as single phasing. When a phase loss occurs, negative-sequence current is equal to the positive-sequence current and unbalance is 100%. In this condition, one motor winding attempts to do the work of three, inevitably leading to overheating.

Phase reversal causes the negative-sequence current and voltage to be greater than the positive-sequence current and voltage. Voltage-based protection is advantageous to prevent a start with incorrect sequence. In some

applications attempting to spin the motor backwards will result in damage to the load. An example of this is certain impeller designs in downhole pumps.

Solution: Modern motor protection relays use digital signal analysis to measure true-sequence components. These sequence components are used for thermal model calculations and take the extra heating into consideration. Voltage unbalance which drives current unbalance can be used as a start inhibit. Sequence components are also used for calculating unbalance, phase loss and phase reversal.

Motor Jogging

NEMA designed motors are rated for two starts from cold and one start from hot per hour. Motor jogging refers to excessive starts and can cause overheating. The motor may not get up to full speed and the forced air cooling is not effective.

Solution: Since the thermal model accurately tracks the motor's used thermal capacity at all times, including during starts and between starts, the starts-per-hour feature may not be required.

It is included for compatibility with protection relays that do not have dynamic thermal-modeling capability.

Motor protection and the NEC®

The NEC® requires the motor be protected by overload devices against excessive heating due to overload and failure to start (NFPA70 430 Section III).

NFPA 70 430, Part IV also specifies the use of devices to protect against overcurrents such as short circuits and grounds. Both of these NEC® requirements and many additional functions can be met with the use of a multifunction motor-protection relay.

NFPA 70 430.32 (A)(4) requires the use of a protection device having embedded temperature detectors that cause current to the motor to be interrupted when the motor attains a temperature rise greater than marked on the nameplate in an ambient temperature of 40°C for motors larger than 1500 hp.

The NEC® defines minimum requirements and is intended to provide protection from fire. Protection relays can provide many enhancements to a facility above simple fire protection.

Communications

Network communications can be added to a motor protection relay to allow remote metering of currents, voltages and temperatures. Datalogging is a useful feature for troubleshooting and comparing event sequences with process stages. Analysis of information can often show operational issues.

Supplemental Monitoring

Monitors are single function devices that only look at one abnormal condition and either alarm or provide a means to remove power. Visual indication can also be used. The purpose of a monitor is to provide a low-cost solution to a dedicated problem. Monitors are typically added to existing protection, such as fuses, circuit breakers, or protection relays.

Insulation Monitors

The single most common reason for electrical system failure is insulation breakdown. Insulation monitors can be installed at any point in the system to detect a problem with the insulation. The monitor is connected to one phase and injects a dc signal to continuously measure the system's insulation resistance. The monitor is typically installed on de-energized feeders or motors and is cycled with feeder's circuit breaker or motor starter. When the circuit breaker is open, the monitor is energized and begins to monitor the de-energized cables and motor windings. In ungrounded systems, the monitor will continuously monitor the insulation resistance to ground regardless whether the system is energized or de-energized.

Ground Continuity Monitors

Ground check monitors are used to detect problems in equipment ground conductors. Mobile equipment typically has an extra wire, or pilot wire, routed with the phase conductors. A monitor uses this pilot wire to send a signal down to the equipment to a terminating device, where the signal is sent back on the equipment ground conductor to the monitor. The monitor continuously monitors this loop for open or short circuits, indicating that a problem has occurred. The monitor provides an alarm for this condition.

As an example, portable loads are grounded via single or multiple conductors in a trailing cable. A ground fault on a portable load will cause fault current to flow through the ground conductors and all other ground-return paths. A hazardous touch voltage can develop when the ground conductor opens and a ground fault develops, assuming there is not enough current to trip a ground-fault relay. If the portable equipment has rubber tires or is not in good contact with earth, then the next person to touch the equipment under fault conditions will become part of the ground-return path.

Resistor Monitors

As discussed in the resistance grounded systems section, a failure in the neutral to ground path will lead to a dangerous situation. Some examples of failure are stolen wires, loose connections, corrosion and broken resistor elements. The resistor monitor continuously monitors the path from system neutral to ground for a problem. When a problem occurs, the monitor provides an alarm.

III. CT APPLICATION

Current Transformers (CTs)

A current transformer is defined as a transformer that produces a current in its secondary circuit that is in proportion to its primary current.

Although there are other types of CTs, only the window (or ring) type will be discussed here. Window-type CTs get their name from their design that consists of a ring-shaped core. This core is formed by a single length of strip ferromagnetic material tightly wound to form the ring-shaped core.

A CT operates on a principle of flux balance, as shown in Figure 13. If the primary winding is energized with the secondary circuit open circuited, the transformer becomes an iron-cored inductor. The primary current generates a magnetic flux in the core as shown (flux direction can be determined by the right-hand rule). When the secondary winding is connected to a burden or is short circuited, current flows through the secondary winding creating magnetic flux in the core in opposition to the magnetizing flux created by the primary current. If losses are ignored, the secondary flux balances exactly to the primary flux. This phenomenon is known as Lenz's Law.

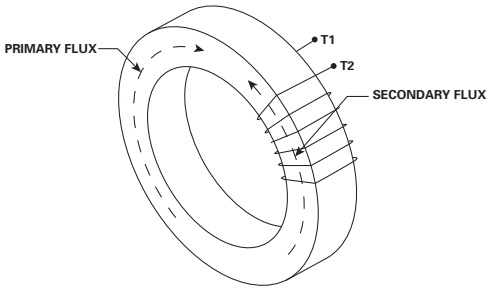


FIGURE 13

Lead Length

The secondary lead resistance of CTs cannot be ignored, particularly with low Volt-Amperes (VA) CTs. For example, let's look at an electronic overload relay.

The relay's CT input impedance or burden (Z_B) = 0.01Ω

The maximum current (I) = 10 A

The CT rating (P) = 5VA

Now let's solve for the maximum length of #14 AWG leads that will result in a rated accuracy for a 10A secondary current. Solving for maximum total impedance (Z_T):

$P = I^2Z_T$

$Z_T = P / I^2 = 5 / 10^2 = 0.05\Omega$

Solving for the maximum lead resistance (Z_W):

$Z_T = Z_W + Z_B$

$Z_W = 0.05 - 0.01 = 0.04\Omega$

If we look up the #14 AWG resistance we find it equals 2.6 ohms/1000 ft.

Therefore, lead length = Z_W / #14 AWG resistance

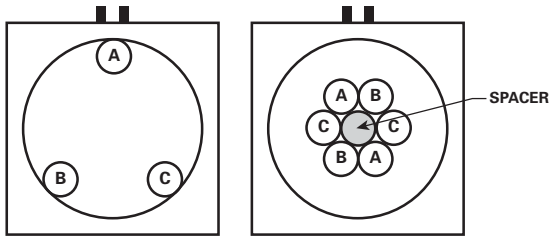
Lead length = (0.04 x 1000) / 2.6 = 15.4 ft.

CT Installation

A CT should not be operated with its secondary open-circuited. If the secondary is opened when primary current is flowing, the secondary current will attempt to continue to flow so as to maintain the flux balance. As the secondary circuit impedance increases from a low value to a high value the voltage across the secondary winding will rise to the voltage required to maintain current flow. If the secondary voltage reaches the breakdown voltage of the secondary winding, the insulation will fail and the CT will be damaged. Furthermore, this situation presents a personnel shock hazard.

When a ring-type CT is used to monitor a single conductor or multiple conductors, the conductors should be centred in the CT window, as shown below, and should be perpendicular to the CT opening.

In some applications it is difficult or impossible to install the primary conductor through the CT window (example: existing bus bar structure). For these applications a split core CT is sometimes used. Performance of split core CTs may be less than that of solid core CTs.



Incorrect *Correct*

FIGURE 14

CT characteristics are normally specified at a single frequency such as 50 or 60 Hz. Therefore the question arises: What happens when CTs are used with variable frequency drives (VFDs)? For CTs that are linear to approximately 10x rated primary current at 60 Hz, the Volts / Hertz ratio is approximately constant. That is, for all other conditions held the same at 6 Hz, the CT will be linear to only 1x rated current and at 30 Hz the CT will be linear to 5x rated current. For a standard silicon steel-core CT, the upper bandwidth frequency is approximately 5 kHz.

IV. RESISTANCE GROUNDING CONVERSION

Convert Ungrounded to Resistance Grounded Systems

Resistance grounding protects a system against transient over-voltages caused by arcing ground faults and it provides a method to locate ground faults. (Transient over-voltages and inability to locate ground fault are the most common safety issues with Ungrounded systems.)

Conversion of delta-connected or wye-connected sources with inaccessible neutrals require a zig-zag transformer to derive an artificial neutral for connection to the neutral grounding resistors (NGRs). The artificial neutral is only used for the NGR and not for distribution. During normal operation the only current that flows in the zig-zag transformer is an extremely small magnetizing current. When one phase is grounded, the NGR and the zig-zag transformer provide a path for ground-fault current to flow.

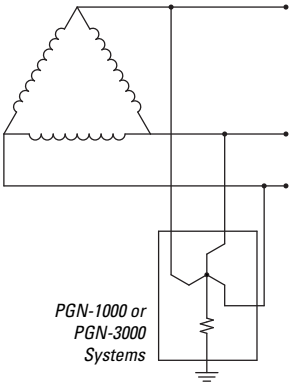


Figure 1

Design Note 1: The PGN Families of NGR systems include the zig-zag transformer when specified.

Design Note 2: The PGN system requires a 3-phase connection to the existing power system, typically at the main transformer or switchgear. See Figure 1.

Design Note 3: The resistor let-through current must be greater than the system capacitive charging current *(See Section I).*

Design Note 4: Protection, coordination, and annunciation systems depend on the integrity of the NGR. PGN-1000 Series has an option for resistor monitoring, whereas the PGN-3000 Series includes resistor monitoring.

Convert Solidly-Grounded to Resistance Grounded Systems

Resistance grounding protects a system against Arc Flash Hazards caused by ground faults and it provides a method for continuous operation or an orderly shut-down procedure. (Ground faults are estimated to be 95% of all electrical faults.)

Since the neutral point of the power source is available, the solid connection between neutral and ground is replaced with a grounding resistor. This resistor physically limits the ground fault current to a pre-determined value, typically 5A for 480V systems (the system capacitive charging current is usually less than 3A). By limiting the ground fault current to 5A or less, there are no Arc Flash Hazards associated with ground faults. This allows for continuous operation during the first ground fault.

During a ground fault on a Resistance Grounded (RG) system, a voltage shift occurs (the same shift experienced on Ungrounded systems). The faulted phase collapses to ~0V and the non-faulted phases rise to line-to-line voltage with respect to ground and the neutral point rises to line-to-neutral voltage with respect to ground.

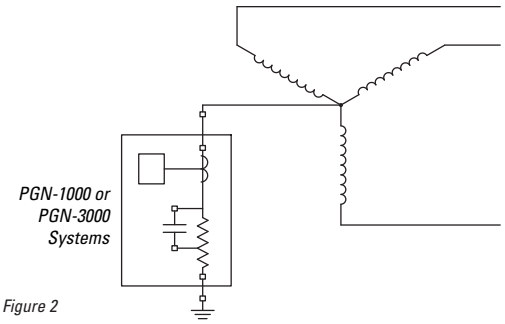


Figure 2

Design Note 1: The PGN system requires a neutral connection to the existing power system, typically at the main transformer or switchgear. See Figure 2.

Design Note 2: The voltage shift requires equipment to be fully rated at line-to-line voltage with respect to ground. This may require TVSSs, VFDs, meters, etc. to be reconfigured or replaced.

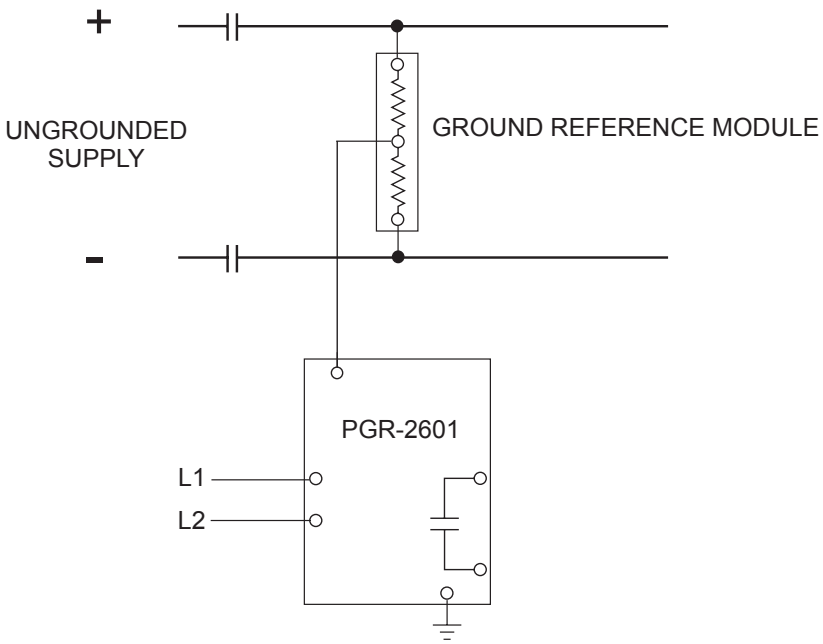
Design Note 3: The voltage shift also restricts neutral distribution. The neutral cannot be distributed due to its potential during ground faults. Line-to-neutral loads must be served by a 1:1 isolation transformer or converted to line-to-line loads.

Design Note 4: The resistor let-through current must be greater than the system capacitive charging current (*see Section I).*

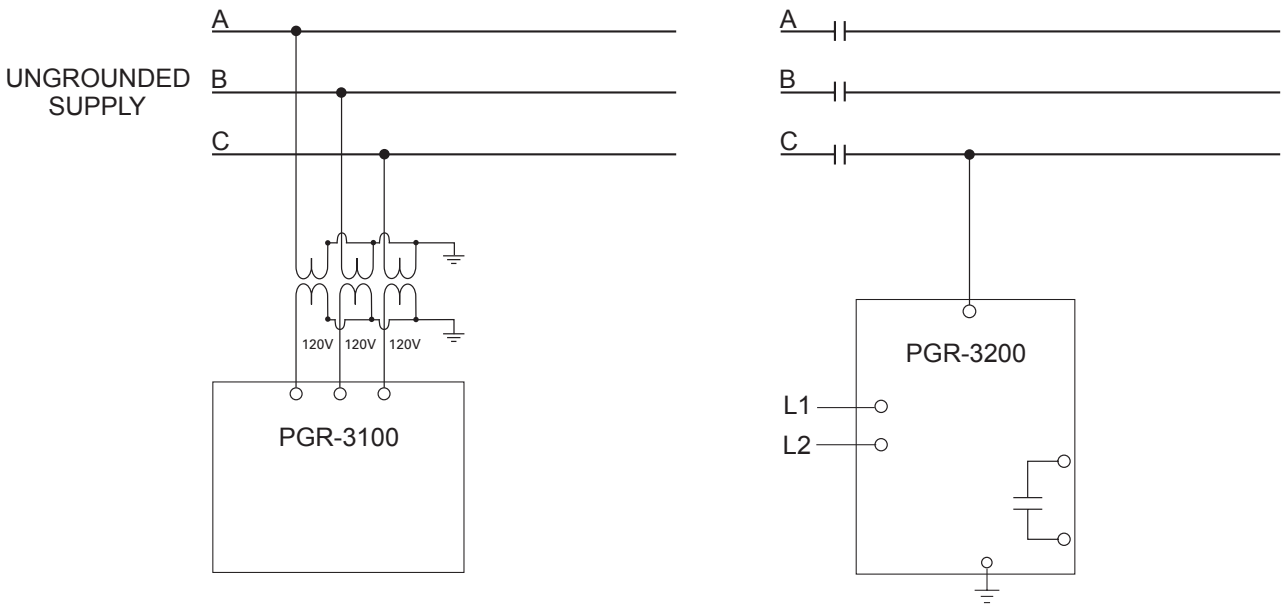
Design Note 5: Protection, coordination, and annunciation systems depend on the integrity of the NGR. PGN-1000 Series has an option for resistor monitoring, whereas the PGN-3000 Series includes resistor monitoring.

GFP
GROUND FAULT PROTECTION

DC GROUND-FAULT PROTECTION

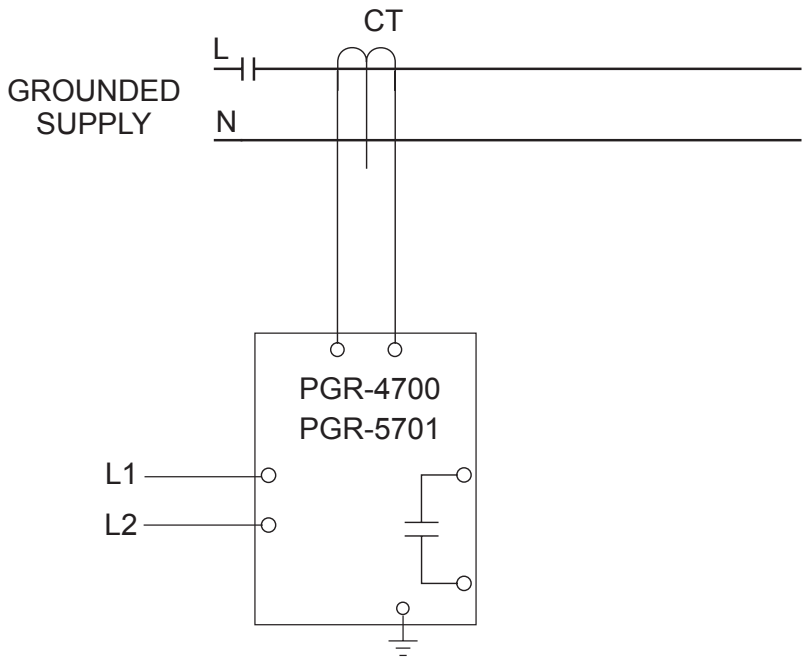


UNGROUNDED GROUND-FAULT DETECTION

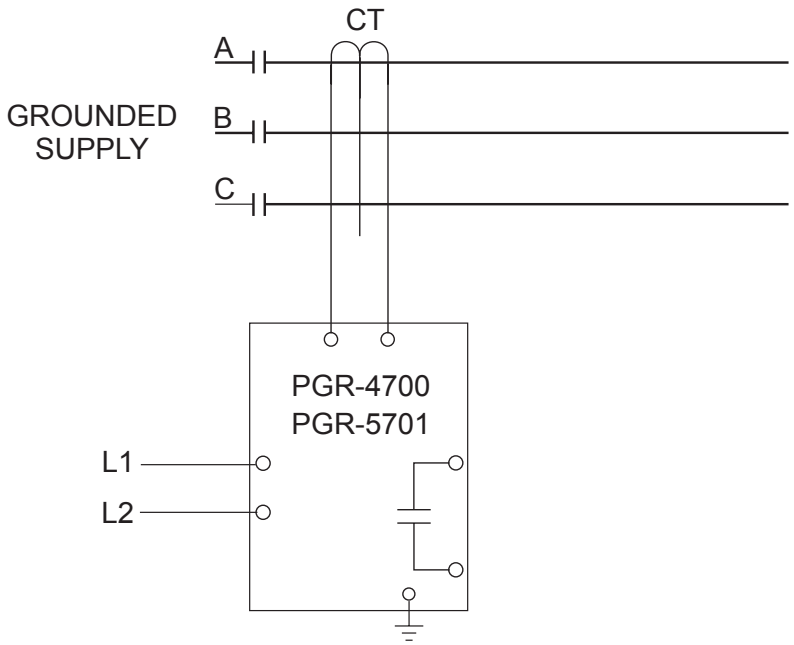


GFP
GROUND FAULT PROTECTION

SINGLE-PHASE GROUND-FAULT PROTECTION

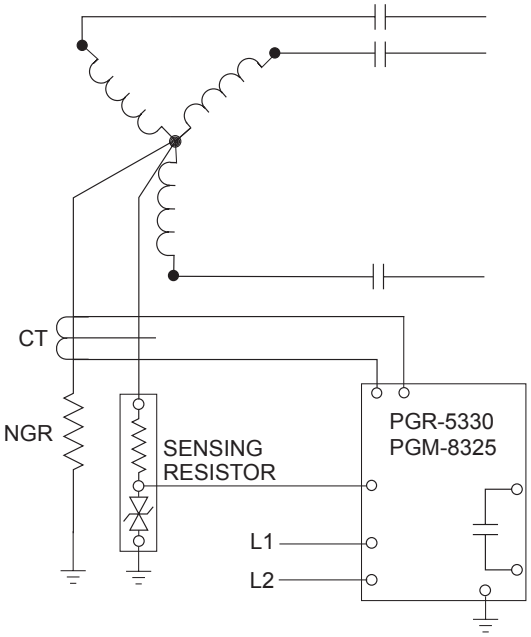


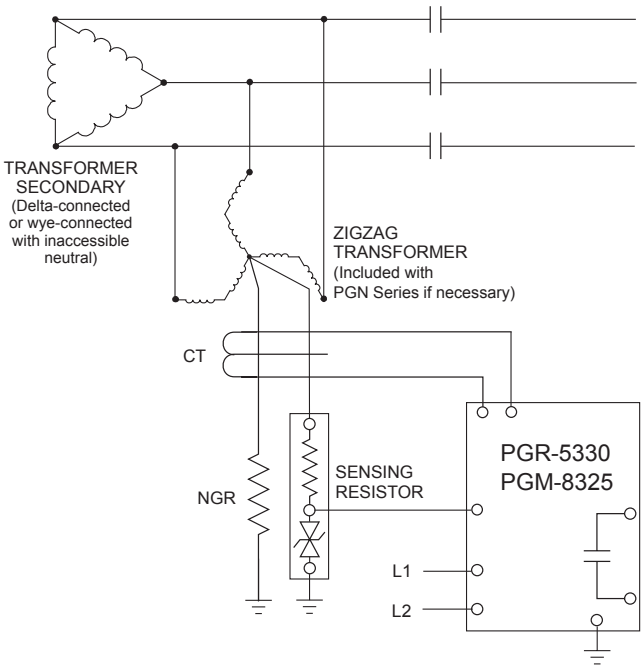
THREE-PHASE GROUND-FAULT PROTECTION



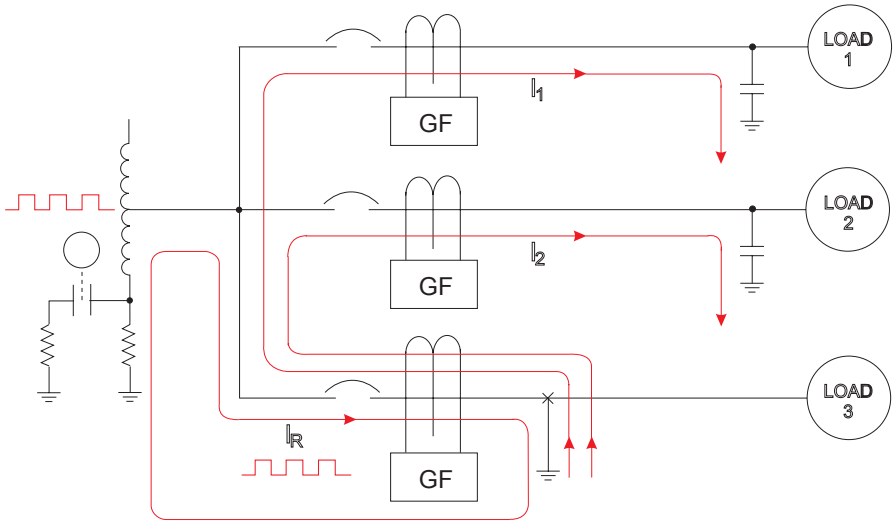
GFP
GROUND FAULT PROTECTION

RESISTANCE GROUNDING



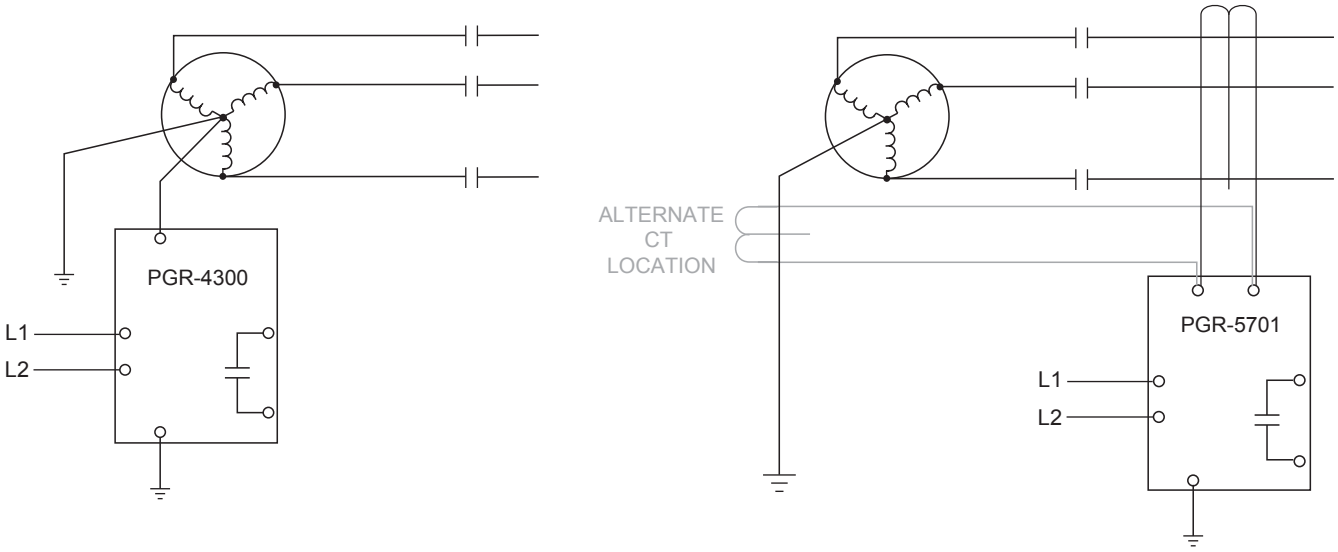


PULSING GROUND-FAULT SYSTEMS

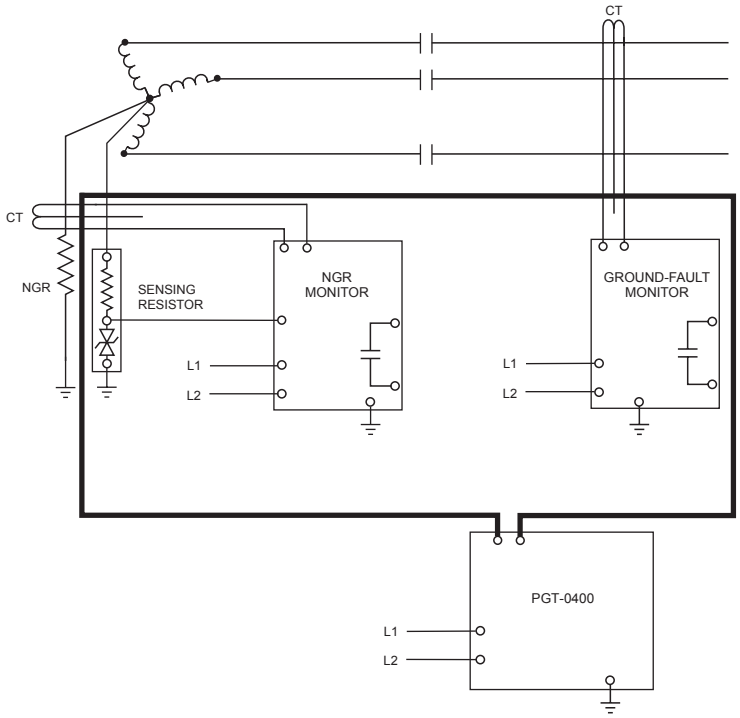


GFP
GROUND FAULT PROTECTION

GENERATOR GROUND-FAULT PROTECTION

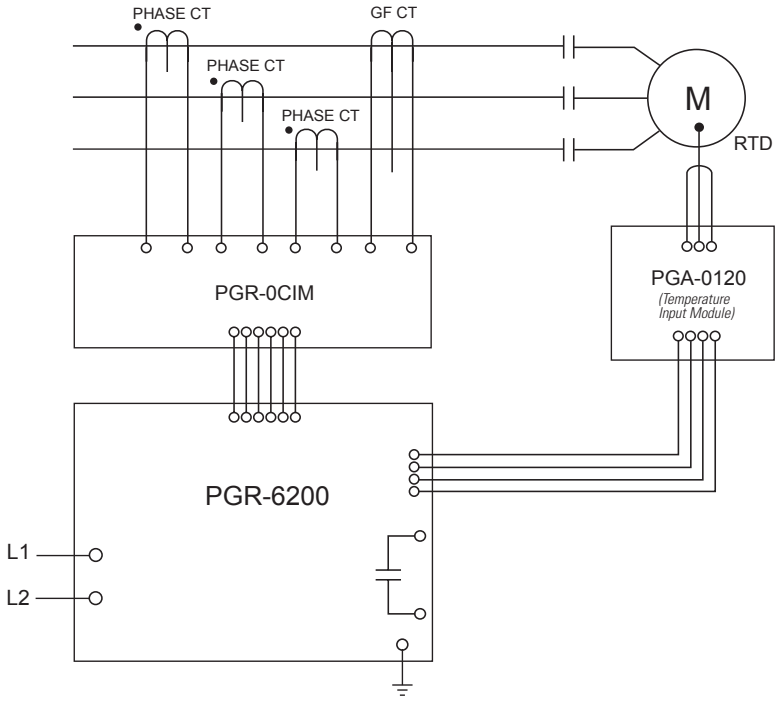


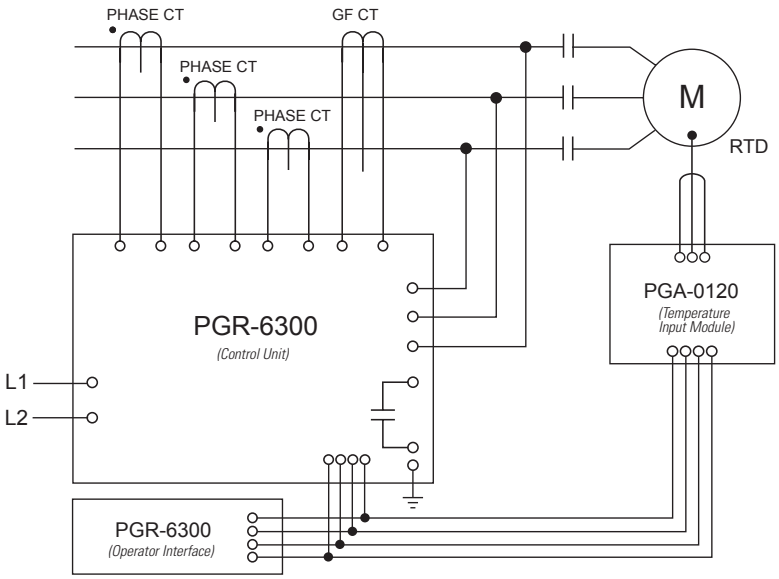
GROUND-FAULT-RELAY TEST UNIT



MP
MOTOR PROTECTION

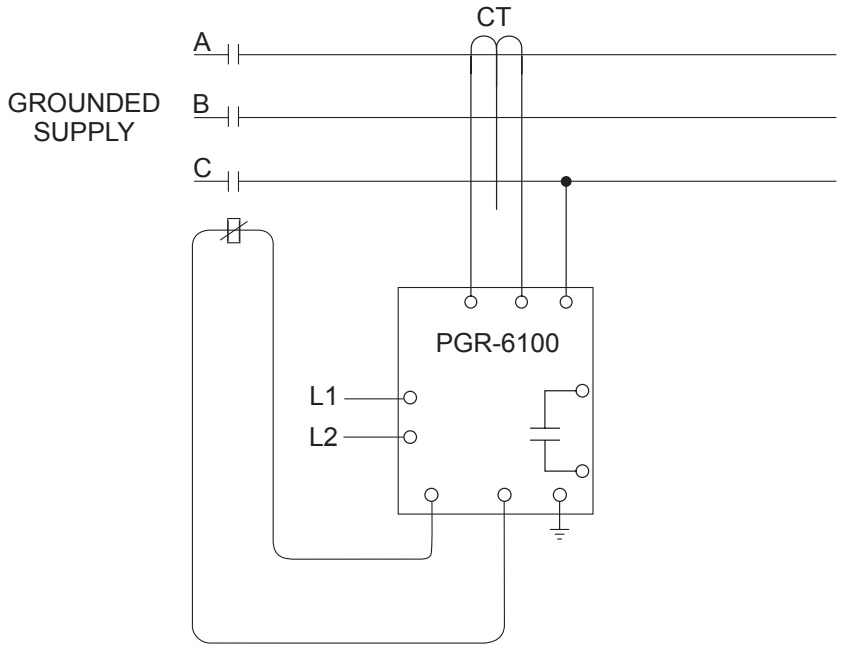
MOTOR PROTECTION UNIT



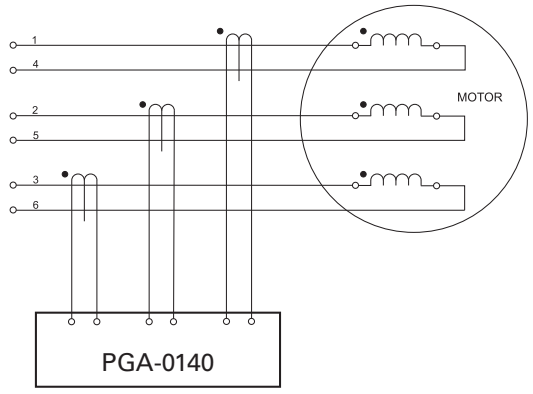


MP
MOTOR PROTECTION

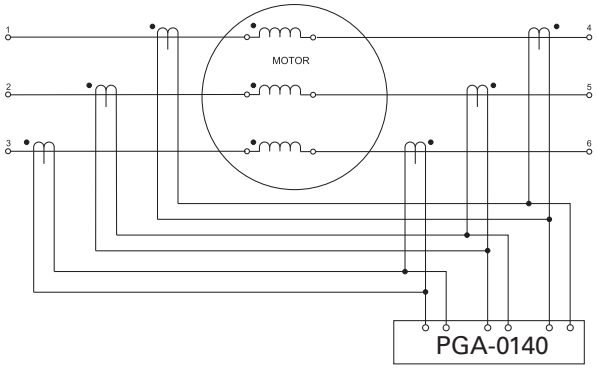
GROUND FAULT PROTECTION AND INSULATION MONITORING



MOTOR DIFFERENTIAL PROTECTION



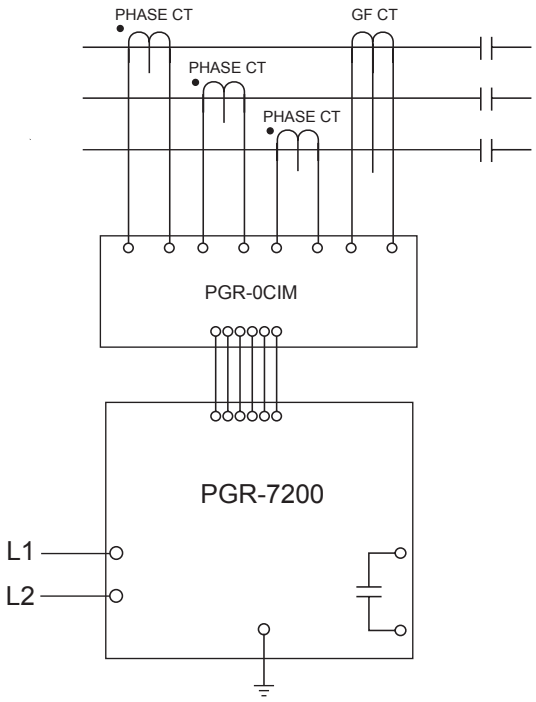
Core-Balance Connection



Summation Connection

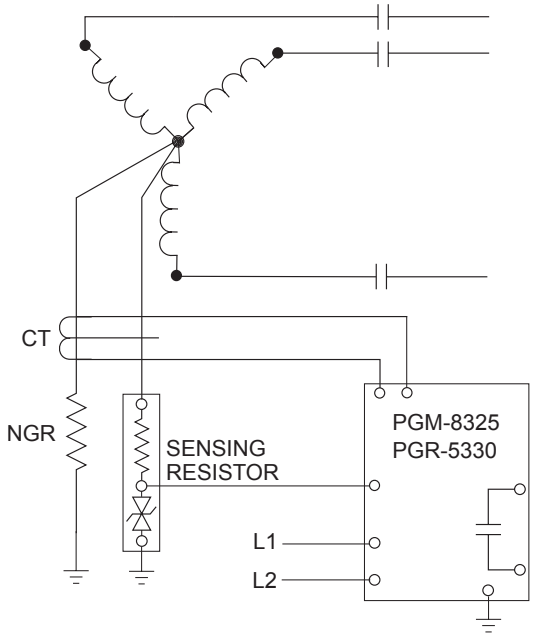
FP
FEEDER PROTECTION

FEEDER PROTECTION UNIT

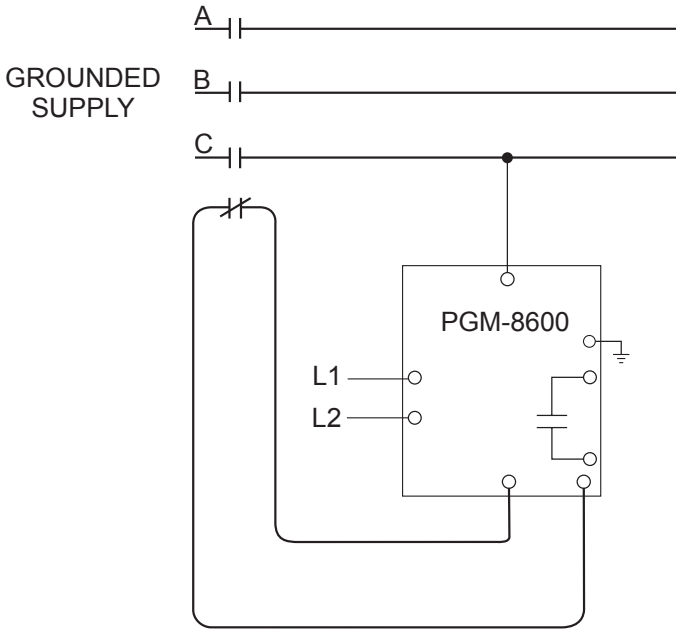


SM
SUPPLEMENTAL MONITORING

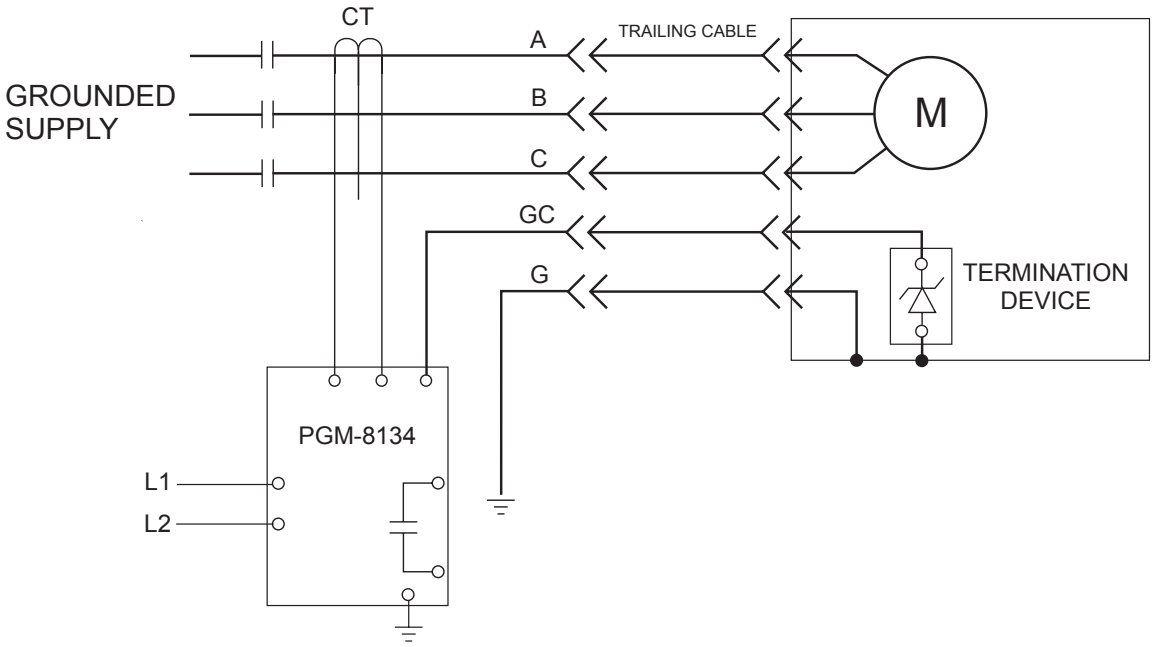
RESISTOR MONITOR



INSULATION MONITOR



GROUND-FAULT GROUND-CHECK MONITOR



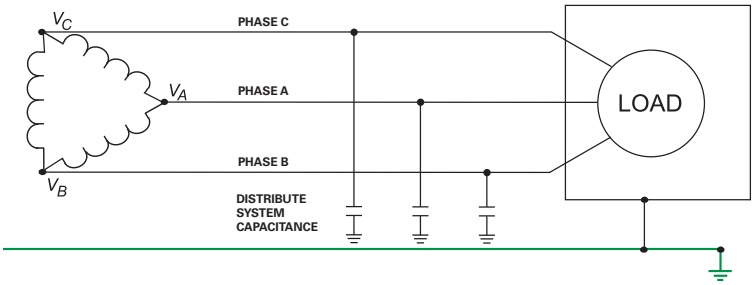
UNGROUNDED SYSTEM

Advantages

- Operation possible with one faulted phase

Disadvantages

- Ground faults are difficult to locate
- Transient overvoltages damage equipment



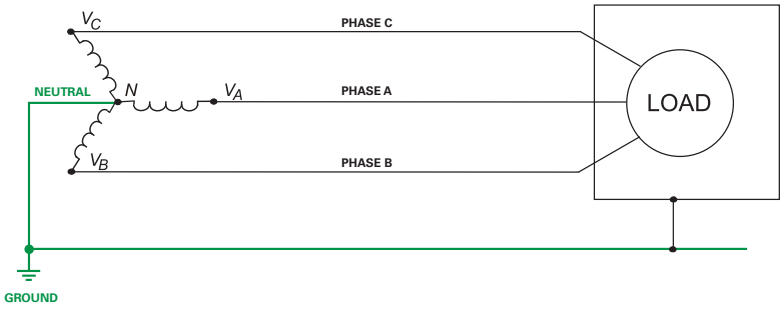
SOLIDLY GROUNDED SYSTEM

Advantages

- Eliminates transient overvoltages
- Selective tripping possible

Disadvantages

- Costly point-of-fault damage
- Cannot operate with a ground fault
- Ground-fault Arc-Flash hazard
- Increased Arc-Flash risk



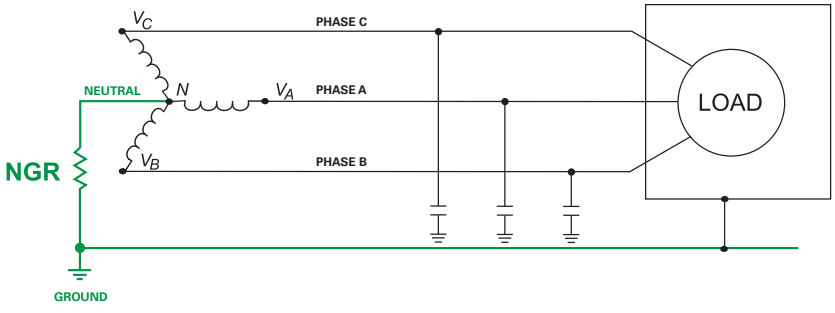
RESISTANCE GROUNDED SYSTEM

Advantages

- Reduced point-of-fault damage and Arc-Flash risk
- Eliminates transient overvoltages
- Simplifies ground-fault location
- Continuous operation with a ground fault
- Selective tripping possible
- No ground-fault Arc-Flash hazard

Disadvantages

- Failure of the neutral-grounding resistor renders current-sensing ground-fault protection inoperative



POWR-GARD RELAYS QUICK REFERENCE GUIDE

PRODUCT	TYPE	SYSTEM	TYPICAL APPLICATIONS	NO CALIBRATION	VISUAL INDICATION	WARRANTY	COMM	CONFORMAL COATING	BENEFITS	PAGE #
PGR-2601	GF Relay	UG DC	DC control systems, battery charging systems, transportation systems	●		5 years		o	Remembers trip status when power is cycled, safely run with GF	8
PGR-3100	GF Relay	UG AC	Older industrial facilities	●		5 years		o	Meets NEC Article 250.21(B)	9
PGR-3200	GF Relay	UG AC	Older industrial facilities		o	5 years		o	Meets NEC Article 250.21(B), provides 2 warnings	10
PGR-4300	GF Relay	SG AC	Manufacturers, rental companies & users of solidly grounded generators	●	o	5 years		o	No CTs, Can be used on 3&4 pole switches, alarms when generator becomes ungrounded	11
PGR-4700	GF Relay	SG AC	Motors, generators, pumps, irrigation systems, heating cables, SCR-controlled heaters, semiconductor mfg. equipment	●	o	5 years		o	Detects low level arcing faults, detects CT wiring problems up to 3A	12
PGR-5330	GF Relay	RG AC	Resistance Grounded Systems	●		5 years	●	o	Can be used on any system up to 35 kV & any resistor size	14
PGR-5701	GF Relay	SG or RG AC	Main, feeder, or load protection, motors, generators, pumps, heating cable, adjustable-speed drives	●	o	5 years		o	Remembers trip status when power is cycled, wide trip range greater than 3A	13
PGN-1000	Systems	UG AC or SG AC	Used on MV systems to reduce Arc-Flash hazards		o	5 years	o		Optional resistor monitoring	24
PGN-3000	Systems	UG AC or SG AC	Used on LV and some MV systems to reduce Arc-Flash hazards and downtime		o	5 years	●		Std. resistor monitoring, eliminates GF Arc-Flash Hazards, allows to safely run with GF	25
PGR-6100	Basic Motor Prot. Relay	AC systems	Smaller motors that need additional protection (typically < 100hp)	●	●	Limited Lifetime		o	Detects problems when motor is energized or de-energized, detects problems w/ CT wiring	15
PGR-6200	Standard Motor Prot. Relay	AC systems	Smaller motors in critical applications & med-sized motors in standard applications (typically > 100hp)	●	●	Limited Lifetime	●	●	Thermal modeling for better accuracy, Arc-Flash hazard reduction, opt. temp and diff. monitoring	16
PGR-6300	Advanced Motor Prot. Relay	AC systems	Larger motors that need maximum protection (typically > 500hp)	●	●	Limited Lifetime	●	●	Thermal modeling for better accuracy, Arc-Flash hazard reduction, opt. temp and voltage monitoring, can be used as starter control	17
PGR-6210	Retrofit Kit	Induction Motors	Replaces GE Multilin 169, 269 & 369	●	●	Limited Lifetime	●	●	Plug and play installation, match existing curves	18
PGR-7200	Feeder Prot. Relay	AC systems	MV distribution circuits	●	●	Limited Lifetime	●	●	IEEE & IEC curves, Arc-Flash hazard reduction	20
PGM-8134	Ground Check Monitor	Grounded AC	Shore-to-ship power, pumps, cranes, material handling	●	o	5 years		●	Provides reliable ground continuity verification	21
PGM-8325	Resistance Monitor	RG	Resistance Grounded Systems			5 years		●	Detects resistor failure	22
PGM-8600	Insulation Monitor	AC/DC systems	Systems in harsh environments such as dust, moisture, vibration or exposure to corrosive mat.	●	o	5 years		o	Detects insulation failure	23

LEGEND: UG = Ungrounded; SG = Solidly Grounded; RG = Resistance Grounded;

● standard o optional

GFP (GROUND FAULT PROTECTION) **RG** (RESISTANCE GROUNDING) **MP** (MOTOR PROTECTION)

FP (FEEDER PROTECTION) **SM** (SUPPLEMENTAL MONITORING)

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Littelfuse POWR-GARD® products and services enhance the productivity and safety of electrical systems. Along with protection relays, POWR-GARD® offers current-limiting fuses to decrease Arc-Flash exposure, fuseholders and fusecovers to reduce incidental contact, and Electrical Safety Services and worker training to improve safety.

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