Littelfuse®

Expertise Applied | Answers Delivered

POWR-GARD® PROTECTION RELAY CATALOG

PROTECTION RELAYS

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

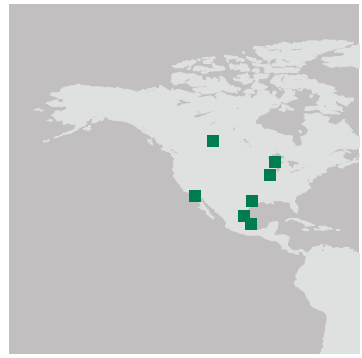
Littelfuse POWR-GARD®

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.

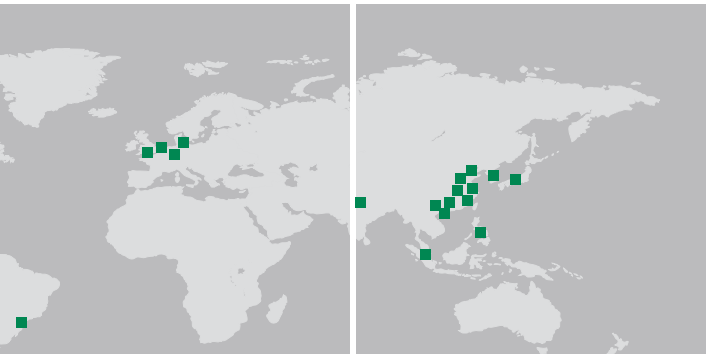
Electrical Safety Services

Safety Training

High Power Testing Lab

Products and Services

We Improve Electrical Safety and Increase Uptime



For decades Littelfuse POWR-GARD® has been helping customers improve their electrical systems. In addition to 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 field application support. This catalog outlines the Littelfuse 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 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 and NGR Monitoring

Motor and Pump Protection Relays

Feeder Protection Relays

Insulation Monitoring

Safeguard Critical Applications with POWR-GARD® Protection Relays

Petrochemical, Oil and Gas
Pipelines and Transportation
Aggregate and Cement
Pulp and Paper
Water and Waste Water
Shore-to-Ship Power
Data Centers
Semiconductor Equipment
Hospitals
Alternative Energy
Power Generators

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
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

Protection Relay 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 and Monitoring
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 and Pump Protection Relays
prevent expensive damage to motors caused by overloads, jams, phase loss or unbalance, 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, ground faults, phase loss or other detrimental conditions in critical applications and processes. They 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. These monitors are designed for application-specific functionality such as insulation monitoring, ground-continuity monitoring and resistor monitoring.

Product Selection Guide

Use the Feature Tables below and the Product Selection Guide on the following pages to choose the appropriate protection relay or monitor for your application.

Ground-Fault Relays Protective Features

FEATURE	PGR-2601	PGR-3100	PGR-3200	PGR-4300	PGR-4704	PGR-5701	PGR-5330	PGR-8134	PGM-8325	PGM-8600
Detects GF via voltage		✔	✔	✔						✔
Detects GF via current	✔				✔	✔	✔	✔	✔	
Adjustable GF Pickup	✔			✔	✔	✔	✔	✔	✔	
Adjustable Time Delay	✔			✔	✔	✔	✔	✔	✔	
Remote Reset	✔		✔	✔	✔	✔	✔	✔	✔	✔
Analog Output	✔		✔	✔	✔	✔	✔			✔
Fail-safe option	✔				✔	✔	✔	✔	✔	
Harmonic Filtering			✔	✔	✔	✔	✔	✔	✔	✔
CT-Loop Monitoring					✔	✔		✔		
Insulation Monitoring			✔							✔
Communications							✔			
Conformal Coating	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

NOTE: Tables are for reference only and include standard and optional configurations. Please see the respective catalog page for exact product specifications.

Motor and Feeder Relays Protective Features

FEATURE (IEEE #)	PGR-6100	PGR-6130	PGR-6150	PGR-6200	PGR-6300	PGR-6800	PGR-7200
Ground fault (50G/N, 51G/N)	✔		✔	✔	✔		✔
Overload (49, 51)		✔	✔	✔	✔	✔	✔
Unbalance (current) (46)		✔	✔	✔	✔	✔	✔
Phase loss (current) (46)		✔	✔	✔	✔	✔	✔
Phase reverse (current) (46)		✔	✔	✔	✔	✔	✔
PTC overtemperature (49)		✔	✔	✔	✔		✔
Undercurrent (37)			✔	✔	✔	✔	✔
Jam			✔	✔	✔		✔
Overcurrent (50, 51)			✔	✔	✔		✔
Failure to accelerate			✔		✔		
RTD temperature (38, 49)				✔	✔		✔
Starts per hour (66)				✔	✔		
Differential (87)				✔	✔		
Reduced Overcurrent Setting				✔	✔		
Phase loss (voltage) (47)					✔		
Phase reverse (voltage) (47)					✔		
Unbalance (voltage) (47)					✔		
Overvoltage (59)					✔		
Undervoltage (27)					✔		
Power factor (55)					✔		
Overfrequency (81)					✔		
Underfrequency (81)					✔		
Starter Control					✔		
Underspeed (14)					✔		
Integrated CTs		✔	✔			✔	
Off-line Insulation Monitoring	✔						
Metering and Data Logging			✔	✔	✔		✔
Communications			✔	✔	✔		✔
Conformal Coating	✔			✔	✔		✔

NOTE: Tables are for reference only and include standard and optional configurations. Please see the respective catalog page for exact product specifications. IEEE Device Numbers are shown in parenthesis after the applicable features.

GFP

GROUND-FAULT PROTECTION

STEP 1 Select product category

STEP 2 Select the needed features in each category

STEP 3 This is the recommended product for your application

UNGROUNDED DC SYSTEM	UNGROUNDED AC SYSTEM	SOLIDLY GROUNDED AC SYSTEM
Detect Ground Faults	Locate Ground Fault & Reduce Transient Overvoltage	Increase Up-Time & Reduce Potential for Arc Flash

- Locate Ground Fault & Reduce Transient Overvoltage → YES: Convert System to Resistance Grounding pgs. 32 & 33
- Locate Ground Fault & Reduce Transient Overvoltage → NO: Detect Insulation Breakdown
  - Detect Insulation Breakdown → YES: **PGR-3200** pg. 10
  - Detect Insulation Breakdown → NO: **PGR-3100** pg. 9
- Increase Up-Time & Reduce Potential for Arc Flash → YES: Convert System to Resistance Grounding pgs. 32 & 33
- Increase Up-Time & Reduce Potential for Arc Flash → NO: Ground-Fault Protection for Generators
  - Ground-Fault Protection for Generators → YES: **PGR-4300** pg. 11
  - Ground-Fault Protection for Generators → NO: Ground-Fault Alarm Level
    - Ground-Fault Alarm Level → 10 mA - 5 A: **PGR-4704** pg. 12
    - Ground-Fault Alarm Level → > 5 A: **PGR-5701** pg. 13
- Detect Ground Faults: **PGR-2601** pg. 8






RG

RESISTANCE GROUNDING

NEUTRAL-GROUNDING-RESISTOR MONITORING

Pulsing, Digital Filtering, Communications and Software

YES

Identify Faulted Feeder

YES

use in combination

PGR-5330 & PGR-5701

pg. 14 *pg. 13*

NO

PGR-5330

pg. 14

NO

PGM-8325

pg. 29

Implement Low-Resistance Grounding

PGN-1000

pg. 32

Implement High-Resistance Grounding

PGN-3000

pg. 33

MP

MOTOR PROTECTION

BASIC

Ground-Fault Protection and Insulation Monitoring

PGR-6100

pg. 16

STANDARD

Protection for Low-Voltage Motors (<1000 V)

Typically <75 hp

PGR-6130

pg. 17

Typically >50 hp

optional display

PGR-6150

pg. 18

MP MOTOR PROTECTION

ADVANCED	PUMPS	RETROFITS
Multi-Function Protection, Reduced Arc-Flash Risk	Undercurrent Protection	Pre-wired, Plug & Play Replacement for Obsolete Relays

Voltage Protection and Starter Control

NO YES

PGR-6200 *pg. 20*

PGR-6300 *pg. 22*

PGR-6800 *pg. 24*

PGR-6210/PGR-6310 *pg. 26*

Motor Protection Relays

FP FEEDER PROTECTION

BASIC	ADVANCED
Ground-Fault Protection and Insulation Monitoring	Multi-Function IEEE/IEC Overload Protection

PGR-6100 *pg. 16*

PGR-7200 *pg. 25*

Feeder Protection Relays

SM SUPPLEMENTAL MONITORING

MONITORS		
Ground Conductor	Neutral-to-Ground	Insulation

PGM-8134 *pg. 28*

PGM-8325 *pg. 29*

PGM-8600 *pg. 30*

Monitors

TABLE OF CONTENTS

PROTECTION RELAYS, MONITORS AND SYSTEMS

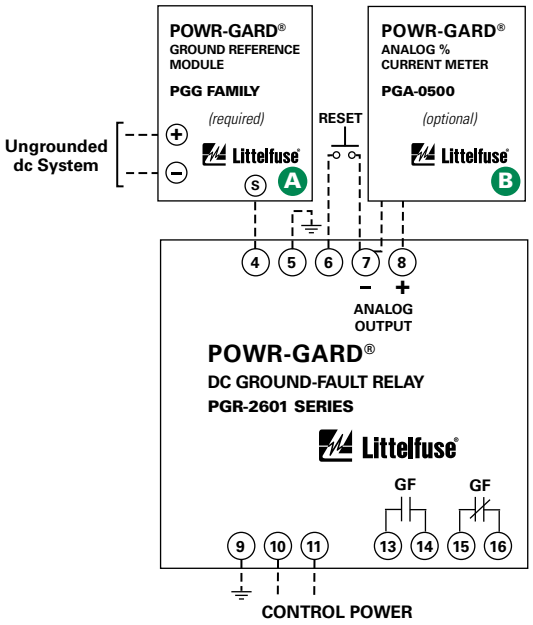
Wiring Diagrams Legend for Following Pages

- *All output contacts 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

Wiring Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
PGR-2601-OD	9-36 Vdc
PGR-2601-OT	32-70 Vdc
PGR-2601-OU	75-275 Vac/dc

ACCESSORIES	REQUIREMENT	PAGE
PGG Family	Required	39
PGA-0500	Optional	41

Note: For optional conformal coating please consult factory.

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 Family Ground-Reference Module—a resistor network that limits ground-fault current to 25 mA. The PGR-2601 is used on ungrounded dc systems ranging from industrial 24-Vdc control circuits to 1000-Vdc transportation systems.

Features & Benefits

FEATURES	BENEFITS
Adjustable Pickup (1–20 mA)	Sensitive setting provides a wide range of low-level protection
Adjustable Time Delay (50 ms–2.5 s)	Adjustable trip delay allows quick protection or delayed response
Output Contacts	Form A and Form B ground-fault output contacts for operation of separate annunciation and trip circuits
Analog Output (0–5 V)	Provides means for connecting to a meter (PGA-0500) or a control system
Non-Volatile Trip Memory	Retains trip state when de-energized to simplify troubleshooting
Selectable Contact Operating Mode	Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil
Microprocessor Based	No calibration required saves on maintenance cost

Accessories

A 

PGG Family Ground Reference Module
Required accessory, used to connect the PGR-2601 Ground-Fault Relay to a dc bus.

B 

PGA-0500 Analog % Current Meter
Optional panel-mounted analog meter displays ground-fault current as a percentage of 22 mA.

Specifications

IEEE Device Numbers	DC Overcurrent Relay (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
Output Contacts	Isolated Form A and Form B
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Test Button	Standard feature
Reset Button	Standard feature
Communications	Analog output
Conformally Coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PGK-0055 or PGK-0060 adapter)

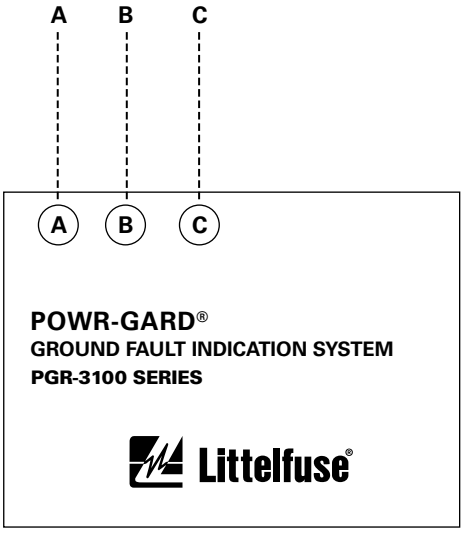
PGR-3100 SERIES

Ground-Fault Indication System

Description

The PGR-3100 indicates the presence of voltage on each phase of a three-phase system. The LEDs on the panel illuminate 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. 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. PTs are not required for system voltages up to 600 Vac.

Wiring Diagram



Features & Benefits

FEATURES	BENEFITS
NEC® Code Compliant	Meets National Electrical Code (NEC®) Article 250.21(B) requirements for ungrounded systems
Phase LEDs	Indicates presence of a ground fault and the faulted phase as well as phase-to-ground voltage on an energized bus
Redundant LEDs	Redundant long-life LEDs (two per phase) ensure reliability
Lamp Test Button	Verifies LEDs are operating

Specifications

Input Voltage	Up to 600 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 feature
Conformally Coated	Standard feature
Warranty	5 years
Mounting	Panel

Ordering Information

CATALOG/SYSTEM NUMBER	MOUNTING
PGR-3100	Panel Mount

Note: To convert to a resistance grounded system, see the PGN Series packages on pages 32 and 33. Also see system overview section starting at page 56.

PGR-3200 SERIES

Ground-Fault Protection Relay

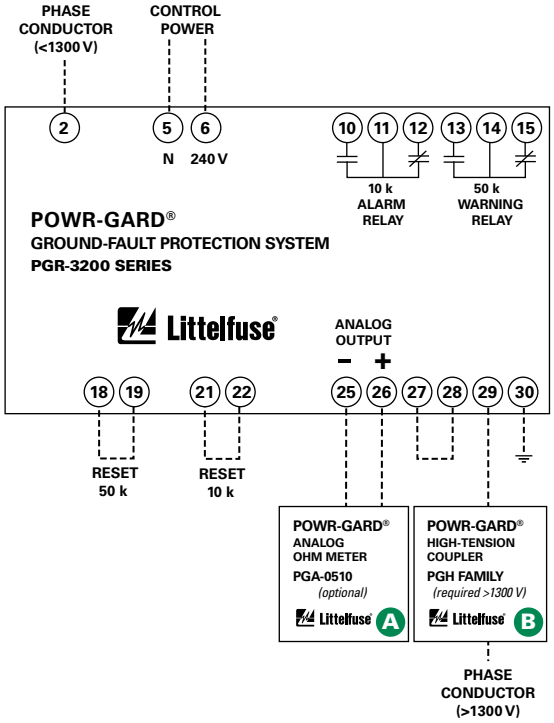
Description

The PGR-3200 detects ground faults by continuously monitoring the insulation integrity of ungrounded electrical systems. The relay monitors the insulation for damage, providing predictive maintenance and troubleshooting for developing ground faults by providing two warnings and an alarm. The unit operates on one- or three-phase ungrounded systems up to 6 kV.

Features & Benefits

FEATURES	BENEFITS
NEC® Code Compliant	Meets National Electrical Code (NEC®) Article 250.21(B) requirements for ungrounded systems
Output Contacts (50 kΩ)	Form C output contact for alarming purposes
Output Contacts (10 kΩ)	Form C output contact for tripping purposes
Analog Output (0–1 mA)	Provides means for connecting an optional meter (PGA-0510) or control system
Harmonic Filtering	Eliminates nuisance tripping
DIN-Rail or Surface Mount	Flexible options for ease of installation

Wiring Diagram



Accessories

A **PGA-0510 Analog Ohm Meter**
Optional PGA-0510 Analog Meter allows for remote metering of insulation resistance.

B **PGH Family High Tension Coupler**
Required (for systems >1,300 V) PGH Family high-tension coupler must be connected between the phase conductor and the PGR-3200 ground-fault relay.

Specifications

IEEE Device Numbers	Undervoltage Relay (27) Ground (Earth) Detector Relay (64)
Input Voltage	240 Vac, 50–60 Hz
Dimensions	**H** 100 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 feature
Reset Button	Standard feature
Output Contacts	Two Form C
Communications	Analog output
Conformally Coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface

Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
PGR-3200	240 Vac

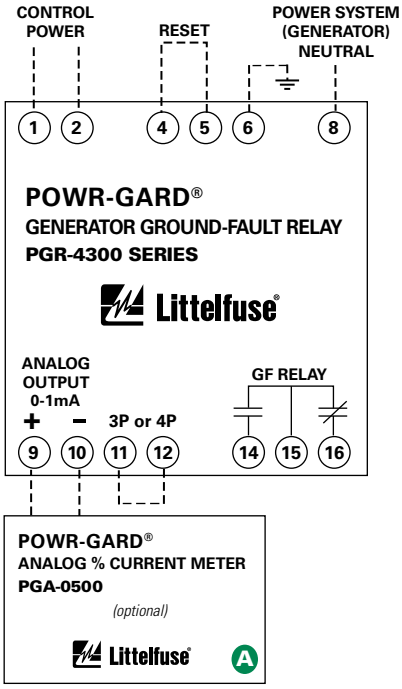
ACCESSORIES	REQUIREMENT	PAGE
PGH Family	Required >1300 V	42
PGA-0510	Optional	41

Note: For optional conformal coating please consult factory. To convert to a resistance grounded system, see the PGN Series packages on pages 32 and 33. Also see system overview section starting at page 56.

PGR-4300 SERIES (GFA300)

Generator Ground-Fault Relay

Wiring Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
PGR-4300-12	12 Vdc
PGR-4300-24	24 Vdc
PGR-4300-120	120 Vac

ACCESSORIES	REQUIREMENT	PAGE
PGA-0500	Optional	41

Note: For optional conformal coating please consult factory.

Description

The PGR-4300 Generator Ground-Fault Relay provides a simple method for detecting a ground-fault condition on generators without the need for current transformers (CTs). This greatly simplifies the installation. In addition, it is compatible with both three- and four-pole transfer switches. This relay also monitors the neutral-to-ground path for continuity. The PGR-4300 is ideal for any gen-set or application where there is not sufficient space to install CTs.

Features & Benefits

FEATURES	BENEFITS
No CTs Required	Saves space and simplifies installation. Use with 3-pole or 4-pole transfer switches
Adjustable Pickup (100–1200 A)	Adjustable trip setting provides a wide range of protection and system coordination
Adjustable Time Delay (0–1.0 s)	Adjustable trip delay allows quick protection and system coordination
Output Contacts	Form C ground-fault output contacts for alarming or tripping purposes or control system
Analog Output (0–1 mA)	Provides means for connecting an optional meter (PGA-0500) or control system
N-G Alarm	Monitors neutral-to-ground integrity and alarm if ground path becomes open circuit
Harmonic Filtering	Eliminates nuisance tripping

Accessories

A 

PGA-0500 Analog % Current Meter
Optional panel-mounted analog meter displays ground-fault current as a percentage of the set-point.

Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N)
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 feature
Reset Button	Standard feature
Output Contacts	Form C
Approvals	UL listed
Communications	Analog output
Conformally Coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PGK-0055 or PGK-0060 adapter)

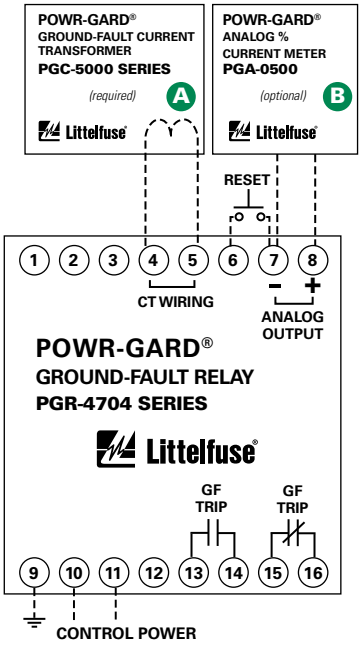
PGR-4704 SERIES

Sensitive Ground-Fault Relay

Description

The PGR-4704 is a microprocessor-based ground-fault relay for resistance- and solidly grounded systems. It offers very sensitive ground-fault detection as low as 10 mA on systems with significant harmonic content. The PGR-4704 provides feeder-level protection or individual-load protection. The output contacts can be connected for use in protective tripping circuits or in alarm indication circuits. The analog output can be used with a PLC or a meter.

Wiring Diagram



Features & Benefits

FEATURES	BENEFITS
Adjustable Pickup (10 mA–5 A)	Adjustable trip setting provides a wide range of low-level protection and system coordination
Adjustable Time Delay (30 ms–2.0 s)	Adjustable trip delay allows quick protection and system coordination
Output Contacts	Form A and Form B ground-fault output contacts for operation of separate annunciation and trip circuits
Analog Output (0–5 V)	Allows for connecting an optional meter (PGA-0500) or control system
CT-Loop Monitoring	Alarms when CT is not connected
Selectable Contact Operating Mode	Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil
Harmonic Filtering	Eliminates nuisance tripping
Non-Volatile Trip Memory	Retains trip state when de-energized to simplify troubleshooting
Microprocessor Based	No calibration required saves maintenance cost
Universal Power Supply	Allows operation in applications where one side of PT is faulted

Accessories

A 

PGC-5000 Series Ground-Fault Transformer
Required zero-sequence current transformer specifically designed for low level detection. Flux conditioner is included to prevent saturation.

B 

PGA-0500 Analog % Current Meter
Optional panel-mounted analog meter displays ground-fault current as a percentage of the set-point or 5 A.

Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N)
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 – 5.0 A
Trip Time Settings	30–2000 ms
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard feature
Test Button	Standard feature
Reset Button	Standard feature
CT-Loop Monitoring	Standard feature
Output Contacts	Isolated Form A and Form B
Approvals	CSA certified to US and Canadian standards, CE (European Union)
Communications	Analog output
Conformally coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PGK-0055 or PGK-0060 adapter)

Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
PGR-4704-OD	9-36 Vdc
PGR-4704-OT	32-70 Vdc
PGR-4704-OU	75-275 Vac/dc

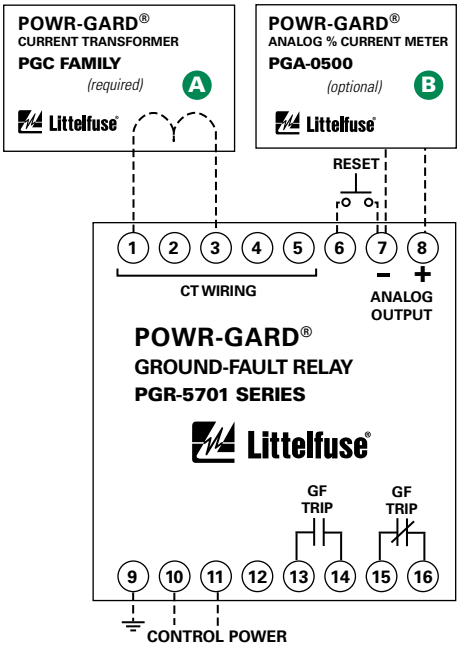
ACCESSORIES	REQUIREMENT	PAGE
PGC-5000 Series	Required	38
PGA-0500	Optional	41

Note: For optional conformal coating please consult factory.

PGR-5701 SERIES

Ground-Fault Relay

Wiring Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
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

ACCESSORIES	REQUIREMENT	PAGE
Current Transformers	Required	38
PGA-0500	Optional	41

Note: For optional conformal coating please consult factory.

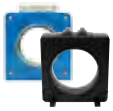
Description

The PGR-5701 is a microprocessor-based ground-fault relay for resistance- and solidly grounded systems. It is uniquely suited for use on systems with significant harmonic content. The PGR-5701 can provide main-plant protection, feeder-level protection, or individual-load protection. Proper current transformer selection provides the desired pickup range. The output contacts can be connected for use in protective tripping circuits or in alarm indication circuits. The analog output can be used with a PLC or a meter.

Features & Benefits

FEATURES	BENEFITS
Adjustable Pickup (unlimited)	Trip setting based on input CT primary, allows use with any CT
Adjustable Time Delay (50 ms–2.5 s)	Adjustable trip delay allows quick protection and system coordination
Output Contacts	Form A and Form B ground-fault output contacts for operation of separate annunciation and trip circuits
Analog Output (0–5 V)	Allows for connecting an optional (PGA-0500) meter or a control system
CT-Loop Monitoring	Alarms when CT is not connected
Selectable DFT or Peak Detection Algorithm	Compatible with variable-speed drives
Harmonic Filtering	Eliminates nuisance tripping
Non-Volatile Trip Memory	Retains trip state when de-energized to simplify troubleshooting
Microprocessor Based	No calibration required saves on maintenance cost
Universal Power Supply	Allows operation in application where one side of PT is faulted

Accessories

A 

PGC Family Ground-Fault Current Transformer
Required current transformer, model depending on application. We offer a variety of sensitive CTs with 5- and 30-A primaries.

B 

PGA-0500 Analog % Current Meter
Optional panel-mounted analog meter displays ground-fault current as a percentage of the CT primary rating.

Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N)
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 feature
Test Button	Standard feature
Reset Button	Standard feature
CT-Loop Monitoring	Standard feature
Output Contacts	Isolated Form A and Form B
Approvals	CSA certified to US and Canadian standards
Communications	Analog output
Conformally coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PGK-0055 or PGK-0060 adapter)

PGR-5330 SERIES

Resistance Grounded Relay

Description

The PGR-5330 is an advanced ground-fault and grounding-resistor-monitoring relay. It measures neutral current, neutral-to-ground voltage, and neutral-to-ground resistance. It provides continuous monitoring of the neutral-to-ground path to verify that the neutral-grounding resistor (NGR) is intact. This is of utmost importance because an open NGR renders current-sensing ground-fault protection inoperative. The PGR-5330 can be used with low- and medium-voltage transformers and generators used in processing, manufacturing, chemical, pulp and paper, petroleum, and water-treatment facilities.

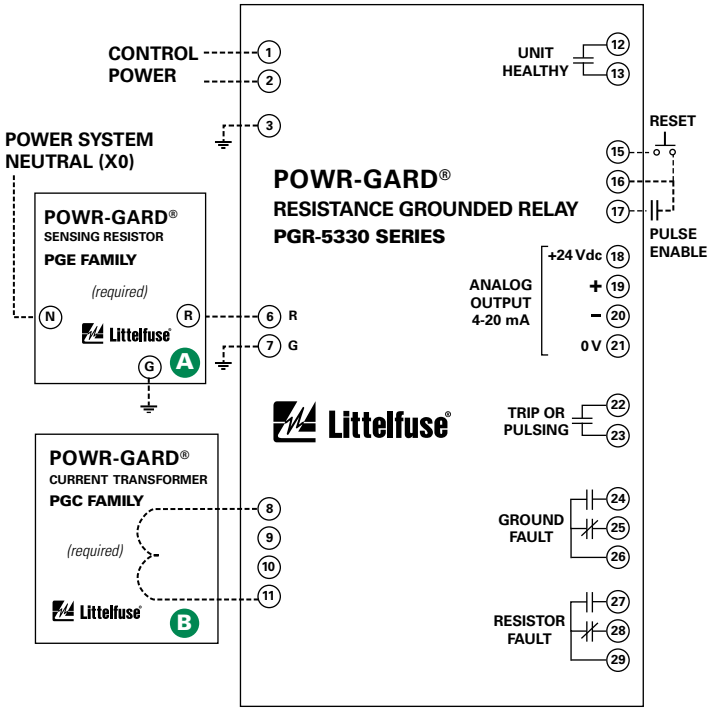
Resistor Monitoring

The PGR-5330 combines the measured values of resistance, current, and voltage to continuously determine that the NGR is intact. It is able to detect a resistor failure with or without a ground fault present. Voltage-rated sensing resistors are used to monitor NGRs on systems up to 35 kV.

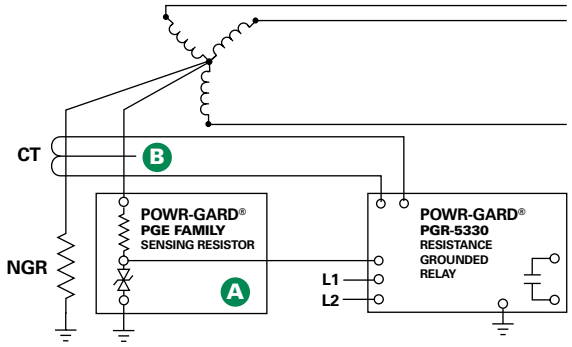
Ground-Fault Monitoring

The PGR-5330 uses an application-appropriate current transformer to reliably detect ground-fault currents as small as 100 mA. DFT filtering ensures that false trips due to harmonic noise from adjustable-speed drives do not occur. Should the resistor open and a ground fault subsequently occur, the PGR-5330 will detect the fault through voltage measurement, while other current-sensing relays will be ineffective.

Wiring Diagram



Simplified Circuit Diagram



Accessories

A 

PGE Family Sensing Resistors
Required interface between the power system and the PGR-5330. Eliminates hazardous voltage levels at the relay.

B 

PGC-3000 Ground-Fault Current Transformers
Sensitive ground-fault current detection (5 A primary)

PGC-5000 Ground-Fault Current Transformers
Sensitive ground-fault current detection (30 A primary)

Other Current Transformers
For low resistance NGRs choose a CT primary approximately equal to the NGR rating.

Features & Benefits

FEATURES	IEEE #	BENEFITS
Continuous NGR Monitoring	3GC	Detects resistor failure within seconds, reduces transient-overvoltage risk, removes risk of ground-fault-detection failure
Ground-Fault Detection	50G/N, 51G/N	Main or backup protection to detect a ground fault anywhere on the monitored system
Adjustable Pickup (unlimited)		Select greatest sensitivity without false operation
Adjustable Time Delay (0.1–10 s)		Adjustable trip delay allows quick protection and system coordination
Universal CT Compatibility		Allows the use of a CT that gives required ground-fault settings
Output Contacts		Two form C output contacts (ground-fault and resistor fault)
Analog Output (4–20 mA)		Allows for connecting an optional PGA-0500 meter or control system
Pulsing Output		Control the operation of a pulsing ground-fault-location circuit
Data Logging		On-board 10-event recorder helps with system diagnostics
Harmonic Filtering (DFT)		Eliminate false trips due to harmonic noise from ASDs
Local Communications		RS-232 port to view measured values, log to a PC & check event records
Network Communications		Remotely view measured values, event records & reset trips
Software		PC-interface software is included
Selectable Contact Operating Mode		Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil
Auto-Reset Switch		Selectable latching or auto-reset operation
Calibrate Push Button		Ensures resistor-failure sensitivity is correct
Unit-Healthy Output		Verifies PGR-5330 is operating correctly
Conformal Coating		Internal circuits are conformally coated to protect against corrosion and moisture

Typical Values

SYSTEM VOLTAGE (VOLTS)	NEUTRAL-GROUNDING RESISTOR		SENSING RESISTOR		GROUND-FAULT PICKUP LEVEL (AMPERES)	V_N PICKUP LEVEL (VOLTS)
	CURRENT (AMPERES)	RESISTANCE (OHMS)	MODEL	RESISTANCE (SWITCH S5 SETTING)		
480	5	55	PGE-600V	20 kΩ	2.5	170
600	5	69	PGE-600V	20 kΩ	2.5	200
2,400	5	277	PGE-05KV	20 kΩ	2.5	800
4,160	5	480	PGE-05KV	20 kΩ	3	1,700
7,200	10	416	PGE-15KV	100 kΩ	4.5	2,000
14,400	15	554	PGE-15KV	100 kΩ	6.5	800 x 5 = 4,000

NOTE: The above table is for illustrative purposes only. Actual values may differ based on a variety of individual system considerations, such as capacitive charging current and coordination study results.

Ordering Information

CATALOG/SYSTEM NUMBER	COMMUNICATIONS	VOLTAGE
PGR-5330-00-00	RS-232	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.

ACCESSORIES	REQUIREMENT	PAGE
PGE Family	Required	42
Current Transformers	Required	38

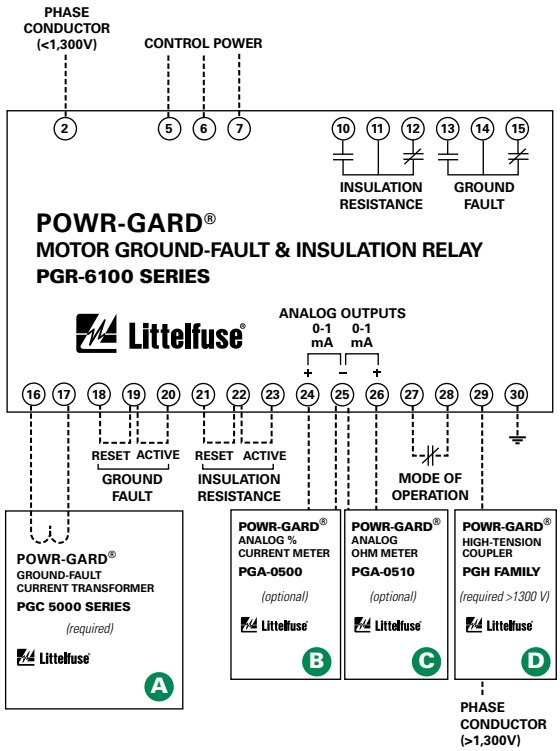
Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N), Check relay (3GC)
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 feature
Reset Button	Standard feature
Output Contacts	Two Form A and Two Form 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, self or loop powered
Conformally Coated	Standard feature
Warranty	5 years
Mounting	Panel, Surface

PGR-6100 SERIES (GFR4000)

Motor Ground-Fault & Insulation Relay

Wiring Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER	VOLTAGE
PGR-6100-120	120 Vac	50–60 Hz, 5 VA
PGR-6100-240	240 Vac	50–60 Hz, 5 VA

ACCESSORIES	REQUIREMENT	PAGE
PGC-5000 Series	Required	38
PGH Family	Required >1300 V	42
PGA-0500	Optional	41
PGA-0510	Optional	41

Note: For optional conformal coating please consult factory.

Description

The PGR-6100 combines the features of a ground-fault motor-protection relay and insulation monitor into one unit. It protects against ground faults, both when the motor is energized (by monitoring the ground-fault current) and de-energized (by monitoring the insulation resistance).The PGR-6100 features two separate analog outputs for optional current and ohm meters, and two separate alarm relays. It operates on one- or three-phase solidly grounded, resistance grounded and ungrounded systems up to 6 kV.

Features & Benefits

FEATURES	BENEFITS
Adjustable GF Pickup (10 mA–3 A)	Trip setting provides a wide range of low-level protection and system coordination
Adjustable Insulation Pickup (250 kΩ–2 MΩ)	Customizable insulation resistance setpoints for maximum protection
Adjustable Time Delay (50 ms–1.0 s)	Adjustable trip delay for quick protection and system coordination
Output Contacts	Two Form C output contacts for ground fault and insulation-resistance fault
Analog Outputs (0–1 mA)	Two analog outputs indicate insulation resistance and ground-fault current
CT-Loop Monitoring	Alarms when CT is not connected
Selectable Contact Operating Mode	Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil

Accessories

A 

PGC-5000 Series Ground-Fault Transformers
Required zero-sequence current transformer specifically designed for low level detection. Flux conditioner is included to prevent saturation.

B C 

PGA-0500 Analog % Current Meter
PGA-0510 Analog Ohm Meter
Optional panel-mounted meters display ground-fault current as a percentage of the set-point and insulation resistance.

D 

PGH Family High Tension Couplers
Required (for systems >1,300 V) PGH Family high-tension coupler must be connected between the phase conductor and the PGR-3200.

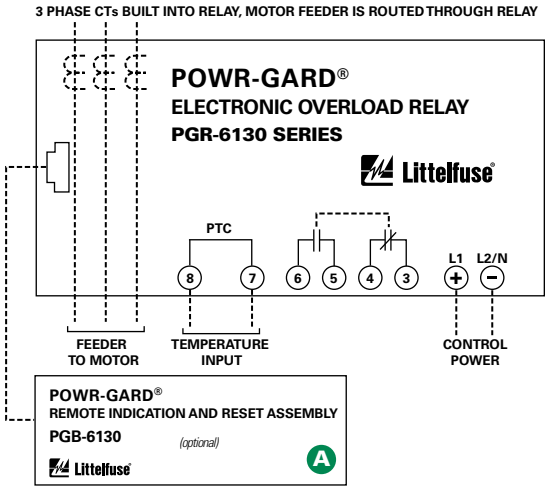
Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N), Alarm Relay (74)
Input Voltage	See ordering information
Dimensions	**H** 99.7 mm (3.9"); **W** 75 mm (3"); **D** 110 mm (4.3")
Response delay	< 250 ms
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard feature
Test Button	Standard feature
Reset Button	Standard feature
CT-Loop Monitoring	Standard feature
Output Contacts	Two Form C
Communications	Two Analog outputs
Warranty	5 years
Mounting	DIN, Surface

PGR-6130 SERIES

Electronic Overload Relay

Wiring Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER	FULL-LOAD CURRENT
PGR-6131-24	24 Vdc	4-16.7 A
PGR-6131-120	120 Vac	4-16.7 A
PGR-6131-240	240 Vac	4-16.7 A
PGR-6132-24	24 Vdc	15-40.5 A
PGR-6132-120	120 Vac	15-40.5 A
PGR-6132-240	240 Vac	15-40.5 A
PGR-6133-24	24 Vdc	40-91 A
PGR-6133-120	120 Vac	40-91 A
PGR-6133-240	240 Vac	40-91 A

NOTE: External CTs can be used for full-load currents >91 A.

ACCESSORIES	REQUIREMENT	PAGE
PGB-6130	Optional	41

Description

The PGR-6130 Electronic Overload Relay provides protection for small three-phase motors up to 1,000 Vac. No current transformers are required for currents up to 91 A. The protective functions include overload, overtemperature, phase unbalance, phase loss, and phase sequence. The PGR-6130 Electronic Overload Relay offers dependable protection and can be used on pumps, conveyor belts, ventilation fans and other small-motor applications that require standard protection.

Features & Benefits

FEATURES	BENEFITS
No CTs Required	No current transformers required for currents up to 91 A
Adjustable Trip Settings	Adjustable overload trip class setting from 5 to 35 to match motor characteristics
Output Contacts	Form A and Form B ground-fault output contacts for operation of separate annunciation and trip circuits
Remote Indication	Allows remote cause-of-trip indication and reset
Overload	Extends motor life and prevents insulation failures and fires
Phase Loss/Phase sequence	Detects unhealthy supply conditions
Unbalance (Current)	Prevents overheating due to unbalanced phases
PTC Overtemperature	Detect high ambient or blocked ventilation and single phasing; prevents shaft/pump damage

Accessories

A

PGB-6130 Remote Indication and Reset Assembly
Optional remote indication of overcurrent, phase unbalance, phase loss, phase sequence and overtemperature. Remote reset included.

Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51) Phase sequence (46) Overcurrent (51) PTC overtemperature (49) Unbalance (current) (46) Phase loss (current) (46)
Input Voltage	See ordering information
Frequency	50, 60 Hz
Dimensions	**H** 83 mm (3.3"); **W** 78 mm (3.1"); **D** 99 mm (3.9")
Test Button	Standard feature
Reset Button	Standard feature
Output Contacts	Isolated Form A and Form B
Approvals	UL listed
Warranty	5 years
Mounting	DIN

PGR-6150 SERIES

Motor Protection System

1

A

Description

The PGR-6150 Motor Protection System provides 13 protective functions by utilizing both current and temperature inputs. It is a modular system consisting of the control unit and an operator interface (PGR-6150-OPI). The OPI allows programming and displays metered values. The PGR-6150 is used to provide current- and temperature-based protection, metering and data logging for three-phase motors used in industrial environments. Current transformers are not required for currents up to 25 A.

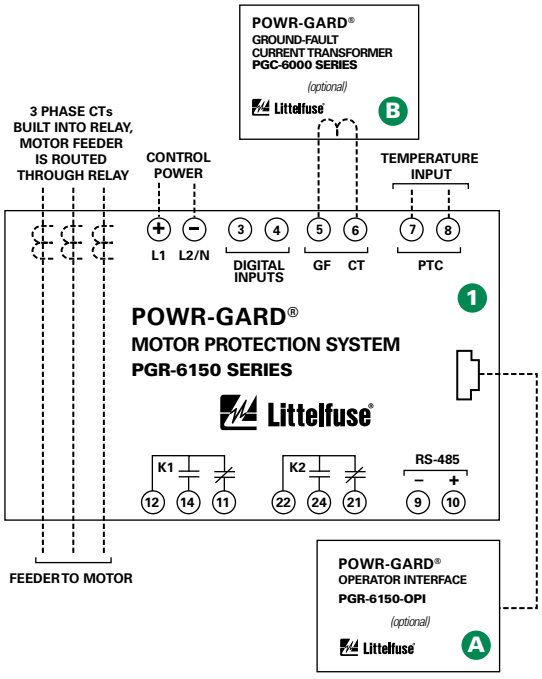
1 Control Unit

Integrated phase CTs (external for applications > 25 A)
Ground-fault CT input
One PTC input and one programmable input
Two programmable output contacts
Eight status LEDs
RS-485 Communications
DIN-rail mountable
PC interface software

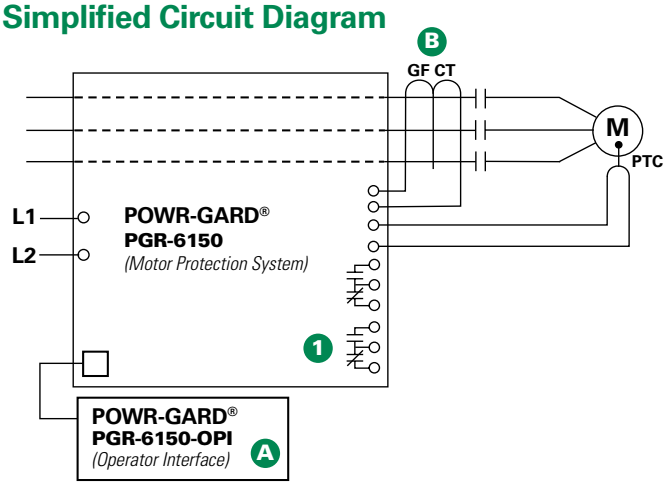
A Operator Interface (optional)

Large, bright, LCD display (2 x 20 alphanumeric characters)
Keypad for menu selection (system parameters, measurements, and fault reports)
Displays metered values
Six user-programmable LEDs
Powered by Control Unit
1 meter (39 inch) connection cable included

Wiring Diagram



Simplified Circuit Diagram



Accessories

A 

PGR-6150-OPI Operator Interface
Optional Operator Interface for displaying metered values and programming

B 

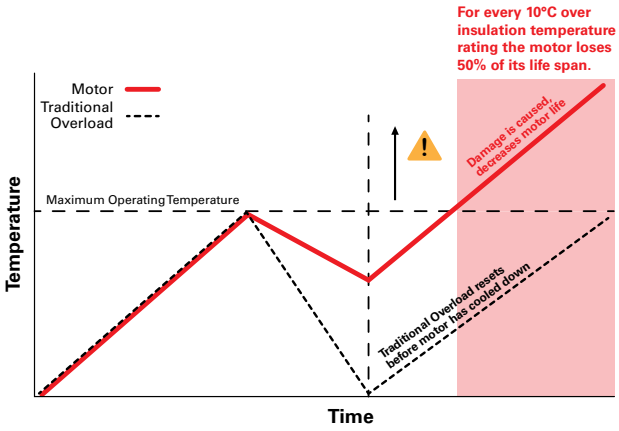
PGC-6000 Series Ground-Fault Transformer
Optional zero-sequence current transformer, used to measure ground-fault current. Required for applications >25 A.

Features & Benefits

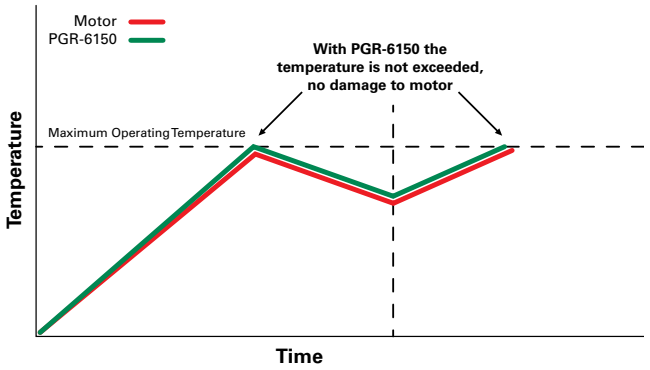
FEATURES	IEEE #	BENEFITS
No CTs required	49, 51	No current transformers are required for currents < 25 A
Adjustable Trip Settings		Adjustable overload trip class setting from 5 to 45 to match motor characteristics
Digital Input		Programmable digital input
Output Contacts		Two programmable Form C output contacts for operation of separate annunciation and trip circuits
Overload	49, 51	Extends motor life and prevents insulation failures and fires
Overcurrent/Jam	50, 51	Detects catastrophic failures and fires; extends motor life
Undercurrent	37	Detects low level or no-load conditions
Unbalance (Current)	46	Prevents overheating due to unbalanced phases
Phase Loss/Phase Sequence	46	Detects unhealthy supply conditions
PTC Overtemperature	49	Detect high ambient or blocked ventilation and single phasing; prevents shaft/pump damage
Dynamic Thermal Model		Provides protection through starting, running, overload, and cooling cycles
Communications		RS-485 communications to remotely display metered values

Dynamic Thermal Modeling

Without Thermal Memory



With Thermal Memory



Ordering Information

CATALOG/SYSTEM NUMBER	CONTROL POWER
PGR-6150-24 (Control Unit)	24/48 Vdc
PGR-6150-240 (Control Unit)	120/240 Vac/dc
PGR-6150-OPI (Operator Interface)	Powered by Control Unit

NOTE: External CTs can be used for full-load currents >25 A.

ACCESSORIES	REQUIREMENT	PAGE
PGC-6000 Series	Optional	39

Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51)	PTC overtemperature (49)
	Phase sequence (46)	Failure to accelerate
	Overcurrent (50, 51)	RTD temperature (49)
	Jam	Unbalance (current) (46)
	Ground fault (50G/N, 51G/N)	Starts per hour (66)
	Undercurrent (37)	Phase loss (current) (46)
Input Voltage	110-230 Vac/Vdc; 24/48 Vdc, 5 W	
AC Measurements	RMS, 16 samples/cycle	
Frequency	50, 60 Hz	
Dimensions		
(Control Unit)	**H** 83 mm (3.3"); **W** 78 mm (3.1"); **D** 99 mm (3.9")	
(Operator Interface)	**H** 56 mm (2.2"); **W** 106 mm (4.2"); **D** 22.8 mm (0.9")	
Output Contacts	Two Form C	
Communications	RS-485 with Modbus® RTU	
Approvals	Consult factory	
Warranty	5 years	
Mounting	DIN (Control Unit); Panel (Operator Interface)	

PGR-6200 SERIES

Motor Protection Relay

1

2

Description

The PGR-6200 Motor Protection Relay offers enhanced motor protection and metering to provide diagnostic and troubleshooting capabilities for critical process motors. The PGR-6200 is used to provide current- and temperature-based protection, metering, and data logging for three-phase low-voltage medium-horsepower induction motors. This relay is ideal for retrofitting and upgrading motor protection using existing CTs. See the PGK Family of Panel Mount Adapter Kits to replace common obsolete relays.

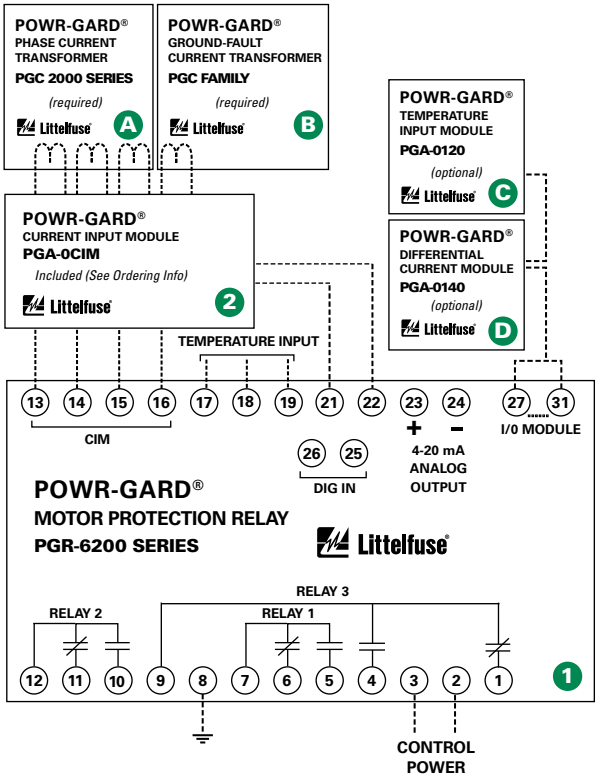
1 Motor Protection Relay

Three ac-current inputs
Earth-leakage-CT input
Programmable digital input
24-Vdc source for digital input
Programmable 4 – 20-mA analog output
Temperature-sensor input, 100-Ω-Platinum RTD or PTC
Three programmable output relays
Local RS-232 communications, optional Network Communications
PC-interface software
4 line x 20 character backlit LCD display
Keypad for programming and display selection
4 LEDs; 1 user programmable

2 Current Input Module

The PGA-0CIM Current Input Module is the interface between the PGR-6200 relay and the 5-A-secondary, 1-A-secondary, and sensitive current transformers. The PGA-0CIM is included with the PGR-6200 and can be surface or DIN-rail mounted.

Wiring Diagram



Accessories

A 

PGC-2000 Series Phase Current Transformers
Required CT detects phase current or ground-fault current (200 A primary).
Other phase CTs can be used

B 

PGC Family Ground-Fault Transformers
Required zero-sequence current transformers detect ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

C 

PGA-0120 Temperature Input Module
Optional module provides 8 inputs to connect Pt100, Ni100, Ni120, and Cu10 RTDs

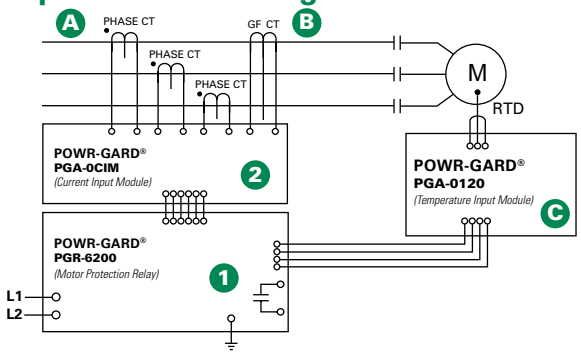
D 

PGA-0140 Differential Current Module
Optional motor differential protection, compatible with core balance and summation current transformer connections

Features & Benefits

FEATURES	IEEE #	BENEFITS
Overload		Extends motor life and prevents insulation failures and fires
Unbalance (Current)	46	Prevents overheating due to unbalanced phases
RTD & PTC Overtemperature	49	Overtemperature (PTC) protection for high ambient or loss-of-ventilation detection
Phase Loss/Phase Reverse (Current)	46	Detects unhealthy supply conditions
Overcurrent/Jam	50, 51	Detects catastrophic failures and fires; extends motor life
Undercurrent	37	Detects low level or no-load conditions
RTD Temperature	38, 49	Optional RTD temperature protection (PGA-0120 module) for high ambient or loss of ventilation protection
Starts Per Hour	66	Limits the motor starts per hour to prevent overheating
Differential	87	Optional with PGA-0140 module allows sensitive winding-fault protection
Dynamic Thermal Model		Provides protection through starting, running, and cooling cycles
Communications		Remotely view measured values, event records & reset trips
Ground Fault	50G/N, 51G/N	Prevents catastrophic failures and fires
Reduced Overcurrent Mode		Minimizes Arc-Flash hazards during maintenance
Metering		Alphanumeric display of conditions
PGA-0CIM		Separate current input module to reduce risk of CT hazard and for convenient installation
Analog Output		Provides means for metering selectable parameters
Data Logging		On-board 100-event recorder for data logging
Conformal Coating		Internal circuits are conformally coated to protect against corrosion and moisture

Simplified Circuit Diagram



Ordering Information

CATALOG/SYSTEM NUMBER	COMMUNICATION
PGR-6200-00-00	TIA-232
PGR-6200-01-00	TIA-232 & RS-485
PGR-6200-02-00	TIA-232 & DeviceNet™
PGR-6200-04-00	TIA-232 & Ethernet

NOTE: The PGR-6200 consists of the Motor Protection Relay and the PGA-0CIM Current Input Module. To order the relay only, add (-MPU) to the part number listed above.

ACCESSORIES	REQUIREMENT	PAGE
PGC Family	Optional	38
PGA 0120	Optional	41
PGA-0140	Optional	41
PGK-0SMK	Optional	41

Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51)	RTD temperature (38, 49)
	Phase reverse (current) (46)	Unbalance (current) (46)
	Overcurrent (50, 51)	Starts per hour (66)
	Jam	Phase loss (voltage) (47)
	Ground fault (50G/N, 51G/N)	Overvoltage (59)
	Undercurrent (37)	Differential (87)
	PTC overtemperature (49)	Phase loss (current) (46)
Input Voltage	65 – 265 Vac, 25 VA; 80-275 Vdc, 25 W	
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/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, programmable	
Output Contacts	Five contact relays — See Product Manual	
Approvals	CSA certified to US and Canadian standards	
Communications	RS-485 with Allen-Bradley® DFI and Modbus® RTU (Standard); DeviceNet™, Profibus®, Ethernet (Optional)	
Conformally Coated	Standard feature	
Warranty	10 years	
Mounting (Control Unit)	Panel (standard)	
	Surface (with PGK-0SMK converter kit)	
(Current Input Module)	DIN, Surface	

PGR-6300 SERIES

Motor Protection System

1

2

Description

The PGR-6300 Motor Protection System monitors voltage, current, and temperature (optional) to provide a comprehensive package of 22 protective functions. The PGR-6300 is a modular system with integrated protection, motor control, metering, and data-logging functions. This system is typically used to provide protection for three-phase low- and medium-voltage, medium- to high-horsepower induction motors.

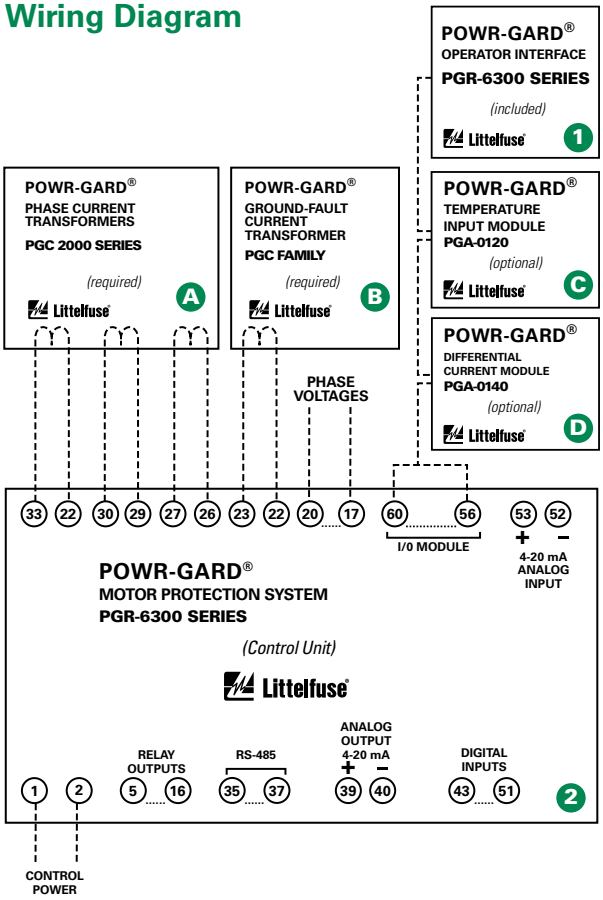
1 Operator Interface

Large, bright, 4 x 20 vacuum-fluorescent display
Display metered values
Keypad for motor control and menu selection
Access set points
Powered by Control Unit
Panel mount or attach directly to Control Unit
Remote mounting (1.2 km or 4000 ft maximum loop length)
1/2 DIN size
Hazardous-location certified

2 Control Unit

Current inputs—5-A or 1-A secondary phase current transformers
Voltage inputs—up to 600 V without PTs
Earth-leakage input—5-A or 1-A secondary or sensitive transformer
Tachometer (high-speed pulse) input
8 digital inputs, 5 relay outputs, 1 analog input and output
24-Vdc supply for OPI and RTD modules, and for digital inputs
IRIG-B time-code input
1/2 DIN size, surface mount
RS-485 network communications
DeviceNet™, Profibus®, or Ethernet communications available

Wiring Diagram



Accessories

A

PGC-2000 Series Phase Current Transformers
Required CT detects phase current or ground-fault current (200-A primary). Other current ratios available.

B

PGC Family Ground-Fault Transformers
Required zero-sequence current transformers detect ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

C

PGA-0120 Temperature Input Module
Optional module provides 8 inputs to connect Pt100, Ni100, Ni120, and Cu10 RTDs.

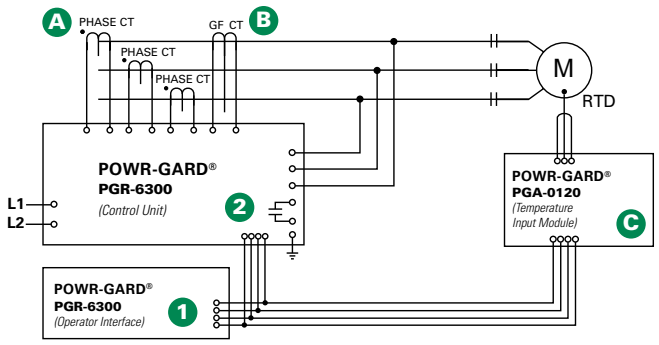
D

PGA-0140 Differential Current Module
Optional differential protection, compatible with core balance and summation current transformer connections.

Features & Benefits

FEATURES	IEEE #	BENEFITS
Overload	49, 51	Extends motor life and prevents insulation failures and fires
Current Unbalance/ Phase Loss/Phase Reverse	46	Prevents overheating and extends motor life
Overcurrent/Jam	50, 51	Prevents catastrophic failures and fires and extends motor life
Undercurrent	37	Detects low-level or no-load conditions
Ground Fault	50G/N, 51G/N	Prevents catastrophic failures and fires
RTD Temperature	38, 49	Optional RTD temperature protection (PGA-0120 module) for high ambient or loss of ventilation protection
Overvoltage	59	Prevents stress to insulation
Undervoltage	27	Prevents a start attempt when it will damage the motor
Voltage Unbalance	47	Detects unhealthy supply voltage
Phase Differential	87	Provides sensitive protection for high-resistance winding faults
Dynamic Thermal Model		Provides protection through starting, running, overload, and cooling cycles
Reduced Overcurrent Mode		Minimizes Arc-Flash hazards during maintenance
Starter Control		Simplifies the installation by reducing component count
Metering		Displays the measured and calculated motor parameters
Data Logging		On-board 64-event recorder helps with system diagnosis
Communications		Remotely view measured values, event records & reset trips
Conformal Coating		Internal circuits are conformally coated to protect against corrosion and moisture

Simplified Circuit Diagram



Ordering Information

CATALOG/ SYSTEM NUMBER	COMMUNICATIONS
PGR-6300-01-00	RS-485
PGR-6300-02-00	RS-485 & DeviceNet™
PGR-6300-03-00	RS-485 & Profibus®
PGR-6300-04-00	RS-485 & Ethernet

ACCESSORIES	REQUIREMENT	PAGE
PGC 2000 Series	Required	38
PGC Family	Required	38
PGA-0120	Optional	41
PGA-0140	Optional	41

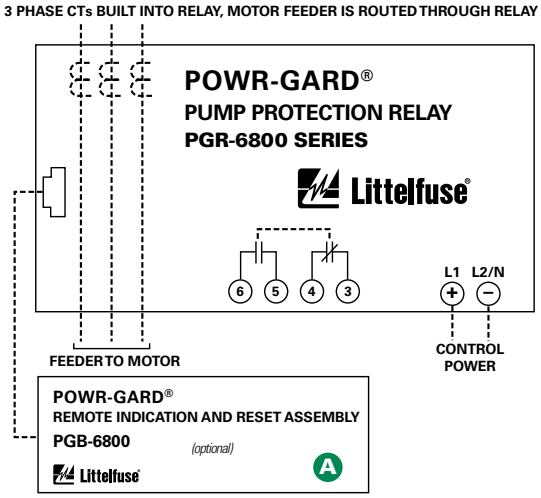
Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51); Phase reverse (current) (46); Overfrequency (81); Overcurrent (50, 51); Jam; Underfrequency (81); Ground fault (50G/N, 51G/N); Undercurrent (37); Unbalance (voltage) (47); Failure to accelerate; RTD temperature (38, 49); Unbalance (current) (46); Underspeed (14); Starts per hour (66); Phase loss (voltage) (47); Overvoltage (59); Differential (87); Phase loss (current) (46); Undervoltage (27); Phase reverse (voltage) (47); Power factor (55)
Input Voltage	65 – 265 Vac, 25 VA; 80-275 Vdc, 25 W
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/cycle, and positive and negative sequence of fundamental
Frequency	50, 60 Hz or ASD
Inputs	Phase-current, Earth-leakage current, Phase-voltage, 7 digital, tachometer, 1 analog
Output 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)
Conformally Coated	Standard feature
Warranty	10 years
Mounting	
(Control Unit)	Surface
(Operator Interface)	Panel

PGR-6800 SERIES

Pump Protection Relay

Wiring Diagram



Ordering Information

CATALOG/ SYSTEM NUMBER	CONTROL POWER	FULL-LOAD CURRENT
PGR-6801-24	24 Vdc	7-19.6 A
PGR-6801-120	120 Vac	7-19.6 A
PGR-6801-240	240 Vac	7-19.6 A
PGR-6802-24	24 Vdc	19-44.2 A
PGR-6802-120	120 Vac	19-44.2 A
PGR-6802-240	240 Vac	19-44.2 A
PGR-6803-24	24 Vdc	40-90.4 A
PGR-6803-120	120 Vac	40-90.4 A
PGR-6803-240	240 Vac	40-90.4 A

ACCESSORIES	REQUIREMENT	PAGE
PGB-6800	Optional	41

Description

The PGR-6800 Pump Protection Relay provides protection for pumps with three-phase motors up to 1,000 Vac. No current transformers are required for currents up to 91 A. The protective functions include overload, phase unbalance, phase loss, phase sequence and undercurrent. The PGR-6800 Pump Protection Relay is ideally suited for applications where operating without load can induce failure. Motor current is monitored and an undercurrent trip occurs when the current drops below a preset level. No additional level detectors are required.

Features & Benefits

FEATURES	BENEFITS
No CTs Required	No current transformers required for currents up to 91 A
Adjustable Trip Settings	Adjustable overload trip class setting from 5 to 15 for use with a wide variety of pumps
Output Contacts	Form A and Form B ground-fault output contacts for operation of separate annunciation and trip circuits
Remote Indication	Cause-of-trip indication and reset button
Overload	Prevents insulation failures and fires; extends motor life
Phase Loss/Phase Sequence	Detects unhealthy supply conditions
Unbalance (Current)	Prevents overheating due to unbalanced phases
Undercurrent	Detects low level or no-load conditions

Accessories

A

PGB-6800 Remote Indication and Reset Assembly
Optional remote indication of overload, undercurrent, phase unbalance, phase loss, and phase sequence. Remote reset included.

Specifications

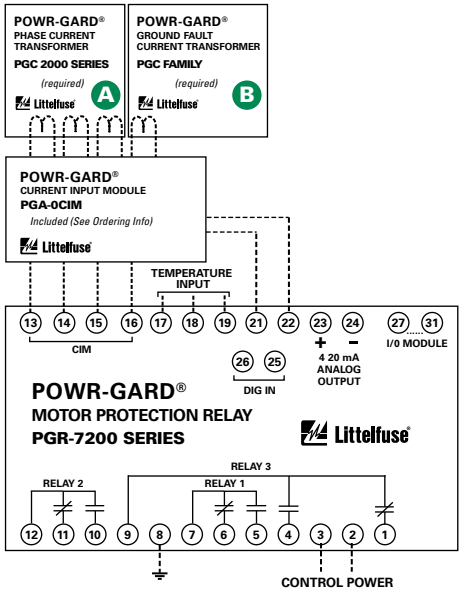
Protective Functions (IEEE Device Numbers)	Overload (49, 51) Phase sequence (46) Undercurrent (37)	Unbalance (current) (46) Phase loss (current) (46)
Input Voltage	See ordering information	
Frequency	50, 60 Hz	
Dimensions	**H** 83 mm (3.3"); **W** 78 mm (3.1"); **D** 99 mm (3.9")	
Test Button	Standard feature	
Reset Button	Standard feature	
Output Contacts	Isolated form A and Form B	
Approvals	UL listed	
Warranty	5 years	
Mounting	DIN	

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).

Wiring Diagram



Ordering Information

CATALOG/ SYSTEM NUMBER	COMMUNICATIONS
PGR-7200-00-00	TIA-232
PGR-7200-01-00	TIA-232 & RS-485
PGR-7200-02-00	TIA-232 & DeviceNet™
PGR-7200-04-00	TIA-232 & Ethernet

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.

ACCESSORIES	REQUIREMENT	PAGE
PGC 2000 Series	Required	38
PGC Family	Required	38

Description

The PGR-7200 Feeder Protection Relay provides integrated protection, metering, and data-logging functions. It is an excellent choice for retrofitting and upgrading older relays, because of its compact size and ability to use existing CTs. The PGR-7200 is used to protect distribution feeders in processing, manufacturing, petroleum, chemical, and wastewater treatment facilities.

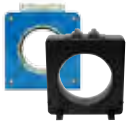
Features & Benefits

FEATURES	BENEFITS
IEC & IEEE Overcurrent Protection Curves	Definite and inverse time settings for system coordination; prevents catastrophic failures
Two Setpoint Groups	Create distinctive settings for maintenance or for two different loads
Reduced Overcurrent Mode	Maintenance mode setting to reduce the risk of Arc-Flash Hazards
Data Logging	On-board 100-event recorder and remote data logging helps with system diagnostics
Overload	Prevents insulation failures and fires; extends motor life
Phase Loss/Phase Reverse (Current)	Detects unhealthy supply conditions
Unbalance (Current)	Prevents overheating due to unbalanced phases
Communications	Remotely view measured values, event records & reset trips

Accessories

A 

PGC-2000 Series Phase Current Transformers
Required CT detects phase current or ground-fault current (200-A primary). Other current ratios available.

B 

PGC Family Ground-Fault Transformers
Required zero-sequence current transformers detect ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51)	Definite-Time Overcurrent (50, 51)
	Phase sequence (46)	Inverse-Time Overcurrent (50, 51)
	Unbalance (46)	Ground fault (50G/N, 51G/N)
	Phase loss (46)	RTD/PTC temperature (49)
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, 60 Hz	
Output Contacts	Three Form C	
Approvals	CSA certified to US and Canadian standards	
Communications	TIA-232 (standard); TIA-485, DeviceNet™, Ethernet (optional)	
Analog Output	4–20 mA, programmable	
Conformally Coated	Standard feature	
Warranty	10 years	
Mounting (Control Unit)	Panel (standard) Surface (with PGK-0SMK converter kit)	
(Current Input Module)	DIN, Surface	

PGR-6210 AND PGR-6310 SERIES

Motor Protection Retrofit Kits

1 PGR-6210

Front

Back

2 PGR-6310

Front

Back

Description

Littelfuse POWR-GARD retrofit kits are an excellent choice for upgrading motor protection, providing current- and temperature-based protection, metering, and data logging.

1 PGR-6210

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 Modules, which are pre-wired on a panel. The kit fits in the existing space and typically can utilize existing current transformers and wiring to simplify the upgrade procedure.

2 PGR-6310

The PGR-6310 Motor Protection Kit replaces the GE Multilin 469 relay. It includes the PGR-6300 Motor Protection System and optional RTD and differential modules pre-wired on a panel that can be installed in the existing 469 cutout. Existing current transformer and wiring can be utilized, simplifying the upgrade procedure.

Features & Benefits

FEATURES	BENEFITS
Mounting	Fits in existing mounting holes and panel openings
Quick Installation	Existing CTs and RTDs can be used to reduce installation time
Factory Tested	100% factory-tested, pre-assembled components ensure reliability
Communications	Add communications capability to older switchgear and improve system performance
Microprocessor Based	No calibration required saves on maintenance cost
Reduced Overcurrent Mode	Maintenance mode setting to reduce the risk of Arc-Flash Hazards
Conformal Coating	Protects circuit boards against corrosion and moisture
Additional Protection	Additional protective functions, including dynamic thermal model and ability to match existing overcurrent curves

PGR-6210 Ordering Information

		MODULE	COMMUNICATIONS
PGR–6210	–	X	X
		0 = None	0 = RS-232
		1 = PGA-0120 RTD Module	1 = RS-232 & RS-485
			2 = RS-232 & DeviceNet™
			3 = RS-232 & Ethernet

PGR-6310 Ordering Information

		MODULES	COMMUNICATIONS
PGR–6310	–	X	X
		0 = None	0 = RS-485
		1 = 1 PGA-0120 RTD Module	1 = RS-485 & DeviceNet™
		2 = 2 PGA-0120 RTD Modules	2 = RS-485 & Profibus®
		3 = 1 PGA-0140 Differential Module	3 = RS-485 & Ethernet
		4 = 1 PGA-0120 RTD Module and 1 PGA-0140 Differential Module	

PGK FAMILY

Panel Mount Adapters

PGK-0012

PGK-0013

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

Description

A variety of protection relay retrofit adapter plates are available for the products listed below. These adapter plates simplify the process of updating electromechanical 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.

Motor, feeder and ground-fault protection upgrades are available for electromechanical or solid state relays that are nearing the end of their life.

Features & Benefits

FEATURES	BENEFITS
Mounting	Fits in existing mounting holes and panel openings
Multiple Adapter Sizes	Plate style or drawout style adapters are available to fit various outdated relays

Adapter Plates

RELAY TO REPLACE	PANEL MOUNT	NEW RELAY
AB BULLETIN 1406	PGK-0014	PGR-6300
FPL-GFRM	PGK-0006	PGR-4704
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 469	PGK-0024	PGR-6300
GE MULTILIN P4A	PGK-0015	PGR-6200
GE MULTILIN P4A	PGK-0015	PGR-7200
GEC/MCGG	PGK-0003	PGR-4704
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 40.

PGM-8134 SERIES

Ground Continuity Monitor

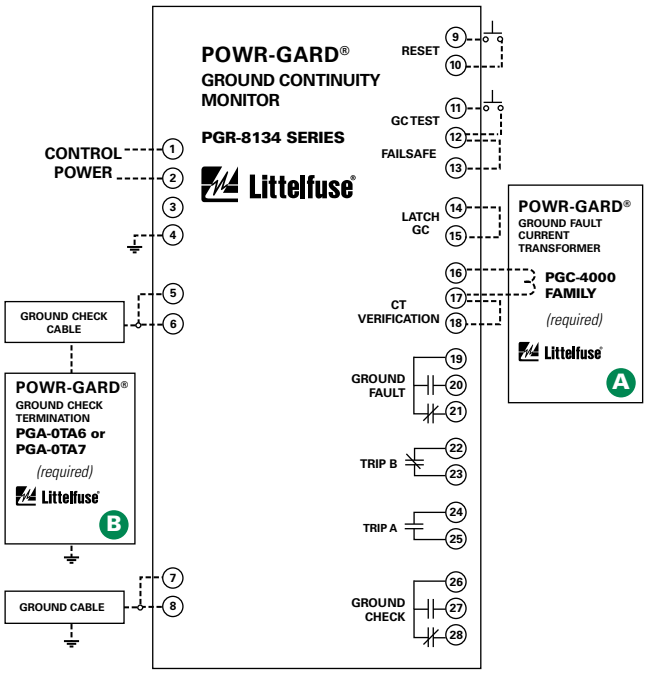
Description

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. The PGM-8134 is field proven in monitoring trailing cables with pilot wire on large mobile equipment such as shore-to-ship power cables, dock side cranes, stacker-reclaimers, submersible pumps, and portable conveyors.

Features & Benefits

FEATURES	BENEFITS
Adjustable Pickup (0.5–12.5 A)	Unit can be used on a wide variety of trailing cable applications
Adjustable Time Delay (1–2.5 s)	Adjustable trip delay for quick protection and system coordination
Output Contacts	Separate annunciation of ground-fault and ground-check faults
Ground-Check LED Indication	Indication of open or short ground-check wire makes it easier to find faults
CT-Loop Monitoring	Alarms when CT is not connected
High-Induced-ac Rejection	Makes unit suitable for applications with high voltages and long cables
DFT (Harmonic) Filter	Prevents false operation
Zener-Characteristic Termination Assembly	Provides reliable ground-check loop verification
Fail-Safe Circuits	Ensures ground-check and ground-fault circuits remain safe even in the event of equipment failure
Conformal Coating	Additional coating protects circuit boards against harsh environment

Wiring Diagram



Accessories

A **PGC-4000 Ground-Fault Current Transformers**
Required zero-sequence current transformer detects ground-fault current.

B **PGA-0TA6 or PGA-0TA7**
Required termination assembly with convenient mounting holes. Temperature compensated.

Specifications

IEEE Device Numbers	Checking or Interlocking Relay (3GC), Ground fault (50G/N, 51G/N)
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 feature
Test Button	Standard feature
Reset Button	Standard feature
Output Contacts	Isolated Form A, Form B and two Form C
Approvals	CSA certified to US and Canadian standards
Conformally Coated	Standard feature
Warranty	5 years
Mounting	Panel, Surface

Ordering Information

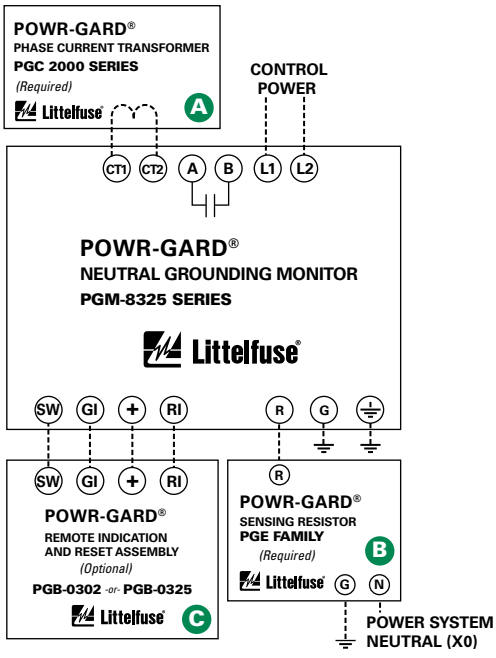
CATALOG/ SYSTEM NUMBER	CONTROL POWER
PGM-8134-00	60-265 Vac; 80-370 Vdc

ACCESSORIES	REQUIREMENT	PAGE
PGC-4000	Required	38
PGA-0TA6/PGA-0TA7	Required	42

PGM-8325 SERIES

Neutral Grounding Monitor

Wiring Diagram



Ordering Information

CATALOG/ SYSTEM NUMBER	CONTROL POWER
PGM-8325	120 Vac 50/60 Hz, 10 VA
PGM-8325-E	240 Vac 50/60 Hz, 10 VA

ACCESSORIES	REQUIREMENT	PAGE
PGC-2000 Series	Required	38
PGE Family	Required	42
PGB-0302/PGB-0325	Optional	41

Description

The PGM-8325 Neutral Grounding Monitor is used on resistance-grounded systems up to 25 kV 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.

Features & Benefits

FEATURES	BENEFITS
Continuous NGR Monitoring	Detects resistor failure within seconds, reduces transient-overvoltage risk, removes risk of ground-fault-detection failure
Ground-Fault Detection	Main or backup protection to detect a ground fault anywhere on the monitored system
Adjustable Pickup (0.5–4 A)	Select greatest sensitivity without false operation
Adjustable Time Delay (0.1–2 s)	Adjustable trip delay allows quick protection and system coordination
Output Contacts	Form A output contact
Selectable Contact Operating Mode	Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil

Accessories

A 

PGC-2000 Series Phase Current Transformers
Required CT detects phase current or ground-fault current (200-A primary). Other current ratios available.

B 

PGE Family Sensing Resistors
Required interface between the power system and the PGM-8325. Eliminates hazardous voltage levels at the monitor.

C 

PGB-0302 or PGB-0325 Remote Indication Assemblies
Optional panel-mounted remote indication and reset assemblies.

Specifications

IEEE Device Numbers	Ground fault (50G/N, 51G/N), Overvoltage (59N), Check Relay (3GC)
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 feature
Output Contacts	Form A
Approvals	CSA certified to US and Canadian standards
Conformally coated	Standard feature
Warranty	5 years
Mounting	Surface

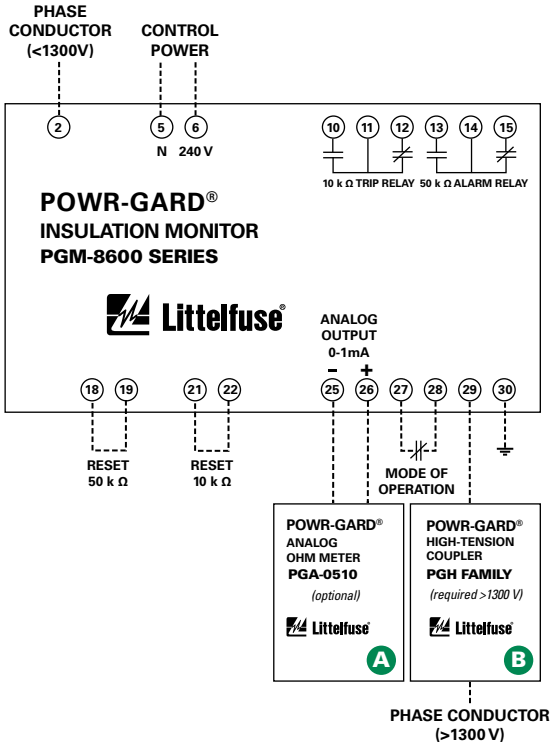
PGM-8600 SERIES (GFR4001-IM)

Insulation Monitor

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. The relay can operate on 1 or 3-phase grounded, resistance grounded or ungrounded systems up to 6 kV. 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 nuisance 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.

Wiring Diagram



Features & Benefits

FEATURES	BENEFITS
Analog Output (0–1 mA)	Provides means for connecting an optional PGA-0510 meter to display insulation resistance.
Output Contacts (50 kΩ)	Form C output contact for alarming purposes
Output Contacts (10 kΩ)	Form C output contact for tripping purposes

Accessories

A 

PGA-0510 Analog Ohm Meter
Optional PGA-0510 Analog meter allows for remote metering of insulation resistance.

B 

PGH Family High Tension Couplers
Required (for systems >1,300 V) PGH Family high-tension coupler must be connected between the phase conductor and the PGM-8600 insulation monitor.

Specifications

IEEE Device Numbers	Lockout Relay (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 warnings (30 kΩ and 50 kΩ) Insulation alarm (10 kΩ)
Contact Operating Mode	Non-fail-safe
Test Button	Standard feature
Reset Button	Standard feature
Output Contacts	Two Form C
Communications	Analog output
Conformally Coated	Optional
Warranty	5 years
Mounting	DIN, Surface

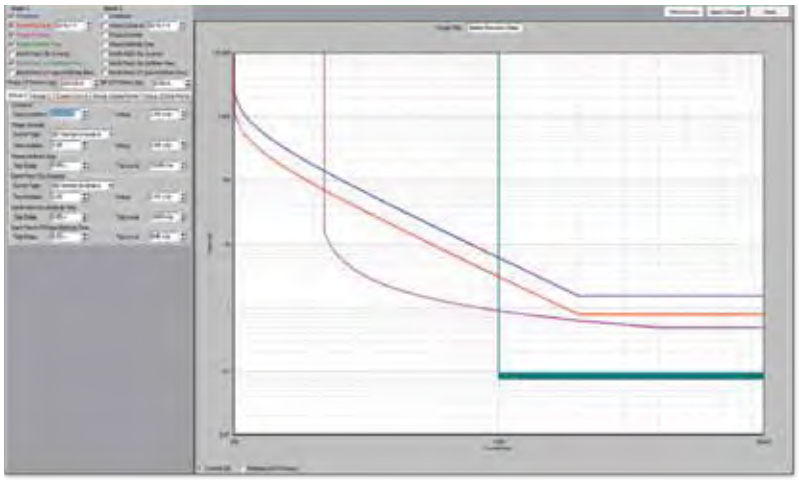
Ordering Information

CATALOG/ SYSTEM NUMBER	CONTROL POWER
PGM-8600	240 Vac

ACCESSORIES	REQUIREMENT	PAGE
PGH Family	Required >1300 V	42
PGA-0510	Optional	41

Note: For optional conformal coating please consult factory.

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 also 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. Setpoints 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**
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-6150 Relay Interface Software		Provides access to the settings, measurements, statuses, configurations, and reports recorded in relay. Allows changes to relay operation parameters and to work offline, creating a library of settings for future applications.	**PGR-6150**
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-OSTT PGR-6200 Online Self-Training Tutorial		Online Self-Training tutorial for PGR-6200 programming.	**PGR-6200**

PGN-1000 SERIES

Low-Resistance Grounding System

Description

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

The PGN-1000 Series Low-Resistance Grounding System includes all necessary components to convert or design a resistance-grounded system. Low-resistance grounding provides benefits over both ungrounded and solidly grounded systems. Because the system is grounded it eliminates transient overvoltages and allows ground-fault current to flow and be detected and measured. However, because a resistor is used to ground the system, the very large and destructive ground-fault currents characteristic of solidly grounded systems can be controlled.

Low-resistance grounding also solves the solidly-grounded system problems of excessive ground-fault damage, and reduces ground-fault Arc-Flash Hazards. 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 56
- Resistance grounded relay or monitor (PGR-5330 or PGM-8325) is optional to provide ground-fault detection and resistor monitoring

Ordering System Information

	SYS. VOLTAGE	RES. CURRENT	TIME		ENCLOSURE			FEATURES		CUSTOM
PGN – 1	X	X	X	–	X	–	0	X	–	XXX
	0 = Other	0 = Other	0 = Other		0 = Other			0 = Other		000 = Standard
	2 = 480/277 V	1 = 5 A	1 = 10 s		N = No Enclosure			1 = Res. Monitor (PGM-8325)		XXX = Drawing #
	3 = 600/347 V	2 = 10 A	2 = 60 s		F = Outdoor Free Standing			2 = Res. Monitor & GF Relay (PGR-5330)		
	4 = 2400/1390 V	3 = 25 A	3 = Extended		W = Outdoor Wall Mount					
	5 = 4160/2400 V	4 = 50 A	4 = Continuous							
	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 the difficulty of locating ground faults. The PGN-3000 Series High-Resistance Grounding System includes all necessary components to convert or design a resistance grounded system.

The PGN-3000 includes a pulsing circuit and optional PGR-5701 ground-fault relays to provide a method for locating ground faults. It also significantly reduces damage caused by ground faults on solidly grounded systems. The current limitation eliminates the Arc-Flash Hazards associated with the first ground fault. 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 the first ground fault 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 (pulsing current 5 A above the selected resistor current is standard; other pulsing options available upon request)
- Optional test circuit to simulate a 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 56

Ordering Information

	CONFIGURATION	SYS. 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 = Standard
	W = Wye	1 = 240 V	1 = 5 A		N = No Enclosure	1 = 1		XXX = Drawing #
	D = Delta	2 = 480/277 V	2 = 10 A		F = Outdoor Free Standing	2 = 2		
		3 = 600/347 V	3 = 15 A		W = Outdoor Wall Mount	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 TESTING EQUIPMENT

Wiring Diagrams Legend for Following Pages

- *All output contacts 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)*

PGT-0400 SERIES

Ground-Fault Relay Test Unit

Description

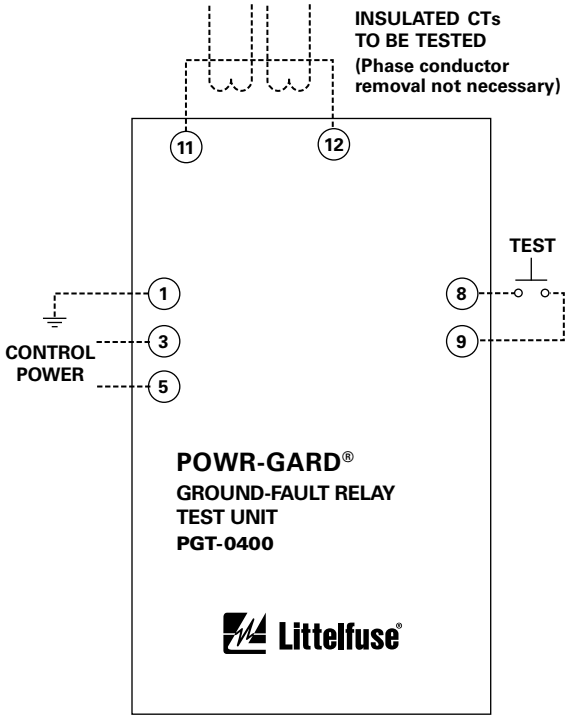
The PGT-0400 is a ground-fault-relay test unit designed to test current pickup level, time-delay and coordination of ground-fault protection.

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

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

The PGT-0400 tests the entire ground-fault circuit including current transformers, wiring, ground-fault relay and the operation of the interrupting device. It is recommended to test every relay and its current interrupting device annually.

Wiring Diagram



Features & Benefits

FEATURES	BENEFITS
Adjustable Current Setpoint	Current range is 0.5 to 9.9 A
Adjustable Time Duration Setpoint	Duration range is 0.1 to 9.9 s, or continuous output
Small Form Factor	Light weight and compact for portability
Remote Test Input	Allows test to be initiated from another location

Ordering Information

CATALOG/ SYSTEM NUMBER	CONTROL POWER
PGT-0400	120 Vac

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 feature
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-4704	PGC-5000 Series	10 mA – 5 A	38
PGR-5330	PGC-2000 Series (200-A Primary)	12 A – 200 A	38
	PGC-3000 Series - EFCT (5-A Primary)	100 mA – 5 A	38
	PGC-5000 Series (30-A Primary)	600 mA – 30 A	38
PGR-5701	PGC-2000 Series (200-A Primary)	10 A – 198 A	38
	PGC-3000 Series (5-A Primary)	50 mA – 4.95 A	38
	PGC-5000 Series (30-A Primary)	300 mA – 29.7 A	38
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	38
PGR-6130	No CTs required <91 A	N/A**	–
PGR-6150	No phase CTs required <25 A, Optional PGC-6000 Series Ground-Fault CT	0.4 A – 150 A	39
PGR-6200*	PGC-2000 Series (200-A Primary)	10 A – 200 A	38
	PGC-3000 Series (5-A Primary)	50 mA – 5 A	38
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	38
PGR-6210*	Same as PGR-6200. Existing CTs can be used in most cases.		
PGR-6300*	PGC-3000 Series (5-A Primary)	50 mA – 5 A	38
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	38
	Standard Iron core CTs (ie 50:5; 100:5, 200:5)	1 to 100% of CT Primary	–
PGR-6310*	Same as PGR-6300. Existing CTs can be used in most cases.		
PGR-6800	No CTs required <91 A	N/A**	–
PGR-7200*	PGC-2000 Series (200-A Primary)	10 A – 200 A	38
	PGC-3000 Series (5-A Primary)	50 mA – 5 A	38
	PGC-5000 Series (30-A Primary)	300 mA – 30 A	38
PGM-8134	PGC-4000 Series	0.5 A – 12.5 A	38
PGM-8325	PGC-2000 Series	0.5 A – 4 A	38
PGM-8600	No CTs required	Warnings at 30 kΩ & 50 kΩ, Alarm at 10 kΩ	–

Note: See page 55 for additional information on CT selection. See page 67 for CT sizing chart.

* 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.
** Trip levels are model specific, see ordering information on page 17 and 24.

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 Current Transformer 	Detects phase current or ground-fault current. (200-A primary)	56 mm (2.20")	**PGR-5330 PGR-6150 PGR-6800 PGR-5701 PGR-6200 PGR-7200 PGR-6130 PGR-6300 PGM-8325**
PGC-2089 Current Transformer 	Detects phase current or ground-fault current. (200-A primary)	89 mm (3.50")	**PGR-5701 PGR-6130 PGR-6150 PGR-6200** **PGR-6300 PGR-6800 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-4704 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-4704 PGR-5330 PGR-5701 PGR-6100** **PGR-6200 PGR-6300 PGR-7200**
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-4704 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-4704 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-4704 PGR-5701 PGR-6100** **PGR-6200 PGR-6300 PGR-7200**

PGC FAMILY, PGG FAMILY

CURRENT TRANSFORMERS			
Product	Features	Inner Diameter	Accessory For
PGC-6035 Ground-Fault Current Transformer 	Current transformer for measuring ground-fault currents.	35 mm (1.38")	**PGR-6150**
PGC-6060 Ground-Fault Current Transformer 	Current transformer for measuring ground-fault currents.	60 mm (2.36")	**PGR-6150**
PGC-6080 Ground-Fault Current Transformer 	Current transformer for measuring ground-fault currents.	80 mm (3.15")	**PGR-6150**
PGC-6110 Ground-Fault Current Transformer 	Current transformer for measuring ground-fault currents.	110 mm (4.33")	**PGR-6150**
PGC-6210 Ground-Fault Current Transformer 	Current transformer for measuring ground-fault currents.	210 mm (8.27")	**PGR-6150**

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**
PGG-1000 Ground Reference Module 	Connects the PGR-2601 relay to an ungrounded 1000 Vdc bus.	**PGR-2601**

PGK FAMILY

PANEL MOUNT ADAPTERS		
Product	Features	Accessory For
PGK-0003 Adapter Plate 	Used when replacing GEC/MCGG ground-fault relays.	**PGR-4704** **PGR-5701**
PGK-0006 Adapter Plate 	Used when replacing FPL-GFRM ground-fault relays.	**PGR-5701**
PGK-0009 Adapter Plate 	Used when replacing relays in the GE S1 Case.	**PGR-6200** **PGR-7200**
PGK-0010 Adapter Plate 	Used when replacing the GE Lodtrak III.	**PGR-6200**
PGK-0012 Adapter Plate 	Used when replacing GE and Westinghouse FT-11 relays.	**PGR-6200**
PGK-0013 Adapter Plate 	Used when replacing the GE Multilin 169, 269, or 369.	**PGR-6300**
PGK-0014 Adapter Plate 	Used for rough cutouts and when replacing the AB Bulletin 1406.	**PGR-6300**
PGK-0015 Adapter Plate 	Used for rough cutouts and when replacing the GE Multilin P4A.	**PGR-6200** **PGR-7200**
PGK-0016 Adapter Plate **PGK-0016-RTDB** Mounting Bracket 	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-0024 Adapter Plate 	Used when replacing the GE Multilin 469.	**PGR-6300**
PGK-0055 Adapter Plate 	Used to panel mount the PGR-2601 and PGR-5701.	**PGR-2601** **PGR-4300** **PGR-4704** **PGR-5701** **PGR-6200**
PGK-0060 Adapter Plate 	Used to panel mount the relay; IP 53 and NEMA 3 rating, tamper resistant.	**PGR-2601** **PGR-4300** **PGR-4704** **PGR-5701** **PGR-6200**
PGA-016A Watertight Cover 	Watertight cover for outdoor applications.	**PGR-6200** **PGR-7200**
PGK-0SMK Converter Kit 	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**
PGA-0CIM Current Input Module		Interface between current transformers and PGR-6200 and PGR-7200 series relays. Prevents open-CT hazards.	**PGR-6200** **PGR-7200**

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.	**PGM-8325**
PGB-0325 Remote Indication and Reset Assembly		Panel-mounted remote indication and reset with NEMA 1 rating.	**PGM-8325**
PGB-6130 Remote Indication and Reset Assembly		Remote indication of overcurrent, phase imbalance, phase loss, phase sequence, and overtemperature. Remote reset included.	**PGR-6130**
PGB-6800 Remote Indication and Reset Assembly		Remote indication of overcurrent, undercurrent, phase imbalance, phase loss, and phase sequence. Remote reset included.	**PGR-6800**
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-4704** **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 systems to be connected to relay.	**PGR-3200** **PGR-6100** **PGR-8600**
PGH-6000 High Tension Couplers 	Allows 6-kV systems 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.

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 typically connected to a visual or audible alarm.

Analog Output – A sealed, continually variable 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 the same as the connected system frequency.

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

Continuous Output - On a PGT-0400, continuous output is defined as current that does not operate for a preset duration.

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 relatively large primary current.

CT Local Saturation – A condition where the magnetic flux is not evenly distributed throughout the CT. This may occur if conductors are not centered in CT window.

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 in saturation.

Current-Based Protection – Protection parameters (trip-levels/used thermal capacity) derived from currents 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 used to measure 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 permeable 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 connection when cable couplers are disconnected.

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 load end of the ground-check loop.

Ground Continuity Monitor – A protection relay that continuously monitors at check loop and trips if the loop opens or shorts.

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 with the use of adjustable-speed drives.

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

High Tension Coupler – An accessory used to separate system voltage from 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 when a voltage is applied; typically measured in mega-ohms. Insulation-resistance change can be monitored to predict 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 ability 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 – Low level ground-fault current, typically measured in milliamperes (mA).

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

LSIG Protection – An acronym for Long-time, Short-time, 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.

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.

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 protection, 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. For example, the first number in the ratio 500:5 is the primary rating. Under ideal conditions 500 A of primary current flowing 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).

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 – Method of operation used for Undervoltage or Shunt trip breakers. (Also see: Fail-safe, Non-Fail-Safe).

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 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 measured before trip action is taken.

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

True RMS – "Root-Mean-Square" Calculation used to derive an average current or voltage value in a waveform.

Ungrounded System – An electrical system in which no point in the system is intentionally grounded, such as a delta-connected system.

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- Inputs and Settings
- Processes
- Outputs

How do protection relays solve electrical problems?

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- Stage 2 – During a failure
- Stage 3 – After a failure

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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 include 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.

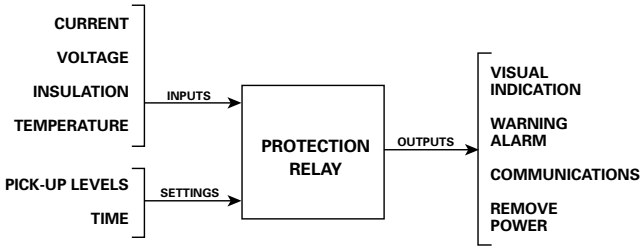


FIGURE 1

Protection relays can be either electromechanical or electronic/microprocessor-based. Electromechanical relays consist 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 lower life-cycle 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, high-tension couplers, RTDs, or other devices.

Settings

Many protection relays have adjustable settings. The user selects 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 made, the relay compares these values and makes a decision. Depending on the need, different types of relays are available for different functions.

Outputs

A relay can have 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 many 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 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 and 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 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 occurs.

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 protection 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). 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 (trip) before greater problems occur. The user can use the alarm indication to help identify the faulty equipment prior to the traditional fuse or circuit breaker 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 divided 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>). While 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 equipment or personnel 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

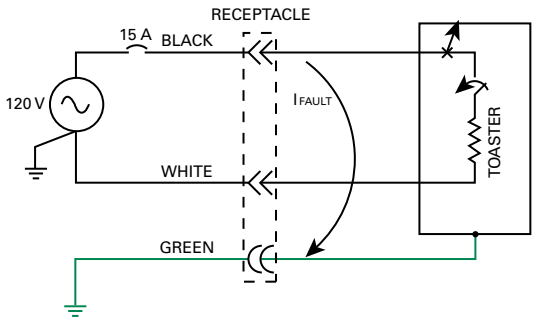


FIGURE 2

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 intentionally 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 (see *Figure 3*). The ground-fault relay uses this neutral point as a reference to detect low-level ground faults.

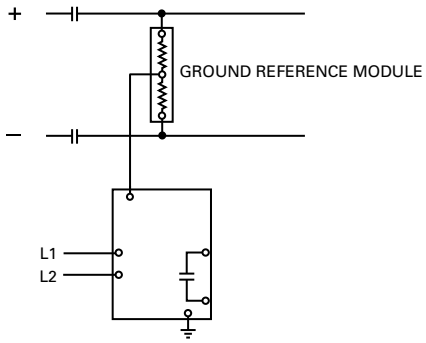


FIGURE 3

Ungrounded AC Systems

Ungrounded ac systems, such as shown in *Figure 4*, 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.

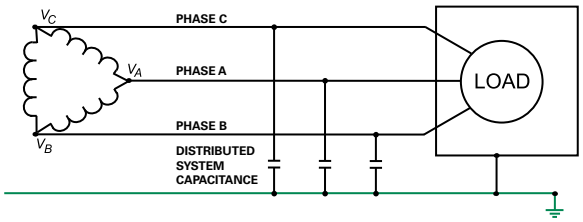


FIGURE 4

- 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 operation 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, it is difficult 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 second 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 indicator 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. A solidly grounded system cannot continue to operate with a ground fault.

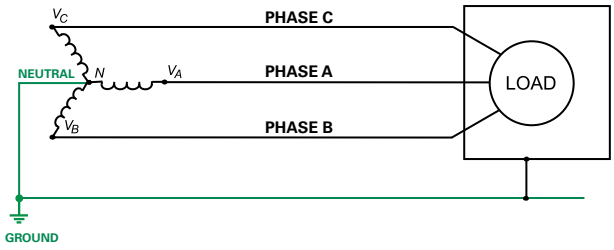


FIGURE 5

- 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.

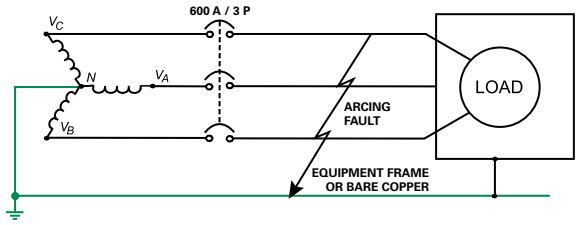


FIGURE 6

- 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, fault current may be as low as 38% of the bolted-fault level. This 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 a fault, 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 can 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 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 (as shown in *Figure 7*). 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).

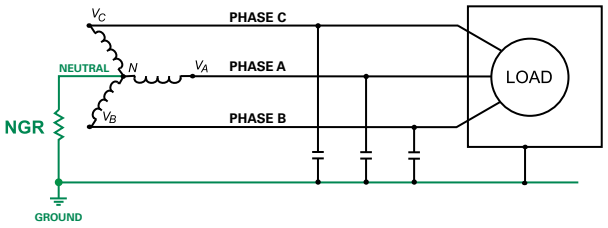


FIGURE 7

- 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 typically allowable when ground fault is ≤10 A.
- The NGR limits the available ground-fault 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.
- 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.

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 above 5 kV, 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 *Figures 5, 6, 7, and 8*.

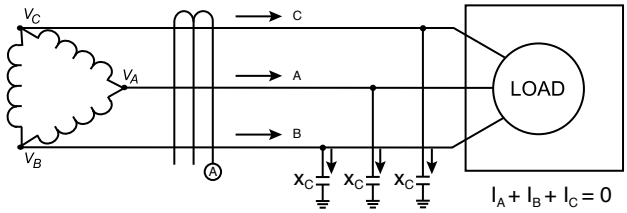


FIGURE 8

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 (see *Figure 9*). 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.

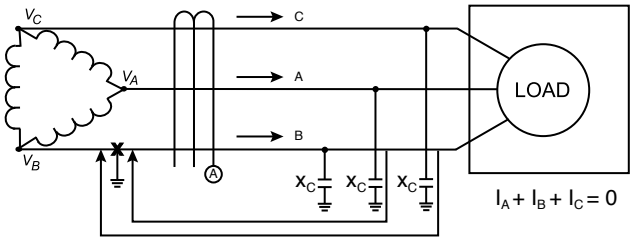


FIGURE 9

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.

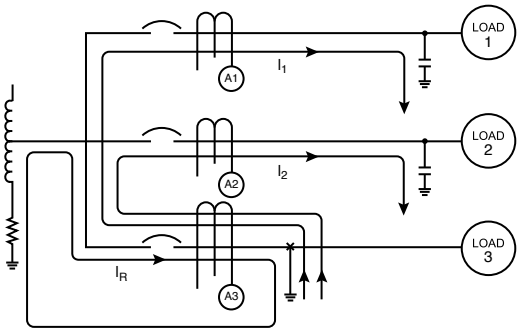


FIGURE 10

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. Sympathetic tripping can be avoided by choosing a relay pickup setting larger than the charging current from the largest feeder. 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 a 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 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 (I^2t).

A dynamic thermal model allows accurate 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 an 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 phase-to-ground, and phase-to-ground-to-phase faults.

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

Undercurrent protection is loss-of-load protection and 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.

Solution: 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

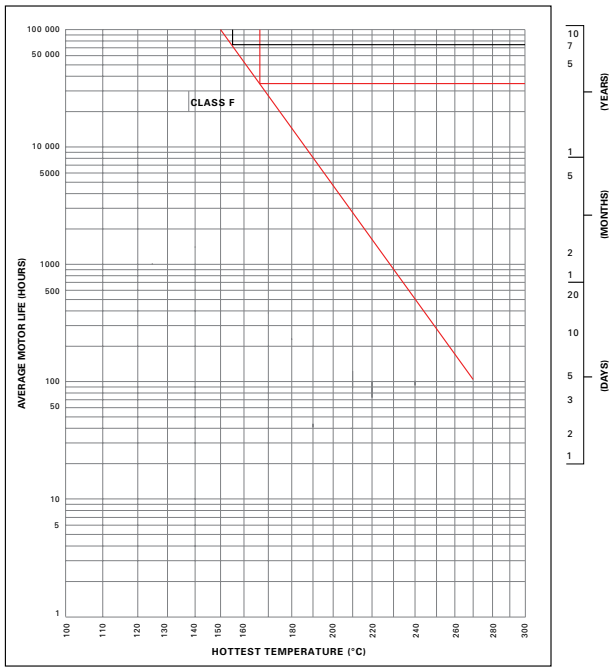


FIGURE 11

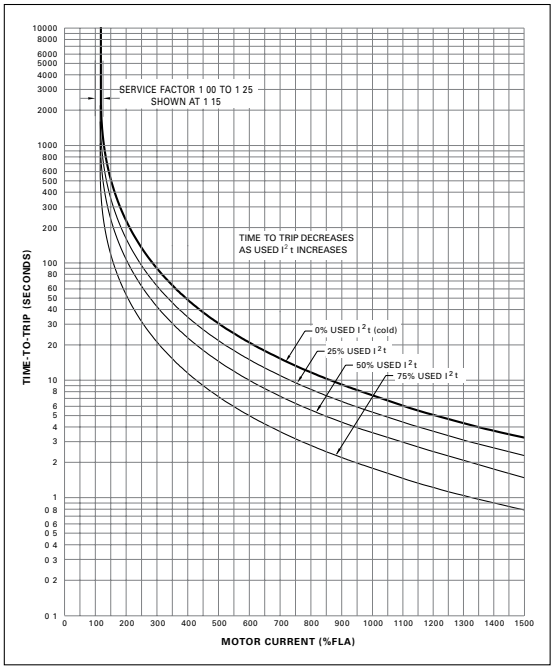


FIGURE 12

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 pro actively 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 Imbalance, Phase Loss, Phase Reverse

Older motor protection did not consider current imbalance and today it is often overlooked. Imbalance 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 imbalance 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 imbalance which drives current imbalance can be used as a start inhibit. Sequence components are also used for calculating imbalance, 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 (Article 430 Section III).

Article 430, Section 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.

Article 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 above simple fire protection.

Communications

Network communications can be added to a motor-protection relay to allow remote metering of currents, voltages and temperatures. Data logging 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 typically operates 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 can continuously monitor the insulation resistance to ground whether the system is energized or de-energized.

Ground-Continuity Monitors

Ground-check monitors are used to detect problems in equipment ground conductors. The cable powering 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 to a terminating device in the equipment, where the signal is sent back on the cable 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 a person who touches 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.

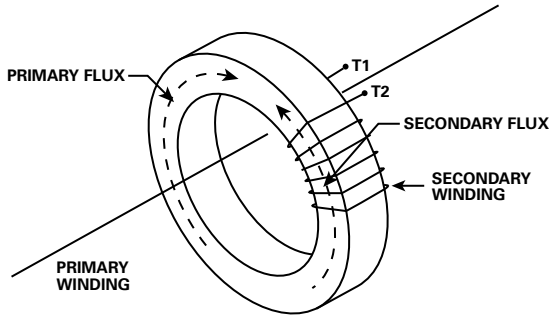


FIGURE 13

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) = 0.01 Ω

The maximum current (I) = 10 A

The CT rating (P) = 5 VA

Now let's solve for the maximum length of #14 AWG leads that will result in a rated accuracy for a 10 A 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

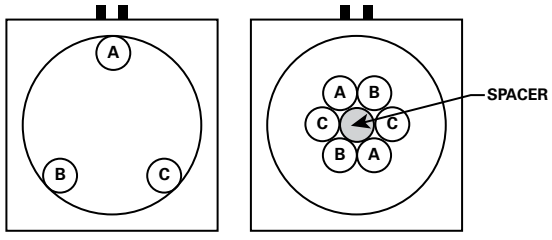
Maximum lead length = (0.04 x 1000) / 2.6 = 15.4 ft.

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 centered 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 overvoltages caused by intermittent ground faults and it provides a method to locate ground faults. (Transient overvoltages 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 a neutral grounding resistors (NGR). 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.

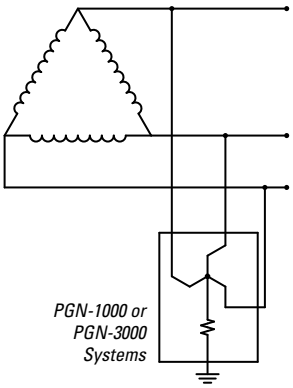


Figure 1

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 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 limits ground fault current to a pre-determined value, typically 5 A for 480 V systems (the system capacitive charging current is usually less than 3 A). By limiting the ground fault current to 5 A 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 ~0 V, 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.

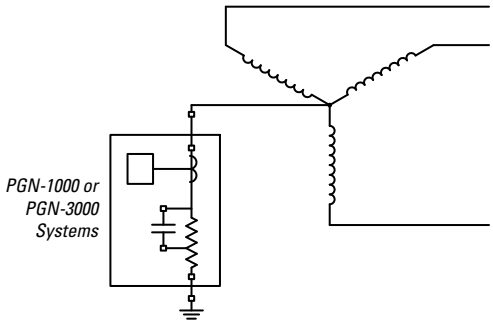


Figure 2

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. Single-phase line-to-neutral-voltage 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.

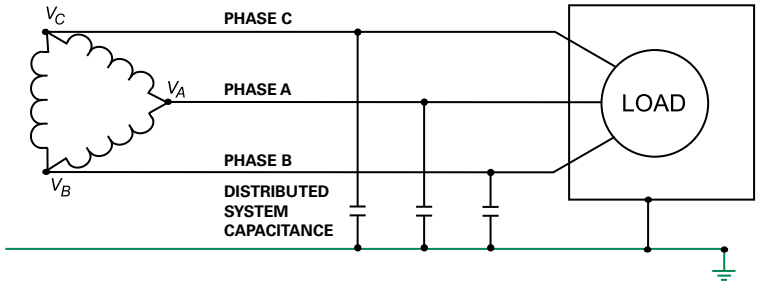
UNGROUNDED SYSTEM

Advantages

- Operation possible with one faulted phase

Disadvantages

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



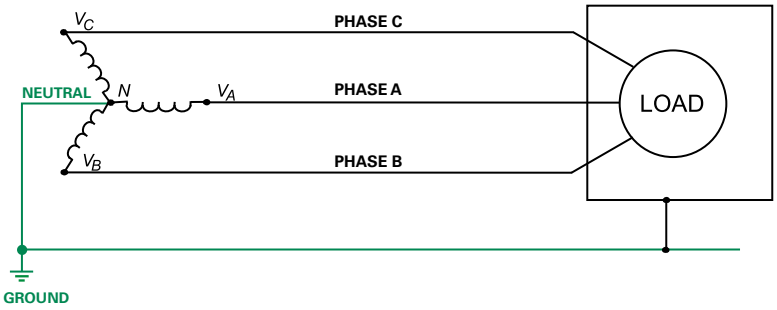
SOLIDLY GROUNDED SYSTEM

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



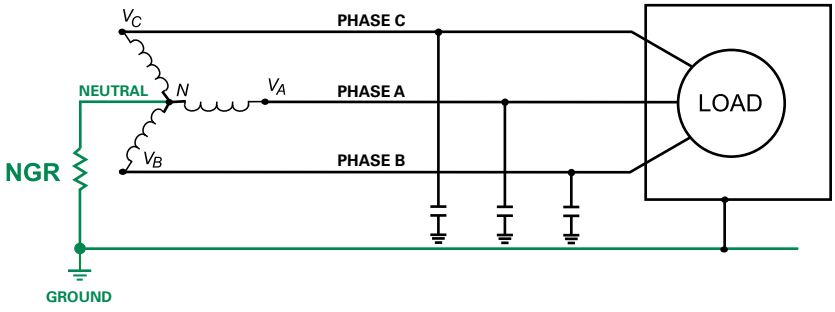
RESISTANCE GROUNDED SYSTEM

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

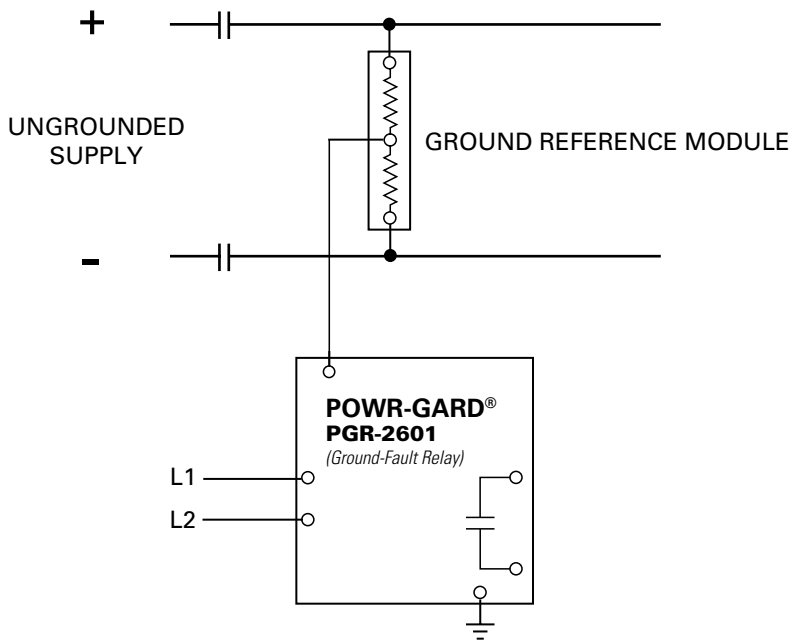
- Failure of the neutral-grounding resistor renders current-sensing ground-fault protection inoperative



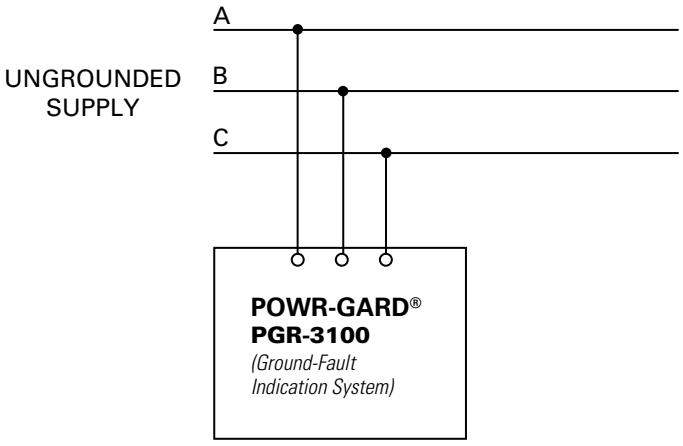
GFP

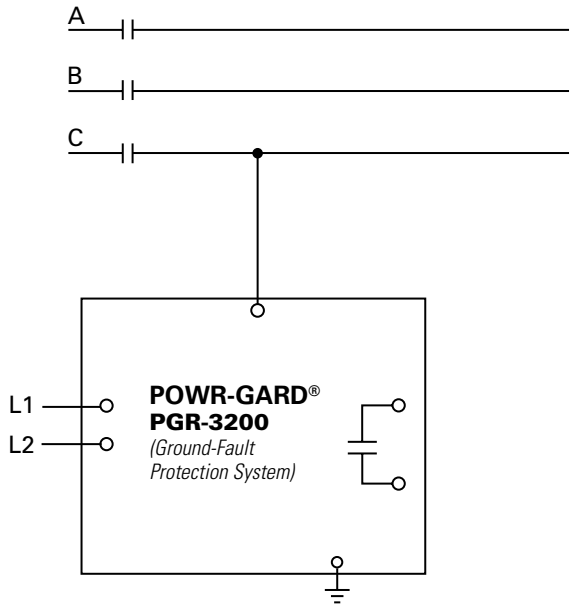
GROUND FAULT PROTECTION

DC GROUND-FAULT PROTECTION



UNGROUNDED GROUND-FAULT DETECTION





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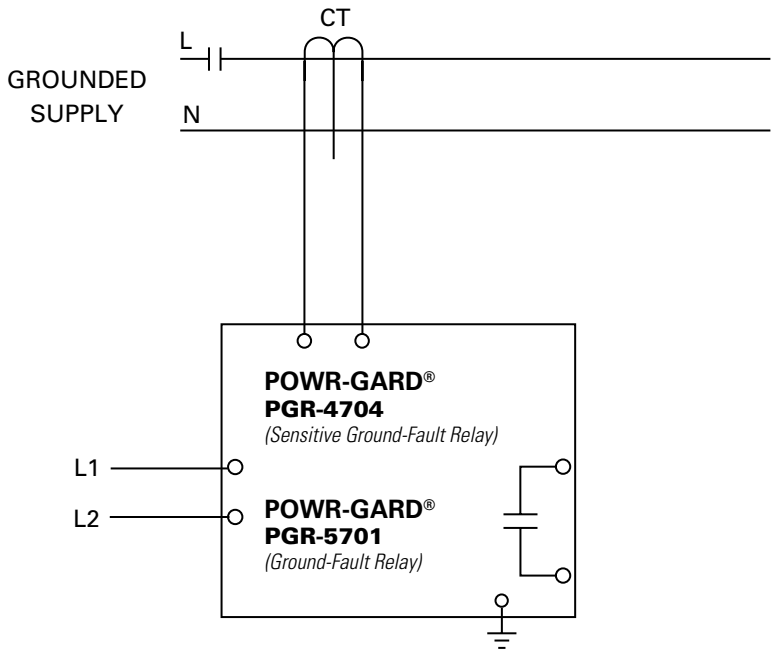
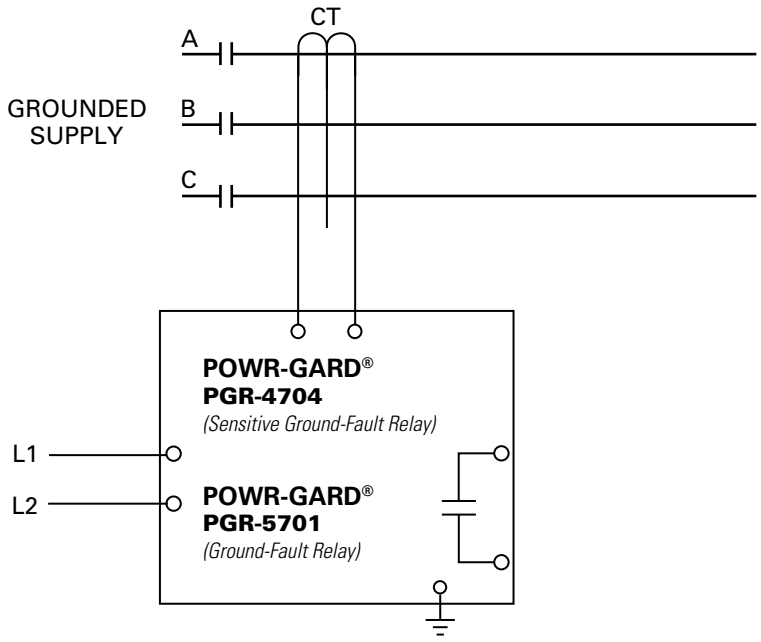
GROUND FAULT PROTECTION

SINGLE-PHASE GROUND-FAULT PROTECTION



THREE-PHASE GROUND-FAULT PROTECTION



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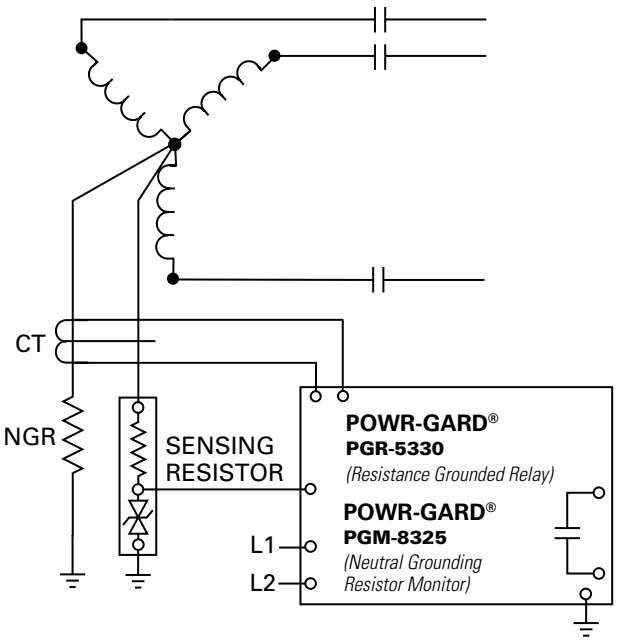
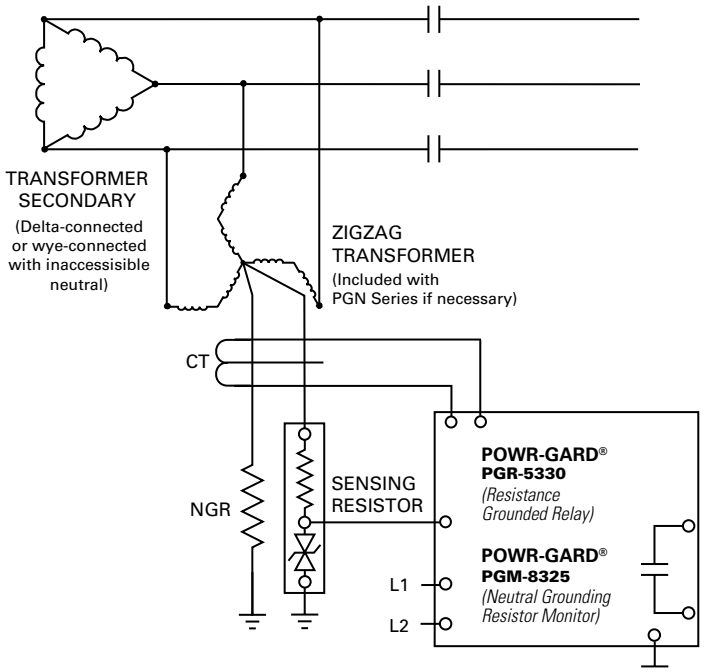
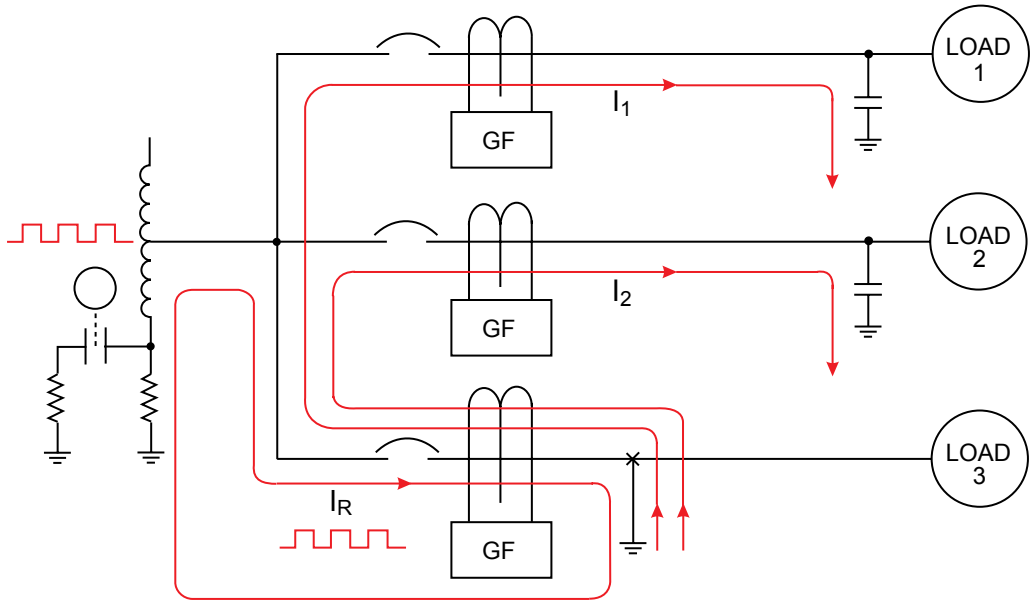
GROUND FAULT PROTECTION

RESISTANCE GROUNDING



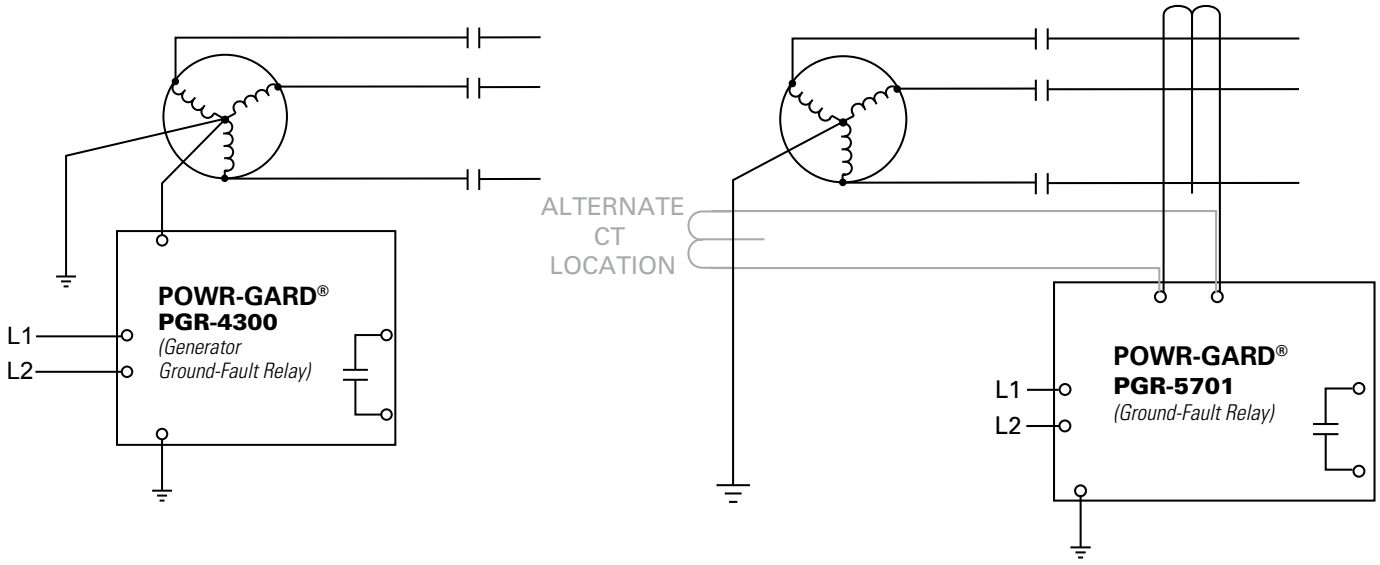


PULSING GROUND-FAULT SYSTEMS

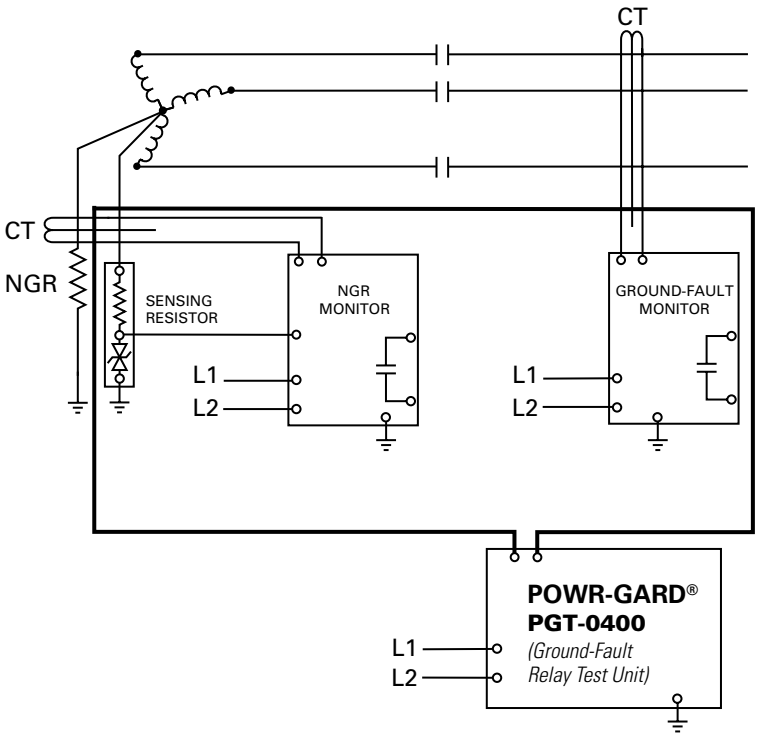


GFP
GROUND FAULT PROTECTION

GENERATOR GROUND-FAULT PROTECTION



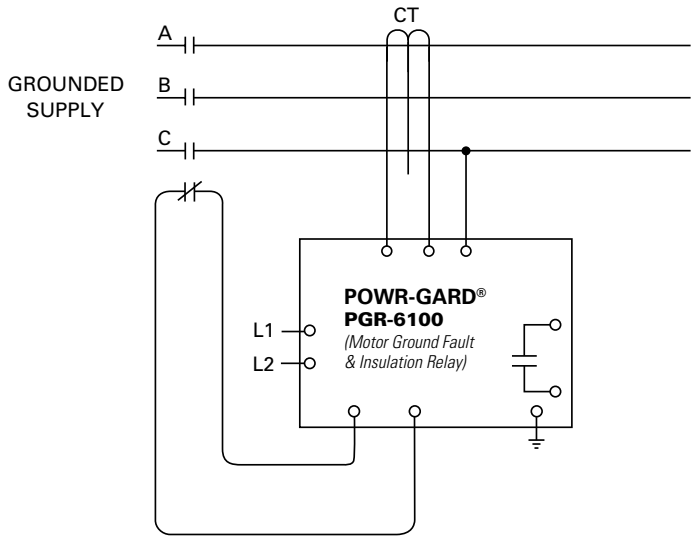
GROUND-FAULT-RELAY TEST UNIT



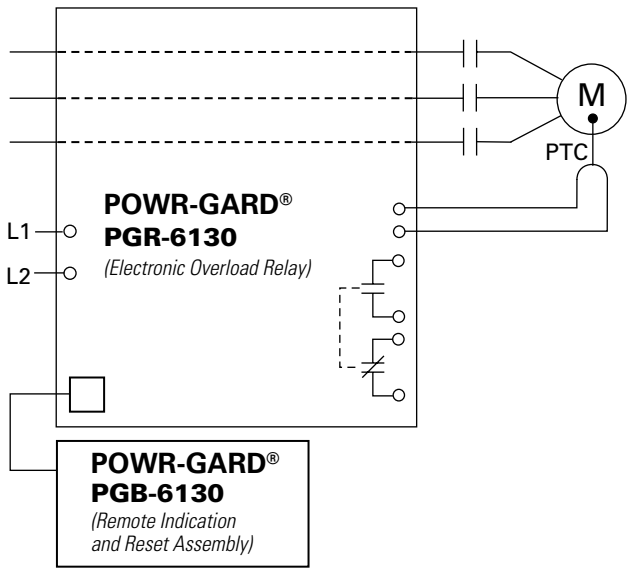
MP

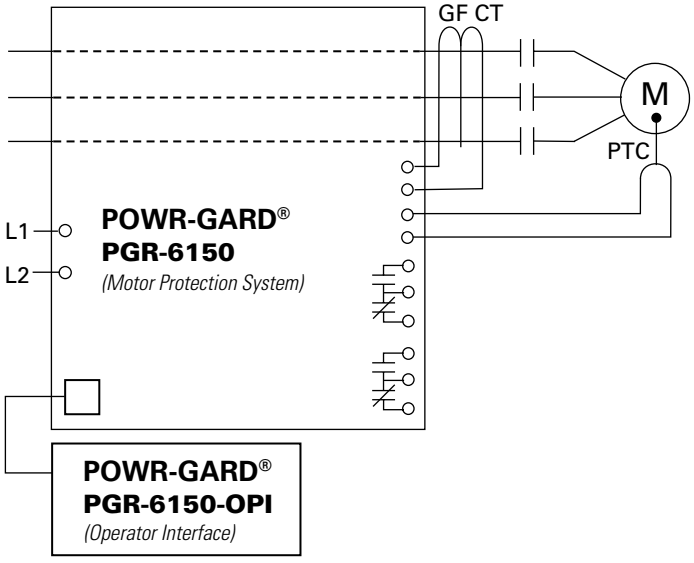
MOTOR PROTECTION

GROUND FAULT PROTECTION AND INSULATION MONITORING



MOTOR PROTECTION RELAYS





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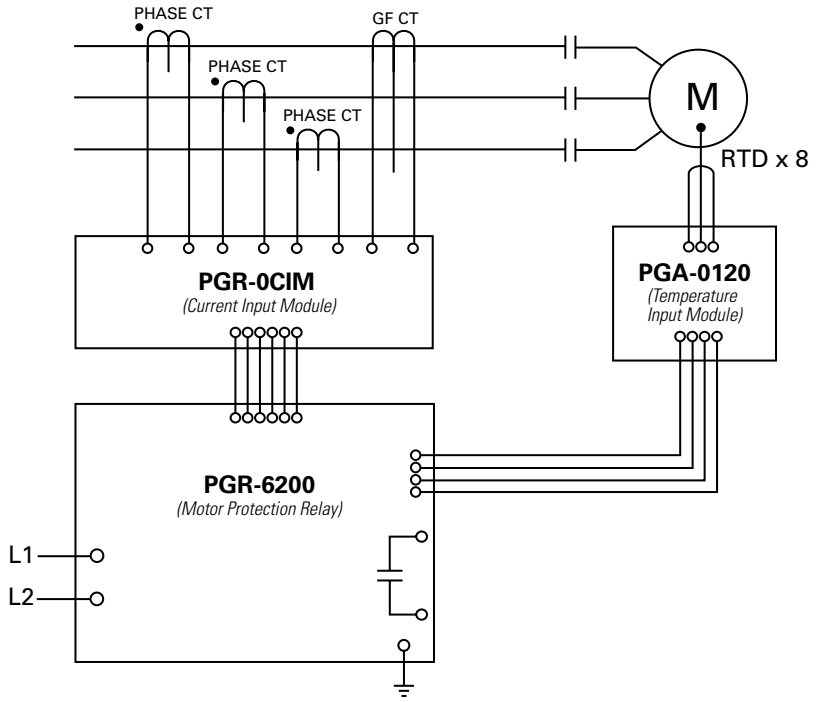
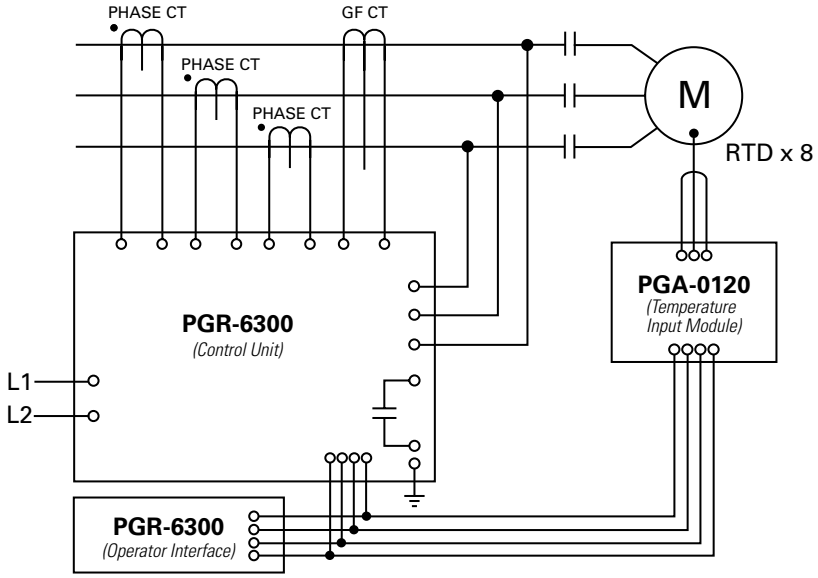
MOTOR PROTECTION

MOTOR PROTECTION UNIT





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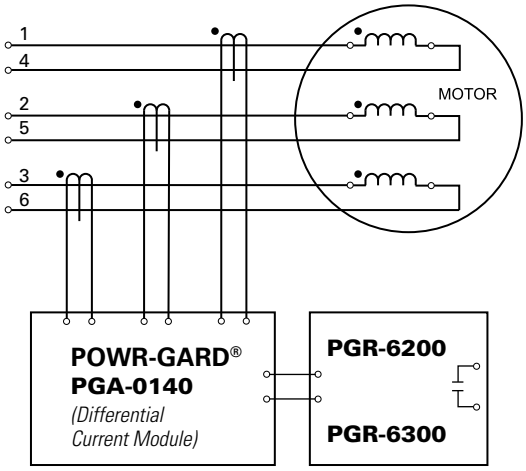
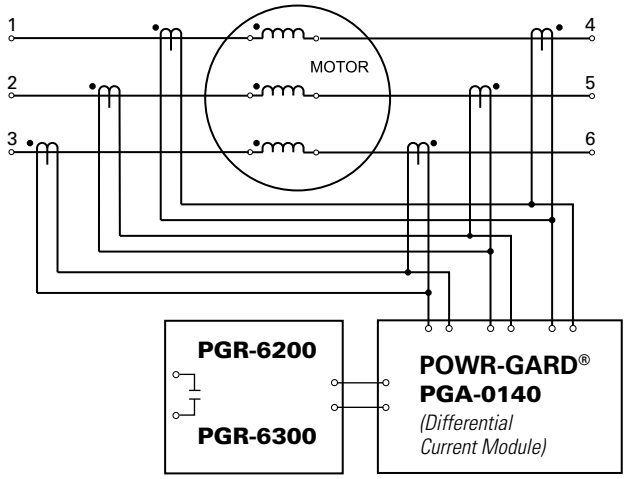
MOTOR PROTECTION

MOTOR DIFFERENTIAL PROTECTION

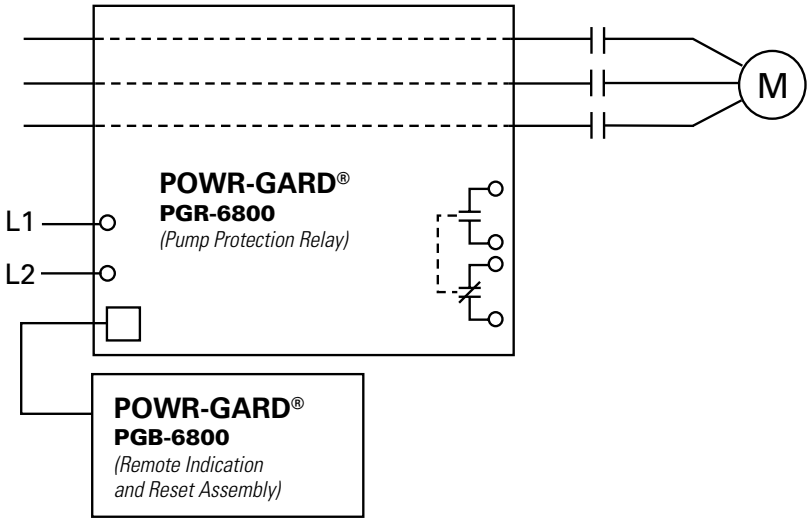


Core-Balance Connection



Summation Connection

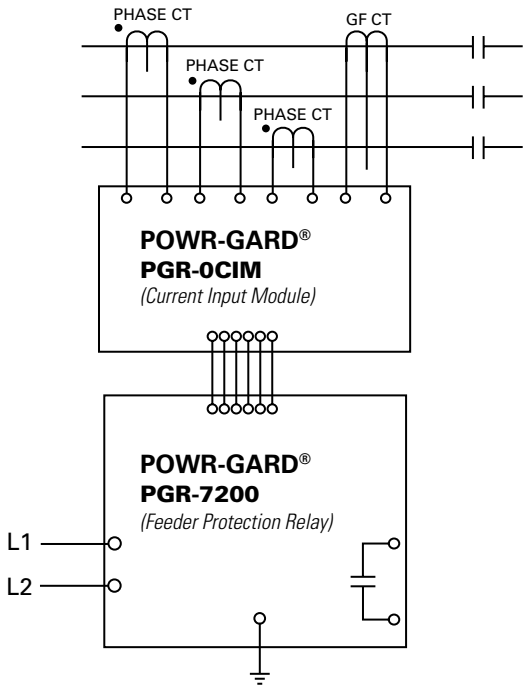
PUMP PROTECTION RELAY



FP

FEEDER PROTECTION

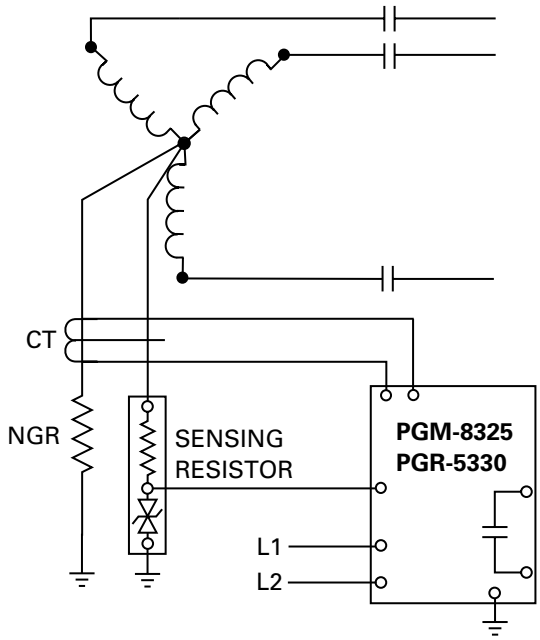
FEEDER PROTECTION UNIT



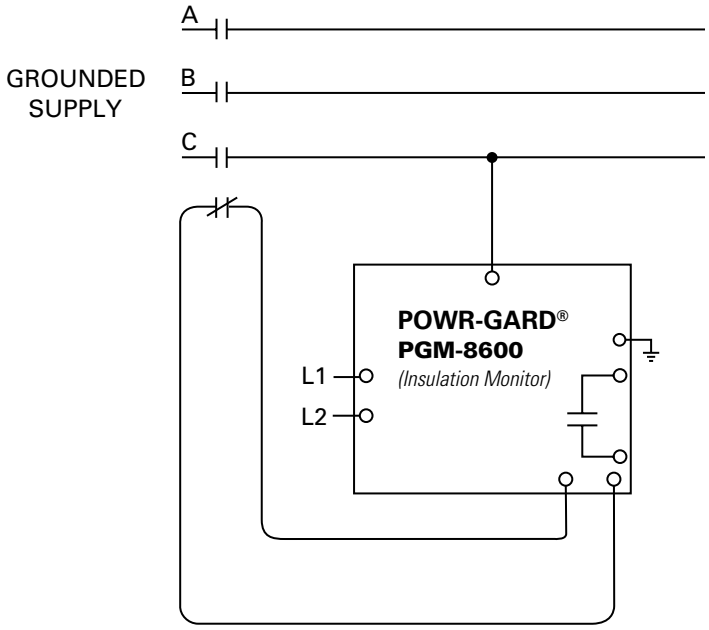
SM

SUPPLEMENTAL MONITORING

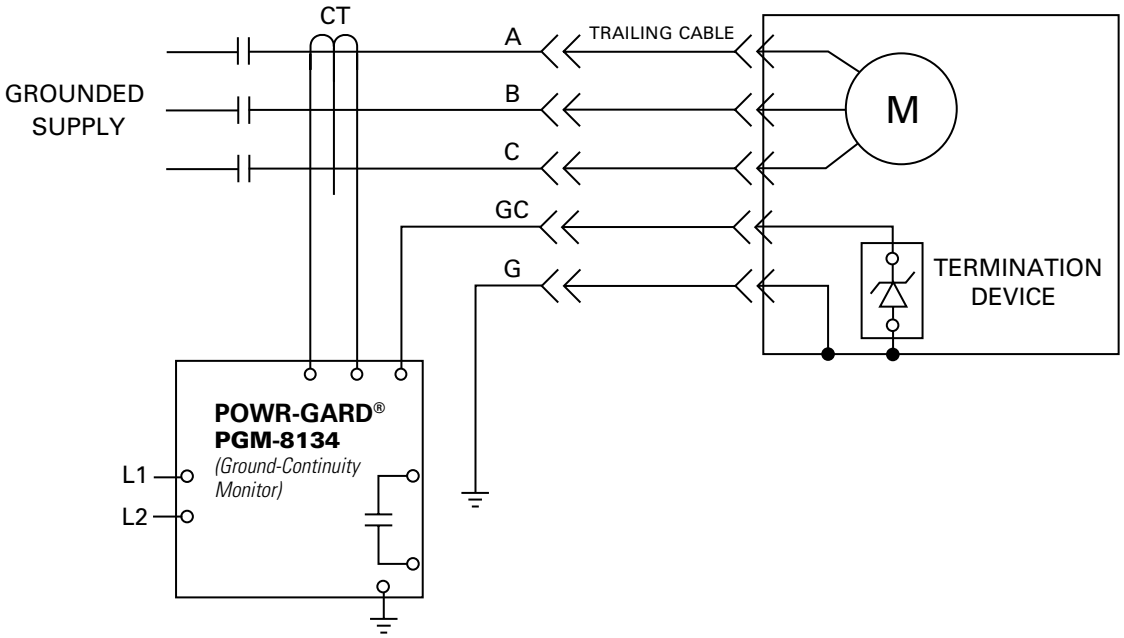
RESISTOR MONITOR



INSULATION MONITOR



GROUND-FAULT GROUND-CHECK MONITOR



IEEE DEVICE NUMBERS

1 - Master Element
2 - Time Delay Starting or Closing Relay
3 - Checking or Interlocking Relay
4 - Master Contactor
5 - Stopping Device
6 - Starting Circuit Breaker
7 - Rate of Change Relay
8 - Control Power Disconnecting Device
9 - Reversing Device
10 - Unit Sequence Switch
11 - Multi-function Device
12 - Overspeed Device
13 - Synchronous-speed Device
14 - Underspeed Device
15 - Speed - or Frequency, Matching Device
16 - Data Communications Device
17 - Shunting or Discharge Switch
18 - Accelerating or Decelerating Device
19 - Starting to Running Transition Contactor
20 - Electrically Operated Valve
21 - Distance Relay
22 - Equalizer Circuit Breaker
23 - Temperature Control Device
24 - Volts Per Hertz Relay
25 - Synchronizing or Synchronism-Check Device
26 - Apparatus Thermal Device
27 - Undervoltage Relay
28 - Flame Detector
29 - Isolating Contactor or Switch
30 - Annunciator Relay
31 - Separate Excitation Device
32 - Directional Power Relay
33 - Position Switch
34 - Master Sequence Device
35 - Brush-Operating or Slip-Ring Short-Circuiting Device
36 - Polarity or Polarizing Voltage Devices
37 - Undercurrent or Underpower Relay
38 - Bearing Protective Device
39 - Mechanical Condition Monitor
40 - Field (over/under excitation) Relay
41 - Field Circuit Breaker
42 - Running Circuit Breaker
43 - Manual Transfer or Selector Device
44 - Unit Sequence Starting Relay
45 - Abnormal Atmospheric Condition Monitor
46 - Reverse-phase or Phase-Balance Current Relay
47 - Phase-Sequence or Phase-Balance Voltage Relay
48 - Incomplete Sequence Relay
49 - Machine or Transformer, Thermal Relay
50 - Instantaneous Overcurrent Relay
51 - AC Inverse Time Overcurrent Relay
52 - AC Circuit Breaker
53 - Exciter or DC Generator Relay
54 - Turning Gear Engaging Device
55 - Power Factor Relay
56 - Field Application Relay
57 - Short-Circuiting or Grounding (Earthing) Device
58 - Rectification Failure Relay
59 - Overvoltage Relay
60 - Voltage or Current Balance Relay
61 - Density Switch or Sensor
62 - Time-Delay Stopping or Opening Relay
63 - Pressure Switch
64 - Ground (Earth) Detector Relay
65 - Governor
66 - Notching or Jogging Device
67 - AC Directional Overcurrent Relay
68 - Blocking or "Out-of-Step" Relay
69 - Permissive Control Device
70 - Rheostat
71 - Liquid Level Switch
72 - DC Circuit Breaker
73 - Load-Resistor Contactor
74 - Alarm Relay
75 - Position Changing Mechanism
76 - DC Overcurrent Relay
77 - Telemetering Device
78 - Phase-Angle Measuring Relay
79 - AC Reclosing Relay
80 - Flow Switch
81 - Frequency Relay
82 - DC Reclosing Relay
83 - Automatic Selective Control or Transfer Relay
84 - Operating Mechanism
85 - Communications, Carrier or Pilot-Wire Relay
86 - Lockout Relay
87 - Differential Protective Relay
88 - Auxiliary Motor or Motor Generator
89 - Line Switch
90 - Regulating Device
91 - Voltage Directional Relay
92 - Voltage and Power Directional Relay
93 - Field Changing Contactor
94 - Tripping or Trip-Free Relay

ANSI DEVICE NUMBERS

AFD - Arc Flash Detector
CLK - Clock or Timing Source
DDR - Dynamic Disturbance Recorder
DFR - Digital Fault Recorder
ENV - Environmental Data
HIZ - High Impedance Fault Detector
HMI - Human Machine Interface
HST - Historian
LGC - Scheme Logic
MET - Substation Metering
PDC - Phasor Data Concentrator
PMU - Phasor Measurement Unit
PQM - Power Quality Monitor
RIO - Remote Input/Output Device
RTU - Remote Terminal Unit/ Data Concentrator
SER - Sequence of Events Recorder
TCM - Trip Circuit Monitor
SOTF - Switch On To Fault

TYPICAL SUFFIXES

A - Alarm/Auxiliary Power
AC - Alternating Current
B - Battery/Blower/Bus
BT - Bus Tie
C - Capacitor/Condenser/ Compensator/Carrier Current/Case/Compressor
DC - Direct Current
E - Exciter
F - Feeder/Field/Filament/ Filter/Fan
G - Generator/Ground*
M - Motor/Metering
N - Network/Neutral*
P - Pump/Phase Comparison
R - Reactor/Rectifier/Room
S - Synchronizing/Secondary/ Stainer/Sump/Suction (Valve)
T - Transformer/Thyratron
TH - Transformer (High-voltage Side)
TL - Transformer (Low-voltage Side)
TT - Transformer (Tertiary-voltage Side)
U - Unit

Note: Descriptions per IEEE Std C37.2-1996
*Suffix N is preferred when the device is connected in the residual of a polyphase circuit, is connected across broken delta, or is internally derived from the polyphase current or voltage quantities. The suffix G is preferred where the measured quantity is in the path of ground or, in the case of ground fault detectors, is the current flowing to ground.

NEUTRAL GROUNDING RESISTOR
SIZING CHART

System Voltage (Line-to-line)	NGR Let-through Current and Resistance	Time Rating
208 V	5 A / 24 Ohms	Continuous
480 V	5 A / 55 Ohms	Continuous
600 V	5 A / 69 Ohms	Continuous
2,400 V	5 A / 277 Ohms or 10 A / 139 Ohms	Continuous or 10 s
4,160 V	5 A / 480 Ohms or 10 A / 240 Ohms	Continuous or 10 s
13,800 V	10 A / 798 Ohms or 200 A / 40 Ohms	10 seconds
25,000 V	200 A / 72 Ohms or 400 A / 36 Ohms	10 seconds
34,500 V	200 A / 100 Ohms or 400 A / 50 Ohms	10 seconds

Note: The values shown are for any size transformer and are typical.
NOTE: The above table is for illustrative purposes only. Actual values may differ based on a variety of individual system considerations, such as capacitive charging current and co-ordination study results.

CURRENT TRANSFORMER
SIZING CHART

Conductor Size (AWG/kcmil)	Minimum CT Window Size (Inner Diameter in mm)					
	Number of Conductors					
	1	3	4	6	8	12
12	4	8	9	11	13	15
10	6	10	11	14	16	19
8	7	12	14	17	20	24
6	9	15	18	22	25	31
4	11	19	22	28	32	39
3	13	22	25	31	36	44
2	14	25	28	35	40	49
1	16	28	32	39	45	55
1/0	18	31	36	44	51	62
2/0	20	35	40	49	57	69
3/0	23	39	45	55	64	78
4/0	25	44	51	62	72	88
250	28	48	55	67	78	95
350	33	56	65	80	92	113
500	39	67	78	95	110	135
750	48	82	95	117	135	165
1000	55	95	110	135	156	191

Installation Instructions:
When installing the PGC Family CTs, ensure the following:

1. Only the load carrying conductors pass through the center of the CT. This means L1 + N for 1-phase and L1+ L2 + L3 for 3-phase.
2. The power conductors pass through the center of the CT and are preferably bound together to keep the conductors uniformly spaced.
3. The power conductors pass perpendicular to the CT and, where practical, continue perpendicular to the CT on both sides of the CT for 3".
4. The power conductors should not be installed in a way that allows them to run along the side edges of the CT.
5. Where practical, locate the CT away from noise-generating devices such as transformers, frequency converters, etc.

POWR-GARD® PROTECTION 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		○	Remembers trip status when power is cycled, safely run with Ground Fault	8
PGR-3100	GF Relay	UG AC	Older industrial facilities	●	●	5 years		○	Meets NEC® Article 250.21(B)	9
PGR-3200	GF Relay	UG AC	Older industrial facilities		●	5 years		○	Meets NEC Article 250.21(B), provides 2 warnings	10
PGR-4300	GF Relay	SG AC	Manufacturers, rental companies and users of solidly grounded generators	●	●	5 years		○	No CTs, can be used on 3- and 4-pole switches, alarms when generator becomes ungrounded	11
PGR-4704	GF Relay	SG AC or RG AC	Motors, generators, pumps, irrigation systems, heating cables, SCR-controlled heaters, semiconductor mfg. equipment	●	●	5 years		○	Detects low level arcing faults, detects CT wiring problems, up to 5 A	12
PGR-5330	GF Relay	RG AC	Resistance Grounded Systems	●	●	5 years	●	●	Can be used on any system up to 35 kV and any resistor size	14
PGR-5701	GF Relay	SG AC or RG AC	Main, feeder, or load protection, motors, generators, pumps, heating cable, adjustable-speed drives	●	●	5 years		○	Remembers trip status when power is cycled, wide trip range	13
PGN-1000	Systems	UG AC or SG AC	Used on Medium Voltage systems to reduce Arc-Flash hazards		○	5 years	○		Optional resistor monitoring	32
PGN-3000	Systems	UG AC or SG AC	Used on Low Voltage and some Medium Voltage systems to reduce Arc-Flash hazards and downtime		●	5 years	●		Standard resistor monitoring, eliminates Ground Fault Arc-Flash Hazards, allows to safely run with Ground Fault	33
PGR-6100	GF & Insulation Monitor	AC systems	Ground Fault Protection and Insulation Monitoring for Motors	●	●	5 years		○	Detects problems when motor is energized or de-energized, detects problems with CT wiring	16
PGR-6130	Electronic Overload Relay	AC systems	Small motors that need additional protection (typically <75 hp)	●	●	5 years			Integral CT and standard protection in compact design	17
PGR-6150	Motor Protection System	AC systems	Premium protection for smaller and medium sized motors (typically >50 hp)	●	●	5 years	●		Integral CT, Operator Interface, and modular design	18
PGR-6200	Advanced Motor Protection Relay	AC systems	Smaller motors in critical applications and med-sized motors in standard applications (typically >100 hp)	●	●	10 years	●	●	Thermal modeling for better accuracy, Arc-Flash hazard reduction, optional temp and differential monitoring	20
PGR-6300	Advanced Motor Protection System	AC systems	Larger motors that need maximum protection (typically >500 hp)	●	●	10 years	●	●	Thermal modeling for better accuracy, Arc-Flash hazard reduction, opt. temp and voltage monitoring, can be used as starter control	22
PGR-6210	Retrofit Kit	Induction Motors	Replaces GE Multilin 169, 269 & 369	●	●	10 years	●	●	Plug and play installation, match existing curves	26
PGR-6310	Retrofit Kit	Induction Motors	Replaces GE Multilin 469	●	●	10 years	●	●	Plug and play installation, match existing curves	26
PGR-6800	Pump Protection Relay	AC systems	Submersible and Process Pump motors	●	●	5 years			Integral CT and Undercurrent to detect low-level	24
PGR-7200	Feeder Protection Relay	AC systems	Medium Voltage distribution circuits	●	●	10 years	●	●	IEEE and IEC curves, Arc-Flash hazard reduction	25
PGM-8134	Ground Check Monitor	Grounded AC	Shore-to-ship power, pumps, cranes, material handling	●	●	5 years		●	Provides reliable ground continuity verification	28
PGM-8325	Resistance Monitor	RG	Resistance Grounded Systems	●	●	5 years		●	Detects resistor failure	29
PGM-8600	Insulation Monitor	AC/DC systems	Systems in harsh environments such as dust, moisture, vibration or exposure to corrosive materials	●	●	5 years		○	Detects insulation failure	30

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

● standard ○ optional

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

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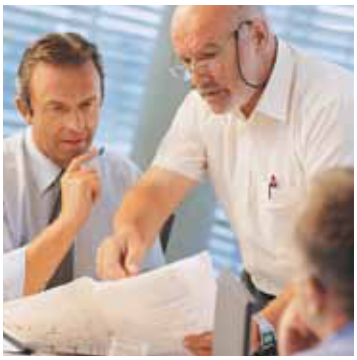

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Application Support

POWR-GARD's staff of professional engineers assists customers with the application of protection relays. By working with the customer during the design phase, our engineers are able to help identify potential issues and provide product recommendations to resolve difficult problems. Since we are involved from the beginning, we are also able to provide recommendations for relay settings.

Field Support

Our experienced product and application engineers are available to provide assistance when investigating the cause of a relay trip or alarm. As systems grow in terms of power and physical size, the protection relays may need to be adjusted. If so, our engineers are available to answer any questions that arise when modifying these applications.

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Featuring easy to use navigation, search and selection tools as well as in-depth product details, **www.littelfuse.com/protectionrelays** is a powerful resource for up-to-date technical information. In addition, our website features various software applications, such as relay-to-PC interface software, firmware, upgrade software, online demos and programming tutorials.

Littelfuse POWR-GARD® products and services enhance safety and productivity 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.

- **Fuses and Fuseholders**
- **Protection Relays**
- **Electrical Safety Services**
- **Worker Training**
- **Remote Indication Products**

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For over 30 years Littelfuse POWR-GARD® has helped OEM engineers, consulting engineers and end-users select the right products to protect critical electrical equipment—supported by our full line of product catalogs and reference materials.

Fuses and Fuseholders Catalog Littelfuse POWR-GARD® offers a complete circuit protection portfolio, including time saving indication products for an instant visual blown fuse identification, even on de-energized systems.

Up-LINK™ Fuseholder Brochure Up-LINK™ is a patented remote indication technology, incorporated in a growing number of fuseholders and other products that improve productivity by providing necessary information to monitoring sites.

Safety Services Catalog From Arc-Flash Hazard assessments to worker training, POWR-GARD® Safety Services improve facility safety and help safety managers meet OSHA standards.

OEM Design Brochure Design engineers can work with Littelfuse POWR-GARD® to add value to their products with standard or custom circuit protection solutions.

To request catalogs for the Littelfuse POWR-GARD® portfolio of fuses, electrical safety products and services, training, or OEM focused products, please contact your authorized Littelfuse sales representative or visit our website at **www.littelfuse.com/catalogs**

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