Littelfuse®

Expertise Applied | Answers Delivered

PROTECTION RELAYS & CONTROLS CATALOG

PROTECTION RELAYS & CONTROLS

Ground-Fault Protection • Motor & Pump Protection • Feeder Protection
Arc-Flash Protection • Custom Products • Generator Protection & Controls
Engine Controls & Diagnostics • Alarm Monitoring

Littelfuse®

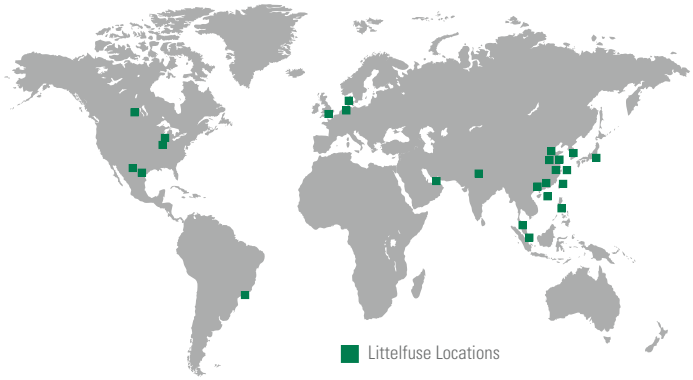
Protection Relays & Controls Catalog

We Are The **GLOBAL EXPERTS** in Electrical Safety and Productivity

Global Resources for A Global Market

From mining installations in Chile to semiconductor fabrication plants in Taiwan, customers trust Littelfuse 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.



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We Improve Electrical Safety and Increase Productivity

For decades Littelfuse 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 line of protection relays, custom products, generator and engine controls, and alarm monitors, plus the technical capabilities we offer for your application.

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

For All Harsh Environments

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

How to use this catalog

Choose your preferred product-selection method from the examples below.

→ By Product Category & Part Number: **Table of Contents** ..... Pg 2-3

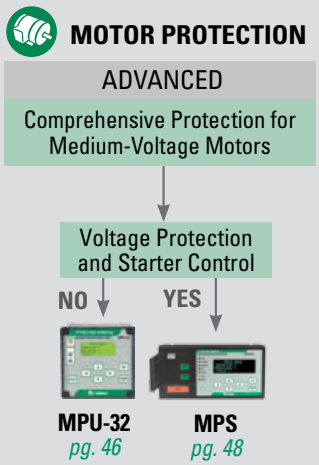
→ By **Application** ..... Pg 4-7

ELECTRIC UTILITY · GENERAL INDUSTRIAL · MARINE INDUSTRY · MINING OILSANDS · PANEL SHOP · PETRO CHEM · POWER GENERATION · PUMP PROTECTION · WASTE WATER

→ By **Feature Set** ..... Pg 8-9

FEATURE (IEEE #)	PGR-6100	PGR-6130	PGR-6150
Ground fault (50G/N, 51G/N)	✔		✔
Overload (49, 51)		✔	✔
Unbalance (current) (46)		✔	✔
Phase loss (current) (46)		✔	✔

→ By Product Category & Common Questions: **Product Selection Guide** ..... Pg 10-15



→ By Keyword or Part Number: **Alphanumeric Index** ..... Pg 159-160

TABLE OF CONTENTS

FIND THE RIGHT PRODUCT FOR YOUR APPLICATION

1 GROUND-FAULT PROTECTION

Create safer working environments and reduce incidents of Arc Flash without affecting the uptime of critical operations. Vital in manufacturing and processing environments, sensitive ground-fault relays with advanced filtering will detect breakdown in insulation resistance without nuisance trips. Breakdown in insulation resistance can be caused by moisture, vibration, chemicals and dust.

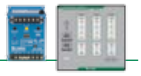
Ungrounded DC System

AC/DC Grounded System

Ungrounded AC Systems

Solidly-Grounded Systems

2 TRAILING CABLE PROTECTION



Continuously monitor the integrity of the ground conductor to protect portable equipment from hazardous voltages caused by ground faults.

3 RESISTANCE GROUNDING/NGR MONITORING

Overcome many of the issues experienced with solidly-grounded and ungrounded electrical systems. High-resistance grounding eliminates the Arc-Flash hazard associated with the first ground fault, transient overvoltages, and allows for continuous operation during a ground fault.

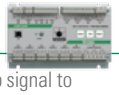
4 MOTOR AND PUMP PROTECTION

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

5 FEEDER PROTECTION

Protect feeder circuits from overcurrents, earth faults, phase loss and other detrimental conditions in critical applications and processes. They provide essential data for predictive and preventive maintenance, extending the life of equipment, enhancing safety and maximizing efficiency.

6 ARC-FLASH PROTECTION



Rapidly detects developing Arc-Flash incidents and sends a trip signal to interrupt power before significant damage occurs.

7 GROUND-FAULT CIRCUIT INTERRUPTION

The first product on the market to provide UL 943C, Class C and D shock protection for personnel in industrial facilities.

8 GENERATOR & SINGLE-FUNCTION PROTECTION

These Single-Function, compact and cost-efficient relays are typically used on low-voltage applications. DIN rail-mountable, easy to operate, install and commission. The wide-range power supply for AC and DC make these relays universal.

9 GENERATOR CONTROL

Synchronizing, frequency control, load sharing, power management and more for marine, emergency or power generation applications.

Basic

Standard

Advanced

10 ENGINE CONTROL

Control and protection for gen-sets, marine propulsion, pump and compressor engines. Communication interfaces for RS485 Modbus RTU and CAN J1939 are available.

11 ENGINE DIAGNOSTICS

The EngineEye diagnostic unit helps improve the efficiency and performance of combustion engines by measuring and analyzing the engine combustion process. It utilizes a handheld high-precision cylinder pressure indicator and a pressure sensor.

12 ALARM MONITORING

Monitor a wide range of alarms in industrial, power generation, petrochemical and marine applications. Both digital and analog signals can be monitored. External communication via RS485 Modbus RTU is available.

13 SOFTWARE

14 MOUNTING ADAPTERS

15 CURRENT TRANSFORMERS

16 ADDITIONAL ACCESSORIES

17 CUSTOM PRODUCTS/RELAY-RELATED ELEC. EQUIP.

Our custom-built portable power centers, distribution panels and substations are products of choice for leading mining companies. Littelfuse Startco manufactures rugged products that are built to withstand the harshest conditions and are fully tested to ensure they meet the most stringent mining requirements.

18 PROTECTION OVERVIEW

19 ALPHANUMERIC INDEX

TYPICAL APPLICATIONS

Ground-Fault Protection Relays

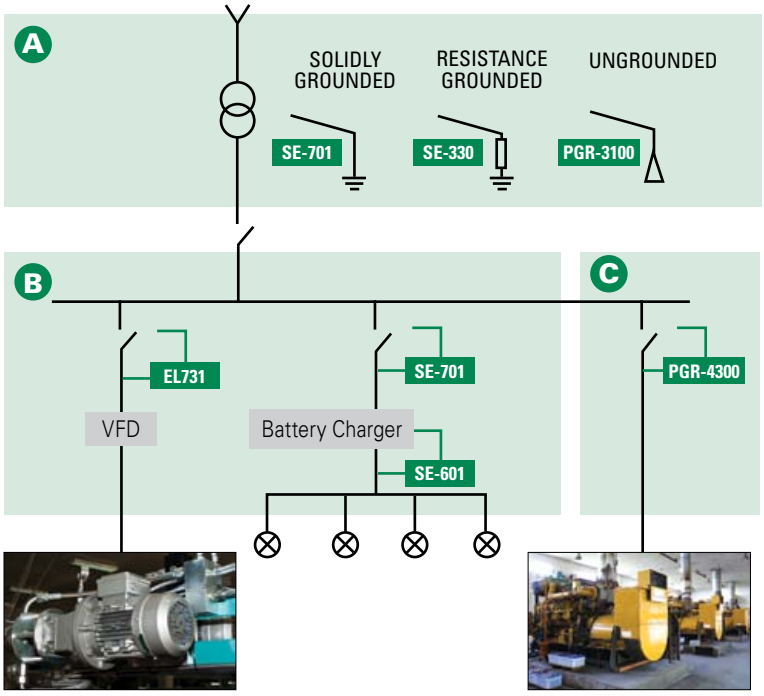
APPLICATION	COMMON PROBLEMS	PRODUCT PROTECTION CATEGORY (PG NO.)
GENERATORS	Insulation breakdown due to vibration and corrosion	Ground Fault (pg 18) Resistance Grounding (pg 34) Arc-Flash (pg 56)
TRANSFORMERS	Overloading and overvoltage	Resistance Grounding (pg 34) Feeder (pg 52)
SWITCHGEAR & MCCs	Highest average downtime (IEEE 493-1997)	Ground Fault (pg 18) Motor (pg 41) Feeder (pg 52) Resistance Grounding (pg 34) Arc-Flash (pg 56)
SWITCHBOARDS & PANELBOARDS	Low-level leakage current undetected by typical OCPDs	Ground Fault (pg 18)
DRIVES	Switching frequencies cause nuisance tripping	Ground Fault (pg 18) Motor (pg 41) Arc-Flash (pg 56)
MOTORS & PUMPS	Winding faults due to overloading, water, dust and vibration	Ground Fault (pg 18) Motor (pg 41) Arc-Flash (pg 56)
FEEDER CIRCUITS	Temperature and mechanical stress lead to severe damage	Ground Fault (pg 18) Feeder (pg 52)
PORTABLE EQUIPMENT	Movement causing broken conductors and failed insulation	Ground Fault (pg 18) Feeder (pg 52) Arc-Flash (pg 56)
GROUNDING RESISTORS	Open-circuit resistors due to corrosion or loose connections	Resistance Grounding (pg 34)

Motor & Feeder Protection Relays

APPLICATION	COMMON PROBLEMS	PRODUCT PROTECTION CATEGORY (PG NO.)
SWITCHGEAR & MCCs	Highest average downtime (IEEE 493-1997)	Ground- Fault (pg 18) Motor (pg 41) Feeder (pg 52), Resistance Grounding (pg 34) Arc-Flash (pg 56)
DRIVES	Switching frequencies cause nuisance tripping	Ground Fault (pg 18) Motor (pg 41) Arc-Flash (pg 56)
MOTORS & PUMPS	Winding faults due to overloading, water, dust and vibration	Ground Fault (pg 18) Motor (pg 41) Arc-Flash (pg 56)
FEEDER CIRCUITS	Temperature and mechanical stress lead to severe damage	Ground Fault (pg 18) Feeder (pg 52)
PORTABLE EQUIPMENT	Cable failure due to overloading	Motor (pg 41) Feeder (pg 52)

TYPICAL PRODUCT APPLICATION

GROUND-FAULT PROTECTION



A Service Entrance

Solidly Grounded GF Relay	**SE-701** (pg 26)
Resistance-Grounded GF Relay	**SE-330** (pg 36)
Ungrounded GF Relay	**PGR-3100** (pg 22)

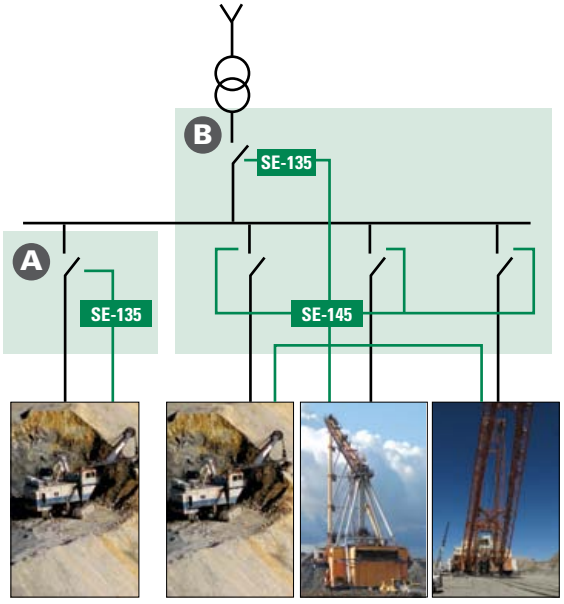
B Loads

Variable Frequency GF Relay	**EL731** (pg 20)
GF Relay	**SE-704** (pg 28)
DC GF Relay	**SE-601** (pg 19)

C Generator Ground-Fault Protection

Generator GF Relay	**PGR-4300** (pg 63)

TRAILING CABLE PROTECTION



A Single-Load Application

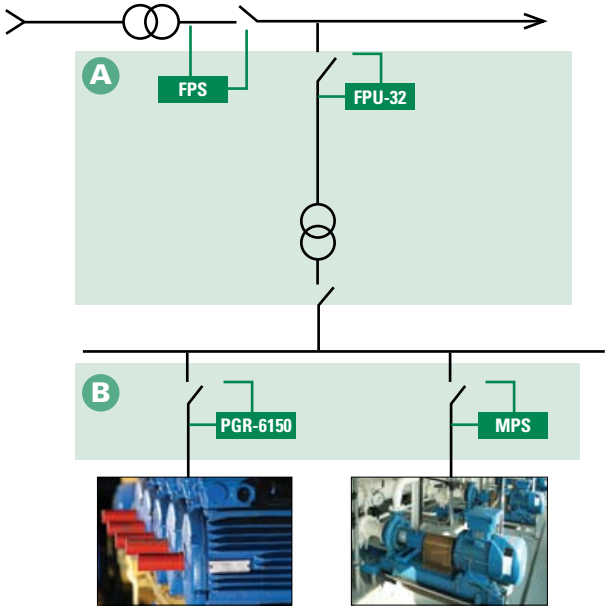
Ground-Check GF Relay	**SE-135** (pg 32)

B Multiple-Load Application

Ground-Check GF Relay System	**SE-145** (pg 33)

MOTOR & PUMP PROTECTION

FEEDER PROTECTION



A Feeder Protection

Feeder Protection Relay	**FPS** (pg 54)
Feeder Protection Relay	**FPU-32** (pg 53)

B Motor Protection

Standard Motor Protection Relay	**PGR-6150** (pg 44)
Advanced Motor Protection Relay	**MPS** (pg 48)

TYPICAL APPLICATIONS

Alarm Monitoring

Why are these Monitors necessary?
Alarm panels for monitoring of critical processes in marine, off-shore and land based applications. Analog or digital inputs for monitoring of for instance current, temperature or pressure. Indication of alarms. Logging of alarm and events.

APPLICATION	COMMON FUNCTIONS	PRODUCT CATEGORY (PG NO.)
MACHINERY ALARM SYSTEMS	Exhaust gas temperature monitoring on internal combustion engines, bearing temperature or coolant temperature monitoring.	Alarm Monitoring (pg 100)
MARINE ALARM SYSTEMS	Water Ingress Detection; Ballast Water Monitoring	
PROCESS AUTOMATION	Pump Control; Flow Control	
STORAGE FACILITY MONITORING	Ambient Condition Monitoring	

Engine Controls

Why are these Controls necessary?
The Engine Controls product group includes equipment for start, stop, monitoring and protection of internal combustion engines.

APPLICATION	COMMON FUNCTIONS	PRODUCT CATEGORY (PG NO.)
MARINE PROPULSION ENGINES	Engine Control and Safety Systems	Engine Control (pg 92)
MARINE AUXILIARY ENGINES	Engine Control and Safety Systems	
GENSET ENGINES	Control and protection of generator sets	

Engine Diagnostics

Why are these Diagnostics necessary?
Monitoring of engine condition for preventive maintanence and optimization.

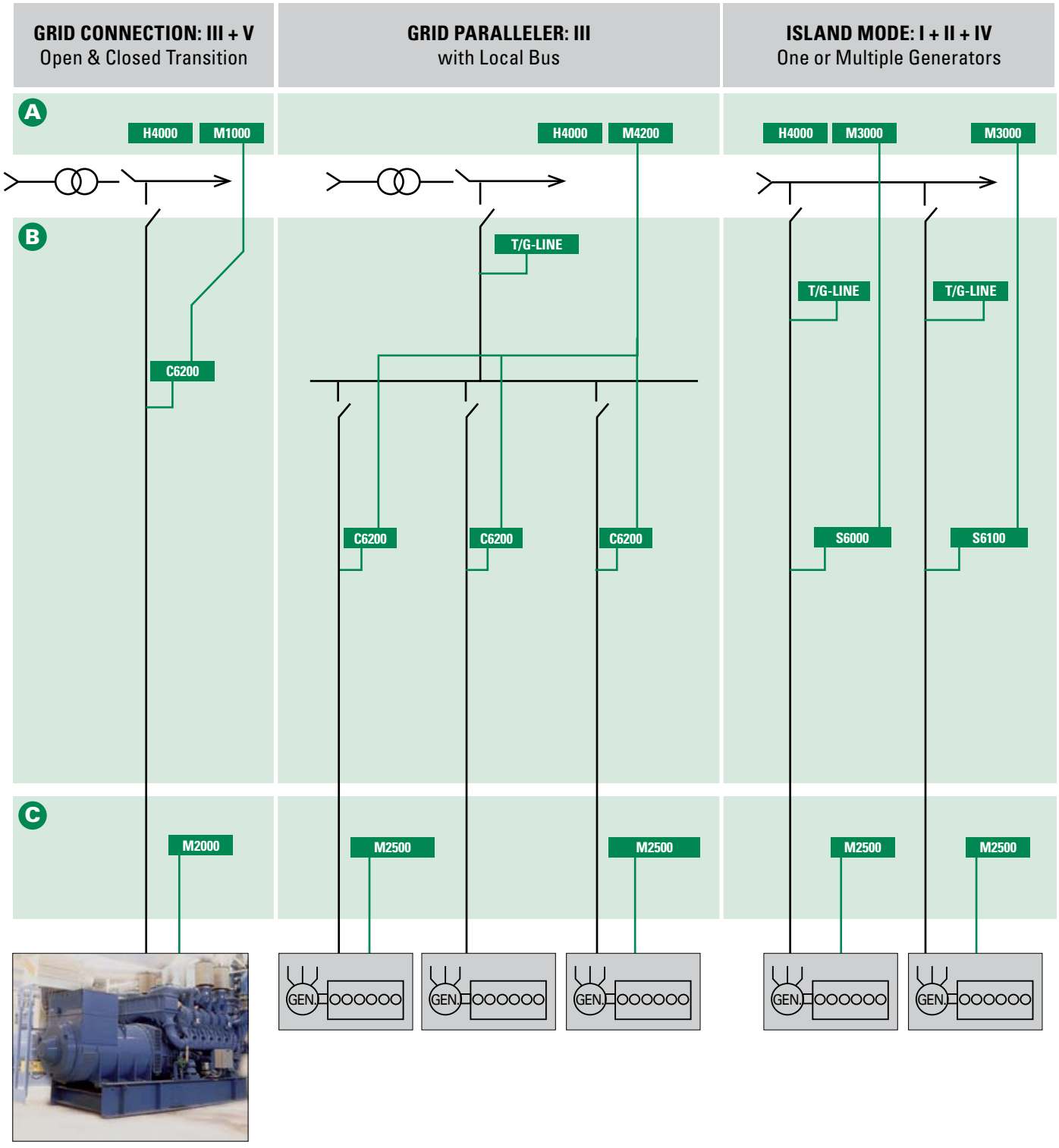
APPLICATION	COMMON FUNCTIONS	PRODUCT CATEGORY (PG NO.)
LARGE MARINE AND POWER STATION INTERNAL COMBUSTION ENGINES	Cylinder Pressure Analyzer, MIP	Engine Diagnostics (pg 97)

Generator Controls

Why are these Controls necessary?
This product group covers equipment for synchronization of Parallel Running Generators, Load Sharing and Power Management.

APPLICATION	COMMON FUNCTIONS	PRODUCT CATEGORY (PG NO.)
I. MARINE GENERATORS	Synchronizing, Load Sharing, Generator Protection, Speed/Voltage Control, Engine Control, Alarm and Safety Systems	Generator Protection (pg 62) Generator Control (pg 78) Engine Control (pg 92) Engine Diagnostics (pg 97) Alarm Monitoring (pg 100)
II. REMOTE POWER STATIONS	Synchronizing, Load Sharing, Generator Protection, Speed/Voltage Control, Engine Control Systems	
III. GRID PARALLEL GENERATORS	Synchronizing, Load Control, Power Factor Relation, Generator Protection, Speed/ Voltage Control, Engine Control Systems	
IV. CONTAINER GENSETS	Synchronizing, Load Sharing, Generator Protection, Speed/Voltage Control, Engine Control Systems	
V. EMERGENCY GENERATORS	Generator Protection, Speed/Voltage Control, Engine Control Systems	

TYPICAL PRODUCT APPLICATION



A Alarm Monitoring & Annunciation

Alarm Monitor	**M1000** (pg 101)
Alarm Monitor	**M3000** (pg 102)
Alarm Monitor	**M4200** (pg 103)
HMI Panel	**H4000** (pg 105)

B Generator Protection & Control

Generator Protection Relays	**T/G-Line** (pg 79-87)
Basic Generator Controls	**T/G-Line** (pg 79-87)
Standard Generator Controls	**C6200** (pg 88)
Advanced Generator Controls	**S6000** (pg 90)
Advanced Generator Controls	**S6100** (pg 90)

C Engine Control & Diagnostics

Engine Control	**M2000** (pg 93)
Engine Control/Monitor	**M2500** (pg 95)
Engine Diagnostics	**E5000** (pg 98)

FEATURE COMPARISONS

Use the feature tables below and the Product Selection Guide on pages 10-15 to choose the appropriate protection relay or monitor for your application.

Ground-Fault Protection Relays

FEATURE	SE-601	EL731	PGR-3100	PGR-3200	T3200	SE-502	SE-703 SE-704	SE-701	T2800	SE-105 SE-107	SE-134C SE-135	SE-145	SE-325	SE-330 SE-330HV SE-330AU
Detects GF via voltage			✓	✓		✓							✓	✓
Detects GF via current	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓
Detects DC GF	✓	✓												
Adjustable GF pickup	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
Adjustable time delay	✓	✓			✓		✓	✓	✓	✓	✓	✓	✓	✓
Remote reset	✓	✓		✓		✓	✓		✓	✓	✓	✓	✓	✓
Analog output	✓	✓		✓	✓		✓							✓
Fail-safe option	✓	✓				✓	✓		✓	✓	✓	✓	✓	✓
Harmonic filtering		✓		✓			✓		✓	✓	✓	✓	✓	✓
CT-Loop monitoring		✓					✓				✓	✓		
Insulation monitoring				✓	✓	✓								
Ground-check monitoring										✓	✓	✓		
Grounding-resistor monitoring													✓	✓
PTC/RTD overtemperature		✓												
Communications		✓												✓
Conformal coating	‡	✓	✓	‡	✓	‡	‡	✓	✓	✓	✓	✓	✓	✓

Arc-Flash Relays

FEATURE	D0100	D0900	PGR-8800
Current detection			✓
Point sensors	✓	✓	✓
Fiber optic sensors			✓
Cable monitoring on sensor inputs			✓
USB			✓
DC supply	✓		✓
AC supply		✓	✓
Data logging			✓

Motor & Feeder Protection Relays

FEATURE (IEEE #)	PGR-6100	PGR-6130	PGR-6150	MPU-32	MPS	PGR-6800	FPU-32	FPS
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					✓			
Breaker control								✓
Underspeed (14)					✓			
Integrated CTs		✓	✓			✓		
Off-line insulation monitoring	✓							
Metering and data logging			✓	✓	✓		✓	✓
Communications			✓	✓	✓		✓	✓
Conformal coating	‡			✓	✓		✓	✓
10-year warranty				✓	✓		✓	✓

Alarm Monitors

FEATURE	M1000	M3000	M4200	M4500	M4600	M4700	M4780
Alarm panel	✓	✓	✓				
Indicator panel	✓	✓	✓	✓	✓	✓	✓
No. of inputs	10	24	8	6	8	20	20
Digital input	✓	✓*	✓	✓	✓	✓	✓
No. of open collector outputs	10	14	4				
Common alarm output†	1oc	1oc	2dryc			1dryc‡	1dryc‡
Siren output	1dryc	1oc	1dryc			1dryc‡	1dryc‡
LCD display		✓					
Configure from PC	✓	✓	✓				
Configure from DIP switches/ jumper	✓		✓			✓	✓
Configure from front panel		✓					
MODBUS-RTU (RS485)	✓	✓					✓
LED dimming	✓	✓	✓				
LED synchronizing	✓		✓				
Panel linking	✓						
Remote reset	✓	✓	✓				
Sensor monitoring	✓	✓	✓				
Insulation monitoring of supply voltage	✓		✓				
Monitoring of supply voltage	✓		✓				

*Both analog and digital input.
†oc=open collector; dryc=dry contact
‡Optional

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.

FEATURE COMPARISONS

Use the feature tables below and the Product Selection Guide on pages 10-15 to choose the appropriate control and protection for your generator or engine.

Generator Protection & Single-Function Relays

FEATURE (IEEE #)	PGR-4300	G2000	G3000	G3300	T2000	T2100	T2200	T2300	T2400	T2500	T2700	T2900	T3000	T3100	T3300
Overload											✓				
Overcurrent							✓		✓	✓					
Undercurrent (37)															
Short circuit								✓		✓					
Reverse power (32)		✓			✓										
Overfrequency (81)			✓										✓		
Underfrequency (81)			✓										✓		
Overvoltage (59)				✓										✓	✓
Undervoltage (27)				✓										✓	✓
Excitation loss (40)						✓									
Earth fault															
Differential current relay (87)												✓			
Insulation monitoring relay															
Single phase measurement		✓	✓		✓	✓					✓		✓	✓	
3-phase measurement				✓			✓	✓	✓	✓		✓			✓
Conformal coating						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Engine Controls

FEATURE (IEEE #)	M2000	M2500	M2600
Start/stop	✓	✓	
Digital sensor inputs	✓	✓	✓
Analog sensor inputs		✓	
Cable monitoring on fuel/ stop solenoid output		✓	✓
Graphical display		✓	
CAN J1939		✓	
USB		✓	
SD card slot		✓	
Pick-up input	✓	✓	✓

Generator Controls

FEATURE (IEEE #)	T2600	T4500	T4800	T4900	T5000	E7800	T7900	M8100	T8400	C6200	S6000	S6100	S6610
3 phase true RMS measurement	✓	✓	✓	✓	✓			✓		✓	✓	✓	
Overcurrent										✓	✓		
Short circuit										✓	✓		
Overload										✓	✓		
Reverse power (32)			✓							✓	✓		
Excitation loss (40)										✓	✓		
Overfrequency (81)										✓	✓	✓	
Underfrequency (81)										✓	✓	✓	
Overvoltage (59)										✓	✓	✓	
Undervoltage (27)										✓	✓	✓	
ROCOF (81)										✓	✓		
Vector shift										✓			
Preferential load trip										✓	✓		
Synchronizing (25)		✓								✓		✓	
Check synchronizer (25)					✓			✓		✓		✓	
Active load sharing [kW]			✓							✓		✓	
Reactive load sharing [kVAR]				✓						✓		✓	
Power factor regulation				✓						✓		✓	
Dead bus monitoring/ black out limiter								✓		✓		✓	
Load depending start/stop (PM)	✓									✓			✓
Large consumer control (PM)										✓			✓
Dynamic grid-parallel operation control										✓		✓	
MODBUS RTU (RS485 interface)										✓	✓	✓	✓
Motorized potentiometer						✓							
Electronic potentiometer							✓						
Dead bus closure									✓				

Engine Diagnostics

FEATURES	BASIC E5000 & E5100	ADVANCED E5000, E5100 & E5200	PROFESSIONAL E5000, E5100, E5200 & 5300
USB	✓	✓	✓
Color LCD	✓	✓	✓
PC software included	✓	✓	✓
Upgradable	✓	✓	✓
Temperature compensation	✓	✓	✓
Calibration-check integration	✓	✓	✓
Connecting sensor ports	1	2	5
Pressure graph	✓	✓	✓
MIP mode		*	✓
Misfire analysis		✓	✓
p^{max}		✓	✓
p/time	✓	✓	✓
p^{max} bar graph		✓	✓
p/alpha		*	✓
dp/alpha		*	✓
p/V		*	✓
Pressure sensor	✓	✓	✓
Crank-angle sensor			✓
Maximum engines (memory)	5	10	20
Maximum cylinders/ engine (memory)	20	20	20
Maximum number of strokes (memory)	30	30	30

NOTE: These tables are for reference only and include standard and optional configurations.

*Possible with a crank angle sensor E5300.

STEP 1 Select product category

STEP 2 Select the needed features in each category

STEP 3 This is the recommended product for your application

GROUND-FAULT PROTECTION

TRAILING CABLE PROTECTION

UNGROUNDED DC	AC/DC	UNGROUNDED AC	SOLIDLY GROUNDED AC	GROUND-CONDUCTOR MONITORING & GROUND-FAULT PROTECTION
Detect & Limit Ground Faults	Low-Level Ground-Fault Protection for VFDs or DC Applications	Locate Ground Fault & Reduce Transient Overvoltage	Detect Ground Faults & Reduce Potential for Arc Flash	Ensure Ground-Conductor Continuity for Portable Equipment and Submersible Pumps and Detect Ground Faults

UNGROUNDED AC: YES → Convert System to Resistance Grounding; NO → Detect Insulation Breakdown
- YES → Dual Channel
  - NO → PGR-3200 pg. 23
  - YES → T3200 pg. 24
- NO → Detect Ground Fault by Phase/Ground Voltage Measurement → YES → PGR-3100 pg. 22

SOLIDLY GROUNDED AC: YES → Convert System to Resistance Grounding; NO → Ground-Fault Protection for Generators
- YES → SE-502 pg. 25
- NO → Ground-Fault Trip Level
  - Wide Range → SE-701 pg. 26
  - 10 mA-5 A → SE-704 pg. 28

GROUND-CONDUCTOR MONITORING & GROUND-FAULT PROTECTION → Cable Voltage
- <5 kV → SE-105 SE-107 pg. 31
- >5 kV → Number of Trailing Cables
  - Single cable or dual termination → SE-134C SE-135 pg. 32
  - Three trailing cables → SE-145 pg. 33

UNGROUNDED DC → SE-601 pg. 19

AC/DC → EL731 pg. 20

Ground-Fault Protection Relays

Trailing Cable Relays

RESISTANCE GROUNDING

RESISTANCE-GROUNDED AC

Neutral-Grounding Resistance (NGR) Continuity Monitoring

Pulsing, Digital Filtering, Communications, or Software

YES

Identify Faulted Feeder

YES

use in combination

SE-330 & SE-701
pg. 36 & 26

NO

SE-330
pg. 36

NO

SE-325
pg. 35

Implement Low-Resistance Grounding

PGN-1000
pg. 39

Implement High-Resistance Grounding

PGN-3000
pg. 40

FEEDER PROTECTION

STANDARD

Current Protection & Metering IEEE/IEC Overcurrent

FPU-32
pg. 53

ADVANCED

Current & Voltage Protection & Metering IEEE/IEC Overcurrent

FPS
pg. 54

Resistance-Grounding Systems

Feeder Protection Relays

STEP 1 Select product category

STEP 2 Select the needed features in each category

STEP 3 This is the recommended product for your application

MOTOR & PUMP PROTECTION

BASIC

Ground-Fault Protection and Insulation Monitoring

PGR-6100
pg. 42

STANDARD

Protection for Low-Voltage Motors (<1000 V), Integrated CTs

Typically <75 hp

Undercurrent Protection for Pump Applications

NO

PGR-6130
pg. 43

YES

PGR-6800
pg. 51

Multi-Function Protection for Low-Voltage Motors (<1000 V), Integrated CTs

Typically >50 hp

optional display

PGR-6150
pg. 44

ADVANCED

Comprehensive Protection for Medium-Voltage Motors, Reduced Arc-Flash Risk

Voltage Protection and Starter Control

NO

MPU-32
pg. 46

YES

MPS
pg. 48

RETROFITS

Pre-wired, Plug & Play Replacement for Obsolete Relays

MPU-32-X69X
MPS-469X
pg. 50

Motor & Pump Protection Relays

ARC-FLASH PROTECTION

ARC-FLASH DETECTION

Sensor Health Monitoring

NO

Overcurrent Detection

NO

Power Supply

DC

D0100
pg. 53

AC

D0900
pg. 53

YES

PGR-8800
pg. 54

YES

Arc-Flash Relays

GENERATOR & SINGLE-FUNCTION PROTECTION

CURRENT	VOLTAGE	POWER	MISC.
Single & Dual Channel Overcurrent, Short-Circuit	Under- & Over-Voltage	Forward & Reverse Power	Frequency, Excitation Loss, Differential

PGR-4300
T2200
T2300
T2400
T2500
pg. 63, 69-72

G3300
T3100
T3300
pg. 66, 76, 77

G2000
T2000
T2700
pg. 64, 67, 73

G3000
T2100
T2900
T3000
pg. 65, 68, 74, 75

ENGINE CONTROL

START/STOP & MONITORING	BACK-UP FOR MARINE SAFETY SYSTEM
J1939 Communication	Speed Detection via Pickup

J1939 Communication: YES → 

M2500
pg. 95

J1939 Communication: NO → Analog Sensor Inputs

Analog Sensor Inputs: YES →

M2500
pg. 95

Analog Sensor Inputs: NO → 

M2000
pg. 93

Speed Detection via Pickup: YES → 

M2600
pg. 96

Speed Detection via Pickup: NO → Speed Detection via Tacho Relay

Speed Detection via Tacho Relay: NO →

M2600
pg. 96

Speed Detection via Tacho Relay: YES → 

M0600
pg. 94

GENERATOR CONTROL

STEP 1 Select product category

STEP 2 Select the needed features in each category

STEP 3 This is the recommended product for your application

BASIC						STANDARD
Load Depending Start/Stop Relay	Synchronization	Load Sharing	Blackout Clearance	Motorized Potentio-meters	Electronic Potentio-meters	Flexible, Integrated Protection & Control
	Manual, Auto-matic	Active Load (kW), Reactive Load (kW)				Synchronizing & Load Sharing (kW), Synchronizing & Load Sharing (kW), Grid Parallel Mode, Island Mode, Load Depending Start & Stop, Marine Power Management

T2600
pg. 79

T5000
M8100
pg. 83, 86

T4500
pg. 80

T4800
pg. 81

T4900
pg. 82

T8400
pg. 87

E7800
pg. 84

T7900
pg. 85

C6200 FlexGen Basic + C6500
pg. 88

C6200 FlexGen Advanced + C6500
pg. 88

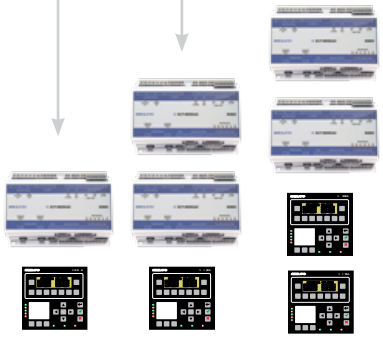
ENGINE DIAGNOSTICS

ALARM MONITORING

ADVANCED

Separate Protection and Control

- Generator Protection
- Generator Protection & Controls
- Complete Marine Power Management (incl. emergency & harbor generator control)



S6000 SIGMA +S6500 *pg. 90*

S6000 SIGMA +S6100 +S6500 *pg. 90*

S6000 SIGMA +S6100 +S6500 +S6610 *pg. 90*

CYLINDER PRESSURE ANALYZER

Crank Angle Measurement

NO

- Top Dead Center Correction

  NO

  E5000.1000 EngineEye Basic *pg. 98*

  YES

  E5000.2000 EngineEye Advanced *pg. 98*

YES

E5000.3000 EngineEye Professional *pg. 98*

ALARM PANELS

Analog Sensor Signal

YES

M3000 *pg. 102*

NO

- Bus Communications

  YES

  M1000 *pg. 101*

  NO

  M4200 *pg. 103*

INDICATOR PANELS

Bus Communications

YES

M4780 *pg. 104*

NO

M4500 M4600 M4700 *pg. 104*

Littelfuse **POWR-GARD®** Fuses...

Experts in Circuit Protection.

As the global leader in circuit protection, Littelfuse POWR-GARD Electrical Business Unit has over 5,000 fuses, fuse blocks and fuse holders for the electrical market—specifically designed to enhance the safety of installation and allow compliance with international codes and standards. Littelfuse provides well designed products, quality manufacturing and experienced support to assist you in attaining the best circuit protection for your application.

Littelfuse can provide immediate access to specialized technical resources, online references or application support in the field. Be sure to request the Littelfuse POWR-GARD® Catalog for all of our industrial fuse and fuse block products and the technical capabilities we offer for your application.

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INDICATING FUSE BLOCKS
TOUCH-SAFE FUSE HOLDERS
MEDIUM VOLTAGE FUSES
SEMICONDUCTOR FUSES
ELECTRONIC FUSES
AUTOMOTIVE FUSES
OEM CUSTOM PRODUCTS
SUPPRESSION PRODUCTS
PRE-ENGINEERED PANELS

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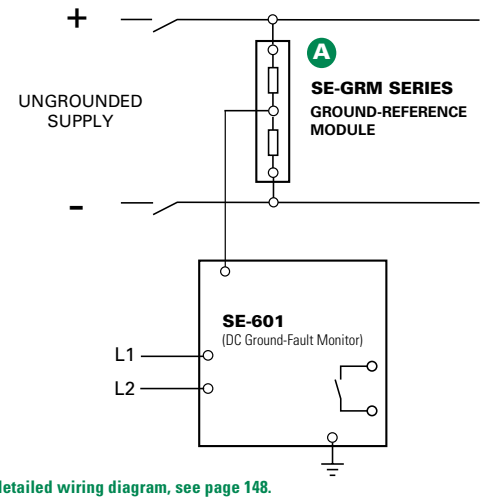
GROUND-FAULT PROTECTION

For More Information...
and to download our White Paper on Ground-fault Protection with VFDs, visit
www.littelfuse.com/technicalcenter

SE-601 SERIES (PGR-2601)

DC Ground-Fault Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 148.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-601-OD	24 Vdc
SE-601-OT	48 Vdc
SE-601-OU	120/240 Vac/Vdc

ACCESSORIES	REQUIREMENT	PAGE
SE-GRM SERIES	Required	117
PGA-0500	Optional	119
PMA-55	Optional	110
PMA-60	Optional	110

Note: For optional conformal coating please consult factory.

Description

The SE-601 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 an SE-GRM Series Ground-Reference Module—a resistor network that limits ground-fault current to 25 mA. The SE-601 is used on ungrounded dc systems ranging from industrial 24-Vdc control circuits to 1000-Vdc solar and transportation systems.

Features & Benefits

FEATURES	BENEFITS
Adjustable pickup (1-20 mA)	Ten settings provide 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 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 allow connection to shunt or undervoltage breaker coil
Microprocessor based	No calibration required saves on maintenance cost

Accessories

A 

SE-GRM Series Ground-Reference Module
Required accessory, used to connect the SE-601 DC Ground-Fault Monitor to the DC bus.

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	0.05-2.5 s
Output Contacts	Isolated Form A and Form B
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Test Button	Local
Reset Button	Local and remote
Analog Output	0-5 V
Conformally Coated	Consult factory
Approvals	CSA certified, UL Listed, CE (European Union), C-Tick (Australian)
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PMA-55 or PMA-60 adapter)

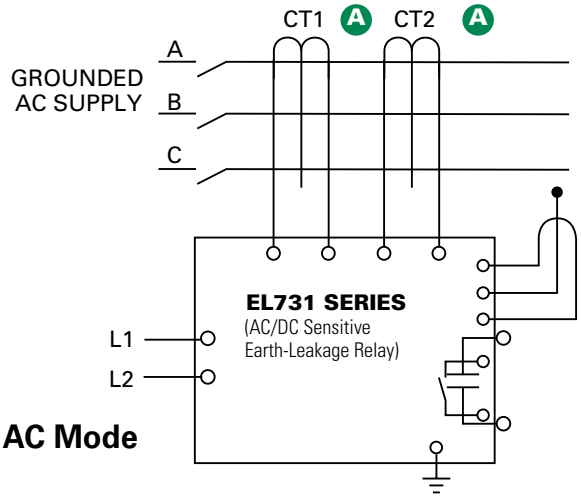
EL731 SERIES

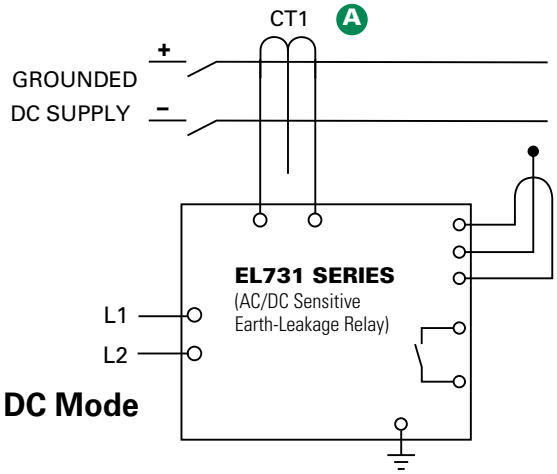
AC/DC Sensitive Earth-Leakage Relay

Description

The EL731 is a microprocessor-based AC/DC Sensitive Earth-Leakage Relay that offers complete coverage for all frequencies from 0-15,000 Hz. Two CT's are required for the entire frequency range, or one CT can be used for only low- or high-frequency detection. An RTD/PTC sensor input allows over-temperature protection. The EL731 offers metering capabilities, password-protected alarm and trip settings and optional network communications. It is used to add low-level ground-fault protection to variable-speed drives, and to dc currents.

Simplified Circuit Diagram





For detailed wiring diagram, see adjacent page and page 148.

Ordering Information

ORDERING NUMBER	CONTROL POWER	COMMUNICATIONS
EL731-00-00	120/240 Vac/Vdc	None
EL731-01-00	120/240 Vac/Vdc	DeviceNet™
EL731-02-00	120/240 Vac/Vdc	Profibus®
EL731-03-00	120/240 Vac/Vdc	Ethernet
EL731-04-00	120/240 Vac/Vdc	Modbus
EL731-10-00	48 Vdc & 24 Vac	None
EL731-11-00	48 Vdc & 24 Vac	DeviceNet™
EL731-12-00	48 Vdc & 24 Vac	Profibus®
EL731-13-00	48 Vdc & 24 Vac	Ethernet
EL731-14-00	48 Vdc & 24 Vac	Modbus
EL731-20-00	24 Vdc	None
EL731-21-00	24 Vdc	DeviceNet™
EL731-22-00	24 Vdc	Profibus®
EL731-23-00	24 Vdc	Ethernet
EL731-24-00	24 Vdc	Modbus

Accessories

EFCT Series Earth-Fault Current Transformer
Required zero-sequence current transformer specifically designed for low level detection.

AC700-CUA Series Communication Adapter
Optional network-interface and firmware-upgrade communications adapters field-install in EL731.

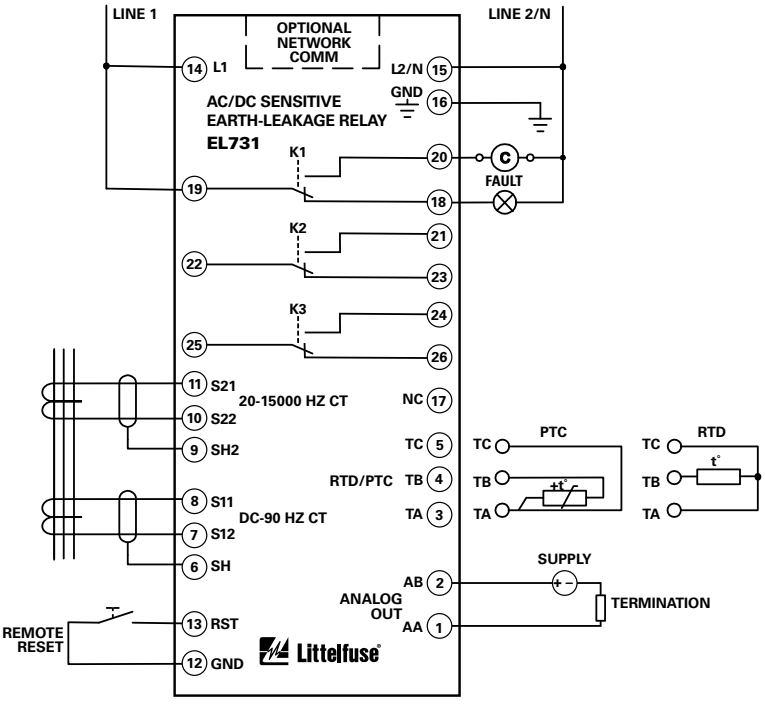
AC700-SMK DIN-rail & Surface-mount Adapter
EL731 plugs into adapter for back-plane mounting.

ACCESSORIES	REQUIREMENT	PAGE
EFCT Series CT	One Required	114
AC700-CUA Series Com. Unit	Optional	121
AC700-SMK Surface-Mount Kit	Optional	111

Features & Benefits

FEATURES	BENEFITS
Adjustable pickup (30-5,000 mA)	Adjustable trip setting provides a wide range of low-level protection and system coordination
Frequency range (0-90 Hz, 20-15,000 Hz)	Operate in either AC or DC mode or both. Use single or combined ranges. Separate metering.
32-char OLED display	Earth-leakage metering, setup and programming
Local LED indication	Visual Trip, Alarm, CT connection indication
CT-Loop monitoring	Alarms when CT is not connected
Analog output (4-20 mA)	Connect to DCS. Allows connection to an optional meter (PGA-0500) or control system
Adjustable time delay	Adjustable trip delay for quick protection and system coordination
Alarm and trip settings	Detect a deteriorating condition before damage occurs
Temperature-sensor input	Drive or motor temperature protection
Output contacts	3 programmable: Operate 2 alarm and 1 trip circuit
Network communication	Optional connection to plant network.
Harmonic filtering	Eliminates nuisance tripping due to harmonic noise
Microprocessor based	No required calibration saves maintenance cost
Universal power supply	Allows operation in application where one side of PT is faulted, provides flexibility for numerous applications

Wiring Diagram



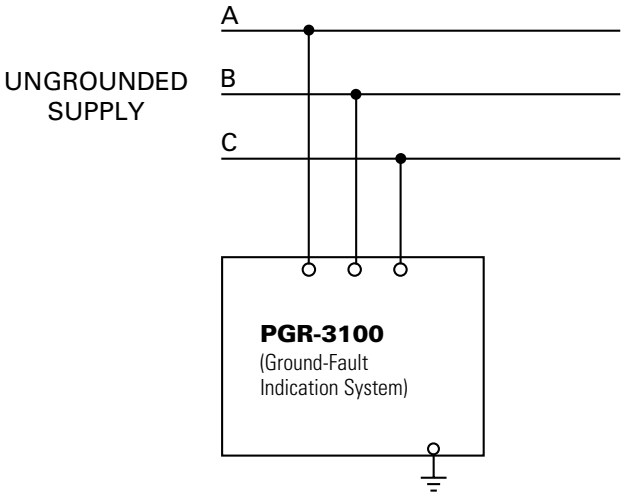
Specifications

IEEE Device Numbers	AC ground fault (50G/N, 51G/N), DC ground fault (79G), PTC overtemperature (49), RTD temperature (38, 49)
Supply Voltage	120/240 Vac/Vdc, 24 Vdc, 48 Vdc/24 Vac
Trip Level Settings	30-5,000 mA AC and DC
Alarm Level Settings	30-5,000 mA AC and DC
Trip Delay	0.05-2 s
Output Contacts	3 Form C (programmable)
Contact Operating Mode	Fail-safe & non-fail-safe
Reset	Front panel and remote
Freq. Response, CT1	0-90 Hz
Freq. Response, CT2	20-15,000, 190-15,000, 20-90 Hz; selectable
Current Transformer	EFCT-x series
CT Detection	Open & short detection
Terminals	Plug-in, wire clamping, 24 to 12 AWG (0.2-2.5 mm^2)
Communications	Ethernet/IP, DeviceNet™, Profibus®, Modbus (optional)
Analog Output	4-20 mA (selectable 0-5 A or 0-100% trip-level setting)
Conformal Coating	Standard feature
Dimensions	**H** 48 mm (1.9"); **W** 96 mm (3.8"); **D** 129 mm (5.0")
Approvals	UL Listed, CSA, C-Tick (Australian)
Warranty	5 years
Mounting	Panel; Surface and DIN (with optional AC700-SMK)

PGR-3100 SERIES

Ground-Fault Indication System

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	MOUNTING
PGR-3100	Panel mount
PGR-3100-PNL-00	Wall-mount enclosure style

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) and the Canadian Electrical Code Part 1, Section 10-106 (2) to have ground detectors, such as the PGR-3100, 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. Also available mounted in NEMA 4 enclosure.

Features & Benefits

FEATURES	BENEFITS
NEC® and CEC Code compliant	Meets National Electrical Code (NEC®) Article 250.21(B) and Canadian Electrical Code Part 1, Section 10-106 (2) 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) to ensure reliability
Lamp test button	Verifies LEDs are operating

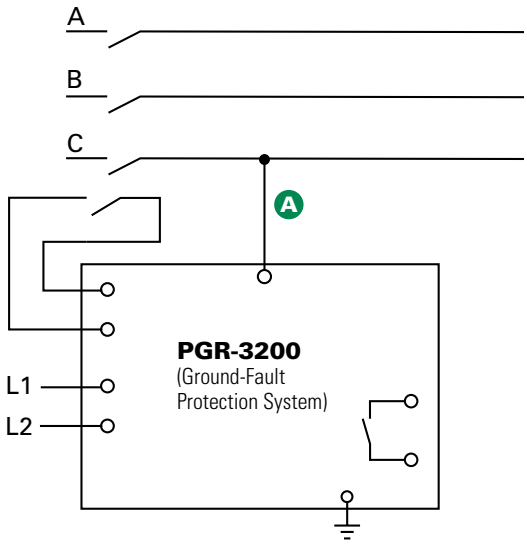
Specifications

Input Voltage Up to 600 Vac 50/60 Hz
Indicator Off Voltage < 30 Vac line to ground
Dimensions **H** 88.9 mm (3.5"); **W** 108 mm (4.3"); **D** 54 mm (2.1")
Test Button Local
Approvals CSA certified, UL Listed
Conformally Coated Standard feature
Warranty 5 years
Mounting Panel

PGR-3200 SERIES

Ground-Fault Protection System

Simplified Circuit Diagram



For detailed wiring diagram, see page 148.

Ordering Information

ORDERING NUMBER	CONTROL POWER
PGR-3200	240 Vac
PGR-3200-120	120 Vac

ACCESSORIES	REQUIREMENT	PAGE
PGH Series	Required >1,300 V	117
PGA-0510	Optional	119

Note: For optional conformal coating please consult factory. To convert to a resistance grounded system, see the neutral-grounding-resistors packages on pages 39 and 40. Also see system overview section starting at page 128.

Description

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

The PGR-3200 can also be used on a grounded system to monitor the insulation for damage, while the power system is de-energized. The mode-of-operation terminals (27-28) are connected to the circuit breaker or contactor auxiliary contacts to toggle the relay off when the contactor or breaker is closed.

Features & Benefits

FEATURES	BENEFITS
NEC® and CEC Code compliant	Meets National Electrical Code (NEC®) Article 250.21(B) and Canadian Electrical Code Part 1, Section 10-106 (2) requirements for ungrounded systems
Output contact (50 kΩ)	Form C output contact for alarming when the insulation resistance is below 50 kΩ
Output contact (10 kΩ)	Form C output contact for tripping when the insulation resistance is below 10 kΩ
Analog output (0-1 mA)	Provides means for connecting to an optional meter (PGA-0510) or control system
DIN-rail or surface mount	Flexible options for ease of installation

Accessories

A 

PGH Series High-Tension Coupler
A PGH Series high-tension coupler is required for systems between 1,300 V and 6,000 V.

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

Specifications

IEEE Device Numbers	Undervoltage Relay (27) Ground Detector Relay (64)
Input Voltage	See ordering information
Dimensions	**H** 75 mm (3"); **W** 100 mm (3.9"); **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	Local
Reset Button	Local and remote
Output Contacts	Two Form C
Analog Output	0-1 mA
Conformally Coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface

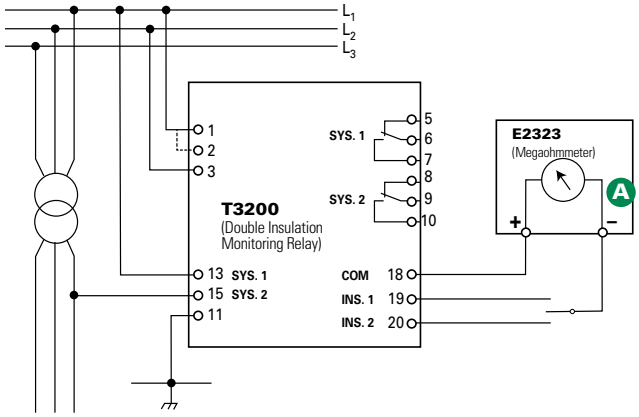
T3200 SERIES

Two-Channel Insulation-Monitoring Relay

Description

The T3200 Insulation-Monitoring Relay is designed for continuous insulation monitoring on three-phase insulated networks on board ships. The relay continuously monitors two systems galvanically separated from each other, e.g. the busbar and the lighting system, or two busbar systems. The unit features two output relays for alarm purposes and two analog outputs for instrument reading. Instruments are available from Littelfuse Selco as standard-sized switchboard instruments. The T3200 carries the CE label and has been approved by major marine classification societies.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfils marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combined monitoring of 2 independent systems	Economic solution and occupying less space in the switch panel
Available with separate 24 Vdc supply	Safe operation. Maintains protection regardless of system voltage failure
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw- mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	1-3 TERMINALS	2-3 TERMINALS
T3200.0010	230 V	–
T3200.0020	450 V	400 V
T3200.0030	480 V	415 V
T3200.0050	110 V	100 V
T3200.0060	127 V	120 V

Other voltages are available on request.

ACCESSORIES	DIMENSION	PAGE
E2323.0010 Megaohmmeter	96 x 96 mm	115
E2333.0010 Megaohmmeter	144 x144 mm	115

Accessories

A 

E2323 Megaohmmeter
Flush mounted units designed for connection with the T3200 for instrument readings.

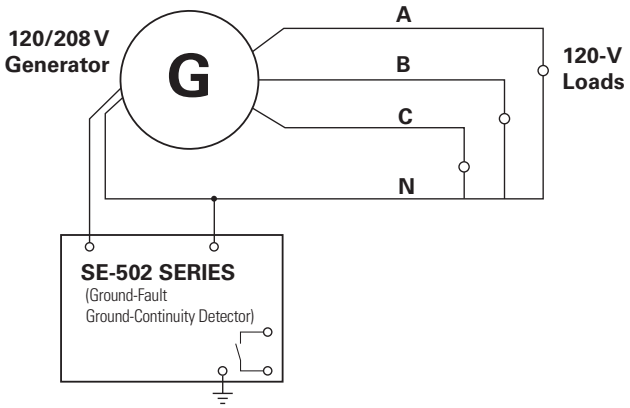
Specifications

InsulationLevel	0-5 MΩ
Delay	1-10 sec.
Max. Voltage	660 V
Voltage Range	80-110%
Consumption	Max. 2 VA
Frequency Range	45-65Hz
Measuring Voltage	15 Vdc
Instrument Output	0-1 mA
Instrument Resistance	Max. 100 Ω
Output relays	Normally de-energized; non-fail-safe
Contact Ratings	AC: 400 V, 2 A, 250 VA; DC: 110 V, 2 A, 100 W
Overall Accuracy	±5% of preset value
Operating Temperature	–20°C to + 70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.75"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

SE-502 SERIES

Ground-Fault Ground-Continuity Detector

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-502-01	120 Vac

Description

The SE-502 Ground-Fault Ground-Continuity Detector provides Class-A GFCI trip level and trip times for personnel protection. As little as 5 mA of ground-fault current can be detected, and the internal neutral-grounding resistor limits the maximum ground-fault current to 100 mA. The SE-502 can be used on both energized and de-energized systems, and will continuously monitor neutral continuity, detect a load-side grounded neutral, and is capable of ground proving. These features make the SE-502 ideal for use with 120/208 V portable generators and in heat-trace applications.

Features & Benefits

FEATURES	BENEFITS
Sensitive 5 mA ground-fault detection	Can be used with an appropriate breaker to provide Class A GFCI people protection
Internal neutral-grounding resistor	Limits maximum ground-fault current to 100 mA, creates a safer system and elminates arc-flash ground-fault hazards
Neutral-to-ground connection monitoring	Can detect a hazardous ungrounded condition and trip or alarm
On- and off-line monitoring	Can detect a ground fault when the system is energized or de-energized
Output contacts	Two Form C output contacts for alarming or tripping purposes

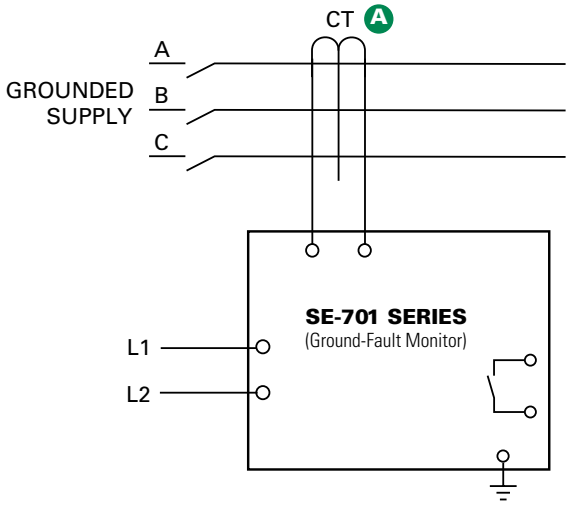
Specifications

IEEE Device Numbers	Ground (Earth) Detector Relay (64) Lockout Relay (86) Open-Neutral Detector Relay (95)
Input Voltage	120 Vac, 50/60 Hz
Dimensions	**H** 75 mm (3.0") **W** 100 mm (4.0") **D** 113 mm (4.4")
Trip Level Settings	5 ± 0.9 mA
Trip Time Settings	Class A GFCI to 25 ms maximum
Contact Operating Mode	Trip: fail-safe or non-fail-safe Alarm: fail-safe
Reset Button	Standard feature plus remote input
Output Contacts	Two Form C
Warranty	5 years
Mounting	DIN, Surface

SE-701 SERIES (PGR-5701)

Ground-Fault Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 149.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-701-0D	12/24 Vdc
SE-701-0T	48 Vdc
SE-701-0U	120/240 Vac/Vdc
SE-701-03	24 Vac

ACCESSORIES	REQUIREMENT	PAGE
Current Transformer	Required	114
PGA-0500	Optional	119
PMA-55, PMA-60	Optional	110
SE-EFVC Voltage Clamp	Optional	See website

Note: For optional conformal coating please consult factory.

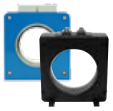
Description

The SE-701 is a microprocessor-based ground-fault relay for resistance- and solidly-grounded systems. In addition to common systems, it is uniquely suited for use on systems with significant harmonic content. The SE-701 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 (1-99%)	Trip setting based on input CT primary, allows use with any CT. Minimum 50 mA with EFCT Series.
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 meter (PGA-0500) or a control system
CT-Loop monitoring	Alarms when CT is not connected
Selectable DFT or peak detection filtering	Compatible with variable-speed drives
Harmonic filtering	Eliminates nuisance tripping
Non-volatile trip memory	Retains trip state while 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, provides flexibility for numerous applications

Accessories



A **Ground-Fault Current Transformer**
Required current transformer model depends 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, UL Listed, CE (European Union), C-Tick (Australian)
Analog Output 0-5 V
Conformally coated Consult factory
Warranty 5 years
Mounting DIN, Surface (standard)
Panel (with PMA-55 or PMA-60 adapter)

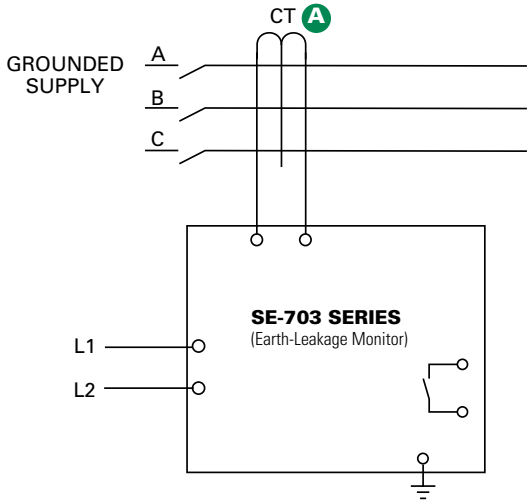
SE-703 SERIES

Earth-Leakage Monitor

Description

The SE-703 is a microprocessor-based ground-fault relay for resistance- and solidly-earthed systems. It offers sensitive ground-fault detection as low as 25 mA and can be used on systems with significant harmonic content. The SE-703 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. The SE-703 is specifically designed to be Australian AS/NZS 2081 compliant.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Adjustable pickup (25-500 mA)	Adjustable trip setting provides a wide range of low-level protection and system coordination
Adjustable time delay (50 -500 ms)	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 allow connection to shunt or undervoltage breaker coil
Harmonic filtering	Eliminates nuisance tripping
Non-volatile trip memory	Retains trip state while de-energized to simplify troubleshooting
Microprocessor based	No calibration required, saves maintenance cost
Universal power supply	Allows operation in application where one side of PT is faulted, provides flexibility for numerous applications

Accessories

A 

EFCT Series Ground-Fault Current Transformer
Required zero-sequence current transformer specifically designed for low-level detection.

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.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-703-0D	12/24 Vdc
SE-703-0T	48 Vdc
SE-703-0U	120/240 Vac/Vdc
SE-703-03	24 Vac

ACCESSORIES	REQUIREMENT	PAGE
EFCT Series	Required	114
PGA-0500	Optional	119
PMA-55, PMA-60	Optional	110
SE-EFVC Voltage Clamp	Optional	See website

Note: For optional conformal coating please consult factory.

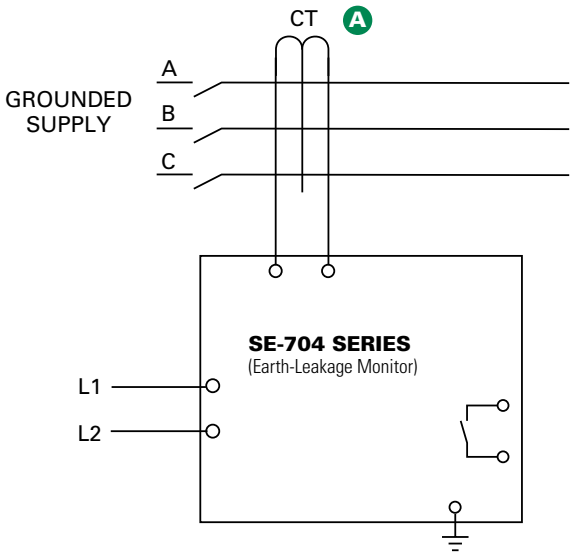
Specifications

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	25-500 mA
Trip Time Settings	50-500 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, UL Listed, CE (European Union), C-Tick (Australian)
Compliance	AS/NZS 2081:2002
Analog Output	0-5 V
Conformally coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PMA-55 or PMA-60 adapter)

SE-704 SERIES (PGR-4704)

Earth-Leakage Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 149.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-704-OD	12/24 Vdc
SE-704-OT	48 Vdc
SE-704-OU	120/240 Vac/Vdc
SE-704-03	24 Vac

ACCESSORIES	REQUIREMENT	PAGE
SE-CS30 Series	Required	114
PGA-0500	Optional	119
PMA-55, PMA-60	Optional	110

Note: For optional conformal coating please consult factory.

Description

The SE-704 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 and can be used on systems with significant harmonic content. The SE-704 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.

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 application where one side of PT is faulted, provides flexibility for numerous applications

Accessories

A 

SE-CS30 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 UL Listed (File No. E340889), CSA, C-Tick (Australian)
Analog Output 0-5 V & 0-1 mA
Conformally coated Consult factory
Warranty 5 years
Mounting DIN, Surface (standard)
Panel (with PMA-55 or PMA-60 adapter)

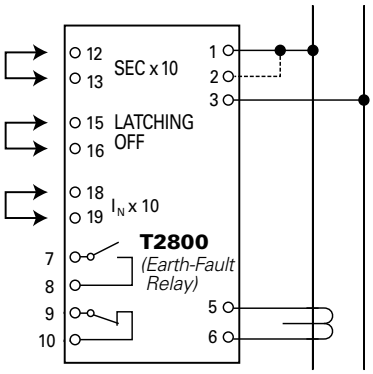
T2800 SERIES

Earth-Fault Relay

Description

The T2800 Earth Fault Relay is part of the T-Line series with modular units for protection, control and monitoring of generators. The T2800 detects the magnitude of the current and, if this exceeds the preset level (0.02-2 x I_N), the pick-up LED will indicate and the delay timer will be started. After the preset time (0.1-10 sec.) has expired the output relay and the corresponding LED will be activated, provided that the current level was exceeded for the entire delay time. The T2800 has a normally energized output relay. The relay is a latching relay which can be reset or disabled.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfils marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs
Wide range of combined current and delay settings	Enables versatile use as earth fault relay or standard overcurrent relay. Combining more units offers economic alternative to relays with inverse time response.
Galvanic isolated linputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw- mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS		I_N
	1-3	2-3	
T2800.00	230 V		5 A
T2800.01	450 V	400 V	5 A
T2800.02	127 V	120 V	5 A
T2800.04	24V DC+AC		5 A
T2800.05	480 V	415 V	5 A
T2800.08	230 V		1 A

Other combinations and voltages are available on request.

Specifications

Trip Level 0.02-0.2 x I_N or 0.2-2 x I_N
Delay 0.1-1.0 sec. or 1.0-10 sec.
Max. Voltage 660 V
Voltage Range 60-110%
Consumption Voltage 5 VA at U_N
Current 0.3 VA at I_N
Continuous Current 2 x I_N
Frequency Range 45-400 Hz
Output Relay Normally energized, latching, resetable
Contact Rating AC: 400 V, 5 A, 2000 VA
DC: 150 V, 5 A, 150 W
Overall Accuracy ±5%
Repeatability ±1%
Operating Temperature –20°C to + 70°C
Dielectric Test 2500 V
EMC CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals Certified by major marine classification societies
Burn-in 50 hours before final test
Enclosure Material Polycarbonate. Flame retardant
Weight 0.5 kg
Dimensions **H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation 35 mm DIN rail or 4 mm (3/16") screws

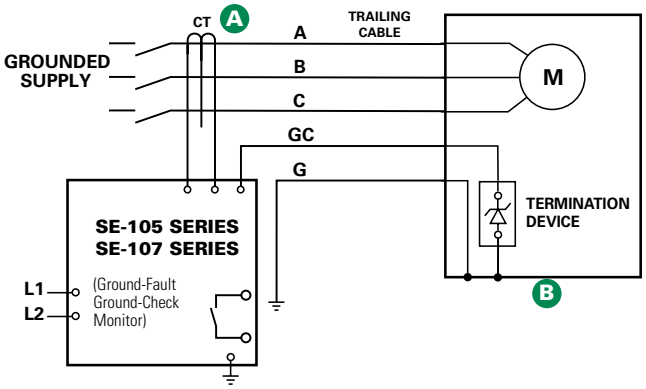
TRAILING CABLE PROTECTION

For More Information...
to download datasheets and manuals on Trailing Cable Protection Relays, click the Technical Resourses tab at
www.littelfuse.com/trailingcable

SE-105, SE-107 SERIES

Ground-Fault Ground-Check Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 150.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-105	120 Vac
SE-105D	120 Vac/Vdc
SE-105E	240 Vac
SE-107	120 Vac
SE-107D	120 Vac/Vdc
SE-107E	240 Vac

Consult manual online for additional ordering options.

ACCESSORIES	REQUIREMENT	PAGE
CT200 Series	Required	114
1N5339B	Included	120
SE-TA6, SE-TA6-SM	Optional	120
SE-TA6A Series	Optional	120
RK-102, RK-105, RK-105I	Optional	118
RK-13	Optional	120
PPI-600V	Optional	120

Description

The SE-105/SE-107 is a combination ground-wire monitor and ground-fault relay for resistance-grounded systems. It continuously monitors the integrity of the ground conductor to protect portable equipment from hazardous voltages caused by ground faults. The SE-105/SE-107 is an excellent choice for trailing cables 5 kV and under in underground mining applications. For higher voltages or long-cable applications, see the SE-134C/SE-135.

Features & Benefits

FEATURES	BENEFITS
Adjustable pickup (0.5, 2.0, 4.0 A)	Unit can be used on a wide variety of trailing cable applications
Adjustable time delay (0.1-2.0 s)	Adjustable trip delay for quick protection and system coordination
Harmonic filter	Prevents false operation
Zener-characteristic termination assembly	Provides reliable ground-check loop verification
Fail-safe ground-check circuit	Ensures ground-check circuit remains safe even in the event of equipment failure
Conformal coating	Additional coating protects circuit boards against harsh environment
SE-105: Selectable UV- or shunt-trip mode	Provides flexibility for different applications
SE-107: UV-trip mode only	Eliminates chance of unauthorized change to trip circuit

Accessories

A **CT200 Series Current Transformer**
Required CT detects ground-fault current.

B **1N5339B Termination Device**
5 W axial-lead ground-check termination; included with SE-105/SE-107.

SE-TA6 Termination Assembly
Optional termination assembly with convenient terminals and mounting holes

SE-TA6-SM Stud-Mount Termination Assembly
Optional 50 W ground-check termination that is robust and compact for submersible pumps. Wire lead simplifies installation.

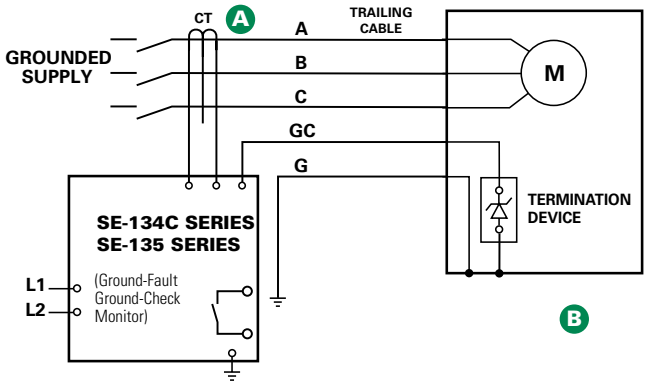
Specifications

IEEE Device Numbers Checking or Interlocking Relay (3GC), Ground Fault (50G/N, 51G/N)
Input Voltage See ordering information
Dimensions **H** 150 mm (5.9"); **W** 109 mm (4.3"); **D** 100 mm (4.0")
Trip Level Settings 0.5, 2.0, 4.0 A
Trip Time Settings 0.1-1.0 s
Contact Operating Mode Selectable fail-safe or non-fail-safe (SE-105) Fail-safe only (SE-107)
Harmonic Filtering Standard feature
Reset Button Local and remote
Output Contacts Isolated Form A
Approvals CSA certified, UL Listed, C-Tick (Australian)
Conformally Coated Standard feature
Warranty 5 years
Mounting Surface

SE-134C, SE-135 SERIES (PGM-8134)

Ground-Fault Ground-Check Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 150.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-134C-00	120/240 Vac/Vdc
SE-134C-10	24-48 Vdc
SE-135-00	120/240 Vac/Vdc
SE-135-00	24-48 Vdc

ACCESSORIES	REQUIREMENT	PAGE
SE-CS10 Series	Required	114
SE-TA6A Series (for SE-134C)	Required	120
SE-TA12A/SE-TA12B Combination (for SE-134C)	Optional	120
SE-TA12A Series (for SE-135)	Required	120
SE-IP65CVR-G	Optional	121
RK-132	Optional	118
PPI-600V	Optional	120

See pg. 112-121 for Current Transformer Selection Guide and Accessory Information.

Description

The SE-134C/SE-135 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 conductor to protect portable equipment from hazardous voltages caused by ground faults. The SE-134C/SE-135 is field proven in monitoring trailing cables on large mobile equipment such as drag-lines, mining shovels, 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

Accessories

A 

SE-CS10 Series Ground-Fault Current Transformer
Required zero-sequence current transformer detects ground-fault current.

B 

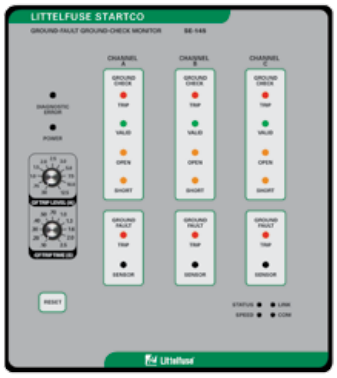
SE-TA6A Series, SE-TA12A Series Termination Assembly
Required termination assembly; temperature compensated.

Specifications

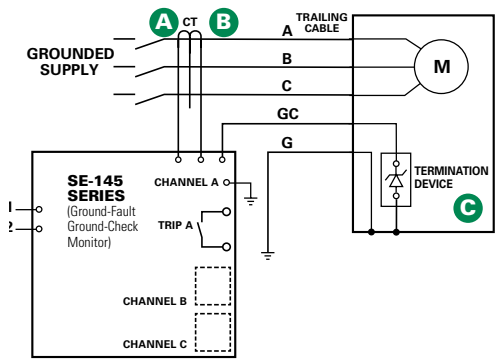
IEEE Device Numbers	Checking or Interlocking Relay (3GC), Ground fault (50G/N, 51G/N)
Input Voltage	60-265 Vac; 80-370 Vdc 15W
Dimensions	**H** 213 mm (8.4"); **W** 99 mm (3.9"); **D** 132 mm (5.2");
Trip Level Settings	0.5-12.5 A
Trip Time Settings	0.1-2.5 s
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard feature
Test Button	Standard feature
Reset Button	Standard feature
Output Contacts	Isolated Form A and Form B
Approvals	CSA certified, UL Listed, C-Tick (Australian)
Conformally Coated	Standard feature
Warranty	5 years
Mounting	Panel, Surface

SE-145 SERIES

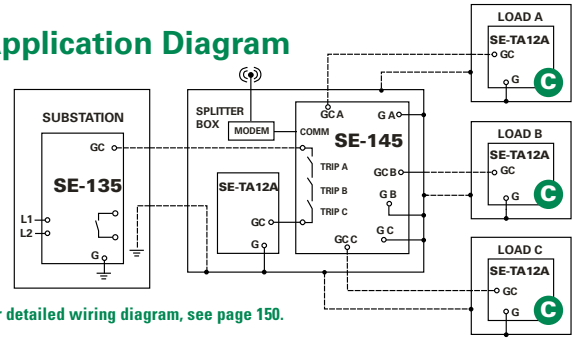
Ground-Fault Ground-Check Monitor



Simplified Circuit Diagram



Application Diagram



For detailed wiring diagram, see page 150.

Ordering Information

ORDERING NUMBER	CONTROL POWER	COMM
SE-145-00-00	120/240 Vac/Vdc	–
SE-145-00-10	24/48 Vdc	–
SE-145-03-00	120/240 Vac/Vdc	Ethernet
SE-145-03-10	24/48 Vdc	Ethernet

ACCESSORIES	REQUIREMENT	PAGE
SE-CS10 or SE-CS40 Series	Required	114
SE-TA12A Series	Required	120
RK-132	Optional	118

See pg. 112-121 for Current Transformer Selection Guide and Accessory Information.

Description

The SE-145 is a three-channel, 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 SE-145 is designed for use on three-way splitter box applications.

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

Accessories

A 

SE-CS10 Series Ground-Fault Current Transformer
Zero-sequence current transformer detects ground-fault current. Provides 0.5 to 12.5 A trip range.

B 

SE-CS40 Series Ground-Fault Current Transformer
Zero-sequence current transformer detects ground-fault current. Provides 2.0 to 50 A trip range.

C 

SE-TA12A Series Termination Assembly
Required termination assembly; 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** 192 mm (7.6"); **D** 176 mm (7.0");
Trip Level Settings 0.5-12.5 A or 2.0-50.0 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
Communications Ethernet Optional
Output Contacts Isolated Form A and Form B
Conformally Coated Standard feature
Warranty 5 years
Mounting Panel, Surface

RESISTANCE GROUNDING/ NGR MONITORING

For More Information...
on Resistance Grounding and NGR Monitoring, and to download Why NGRs Need Contiuous Monitoring, visit
www.littelfuse.com/technicalcenter

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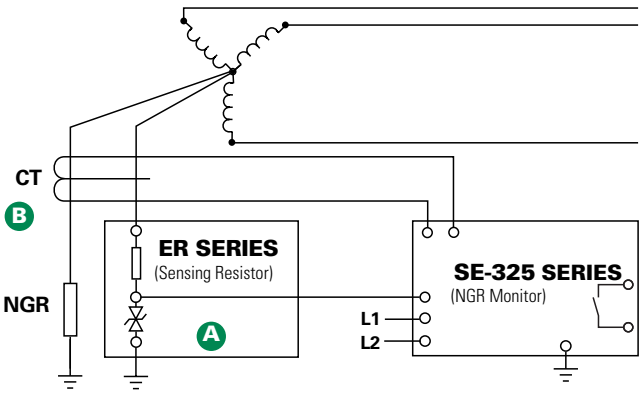
SE-325 SERIES (PGM-8325)

Neutral-Grounding-Resistor Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see page 151.

Ordering Information

ORDERING NUMBER	CONTROL POWER
SE-325	120 Vac
SE-325D	120 Vac/Vdc
SE-325E	240 Vac

Consult manual online for additional ordering options.

ACCESSORIES	REQUIREMENT	PAGE
CT200 Series	Required	114
ER Series	Required	119
SE-MRE-600	Optional	111
RK-325, RK-325I, RK-302	Optional	118-119
RK-13	Optional	120
NGRM-ENC	Optional	111

Description

The SE-325 Neutral-Grounding-Resistor Monitor is used on resistance-grounded systems up to 25 kV to monitor the integrity of the neutral-to-ground path and to detect ground faults. It measures current and voltage in a transformer or generator neutral-to-ground connection and continuity of the neutral-grounding resistor (NGR). The SE-325 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 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 or alarm system

Accessories

A 

ER Series Sensing Resistor
Required interface between the power system and the SE-325. Eliminates hazardous voltage levels at the monitor.

B 

CT200 Series Current Transformer
Required CT detects ground-fault current.

RK Series Remote Indication and Reset
Optional panel-mounted remote indication and reset assemblies. Available in NEMA 1 or NEMA 4 configurations.

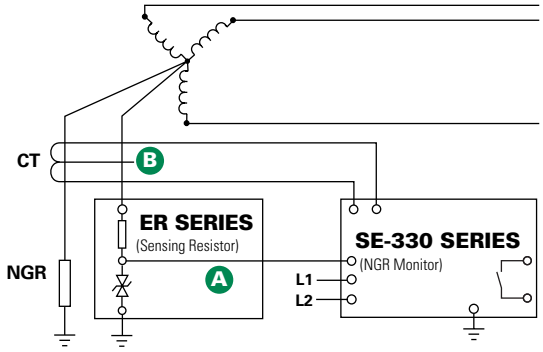
Specifications

IEEE Device Numbers	Ground Fault (50G/N, 51G/N), Overvoltage (59N), Lockout Relay (86), Checking Relay (3)
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) 100-2,000 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, UL Listed, C-Tick (Australian)
Conformally coated	Standard feature
Warranty	5 years
Mounting	Surface

SE-330, SE-330HV SERIES (PGR-5330)

Neutral-Grounding-Resistor Monitor

Simplified Circuit Diagram



For detailed wiring diagram, see adjacent page and page 151.

Ordering Information

ORDERING NUMBER		POWER SUPPLY	COMM		CERTIFICATION	K4 UNIT HEALTHY CONTACT
SE-330	-	X	X	-	X	X
SE-330 for all apps. 35 kV or less SE-330HV for 72 kV apps.		0=120/240 Vac/Vdc 2=48 Vdc	0=RS-232 1=RS-232 & DeviceNet™ 2=RS-232 & Profibus® 3=RS-232 & Ethernet		0=CSA, UL, C-Tick 1=CSA, UL, CE, C-Tick	0=Normally Open 1=Normally Closed

NOTE: For Australian applications, see the SE-330AU on pg. 38.

ACCESSORIES	REQUIREMENT	PAGE
ER Series Sensing Resistor	Required	119
Current Transformer	Required	114
SE-IP65CVR-G	Optional	111
SE-MRE-600	Optional	111
RK-332	Optional	119
NGRM-ENC	Optional	111

Description

The SE-330 is an advanced ground-fault and neutral-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—an open NGR renders current-sensing ground-fault protection inoperative and could result in a false belief that the system is functioning properly. The SE-330 can be used with low- and medium-voltage transformers and generators with low- or high-resistance grounding used in processing, manufacturing, chemical, pulp and paper, petroleum, and water-treatment facilities. For high-voltage applications, use the SE-330HV. For applications that require conformance to Australian standard AS/NZS 2081.3:2002, see the SE-330AU.

Resistor Monitoring

The SE-330 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. Sensing resistors are matched to the system voltage and are used to monitor NGRs on systems up to 72 kV.

Ground-Fault Monitoring

The SE-330 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 SE-330 will detect the fault through voltage measurement, while other current-only sensing relays would be ineffective.

Pulsing Ground-Fault Location

The SE-330 is capable of controlling a pulsing contactor, which is used to switch the NGR resistance in a pulsing-compatible NGR package. The resulting ground-fault current is distinguishable from charging currents and noise and will only appear upstream of the ground fault, making fault location fast and easy, even without isolating feeders or interrupting loads.

Accessories

A

ER Series Sensing Resistor
Required interface between the power system and the SE-330/SE-330HV. Eliminates hazardous voltage levels at the relay.

B

EFCT Series Ground-Fault Current Transformer
Sensitive ground-fault current detection (5 A primary).

SE-CS30 Series Ground-Fault Current Transformer
Sensitive ground-fault current detection (30 A primary).

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

Features & Benefits

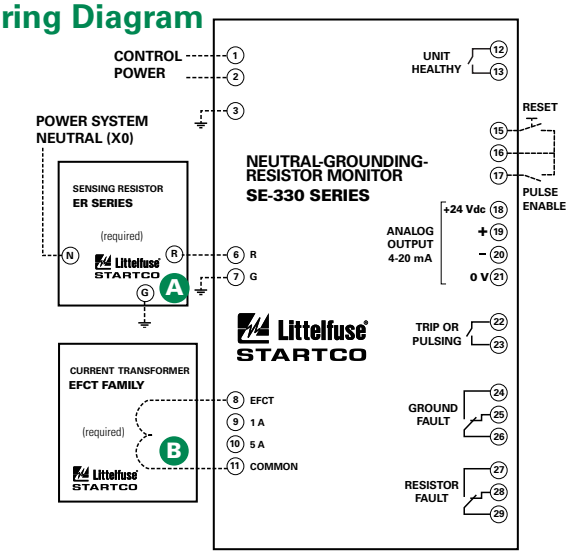
FEATURES	IEEE #	BENEFITS
Continuous NGR monitoring	3	Detects resistor failure within seconds, reduces transient-overvoltage risk, removes risk of ground-fault-detection failure
Ground-fault detection	50G/N, 51G/N, 59N	Main or backup protection to detect a ground fault anywhere on the monitored system
Adjustable pickup (2-100%)		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 (Ground Fault and Resistor Fault), Two Form A (Trip/Pulse, Healthy)
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 and check event records
Network communications		Remotely view measured values and event records, reset trips, and cause a remote trip
Software		PC-interface software (SE-MON330) is included
Selectable contact operating mode		Selectable fail-safe or non-fail-safe operating modes allows connection to shunt or undervoltage breaker coil or alarm circuit
Selectable reset mode		Selectable latching or auto-reset operation
Calibrate push button		Ensures resistor-failure sensitivity is correct
Unit-healthy output		Verifies SE-330 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	ER-600VC	20 kΩ	2.5	170
600	5	69	ER-600VC	20 kΩ	2.5	200
2,400	5	277	ER-5KV	20 kΩ	2.5	800
4,160	5	480	ER-5KV	20 kΩ	3	1,700
7,200	10	416	ER-15KV	100 kΩ	2	170 x 5 = 850
14,400	15	554	ER-15KV	100 kΩ	3	340 x 5 = 1,700

DISCLAIMER: 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.

Wiring Diagram



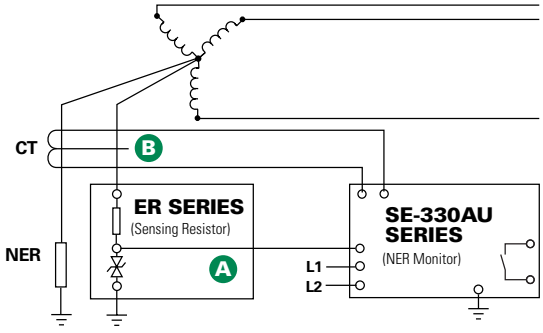
Specifications

IEEE Device Numbers	Ground Fault (50G/N, 51G/N, 59N), Checking Relay (3), Lockout Relay (86)
Input Voltage	See ordering information
Dimensions	**H** 213 mm (8.4"); **W** 98 mm (3.9"); **D** 132 mm (5.2")
GF Trip-Level Settings	2-100% of CT-Primary Rating
GF Trip-Time Settings	0.1-10 s
Vn Trip-Level Settings	20-2,000 Vac (≤5 kV systems) 100-10,000 Vac (>5 kV systems)
Contact Operating Mode	Selectable fail-safe or non-fail-safe (K1)
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, UL Listed, CE (European Union) optional, C-Tick (Australian)
Communications	RS-232; (standard) DeviceNet™, Profibus®, Ethernet (optional)
Analog Output	4-20 mA, self or loop powered
Conformally Coated	Standard feature
Warranty	5 years
Mounting	Panel and Surface

SE-330AU SERIES

Neutral-Earthing-Resistor Monitor

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	COMMUNICATIONS	CONTROL POWER
SE-330AU-00-00	RS-232	120/240 Vac/Vdc
SE-330AU-01-00	RS-232 & DeviceNet™	120/240 Vac/Vdc
SE-330AU-02-00	RS-232 & Profibus®	120/240 Vac/Vdc
SE-330AU-03-00	RS-232 & Ethernet	120/240 Vac/Vdc

NOTE: For 48 Vdc Control Power use part numbers SE-330AU-20-00, SE-330AU-21-00, SE-330AU-22-00 or SE-330AU-23-00 respectively.

ACCESSORIES	REQUIREMENT	PAGE
ER Series Sensing Resistor	Required	119
Current Transformer	Required	114
SE-IP65CVR-G	Optional	111
SE-MRE-600	Optional	111
RK-332	Optional	119

Description

The SE-330AU is an advanced earth-fault and earthing-resistor monitoring relay for low- and medium-voltage transformers and generators. It monitors neutral current, neutral-to-earth voltage, and neutral-to-earth resistance. It provides continuous monitoring of the neutral-to-earth path to verify that the neutral-earthing resistor (NER) is intact. This is of utmost importance—an open NER renders current-sensing earth-fault protection inoperative and could result in a false belief that the system is functioning properly. The SE-330AU earth-fault function complies with AS/NZS 2081.3:2002. Outputs include four relay outputs, an analog output, and an RS-232 interface. Network communications options are available. For non-AS/NZS 2081 applications, see the SE-330 or SE-330HV.

Resistor Monitoring

The SE-330AU combines the measured values of resistance, current, and voltage to continuously determine that the NER is intact. It is able to detect a resistor failure with or without an earth fault present. Sensing resistors are matched to the system voltage and are used to monitor NGRs on systems up to 35 kV.

Earth-Fault Monitoring

The SE-330AU uses a 5- or 30-A-primary current transformer to provide a pickup-setting range of 0.125 to 5 A or 0.75 to 30 A to comply with AS/NZS 2081.3:2002. DFT filtering ensures that false trips due to harmonic noise from adjustable-speed drives do not occur. Open-CT detection is provided.

Accessories

A

ER Series Sensing Resistor
Required interface between the power system and the SE-330AU. Eliminates hazardous voltage levels at the relay.

B

EFCT Series Earth-Fault Current Transformer
Sensitive earth-fault current detection (5 A primary).

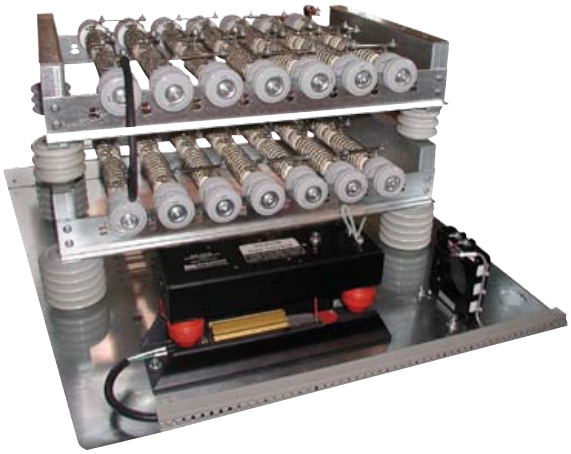
SE-CS30 Series Earth-Fault Current Transformer
Sensitive earth-fault current detection (30 A primary).

Specifications

Input Voltage	80 to 265 Vac/Vdc or 36 to 72 Vdc
Dimensions	**H** 213 mm (8.4"), **W** 98 mm (3.9"), **D** 132 mm (5.2")
GF Trip-Level Settings	0.125 to 30 A
GF Trip-Time Settings	0.1 to 0.5 s
Vn Trip-Level Settings	20-2,000 Vac (≤5 kV systems) 100-10,000 Vac (>5 kV systems)
Output Contacts	Two Form A, Two Form C
Operating Mode	Fail-Safe
Harmonic Filtering	Standard feature
Reset	Front panel push button and remote input
Approvals	CSA certified; C-Tick (Australian)
Communications	RS-232; (standard) DeviceNet™, Profibus®, Ethernet (optional)
Analog Output	4-20 mA, self or loop powered
Conformal Coating	Standard feature
Warranty	5 years
Mounting	Panel, Surface (optional)

NGR SERIES

Neutral-Grounding-Resistor System



For information about the NGRM-ENC NGR Monitor Control Panel, see page 111.

Description

Neutral-Grounding Resistors (NGRs) are used to ground power systems by inserting a resistor between the system neutral and ground. This lowers the prospective ground-fault current to a predetermined value.

A properly designed resistance-grounded system provides benefits over both ungrounded and solidly grounded systems. Because the system is grounded, transient overvoltages do not occur and ground-fault current can flow, allowing it to be detected and measured. Also, because a resistor is used to ground the system, the very large and destructive ground-fault currents of solidly grounded systems are absent. Ground-fault relays (such as the SE-701) can be used on feeders to provide selective coordination and the ability to quickly locate or isolate the fault.

Applications

Resistance grounding is typically applied on transformers and generators where safety and continuity of service are important. A faulted feeder may remain in operation until it is safe to repair the fault, where allowed by the local electrical code.

Benefits

- Eliminate phase-to-ground arc-flash incidents
- Eliminate transient overvoltages
- Reduced point-of-fault damage
- Can provide continuity of service during a ground fault

Features

- ER-series Sensing Resistor and Current Transformer required for NGR monitoring come pre-installed inside the enclosure
- Can be packaged with a zigzag transformer to resistance ground an ungrounded delta system, or a system with an inaccessible neutral
- SE-325 or SE-330 NGR Monitor can provide continuous NGR monitoring and ground-fault protection; NGR failure will render current-sensing ground-fault protection inoperative
- Stainless steel resistor elements prevent corrosion

Ordering Information

	SYSTEM LINE-NEUTRAL VOLTAGE		NGR CURRENT		DUTY CYCLE		DRAWING NUMBER		MONITORING COMPONENTS IN NGR ENCLOSURE			OTHER OPTIONS		ENCLOSURE STYLE
NGR	X	–	X	–	X	–	XXXX-RX	–	X	X	–	X	–	X
	277, 347,...44000		AMPERES		C = continuous		Assigned by factory		ER/ = Includes Sensing Resistor	CT = CT200				N3R = Galvanized NEMA 3R
					10 = 10 seconds					E1 = EFCT-1				
					30 = 30 seconds				Blank = No Sensing Resistor	E26 = EFCT-26		ZZ = Zigzag transformer (Note: may be in separate N3R enclosure)		N3RSS = Stainless Steel NEMA 3R
					60 = 60 seconds					C26 = SE-CS30-26				
										C70 = SE-CS30-70				
										Contact factory for other choices.				
												Blank = None		
									OPEN = None					

Note: Order SE-325, SE-330, and SE-701 separately. See pages 35, 36 and 26, respectively.

PGN SERIES

Pulsing High-Resistance-Grounding System

Description

The PGN Pulsing 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. They also significantly reduce 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. High-Resistance Grounding Systems include all necessary components to convert to a resistance grounded system.

Options include a pulsing circuit and SE-701 Ground-Fault Monitors to provide a method for locating ground faults.

Applications

High-resistance grounding is typically applied on transformers and generators where safety and continuity of service 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 allowed by the electrical code.

Benefits

- Eliminate phase-to-ground arc-flash incidents
- Eliminate transient overvoltages
- Reduced point-of-fault damage
- Pulsing ground-fault current to aid in fault location

Features

- Pulsing current 5 A above the selected resistor current is standard; other pulsing options available upon request
- All PGN systems include resistor monitoring, ground-fault detection, and integrated pulsing control with the SE-330 NGR Monitor
- ER-series Sensing Resistor and Current Transformer required for NGR monitoring come pre-installed inside the enclosure
- Optional test circuit to simulate a ground fault
- Continuous-rated resistors
- Stainless steel resistor elements prevent corrosion

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		

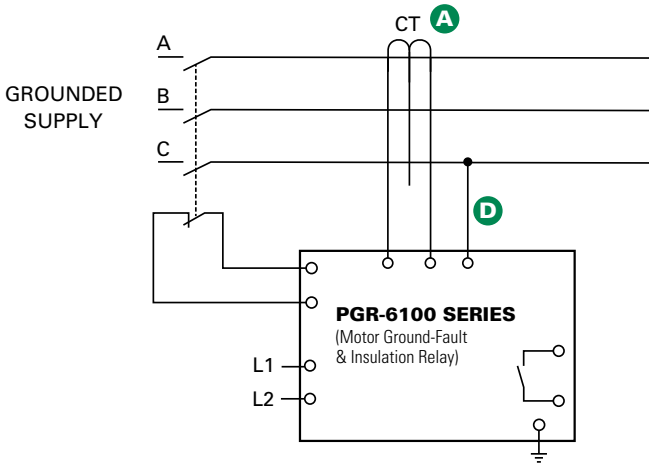
MOTOR & PUMP PROTECTION

For More Information...
and to download our Motor Protection Brochure or White Paper, click on Technical Resources at
www.littelfuse.com/motorprotection

PGR-6100 SERIES (GFR4000)

Motor Ground-Fault & Insulation Relay

Simplified Circuit Diagram



For detailed wiring diagram, see page 152.

Ordering Information

ORDERING NUMBER	CONTROL POWER
PGR-6100-120	120 Vac
PGR-6100-240	240 Vac

ACCESSORIES	REQUIREMENT	PAGE
PGC-5000 Series	Required	115
PGH Family	Required >1300 V	117
PGA-0500	Optional	119
PGA-0510	Optional	119

Note: For optional conformal coating please consult factory.

Description

The PGR-6100 combines the features of a ground-fault protection relay and insulation monitor into one unit. It protects against ground faults by monitoring insulation resistance when the motor is de-energized and by monitoring ground-fault current when the motor is energized. 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 

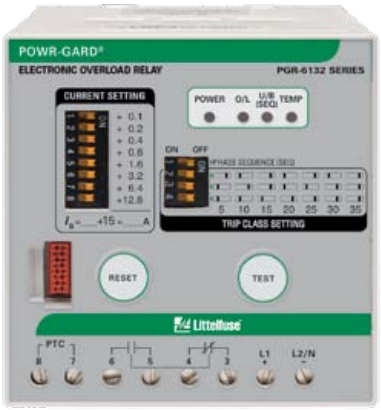
PGH Family High Tension Couplers
Required (for systems >1,300 V) PGH Family high-tension coupler must be connected between the phase conductor and the PGR-3200.

Specifications

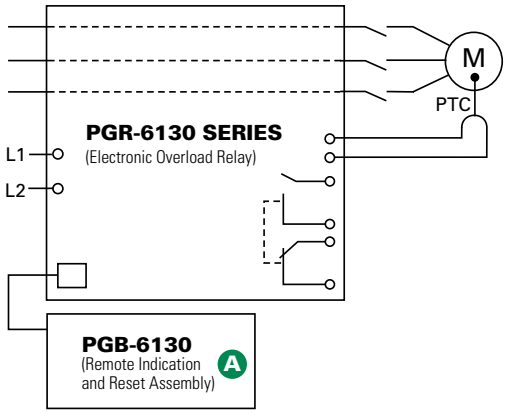
IEEE Device Numbers	Ground Fault (50G/N, 51G/N), Ground detector (64), Alarm Relay (74)
Input Voltage	See ordering information
Dimensions	**H** 75 mm (3"); **W** 99.7 mm (3.9"); **D** 110 mm (4.3")
Response delay	< 250 ms
Contact Operating Mode	Selectable fail-safe or non-fail-safe
Harmonic Filtering	Standard feature
Test Button	Standard feature
Reset Button	Standard feature
CT-Loop Monitoring	Standard feature
Output Contacts	Two Form C
Analog Output	0-1 mA
Approvals	UL Listed, GFR4000 only; PGR-6100, in Progress
Warranty	5 years
Mounting	DIN, Surface

PGR-6130 SERIES

Electronic Overload Relay



Simplified Circuit Diagram



For detailed wiring diagram, see page 152.

Ordering Information

ORDERING 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	119

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, simplifies installation and reduces cost
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.

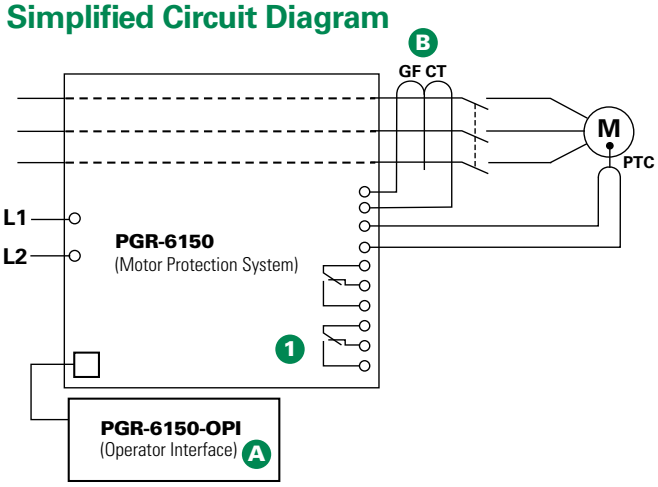
1 Control Unit

- 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

Simplified Circuit Diagram



For detailed wiring diagram, see adjacent page and page 152.

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.

Ordering Information

ORDERING NUMBER	CONTROL POWER
PGR-6150-24 (Control Unit)	24/48 Vdc
PGR-6150-120 (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.

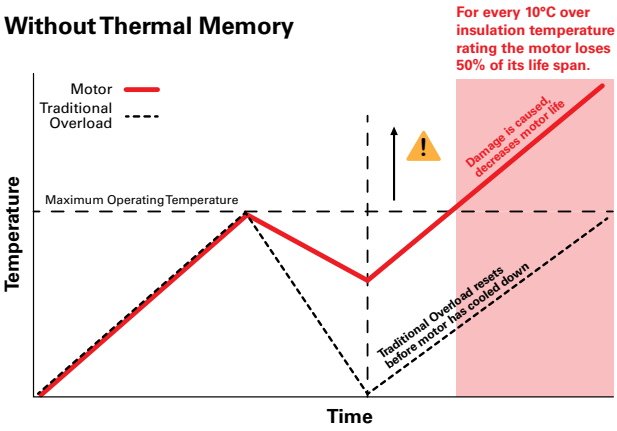
ACCESSORIES	REQUIREMENT	PAGE
PGC-6000 Series	Optional	115

Features & Benefits

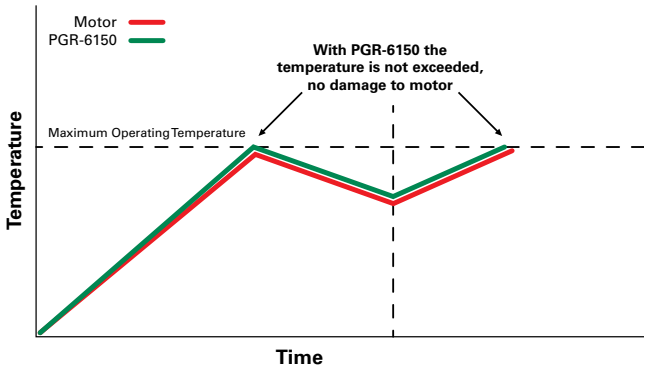
FEATURES	IEEE #	BENEFITS
No CTs required	49, 51	No current transformers are required for currents < 25 A
Adjustable trip settings		Adjustable overload trip class setting from 5 to 45 to match motor characteristics
Digital input		Programmable digital input
Output contacts		Two programmable Form C output 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

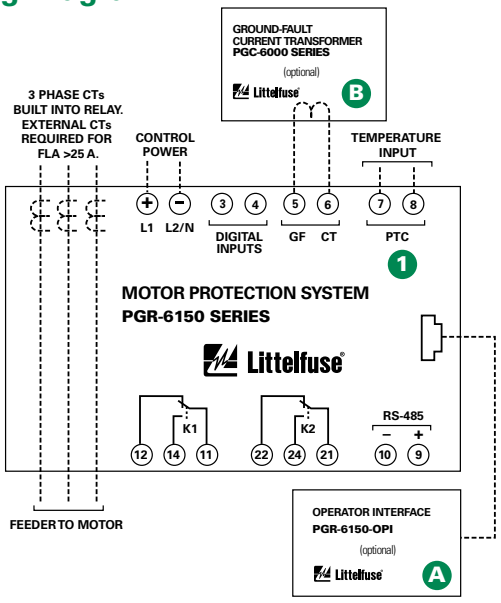
Without Thermal Memory



With Thermal Memory



Wiring Diagram



Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51) Phase sequence (46) Overcurrent (50, 51) Jam Ground fault (50G/N, 51G/N) Undercurrent (37)	PTC overtemperature (49) Failure to accelerate RTD temperature (49) Unbalance (current) (46) Starts per hour (66) 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)	

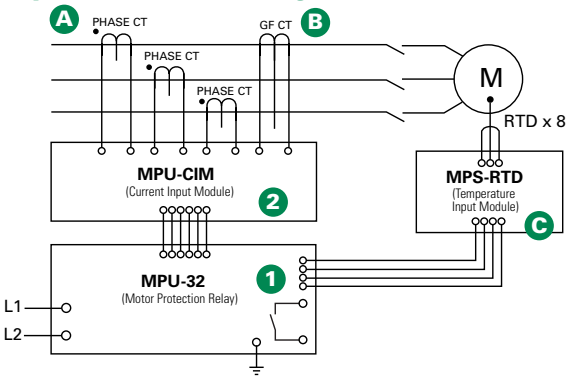
MPU-32 SERIES (PGR-6200)

Motor Protection Unit

1

2

Simplified Circuit Diagram



For detailed wiring diagram, see page 153.

Ordering Information

ORDERING NUMBER	COMMUNICATION
MPU-32-00-00	TIA-232
MPU-32-01-00	TIA-232 & RS-485
MPU-32-02-00	TIA-232 & DeviceNet™
MPU-32-04-00	TIA-232 & Ethernet

NOTE: One of the following is required: MPU-CIM-00-00 Current Input Module, or MPU-CTI-RT-00 Current Input Module with ring-tongue terminals.

ACCESSORIES	REQUIREMENT	PAGE
Phase CTs	Required	114
MPS-RTD-01-00	Optional	118
MPS-DIF-01-00	Optional	118
MPU-32-SMK	Optional	118
CA-945	Optional	120
MPU-16A-Y92A-96N	Optional	111

Description

The MPU-32 Motor Protection Unit 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 obsolete or aging motor protection using existing CTs. See the PMA Family of Panel Mount Adapter Kits to replace common obsolete relays.

1 Motor Protection Unit

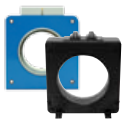
- Three ac-current inputs
- Earth-leakage-CT input
- Programmable digital input
- 24-Vdc source for digital input
- Programmable 4-20-mA analog output
- On-board temperature-sensor input,
- 100-Ω-Platinum RTD or PTC
- Three programmable output relays
- Local RS-232 communications, optional Network Communications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

2 Current Input Module (MPU-CIM)

The MPU-CIM Current Input Module is the interface between the MPU-32 relay and the 5-A-secondary, 1-A-secondary, and sensitive current transformers. The MPU-CIM is ordered separately from the MPU-32 and can be surface- or DIN-rail mounted. Wire-clamping terminals are standard but the MPU-CTI is available for those who require ring-tongue terminals.

Accessories

A Phase Current Transformers
Phase CTs are required to detect phase currents. For upgrade applications, existing CTs can be used.



B Ground-Fault Current Transformer
Optional zero-sequence current transformer detects ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

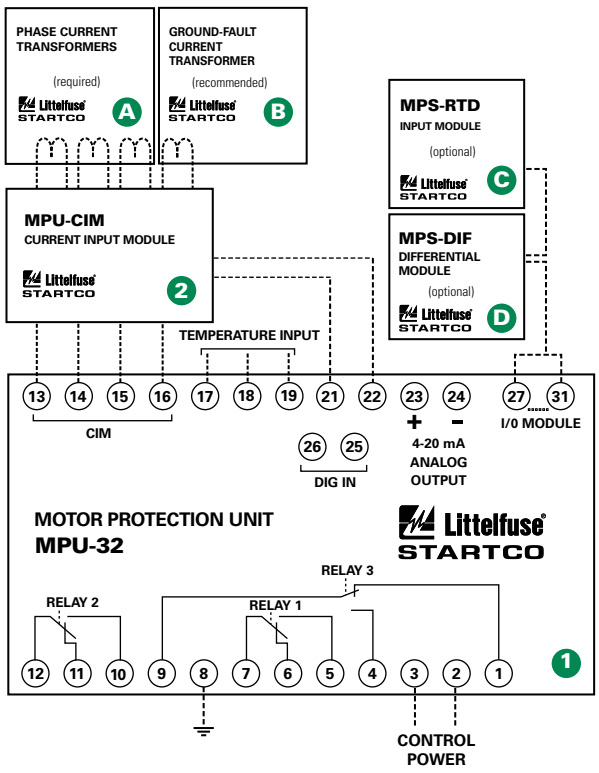
C MPS-RTD Temperature Input Module
Optional module provides 8 inputs to connect Pt100, Ni100, Ni120, and Cu10 RTDs.

D MPS-DIF Differential Current Module
Optional motor 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
Dynamic thermal model		Provides protection through starting, running, and cooling cycles
Communications		Remotely view measured values and event records, reset trips, and access setpoints
Ground fault	50G/N, 51G/N	Prevents catastrophic failures and fires
Current unbalance/ Phase loss/Phase reverse	46	Prevents overheating due to unbalanced phases
RTD temperature	38, 49	RTD temperature protection (MPS-RTD module) for high-ambient or loss-of-ventilation protection
Phase loss/Phase reverse (current)	46	Detects unhealthy supply conditions
Overcurrent	50, 51	Prevents catastrophic failures and fires; extends motor life
Jam		Prevents motor damage by detecting mechanical jams or excessive loading
Undercurrent	37	Detects low level or no-load conditions
PTC overtemperature	49	Overtemperature (PTC) protection for high-ambient or loss-of-ventilation detection
Starts per hour	66	Limits the motor starts per hour to prevent overheating
Differential	87	Optional MPS-DIF module for sensitive winding-fault protection
Reduced overcurrent mode		Minimizes arc-flash hazards during maintenance
Metering		View measured and calculated parameters with on-board display
MPU-CIM		Separate current input module to reduce risk of open-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

Wiring Diagram



Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51); Phase reverse (current) (46); Overcurrent (50, 51); Jam; Ground fault (50G/N, 51G/N); PTC overtemperature (49; RTD temperature (38, 49); Unbalance (current) (46); Starts per hour (66); Differential (87); Phase loss (current) (46); Undercurrent (37)
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
Output Contacts	Three Form C programmables
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 MPU-32-SMK converter kit)
(Current Input Module)	DIN, Surface
Approvals	CSA certified, C-Tick (Australian)

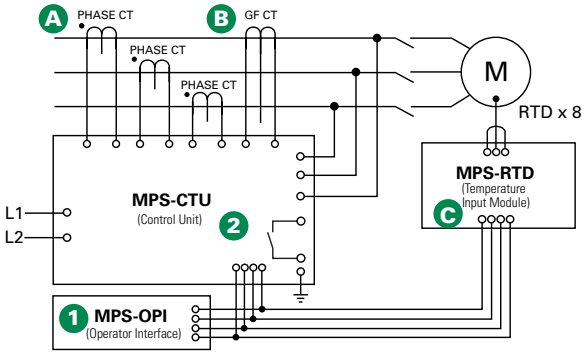
MPS SERIES (PGR-6300)

Motor Protection System

1

2

Simplified Circuit Diagram



For detailed wiring diagram, see page 153.

Ordering Information

ORDERING NUMBER	COMMUNICATIONS
MPS-CTU-01-00	RS-485
MPS-CTU-02-00	RS-485 & DeviceNet™
MPS-CTU-03-00	RS-485 & Profibus®
MPS-CTU-04-00	RS-485 & Ethernet

ACCESSORIES	REQUIREMENT	PAGE
MPS-OPI-01-00	Recommended	See above
Phase CTs	Required	114
Ground-Fault CT	Recommended	114
MPS-RTD-01-00	Optional	118
MPS-DIF-01-00	Optional	118
SE-IP65CVR-M	Optional	111

Description

The MPS Motor Protection System monitors voltage, current, and temperature to provide a comprehensive package of 22 protective functions. The MPS 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 (MPS-OPI)

- Large, bright, 4 x 20 vacuum-fluorescent display
- Display metered values
- 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 (MPS-CTU)

- 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 (Standard)
- DeviceNet™, Profibus®, or Ethernet communications available

Accessories

A 

Phase Current Transformers
Phase CTs are required to detect phase currents.

B 

Ground-Fault Current Transformer
Required zero-sequence current transformer detects ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

C 

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

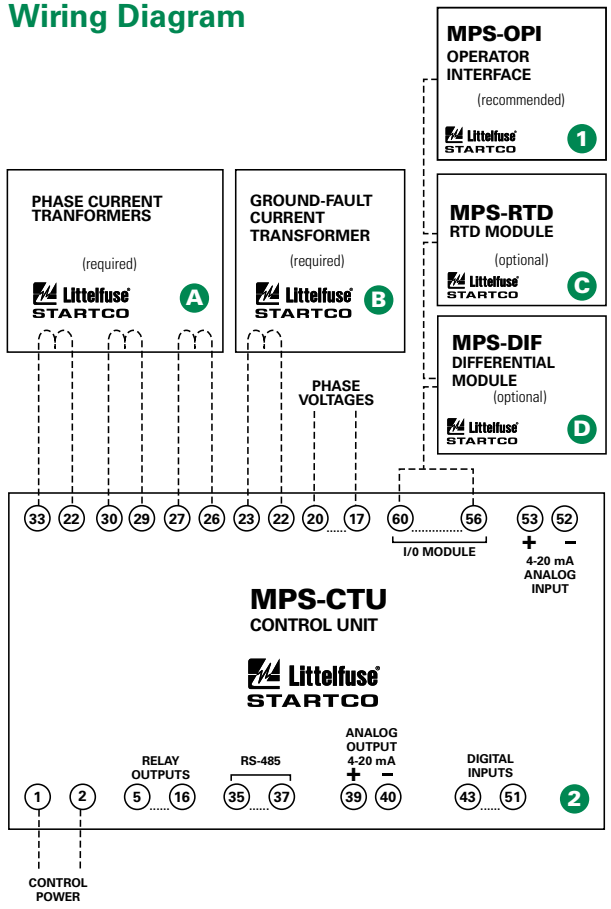
D 

MPS-DIF Differential Current Module
Optional motor 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 (MPS-RTD 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 mode		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

Wiring Diagram



Specifications

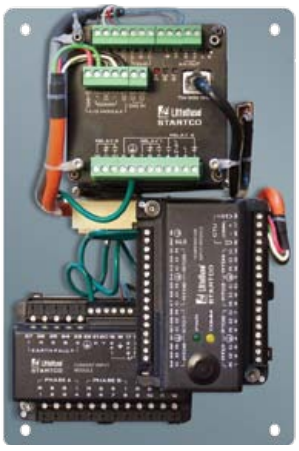
Protective Functions (IEEE Device Numbers)	Overload (49, 51) Phase reverse (current) (46) Overfrequency (81) Overcurrent (50, 51) Jam Underfrequency (81) Ground fault (50G/N, 51G/N) Undercurrent (37) Unbalance (voltage) (47) Failure to accelerate RTD temperature (38, 49) Unbalance (current) (46) Underspeed (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, C-Tick (Australian)
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, Control-Unit mounted

MPU-32-X69X (PGR-6210) SERIES AND MPS-469X (PGR-6310) SERIES

Motor Protection Retrofit Kits

1 MPU-32-X69X

Front



Back

2 MPS-469X

Front

Back

Description

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

1 MPU-32-X69X

The MPU-32-X69X Motor Protection Retrofit Kit is designed to replace GE Multilin 169, 269, and 369 relays. It includes the MPU-32 Motor Protection Relay, MPU-CIM Current Input Module, and optional MPS-RTD 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 MPS-469X

The MPS-469X Motor Protection Retrofit Kit replaces the GE Multilin 469 relay. It includes the MPS Motor Protection System and optional RTD and differential modules mounted 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

MPU-32-X69X Ordering Information

		RTD INPUTS	MPU-32 COMMUNICATIONS	GROUND-FAULT CT	FUTURE OPTIONS
MPU-32-X69X	–	X	X	X	00
		0 = One Platinum 100 Ω	0 = TIA232	0 = Wired for Sensitive Ground-Fault CT (50 mA Secondary)	
		1 = One Platinum 100 Ω and 8-input MPS-RTD Module	1 = TIA232 & TIA485	1 = Wired for 1- or 5-A Secondary Ground-Fault CT	
			2 = TIA232 & DeviceNet		
			4 = TIA232 & Ethernet		

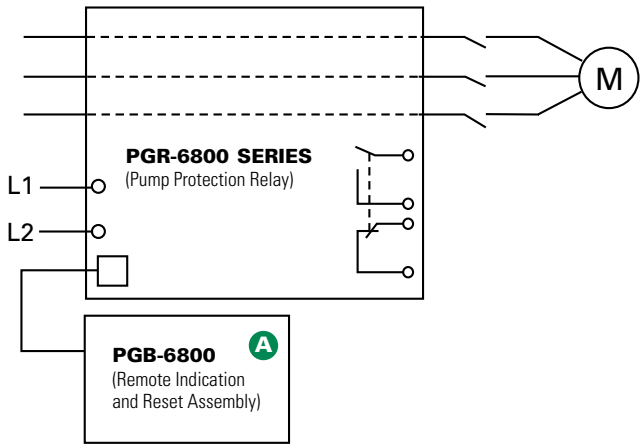
MPS-469X Ordering Information

		MODULE CONFIGURATION	MPS COMMUNICATIONS	FUTURE OPTIONS
MPS-469X	–	X	X	000
		0 = None	1 = RS485	
		1 = One MPS-RTD Module	2 = RS485 & DeviceNet	
		2 = Two MPS-RTD Modules	3 = RS485 & Profibus	
		3 = One MPS-DIF Module	4 = RS485 & Ethernet	
		4 = One MPS-RTD Module and One MPS-DIF Module		

PGR-6800 SERIES

Pump Protection Relay

Simplified Circuit Diagram



For detailed wiring diagram, see page 154.

Ordering Information

ORDERING 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	119

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	

FEEDER PROTECTION

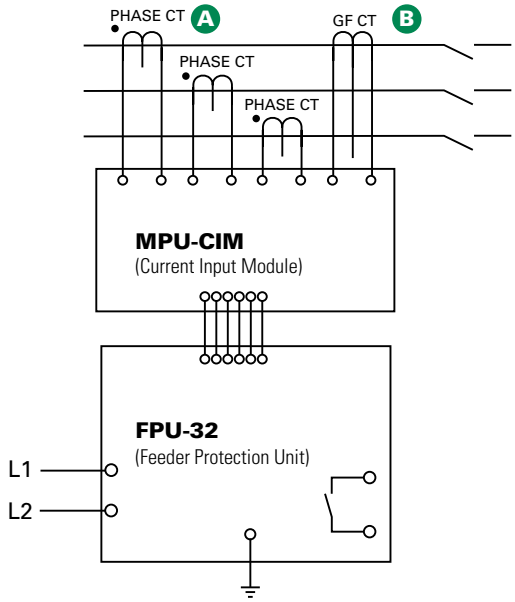
For More Information...
and to download datasheets and manuals on our Feeder Protection Relays, click Technical Resources at
www.littelfuse.com/feederprotection

FPU-32 SERIES (PGR-7200)

Feeder Protection Unit

NOTE: The FPU-32 consists of the Feeder Protection Unit (pictured above) and the MPU-CIM Current Input Module (not pictured).

Simplified Circuit Diagram



For detailed wiring diagram, see page 154.

Ordering Information

ORDERING NUMBER	COMMUNICATIONS
FPU-32-00-00	TIA-232
FPU-32-01-00	TIA-232 & RS-485
FPU-32-02-00	TIA-232 & DeviceNet™
FPU-32-04-00	TIA-232 & Ethernet

NOTE: One of the following is required: MPU-CIM-00-00 Current Input Module, or MPU-CTI-RT-00 Current Input Module with ring-tonque terminals.

ACCESSORIES	REQUIREMENT	PAGE
Phase CTs	Recommended	114
Ground-Fault CT	Optional	114
MPU-16A-Y92A-96N	Optional	111

Description

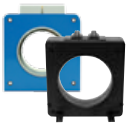
The FPU-32 Feeder Protection Unit provides integrated protection, metering, and data-logging functions. It is an excellent choice for retrofitting and upgrading older relays because of its compact size and ability to use existing CTs. The FPU-32 is used to protect distribution feeders in processing, 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	Thermal protection for connected load
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 **Phase Current Transformers**
Phase CTs are required to detect phase currents.



B **Ground-Fault Transformer**
Zero-sequence current transformer detects 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)
Phase sequence (46)
Unbalance (46)
Phase loss (46)
Definite-time overcurrent (50, 51)
Inverse-time overcurrent (50, 51)
Ground fault (50G/N, 51G/N)
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, C-Tick (Australian)
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 MPU-32-SMK converter kit)
(Current Input Module) DIN, Surface

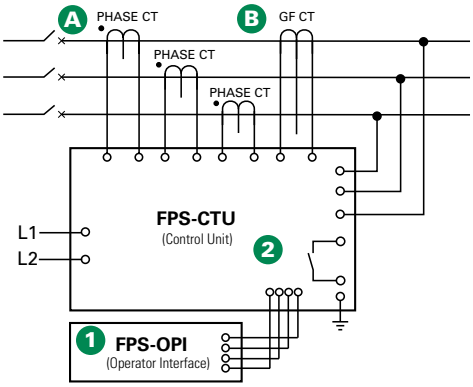
FPS SERIES

Feeder Protection System

1

2

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	COMMUNICATIONS
FPS-CTU-01-00	RS-485
FPS-CTU-02-00	RS-485 & DeviceNet™
FPS-CTU-03-00	RS-485 & Profibus®
FPS-CTU-04-00	RS-485 & Ethernet

ACCESSORIES	REQUIREMENT	PAGE
FPS-OPI-01-00	Recommended	See above
SE-IP65CVR-M	Optional	111
Phase CTs	Required	114
Ground-Fault CT	Recommended	114
MPS-RTD-01-00	Optional	118

Description

The FPS Feeder Protection System monitors voltage and current to provide a comprehensive package of 17 protective functions. The FPS is a modular system with integrated protection, breaker control, metering, and data-logging functions.

1 Operator Interface (FPS-OPI)

- Large, bright, 4 x 20 vacuum-fluorescent display
- Display metered values
- 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

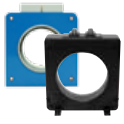
2 Control Unit (FPS-CTU)

- 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
- 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 (Standard)
- DeviceNet™, Profibus®, or Ethernet communications available

Accessories

A 

Phase Current Transformers
Phase CTs are required to detect phase currents.

B 

Ground-Fault Current Transformer
Zero-sequence current transformer detects ground-fault current. Available with 5-A and 30-A primary ratings for low-level pickup.

C 

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

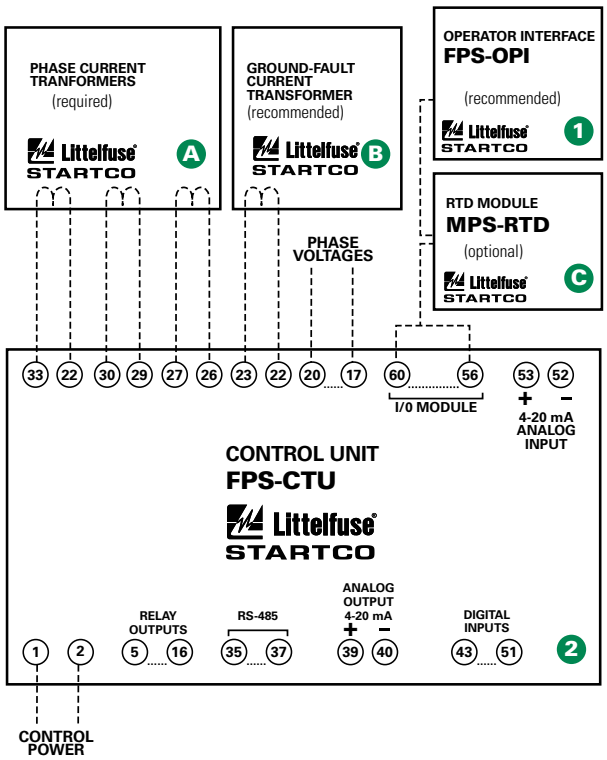
D 

SE-IP65CVR-M Cover
Optional gasketed, transparent cover for limited access and IP65 protection for an Operator Interface Module.

Features & Benefits

FEATURES	IEEE #	BENEFITS
Overload	49, 51	Long-time overcurrent provides thermal protection for feeder or load
Inverse-time overcurrent	50, 51	Coordination using IEEE and IEC Curves
Definite-time overcurrent	50, 51	Instantaneous overcurrent to detect catastrophic failure
Current unbalance/ Phase loss/Phase reverse	46	Detects an open or high-impedance phase
Ground fault	50G/N, 51G/N	Inverse and definite time. Early insulation-failure detection.
RTD temperature	38, 49	Optional protection (MPS-RTD module) for load-temperature monitoring
Overvoltage	59	Limits stress to insulation
Undervoltage	27	Detects a damaging brown-out condition
Voltage unbalance	47	Detects unhealthy supply voltage
Two setting groups		Minimizes Arc-Flash hazards during maintenance
Breaker control		Allows local and remote operation; reduces component count
Metering		Displays the measured and calculated 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

Wiring Diagram



Specifications

Protective Functions (IEEE Device Numbers)	Overload (49, 51); Unbalance (current) (46); Phase reverse (current) (46); Phase loss (voltage) (47); Overfrequency (81); Overvoltage (59); Overcurrent (50, 51); Phase loss (current) (46); Underfrequency (81); Undervoltage (27); Ground fault (50G/N, 51G/N); Phase reverse (voltage) (47); Unbalance (voltage) (47); Power factor (55); RTD temperature (38, 49)
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 or 60 Hz
Inputs	Phase current, Earth-leakage current, Phase voltage, 7 digital, 1 analog
Output Contacts	5 contacts — See Product Manual
Approvals	CSA certified, C-Tick (Australian)
Communications	Allen-Bradley® DFI and Modbus® RTU (Standard); DeviceNet™, Profibus®, Ethernet (Optional)
Conformal Coating	Standard feature
Warranty	10 years
Mounting:	
Control Unit	Surface
Operator Interface	Panel, Control-Unit mounted

ARC-FLASH PROTECTION

For More Information...
to download our White Paper on Key Considerations for Selecting an Arc-Flash Relay or our Arc-Flash Energy Reduction Workbook, visit
www.littelfuse.com/afv

D0100 SERIES & D0900 SERIES

Arc-Flash Relay

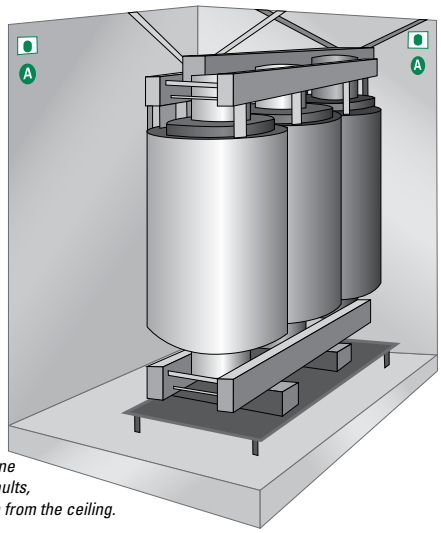
CE

Description

The D0100/D0900 Arc-Flash relays provide a simple and cost-effective solution for Arc-Flash monitoring. Two light sensors can be connected directly to one relay, or optional junction boxes allow up to 16 sensors per relay.

Light Sensors react to light and are available with 180° or 360° detection area. Sensors are supplied with 5, 10 or 15 m of cable and a mounting bracket. 1-2 sensors are recommended per cubicle or drawer.

Installation Diagram



Place sensors in direct line of sight to possible arc faults, preferably pointing down from the ceiling.

Features & Benefits

FEATURES	BENEFITS
Compact module	Fits into wide range of Arc-Flash applications
Trip time <1 ms	Limits Arc-Flash damage and risk of injury
Two optical sensor types	Point sensors with 180° or 360° detection area depending on specific installation
Dual sensor input	Single Arc-Flash relay can monitor 2 sensors or junction boxes
Sensor expansion option	Junction box allows for up to 16 sensors per Arc-Flash relay (8 sensors/box)
Adjustable light sensitivity	Allows for operation in bright environments and maximum sensitivity in dark environments
Service mode	Allows for system test without tripping

Ordering Information

ORDERING NUMBER	CONTROL POWER
D0100.0010	48-220 Vdc
D0100.0020	24 Vdc
D0900.0010	220-250 Vac

ACCESSORIES	REQUIREMENT	PAGE
A0033.0010 Detector cable 2 x 0.25 mm w/screen. 100 m	Optional	121
A0200.0010 Light Sensor 180°; 5 m cable	Required: At least 1 sensor per cubicle or drawer	118
A0200.0020 Light Sensor 180°; 10 m cable		
A0200.0030 Light Sensor 180°; 15 m cable		
A0300.0010 Light Sensor 360°; 5 m cable		
A0300.0020 Light Sensor 360°; 10 m cable		
A0300.0030 Light Sensor 360°; 15 m cable		
D0400.0010 Junction Box. For 8 sensors, without indication	Optional	121
D0500.0010 Junction Box. For 8 sensors, with indication	Optional	121
D1100.0010 Diode Logic Unit	Optional	See website for more details

Accessories

A

A0200 (180˚)/A0300 (360˚) Light Sensors
Line-of-sight light sensor detects an arc as small as 3 kA within a 2-m half-sphere. Available in 180˚ or 360˚; 5, 10, or 15 m cable.

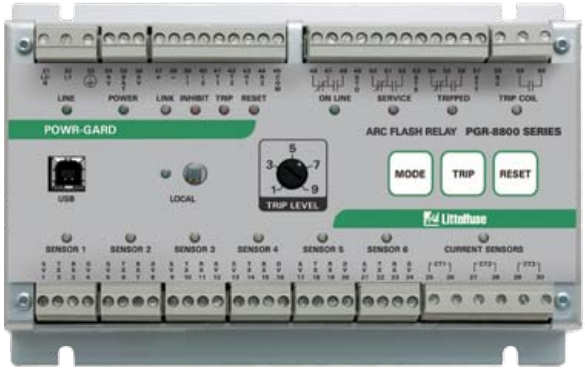
D0400/D0500 Junction Box for parallel connection of more than 2 sensors for one relay. Designed to connect up to 8 sensors, and is available with and without indication. Max. 2 junction boxes can be connected to one Arc-Flash relay.

Specifications

Voltage Supply — **D0100.0010**: 48-220 Vdc; **D0100.0020**: 24 Vdc; **D0900.0010**: 220-250 Vac; **D0900.0020**: 220-250 Vac; **D0900.0030**: 110 Vac
Thyristor Output — 250 Vac/Vdc, 8 A cont., 25 A. for 0.1s, min. load 50 mA
Sensitivity — Adjustable 2,000-24,000 lux
Number of Sensors — Max. 16 pcs. with 2 junction boxes
Response Time — Less than 1 ms
Power Consumption — **D0100**: 4.3 W; **D0900**: 3.5 W
Ambient Temperature — –25°C to + 70°C
EMC — EN50081-1/2 and EN50082-1/2
Dimensions — **H** 90 mm (3.5"); **W** 105 mm (4.1"); **D** 75 mm (3.0")

PGR-8800 SERIES (D1000)

Arc-Flash Relay



Description

The PGR-8800 is a microprocessor-based relay that limits arc-fault damage by detecting the light from an arc flash and rapidly tripping. Phase-current-transformer inputs are provided for current-constrained arc-flash protection and, when so equipped, a programmable definite- time overcurrent function can be enabled. An optical sensor on the PGR-8800 and adjustable trip level reduce the chance of nuisance tripping by setting a threshold for ambient light. Sensors, inputs, and connections are monitored to ensure fail-safe operation. A secondary solid-state trip circuit provides a redundant trip path. A USB port is used for configuration and access to event logs and graphs.

Optical Sensors

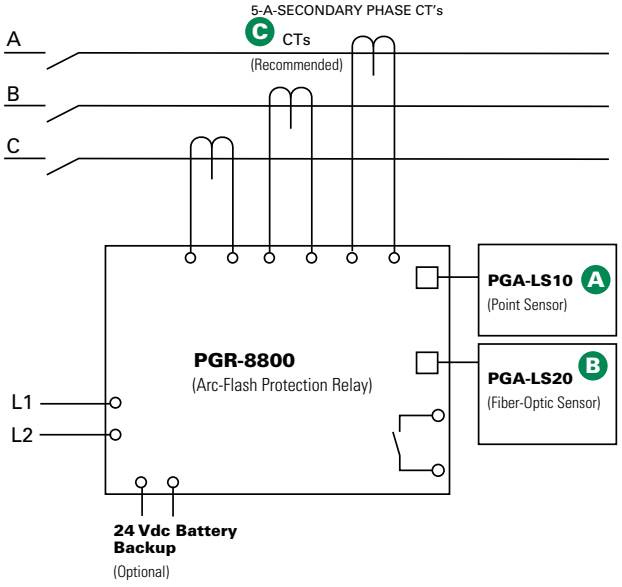
The PGR-8800 accepts both PGA-LS10 and PGA-LS20 optical sensors designed to collect light over a wide angle and with high sensitivity. For fast fault location, front-panel and sensor LED's indicate sensor health and which sensor detected an arc fault.

Sensor Placement

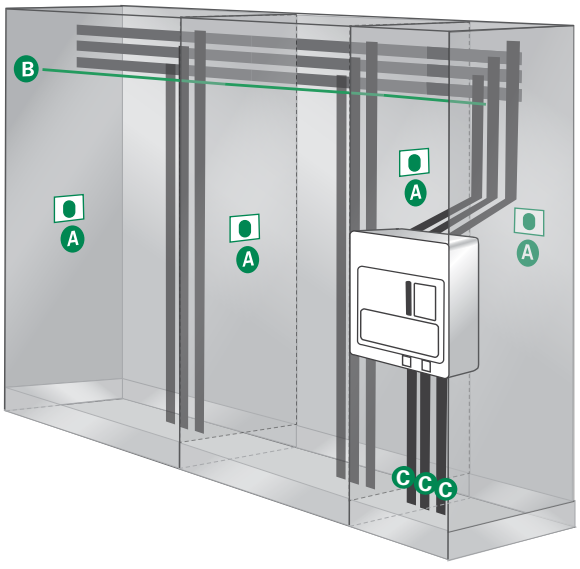
The PGR-8800 Arc-Flash Relay and sensors are easily installed in retrofit projects and new switchgear with little or no re-configuration. Even elaborate systems with multiple power sources take minutes to configure using the relay's built-in USB interface software.

Generally, it is recommended to mount 1 or 2 sensors per cubicle to cover all horizontal and vertical bus bars, breaker compartments, drawers, and anywhere that there is potential for an arc-fault. Threading a fiber-optic sensor through the cabinets and in areas where point-sensor coverage is uncertain results in complete coverage and an added level of redundancy. Even if policy is to only work on de-energized systems, all maintenance areas should be monitored to prevent potential damage and additional cost. At least one sensor should have visibility of an arc fault if a person blocks the other sensor(s).

Simplified Circuit Diagram



For detailed wiring diagram, see adjacent page and page 155.



Ordering Information

ORDERING NUMBER	COMMUNICATIONS
PGR-8800-00 (D1000)	Multi-unit linking, USB

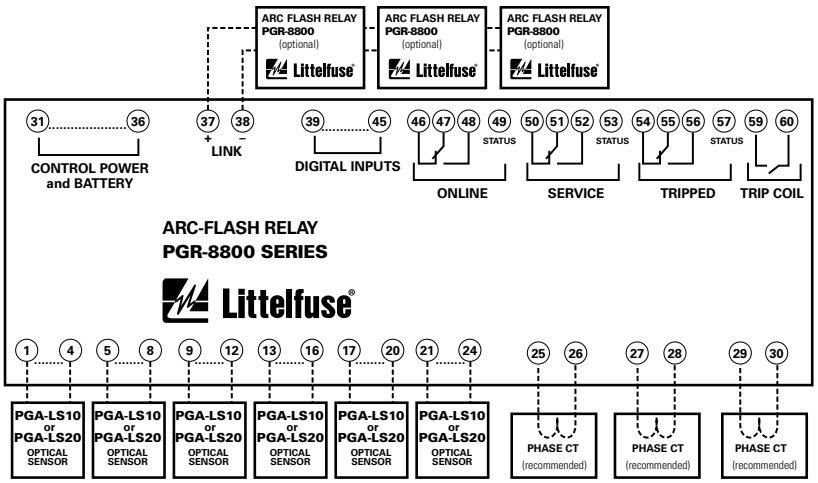
ACCESSORIES	REQUIREMENT	PAGE
PGA-LS10 (A1000)	Required*	118
PGA-LS20 (A2000)	Required*	118
Current Transformer	Recommended	114

*At least one sensor is required. However, the exact number of sensors for proper coverage depends on the application.

Features & Benefits

FEATURES	BENEFITS
Arc-Flash trip time <1 ms	Limits arc-flash damage and risk of injury
Multiple sensors (up to 24)	Single module can monitor 6 sensors. Up to 4 PGR-8800 units can be linked into one system
Fail-safe system	Continuous monitoring of optical sensors and inputs ensures protection
Redundant trip circuit	Solid-state backup arc-detection circuit adds a second layer of safety
Adjustable light sensitivity	Allows for operation in bright environments and maximum sensitivity in dark environments
LED indication (on unit and each sensor)	18 LEDs provide at-a glance status for module and I/O state
Current detection	Phase-CT inputs provide overcurrent protection and prevent nuisance trips
Optical detection	Point and fiber-optic sensors provide wide detection area with sensor health trip indication
Digital inputs (6)	Two each: remote trip, inhibit, and reset inputs
Service mode	Allows for system test without tripping
Trip coil contact	Solid-state 24-600 Vdc/24-440 Vac IGBT
Indication contacts	Form C and status outputs
USB interface	Data logging and configuration software uses a USB interface with no drivers or software installation
Built-in sensor	Can be used in single-sensor systems, as a seventh sensor, and for calibration
Universal power supply/Battery backup	100-230 Vac, 12-60 Vdc, or 100-250 Vdc supply accepted. Ability to charge and run off an external, user-supplied 24 Vdc battery.
Data logging	On-board event recorder helps with system diagnostics

Wiring Diagram



Accessories

A 

PGA-LS10 (A1000) Point Sensor
Line-of-sight light sensor detects an arc as small as 3 kA within a 2-m half-sphere. Sensor health and trip indication.

B 

PGA-LS20 (A2000) Fiber-Optic Sensor
360° light sensor for tricky installations with many shadows or to run along bus bars. Sensor health and trip indication.

C 

Current Transformers
Eliminate nuisance arc-flash trips and use for overcurrent protection.

Specifications

IEEE Device Numbers	Overcurrent (50), Arc Flash (AFD)
Input Voltage	100-230 Vac, 12-60 Vdc, and 100-250 Vdc
Dimensions	**H** 130 mm (5.2"); **W** 200 mm (7.9"); **D** 54 mm (2.2")
Optical Trip Settings	10-40 klux, 200 µs-2 s
Current Trip Setting (A)	Programmable
Indication Contact Mode	Fail-safe
Trip Coil Contact Mode	Selectable fail-safe or non-fail-safe
Redundant Trip Circuit	Standard feature
Input Monitoring	Standard feature
USB Interface	Standard feature
Trip, Reset, Service Buttons	Standard feature
Expandable System	Link up to 4 PGR-8800 units
Warranty	5 years
Mounting	DIN (with D0050 adapter clips), Surface

GFCI

For More Information...
on GFCIs, visit
www.littelfuse.com/industrialshockblock

SB6000 SERIES

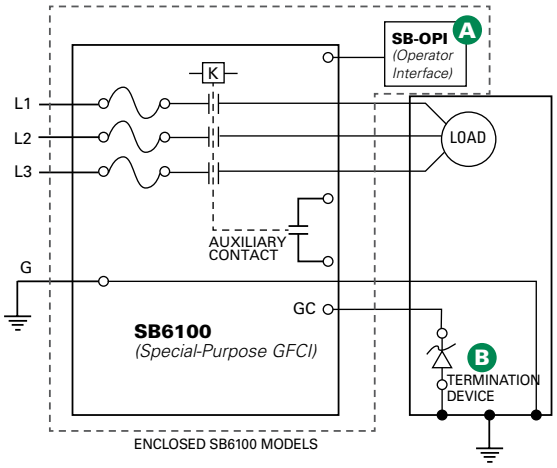
Industrial Shock-Block

Industrial SHOCK BLOCK™ LITTELFUSE® Products

Enclosed Model

Open-Chassis Model

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	VOLTAGE (V)	TRIP LEVEL (mA)	UL CATEGORY/CLASS
SB6100-00x-0	208	20 (Fixed)	UL 943C Class C special-purpose GFCI
SB6100-10x-0	240		
SB6100-20x-0	480		
SB6100-30x-0	600	20 (Fixed)	UL 943C Class D special-purpose GFCI
SB6100-01x-0	208	6, 10, 20, 30 (Selectable)	UL 943/UL 1053 Equipment ground-fault protective device (EGFPD)
SB6100-11x-0	240		
SB6100-21x-0	480		
SB6100-31x-0	600		

Note: x=0 for open-chassis models and 1 for enclosed models

Description

Special Purpose Ground-Fault Circuit Interrupter (GFCI), Class C and Class D

Industrial Shock-Block is the first permanently connected special-purpose GFCI that meets UL Standard 943C Class C and Class D—designed for people protection in industrial facilities. According to UL 943C, special-purpose GFCI's can be used in the following applications:

1. On grounded-neutral systems where voltage to ground is above 150 Vac and equipment grounding or double insulation is required by the NEC®, ANSI and NFPA 70.
2. On grounded-neutral systems where voltage to ground is 150 Vac or less and equipment grounding or double insulation is provided, but the use of a Class A ground-fault circuit-interrupter is not practical.

Equipment Ground-Fault Protective Device (EGFPD)

Industrial Shock-Block is available with adjustable protection settings as an EGFPD. While adjustable to a Class A or Class C/Class D protection level, Industrial Shock-Block EGFPD protection can be adjusted up to 30 mA for applications in which nuisance tripping at A or C levels can be expected. (GFCI devices are not allowed to have an adjustable trip level.)

Industrial Shock-Block is available in GFCI, EGFPD, open-chassis, and enclosed models, for voltages from 208 to 600 V. All models are rated at 100 A with built-in overcurrent protection supplied by Littelfuse Class T fuses. The enclosed models are in a NEMA-4X UL-listed enclosure, and the open-chassis models are UL-recognized for installation by an OEM.

A Operator Interface (SB-OPI)

Power and Operational LED indicators; Percentage leakage current LED indicators; Trip LED indicator; Incorrect supply connection LED indicator; Load Ground-Check (GC) LED indicator; Test (OFF) and Reset (ON) buttons. Included with SB6000 Series.

B 1N5339B Termination Device

5 W axial-lead ground-check termination; included with SB6000 Series.

Features & Benefits

FEATURES	BENEFITS
UL 943 inverse time trip curve	Reduces the probability of nuisance tripping
UL 943C trip level (20 mA)	GFCI protection for systems with leakage current higher than the standard 6 mA required by UL 943 Class A
UL 943C ground monitor/interrupt	Trips if continuity of the load ground is lost
3 x Class T, 600 V incoming fuses	Provides overcurrent protection for the internal contactor

Specifications

Voltage Rating	See ordering information
Amperage Rating	100 A (continuous)
Trip Level Settings	Selectable (6, 10, 20, 30 mA), or Fixed 20 mA
System	3-phase, 3-wire (no neutral). 60 Hz
Enclosure	NEMA 4X, Polyester, Lockable
Operating Temperature	–35°C (–31°F) to +66°C (149°F)
Wiring Requirements	2 AWG (maximum)
Approval	UL-Listed (enclosed models) and UL-Recognized component (open-chassis models)
Conformally Coated	Standard feature
Dimensions	**Enclosed: H** 453.80 mm (17.78"); **W** 406.15 mm (15.99"); **D** 223.25 mm (8.79") **Open-chassis: H** 387.00 mm (15.20"); **W** 341.00 mm (13.40"); **D** 161.00 mm (6.40")

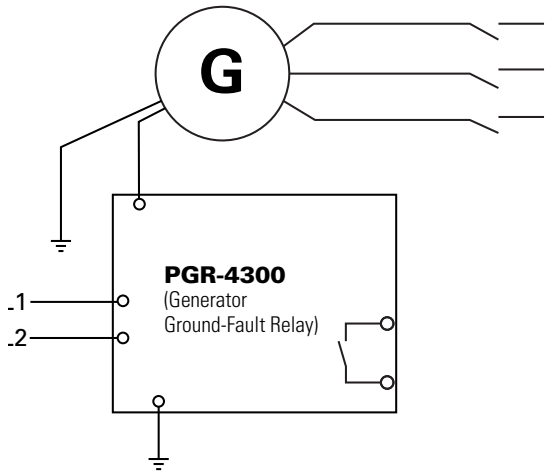
GENERATOR & SINGLE-FUNCTION PROTECTION

For More Information...
and to download our T-Line and G-Line Brochures, visit
www.littelfuse.com/relayscontrols

PGR-4300 SERIES (GFA300)

Generator Ground-Fault Relay

Simplified Circuit Diagram



For detailed wiring diagram, see page 154.

Ordering Information

ORDERING NUMBER	CONTROL POWER
PGR-4300-12	12 Vdc
PGR-4300-24	24 Vdc
PGR-4300-120	120 Vac

ACCESSORIES	REQUIREMENT	PAGE
PGA-0500	Optional	119
PMA-55	Optional	110
PMA-60	Optional	110

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 generator or application where there is not sufficient space to install CTs.

Features & Benefits

FEATURES	BENEFITS
No CTs required	Saves space and simplifies installation
Adjustable pickup (100-1200 A)	Adjustable trip setting provides a wide range of protection and allows 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
Analog output (0-1 mA)	Provides means for connecting to an optional meter (PGA-0500) or control system
N-G continuity alarm	Monitors neutral-to-ground integrity and alarms if ground path becomes open circuit
Passive filtering	Eliminates nuisance tripping

Accessories

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

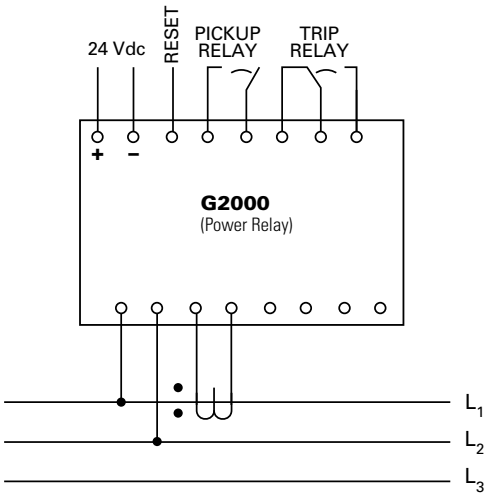
Specifications

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	Local
Reset Button	Local and remote
Output Contacts	Form C
Approvals	UL Listed
Analog Output	0-1 mA
Conformally Coated	Consult factory
Warranty	5 years
Mounting	DIN, Surface (standard) Panel (with PMA-55 or PMA-60 adapter)

G2000 SERIES

Power Relay

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	CONTROL POWER
G2000.0010	24 Vdc, 5 A

ACCESSORIES	REQUIREMENT	PAGE
G0100	Optional	121

Accessories

G0100 Programming Kit
Connects to RS232 port. Includes blank front-plate labels and permanent pen for texting scales.

Description

The G2000 Power Relay is intended for detection of power level for protection, control and monitoring purposes. In the default configuration, the G2000 acts as a reverse power relay for protection of generators running in parallel. Basic adjustments can be done on the dials on the front panel. More configuration options are available through PC configuration via the optional G0100 Programming Kit. PC programming enables the user to reconfigure the relay as an overload relay and allows extension of the ranges on the dials on the front panel.

One version covers all system voltages from 63 Vac to 690 Vac. Rated voltage can be adjusted by a preset button or PC configuration. Auxiliary supply voltage is 24 Vdc.

Features & Benefits

FEATURES	BENEFITS
PC configuration	Forward power or reverse power relay functionality
User configurable scales and setpoints	Suits broad variety of applications
63 Vac to 690 Vac systems can be monitored by the same unit	Supports wide range of system voltages

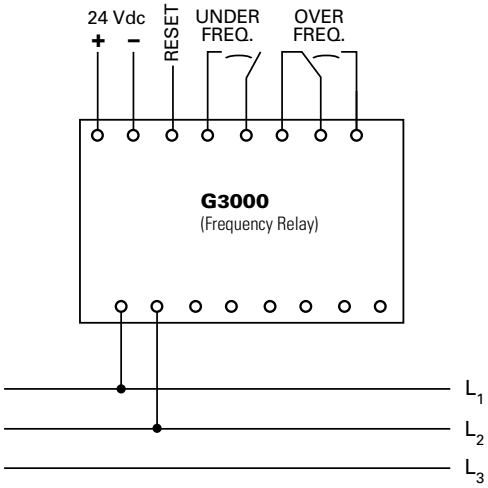
Specifications

Supply	8-36 Vdc/0.75 W at 24 Vdc
Input Voltage	63-690 Vac ± 30%
Input Current	5 A CT, max. 10 A
Frequency	35-75Hz
Trip Level	RP: 2-20% (max. 2-50%) FP: 50-140% (max. 50-150%)
Hysteresis	1-10% (max. 1-50%)
Delay	2-20 sec. (max. 1-360 sec.)
Relay Rating	380 Vac, 5 A, 1250 VA, 150 Vdc, 5 A, 120 W
Pick-up Relay	Normal state: ND (NE) Latching: Non-latching
Trip Relay	Normal state: ND (NE) Latching: Non-latching (latching)
Reset	Automatic (manually by terminal 11)
Accuracy	± 5%
Repeatability	± 1%
Serial Link	RJ11-modular
Operating Temperature	–20°C to + 70°C
EMC	EN50263
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.3 kg
Dimensions	**H** 73 mm (2.87"); **W** 75 mm (2.95"); **D** 114 mm (4.49")
Installation	35 DIN rail or two 4 mm, (3/16") screws

G3000 SERIES

Frequency Relay

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	CONTROL POWER
G3000.0010	24 Vdc

ACCESSORIES	REQUIREMENT	PAGE
G0100	Optional	121

Accessories

G0100 Programming Kit
Connects to RS232 port. Includes blank front-plate labels and permanent pen for texting scales.

Description

The G3000 Frequency Relay is intended for frequency monitoring on generators, busbars or other distribution systems. The relay contains the functions "under frequency" and "over frequency", time delayed, and two individual output relays—one relay for each function.

Basic adjustments can be done on the dials on the front panels. More configuration options are available through PC configuration via the optional G0100 Programming Kit. PC programming enables the user to extend the ranges on the dials on the front panel.

One version covers all system voltages from 63 Vac to 690 Vac. Rated voltage can be adjusted by a preset button or PC configuration. Auxiliary supply voltage is 24 Vdc.

Features & Benefits

FEATURES	BENEFITS
PC configuration	Over and under frequency protection in one relay
User configurable scales and setpoints	Suits broad variety of applications
63 Vac to 690 Vac systems can be monitored by the same unit	Supports wide range of system voltages

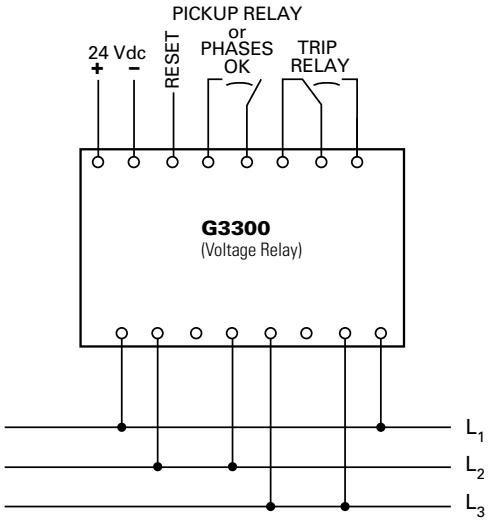
Specifications

Supply	8-36 Vdc/0.75 W at 24 Vdc
Input Voltage	63-690 Vac ± 30%
Input Current	5 A CT, max. 10 A
Frequency	35-75Hz
Trip Level	OF: 85 to 115% (max. 75 to 125%) UF: 85 to 115% (max. 75 to 125%)
Delay	1-10 sec. (max. 1-360 sec.)
Relay Rating	380 Vac, 5 A, 1250 VA, 150 Vdc, 5 A, 120 W
Overfrequency Relay	Normal state: ND (NE) Latching: Non-latching (latching)
Underfrequency Relay	Normal state: ND (NE) Latching: Non-latching (latching)
Reset	Automatic (manually by terminal 11)
Accuracy	± 5%
Repeatability	± 1%
Serial Link	RJ11-modular
Operating Temperature	–20°C to + 70°C
EMC	EN50263
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.3 kg
Dimensions	**H** 73 mm (2.87"); **W** 75 mm (2.95"); **D** 114 mm (4.49")
Installation	35 DIN rail or two 4 mm, ($^3/_{16}$") screws

G3300 SERIES

Voltage Relay

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	CONTROL POWER
G3300.0010	24 Vdc

ACCESSORIES	REQUIREMENT	PAGE
G0100	Optional	121

Accessories

G0100 Programming Kit
Connects to RS232 port. Includes blank front-plate labels and permanent pen for texting scales.

Description

The G3300 Voltage Relay monitors voltage on generators, busbars or other distribution systems. The relay provides "undervoltage" and "overvoltage", time delayed, and two individual output relays—one for each function.

Basic adjustments can be done on the dials on the front panels. More configuration options are available through PC configuration via the optional G0100 programming Kit. PC programming enables the user to extend the ranges on the dials on the front panel.

One version covers all system voltages from 63 Vac to 690 Vac. Rated voltage can be adjusted by a preset button or PC configuration. Auxiliary supply voltage is 24 Vdc.

Features & Benefits

FEATURES	BENEFITS
PC configuration	Over and undervoltage protection in one relay
User configurable scales and setpoints	Suits broad variety of applications
Phase symmetry monitor	Enables use in grid connection applications
63 Vac to 690 Vac systems can be monitored by the same unit	Supports wide range of system voltages

Specifications

Supply	8-36 Vdc/0.75 W at 24 Vdc
Input Voltage	63-690 Vac ± 30%
Frequency	35-75Hz
Trip Level	100 to 120% (max. 1 to 130%)
Hysteresis	1-10% (max. 1-50%)
Delay	1-10 sec. (max. 1-360 sec.)
Relay Rating	380 Vac, 5 A, 1250 VA, 150 Vdc, 5 A, 120 W
Phase Monitor	Phase failure, phase order & symmetry
Pick-up (Phase) Relay	Normal state: ND (NE) Latching: Non-latching
Trip Relay	Normal state: ND (NE) Latching: Non-latching
Reset	Automatic (manually by terminal 11)
Accuracy	± 5%
Repeatability	± 1%
Serial Link	RJ11-modular
Operating Temperature	–20°C to + 70°C
EMC	EN50263
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.3 kg
Dimensions	**H** 73 mm (2.87"); **W** 75 mm (2.95"); **D** 114 mm (4.49")
Installation	35 DIN rail or two 4 mm, (3/16") screws

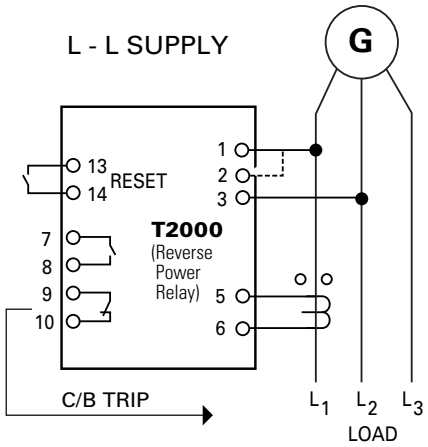
Littelfuse
Expertise Applied | Answers Delivered

T2000 SERIES

Reverse Power Relay

CE

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS 1-3	TERMINALS 2-3	I_N	SUPPLY	FUNCTION
T2000.0010	230 V		5 A	L-N	
T2000.0020	450 V	400 V	5 A	L-L	
T2000.0030	127 V	120 V	5 A	L-N	
T2000.0040	110 V	100 V	5 A	L-L	
T2000.0050	110 V	100 V	5 A	L-L	No time delay
T2000.0060	230 V		1 A	L-N	
T2000.0070	660 V		5 A	L-L	
T2000.0080	450 V	400 V	5 A	L-N	Delay 0.2 - 2.0 sec.
T2000.0090	127 V	120 V	5 A	L-L	
T2000.0100	110 V	100 V	1 A	L-L	
T2000.0110	450 V	400 V	5 A	L-L	No time delay
T2000.0120	480 V	415 V	5 A	L-L	
T2000.0130	230 V		5 A	L-N	No time delay
T2000.0140	230 V		5 A	L-L	
T2000.0150	480 V	415 V	1 A	L-L	
T2000.0160	450 V	400 V	1 A	L-L	

Other supply voltages and combinations are available on request.

Description

Under parallel operation, the T2000 Reverse Power Relay will protect the generator from being run as an electric motor. The T2000 will protect the prime mover of the generator against physical damage, but will also protect the parallel running generators from overload caused by the inversed load shift in a reverse power situation.

The T2000 calculates I x cos F, representing the active power. If the active power becomes negative and exceeds the preset level (2-20%), the pick-up LED will indicate this and the delay timer will be started. After the preset time (2-20 sec.) has expired, the output relay and LED will be activated, provided that the reverse power level was exceeded for the entire delay time.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs or separate power supply
Available with instant output trip	Enables alternative use for detection of current direction
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

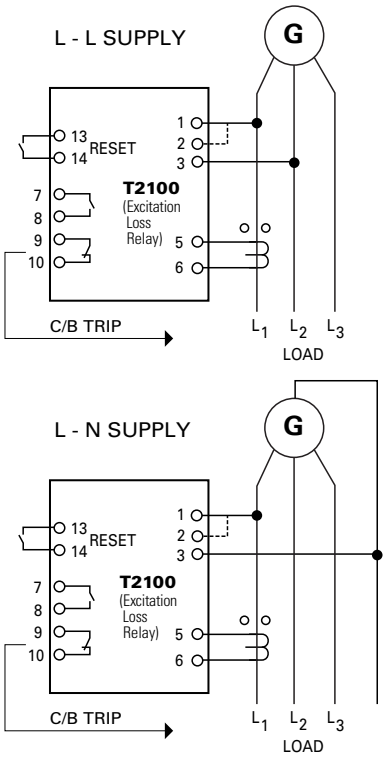
Specifications

Trip Level	2-20% I_N
Delay	2-20 sec.
Max. Voltage	660 V
Voltage Range	50-110%
Consumption	5 VA at U_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized, latching, resetable
Contact Rating	AC: 400 V, 5 A, 1250 VA DC: 150 V, 5 A, 120 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

T2100 SERIES

Excitation Loss Relay

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS		I_N	SUPPLY	FUNCTION
	1-3	2-3			
T2100.0010	230 V		5 A	L-N	
T2100.0020	480 V	415 V	5 A	L-L	
T2100.0030	450 V	400 V	5 A	L-L	
T2100.0040	110 V	100 V	1 A	L-L	
T2100.0050	110 V	100 V	5 A	L-L	
T2100.0060	110 V	100 V	5 A	L-L	Current 0.2-1.2 x I_N
T2100.0070	480 V	415 V	5 A	L-L	Normally energized output, current 0.05 -0.15 x I_N
T2100.0080	110 V	100 V	5 A	L-L	24 V DC aux. voltage supply, current 0.2 1.2 x I_N

Other supply voltages and combinations are available on request.

Description

The T2100 Excitation Loss Relay protects against loss of excitation in a synchronous generator. T2100 detects the high-inductive current running into a generator in case of low excitation. The faulty generator breaker is tripped, thus protecting the generator, and avoiding undervoltage on the busbar with a possible blackout of the system.

The T2100 calculates I x sin φ, representing the reactive power. If the reactive power becomes negative and exceeds the preset level (0.5-1.5 x I_N), the pickup LED will indicate and the delay timer will be started. After the preset time (2-20 sec.) has expired, the output relay and LED will be activated, provided that the negative reactive power level was exceeded for the entire delay time.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Available with separate 24 Vdc supply	Safe operation. Maintains protection regardless of system voltage failure
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Specifications

Trip Level	0.5-1.5 x I_N
Delay	2-20 sec.
Max. Voltage	660 V
Voltage Range	50-110%
Consumption	Voltage 5 VA at U_N Current 0.3 VA at I_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized, latching, resetable
Contact Rating	AC: 400 V, 5 A, 1250 VA DC: 150 V, 5 A, 120 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

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T2200 SERIES

3-Phase Overcurrent Relay

CE

Description

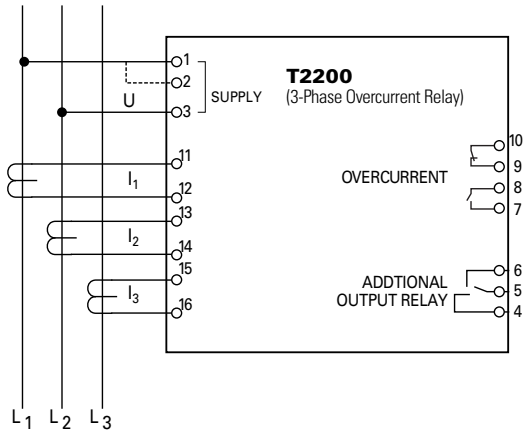
The T2200 Overcurrent Relay is designed for generator or feeder protection against overcurrent in each of the three phases.

The T2200 detects the highest of the 3 input currents and, if this exceeds the preset level (0.5 - 1.4 x I_N), the pick-up LED will indicate and the delay timer will be started. After the preset time (3-30 sec.) has expired, the output relay and the corresponding LED will be activated, provided that the current level was exceeded for the entire delay time.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Available with extra output with instant trip	Economic solution for tripping non-essential load, before main breaker trip
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS		I_N	FUNCTION
	1-3	2-3		
T2200.0010	450 V	400 V	5 A	Latching output, resetable
T2200.0020	450 V	400 V	5 A	Normally energized output, latching, resetable
T2200.0030	230 V		5 A	Latching output, resetable
T2200.0040	230 V	110 V	5 A	Latching output, resetable
T2200.0050	230 V		1 A	Latching output, resetable
T2200.0060	450 V	400 V	5 A	Normally energized output, latching, resetable, delay 6-60 sec.
T2200.0070	110 V	100 V	5 A	Latching output, resetable
T2200.0080	480 V	415 V	5 A	Latching output, resetable
T2200.0090	24 Vdc		5 A	Latching output, resetable
T2200.0100	450 V	400 V	5 A	Instantly extra output relay
T2200.0110	450 V	400 V	1 A	Instantly extra output relay

Other supply voltages and combinations are available on request.

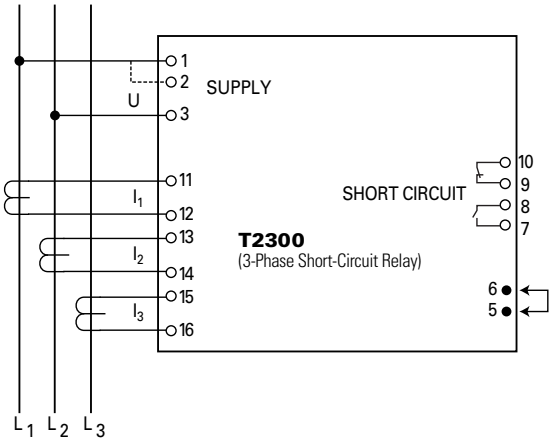
Specifications

Trip Level	0.5-1.4 x I_N
Delay	3-30 sec.
Max. Voltage	660 V
Voltage Range	60-110%
Consumption	Voltage 5 VA at U_N Current 0.3 VA at I_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized
Contact Rating	AC: 400 V, 5 A, 2000 VA DC: 150 V, 5 A, 150 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

T2300 SERIES

3-Phase Short-Circuit Relay

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS		I_N	FUNCTION
	1-3	2-3		
T2300.0100	230 V		5 A	
T2300.0020	450 V	400 V	5 A	
T2300.0030	24 Vdc		5 A	
T2300.0040	24 Vdc		1 A	
T2300.0050	450 V	400 V	5 A	Normally de-energized output
T2300.0060	480 V	415 V	5 A	
T2300.0070	230 V		1 A	

Other supply voltages and combinations are available on request.

Description

The T2300 3 Phase Short-Circuit Relay is designed for protection of generators, power transmissions and consumer's supply against short circuit. The T2300 reacts on a definite delay versus current level.

The T2300 detects the highest of the 3 input currents and, if this exceeds the preset level (1.0 - 4.0 x I_N), the pick-up LED will indicate and the delay timer will be started. After the preset time (0.1-1.0 sec.) has expired, the normally energized output relay will de-energize and the relay LED will be activated, provided that the current level was exceeded for the entire delay time. The T2300 has a normally energized output relay.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Built-in capacitor cack-up supply	Ensures correct operation in spite of drop in the supply voltage
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Specifications

Trip Level 1.0-4.0 x I_N
Delay 0.1-1.0 sec.
Max. Voltage 660 V
Voltage Range 60-110%
Consumption Voltage 5 VA at U_N
Current 0.3 VA at I_N
Continuous Current 2 x I_N
Frequency Range 45-400 Hz
Output Relay Normally de-energized, latching, resetable
Contact Rating AC: 400 V, 5 A, 2000 VA
DC: 150 V, 5 A, 150 W
Overall Accuracy ±5%
Repeatability ±1%
Operating Temperature –20°C to + 70°C
Dielectric Test 2500 V, 50 Hz
EMC CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals Certified by major marine classification societies
Burn-in 50 hours before final test
Enclosure Material Polycarbonate. Flame retardant
Weight 0.5 kg
Dimensions **H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation 35 mm DIN rail or 4 mm (3/16") screws

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T2400 SERIES

3-Phase Dual Overcurrent Relay

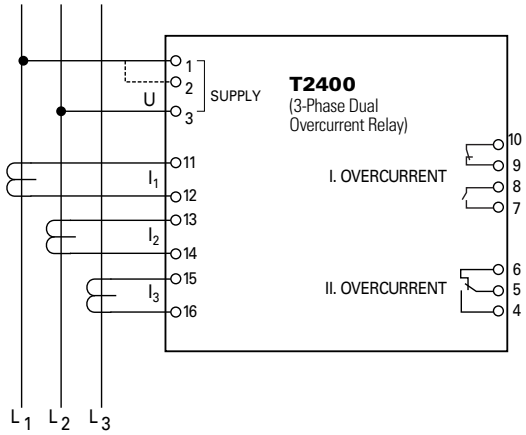
CE

Description

The T2400 3-Phase Dual Overcurrent Relay includes two combined overcurrent relays, designed for protection or monitoring of generators and power transmissions. A typical application is to use one of the overcurrent functions to trip the generator circuit breaker, and the other overcurrent function to trip a non-essential consumer.

The T2400 consists of two overcurrent circuits with similar current settings and time delays. Each circuit detects the highest of the 3 input currents and, if this exceeds the preset level (0.5-1.4 x I_N), the corresponding pick-up LED will indicate and the delay timer will be started. After the preset time (3-30 sec.) has expired, the corresponding output relay and LED will be activated, provided that the current level was exceeded for the entire delay time.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combining 2 relays in same enclosure	Economic solution for non-essential load tripping, and occupying less space in the switch panel
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS 1-3	TERMINALS 2-3	I_N	FUNCTION
T2400.0010	230 V		5 A	
T2400.0020	450 V	400 V	5 A	
T2400.0030	110 V	100 V	5 A	
T2400.0040	450 V	400 V	5 A	Latching output on relay 1, 6-60 sec. delay on relay 1
T2400.0050	480 V	415 V	5 A	
T2400.0060	450 V	400 V	1 A	
T2400.0070	450 V	400 V	5 A	Latching output on relay 1, normally energized relay 1
T2400.0080	127 V	120 V	5 A	
T2400.0090	24 Vdc		5 A	

Latching output relays are reset by disconnecting the power supply.
Other supply voltages and combinations are available on request.

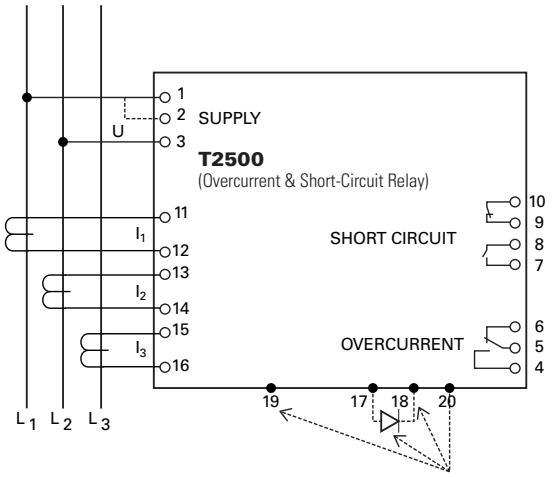
Specifications

Trip Level	0.5-1.4 x I_N
Delay	3-30 sec.
Max. Voltage	660 V
Voltage Range	60-110%
Consumption	Voltage 5 VA at U_N Current 0.3 VA at I_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized
Contact Rating	AC: 400 V, 5 A, 2000 VA; DC: 150 V, 5 A, 150 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

T2500 SERIES

Overcurrent and Short-Circuit Relay

Simplified Circuit Diagram



Connection between 20 and 19 gives instant operation of Relay 2.
Connection between 20 and 17 gives delayed operation of Relay 2.
Connection between 20 and 18 gives synchronized operation of Relay 1 and Relay 2.
Disconnecting the diode between 17 and 18 will disable operation of Relay 1 from overcurrent.
Latching output relays can be reset or disabled by bridging terminals 5 and 6.

Ordering Information

ORDERING NUMBER	TERMINALS		I_N	FUNCTION
	1-3	2-3		
T2500.0010	450 V	400 V	5 A	Latching output, resetable
T2500.0020	230 V		5 A	Latching output, resetable
T2500.0030	480 V	415 V	5 A	Latching output, resetable
T2500.0040	450 V	400 V	1 A	Latching output, resetable
T2500.0050	24 Vdc		5 A	Latching output, resetable
T2500.0060	230 V		5 A	De-energized extra output relay
T2500.0070	450 V	400 V	5 A	De-energized extra output relay
T2500.0080	450 V	400 V	5 A	De-energized extra output relay, latching outputs
T2500.0090	480 V	415 V	5 A	De-energized extra output relay
T2500.0100	24 Vdc		1 A	De-energized extra output relay
T2500.0110	450 V	400 V	5 A	De-energized extra output relay, latching short circuit output
T2500.0120	24 Vdc		5 A	De-energized extra output relay, de-energized relay 1, no internal power backup

Other combinations and voltages are available on request.

Description

The combined T2500 3-Phase Overcurrent and Short-Circuit Relay is used for protection of generators and power transmissions. The short-circuit relay protects against faults causing high currents, and the overcurrent relay protects against thermal damage.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combining 2 protection functions in same enclosure	Economic solution, occupying less space in the switch panel
Available with extra output	Economic solution for non-essential load tripping
Versions available with separate 24 Vdc supply	Safe operation–Maintains protection regardless of system voltage failure
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Specifications

Overcurrent Trip Level 0.5-1.4 x I_N
Delay 3-30 sec.
Short-Circuit Trip Level 1.0-4.0 x I_N
Delay 0.1-1.0 sec.
Max. Voltage 660 V
Voltage Range 60-110%
Consumption 5 VA at U_N
Continuous Current 2 x I_N
Frequency Range 45-400 Hz
Output Relay Normally energized
Extra Output Relay Normally de-energized
Contact Rating AC: 400 V, 5 A, 2000 VA; DC: 150 V, 5 A, 150 W
Overall Accuracy ±5%
Repeatability ±1%
Operating Temperature –20°C to + 70°C
EMC CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals Certified by major marine classification societies
Burn-in 50 hours before final test
Enclosure Material Polycarbonate. Flame retardant
Weight 0.5 kg
Dimensions **H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation 35 mm DIN rail or 4 mm (3/16") screws

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T2700 SERIES

Power Relay

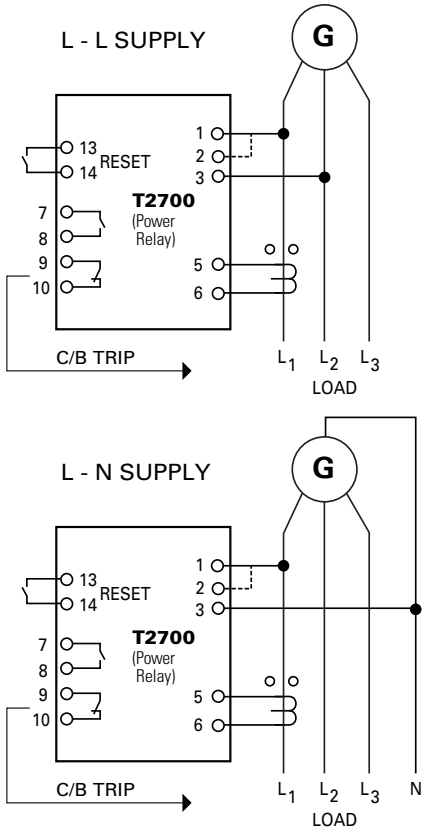
CE

Description

The T2700 Power Relay is intended for detection of power levels for protection, control or monitoring purposes. The T2700 will protect a generator from excessive active loads [kW].

The T2700 calculates I x cos φ, representing the active power. If the active power exceeds the preset level (15-150%), the pick-up LED will indicate this and the delay timer will be started. After the preset time (2-20 sec.) has expired, the output relay and LED will be activated, provided that the active power level was exceeded for the entire delay time.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Specifications

Trip Level	15-150% I_N
Delay	2-20 sec.
Max. Voltage	660 V
Voltage Range	60-110%
Consumption	Voltage 5 VA at U_N Current 0.3 VA at I_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized, latching, resetable
Contact Rating	AC: 400 V, 5 A, 1250 VA; DC: 150 V, 5 A, 120 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

Ordering Information

ORDERING NUMBER	TERMINALS		I_N	SUPPLY	FUNCTION
	1-3	2-3			
T2700.00	230 V		5 A	L-N	
T2700.02	450 V	400 V	5 A	L-L	
T2700.03	230 V	400 V	5 A	L-L	
T2700.04	110 V	100 V	5 A	L-L	Normally energized output
T2700-08	127 V	120 V	5 A	L-N	

Other supply voltages and combinations are available on request.

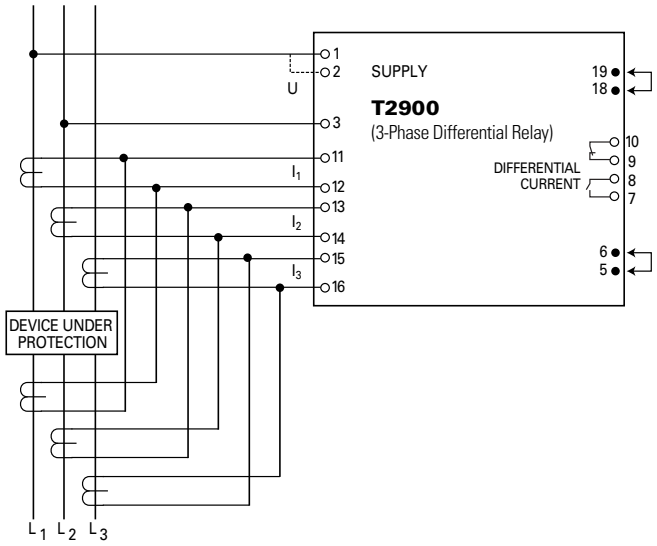
T2900 SERIES

3-Phase Differential Relay

Description

The T2900 3-Phase Differential Relay is designed for monitoring current leakage in generators. The T2900 measures the differential current of each of the 3 phases. The differential currents are measured by connecting a current transformer for each winding in parallel with inverse polarity. The highest of the 3 currents is selected and, if it exceeds the preset level (0.04-0.4 x I_N), the pick-up LED will indicate this and the delay timer will be started. After the preset time has expired, the output relay and the corresponding LED will be activated, provided that the current level was exceeded for the entire delay time. The time delay can be adjusted between 1-10 sec. This time delay can be reduced by a factor 10 by bridging terminals 18 and 19.

Simplified Circuit Diagram



Bridge between terminals 5 and 6 results in latching relay.
Bridge between terminals 18 and 19 reduces time delay to 0.1-1 sec.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Built-in capacitor back-up supply	Ensures correct operation in spite of drop in the supply voltage
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS		I_N
	1-3	2-3	
T2900.0010	450 V	400 V	5 A
T2900.0020	230 V		5 A
T2900.0030	480 V	415 V	5 A
T2900.0040	110 V	100 V	5 A

Standard types: I_N = 5 A and output relay normally de-energized.
Other combinations and voltages are available on request.

Specifications

Trip Level	0.04-0.4 x I_N
Delay	1-10 sec. (0.1-1 sec. when bridging terminals 18 and 19)
Max. Voltage	660 V
Voltage Range	60-110%
Consumption	Voltage 5 VA at U_N Current 0.3 VA at I_N
Continuous Current	2 x I_N
Frequency Range	45-400 Hz
Output Relay	Normally de-energized, latching, resetable
Contact Rating	AC: 400 V, 5 A, 2000 VA DC: 150 V, 5 A, 150 W
Overall Accuracy	±5%
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

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T3000 SERIES

Frequency Relay

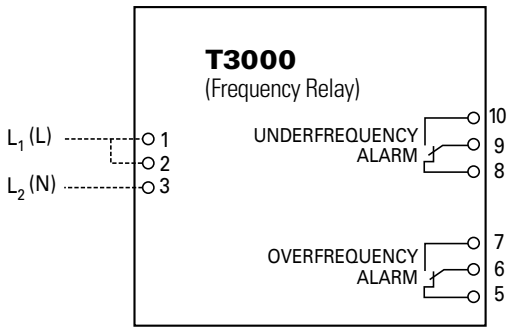
CE

Description

The T3000 Frequency Relay is designed for frequency monitoring on generators, bus bars or other distribution systems.

The T3000 consists of two circuits, one circuit for over frequency and one for under frequency monitoring. Each circuit has individual settings for frequency levels and time delays. The output relays are normally energized output relays. The output relay for under frequency is activated at frequencies higher than the preset value, while the output relay for over frequency is activated at frequencies lower than the preset value. This means that both output relays are activated at frequencies within the interval between the under and over frequency scale range.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combining 2 relays in same enclosure	Economic solution . Monitoring both underfrequency and overfrequency in same unit, and occupying less space in the switch panel
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS	
	1-3	2-3
T3000.0010	230 V	
T3000.0020	450 V	400 V
T3000.0030	110 V	100 V
T3000.0040	480 V	415 V
T3000.0050	127 V	120 V

Other voltages are available on request.

Specifications

Overfrequency Level 45-65 Hz
Delay 1-10 sec.
Underfrequency Level 45-65 Hz
Delay 1-10 sec.
Max. Voltage 660 V
Voltage Range 70-110%
Consumption 5 VA at U_N
Continuous Current 2 x I_N
Frequency Range 40-70 Hz
Output Relay Normally energized
Contact Rating AC: 250 V, 2 A, 250 VA; DC: 60 V, 2 A, 100 W
Overall Accuracy ±3% of highest value
Repeatability ±1%
Operating Temperature –20°C to + 70°C
Dielectric Test 2500 V, 50 Hz
EMC CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals Certified by major marine classification societies
Burn-in 50 hours before final test
Enclosure Material Polycarbonate. Flame retardant
Weight 0.5 kg
Dimensions **H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation 35 mm DIN rail or 4 mm ($^3/_{16}$") screws

T3100 SERIES

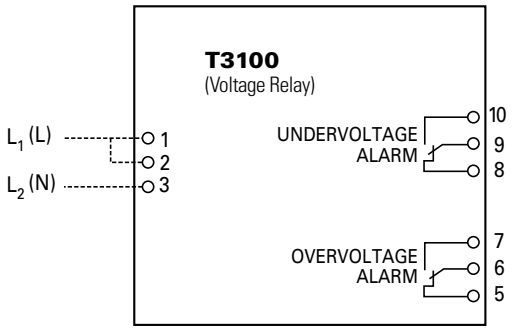
Voltage Relay

Description

The T3100 Voltage Relay is designed for voltage monitoring on generators, bus bars or other distribution systems. The T3100 will signal when the voltage is out of limits for a preset time period.

The T3100 consists of two circuits, one circuit for overvoltage and one for undervoltage monitoring. Each circuit has individual settings for voltage levels and time delays.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combining 2 relays in same enclosure	Economic solution. Monitoring both undervoltage and overvoltage in same unit, and ccupying less space in the switch panel
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS	
	1-3	2-3
T3100.0010	230 V	
T3100.0020	450 V	400 V
T3100.0030	110 V	100 V
T3100.0040	480 V	415 V
T3100.0060	127 V	120 V

Other voltages are available on request.

Specifications

Overvoltage Level	100-120%
Delay	1-10 sec.
Hysteresis	1-10%
Undervoltage Level	80-100%
Delay	1-10 sec.
Hysteresis	1-10 %
Max. Voltage	660 V
Voltage Range	70-120%
Consumption	5 VA at U_N
Frequency Range	40-400 Hz
Overvoltage Relay	Normally de-energized
Undervoltage Relay	Normally energized
Contact Rating	AC: 250 V, 2 A, 250 VA DC: 60 V, 2 A, 100 W
Overall Accuracy	±3% of highest value
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

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T3300 SERIES

3-Phase Voltage Relay

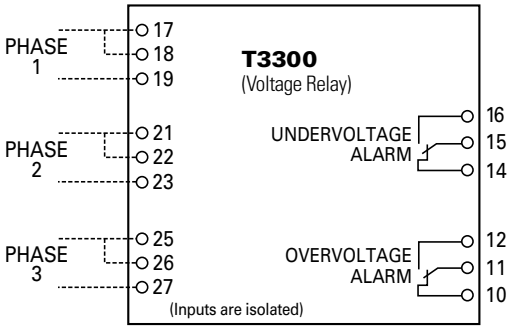
CE

Description

The T3300 Voltage Relay is designed for voltage monitoring on generators, bus bars or other distribution systems. The T3300 will signal when the voltage is out of limits for a preset time period.

The T3300 consists of two circuits, one circuit for overvoltage and one for undervoltage monitoring. Each circuit has individual settings for voltage levels and time delays.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Combining 2 relays in same enclosure	Economic solution. 3-phase monitoring of both undervoltage and overvoltage in same unit, and occupying less space in the switch panel
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS	
	17-19 21-23 25-27	18-19 22-23 26-27
T3300.0010	230 V	
T3300.0020	450 V	400 V
T3300.0030	110 V	100 V
T3300.0040	480 V	415 V

Other voltages are available on request.

Specifications

Overvoltage Level	100-120%
Delay	1-10 sec.
Hysteresis	1-10%
Undervoltage Level	80-100%
Delay	1-10 sec.
Hysteresis	1-10 %
Max. Voltage	660 V
Voltage Range	70-120%
Consumption	5 VA at U_N
Frequency Range	40-400 Hz
Overvoltage Relay	Normally de-energized
Undervoltage Relay	Normally energized
Contact Rating	AC: 250 V, 2 A, 250 VA DC: 60 V, 2 A, 100 W
Overall Accuracy	±3% of highest value
Repeatability	±1%
Operating Temperature	–20°C to + 70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	1.2 kg
Dimensions	**H** 70 mm (2.76"); **W** 150 mm (5.9"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

GENERATOR CONTROL

For More Information...
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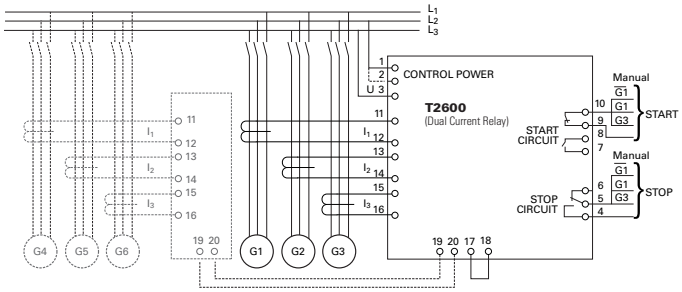
T2600 SERIES

Dual-Current Relay

CE

Simplified Circuit Diagram



To check relay operation, check that the "POWER" LED is on, ensuring that the supply is present. Measure the supply voltage which must be compatible with information label on top of enclosure. Measure the current circulating in terminals 11 -12, 13-14 and 15-16 and observe that at least one of the currents are above setting. 0.5 x I_N = 2.5A; 2 x I_N = 10A.

Ordering Information

ORDERING NUMBER	TERMINALS 1-3	TERMINALS 2-3	I_N	FUNCTION
T2600.0010	230 V		5 A	30 sec. or 1 sec.*
T2600.0020	450 V	400 V	5 A	30 sec. or 1 sec.*
T2600.0030	480 V	415 V	5 A	30 sec. or 1 sec.*
T2600.0040	450 V	400 V	5 A	30 sec.*, bridge 17-18 = stop current increased 34%
T2600.0050	480 V		5 A	30 sec.*, bridge 17-18 = stop current increased 34%
T2600.0060	110 V	100 V	5 A	30 sec. or 1 sec.*
T2600.0070	110 V	100 V	5 A	30 sec. or 1 sec.*, start current delay 1.0-10 secs
T2600.0080	230 V		5 A	30 sec. or 1 sec.*, normally de-energized start relay
T2600.0090				Extension Unit

**Pulse duration time for stop signal, bridge 17-18 = 1 sec.*

Description

The T2600 Dual-Current Relay combines two current relays. The function of the unit is to start or stop the standby diesel generator according to the load situation. Current is measured as a single phase measurement in each of the generators. Both relays will respond to the highest of the currents, independent of phase angle.

Starting signal: The starting output relay is controlled by the high level start current relay (0.3-1.2 x I_N) with a time delay of 3-30 seconds. If one of the 3 input currents exceeds the current setting for a longer period than the time setting, the output relay will become deactivated.

Stopping signal: The low level current relay (0.2-0.8 x I_N) controls a time delay (1-10 minutes) which again controls the stop output relay. If all input currents are lower than the current setting for a longer period than the time delay setting of 1-10 minutes, the output relay will be activated.

Features & Benefits

FEATURES	BENEFITS
Accepts high supply voltage variation	Ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)
Visual indication of power, pick-up, and output trip	Provides quick and concise status information
Direct line-line or line-neutral voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs.
Simultaneous monitoring of load level on 3 synchronous generators	Economic solution for load depending start/ stop of generators in parallel operation
Combining 2 trip outputs in same enclosure	Providing both start signal to stand-by generator and stop signal of running generator from same unit
Extension module available for monitoring of additional 3 generators	Economic and easy to install system enhancement
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Specifications

Start Level	30-120%
Delay	3-30 sec.
Stop Level	20-80%
Delay	1-10 min.
Max. Voltage	660 V
Voltage Range	60-110%
Consumption	5 VA at U_N
Frequency Range	40-65 Hz
Contact Rating	AC: 400 V, 8 A, 2000 VA; DC: 35 V, 8 A, 150 W
Overall Accuracy	±3% of highest value
Repeatability	±1%
Operating Temp.	–20°C to +70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Weight	0.5 kg
Dimensions	**H** 70 mm (2.76"); **W** 100 mm (3.94"); **D** 115 mm (4.52")
Installation	35 mm DIN rail or 4 mm (3/16") screws

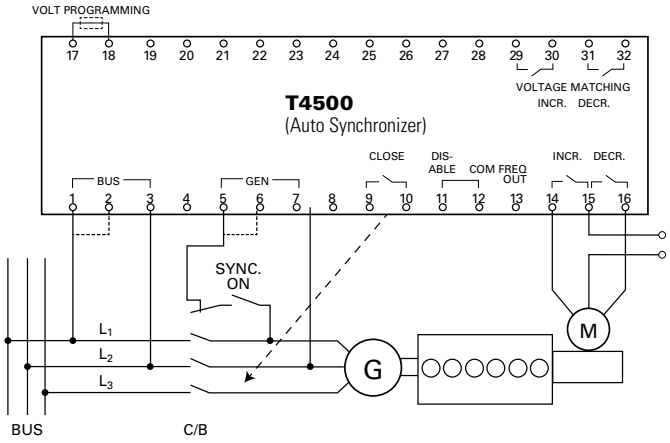
T4500 SERIES

Auto Synchronizer for Conventional Governors

Description

The T4500 Auto Synchronizer provides automatic synchronization of a generator to a busbar in a minimum of time, by controlling the speed via the electric servomotor on a conventional speed governor, or by controlling an electronic speed controller via an intermediate motorized potentiometer. A unique feature of the T4500 is the possibility of simultaneous synchronization of already parallel running generators to another busbar section, a shaft generator or the grid. The T4500 includes outputs for controlling the Automatic Voltage Regulator (AVR) as well. When used, T4500 will not only control the speed of the generator, but also the alternator voltage (Voltage Matching).

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Adjustable delta frequency, synchronizing window (delta voltage), & breaker make time by front panel potentiometers & terminal bridging resistors	Facilitates adjustment during installation and commissioning
Inputs for disabling internal frequency control	Enables synchronization to external frequency set-point from other busbar sections, shaft generators or the main grid (grid-parallel operation)
Automatic voltage matching	Enables use in installations with fluctuating system voltage
Visual indication of bus, generator, & delta voltage, closing signal, & speed & voltage increase/decrease signals	Provides quick and concise status information
Direct line-line voltage Supply (up to 690 Vac)	Simplifies design and installation. No need for PTs or separate power supply
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN rail or screw-mount	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS	
	1-3 5-7	2-3 6-7
T4500.0010	450 V	400 V
T4500.0020	230 V	
T4500.0030	480 V	415 V
T4500.0040	110 V	63 V
T4500.0050	127 V	120 V
T4500.0060	110 V	100 V
T4500.0070	600 V	

Other supply voltages and combinations are available on request.

Specifications

Max. Voltage	660 V
Voltage Range	70-110%
Consumption	4 VA at U_N
Frequency Range	35-70 Hz
Frequency Difference	0.1-1.0 Hz
C/B Make Time	20-200 ms
Voltage Difference	2-10%
Contact Rating	AC: 400 V, 2 A, 250 VA; DC: 110 V, 2 A, 100 W
Operating Temperature	–20°C to +70°C
Vibration Test	4 g (500-100 Hz)
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate, flame retardant
Weight	0.7 kg
Dimensions	**H** 70 mm (2.7"); **W** 100 mm (3.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

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T4800 SERIES

Load Sharer for Conventional Governors

CE

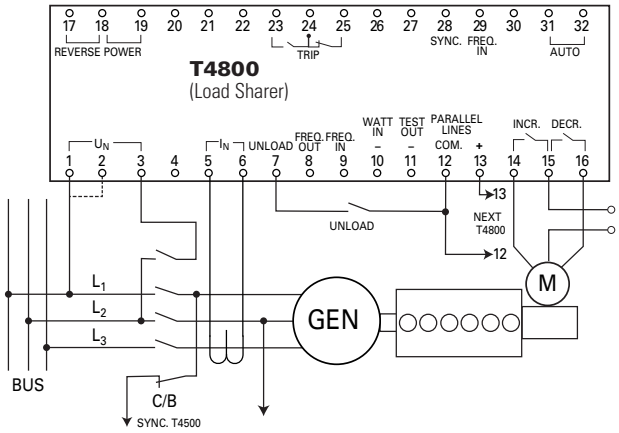
Description

The T4800 Load Sharer provides automatic load sharing and frequency control for parallel running generators. The load sharing is proportional, meaning that the generators will be loaded equally compared to their individual capacity.

The load on each generator is compared with the load on the other generators and corrected until balance is obtained. Load sharing is necessary after synchronization in order to reestablish load balance and to obtain long term stability of load and system frequency (compensating the droop of the speed governor).

The T4800 has a built-in reverse power protection with selectable limits and time delays.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Adjustable delta frequency, stability and % load deviation by front panel potentiometers	Facilitates adjustment during installation and commissioning. Load deviation adjustment enables paralleling of differenst size generators.
Inputs for disabling internal frequency control	Enables operation where system frequency is set externally such as in grid-parallel operation
Reverse power trip	Economic solution for reverse power protection
Visual indication of voltage, increase/decrease and unload signals	Provides quick and concise status information
Direct line-line voltage supply (up to 690 Vac)	Simplifies design and installation–no need for PTs–or separate power supply
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN rail or screw-mount	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS		I_N
	1-1	1-3	
T4800.0010	450 V	400 V	5 A
T4800.0020	230 V		5 A
T4800.0030	480 V	415 V	5 A
T4800.0040	110 V	100 V	1 A
T4800.0050	450 V	400 V	1 A
T4800.0060	127 V	120 V	5 A
T4800.0070	110 V	100 V	5 A

Other supply voltages, nominal currents and combinations are available on request.

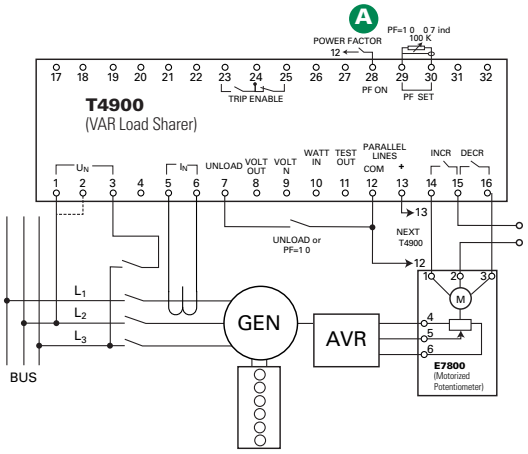
Specifications

Max. Voltage	660 V
Voltage Range	70-110%
Consumption	Voltage 4 VA at U_N; Current 0.4 VA at U_N;
Continuous Current	2 x I_N
Frequency Range	35-70 Hz
Frequency Adjustment	48-62 Hz
Proportional Band	±50 - 250% load; ±5 - 25% frequency
Dead Band Zone	±2 - 10% load; ±0.2 - 1.0% frequency
Contact rating	AC: 400 V, 2 A, 250 VA DC: 110 V, 2 A, 100 W
Operating Temperature	–20°C to +70°C
Vibration Test	4 g RMS according to IEC 60068-2-64
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2, EN61000-6-2:1999
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate, flame retardant
Weight	0.7 kg
Dimensions	**H** 70 mm (2.7"); **W** 150 mm (5.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

T4900 SERIES

VAR Load Sharer

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS		I_N
	1-3	2-3	
T4900.0010	450 V	400 V	5 A
T4900.0020	230 V	–	5 A
T4900.0030	480 V	415 V	5 A
T4900.0040	110 V	63 V	5 A
T4900.0050	127 V	120 V	1 A
T4900.0060	110 V	100 V	1 A

Other supply voltages, nominal currents and combinations are available on request.

Accessories

A 

T4910-07 Potentiometer with Cable for External Power Factor Setting
External contact between terminals 12 (COM) and 28 (PF ON). Included.

Description

The T4900 VAR Load Sharer provides automatic load sharing of reactive power [kVAR] and voltage control for parallel running generators. The reactive load on each generator is compared with the reactive load on the other generators and corrected on the AVR (Automatic Voltage Regulator) until balance is obtained. The T4900 can also be used for power factor (PF) control in applications where one or more generators are operated in parallel with the grid (utility). The input to the T4900 are the voltage and the current from which the reactive power and voltage is determined. The T4900 calculates I x sin φ, representing the reactive load.

Power factor control for parallel operation with the public grid can be obtained by connecting an external contact between terminals 12 (COM) and 28 (PF ON). The setting is determined by an external potentiometer (100 kW) across terminals 29 and 30 (PF-SET).

Features & Benefits

FEATURES	BENEFITS
Adjustable delta voltage, stability and % VAR load deviation by front panel potentiometers	Facilitates adjustment during installation and commissioning. VAR Load deviation adjustment enables paralleling of differenst size generators
Inputs for disabling internal voltage control	Enables operation where system voltage is set externally such as in grid-parallel operation
Power factor control function	Enabling alternative use as power factor controller, thus maintaining fixed power factor (cos phi) in installations with fluctuating inductive loads
Visual indication of voltage, increase/decrease and unload signals	Provides quick and concise status information
Direct line-line voltage supply (up to 690 Vac)	Simplifies design and installation. No need for PTs or separate power supply
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN-rail or screw mount	Easy installation

Specifications

Max. Voltage	660 V
Voltage Range	110%
Voltage Dev. Adjustment	0- ±12 V
Consumption	Voltage 4 VA at U_N Current 0.4VA at I_N
Continuous Current	2 x I_N
Frequency Range	35-70 Hz
Proportional Band	±25-125% load
Dead Band Zone	±1-10% load
Contact Rating	AC: 400 V, 2 A, 250 VA; DC: 110 V, 2 A, 100 W
Operating Temperature	–20°C to +70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate, flame retardant
Weight	0.7 kg
Dimensions	**H** 70 mm (2.7"); **W** 150 mm (5.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

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T5000 SERIES

Paralleling Relay

CE

Description

The T5000 Paralleling Relay is a check synchronizer, inhibiting closure of circuit breaker if synchronizing parameters such as voltage, frequency and phase angle are outside limits, thus preventing generator damage and disturbance to the busbar.

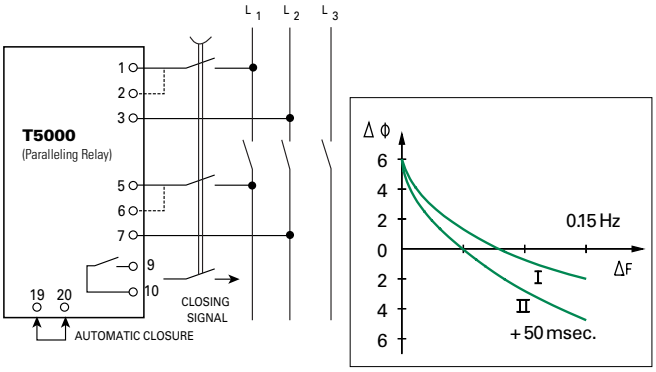
The T5000 can also be used as synchronizing aid for manual or automatic synchronization where voltage and frequency are adjusted by the operator to roughly the values required, and the unit will provide a closing signal to the circuit breaker at phase accordance.

Automatic closure
In order to use the T5000 with automatic closure, terminals 19 and 20 should be interconnected, and the T5000 will now operate as illustrated in graph at left.

Line I shows the closing signal directly from the T5000.

Line II shows the main contact closure with an additional circuit breaker operation time of 50 msec.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Visual indication of voltage and closing signal	Provides quick and concise status information
Adjustable combined setting, %U, of synchronizing window (delta frequency, delta voltage, delta phase)	Facilitates adjustment during installation and commissioning
Automatic closure function	Enables use with fast reacting circuit breakers
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
DIN rail or screw-mount	Easy installation
N-G continuity alarm	Monitors neutral-to-ground integrity and alarms if ground path becomes open circuit
Passive filtering	Eliminates nuisance tripping

Ordering Information

ORDERING NUMBER	TERMINALS 1-1 5-7	TERMINALS 1-3 6-7	FUNCTION
T5000.0010	450 V	400 V	
T5000.0020	230 V		
T5000.0030	480 V	415 V	
T5000.0040	110 V	100 V	
T5000.0050	127 V	120 V	
T5000.0060	480 V	415 V	Δϕ=9-13.5°, ΔF=0.2-0.3 Hz
T5000.0070	450 V	400 V	ΔU=15-20%, Δϕ=9-13.5°, ΔF=0.2-0.3 Hz
T5000.0080	110 V	100 V	ΔU=15-20%, Δϕ=9-13.5°, ΔF=0.2-0.3n Hz
T5000.0090	450 V	400 V	Δϕ=9-13.5°, ΔF=0.2-0.3 Hz
T5000.0100	660 V		

Other supply voltages, nominal currents and combinations are available on request.

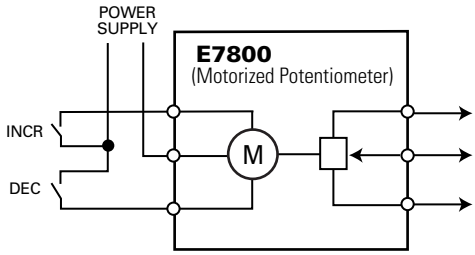
Specifications

Max. Voltage	660 V
Voltage Range	70-110%
Consumption	2 x 5 VA max.
Frequency Range	45-65 Hz
Voltage Difference	10-15% } Combined setting
Frequency Difference	0.15 - 0.225 Hz
Phase Difference	6-9°
Contact rating	AC: 400 V, 5 A, 1250 VA; DC: 150 V, 5 A, 120 W
Operating Temperature	–20°C to +70°C
Dielectric Test	2500 V, 50 Hz
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate, flame retardant
Weight	0.7 kg
Dimensions	**H** 70 mm (2.7"); **W** 100 mm (3.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm (3/16") screws

E7800 SERIES

Motorized Potentiometer

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	VOLTAGE	RPM	POTENTIOMETER
E7800.00.xx	230 V-240 Vac	1.0 (50 Hz)	5 kΩ-1 turn
E7800.01.xx	220 V-240 Vac	2.0 (50 Hz)	5 kΩ-10 turn
E7800.02.xx	100 V-110 Vac	1.0 (50 Hz)	5 kΩ-1 turn
E7800.03.xx	24 Vac	2.0 (50 Hz)	5 kΩ-10 turn
E7800.04.xx	100 V-110 Vac	2.0 (50 Hz)	5 kΩ-10 turn
E7800.05.xx	220 V-240 Vac	2.0 (50 Hz)	5 kΩ-1 turn
E7800.09.xx	24 Vac	1.0 (50 Hz)	5 kΩ-1 turn
E7800.23.xx	24 Vdc	0.8-6 Adj.	5 kΩ-1 turn
E7800.24.xx	24 Vdc	0.8-6 Adj.	5 kΩ-10 turn
E7800.90.00	24 Vdc	0.8-6 Adj.	DC output voltage, 0-1.0 V (0-100%)

The E7800 cannot be used for both AC and DC. The unit must be specified to order. Other voltages and combinations are available on request.

Indicate potentiometer value by replacing "xx" with digits per this table.

INDEX "XX"	POTENTIOMETER VALUE
00	5 kΩ (standard)
01	100 Ω
02	200 Ω
03	500 Ω

INDEX "XX"	POTENTIOMETER VALUE
04	1 kΩ
05	2 kΩ
06	10 kΩ

Description

The E7800 Motorized Potentiometer is typically used as an interface between increase/decrease contacts and a device requiring control/adjustments by an external potentiometer.

In generator control applications, the E7800 can be used as speed trim of an electronic speed governor, interfacing the synchronizer or the load sharer. It can also be used alone for manual speed adjustment or speed trim of electronic governors, or for remote control of generator voltage, power factor and reactive load (E7800 connected to Automatic Voltage Regulator (AVR)).

Features & Benefits

FEATURES	BENEFITS
Wire-wound potentiometer	Longer life expectation than carbon potentiometers
Friction clutch	Motor can turn potentiometer against end position continuously, without damaging it
Resistance from 100 Ω to 10 kΩ	Wide range of potentiometers suitable for any governor or AVR
24 V DC version with Adjustable RPM	Simple fine tuning possibility in regulation applications
Built-in dust seal	Long life expectation

Specifications

Voltage range AC: 90-120%
DC: 75-125%
Consumption AC: 2.5 VA
DC: 2 W
Operating Temperature –15° C to +70° C
EMC CE according to
EN50081-1
EN50082-1
EN50081-2
EN50082-2
Approvals CSA, UL component recognition
Burn-in 50 hours before final test
Weight 0.35 kg
Dimensions **H** 96 mm (3.8"); **W** 96 mm (3.8"); **D** 80 mm (3.1")
Panel cut out **H** 92 mm (3.6"); **W** 92 mm (3.6")

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T7900 SERIES

Electronic Potentiometer

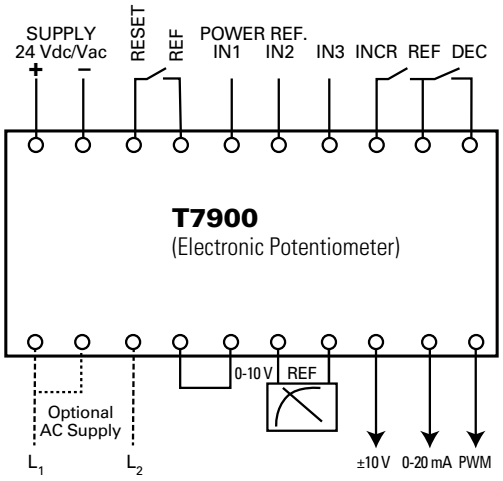
CE

Description

The T7900 Electronic Potentiometer is used as converter between pulse contacts and a device requiring control adjustment by a voltage or current signal, such as an electronic speed controller. The T7900 acts in a similar manner to a motorized potentiometer, except that the outputs are a voltage, a current or a pulse width modulated signal (PWM), while the motorized potentiometer has a variable resistor output.

In generator control applications, the T7900 can be used together with a Synchronizer and a Load Sharer. The T7900 converts the increase and decrease pulses of these modules into a suitable analog voltage, current or PWM signal. This analog output signal can be used as a control input to the electronic speed controller.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Wide selection of output ranges including PWM	Ensures possible use with a broad variety of speed governors and voltage regulators
Independent ramp-up & ramp-down time setting	Provides optimum controlabilty of speed governors and voltage regulators regardless of generator size
Power reference function	Enables alternative use as power reference unit providing generator load set point in grid parallel installations
Available with Vac supply	Enables direct supply from installation
Visual indication of increase/decrease signals	Provides quick and concise status information
DIN-rail or screw-mount & adjustment by potentiometers	Easy installation

Ordering Information

ORDERING NUMBER	TERMINALS	
	11-12	1-3
T7900.0010	24 Vdc/Vac	
T7900.0030		250 Vac

Specifications

Supply	8-36 Vdc/Vac
Consumption	Max. 120 mA at 24 Vdc
Output Ranges	–10 V-+10 V (or any part of this, e.g. 0 V-+1 V) 0-20 mA (or any part this, e.g. 4 mA-20 mA) 0-100% PWM 500 Hz (or any part of this e.g. 10-90%) 0-100% PWM 2.94 MHz (or any part of this e.g. 10%- 90%)
PWM Output Signal	Frequency: 500 Hz of 2,94 KHz. Level: 0-10 V Default reference: 50%
Operating Temperature	–20°C to +70°C
EMC	EN50263
Burn-in	50 hours before final test
Enclosure Material	Polycarbonate. Flame retardant
Weight	0.3 kg for T7900-00, 0.5 kg for other types
Dimensions	**H** 70 mm (2.7"); **W** 100 mm (3.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm ($^3/_{16}$") screws

M8100 SERIES

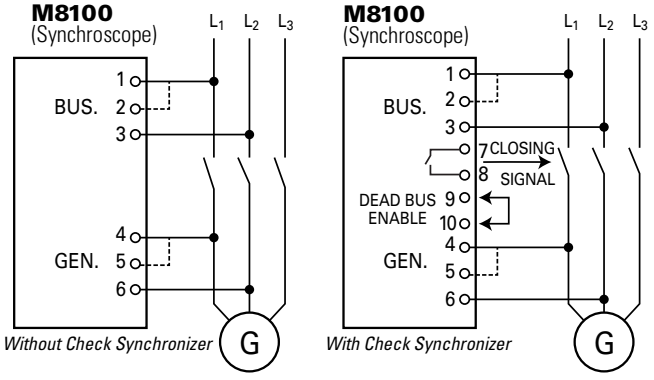
Synchroscope

Description

The M8100 Synchroscope provides illuminated indication of the phase and frequency difference between voltages on two separate AC systems, e.g. a generator and a busbar. The M8100 will also indicate whether or not the two systems are on voltage.

The M8100 is also available in a version with a built-in relay for automatic closure of the circuit breaker (Synchro Check Relay). The voltage and frequency are adjusted by the operator to roughly match the values required, and the unit will provide a closing signal to the circuit breaker at phase accordance.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
High resolution visual indication by 38 LEDs	Phase and frequency difference; Bus and generator voltage and phase accordance. Provides quick, concise status information; steady viewing of the synchronization process.
Available with check synchronizer relay	Enables use as manual synchronizing unit, or as auto-synchronizer back-up
Versions available with dead bus closure	Enables use as dead bus monitor in back-up power installation
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation including spikes
Sturdy casing for flush-mount installation, Q96 standard, with protection class IP52 on the front	Easy installation, allowing use in harsh environments

Ordering Information

ORDERING NUMBER	TERMINALS 1-1 5-7	TERMINALS 1-3 6-7	FUNCTION
M8100.0010	450 V	400 V	
M8100.0020	230 V		
M8100.0030	480 V	415 V	
M8100.0040	110 V	100 V	
M8100.0050	450 V	400 V	With check synchronizer relay
M8100.0060	230 V		With check synchronizer relay
M8100.0070	480 V	415 V	With check synchronizer relay
M8100.0080	110 V	100 V	With check synchronizer relay

Other voltages are available on request.

Specifications

Max. Voltage	660 V
Voltage Range	70-110%
Consumption	2 x 3 VA max.
Frequency Range	35-70 Hz
Pull-in/Drop-out Diff. Frequency	±9 Hz
Operating Temperature	–20°C to +70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Enclosure Material	Flame retardant
Weight	0.7 kg
Dimensions	**H** 96 mm (3.8"); **W** 96 mm (3.8"); **D** 80 mm (3.1")
Panel Cut-out	**H** 92 mm (3.6"); **W** 92 mm (3.6")

Unit with check synchronizer relay

Voltage Difference	10-20%	Combined setting
Frequency Difference	0.15-0.3 Hz	
Phase Difference	6-12°	
Dead-bus Delay	1s-5s	
Dead-bus Voltage Offset	20%-40%	
Min. Generator Voltage for DB Closure	80% of nominal voltage	
Contact Rating	AC: 250 V, 1.2 V, 125 VA; DC: 30 V, 1 A, 30 W	

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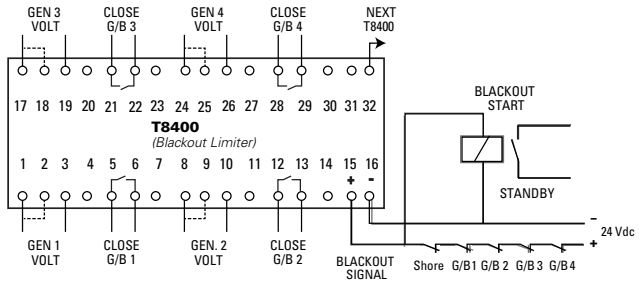
T8400 SERIES

Blackout Limiter

CE

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	TERMINALS 1-3 17-19 8-10 24-26	FUNCTION
T8400.0010	400 V	1-1.5-2-2.5 sec.
T8400.0020	400 V	3-3.5-4-4.5 sec.
T8400.0030	230 V	1-1.5-2-2.5 sec.
T8400.0040	230 V	3-3.5-4-4.5 sec.
T8400.0050	415 V	1-1.5-2-2.5 sec.
T8400.0060	415 V	3-3.5-4-4.5 sec.

Other supply voltages are available on request.

Description

The T8400 Blackout Limiter enables fast clearing of a blackout. It is possible to monitor up to 4 generators with 1 unit and maximum 8 generators with 2 units. If a blackout occurs, the first generator to have more than 90% voltage will close the generator breaker.

Function:
When a 24 Vdc signal is supplied over terminals 15 and 16, the T8400 becomes active, indicating that a blackout occurred. All generators are now checked and the first generator to have more than 90% voltage will close the contact to the generator breaker. If generator 1 is the first generator to have more than 90%, this will happen after 1 sec. If generator 2 is the first generator on voltage it will happen after 1.5 sec. If generator 3 is the first one, it will happen after 2 sec. etc. By adding a second unit with time delays 3, 3.5, 4, 4.5 sec., 8 generators can be handled. When one of the generators has been switched on, the blackout signal of 24 Vdc should be switched off.

Features & Benefits

FEATURES	BENEFITS
Monitors up to 4 generators; 8 generators by interconnecting 2 units	Economic solution. Only 1 or 2 units for monitoring installations with several generators. Occupying less space in the switch panel
Independent 24 Vdc supply with wide tolerance	Safe operation. Operates regardless of system voltage failure
Galvanic isolated inputs	Protects the unit against high AC voltage and currents from the installation, including spikes
DIN-rail or screw-mount	Easy installation

Specifications

Supply Voltage	24 Vdc 30%
Max. Generator Voltage	660 Vac
Frequency Range	35-70 Hz
Contact Rating	AC: 250 V, 2 A, 250 VA DC: 60 V, 2A, 100 W
Operating Temperature	–20°C to +70°C
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Burn-in	50 hours before final test
Weight	0.5 kg
Dimensions	**H** 70 mm (2.7"); **W** 150 mm (5.9"); **D** 115 mm (4.5")
Installation	35 mm DIN rail or 4 mm ($^{3}/_{16}$") screws

C6200 FLEXGEN SERIES

Generator Control

Description

FlexGen controllers are intended for paralleling of generators with each other or with the grid. One FlexGen controller is installed for each generator in the installation and handles all electrical control.

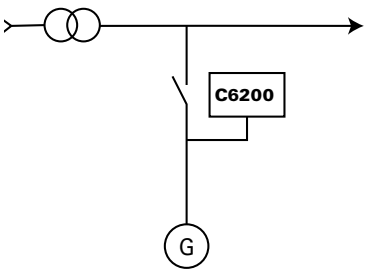
There are two versions available, Basic and Advanced.

Both versions include basic functions such as autosynchronizing, frequency control, active load sharing, dead bus monitoring and reverse power protection. In addition the FlexGen Advanced contains reactive load sharing, voltage matching, power factor control, grid-parallel operation control, and protection against excitation loss, RoCoF (df/dt), and vector shift. FlexGen Advanced also contains over-current and short-circuit protection and power management features like preferential load trip, load depending start/stop and large consumer control.

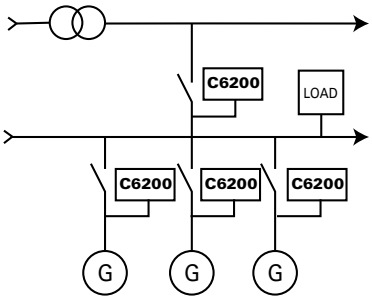
Both models include MODBUS RTU interface enabling integration with equipment from other manufacturers, for example, control and monitoring from PC with a graphic SCADA interface. FlexGen is type-approved by major marine classification societies and can be used for marine power management systems.

Simplified Circuit Diagram

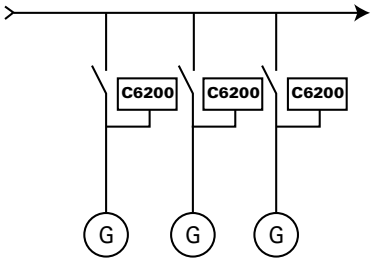
Grid Parallel



Grid Parallel with Local Bus



Island Mode



Ordering Information

ORDERING NUMBER	MODEL NAME
C6200.0060	FlexGen Basic
C6200.0100	FlexGen Advanced

ACCESSORIES	REQUIREMENT	PAGE
C6500	Recommended	See above

Accessories

C6500 FlexGen UI User Interface Module
Provides indication of measurements, alarms, alarm log and configuration of the generator module.

The user interface is designed for mounting in the switch panel door. It furnishes a large back-lit display showing all electrical measurements and control parameters.

- User interface unit for any FlexGen controller
- Separate LEDs provide clear indication
- Valuable alarm log
- Onsite configuration capability
- Connects through the RS232 serial link

FlexGen Technical Data

FEATURES	BASIC	ADVANCED
3-phase true RMS measurement	●	●
Frequency control	●	●
Automatic synchronization	●	●
Active load sharing	●	●
Voltage control/Voltage matching		●
Reactive load sharing		●
Reverse power protection	●	●
Excitation loss protection		●
RoCoF protection (df/dt)		●
Vector shift protection		●
Overcurrent (I >) and Overload protection (P>)		●
Short-circuit protection (I >>)		●
Overvoltage (U >)	●	●
Undervoltage (U <)	●	●
Overfrequency (F >)	●	●
Underfrequency (F <)	●	●
Dead bus monitoring /Black-out limiter	●	●
External circuit-breaker trip		●
Engine error trip		●
Preferential load trip (PM)		●
Load depending start/stop (PM)		●
Large consumer control (PM)		●
Dynamic grid-parallel operation control		●
Analog I/O		●
MODBUS RTU (RS485 interface)	●	●

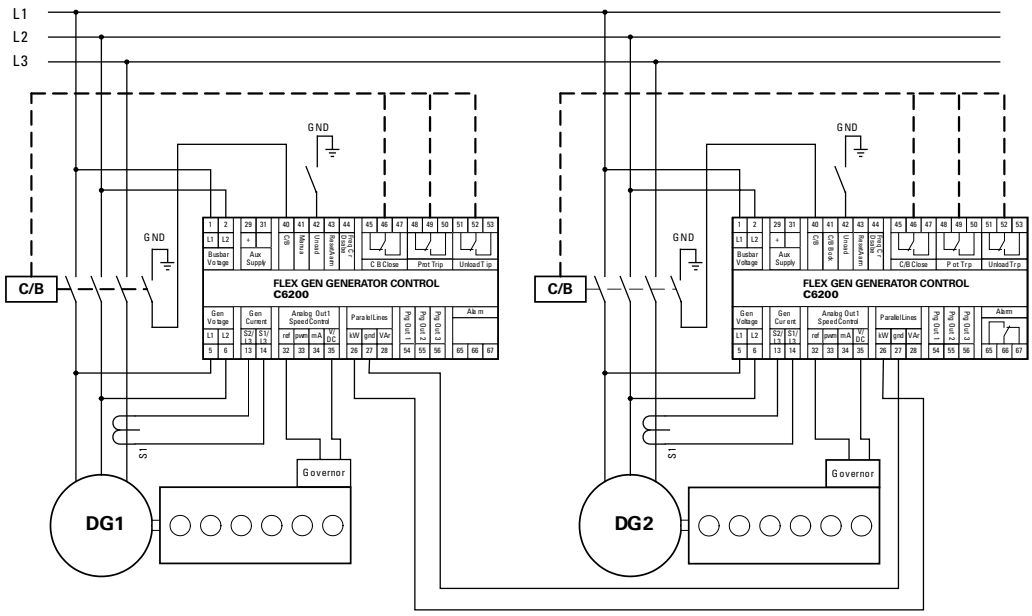
Features & Benefits

FEATURES	BENEFITS
3-phase true RMS measurement	Reliable measurement, high noise immunity
Analog outputs for speed and voltage control	Fits most electronic governors and ECUs
PWM outputs for speed and voltage control	Compatible with e.g. CAT and Woodward
Pulse outputs for speed and voltage control	Compatible with conventional governors, motorized potentiometers and some ECUs
10 programmable Inputs and outputs	Flexible configuration for a wide range of applications such as marine PMS, on site power or grid parallel applications
Type-approved by marine classification societies	Approved for marine power management

Specifications

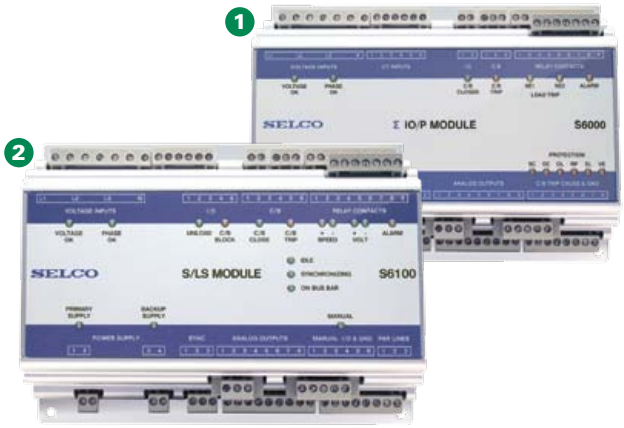
Auxiliary Supply	10 Vdc to 36 Vdc (24 Vdc-58%/+50%)
Generator Voltage	63 V-690 V
Generator Rated Frequency	50 Hz/60 Hz
C/T Secondary Current	5 A
Consumption	7 W
Burden C/T Input	0.4 VA at I_N
Ambient Temp Range	–20°C to +70°C
Vibration	IEC 60068-2-6
Humidity	IEC 60068-2-30
EMC	IEC 61000-4-3:2006, IEC 61000-4-6:2004, IEC 61000-4-5:2005, IACS E10:2006 Test No.15, CISPR 16-1:1999, CISPR 16-2:2002
Relay Contacts	230 Vac/2 A & 30 Vdc/2 A
External Communication	MODBUS RTU
Enclosure	IP20
Weight	1,5 Kg
Dimensions	**H** 182 mm (7.2"); **W** 282 mm (11.1"); **D** 50 mm (2.0")

Wiring Diagram



SIGMA SERIES

Generator Control and Protection System



Description

The SIGMA Generator Control and Protection System is a range of integrated modules for protection and control of marine and land based generators. The modules are marine approved and include all relevant functions, such as protection of generators, synchronizing and active/ reactive load sharing and Power Management.

1 IO/P Module S6000

Input/ Output and Protection Module

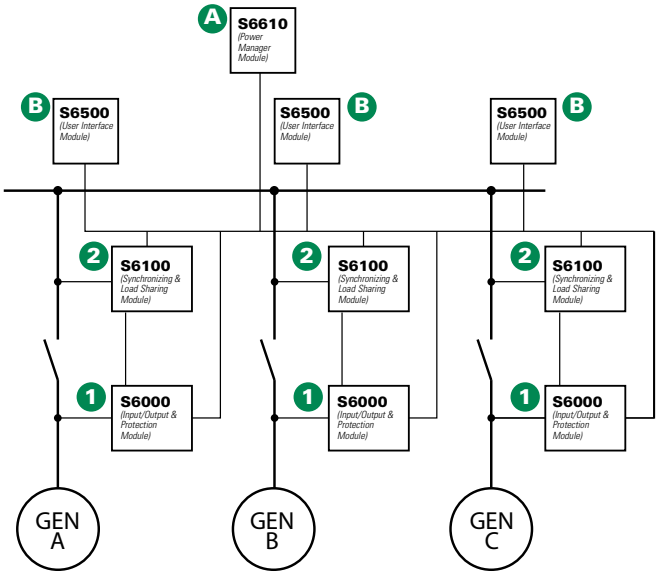
The SIGMA S6000 performs all measurements on the generator side (voltages, currents, frequency), does the generator protection, includes a non-essential load trip in two steps and includes three measurement transducers.

2 S/LS Module S6100

Synchronizing and Load-Sharing Module

This module performs the control functions like synchronizing and active and reactive load sharing. It performs the measurements on the busbar side.

Simplified Circuit Diagram



Accessories

A

S6610 Power Manager Module
Controls the number of generators that are supplying to the bus. It will issue start and stop signals to the generators depending on power requirement. There are 10 inputs for large consumer requests.

B

S6500 User Interface Module
This unit is optional, as the S6000/S6100 also can be programmed from a PC. It is possible to use one or more units per installation.

Ordering Information

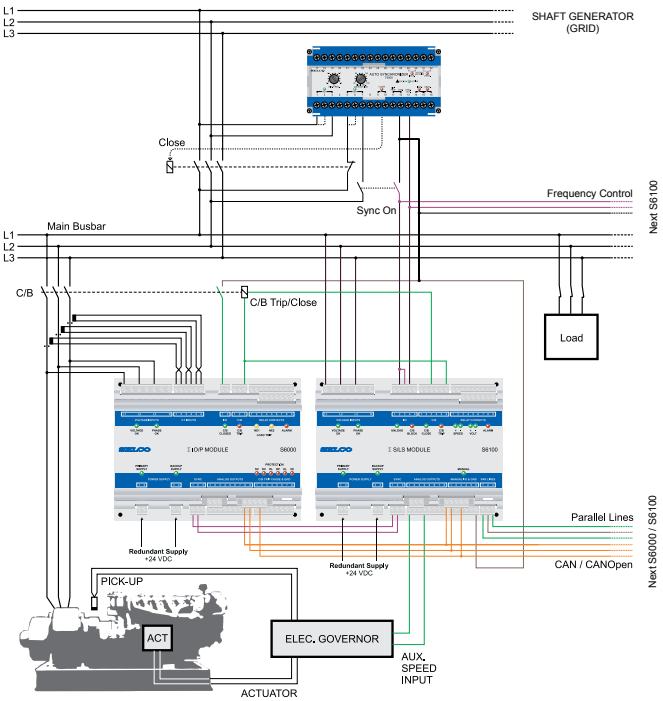
ORDERING NUMBER	DESCRIPTION
S6000.0010	Input/ Output and Protection Module– 5 A C/T
S6000.0020	Input/ Output and Protection Module– 1 A C/T
S6100.0010	Synchronization and Load Sharing Module

ACCESSORIES	REQUIREMENT	PAGE
S6500.0010	Optional	See above
S6610.0010	Optional	See above

SIGMA Technical Data

FEATURES	SIGMA S6000	S/LS MODULE S6100	PM MODULE S6610	UI MODULE S6500
Reverse power protection	●			
Overcurrent trip	●			
Short-circuit trip	●			
Power trip	●			
Excitation loss relay trip	●			
Over/ Undervoltage trip	●			
Nonessential load trip in 2 steps	●			
RS485/ Modbus RTU (RS485)	●			
Synchronizer		●		
Load sharer		●		
VAR load sharer		●		
Indication of measurements			●	●
Programming of the S6000 and S6100 modules			●	●
Load depending start and stop of generators			●	
Large consumer request			●	
Large consumer inhibit			●	

Wiring Diagram



Features & Benefits

FEATURES	BENEFITS
3-phase true RMS measurement	Reliable measurement, high noise immunity
Analog outputs for speed and voltage control	Fits most electronic governors and ECUs
PWM outputs for speed and voltage control	Compatible with e.g. CAT and Woodward
Pulse outputs for speed and voltage control	Compatible with conventional governors, motorized potentiometers and some ECUs
Large consumer request inputs with load feed back	Optimizes quantity of running generators and saves fuel
Type-approved by marine classification societies	Pre-configured Marine Power Management System

Specifications (S6000)

Primary Supply		+24 Vdc (-30%/+30 %) Isolated, 500 mA
Backup Supply		+24 Vdc (-30%/+30 %) Isolated, 500 mA
Environmental Temp Range		–15°C to +70°C
Gen. Phase-Phase Voltage (GPPV)		63.0-690.0 Vac (-2 %/+2 %) 3-phased
Gen. Indicated Voltage (GIV)		63-32 kV AC
CT Secondary Current (CTSC)		1 A or 5 A (consumption 25 mW or 125 mW) 3-phased
Gen. Rated Frequency (GRF)		40.0-500.0 Hz
Gen. Maximum Current (GMC)		0.5-3,000.0 A / 500-30,000 A
Protection Functions		
C/B Trip Relay	Contact rating:	AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc
NE1 Trip Relay	Contact rating:	AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc
NE2 Trip Relay	Contact rating:	AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc
Alarm Relay	Contact rating:	AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc
CAN Bus	Connection:	Screw terminals,2-wire with COM (limp back function)
	Protocol:	CANopen derivative
RS232	Connection:	Customized plug, 4-wire (non-isolated)
	Function:	Configuration, Debugging or firmware update
	Protocol:	ANSI terminal
RS485	Connection:	Screw terminals, 2-wire (isolated)
	Protocol:	MODBUS-RTU
EMC		EN 50081-2:1993, EN 50263: 1999
Marine Tests		EN 60945:1997, IACS E10:1997
Connections		Plug-in screw terminals (spring terminals available as option)
Mounting		Screw mounting (4 pcs. 4.2 x 12 mm)
Weight		1,150 g
Dimensions		**H** 145 mm (5.7”) **W** 190 mm (7.5”) **D** 64.5 mm (2.5”)

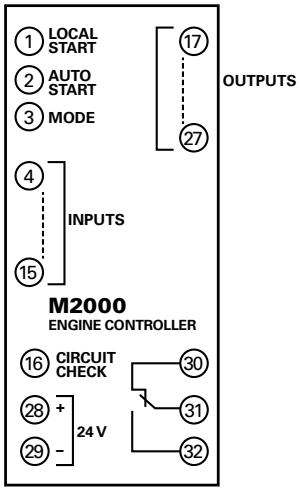
ENGINE CONTROL

For More Information...
and to download our
Engine Control Brochure, visit
www.littelfuse.com/enginecontrol

M2000 SERIES

Engine Control

Wiring Diagram



Accessories

M0500 Tacho Detector
Reads engine speed from frequency of the generator output voltage. The reading is converted to a square wave signal and this signal is provided on a dedicated output.

K3452 RS232 Cable
For configuration from PC.

Ordering Information

ORDERING NUMBER	CONTROL POWER
M2000.0130	12 V–24 Vdc, IP54 at front.

ACCESSORIES	REQUIREMENT	PAGE
M0500	Optional	121
K3452	Optional	121

Description

The M2000 Engine Control controls start and stop of the engine, monitors and protects the engine during start and operation, and simultaneously indicates the engine and alarm status on the front of the unit. It has 9 shutdown/alarm inputs. It is controlling the cranking, fuel valve and stop solenoid of the engine. It is possible to configure the unit to perform up to 6 start attempts, with user configurable crank and rest periods. When the engine fires, cranking will be disconnected by activating the crank disconnect input from a tacho relay or from a direct measurement from a magnetic pick up. When stopping the engine, a generator circuit breaker trip is available for genset applications. A stop delay can be configured for cooling down the engine before stop. M2000 includes cable check of all sensor inputs. Basic configuration can be set by dip-switches on the rear of the unit.

Extended configuration is possible using a PC. Easy installation is ensured by means of clamping fittings, and plug-in connection terminals. The M2000 includes an RS485 interface enabling MODBUS RTU communication. The M2000 has been designed and tested for use in harsh environments.

Features & Benefits

FEATURES	BENEFITS
8 Alarm/shutdown inputs	Monitoring of e.g. oil pressure, coolant temperature and engine speed
Cable monitoring on sensor inputs	Fail safe system
Speed detection from magnetic pick-up	No tacho relay required
Type-approved by marine classification societies	Applicable in marine control and alarm systems
RS485 Modbus RTU	Communication with HMI and SCADA systems

Specifications

Voltage Supply	12-24 Vdc±30% (8-32 Vdc)
Consumption	Max. 180 mA
Inputs	7 normally open contacts; 1 tacho voltage;1 pick-up
Tacho Input	Square or sine wave between 0 Vdc and supply voltage
Pick-up Input	Square or sine wave, range 2.5 Vac to 33 Vac
Tolerance, Freq. Meas.	±2%
Frequency Range	50 Hz to 10 kHz
Outputs	11 open collector outputs, max. 150 mA per channel
Siren Relay Contact	230 Vac/2 A; 30 Vdc/2 A, 30 W
Tolerance, Delays	± 2%
LED Flash Frequency	Slow flashing light: 1.25 Hz ±10%
Quick Flashing Light	5 Hz ±10%
Programming	16 dip-switches or via RS232 interface
Communication	RS485 interface
Protocol	MODBUS-RTU
Baud Rate	1200, 2400, 4800, 9600
Parity	None
Data Bits	8
Stop Bits	1
Operating Temp.	–20°C to +70°C
Humidity	95% RH at 20°C
Vibration Test	4 g RMS according to IEC 60068-2-64
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Weight	0.4 kg
Dimensions	**H** 144 mm (5.7"); **W** 144 mm (5.7"); **D** 35 mm (1.4")
Panel Cut-out	**H** 138 mm (5.4"); **W** 138 mm (5.4")
Protection Degree-Front	IP54 or IP32 (see Type Description)

M0600 SERIES

Shutdown Unit

Description

The M0600 Shutdown Unit is a back-up protection device designed for marine engines. It is ensuring safety shutdown of the engine in case normal primary shutdown fails. The unit works as a stand-alone protection unit, and is for DIN-rail mounting. Alternatively it can be mounted directly on the back of the M2000 Engine Controller.

Together with Engine controller units M2000 it can be used to build a complete control, alarm and safety system for marine engines. The unit has inputs for overspeed, low oil pressure and one more user defined parameter, which could be e.g. high water temperature. It also has an input to indicate that the engine is running and one to indicate that the engine is stopping.

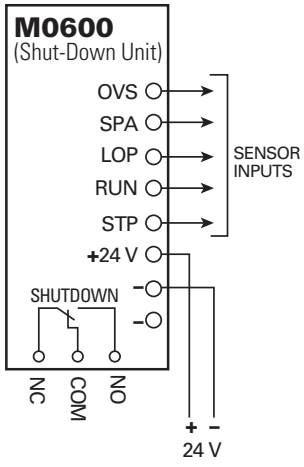
The monitoring of low oil pressure is only active when the engine is running with a few seconds delay after detection of the running signal. This time delay can be defined via programming switches. A normally open (NO) output relay can give a closing signal which can be used to stop the engine via it's stop coil, and a normally closed (NC) relay can open in order to stop the engine via the fuel valve. The length of the relay activation time can be defined via programming switches.

The M0600 is type approved by major marine classification societies.

Input terminals

1. OVS	Overspeed
2. SPA	Spare
3. LOP	Low Oil Pressure
4. RUN	Running (Crank Disconnect)
5. STP	Stop (Engine Stop)
6. + 24 V	Supply Voltage (+)
7. –	Supply Voltage (-)
8. –	Supply Voltage (-)

Simplified Circuit Diagram



Ordering Information

ORDERING NUMBER	DELAY FOR SPA	DELAY FOR LOP
M0600.0010	100 msec.	500 msec.
M0600.0020	1.5 sec.	1.5 sec.

Features & Benefits

FEATURES	BENEFITS
Stand-alone unit	Runs independantly, as a back-up for the M2000
Combines with M2000	Provides complete redundancy
Mountable on rear of M2000	Flexibility of use; Also DIN-rail mountable

M2500 SERIES

Engine Control & Monitoring Unit

CE

Features & Benefits

FEATURES	BENEFITS
9 digital alarm/shut-down inputs	Monitoring of e.g. oil pressure, coolant temperature and engine speed
8 Analog measurement inputs	Monitoring and indication of analog measurements
Cable monitoring on sensor inputs	Fail safe system
Cable monitoring on solenoid outputs	Fail safe system, no need of separate cable monitoring module
Large graphical display	Easy overview of engine condition and operation
SD card	Storage of copies of log and configuration files, programmable from SD card
Type-approved by marine classification societies	Applicable in marine control and alarm systems
USB mass-storage device	Easy access to log and configuration files. Programming software installed on the module.
RS485 Modbus RTU	Communication with HMI and SCADA systems

Accessories

M2600 Shutdown Unit
Safety shutdown device for protection of marine engines. Speed detection from magnetic pickup or digital input.

K2502 SD card
Included with the M2500.

K1025 USB A to B cable

Ordering Information

ORDERING NUMBER	CONTROL POWER
M2500.0010	12-24 Vdc

ACCESSORIES	REQUIREMENT	PAGE
M2600.0010	Optional	121
K2502	Included	121
K1025	Optional	121

Description

The M2500 is designed for control and monitoring of engines in marine applications such as auxiliary generators, emergency generators and propulsion engines. The unit allows manual (local) and remote (automatic) start of the engine and will monitor all engine parameters.

Engine parameters can be monitored via digital and analog sensor inputs. Cable monitoring is available on all sensor inputs. Twelve programmable output relays are available for configuration of common warnings, alarms or shutdowns. Additionally there are pre-defined outputs for common alarms, shutdowns and status indications. The LED display provides an easy overview on the engine status. The front label next to the LEDs is an exchangeable paper label, thus the text can be in any language. A large graphical display provides indication of measurements, alarms, shutdowns and an event log.

Communication with the engine ECU is possible via SAE CAN J1939. RS485 MODBUS is available for communication with external equipment such as alarm systems or PLCs. Easy and user friendly configuration of the unit by the front panel or remotely by PC/ USB interface. The configuration is pin code protected. The unit includes an SD card slot for downloading or uploading the configuration via an SD card. A copy of the engine log is automatically saved on the SD card. The M2500 unit carries the CE label and has been approved by the major marine classification societies. Together with the optional M2600 Shutdown Unit, M2500 can form a complete engine control, alarm and safety system.

Specifications

Operating Temp. –15°C to +70°C
Humidity 95%
Vibration DNV vibrations class B
EMC IEC 60945
Enclosure IP44 (panel front only)
Primary Supply +24 Vdc (-30 %/+30 %)
Backup Supply +24 Vdc (-30 %/+30 %)

All Relays except where otherwise specified
Relay Response Time 20 ms (worst case)
Contact Set(s) 1 normally open
Contact Rating AC: 1 A, 250 Vac; DC: 1 A, 35 Vac

Run/ Stop Solenoid relay
Relay Response Time 20 ms (worst case)
Contact Set(s) 1 normally open
Contact Rating: AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc

System fault output relay (Siren)
Relay response time 20 ms (worst case)
Contact Set(s) 1 change over
Contact Rating: AC: 1 A, 250 Vac; DC: 1 A, 35 Vdc
Dimensions **H** 137 mm (6.2"); **W** 209 mm (8.2"); **D** 39 mm (1.5")

M2600 SERIES

Shutdown Unit

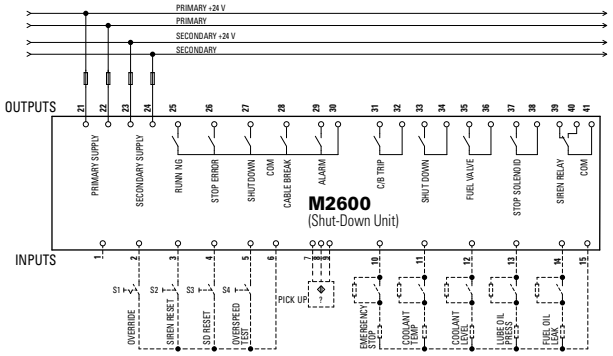
CE

Description

The M2600 Shutdown Unit is a back-up protection device designed for marine engines. It is ensuring safety shutdown of the engine in case normal primary shutdown fails. Together with Engine controller units M2000 or M2500 or other engine controllers it can be used to build a complete control, alarm and safety system for marine engines. Alternatively it can work as a standalone primary shutdown unit in applications where shutdown functionality is not included in the start/stop device of the engine. The M2600 design is based entirely on discreet logic, thus meeting requirements to safety shutdown devices from the marine classification societies.

All inputs and outputs of the M2600 have corresponding LED indication clearly showing whether they are active or not. The unit furnishes 10 digital shutdown inputs. One is pre-defined for overspeed and another for emergency stop. All inputs are dry contacts. Output relays are provided for control of the fuel valve and the stop solenoid when stopping the engine in normal conditions. Another output relay is provided for emergency shutdown. Additionally the unit provides an output for circuit breaker trip for use with gen-sets. Engine speed (rpm) can be detected from magnetic and inductive pick-ups connected to dedicated inputs. Alternatively the speed can be detected from digital inputs. M2600 provides cable monitoring on all sensor inputs and for the shutdown relay output. Configuration is made solely with the dip-switches and rotary switches on the unit.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
10 digital shutdown inputs with cable monitoring	Monitoring of e.g. oil pressure, coolant temperature and engine speed
Speed detection via magnetic or inductive pick-up	No tacho relay required
LEDs for status indication	Easy overview of engine condition and operation
Cable monitoring on fuel valve and stop solenoid output	Fail safe system, no need of separate cable monitoring module
Configuration by DIP switches	Easy installation and configuration

Ordering Information

ORDERING NUMBER	REQUIREMENT
M2600.0010	Optional

Specifications

Operating Temp. –15°C to +70°C
Humidity 95%
Vibration DNV vibrations class B
EMC IEC 60945
Enclosure IP30
Primary Supply +24 Vdc (-30 %/+30 %) <3 W
Backup Supply +24 Vdc (-30 %/+30 %) <3 W
Connection Screw terminals
Type Magnetic (2-wire), NPN and PNP (3-wire)
Rated Frequency 25.0-25,000 Hz
9 Digital Sensor Inputs Normally open contacts to COM (default) or normally closed contacts to COM. Optional cable monitoring.

All Relays except where otherwise specified
Relay Response Time 20 ms (worst case)
Contact set(s) 1 normally open
Contact rating AC: 1 A, 250 Vac; DC: 1 A, 35 Vac

Run/ Stop Solenoid relay
Relay Response Time 20 ms (worst case)
Contact Set(s) 1 normally open
Contact rating: AC: 8 A, 250 Vac; DC: 8 A, 35 Vdc

System fault output relay (Siren)
Relay response time 20 ms (worst case)
Contact set(s) 1 change over
Contact rating: AC: 1 A, 250 Vac; DC: 1 A, 35 Vdc
Dimensions **H** 157 mm (6.2"); **W** 210 mm (8.3"); **D** 52 mm (2.0")

ENGINE DIAGNOSTICS

For More Information...
and to down load our EngineEye Brochure, visit
www.littelfuse.com/engineeye

E5000 SERIES EngineEye

Cylinder Pressure Analyzer

CE

1
2

Ordering Information

ORDERING NUMBER	DESCRIPTION
E5000.1000	**EngineEye Basic** (E5000.0010 + E5100.0010)
E5000.2000	**EngineEye Advanced** (E5000.0020 + E5100.0010 + E5200.0010)
E5000.3000	**EngineEye Professional** (E5000.0030 + E5100.0010 + E5300.0010)
E5100.0010	Pressure Sensor with 1.5 m armored cable
E5200.0010	Inductive TDC Sensor+Junction Box+Extension Cable (10 m armored)
E5300.0010	Crank Angle Sensor+ Crank Angle Band + Junction Box + Extension Cable

Accessories

3 

E5250 Crank Angle Band
Separate crank angle band (2.98 m).

4 

E5220 Break-out Box
For TDC/Crank Angle Sensor.

Description

The EngineEye is a reliable and robust tool for engine diagnostics. The system consists of a handheld Cylinder Pressure Analyzer for collection of measurements, a pressure sensor, an optional Top Dead Center (TDC) sensor and an optional crank angle sensor.

1 E5000 Handheld Diagnostic Unit

The collected data is shown on the display and can be saved and analyzed with the PC software. Operation is intuitive and requires no training. The unit is menu-driven and will be recognized as a mass-storage device on a PC. The EngineEye is designed with ease-of use in mind.

2 E5100 Pressure Sensor

Due to a unique sensor technology based on a $GaPO_4$ crystal with excellent linearity and extremely low thermal drift, the new system allows for long term pressure readings. The sensor may be left measuring on the open indicator cock for hours.

E5200 TDC Sensor

Detection of top dead center for TDC correction.

3 E5300 Crank Angle Sensor

The crank angle can be measured with a special crank angle sensor-belt with high resolution. The unique design is easy to cut and adapt and thus applicable for all shaft diameters. The crank angle sensor belt installation can easily be made by ships' crew themselves, reducing installation costs.

3 

With the EngineEye, operators can:

- Work safely due to insulated grip
- Tune and balance the engine during operation
- Work with intuitive software on large display—even with gloves
- Run the engine with optimal settings of the operation parameters
- Analyze software data (incl. TDC & ISO correction) and e-mail readings to the head office
- Easily install the advanced sensor-belt on all shaft diameters
- Expect reduced costs for maintenance

Technical Data

FEATURES	BASIC E5000 & E5100	ADVANCED E5000, E5100 & E5200	PROFESSIONAL E5000, E5100, E5200 & 5300
USB	●	●	●
Color LCD	●	●	●
PC software included	●	●	●
Upgradable	●	●	●
Temperature compensation	●	●	●
Calibration-check integration	●	●	●
Connecting sensor ports	1	2	5
Pressure graph	●	●	●
MIP mode		*	●
Misfire analysis		●	●
p^{max}		●	●
p/time	●	●	●
p^{max} bar graph		●	●
p/alpha		*	●
dp/alpha		*	●
p/V		*	●
Pressure sensor	●	●	●
Crank-angle sensor			●
Maximum engines (memory)	5	10	20
Maximum cylinders/engine (memory)	20	20	20
Maximum number of strokes (memory)	30	30	30

*Possible with a crank angle sensor E5300.

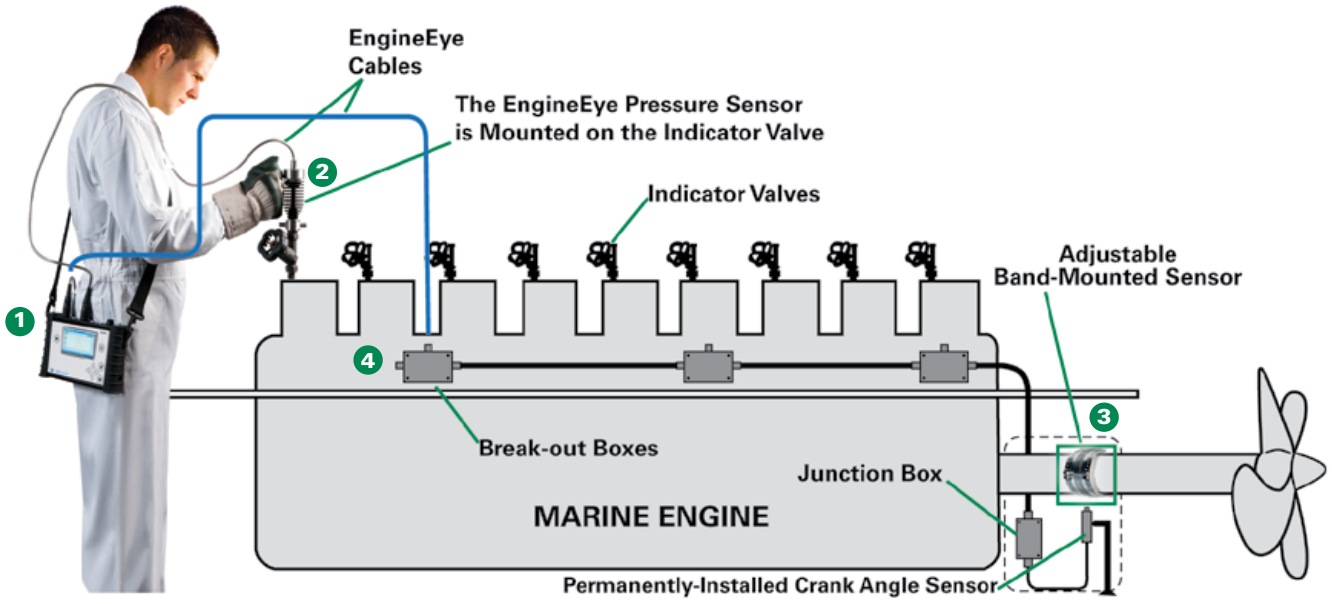
Features & Benefits

FEATURES	BENEFITS
High-temperature resistant pressure sensor	Possibility of prolonged measurements without overheating
Sensor belt for crank angle measurement	Easy installation even in case of retrofit
Large LCD display on handheld unit	Operation is intuitive and requires no training
USB mass-storage device	Very simple download of engine measurements from handheld device to the PC software
Automatic sensor recognition on handheld device	After connection of sensors the handheld devices detects the sensor type automatically without any manual configuration.
Crank-angle sensor	TDC and ISO correction in PC software

Specifications

Pressure Range 0-250 Bar
Pressure Accuracy 1%
Temperature Range –50 to +350˚ C
Sensor Technology $GaPO_4$
Speed Range 30-2000 RPM
Weight (E5000) 1.4 Kg
Dimensions (E5000) **H** 150 mm (5.9")
W 260 mm (10.2")
D 55 mm (2.2")

Usage Diagram



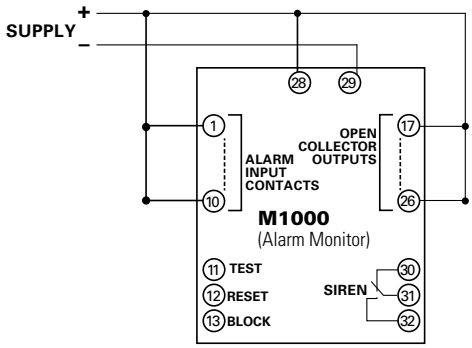
ALARM MONITORING

For More Information...
or to download our Process Alarm Solutions Brochure, visit
www.littelfuse.com/alarmmonitoring

M1000 SERIES

Alarm Monitor

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
10 configurable digital inputs	Supports both NO and NC input contacts
11 open collector outputs	Allows external control and remote indication
1 siren relay output	Direct connection of alarm siren
Special indication of first alarm	Provides clear alarm overview in larger systems
Multiple units can be connected as one system	Modular and scalable solution
Voltage and insulation monitoring	Replaces voltage and insulation monitoring relay on the DC system
Dimming of LEDs	Suitable for bridge consoles
Type-approved by marine classification societies	Applicable in harsh environments
Configuration by DIP switches or PC	Easy installation and configuration
RS485 Modbus RTU	Communication with HMI and SCADA systems

Ordering Information

ORDERING NUMBER	CONTROL POWER	FUNCTION
M1000.0040	48-110 Vdc	IP54 front
M1000.0080	12-24 Vdc	IP54 front
M1000.0220	12-24 Vdc	Internal siren, IP54 at front

Description

The M1000 is an alarm panel with 10 digital inputs. Inputs from a dry contact (normally open [NO] or normally closed [NC]) will cause the corresponding LED to flash. Simultaneously a common alarm output and a siren output will be activated as well as an individual output. The unit has separate indications of first alarm, following alarms and acknowledged alarms. It also has dedicated inputs for remote reset and blocking. The unit can be configured for cable monitoring and monitoring of its own supply and insulation level.

Multiple M1000 units can be interconnected to form a large scale alarm system. In this situation functions are available for synchronizing the flashing of the LEDs and enabling global indication of first alarm for all connected units. Alarm related parameters like time delays, reset functions and other features can be configured through 18 programming switches. The M1000 can also be configured via the RS232 interface. A standard ANSI/VT100 terminal is used as programming tool. The M1000 is equipped with a 2-wire RS485 interface supporting MODBUS-RTU communication.

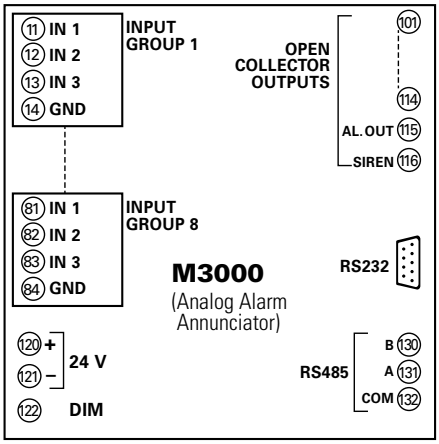
Specifications

Voltage Supply	12-24 Vdc-30%/+30% (8-32 Vdc) 48-110 Vdc-30%/+40% (33-155 Vdc)
Max. Power Consumption	180 mA
Ambient Temp.	–10°C to +70°C (also available for –40°C to +70°C)
Siren Relay Contact	220 Vac/2 A; 30 Vdc/2 A, 30 W
Output	Max. 150 mA per channel
Resistance in Sensing Cable	Max. 1000 W
Insulation Monitor	25 kW±8 kW (50 kW±10 kW for M1000-11-XXC)
Impulse Test	4.5 kV 1/50 µsec.
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2 and EN61000-2-6
Programming	16 dip-switches or via RS232 interface
Communication	RS485 interface
Weight	0.4 kg
Dimensions	**H** 144 mm (5.7"); **W** 144 mm (5.7"); **D** 35 mm (1.4")
Panel Cut-out	**H** 138 mm (5.4"); **W** 138 mm (5.4")
Protection Degree at Front	IP54 (see Type Description)

M3000 SERIES

Analog Alarm Annunciator

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
24 inputs	One unit for both, digital and analog sensors
48 alarms	Individual reference to any of the 24 inputs allows easy configuration of group and individual alarms
Programmable 10-character LCD text	Each alarm is indicated as clear text
24 LEDs with indication of new and acknowledged alarms.	First incoming alarm can be identified easily
14 open collector outputs	Provide ON/OFF control and simple connection to remote displays
RS485 interface	For field-bus communication with PLC or HMI
RS232 link	Allows easy programming with PC-based software

Ordering Information

ORDERING NUMBER	CONTROL POWER
M3000.0010	24 Vdc

ACCESSORIES	REQUIREMENT	PAGE
M1500	24 Vdc	118

Description

The M3000 Analog Alarm Annunciator has 24 inputs that can be configured individually for dry contact (NO or NC) inputs or analog inputs. Analog inputs can read measurements through 4-20 mA, 0-10 Vdc or 0-24 Vdc transmitters. Up to 48 alarms can be configured with individual reference to any of the 24 inputs. An alarm is activated and indicated when the input value exceeds a preset critical low or high level. The alarm can be related to any of the 24 LEDs and any of the 14 outputs. Several alarms may activate the same LED and/or output. The M3000 has a common alarm output, a siren output, as well as dedicated inputs for remote reset and blocking.

Configure the unit from a PC through the built-in RS232 interface or the front panel. It also comes equipped with an RS485 interface supporting MODBUS-RTU and with configuration software. It features a spreadsheet-like graphical interface enabling flexible configuration of all the parameters in the unit. The M3000 also offers configuration of average deviations alarms. This feature is used in monitoring of the exhaust gas temperatures of diesel or gas engines. The average temperature from a number of cylinders is calculated. If the temperature value of one of the cylinders deviates from the average of the remaining cylinders by more than a preset ± offset, a deviation alarm will be activated.

Accessories

A 

M1500 PT100 6-way Transmitter
Six current transducers in one box for use with DIN60751 3-wire PT100 temperature sensors. The output signals are 4-20 mA current, which can be easily fed into the M3000. Each sensor input can be configured for 3 different temperature ranges.

Specifications

Voltage Supply	24 Vdc ±30%
Consumption	Max. 400 mA
Sensor Inputs	24
Input Types	20 mA, 10 Vdc and 24 Vdc
Alarms	48
Alarm Delays	300 msec. to 10 days
Outputs	14 on/off open collector outputs, each controlled by one or more alarms. Max. 150 mA per output
General Alarm Output	Max. 150 mA
Siren Control	Max. 150 mA
LEDs	24
LCD Display	2 x 16 characters with background light
Communication	RS485 interface
Protocol	MODBUS-RTU
Operating Temp.	–20°C to +70°C
Humidity	95% RH at 20°C
Vibration Test	4 g RMS according to IEC 60068-2-64
EMC	CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2 and EN61000-2-6
Approvals	Certified by major marine classification societies
Burn-in	50 hours before final test
Weight	0.8 kg
Dimensions	**H** 144 mm (5.7"); **W** 144 mm (5.7"); **D** 70 mm (2.7")
Panel Cut-out	**H** 138 mm (5.4"); **W** 138 mm (5.4")

Protection Degree at Front IP54

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M4200 SERIES

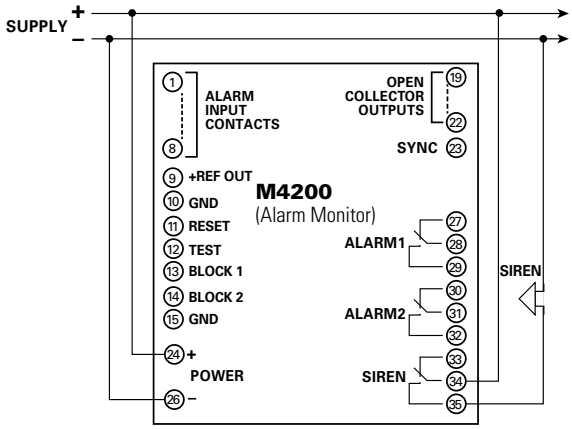
Alarm Monitor

Description

The M4200 Alarm Monitor provides a cost effective solution, with the possibility of monitoring eight individual sensors. The inputs can accept NO or NC contacts. Each input can be programmed to control both of the two alarm relays for group alarm outputs. All inputs will, in default mode, activate the alarm relay and the siren relay. The delays for the inputs can be individually selected between 25 milliseconds and 999 seconds.

Cable monitoring provides extra security to the alarm system. It is possible to adjust the brightness and color of the LEDs. Configuration can be done either by dip switches on the back of the unit or by PC.

Simplified Circuit Diagram



Features & Benefits

FEATURES	BENEFITS
Programmable LED color change	Flexible adjustment according to application
Cable monitoring on sensor inputs	Health monitoring of the inputs with an alarm in case a sensor is lost
Compact dimensions	Fits limited spaces
N-G continuity alarm	Easy configuration of group and individual alarms
Special indication of cable break or short circuit	Sensor monitoring included

Ordering Information

ORDERING NUMBER	CONTROL POWER
M4200.0010	24 Vdc

Specifications

Voltage Supply	8.4-60 Vdc; 8.4-50 Vac
Power Consumption	Max. 180 mA
Ambient Temp.	–15°C to +70°C
Relay Output (Load Capacity)	Max. 250 Vac/6 A
Open Collector Outputs	Max. 60 Vdc/700 mA per output
Min. Input Delay	25 ms
Resistance in Sensing Cable	1000 Ω (full length)
Burn-in	50 hours before final test
Maritime Application	IEC 60945
Industrial Application	EN 61000-4-3, EN 61000-4-4, EN 61000-4-5, EN 61000-4-6
Weight	0.222 kg
Dimensions	**H** 96 mm (3.8"); **W** 96 mm (3.8"); **D** 20 mm (0.8")
Panel Cut-out	**H** 92 mm (3.6"); **W** 92 mm (3.6")
Protection Degree at Front	IP54

M4500, M4600, & M4700 SERIES

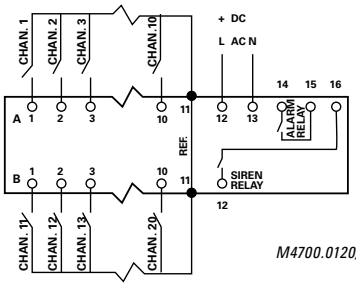
Alarm Indicators


M4700


M4500


M4600

Simplified Circuit Diagram



M4700.0120/0130/0140 Connection Diagram

Ordering Information

ORDERING NUMBER	CONTROL POWER	INPUT REFERENCE
M4500.0010	24 Vdc/Vac	+24 Vdc
M4500.0020	48 Vdc/Vac	+48 Vdc
M4500.0030	12 Vdc/Vac	+12 Vdc
M4500.0040	24 Vdc/Vac	0 Vdc
M4500.0050	48 Vdc/Vac	0 Vdc
M4500.0060	12 Vdc/Vac	0 Vdc
M4600.0010	24 Vdc/Vac	+24 Vdc
M4600.0020	48 Vdc/Vac	+48 Vdc
M4600.0030	12 Vdc/Vac	+12 Vdc
M4600.0040	110 Vdc	+110 Vdc
M4600.0050	24 Vdc/Vac	0 Vdc
M4600.0060	48 Vdc/Vac	0 Vdc
M4600.0070	12 Vdc/Vac	0 Vdc
M4700.0010	24 Vdc/Vac	+24 Vdc
M4700.0020	48 Vdc/Vac	+48 Vdc
M4700.0030	12 Vdc/Vac	+12 Vdc
M4700.0040	110 Vdc	+110 Vdc
M4700.0050	24 Vdc/Vac	0 Vdc
M4700.0060	48 Vdc/Vac	0 Vdc
M4700.0070	12 Vdc/Vac	0 Vdc
M4700.0080	110 Vdc	0 Vdc
M4700.0090	230 Vac	+24 Vdc
M4700.0100	110 Vac	+24 Vdc
M4700.0110	230 Vac	0 Vdc
M4700.0120*	24 Vdc	+24 Vdc
M4700.0120*	24 Vdc	+24 Vdc
M4700.0130†	230 Vac	+24 Vdc
M4780.0010‡	24 Vdc	24 Vdc

ACCESSORIES	DESCRIPTION	PAGE
M0845.0010	Front cover for M4500 with handle IP54	123
M0845.0020	Front cover for M4500 with key IP54	123
M0846.0010	Front cover for M4600 with handle IP54	123
M0846.0020	Front cover for M4600 with key IP54	123
M0847.0010	Front cover for M4700/ M4780 with handle IP54	123
M0847.0020	Front cover for M4700/ M4780 with key IP54	123

*With common alarm relay, siren relay and built-in siren.
†Inverted reference. With common alarm relay, siren relay and built-in siren.
‡ Modbus Indicator Panel, 20 channels, 24 Vdc, common alarm relay and built in siren.

Description

The M4500, M4600 and M4700 Indicator Panels are intended for status indication of any process providing on/off outputs. The panels contain 6, 8 or 20 channels, respectively.

An input through a dry contact will light the corresponding LED.

These panels are an ideal solution for local or remote indication of the output signals from, for example, a PLC or from alarm monitors such as the M1000. The 20 channel M4700 is available in a version with built-in alarm and siren relays.

M4780 is a versatile 20 channel indicator panel which can be used for monitoring of dry contacts and signal states transmitted through a common 2-wire RS485 communication bus using the MODBUS-RTU protocol. This unit is a combination of a traditional indicator panel with dry contact inputs and a MODBUS indicator panel. M4780 can also work as an alarm monitor using two internal relays for group alarms and control of an external siren. An internal siren for local use is built-in. Via the MODBUS-RTU a PLC can read the state of the LEDs and the inputs on the M4780. This feature makes the M4780 a cost effective 20 channel digital input device with indications in PLC systems.

Features & Benefits

FEATURES	BENEFITS
Clamping fittings and plug-in terminals blocks	Easy installation
RS485 communication available	Remote display for alarm panels or PLCs
Alarm and siren relay available	Audible remote alarm

Specifications

Voltage Supply 24 Vdc ±25%
Inputs M4500: 6; M4600: 8; M4700: 20
Extra Push-Button M4500/M4600: 250 Vac, 0.5 A
Alarm & Siren Relays M4700: Normally open (NO) contact
Contact Data M4700: AC=250 V, 1.2 A, 125 VA
DC=30 V, 1 A, 30 W
Operating Temp. –10 to +70°C
EMC CE according to EN50081-1, EN50082-1, EN50081-2, EN50082-2
Burn-in 50 hours before final test
Weight M4500 0.2 kg, M4500 230 Vac supply, 0.3 kg
M4600 0.3 kg, M4500 110 V and 230 Vac supply, 0.4 kg
M4700.01xx 0.5 kg (with 230 Vac supply, 0.7 kg)
Dimensions M4500: **H** 72 (2.8"); **W** 72 (2.8"); **D** 67 mm (2.6")
M4600: **H** 96 (3.8"); **W** 96 (3.8"); **D** 67 mm (2.6")
M4700: **H** 144 (5.7"); **W** 144 (5.7"); **D** 67 mm (2.6")
Panel Cut-out M4500: **H** 68 (2.7"); **W** 68 (2.7")
M4600: **H** 92 (3.6"); **W** 92 (3.6")
M4700: **H** 138 (5.4"); **W** 138 (5.4")
Protection Degree at Front IP31

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H4000 HMI SERIES

Operator Panels

CE

Description

The HMI operator panel is a touch-screen solution for SCADA solutions, designed for applications like engine control and supervision systems, power management systems and alarm systems. They can be integrated with products such as the M2500, Engine Controller, Generator Controllers and Alarm Panels.

The clear, high-resolution screen provides a high level of details on images, charts, meters and alarms.

The SELCO HMI solutions support a broad variety of communication buses, MODBUS-RTU, and can work as gateways between different bus protocols such as Ethernet to MODBUS. The operator panel is configured with a software tool.

Available in three sizes: H4000 6,5", H4100 10,4", H4200 15,1". The units are marine approved.

Features & Benefits

FEATURES	BENEFITS
Clear, high-resolution screen	High level of details (images, charts, meters and alarms)
Wide range of communication interfaces	Compatible with many communication protocols
Sun-readable versions	Clear image even in direct sunlight
Type-approved by marine classification societies	Approved for marine alarm systems

Ordering Information

ORDERING NUMBER	DESCRIPTION
H4000.0010	HMI Panel 6,5"
H4000.0020	HMI Panel 6,5", sun readable
H4100.0010	HMI Panel 10,4"
H4100.0020	HMI Panel 10,4" sun readable
H4200.0010	HMI Panel 15,1"
H4200.0020	HMI Panel 15,1" sun readable
H4900.0010	Programming Software

Specifications

Front Panel Dimension
H4000: **H** 219 mm (8.6"); **W** 154 mm (6.0"); **D** 6 mm (0.2")
H4100: **H** 302 mm (11.9"); **W** 228 mm (9.0"); **D** 6 mm (0.2")
H4200: **H** 398 mm (15.7"); **W** 304 mm (12.0"); **D** 6 mm (0.2")

Mounting Depth
H4000: 56 mm (2.2"),156 mm including clearance
H4100: 58 mm (2.3"),158 mm including clearance
H4200: 60 mm (2.4"),160 mm including clearance

Front Panel Seal IP 66
Rear Panel Seal IP 20
Serial Port RS422/ RS485
Serial Port RS232C
Ethernet Shielded RJ 45
USB Host type A (USB 1.1), max output current 500 mA Device type B (USB 1.1)
CF-Slot Compact flash, type I and II
Flash Memory for Application 12 MB (incl. fonts)

Power Consumption at Rated Voltage
H4000: Normal: 0.4 A; Maximum: 0.9 A
H4100: Normal: 0.5 A; Maximum: 1.0 A
H4200: Normal: 1.2 A; Maximum: 1.7 A

Display **TFT-LCD, 64K color. CCFL backlight lifetime at the ambient temperature of +25°C: >50,000 h.**
H4000: 640 x 480 pixels
H4100: 800 x 600 pixels
H4200: 1024 x 768 pixels

Active Area of Display
H4000: 132.5 mm (5.2") x 99.4 mm (3.9")
H4100: 211.2 mm (8.3") x 158.4 mm (6.2")
H4200: 304.1 mm (12.0") x 228.1 mm (9.0")

Power Supply +24 Vdc (20-30 Vdc)
Ambient Temperature Horizontal installation: 0°C to +40°C
Storage Temperature –20°C to +70°C
Relative Humidity 5-85 % non-condensed

SOFTWARE

For More Information...
on Relay and other Software, visit
www.littelfuse.com/relaysoftware

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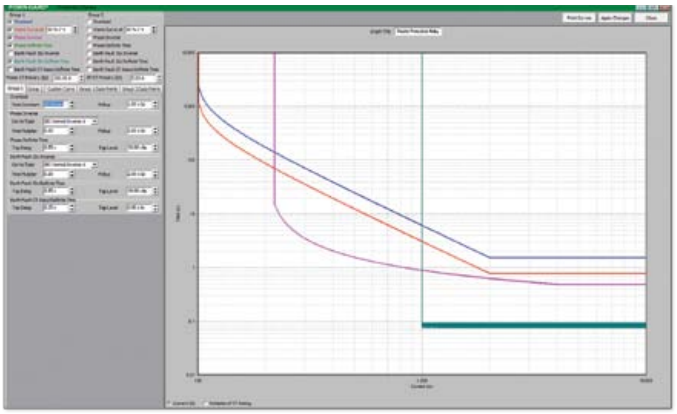
SOFTWARE



Protection Relays and Alarm Systems 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
SE-COMM-RIS 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.	**MPU-32** **MPS** **FPU-32** **FPS**
SE-FLASH Firmware Update Utility		Used to update relay firmware to add new features.	**MPU-32** **MPS** **FPU-32** **FPS EL731**
SE-MON330 Relay Interface Software		Used to receive data from the SE-330. It displays relay set points and measured values, and features data logging of information at a selectable interval.	**SE-330** **SE-330HV** **SE-330AU**
PGW-6150 Relay Interface Software		Provides access to the settings, measurements, configurations, and reports recorded in the relay. Allows changes to operation parameters and to work offline, and creating a library of settings for future applications.	**PGR-6150**
PGW-8800 Relay Interface Software		Provides access to basic and advanced settings over a USB connection. No installation required.	**PGR-8800**
VMPU Virtual Motor Protection Relay		Allows the user to scroll through the MPU-32 Motor Protection Relay menu.	**MPU-32**
VMPS Virtual Motor Protection System		Allows the user to scroll through the MPS Motor Protection System menu.	**MPS**
VFPU Virtual Feeder Protection Relay		Allows the user to scroll through the FPU-32 Feeder Protection Relay menu.	**FPU-32**
MPU-32 Tutorial MPU-32 Online Self-Training Tutorial		Online Self-Training tutorial for MPU-32 programming.	**MPU-32**
H4900 Programming Software		For configuring the operator panel.	**H4000** **H4100** **H4200**

13
SOFTWARE S

MOUNT ADAPTERS

For More Information...
on Retrofits, Panel Mount Adapters and more accessories, visit
www.littelfuse.com/relayaccessories

PMA SERIES

Panel Mount Adapters

Example Shown: PMA-3

Example of a panel mount adapter (PMA-3). Relay is for illustrative purposes only and must be purchased separately from adapter plate. For more information on our complete offering of panel mount adapters see page 110.

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. 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	PMA-14	MPS
FPL-GFRM	PMA-6	SE-701/SE-704
GE S1	PMA-9	MPU-32/FPU-32
GE LODTRAK III	PMA-10	MPU-32
GE MULTILIN 169, 269, or 369	PMA-13	MPS
	PMA-16	MPU-32
	PMA-16	FPU-32
GE MULTILIN 469	PMA-24	MPS
GE MULTILIN P4A	PMA-15	MPU-32/FPU-32
GEC/MCGG	PMA-3	SE-701/SE-704
GE & WESTINGHOUSE FT-11	PMA-12	MPU-32
P&B GOLDS	Contact Factory	FPU-32
WESTINGHOUSE CO9 & CO11	Contact Factory	FPU-32

For a complete list of the Littelfuse Panel Mount Adapter Plates please see page 110.

PANEL-MOUNT ADAPTERS

PANEL MOUNT ADAPTERS		
Product	Features	Accessory For
PMA-2 Adapter Plate	Used when replacing the AB Bulletin 1406.	**MPU-32**
PMA-3 Adapter Plate	Used when replacing GEC/MCGG ground-fault relays. Requires PMA-55 or PMA-60.	**SE-704 SE-701**
PMA-4 Adapter Plate	Used when replacing the Multilin 139/239.	**MPU-32**
PMA-6 Adapter Plate	Used when replacing FPL-GFRM ground-fault relays. Requires PMA-55 or PMA-60.	**SE-701**
PMA-7 Adapter Plate	Used when replacing the GE Lodtrak II.	**MPU-32**
PMA-8 Adapter Plate	Used when replacing an Atkinson Omser II with an SE-130-Series Monitor.	**SE-134C SE-135**
PMA-9 Adapter Plate	Used when replacing relays in the GE S1 Case. Requires PMA-55 or PMA-60.	**MPU-32 FPU-32**
PMA-10 Adapter Plate	Used when replacing the GE Lodtrak III.	**MPU-32**
PMA-12 Adapter Plate	Used when replacing GE and Westinghouse FT-11 relays.	**MPU-32**
PMA-13 Adapter Plate	Used when replacing the GE Multilin 169, 269, or 369.	**MPS**
PMA-14 Adapter Plate	Used for rough cutouts and when replacing the AB Bulletin 1406.	**MPS**
PMA-15 Adapter Plate	Used for rough cutouts and when replacing the GE Multilin P4A.	**MPU-32 FPU-32**
PMA-16 Adapter Plate **PMA-16-RTDB** Mounting Bracket	The PMA-16 mounting plate is used when replacing the GE Multilin 169, 269, and 369 relays. The PMA-16-RTDB is a mounting bracket for the optional MPS-RTD Temperature Input Module.	**MPU-32 FPU-32**
PMA-17 Adapter Plate	Used when replacing Sprecher & Schuh Cet 4.	**MPU-32**
PMA-18 Adapter Plate	Used when replacing Sprecher & Schuh Cet 3.	**MPU-32**
PMA-21 Adapter Plate	Used when replacing an ABB RACIF.	**FPU-32**
PMA-23 Adapter Plate	Custom mounting plate for FPU-32 to replace 3 Westinghouse C0 relays.	**FPU-32**
PMA-24 Adapter Plate	Used when replacing the GE Multilin 469.	**MPS**
PMA-55 Adapter Plate	Used to panel mount the SE-601 and SE-701.	**SE-601 SE-701 PGR-4300 SE-704**
PMA-60 Adapter Plate	Used to panel mount the relay; IP 53 and NEMA 3 rating, tamper resistant.	**SE-601 SE-701 PGR-4300 SE-704**
MPU-32-SMK Surface-Mount Kit	Used to surface mount the MPU-32 or FPU-32.	**MPU-32 FPU-32**

Note: Relays are not included with the PMA-Series Panel Mount Adapters.

DIN-MOUNT ADAPTERS & WATERTIGHT COVERS

DIN-MOUNT ADAPTERS		
Product	**Features**	**Accessory For**
AC700-SMK Mount Adapter 	DIN-rail and Surface-mount adapter for back-plane mounting.	**EL731**
D0050 DIN-Rail Adapter Clip 	Plastic clip allowing DIN-rail mounting of the PGR-8800 Arc-Flash Relay.	**PGR-8800**

WATERTIGHT COVERS		
Product	**Features**	**Accessory For**
MPU-16A-Y92A-96N Watertight Cover 	Watertight cover for outdoor applications.	**MPU-32** **FPU-32**
SE-IP65CVR-G Watertight Cover 	Watertight cover. Tamper-resistant. IP65 protection.	**SE-134C SE-135** **SE-330 SE-330AU** **SE-330HV SE-400**
SE-IP65CVR-G2 Watertight Cover 	Watertight cover. Tamper-resistant. IP65 protection.	**SE-145**
SE-IP65CVR-M Watertight Cover 	Watertight cover. Tamper-resistant. IP65 protection.	**MPS** **FPS**
SE-MRE-600 Moisture-Resistant Enclosure Kit 	Protects the connection terminals from snow and rain in outdoor applications.	**ER-600VC** **ER-1000HV**
M0845 Watertight Cover 	Front cover with handle IP54 (-0010) Front cover with key IP54 (-0020)	**M4500**
M0846 Watertight Cover 	Front cover with handle IP54 (-0010) Front cover with key IP54 (-0020)	**M4600**
M0847 Watertight Cover 	Front cover with handle IP54 (-0010) Front cover with key IP54 (-0020)	**M4700** **M4780**

ENCLOSURES		
Product	**Features**	**Accessory For**
NGRM-ENC NGR Monitor Control Panel	NEMA 4 painted steel control panel, complete with the SE-325 or SE-330, and a fused 600/480:120 V PT for relay control power. Suitable for indoor or outdoor mounting, CSA certified. When NGR Monitor is back-plane mounted, 22-mm NEMA 4 indicators and reset button are included. Please contact factory for additional information.	**SE-325** **SE-330**

CURRENT TRANSFORMERS

For More Information...
on Current Transformers, visit
www.littelfuse.com/relayct

CT SELECTION GUIDE

	PRODUCT	GROUND-FAULT CT	GROUND-FAULT TRIP LEVEL (or insulation level)	PAGE #
GROUND FAULT PROTECTION	SE-601	No CTs required	1-20 mA	–
	PGR-3100	No CTs required	Indication only	–
	PGR-3200	No CTs required	Warnings at 30 kΩ & 50 kΩ, Alarm at 10 kΩ	–
	SE-502	No CTs required	5 ± 0.9 mA	–
	SE-701/SE-703	CT-200 Series	10-198 A	114
		EFCT Series	50 mA-4.95 A	114
		SE-CS30 Series	300 mA-29.7 A	114
	SE-704	SE-CS30 Series	10 mA-5 A	114
	EL731	EFCT Series	30-5,000 mA AC and DC	114
TRAILING CABLE PROTECTION	SE-105/SE-107	CT200 Series	0.5-4 A	114
	SE-134C/SE-135	SE-CS10 Series	0.5-12.5 A	114
	SE-145	SE-CS10 Series	0.5-12.5 A	114
		SE-CS40 Series	2.0-50 A	114
RESISTANCE GROUNDING	SE-330	CT200 Series	12-200 A	114
		EFCT Series	100 mA-5 A	114
		SE-CS30 Series	600 mA-30 A	114
	SE-325	CT200 Series	0.5-4 A	114
MOTOR & PUMP PROTECTION	PGR-6150	No phase CTs required <25 A, Optional SE-CS30 Series Ground-Fault CT	0.4-150 A	115
	MPU-32*	CT200 Series	10-200 A	114
		EFCT Series	50 mA-5 A	114
		SE-CS30 Series	300 mA-30 A	114
	MPS*	CT200	10-200 A	114
		EFCT Series (5-A Primary)	50 mA-5 A	114
		SE-CS30 Series (30-A Primary)	300 mA-30 A	114
	MPU-32-X69X-PMA16	Existing CTs can be used or same as MPU-32.		
	MPS-469X-PMA24	Existing CTs can be used or same as MPS.		
	PGR-6800	No CTs required <91 A	N/A†	–
FEEDER PROTECTION	FPU-32*	CT200 Series	10-200 A	114
		EFCT Series	50 mA-5 A	114
		SE-CS30 Series	300 mA-30 A	114
	FPS*	CT200	10-200 A	114
		EFCT Series (5-A Primary)	50 mA-5 A	114
		SE-CS30 Series (30-A Primary)	300 mA-30 A	114
ARC-FLASH PROTECTION	PGR-8800‡	CTs are optional	N/A	–

Note: See page 141 for additional information on CT selection. See page 156 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 51.
‡Select a CT with a primary rating approximately equal to the system's rated current. CTs with 5-A secondary current are accepted.

CURRENT TRANSFORMERS

CURRENT TRANSFORMERS			
Product	Features	Inner Diameter	Accessory For
CT200 (PGC-2056) Current Transformer 	Detects phase current or ground-fault current. (200-A primary)	56 mm (2.20")	**SE-330 SE-105/107 FPS SE-701 MPU-32 FPU-32 MPS SE-325 PGR-8800**
CT200L (PGC-2089) Current Transformer 	Detects phase current or ground-fault current. (200-A primary)	89 mm (3.50")	**SE-701 SE-105 MPU-32 SE-107 MPS FPU-32 PGR-8800 FPS**
EFCT-26 (PGC-3026) Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5-A primary)	26 mm (1.02")	**SE-330 MPS MPU-32 SE-701 FPU-32 FPS EL731**
EFCT-1 (PGC-3082) Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5-A primary)	82 mm (3.23")	**SE-330 MPS MPU-32 SE-701 FPU-32 FPS EL731**
EFCT-2 (PGC-3140) Ground-Fault Current Transformer 	Sensitive current transformer used to detect ground-fault current. (5-A primary)	140 mm (5.50")	**SE-701 MPS MPU-32 FPU-32 EL731 FPS**
EFCT-1FC (PGC-31FC) Flux Conditioner 	Fits in the EFCT-1 window to reduce saturation and prevent false operation due to large surge currents.	70 mm (2.75")	**EFCT-1**
SE-CS10-2.5 (PGC-4064) Current Sensor 	Detects ground-fault current.	64 mm (2.50")	**SE-134C SE-135 SE-145**
SE-CS10-4 (PGC-4108) Current Sensor 	Detects ground-fault current.	108 mm (4.25")	**SE-134C SE-135 SE-145**
SE-CS10-6 (PGC-4160) Current Sensor 	Detects ground-fault current.	160 mm (6.31")	**SE-134C SE-135 SE-145**
SE-CS10-8 (PGC-4210) Current Sensor 	Detects ground-fault current.	210 mm (8.25")	**SE-134C SE-135 SE-145**
SE-CS30-26 (PGC-5025) Ground-Fault Current Transformer 	Current Transformer for low-level ground faults, flux conditioner is standard. (30-A primary)	25 mm (0.98")	**SE-704 MPU-32 SE-330 MPS SE-701 FPU-32 PGR-6100 FPS**
SE-CS30-70 (PGC-5060) Ground-Fault Current Transformer 	Current Transformer for low-level ground faults, flux conditioner is standard. (30-A primary)	60 mm (2.36")	**SE-704 MPU-32 SE-330 MPS SE-701 FPU-32 PGR-6100 FPS**
SE-CS30-4 (PGC-5095) Ground-Fault Current Transformer 	Current Transformer for low-level ground faults, flux conditioner is standard. (30-A primary)	95 mm (3.74")	**SE-704 MPU-32 SE-701 MPS PGR-6100 FPU-32 FPS**
SE-CS30-5 (PGC-5130) Ground-Fault Current Transformer 	Current Transformer for low-level ground faults, flux conditioner is standard. (30-A primary)	130 mm (5.12")	**SE-704 MPU-32 SE-701 MPS PGR-6100 FPU-32 FPS**
SE-CS30-8 (PGC-5200) Ground-Fault Current Transformer 	Current Transformer for low-level ground faults, flux conditioner is standard. (30-A primary)	200 mm (7.87")	**SE-704 MPU-32 SE-701 MPS PGR-6100 FPU-32 FPS**
SE-CS40-6 Current Sensor 	Detects ground-fault current	160 mm (6.31")	**SE-135 SE-145**

PGC FAMILY, PGG FAMILY

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

NOTE: Contact factory for additional CT offerings.

ADDITIONAL ACCESSORIES

For More Information...
on Additional Accessories, visit
www.littelfuse.com/relayaccessories

GR MODULES, HIGH-TENSION COUPLERS, RELAY TESTERS

GROUND-REFERENCE MODULES

Product	Features	Accessory For
SE-GRM024 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 24 Vdc bus.	**SE-601**
SE-GRM048 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 48 Vdc bus.	**SE-601**
SE-GRM125 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 125 Vdc bus.	**SE-601**
SE-GRM250 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 250 Vdc bus.	**SE-601**
SE-GRM500 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 500 Vdc bus.	**SE-601**
SE-GRM780 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 780 Vdc bus.	**SE-601**
SE-GRM1000 Ground Reference Module 	Connects the SE-601 relay to an ungrounded 1000 Vdc bus.	**SE-601**

HIGH-TENSION COUPLERS

Product	Features	Accessory For
PGH-5000 High Tension Couplers 	Allows 5-kV systems to be connected to relay.	**PGR-6100** **PGR-3200**
PGH-6000 High Tension Couplers 	Allows 6-kV systems to be connected to relay.	**PGR-6100** **PGR-3200**

PROTECTION RELAY TESTERS

Product	Features	Accessory For
SE-100T c SP us Ground-Fault Relay Tester 	Tests the current pickup level ground-fault protection. Tests the entire ground-fault circuit.	**Any Relay on Substations, MCCs, Central Distribution Panels, Switchboards, and Test Benches**
SE-400 Ground-Fault-Relay Test Unit 	Tests the current pickup level, time delay and coordination of ground-fault protection. Tests the entire ground-fault circuit.	**Any Relay on Substations, MCCs, Central Distribution Panels, Switchboards, and Test Benches**

INPUT MODULES, REMOTE INDICATION

INPUT MODULES		
Product	Features	Accessory For
MPS-RTD Temperature Input Module 	Provides 8 programmable inputs to connect Pt100, Ni100, Ni120, and Cu10 RTDs.	**MPU-32** **MPS**
MPS-DIF Differential Current Module 	Adds motor differential protection, compatible with core balance and summation current transformer connections.	**MPU-32** **MPS**
MPU-CIM Current Input Module 	Interface between current transformers and MPU-32 or FPU-32 series relays. Reduces potential for open CT hazard.	**MPU-32** **FPU-32**
SIO-RTD c SP us Temperature Input Module 	Data-acquisition system for measuring temperatures with resistance temperature detectors (RTDs) and for monitoring 4-20 mA analog-output devices in industrial environments.	
M1500 PT100 6-way Transmitter 	Six current transducers in one box for use with DIN60751 3-wire PT100 temperature sensors. The output signals are 4-20 mA current, which can be easily fed into the M3000. Each sensor input can be configured for 3 different temperature ranges.	**M3000**
PGA-LS10 Point Sensor 	Line-of-sight light sensor detects an arc as small as 3 kA within a 2-m half-sphere. Local LED continually displays sensor health or trip state.	**PGR-8800**
PGA-LS20 Fiber-Optic Sensor 	Used to detect light and coordinate with current detection to eliminate nuisance tripping.	**PGR-8800**
A0200/A0300 Light Sensor 	Line-of-sight light sensor detects an arc as small as 3 kA within a 2-m halfsphere. Available in both 180˚ and 360˚.	**D0900**

REMOTE INDICATION & METERS		
Product	Features	Accessory For
RK-105 Remote Indication and Reset Assembly UL c SP us 	Panel-mounted remote indication and reset with NEMA 1 rating.	**SE-105** **SE-107**
RK-105I Remote Indication Assembly UL c SP us 	Panel-mounted remote indication with NEMA 1 rating.	**SE-105** **SE-107**
RK-102 Industrial Remote Indication and Reset Kit UL c SP us 	Panel-mounted remote indication and reset, standard 22 mm mounting, with NEMA 4 and NEMA 13 rating.	**SE-105** **SE-107**
RK-132 Industrial Remote Indication and Reset Kit UL c SP us 	Panel-mounted remote indication and reset, standard 22 mm mounting, with NEMA 4 and NEMA 13 rating.	**SE-134C** **SE-135** **SE-145**
RK-325 Remote Indication and Reset Assembly UL c SP us 	Panel-mounted remote indication and reset with NEMA 1 rating.	**SE-325**
RK-325I Remote Indication Assembly UL c SP us 	Panel-mounted remote indication with NEMA 1 rating.	**SE-325**

REMOTE INDICATION, SENSING RESISTORS

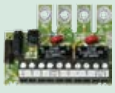
REMOTE INDICATION & METERS

Product	Features	Accessory For
RK-302 Remote Indication and Reset Kit 	Panel-mounted remote indication and reset, standard 22 mm mounting with NEMA 4 and NEMA 13 rating.	**SE-325**
RK-332 Remote Indication and Reset Kit 	Panel-mounted remote indication and reset, standard 22 mm mounting with NEMA 4 and NEMA 13 rating.	**SE-330 SE-330AU SE-330HV**
PGB-6130 Remote Indication and Reset Assembly 	Remote indication of overcurrent, phase unbalance, phase loss, phase sequence, and overtemperature. Remote reset included.	**PGR-6130**
PGB-6800 Remote Indication and Reset Assembly 	Remote indication of overcurrent, undercurrent, phase unbalance, 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.	**SE-601 SE-701 PGR-4300 SE-703 PGR-6100 SE-704**
PGA-0510 Analog Ohm Meter 	Panel-mounted analog ohmmeter displays insulation resistance from 0 Ω to infinity.	**PGR-3200 PGR-6100**
E2323 & E2324 Megaohmmeter & Kiloohmmeter 	Flush-mounted units designed for connection with the T3200 for instrument readings.	**T3200**
M8100 Synchroscope 	Flush-mounted units provide illuminaated indication of the phase and frequency difference between voltages on two separate AC systems.	**T5000 T4500 C6200 FlexGen S6000 Sigma**

SENSING RESISTORS

Product	Features	Accessory For
ER-600VC (PGE-600V) Sensing Resistor 	Used on systems up to 1 kV. (Continuous duty)	**SE-330 SE-325 SE-330AU**
SE-MRE-600 Enclosure 	Used in outdoor enclosures. (ER-600VC ordered separately)	**ER-600VC**
ER-5KV (PGE-05KV) Sensing Resistor 	Used on systems up to 5 kV. (Continuous duty)	**SE-330 SE-325 SE-330AU**
ER-5WP (PGE-05WV) Sensing Resistor 	Used on systems up to 5 kV, includes weather-protected terminals for use in outdoor enclosures. (Continuous duty)	**SE-330 SE-325 SE-330AU**
ER-15KV (PGE-15KV) Sensing Resistor 	Used on systems up to 15 kV. (Non-continuous duty)	**SE-330 SE-325 SE-330HV SE-330AU**
ER-25KV (PGE-25KV) Sensing Resistor 	Used on systems up to 25 kV. (Non-continuous duty)	**SE-330 SE-325 SE-330HV SE-330AU**
ER-35KV (PGE-35KV) Sensing Resistor 	Used on systems up to 35 kV. (Non-continuous duty)	**SE-330 SE-330HV SE-330AU**
ER-72KV (PGE-72KV) Sensing Resistor 	Used on systems up to 72 kV. (Non-continuous duty)	**SE-330HV**

TERMINATIONS AND ADAPTERS

TERMINATIONS AND ADAPTERS		
Product	**Features**	**Accessory For**
1N5339B Termination Device 	5 W axial-lead ground-check termination. Included with SE-105 and SE-107.	**SE-105** **SE-107**
SE-TA6-SM Stud-Mount Termination Assembly 	50 W ground-check termination that is robust and compact for submersible pumps. Wire lead simplifies installation. (Replacement for 1N4553B)	**SE-105** **SE-107**
SE-TA6 Termination Assembly 	50 W ground-check termination with convenient mounting holes and screw terminals.	**SE-105** **SE-107**
SE-TA6A **(PGA-0T6A)** Termination Assembly 	Temperature compensated 50 W ground-check termination with convenient mounting holes and screw terminals.	**SE-105** **SE-107** **SE-134C**
SE-TA6A-WL Termination Assembly 	Temperature compensated 50 W ground-check termination with convenient mounting holes and screw terminals.	**SE-105** **SE-107** **SE-134C**
SE-TA6ASF-WL Small-Format Termination Assembly with Wire Leads 	Temperature compensated 12 W ground-check termination, ideal for use in cable-coupler end caps and submersible pumps. Mounting holes and wire leads.	**SE-105** **SE-107** **SE-134C**
SE-TA12A Termination Assembly 	Temperature compensated 50 W ground-check termination with convenient mounting holes and screw terminals.	**SE-135** **SE-145**
SE-TA12ASF-WL Small-Format Termination Assembly with Wire Leads 	Temperature compensated 12 W ground-check termination, ideal for use in cable-coupler end caps and submersible pumps. Mounting holes and wire leads.	**SE-135** **SE-145**
SE-TA12A-WL Termination Assembly 	Temperature compensated 50 W ground-check termination with convenient mounting holes and screw terminals.	**SE-135** **SE-145**
SE-TA12A **SE-TA12B** Termination Assemblies 	Used together to allow an SE-134C to monitor a splitter box and two cables.	**SE-134C**
PPI-600V Parallel Path Isolator 	Parallel ground-path rejection for ground-check monitors. Eliminates intermachine arcing and prevents stray DC currents from flowing in a monitored ground wire.	**SE-105 SE-107** **SE-134C SE-135**
RK-13 Relay Interface Module 	Separate ground-fault and ground-check indication contacts for the SE-105, and separate ground-fault and resistor-fault contacts for the SE-325. Used to provide output to a PLC and operate standard pilot lights. Complete with conformally coated circuit boards.	**SE-105 SE-107** **SE-325**
SE-485-DIN Industrial RS-485 to RS-232 Converter 	Industrial network quality RS-485 to RS-233 serial converter. DIN-rail mounted, 24 Vdc required.	**MPS** **FPS**
SE-485-PP Port-Powered Serial Converter 	Converts an RS-485 signal to an RS-232 signal. Used for set-point programming and updating flash memory. 115.2 kbit/s maximum transfer rate.	**MPU-32 MPS** **FPU-32 FPS**
CA-945 Serial Connector Adapter Kit 	Connects an RJ45 to a 9-pin serial connector. Includes 1.5 m cable and plug-in adapter.	**MPU-32** **FPU-32**
SE-ICUSB232 USB to RS-232 Converter 	Connects a 9-pin serial cable to a USB port.	**SE-330 CA-945** **SE-330AU SE-330HV** **SE-485-PP SE-485-DIN**

ADAPTERS & CONTROLS/DIAGNOSTICS

TERMINATIONS AND ADAPTERS

Product	Features	Accessory For
A0033 Detector Cable 	Extension cable for the A0200 and A0300 sensors.	**D0900**
AC700-CUA Communications Adapter 	Optical network-interface and firmware-upgrade communication adapter. Field-installed.	**EL731**
D0400 Junction Box (No Indication) 	Junction box without indication, for parallel connection of more than 2 sensors for one relay. Designed to connect up to 8 sensors.	**D0900**
D0500 Junction Box (Indication) 	Junction box with indication, for parallel connection of more than 2 sensors for one relay. Designed to connect up to 8 sensors.	**D0900**
E5540 USB Cable	USB Cable with A/Mini-B plug (2 m).	**E5000**
G0100 Programming Kit 	Connects to RS232 port. Includes blank front-plate labels and permanent pen for texting scales.	**G2000 G3000 G3300**
K 3452 &K3450 RS232 Cable 	For configuration from PC.	**M2000**
K1025 USB A-B Cable 	USB A to B cable.	**M2500**
T4910 Potentiometer with Cable 	For external power factor setting. External contact between terminals 12 (COM) and 28 (PF ON). Included.	**T4900**

ACCESSORIES FOR CONTROLS & DIAGNOSTICS

Product	Features	Accessory For
E5520 Break-out Box 	Break-out Box For TDC/Crank Angle Sensor.	**E5000**
E5330 Charger	Charger with USB Plug 110/240 Vac (incl. EU/UK/US adapter).	**E5000**
E5200 TDC Sensor	Detection of top dead center for TDC correction.	**E5000**
E5300 Crank-Angle Sensor 	The unique, high-resolution design is easy to cut and adapt and thus applicable for all shaft diameters. Can easily be installed by crew.	**E5000**
K2502 SD Card 	Included with the M2500.	**M2500**
M0500 Tacho Detector 	Reads engine speed from frequency of the generator output voltage. The reading is converted to a square wave signal and this signal is provided on a dedicated output.	**M2000 M2100**
M2600 Shutdown Unit 	Safety shutdown device for protection of marine engines. Speed detection from magnetic pickup or digital input.	**M2500 M2600**

NOTE: Refer to Terminations and Adapters table above for additional accessories.

CUSTOM PRODUCTS

For More Information...
and to download our
Custom Products Brochure, visit
www.littelfuse.com/customproducts

PORTABLE POWER CENTERS

Portable Power Center

Description

Littelfuse Startco is the leading Canadian manufacturer of custom-built, portable mine power centers. Littelfuse Startco portable mine power centers are skid-mounted, metal-enclosed, and typically used in underground mines. The extremely rugged enclosure is mine-duty NEMA-12 casing, tub type, flat bottom, and typically features a dry-type power transformer, three-pole medium-voltage load interrupter switch, secondary power-distribution breakers, and application-specific controls and protection. Each Littelfuse Startco power center is HIPOT and High Voltage tested, and is fully tested and inspected before shipping.

Typical Application

- Underground mining

Features & Benefits

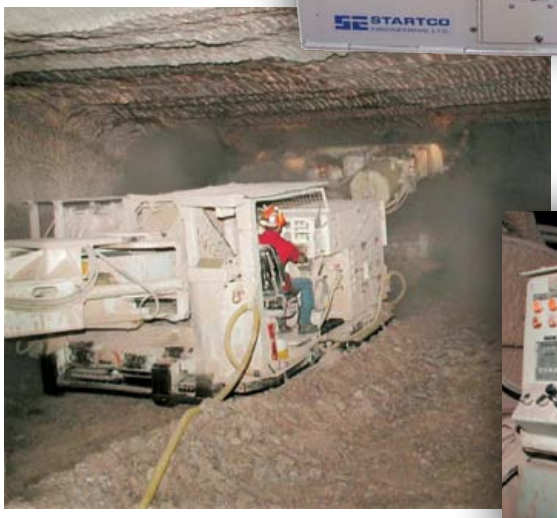
FEATURES	BENEFITS
Sandblasted & finished with polyester powder coat	Corrosion resistant, long life in harsh environments
SE-325/SE-330 NGR Monitor	To detect grounding-resistor failure; meets CSA M421-00
SE-105/SE-107 Ground-Fault Ground-Check Monitor	To protect portable trailing-cable fed equipment; meets CSA M421-00
Plated steel hinges, latches, and hardware	Long trouble-free life for heavy-duty use
Stainless steel hardware available for wet or humid environments	Corrosion resistant, long trouble-free life for heavy-duty use
Combination starter	With the use of a ground-check relay, provides remote start/stop capabilities to control mobile electric equipment
Key-interlocked system, padlockable	To keep unauthorized personnel out of hazardous compartments
Wired-glass or Lexan viewing windows	Long trouble-free life for heavy-duty use

MINING MACHINE CONTROLS

Miner Control Console

Description

Littelfuse Startco builds very rugged and high-quality control consoles for portable mining machines. These consoles typically include Littelfuse MPU-32 or MPS Motor Protection Relays, rugged industrial automation equipment, and custom Littelfuse Startco keypads.



Miner Controls In Use

Custom-Built Panels

Description

Littelfuse Startco can assemble custom panels, complete with ground-fault and motor protection relays as required.

SOFT STARTERS

Solid-State Starter

Description

Littelfuse Startco Starters are designed for starting squirrel-cage induction motors in single or parallel operation on pumps, fans, conveyor belts, centrifuges, and other high-inertia loads. The Littelfuse Starters are an extremely rugged design that incorporates the SE-3SCR-LM Load Manager and Littelfuse motor protection.

Features & Benefits

FEATURES	BENEFITS
SE-3SCR-LM Load Manager	Provides starter control, load sharing, motor shedding
MPU-32 or MPS Motor Protection	Prevents catastrophic failure due to unhealthy load conditions
Controlled starting through current or tachometer feedback	Provides smooth starts to eliminate belt tearing, water hammer, or other damage to load
Continuously-rated SCR and power module	SCR is not bypassed during running conditions providing longer useful life in heavy-duty applications

Typical Applications

- Pumps, fans, centrifuges, and other high-inertia loads
- Multiple-motor conveyor drives
- Heavy-duty use

SEL-PTO GROUND-FAULT PANEL

Power Take-Off Panels

Description

The Littelfuse Startco SEL-PTO is a custom product that typically incorporates the SE-105/SE-107 Ground-Fault Ground-Check Monitor, overload protection, breaker, motor starter, and door-mounted indication into a rugged wall-mount or free-standing enclosure. The SEL-PTO offers a convenient way to connect portable equipment to an electrical distribution system.

Typical Applications

The Littelfuse Startco SEL-PTO can be used in any installation that uses portable cables. The SEL-PTO can also be used by a main supply to add overcurrent protection and NGR monitoring.

Features & Benefits

FEATURES	BENEFITS
Overload protection	To detect unhealthy conditions and prevent catastrophic equipment failure
SE-105/SE-107 Ground-Fault Ground-Check Monitor	To protect portable trailing-cable fed equipment; meets CSA M421-00
Combination starter	With the use of a ground-check relay, provides remote start / stop capabilities to control mobile electric equipment

CUSTOM BUILDINGS

Electrical/Modular Buildings & Substations

Description

Electrical/Modular Buildings for:

- Motor Controls
- Switchgear
- PLCs
- Substations
- Monitoring Equipment
- Etc.

Substations

- Fixed
- Portable (skid/wheel/trailer)

Key Features of Building Design

- 10 gauge steel walls
- Continuous welding—max strength, no water entry for rust
- Inside walls as required
- Insulation to spec
- All 3-D designed

OVERVIEW

For More Information...
and to download our
Protection Relay Overview, visit
www.littelfuse.com/technicalcenter

Active Power–Measured in kW. In a diesel generator application, it is the power produced by the engine.

Alarm Level–A setting on a protection relay at which an LED or output contact operates.

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

Analog Output–A discrete, 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.

Apparent Power–The vector sum of the active and reactive power.

Asynchronous Motor–A motor in which the speed of the rotor is not the same as the connected system frequency.

Auxiliary Generator–Creates the main power supply on a ship. Usually driven by diesel engines and in some cases by gas engines or turbines.

AVR (Automatic Voltage Regulator)–The voltage regulator will control the alternator voltage and keep it at set point (e.g. 400 V). The AVR often includes a remote voltage setting input. Via this input the voltage set point can be adjusted by external equipment such as reactive load sharers or power factor regulators.

Base Load–An operational mode of generators running in parallel with the utility. In this mode, a fixed amount of load is being generated, while local load fluctuations are being covered by the utility.

Charging Current–System charging current is the current that will flow into the grounding connection when one phase of an ungrounded system is faulted to ground. 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.

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

Core-Balance Current Transformer–See Earth-Fault Current Transformer.

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

CT Verification–A continuous check of CT continuity to verify connection.

CT Saturation–A condition that occurs when a 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. A resulting secondary current could be induced when no ground fault is present; it may lead to the false operation of a protective relay. This could occur if conductors are not centered in a CT window.

CT Saturation Compensation–A feature in which a protective relay can recognize that a CT is saturated and compensate for the condition in order to maintain service.

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

DFT–See Discrete Fourier Transform.

Differential Module–An accessory for the MPU-32 Motor Protection Relay and MPS Motor Protection System to add phase-differential protection.

Digital Harmonic Filter–The use of digital signal-processing techniques such as a discrete fourier transform to eliminate the measurement of harmonic components. With regard to ground-fault detection, this allows for a setting below the background noise level.

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

Droop–See Speed Droop and Voltage Droop.

Earth Leakage–See Leakage Current.

Earth-Fault Current Transformer–A current transformer used to measure low-level ground-fault current.

Fail-Safe Mode (also known as Undervoltage or UV)–An 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–A current that flows when a phase conductor is faulted to another phase or ground.

Feeder–All circuit conductors between the service equipment or other power-supply source and the load or branch-circuit overcurrent device.

Feeder Protection–Overcurrent or overvoltage devices installed on a feeder circuit to interrupt the supply in the event of a fault.

Flux Conditioner–A ring of magnetically permeable material inserted in an earth-fault current transformer window; used to reduce local saturation.

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).

Governor–The governor or speed regulator will keep the speed of the engine at set point (i.e. 1500 rpm). In generator application the governor often includes a remote speed setting input. Via this input the speed set point can be adjusted by external equipment such as synchronizers or load sharers.

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–A circuit that includes a ground-check conductor, a ground-check termination device, and a ground conductor.

Ground-Check Termination–A device installed at the load end of a ground-check loop.

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

Ground Fault–An unintentional contact between a phase conductor and ground or equipment frame. The words "ground" and "earth" are used interchangeably.

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

Ground-Fault Current Transformer–See Earth-Fault Current Transformer.

Ground-Fault Relay–A protection relay designed to detect a phase-to-ground fault on a system and trip or alarm when the condition exceeds its pickup setting for longer than its time delay.

Ground-Fault Protection–The use of a ground-fault relay or indication system in order to interrupt the supply or alarm personnel in the event of a ground fault.

Ground Reference Module–A resistor network that limits ground-fault current and provides a system reference for 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-grounding resistor 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 isolate system voltage from a protective relay.

I^2t (I squared t)–Thermal capacity, or used thermal capacity. With regard to 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 the IEEE. This numbering system is used on connection diagrams, in instruction literature, 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 megaohms (MΩ). Insulation resistance change can be monitored to predict failure.

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

ISO Correction–Performed in engine diagnostics to be able to compare measurements taken under different environmental conditions. For this, the atmospheric data is collected together with the measurements on the engine.

Isochronous Mode–Generators can operate in droop mode or isochronous mode. Isochronous mode means there is no droop (0%) and the generator speed remains constant regardless of generator load.

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 **L**ong-time, **S**hort-time, **I**nstantaneous overcurrent, and **G**round-fault protection; a term often used to describe protection required for a power-distribution feeder, or a protection relay with these functions.

Motor Protection–Technology designed to ensure that a motor operates within its rated thermal capacity in order to maximize its service life.

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

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

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

Non-Fail-Safe Mode (also known as Shunt Trip or SH)–An 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 Mode.)

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

Nuisance Trip–A false operation of a protective relay.

Peak Shaving–An operational mode of generators running in parallel with the utility. In this mode, a fixed amount of load is being either imported from, or exported to, the utility, while local load fluctuations are being covered by the generators.

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. With regard to 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 low-level winding-to-winding and winding-to-ground failures in an AC motor.

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

Power factor (cosϕ)–The relation between the active power [kW] and apparent power [kVA].

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. 500 A of primary current flowing through the CT will produce 5 A of current out of the secondary terminals.

Pulsing Ground-Fault Systems–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). This technique is used to locate ground faults by tracing the pulsing ground-fault current to the source of the fault.

Online or Offline Monitoring–Monitoring system parameters such as insulation integrity when the system is energized or de-energized, respectively.

Open-CT Hazard–An open-circuited CT secondary which can develop a dangerously high voltage when primary current is present.

Reactive Power–Measured in kVAR. The power used for magnetization of asynchronous alternators, motors and transformers, coils etc. The amount of reactive power has no effect on the torque of the prime mover (e.g. diesel engine). Therefore the reactive power has no effect on the engine. It is however very important for the alternator, as the total load on the alternator is the vector sum of active and reactive load.

Relay (1)–An electrical switch that opens and closes a contact (or contacts) under the control of another circuit. Typically an electromagnet.

Relay (2)–A device that receives inputs, compares them to set points, and provides outputs based upon that comparison.

Relay Operating Mode–Method of operation used for undervoltage or shunt-trip breakers. (Also see **Fail-Safe Mode, Non-Fail-Safe Mode**.)

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**.)

Reverse Power–An active power [kW] fed into a generator that thus is working as an electric motor, turning the prime mover. As this would damage the prime mover (e.g. an internal combustion engine), reverse power relays are used in applications where generators run in parallel with each other or with the utility. These relays detect the amount and direction of the power, and in case of excessive reverse power, disconnect the generator breaker.

Ride-Through Time–The amount of time a protection relay can maintain operation during a supply voltage loss.

RTD (Resistance Temperature Detector)–A device that experiences a linear change in resistance with a change in temperature. It is 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-level ground-fault current.

Shaft Generator–Coupled to, and driven by the main propulsion engine on a ship. Advantage of this setup is reduced fuel consumption than what could be achieved with auxiliary engines. Even though a ship has a shaft generator it still needs auxiliaries as well.

Solidly Grounded System–An electrical system in which the neutral point of a wye-connected supply transformer is connected directly to ground. (Also see **Resistance-Grounded System, Ungrounded System**.)

Speed Droop–The frequency reduction between no-load situation and operation, and full-load in generator applications. A typical droop adjustment is 3%.

Synchronous Generator–A generator in which the rotor speed is the same as the connected system frequency.

TDC (Top Dead Center)–The position of the piston when it is farthest from the crankshaft in a reciprocating engine.

TDC Correction–Used to find the exact TDC position. To do this, it is necessary to compensate for the elastic twist in the crankshaft and the delay in the indicator valve.

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

Trailing Cable–A power cable used to supply electrical power to mobile equipment. They typically contain three phase conductors, two ground conductors, and a pilot wire (also known as a ground-check conductor).

Trip Level–A setting on a protection relay at which an LED or output contact operates.

Trip Relay Contact–An output of a relay that acts as a switch and is typically connected to an undervoltage-release or shunt-trip coil of a circuit breaker.

Trip State–The state of the output contact 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 of the system is intentionally grounded, such as a delta-connected supply transformer.

Voltage Droop–The voltage reduction between no-load situation (reactive loads [kVAR]) and operation, and full-load in generator applications. A typical droop adjustment is 3%.

Zero-Sequence Current Transformer–See **Earth-Fault Current Transformer.**

I. INTRODUCTION TO PROTECTION RELAYS

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.

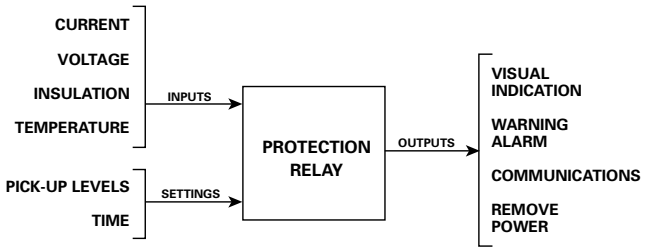


FIGURE 1

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-based or electronic relays 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-based 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 wear, 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 common practice 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 the 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 contaminated 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

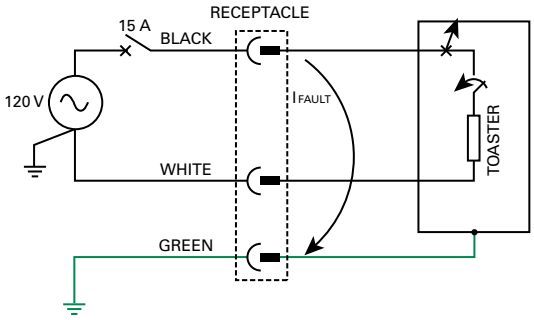


FIGURE 2

As an 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 through 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 10 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.

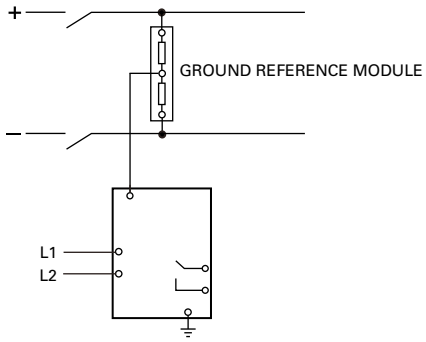


FIGURE 3

Ungrounded AC Systems

Ungrounded AC systems, 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.

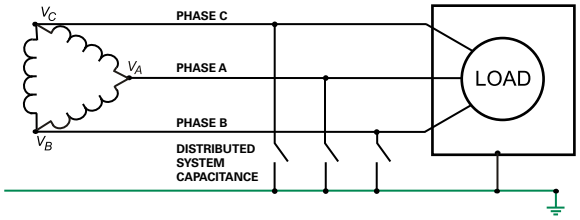


FIGURE 4

- 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 on 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.

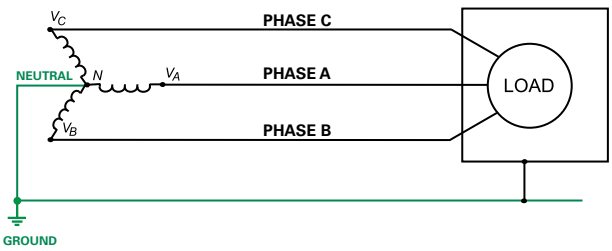


FIGURE 5

- 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.

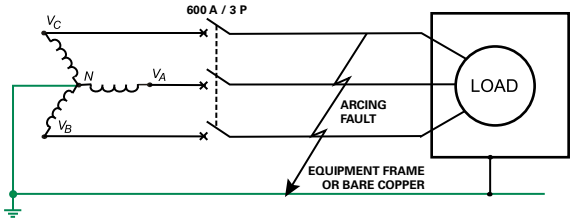


FIGURE 6

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).

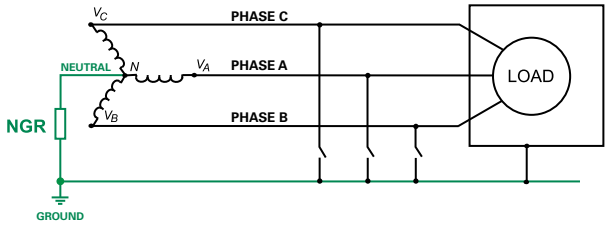


FIGURE 7

- 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 current 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 current can be used to locate ground faults when ground-fault current is ≤10 A. Pulsing current 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 feeder from service upon the detection of 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, neutral-grounding resistors are typically rated for 25 A or more, and ground-fault current 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*.

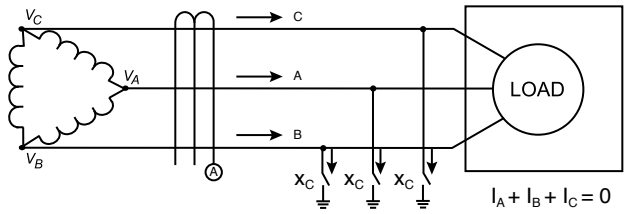


FIGURE 8

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.

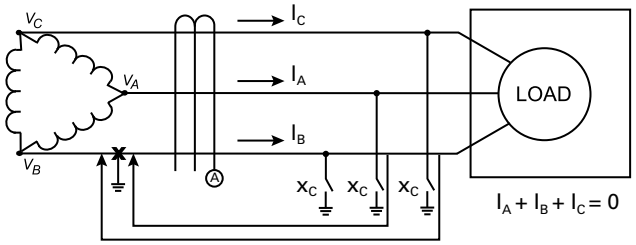


FIGURE 9

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.

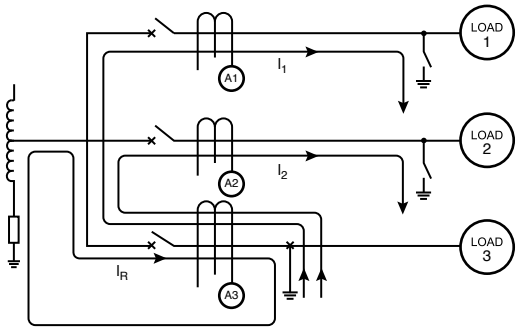


FIGURE 10

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 largest feeder charging current and multiply the operating value by an acceptable tripping ratio. Use the greater of this value or system charging current and select the next-largest available standard let-through current rating.

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.

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.

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 inexpensive devices installed between the stator windings during manufacturing and may be included on motor-end bearings.

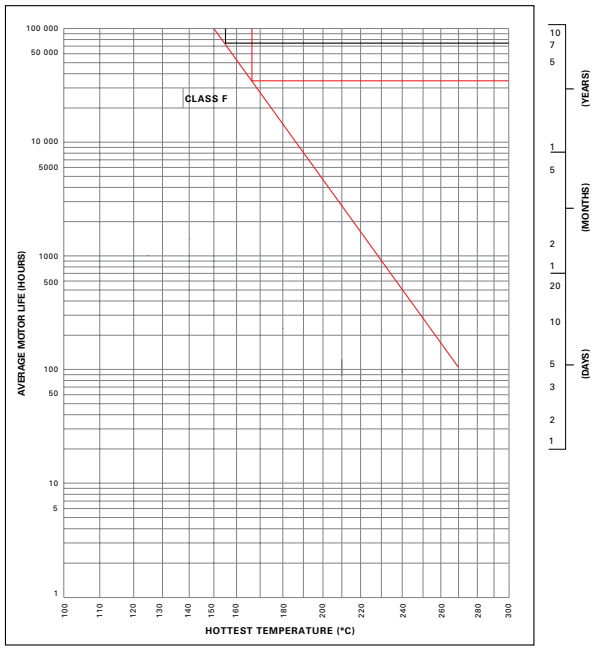


FIGURE 11

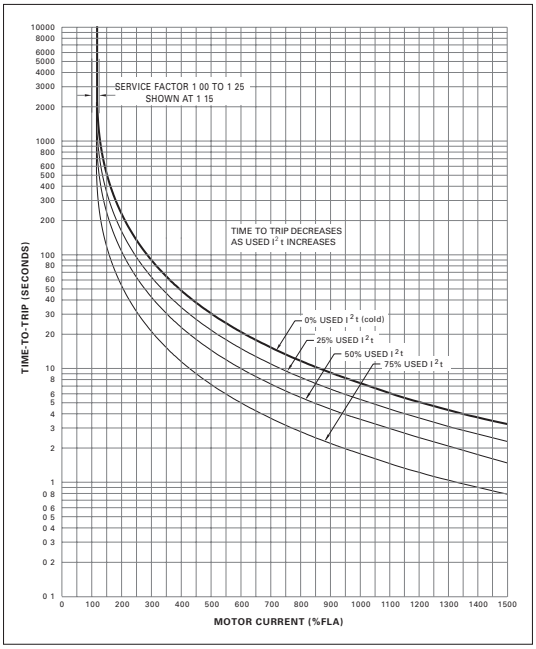


FIGURE 12

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 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 higher-end motor protection relays. Voltage protection can be used proactively to inhibit a start.

Ground Faults

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

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

High-Resistance Winding Faults

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

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

Current and Voltage Imbalance, Phase Loss, Phase Reverse

Older motor protection devices 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 to 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.

Arc-Flash Protection

The Consequences of Arc Flash

Arcing and arc flashes are uncontrolled, intense, luminous discharges of electrical energy that occur when electric current flows across what is normally an insulating medium. The most common cause of arc faults is insulation failure. These failures may be caused by defective or aging insulation material, poor or incorrect maintenance, dust, moisture, vermin, and human error (touching a test probe to the wrong surface or a tool slipping and touching live conductors).

Arc-Flash events are dangerous, and potentially fatal, to personnel. According to OSHA, industrial Arc-Flash events cause about 80% of electrically-related accidents and fatalities among qualified electrical workers. Even if personnel injuries are avoided, Arc Flash can destroy equipment, resulting in costly replacement and downtime.

Arc-Flash Safety Standards

NFPA 70E, Handbook for Electrical Safety in the Workplace. outlines the practices and standards that companies should follow to protect workers and equipment from Arc Flash and other electrical hazards. It specifies practices designed to make sure that an electrically safe work condition exists. In Canada, CSA Z462, Workplace electrical safety, specifies safe workplace practices. There are also various provincial regulations pertaining to electrical safety.

The NFPA 70E and the CSA Z462 hold both employers and their employees responsible for creating a workplace for electrical workers that is not just safe but puts in place the best possible processes and procedures that are fully understood, practiced and enforced for optimal results. Using Arc-Flash relays is one way to protect the functional reliability of the distribution board and at the same time comply with the requirements of NFPA 70E and CSA Z462.

Arc-Flash Mitigation

NFPA 70E goes into great detail on procedures to avoid electrical shock and Arc-Flash events. Sometimes, though, it's necessary to work on live circuits. For these cases, NPFA 70E specifies approach distances and use of personal protection equipment (PPE).

Current limiting fuses or current-limiting circuit breakers help protect against arc flashes. They allow only a certain amount of energy to pass before they open a circuit. Because an Arc Flash can draw a fraction of bolted-fault current, circuit breakers cannot be relied upon to distinguish between the arcing current and a typical inrush current.

High-resistance grounding (HRG) is another technique for protecting against arc flashes. If a phase faults to ground, then the resistance limits current to just a few amps; not enough to cause downtime by tripping the overcurrent protection device, and not enough to allow an Arc Flash. It is important to remember that while resistance grounding prevents Arc Flash from phase-to-ground shorts, it has no effect on phase-to-phase shorts.

Another way to mitigate the dangers of arc flashing is by redesigning the switchgear. Switchgear cabinets can be designed to contain and channel energy away from personnel during an Arc Flash.

Arc-Flash relays

Arc-Flash relays are microprocessor-based devices that use optical sensors to detect the onset of a flash. The sensors are strategically placed in various cubicles or drawers inside the switchboard.

Installing an Arc-Flash relay to rapidly detect developing arc flashes greatly reduces the total clearing time and the amount of energy released through an arcing fault. In turn, there is less damage to equipment and fewer and less severe injuries to nearby personnel.

Arc-Flash Relay Selection Criteria

When selecting an Arc-Flash relay, there are six important criteria:
1. Reaction time
2. Trip reliability
3. Avoidance of nuisance tripping
4. Sensor design and installation
5. Ease of use

Reaction Time

Since light is the earliest detectable indication that an Arc Flash is occurring, Arc-Flash relays use optical light sensors to detect the arc that is forming. The output of the light sensor is hard-wired to the Arc-Flash relay, which trips a circuit that interrupts the energy supply in the Arc.

The response time of an Arc-Flash relay is approximately 1-5 ms at light intensities of about 10,000 lux or higher. Within that timeframe, the optical sensor output can actuate a switch or circuit breaker to cut off current feeding the arc. The overall current clearing time depends on the protection strategy used and the performance of the external switch or circuit breaker used. The breaker will typically take an additional 35-50 ms to open, depending on the type of breaker and how well it is maintained.

The electronic output to turn on is a function of the type of output relay used. Solid-state outputs (for example, insulated gate bipolar transistors (IGBTs)) are much faster than electromechanical relays and can operate within 200 microseconds.

Trip Reliability

Reliable tripping is the most important characteristic of an Arc-Flash relay, because this ensures mitigation of an arcing fault. Two aspects of reliability should be considered: trip redundancy and system-health monitoring.

Redundant Tripping. Arc-Flash relays should offer a redundant tripping feature, which means it has both primary and secondary trip path logic. The primary path is controlled by the internal microprocessor and its embedded software, and works by activating the coil of the primary trip relay.

The redundant path typically uses a discrete solid-state device that does not go through the microprocessor. Any failure in the primary (microprocessor) path will cause the unit to automatically switch to its redundant path, which activates a shunt-trip relay without delay when a sensor input is above the light detection threshold.

An often overlooked advantage of a solid-state trip path compared to a microprocessor-based circuit is the reaction time when the relay is first powered up. Wiring mistakes, tools left in hazardous locations, and the regular stresses of powering up all contribute to the risk of an Arc Flash on power up. A microprocessor can require 200 ms or more before it is able to start scanning the optical sensors. However, a solid-state trip path can detect an Arc and send a trip signal in as little as 2 ms. In addition, there are fail- safe features that alert operators when, for example, the microprocessor fails.

Health monitoring. Health monitoring makes sure the system is in good operating condition and should extend from the light sensors to the output of the Arc-Flash relay trip circuitry. Health monitoring starts on the sensors. A signal is sent from the relay to the light sensors, where a test light is detected by the sensor and sent back to the relay. In the case of a fiber-optic sensor, this also verifies the entire length of the fiber is not pinched or broken. On-sensor health indication is critical in preventing maintenance work on equipment where protection is not working. It also has the added benefit of providing rapid fault location.

Following the path of a trip signal from the sensor, internal monitoring must also include the primary and redundant trip circuit. Low voltage across the IGBT indicates a wiring fault or an error in the trip coil, and a high voltage is a sign of an error in the IGBT switch, both of which are also reported and logged. The IGBT is also thermally protected against overloads, and will turn off if it overheats. However, the thermal protection has a 100 ms delay before acting, meaning that even a dangerously overheated coil will attempt to signal a trip before resuming thermal protection.

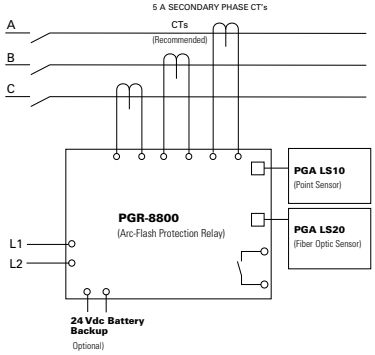
Avoidance of Nuisance Tripping

A typical Arc-Flash Relay system has an integrated three-phase current measurement function that detects and reacts to short circuit and overcurrent conditions. Although this is not a requirement for the system to operate, this option will increase the reliability of the system (minimize unwanted tripping).

If the microprocessor logic receives an input from a light sensor, it checks for a rapidly rising input from the current transformers. Two conditions need to be fulfilled before the trip is sent to the circuit breaker: a certain current flow that exceeds the normal operating current of the system (the threshold level is adjustable from 10-1000% of the full load current) and a signal from the arc-flash sensor, implying that the sensor has reacted to a high-intensity light source.

Sensor Design and Installation

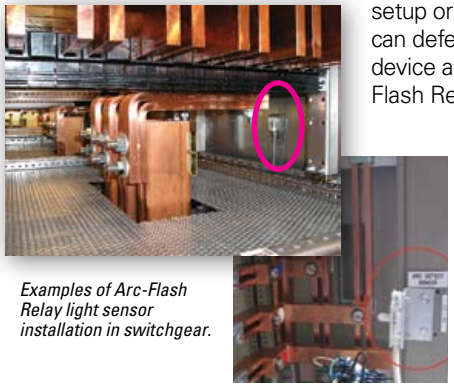
Arc-Flash relay installations utilize multiple fixed-point light sensors near vertical and horizontal bus bars where arcing faults are apt to occur in feeder switchgear cabinets. Sufficient numbers of sensors should be installed to cover all accessible areas, even if policy is to only work on de- energized systems. At least one sensor should have visibility to an arc fault if a person blocks another sensor's field of view. Light sensors may also be installed in other electrical cabinets and on panels that are subject to routine maintenance and repairs.



A fiber-optic sensor, which have a 360° field of view for detecting light, allows more flexible positioning of the light sensing locations, as the fiber-optic strands can be looped throughout an enclosure or panel to cover challenging component layouts.

Easy to Use Hardware and Software

Another important factor to consider is ease of use. Some relays may require field assembly, calibration, or advanced configuration before installing. It is critical to consider those extra steps and the capabilities of the operators who will be using the devices. Often, very complicated devices can be misused because of incorrect setup or configuration, which can defeat the purpose of the device altogether. A few Arc-Flash Relays have software that provides event logging. To make troubleshooting easier, this software should record the specific sensor that initiated the fault in the data records.



Examples of Arc-Flash Relay light sensor installation in switchgear.

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 current in its primary circuit.

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 1*. 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.

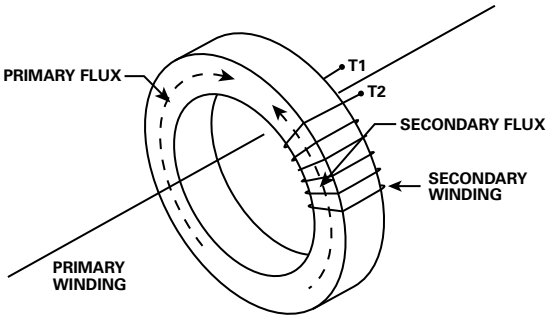


FIGURE 1

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):

$P = I^2 Z_T$

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

Solving for the maximum lead resistance (Z_W):

$Z_T = Z_W + Z_B$

$Z_W = 0.05\text{-}0.01 = 0.04\ \Omega$

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 in *Figure 2*, 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.

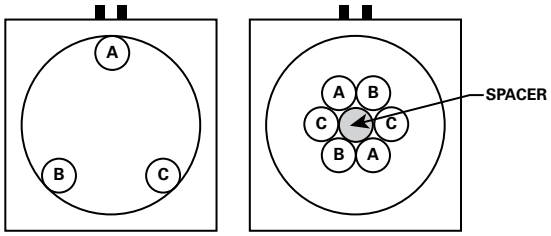


FIGURE 2

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.

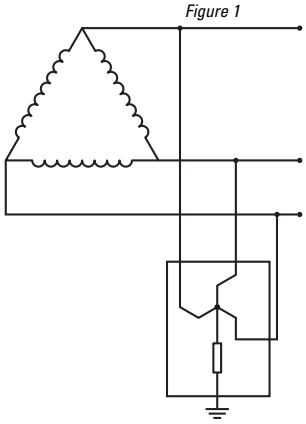
IV. RESISTANCE-GROUNDING CONVERSION

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 faults are the most common safety issues with ungrounded systems.)

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

Figure 1



Design Note 1: A zigzag conversion requires a three-phase connection to the existing power system, typically at the main transformer or switchgear. See *Figure 1*.

Design Note 2: The resistor let-through current must be greater than the system capacitive charging current *(see Section I).*

Design Note 3: Protection, coordination, and annunciation systems depend on the integrity of the NGR. NGR monitoring with an SE-330 or SE-325 is recommended.

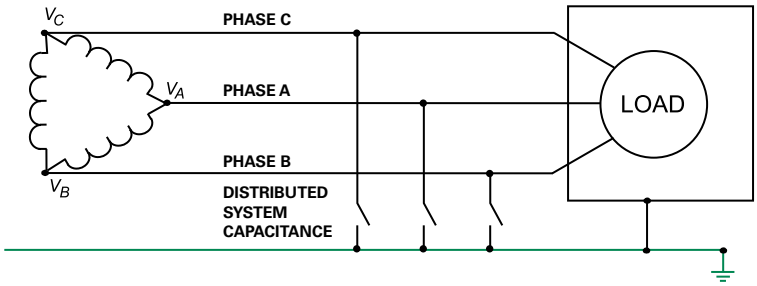
UNGROUNDED SYSTEM

Advantages

- Operation possible with one faulted phase

Disadvantages

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



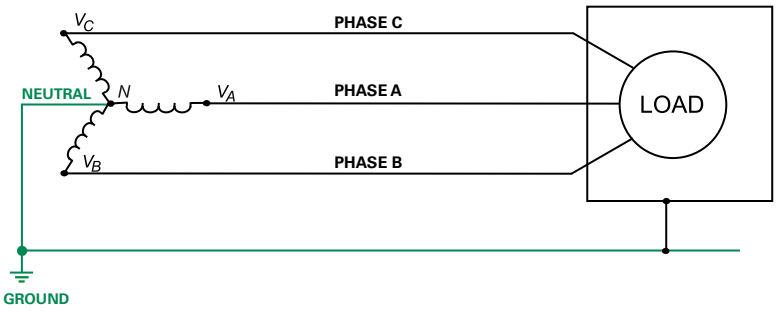
SOLIDLY GROUNDED SYSTEM

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



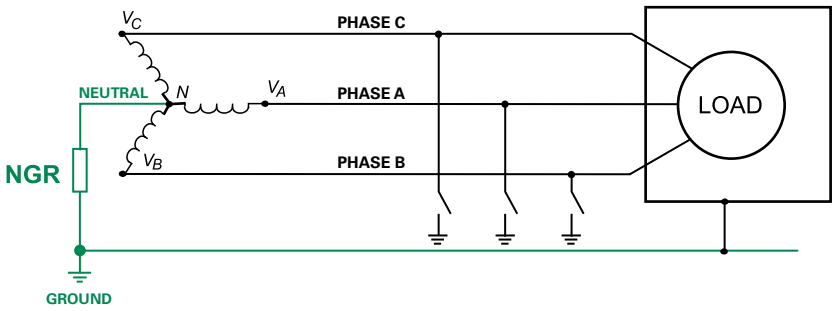
RESISTANCE-GROUNDED SYSTEM

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



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 shutdown procedure. (Ground faults are estimated to be 98% 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.

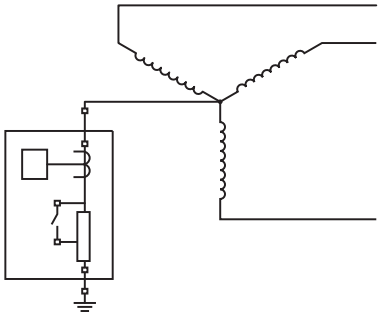


Figure 2

Design Note 1: An NGR conversion for a solidly grounded 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 typically cannot be distributed due to its potential rise 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. Monitoring with an SE-330 or SE-325 NGR Monitor is recommended.

V. GENERATOR CONTROL

Synchronizing

To connect a synchronous alternator to a live bus bar in an AC system, the following conditions have to be satisfied:

- Voltage difference of incoming generator and bus bar must be within acceptable limits
- Frequency difference of generator and bus bar must be within acceptable limits
- There must be phase accordance between generator and the bus bar
- Phase sequence must be the same (Same phase rotation)

Voltage Adjustment

The voltage of the generator is controlled by the AVR (Automatic Voltage Regulator) of the alternator. This device compares the alternator voltage with a set point and adjusts the voltage accordingly. The AVR controls the alternator voltage by controlling the excitation of the alternator.

Some synchronizing systems allow voltage matching. A synchronizer with voltage matching gives a remote voltage set point to the AVR. The advantage of this is that such a system can synchronize to a bus bar that runs with a slightly different voltage than adjusted on the AVR.

Frequency Adjustment

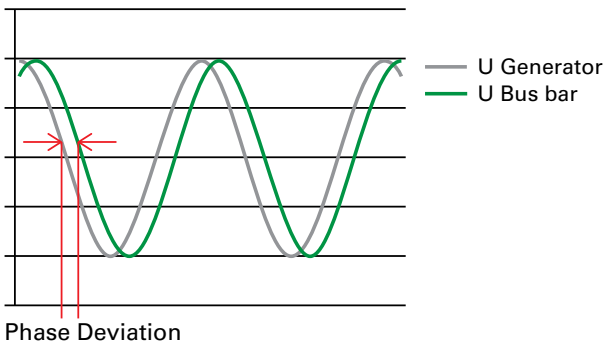
The frequency of the generator is controlled through the speed of the prime mover (e.g. a diesel engine or a turbine).

The speed of the engine is controlled by a governor (speed regulator). The governor compares the engine speed with its speed set point and adjusts accordingly. On a diesel engine this is done through control of the fuel supply.

In order to match the generator frequency according to the bus frequency, the synchronizer gives a remote speed set point to the governor.

Phase Accordance

As the voltages of the synchronous alternator are sinus shaped, it is not enough just to meet speed and voltage. There must be phase accordance as well (phase deviation = 0°).



Phase Rotation

Last but not least, the phase rotation between incoming generator and bus bar must be the same. This is simply a question of correct wiring.

If the us bar phase order is L1, L2, L3, it should be the same on the generator.

There are two different synchronization schemes—static synchronization and dynamic synchronization.

Static Synchronization

Under static synchronization, the prime mover is adjusted so that the difference between generator and bus bar is within a pre-adjusted window, typically max. 0.2 Hz to 1 Hz frequency deviation and max. +/-5˚ to +/-15˚ phase deviation.

Load Sharing

Load sharing typically refers to active load [kW] load sharing unless specified otherwise.

The purpose of load sharing is to make sure that in a generator parallel application, all generators run with the same rating (percentage of their nominal power).

Load sharing between generators is done by controlling the speed of the prime mover through the governor. Each generator gets a load sharer. The load sharer measures voltage (directly or through measurement transformers) and current (through C/Ts) and calculates the power or active current of the generator. It compares the power output of its generator with the power output of the other generators. To do this, it gets a load signal from the other generators either as an analog signal (parallel lines) or through a bus. In case the load of the generator is lower than the load of the other generators, the load sharer gives a speed increase command and vice versa.

It is important to note that while running in parallel, the speed (frequency) of all connected generators is identical. The active load [kW] difference between parallel running generators cannot be seen by their speed, but by the torque on the shaft. In order to keep the frequency constant, it is therefore necessary to decrease fuel supply on the engine that is to reduce load, while the other increases the fuel supply in order to accept more load. This is the job of the load sharers.

When these conditions are met, the breaker is closed. When doing static synchronizing, there is no guarantee that the incoming generator takes load immediately. Typically this type of synchronization is used with electronic governors or ECUs, as they react quickly.

Dynamic Synchronization

In case of dynamic synchronization, the incoming generator is connected at a slightly higher speed than the bus bar frequency. The purpose of this is to make sure the generator takes load immediately.

The speed of the engine is adjusted slightly higher than the bus bar frequency, and as soon as frequency, phase deviation and voltage are within the permitted range, the breaker is closed.

Under dynamic synchronization, it is necessary to observe the circuit breaker make time (the time the breaker needs from receipt of close command until the contacts are closed). This is typically between 50 ms to 300 ms. The close command is then issued earlier (C/B make time) than phase accordance.

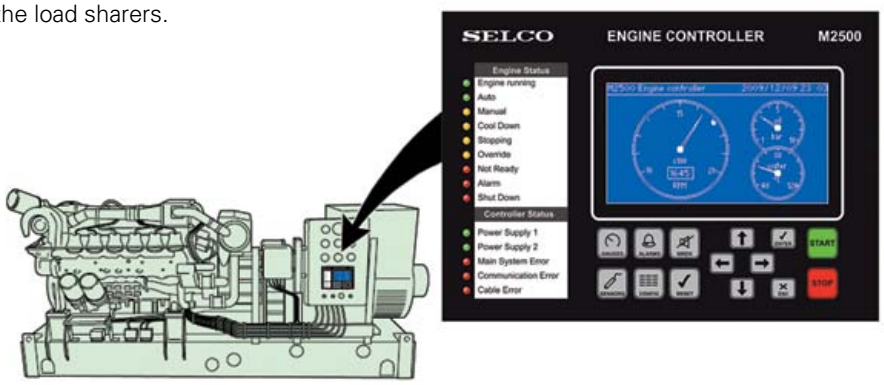
VI. ENGINE CONTROL

Engine Controllers

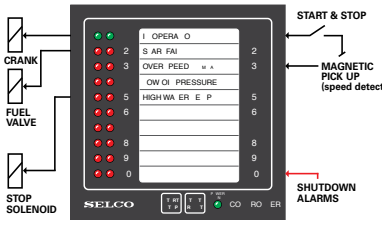
Engine Controllers are used for automatic start, stop and monitoring of internal combustion engines. They offer possibilities for local and remote start and stop.

The start procedure is controlled with regard to crank times, number of start attempts and detection of ignition speed. After startup of the engine, the device will monitor the engine with regards to alarms and shut downs. Alarms are indication only, while shut downs will stop the engine.

Typical alarms are low oil pressure, high cooling water temperature or low cooling water level. Typical shut downs are emergency stop or overspeed (engine turning with too high rpm).



The decision whether an event is to be handled as an alarm or a shut-down depends on the application and the applicable standards and rules. The alarms and shutdowns are monitored through a number of input signals. These can be digital inputs, analog inputs or a bus protocol (typically CAN J1939). Stop procedure is controlled with regard to stop times.



Shut-Down Units

Shut-Down Units are used as safety backup in marine engine applications. The marine classification societies demand the safety system to be independent from the control system (Engine Controller). The shut-down unit will monitor the engine, and in case of an abnormal condition, shut down the engine. Shut-downs are monitored through a number of digital shut-down inputs.

VII. ENGINE DIAGNOSTICS

Maintenance programs for larger internal combustion engines include periodically monitoring the combustion process. This is done by taking pressure readings (Indicator diagrams—Pressure over time) on the individual cylinders and analyzing them. Analyzing the pressure readings alone may give the engineer a good indication of whether the cylinder is performing as expected or not. And if not, it may point the engineer towards what the problem might be.

When both pressure readings and crank angle information is available (EngineEye Advanced and Professional variants) further parameters indicative of the engine performance can be deducted.

Comparing new measurements against historic data makes it possible to detect early signs of wear and plan maintenance.

For a diagram of EnginEye System Components, see page 99.

Measurements

The measurements taken with the EngineEye system, fall into two categories; recorded measurements and live data.

The recorded measurements are kept on the handheld for safe keeping—Even when copied into the PC software. The Pressure over time and MIP measurements are examples of recorded data.

The live data is not stored, but shown live on the display and include cylinder balancing and misfiring.

Pressure Over Time

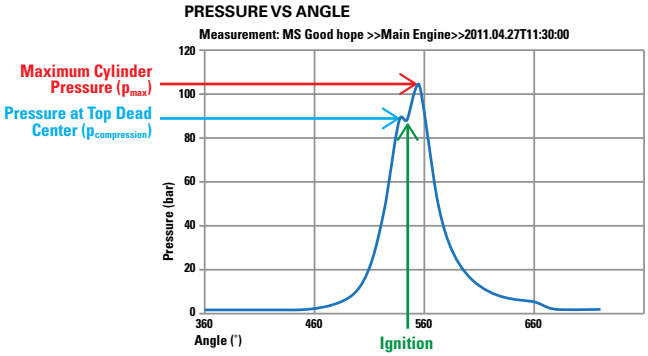
All variants of the EngineEye system, including the Basic variant, are able to record the cylinder pressure over time (p/t – Indicator diagram).

From the pressure curve (Indicator diagram), the operator is able to determine key values like the compression, combustion and maximum pressure for the work cycles that were analyzed. These values together with the general shape of the curve, aids determining the overall condition of the engine.

The figure below shows the presentation of a single cylinder p/t measurement as it appears in the PC analysis software.

MIP measurement (pressure + TDC or crank angle sensor)

When the EngineEye system is installed with a TDC or Crank angle sensor (CAS) it is able to deduct the piston position and present p/V diagrams, also known as the power card diagram. With this information the system is able to calculate the mean indicated pressure (MIP) and the power delivered by the individual cylinders.



The TDC sensor is a low resolution crank angle system with just one pulse over one revolution of the crank shaft indicating TDC of cylinder 1.

The CAS system, on the other hand, is a high resolution system with a much higher number of pulses per revolution. The Actual number depends on the circumference of the CAS belt. The point where the belt is assembled is adjusted such that it marks TDC of cylinder 1. The higher angle resolution results in higher precision calculations.

Analysis of the Measurements—PC Software

The handheld device is connected to the computer via USB, and the measurements are copied to the PC software.

The PC software will calculate the cylinder power for each cylinder and show a comparison of the cylinder pressures for cylinder balancing.

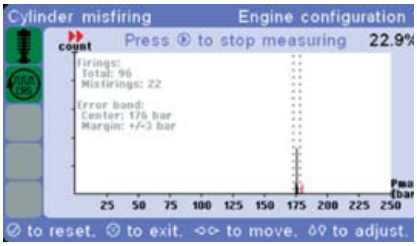
Condition Monitoring

The data provided by the EngineEye can be used for condition monitoring of the engine. Worn off piston rings or problems with the fuel injection can be found at an early stage. Thus the owner can take preventive action and service the engine at a

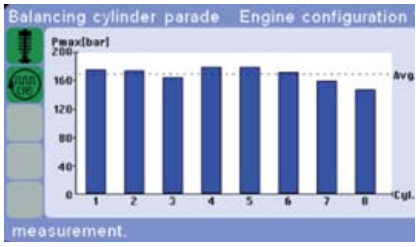
time of his choice, before wear and tear becomes a problem for the reliability of the engine.

Engine Balancing

The data provided by the EngineEye can be used for improving engine efficiency. This is done by so called "Engine Balancing", where the timing of the fuel injection on each cylinder is adjusted.



Cylinder misfire on the handheld display.



Balancing feature on the handheld display.

Balancing the engine makes it run more smoothly whereby the power that was previously lost due to imbalance is instead used for propulsion. Below is an example of a "Cylinder parade" produced by the EngineEye PC software—it is basically the pressure reading of each cylinder put in a queue for comparison.

For engine balancing the engine is adjusted according the measurements. After that the cylinder pressures are measured again and compared with each other. Adjustment and measurement are repeated until the result is satisfactory.

VII. ALARM MONITORING

Alarm monitors are used in many applications where input signals from digital or analog sensors have to be monitored. Applications could be level alarm systems, engine monitoring, pump control and many others.

When designing an alarm system the first question is always what kind of sensors are to be used.

Digital Sensors

Digital sensors are basically on/ off switches (e.g. a level switch). The alarm level is not defined in the alarm monitor, but in the alarm sensor.

Normally Open sensor (NO, Form A):

Normally-open contacts connect the circuit when activated; the circuit is disconnected when the contact is inactive. The input of the alarm monitor is considered active when the sensor connects the circuit.

Normally closed sensor (NC, Form B):

Normally-closed contacts disconnect the circuit when activated; the circuit is connected when the contact is inactive. The input of the alarm monitor is considered active when the sensor disconnects the circuit. This is also called fail safe principle, as a disconnection of the input generates an alarm.

Analog Sensors

Analog sensors do not only give condition information to the alarm monitor like above digital sensors, but they send measurements to the alarm monitor. The alarm level is defined in the alarm monitor.

A wide range of signals exist, such as thermocouples, RTDs , pressure transducers, voltage or current signals. In many cases an intermediate transmitter converts the measurement into some standardized signal like 4-20 mA.

Sensor Monitoring

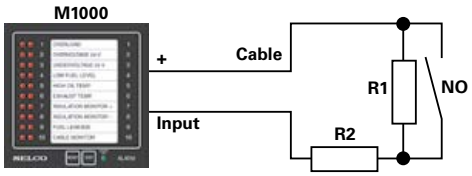
Sensor monitoring is used in order to make sure that the sensor stays connected to the alarm monitor and is healthy.

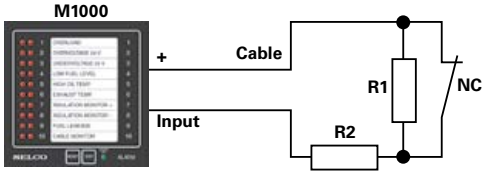
Digital Sensors

With digital sensors this is usually being done by parallel (NO sensor) or serial (NC sensor) resistors. In these applications a small current is flowing from the alarm monitor through the resistor and sensor to sensor reference. In case the sensor gets disconnected, the current is interrupted and the alarm monitor issues a sensor fail alarm. The resistors must be mounted as close to the sensor contacts as possible.

Analog Sensors

When using a 4-20 mA signal, the sensor is monitored through the current signal. In case the current is lower than 4 mA, a sensor fault alarm will be issued. No external resistors are necessary for this.





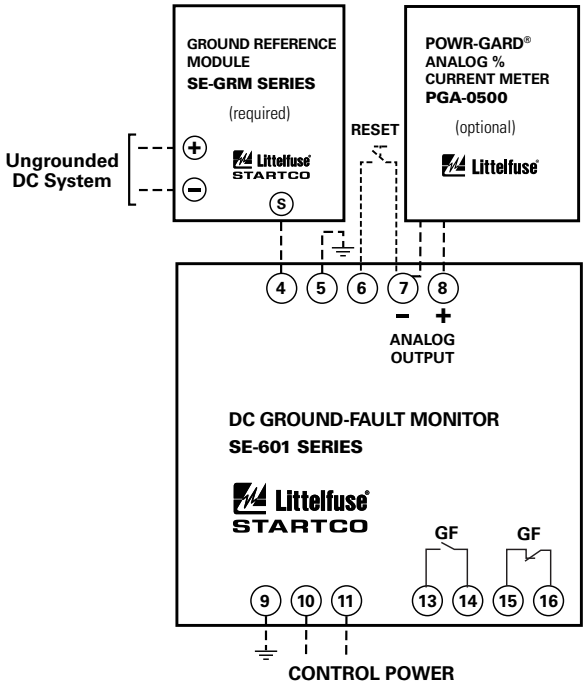
Alarm Monitors/Indicator Panels

Alarm monitors are used in the process. The sensors are directly connected to the alarm monitor. The alarm monitor generates the alarm or the control functions. Alarms must in most cases be manually acknowledged.

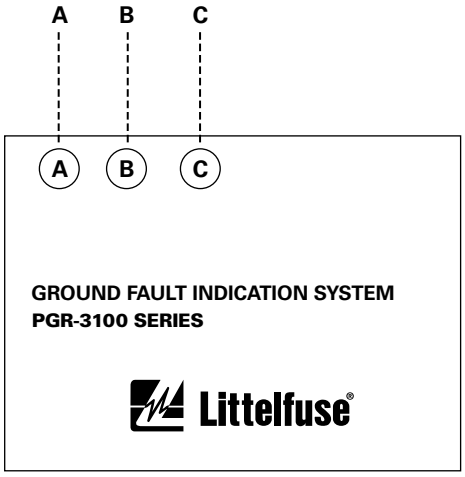
Indicator panels are used for remote indication of alarms. They can be used as slave panels for the alarm monitors. In most cases they only display the input conditions on their front LEDs.

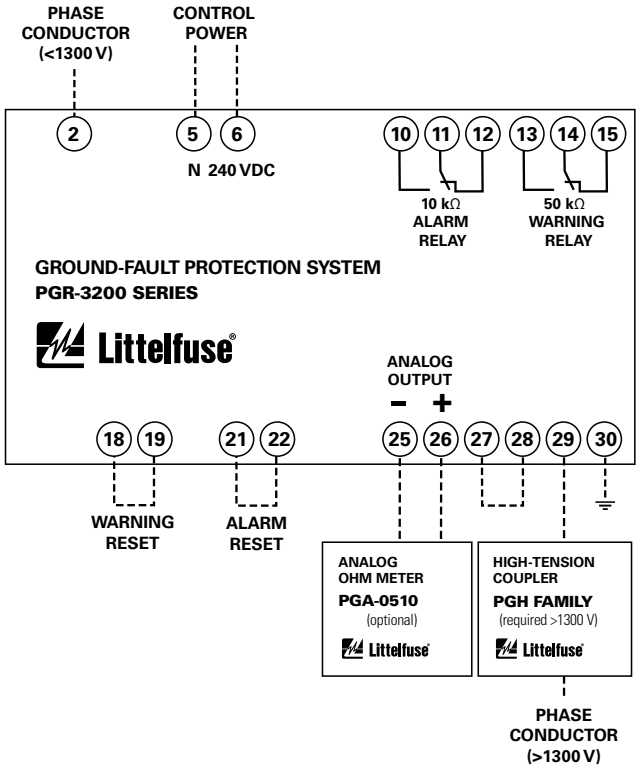
GROUND-FAULT PROTECTION

SE-601
DC Ground-Fault Protection



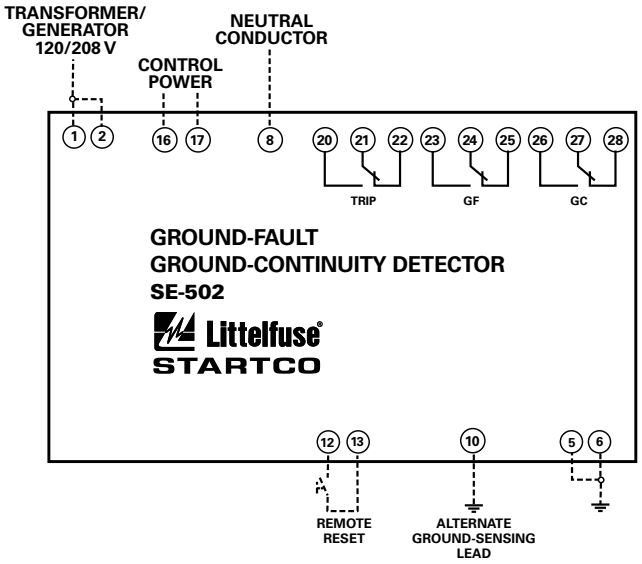
PGR-3100 & PGR-3200
Ungrounded Ground-Fault Detection



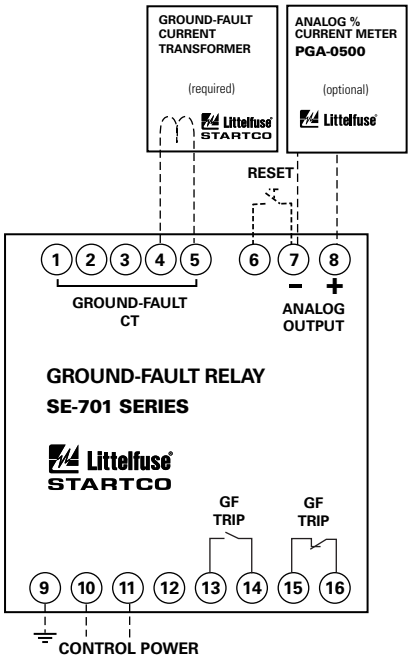


GROUND-FAULT PROTECTION

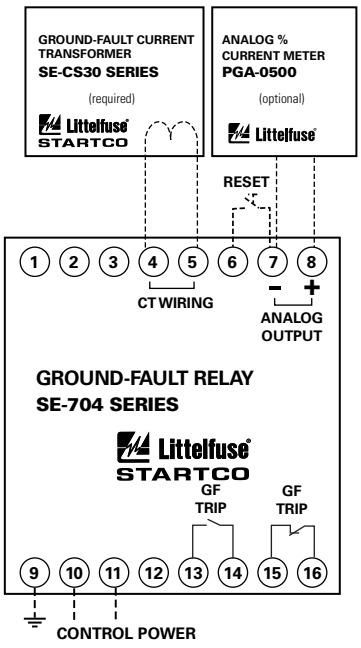
SE-502
Ground-Fault Ground-Continuity Detection



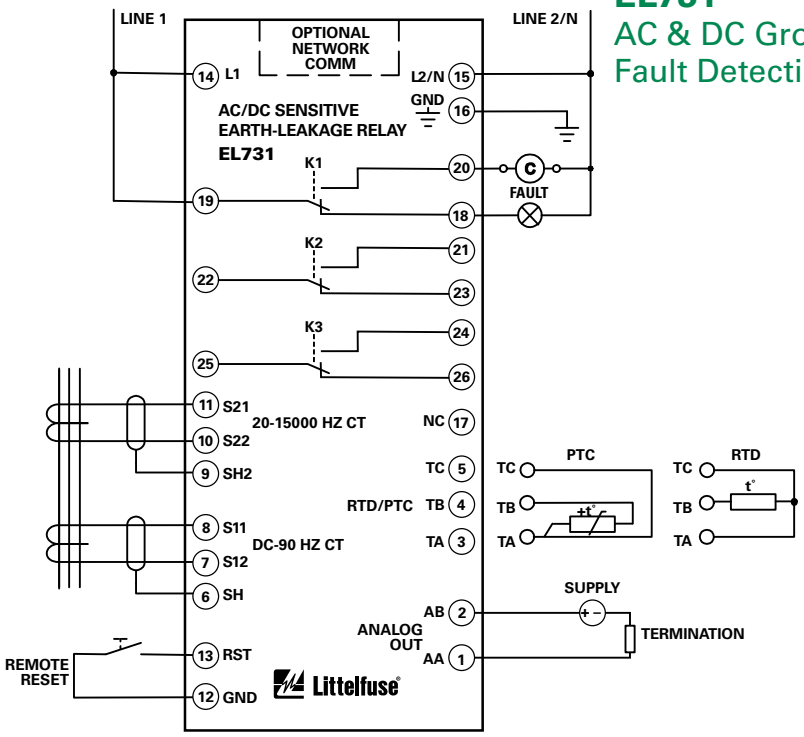
SE-701
AC Ground-Fault Detection



SE-704
AC Ground-Fault Detection



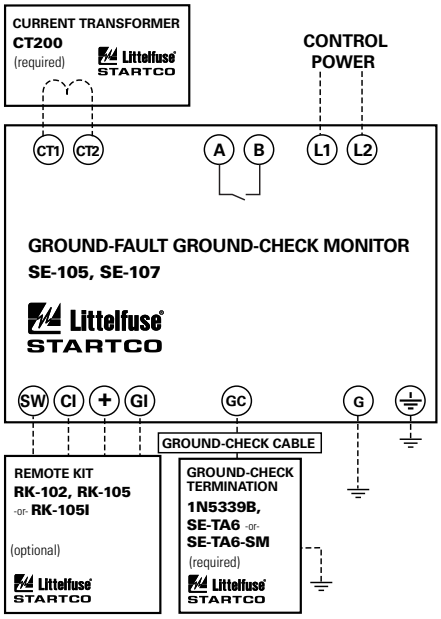
EL731
AC & DC Ground-Fault Detection

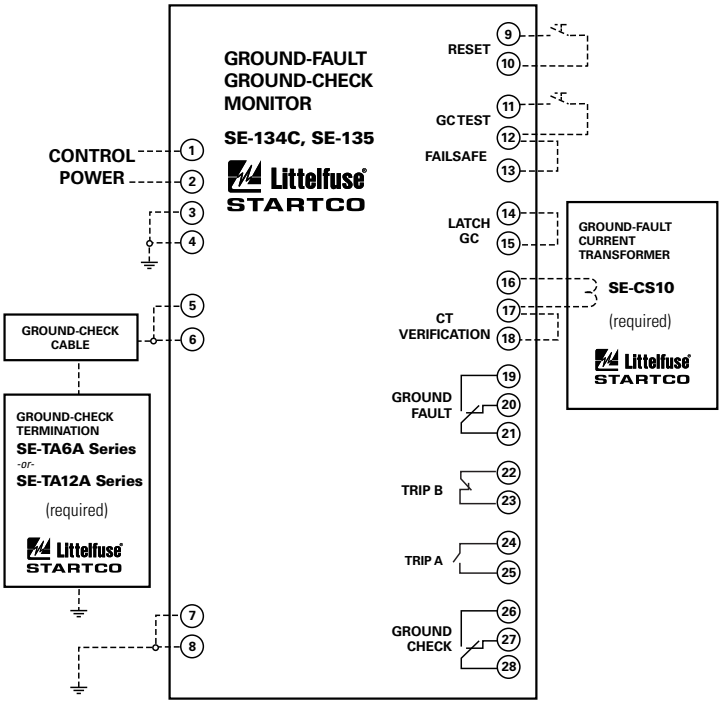


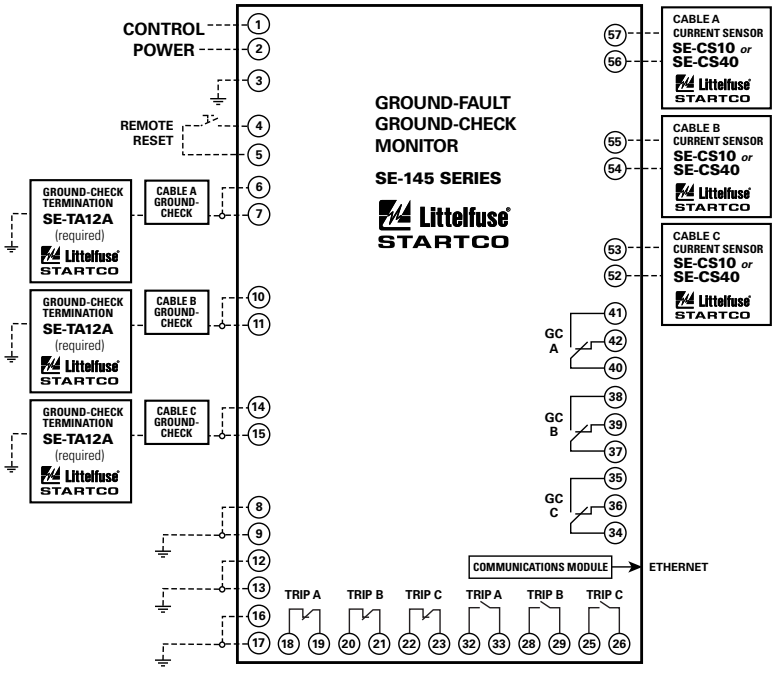
TRAILING CABLE PROTECTION

SE-105 & SE-107, SE-134C & SE-135, and SE-145

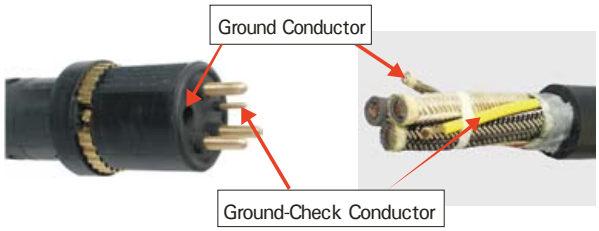
Ground-Fault Ground-Check Montoring





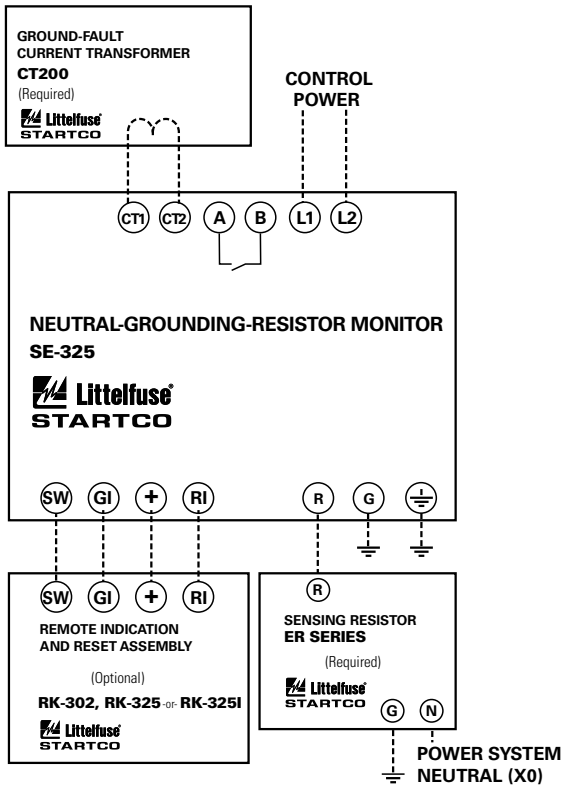


Trailing Cable and Coupler Illustration

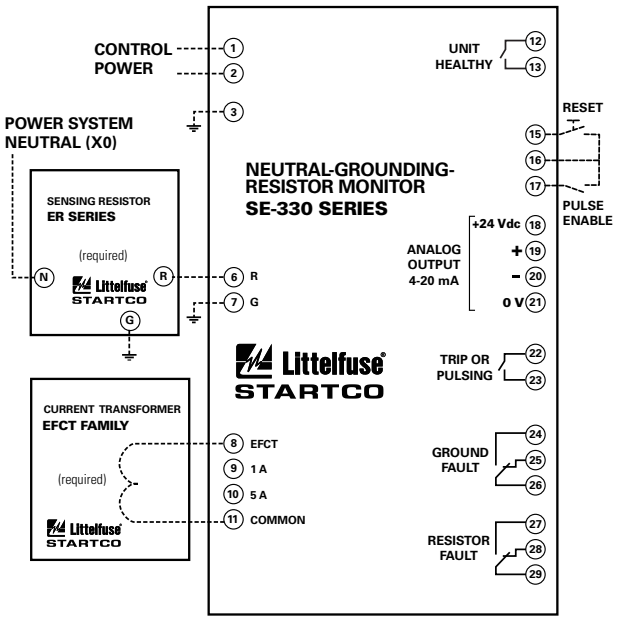


RESISTANCE GROUNDING

SE-325
Neutral-Grounding-Resistor Monitoring

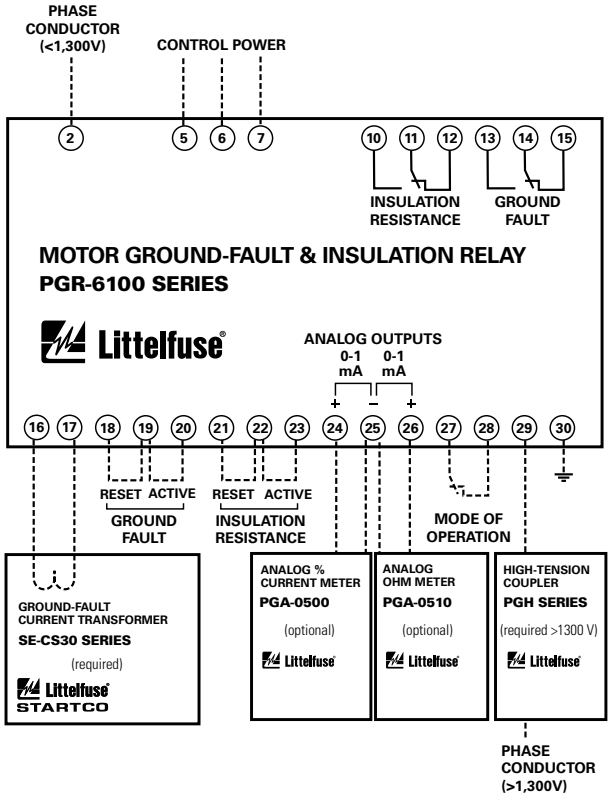


SE-330, SE-330HV
Neutral-Grounding-Resistor Monitoring

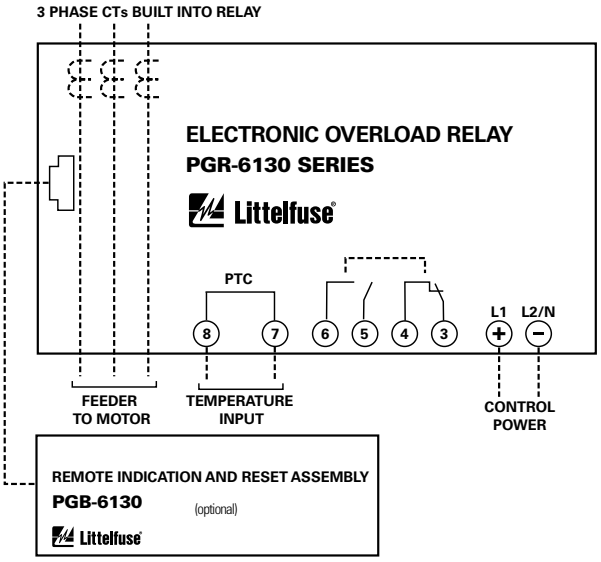


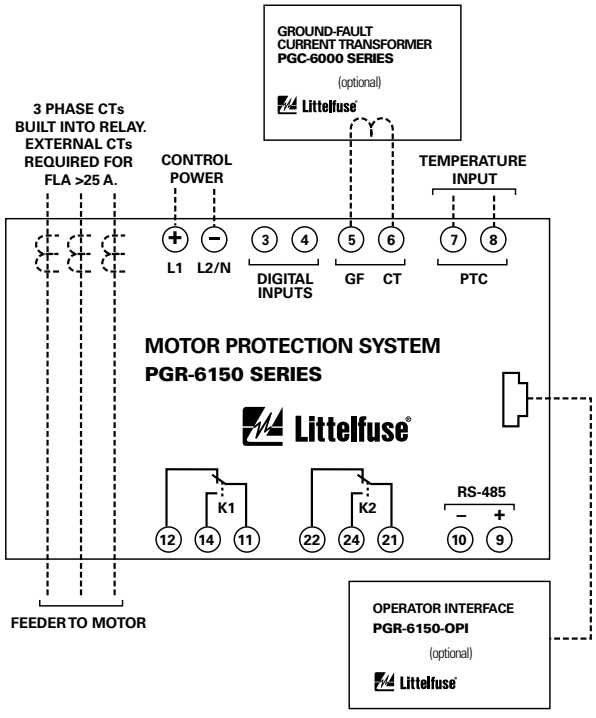
MOTOR AND PUMP PROTECTION

PGR-6100
Ground-Fault Protection and Insulation Montoring



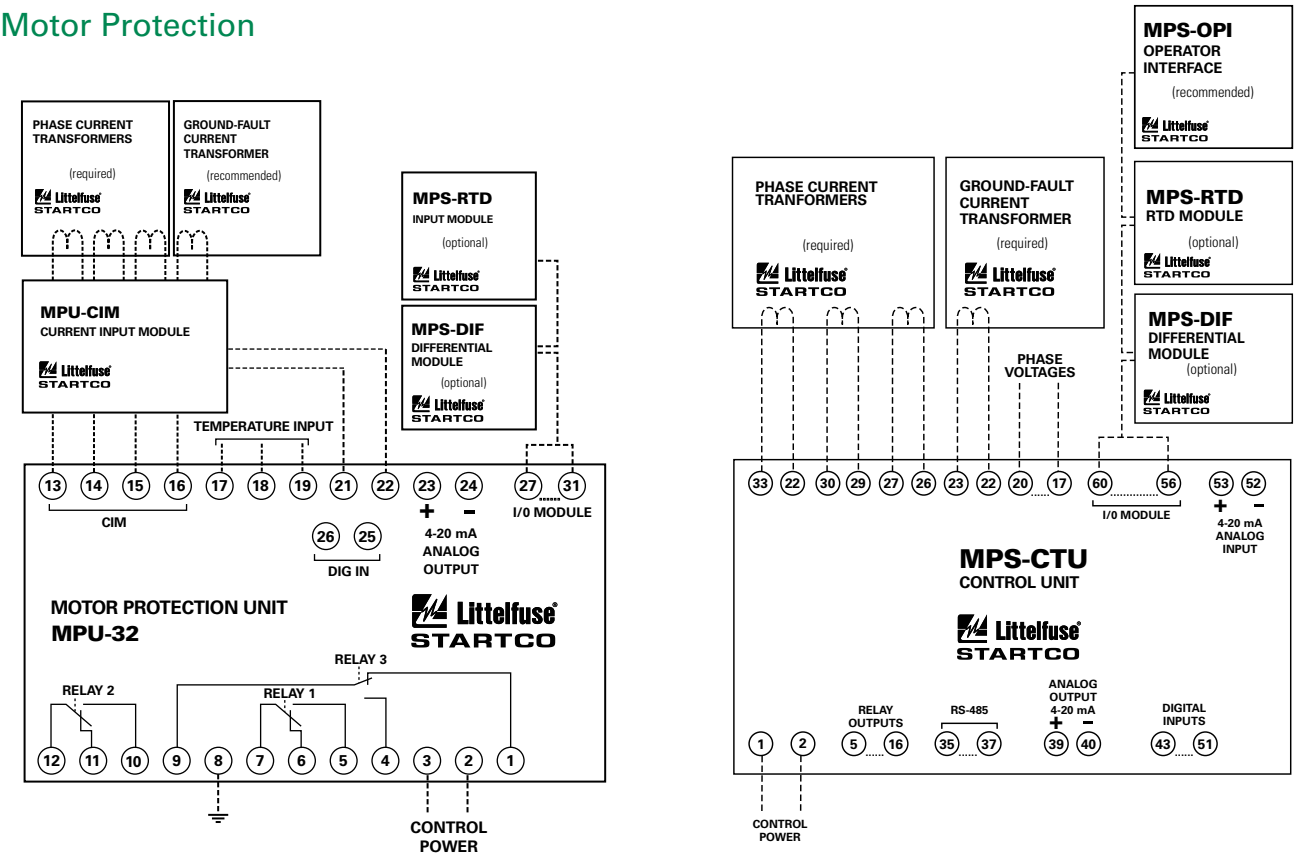
PGR-6130 & PGR-6150
Motor Protection



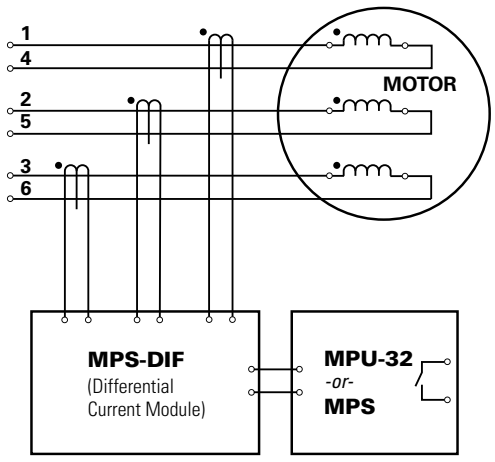


MOTOR AND PUMP PROTECTION

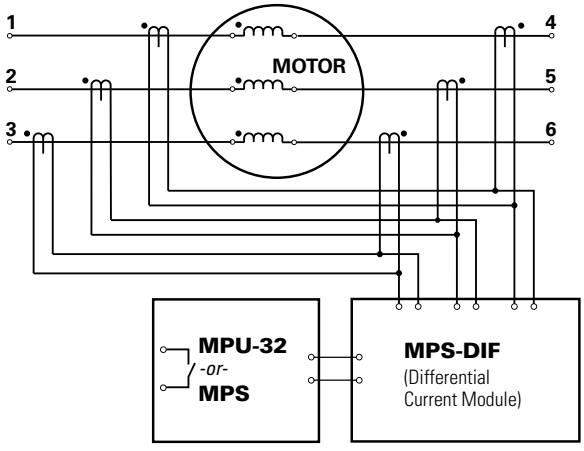
MPU-32 & MPS
Motor Protection



Motor Differential Protection



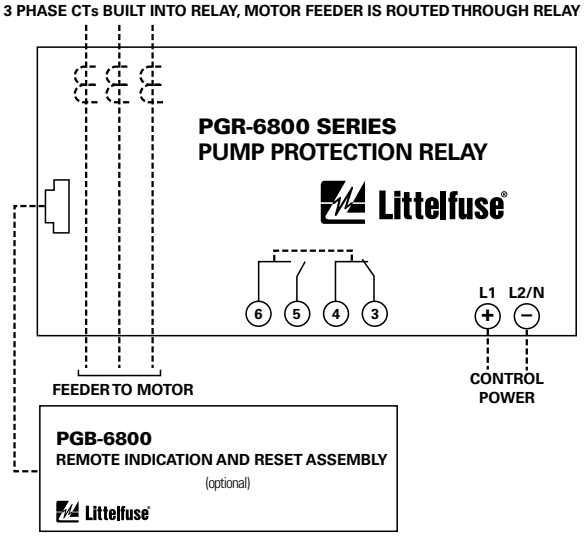
CORE-BALANCE CONNECTION



SUMMATION CONNECTION

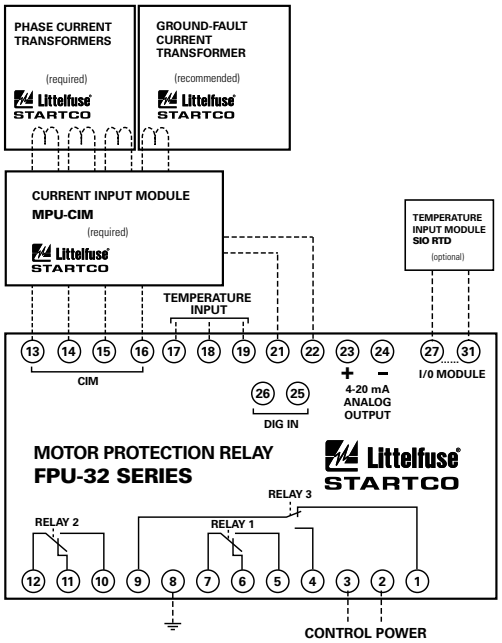
MOTOR AND PUMP PROTECTION

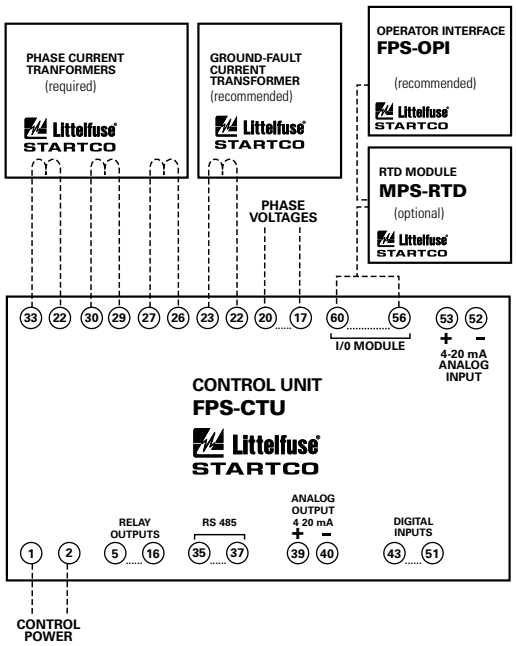
PGR-6800
Pump Protection



FEEDER PROTECTION

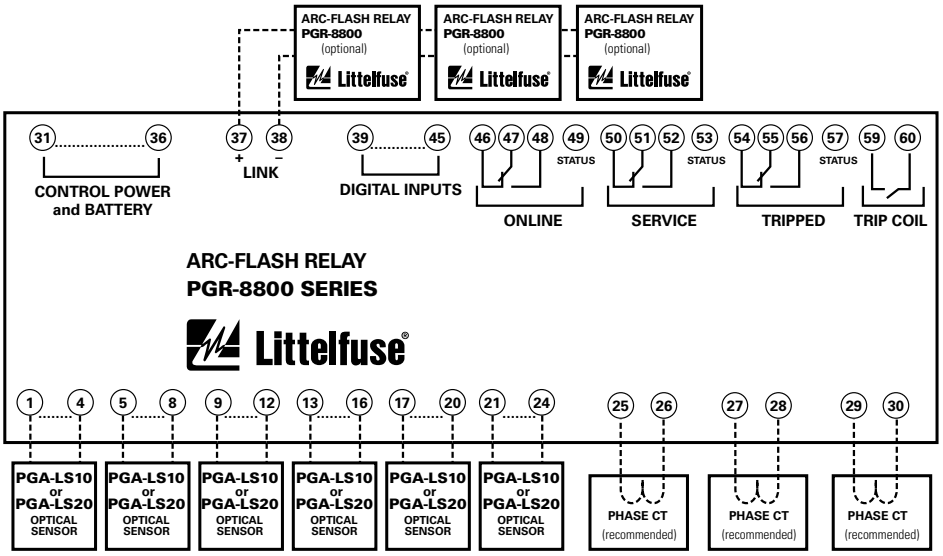
FPU-32 & FPS
Feeder Protection





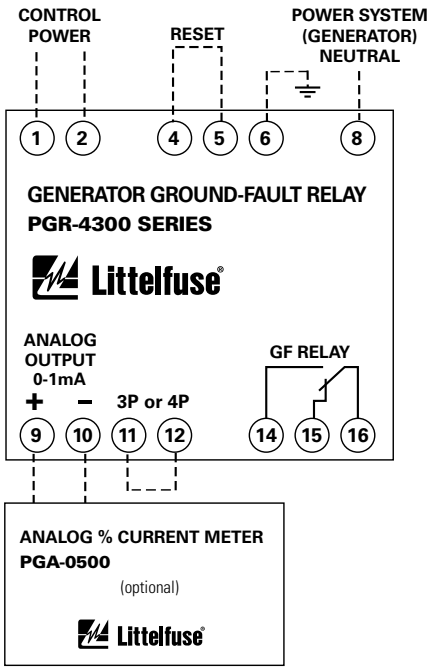
ARC-FLASH PROTECTION

PGR-8800
Arc-Flash
Protection



GENERATOR & SINGLE-FUNCTION PROTECTION

PGR 4300
Generator
Ground-Fault Protection



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 sec
4,160 V	5 A / 480 Ohms or 10 A / 240 Ohms	Continuous or 10 sec
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.

MARINE CERTIFICATIONS

Littelfuse Selco products are certified and in accordance with all the significant international standards. See page 158 for complete list of Marine Certified Products.

ABS ABS Copenhagen Port
BV Bureau Veritas
CCS China Classification Society
DNV Det Norske Veritas
GL Germanischer Lloyd
KRS Korean Register of Shipping
LRS Lloyd's Register of shipping
NKK Nippon Kaiji Kyokai
PRS Polski Rejestr Statków S. A.
RINA Royal Institution of Naval Architects
RMRS Russian Maritime Register of Shipping
RRR Russian River Register

PROTECTION RELAYS QUICK REFERENCE GUIDE

	PRODUCT	TYPE	SYSTEM*	TYPICAL APPLICATIONS	NO CALIBRATION	VISUAL INDICATION	WARRANTY	COMM	CONFORMAL COATING	BENEFITS	PAGE #
GROUND-FAULT PROTECTION	SE-601	GF Relay	UG DC	DC control systems, battery charging systems, transportation systems	●	●	5 years		O	Remembers trip status when power is cycled, safely run with Ground Fault	19
	EL731	Earth-Leakage Monitor	AC and/or DC	Variable speed drives; AC, mixed frequency, & DC systems		●	5 years	O	●	Low-level broad-spectrum fault protection for drives on RG systems. Fault current metering	20
	PGR-3100	GF Relay	UG AC	Older industrial facilities	●	●	5 years		●	Meets NEC® Article 250.21(B)	22
	PGM-3200	GF Relay	UG AC	Older industrial facilities		●	5 years		O	Meets NEC Article 250.21(B), provides 2 warnings	23
	SE-502	GF Grnd Continuity Monitor	208/120 Vac	3-ph generators for entertainment production; set lighting, etc.	●	●	5 years			Class A GFCI level and time; Built-in HRG (<100 mA)	25
	SE-701	GF Relay	SG AC or RG AC	Main, feeder, or load protection, motors, generators, pumps, heating cable, adjustable-speed drives	●	●	5 years		O	Wide setting range for any pickup level > 50 mA Harmonic filtering prevents nuisance trips	26
	SE-703	Earth-Leakage Monitor	RG AC	Australian mining HRE systems	●	●	5 years	O		Meet AS2081.3-2002 without false trips	27
	SE-704	Earth-Leakage Monitor Relay	SG AC or RG AC	Motors, generators, pumps, irrigation systems, heating cables, SCR-controlled heaters, semiconductor mfg. equipment	●	●	5 years		O	Detects low level arcing faults, detects CT wiring problems, up to 5 A, noise filtering	28
TRAILING CABLE PROTECTION	SE-105 SE-107	GF GC Monitor	RG AC	Portable power cables with integrated pilot conductor. Mining equipment, conveyors, cranes	●	●	5 years		●	Reliable ground-fault and ground-continuity detection for smaller systems	31
	SE-134C	GF GC Monitor	SG AC or RG AC	Shore-to-ship power, pumps, cranes, mining cables, material handling	●	●	5 years		●	Provides reliable ground continuity verification	32
	SE-145	GF GC Monitor	SG AC or RG AC	Three-way splitter boxes formine trailing cables	●	●	5 years	O	●	Reduce amount of cable to supply up to three loads, with proper ground and ground-fault monitoring	33
RESISTANCE GROUNDING	SE-325	NGR Monitor	RG AC	Resistance grounded systems	●	●	5 years		●	Detects resistor failure and ground faults	35
	SE-330	NGR Monitor	RG AC	Resistance grounded systems		●	5 years	●	●	Can be used on any system up to 72 kV and any resistor size	36
MOTOR PROTECTION	PGR-6100	GF & Insulation Monitor	AC systems	Ground-fault protection and insulation monitoring for motors	●	●	5 years		O	Detects problems when motor is energized or de-energized, detects problems with CT wiring	42
	PGR-6130	Electronic Overload	AC systems	Small motors that need additional protection (typically <75 hp)	●	●	5 years			Integral CT and standard protection in compact design	43
	PGR-6150	Standard Motor Protection	AC systems	Premium protection for smaller and medium sized motors (typically >50 hp)	●	●	5 years	●		Integral CT, Operator Interface, and modular design	44
	MPU-32	Advanced Motor Protection	AC systems	Smaller motors in critical applications and medium-sized motors in standard applications (typically >100 hp)	●	●	10 years	●	●	Thermal modeling for better accuracy, Arc-Flash hazard reduction, optional temp and differential monitoring	46
	MPS	Advanced Motor Protection	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	48
	MPU-32-X69X	Retrofit Kit	Induction Motors	Replaces GE Multilin 169, 269 & 369	●	●	10 years	●	●	Plug and play installation, match existing curves	50
	MPS-469X	Retrofit Kit	Induction Motors	Replaces GE Multilin 469	●	●	10 years	●	●	Plug and play installation, match existing curves	50
	PGR-6800	Pump Protection	AC systems	Submersible and process pump motors	●	●	5 years			Integral CT and Undercurrent to detect low-level	51
FEEDER PROTECTION	FPU-32	Standard Feeder Protection	AC systems	Medium voltage distribution circuits	●	●	10 years	●	●	IEEE and IEC curves, Arc-Flash hazard reduction	53
	FPS	Advanced Feeder Protection	AC systems	Medium voltage distribution circuits with remote breaker control	●	●	10 years	●	●	IEEE and IEC curves, Arc-Flash hazard reduction, current and voltage protection	54
ARC-FLASH PROTECTION	D0900	Arc-Flash Relay	AC or DC	Switchgear in wind turbines, offshore oil rigs, marine, industrial, and power generation		●	1 year			Trip quickly and minimize hazard of an arc flash	57
	PGR-8800	Arc-Flash Relay	AC/DC systems	Switchgear in wind turbines, offshore drill rigs, marine and power generation	●	●	5 years			Trip quickly and minimize hazard of an arc flash	58

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

● standard O optional

GENERATOR, ENGINE CONTROLS & PROTECTION QUICK REFERENCE GUIDE

PRODUCT	DESCRIPTION	TYPICAL APPLICATIONS	FEATURES	MARINE CERTIFICATIONS	PAGE #
PGR-4300	Generator Ground-Fault Relay (SG AC)	Manufacturers, rental companies and users of solidly grounded generators	No calibration, visual indication, 5-yr warranty . No CTs, can be used on 3- and 4-pole switches, alarms when generator becomes ungrounded	N/A	63
G2000	Power Relay	Generator protection	User configurable scales and setpoints	N/A	64
G3000	Frequency Relay	Generator protection	User configurable scales and setpoints	N/A	65
G3300	Voltage Relay	Bus bar monitoring	User configurable scales and setpoints. Combined over- and undervoltage relay	N/A	66
T2000	Reverse Power Relay	Generator protection	Works even if supply voltage drops to 50% of rated	ABS, BV, PRS, RMRS, RRR	67
T2100	Excitation Loss Relay	Generator protection	Works even if supply voltage drops to 50% of rated	BV, RMRS, RRR	68
T2200	Overcurrent Relay	Generator protection/trip on non essential loads	The non-essential trip function is used to reduce the chance of blackouts	BV, PRS, RMRS, RRR	69
T2300	3-Phase Short-Circuit Relay	Generator protection	Accepts high supply voltage variations – 60 to 110%	BV, PRS, RMRS, RRR	70
T2400	3-Phase Dual Overcurrent Relay	Generator Protection/trip on non essential loads	Combining two relays in same enclosure	BV, RMRS	71
T2500	Overcurrent and Short-Circuit Relay	Generator protection	Combining two protection functions in same enclosure	BV, PRS, RMRS, RRR	72
T2700	Power Relay	Generator protection	Accepts high-supply voltage variation, ensures correct operation in spite of voltage supply fluctuations (fulfills marine class requirement)	BV, RMRS, RRR	73
T2800	Earth-Fault Relay	Generator protection	Protects generators against earth faults (Combined with T2200 overcurrent protection is also provided)	BV, RMRS, RRR	29
T2900	3-Phase Differential Relay	Generator protection	Protection of generators, power transmission equipment and circuit breakers against differential currents	RRR	74
T3000	Frequency Relay	Bus bar monitoring/non essential load trip	Combined over- and underfrequency relay	ABS, BV, KRS, PRS, RMRS, RRR	75
T3100	Voltage Relay	Bus bar monitoring	Combined over- and undervoltage relay	ABS, BV, KRS, PRS, RMRS, RRR	76
T3200	Double Insulation Monitoring Relay	Bus bar monitoring	Insulation monitoring of AC systems. One relay monitors two separate systems.	BV, PRS, RMRS, RRR	24
T3300	Voltage Relay	Bus bar monitoring	Combining two relays in same enclosure	N/A	77
T2600	Dual Current Relay	Load depending start and stop of generators	Simple and economic load depending start/stop device	BV, DNV, KRS, RMRS	79
T4500	Auto Synchronizer	Synchronization of a generator to a busbar	Facilitates easy adjustment during installation and commissioning	ABS, BV, DNV, KRS, PRS, RMRS, RRR	80
T4800	Load Sharer	Load sharing between generators or parallel operation of generators with the grid	Includes reverse power trip	ABS, BV, DNV, KRS, PRS, RMRS, RRR	81
T4900	VAR Load Sharer	Reactive load sharing between generators or parallel operation of generators with the grid	Power factor regulation for grid parallel operation is included.	N/A	82
T5000	Paralleling Relay	Paralleling of generators	Check synchronizer for enabling closure of circuit breakers	BV, PRS, RMRS	83
E7800	Motorized Potentiometer	Interfacing of synchronizers and load sharers with governors and AVRs	Resistance range from 100 ohm to 10 K ohm	RRR	84
T7900	Electronic Potentiometer	Interfacing of synchronizers and load sharers with governors and AVRs	Provides a wide selection of output ranges including PWM	N/A	85
M8100	Synchroscope	Paralleing of generators	Versions with C/B close output and dead bus closure available.	BV, GL, RMRS, RRR	86
T8400	Blackout Limiter	Paralleling of generators	Economic solution - only one or two units for monitoring installations with several generators. Occupying less space in the switch panel	N/A	87
C6200	FlexGen Generator Control	Generator control and protection device	Many operational modes are covered with the same unit	ABS, BV, CSS, KRS, RMRS, RRR	88
S6000, S6100, S6610	SIGMA Protection Module	Generator protection, control and full power management system	Covers all power management functions	ABS, BV, CCS, DNV, GL, KRS, LRS, NKK, RINA, RMRS, RRR	90
M2000	Engine Control	Engine control and monitoring	Possibility of changing between emergency generator mode and harbour generator mode via external switch.	BV, DNV, GL, LRS, NKK, PRS, RINA, RMRS, RRR	93
M2500	Engine Control and Monitoring Unit	Engine control and monitoring	Digital and analog sensor inputs, J1939 communication. Configuration and log read-out via SD card	ABS, DNV, GL, LRS, RMRS, RRR	95
E5000	Handheld EngineEye Unit	Engine diagnostics	MIP with large display and patented sensor, TDC and ISO correction	N/A	98
M1000	Alarm Monitor	Monitoring of digital alarm signals	Voltage and insulation monitoring of supply voltage	ABS, BV, DNV, GL, KRS, LRS, NKK, PRS, RINA, RMRS, RRR	101
M3000	Alarm Monitor	Monitoring of digital and analog alarm signals	Calculation of average value of input signals for exhaust gas monitoring	ABS, BV, DNV, GL, LRS, NKK, RINA, RMRS, RRR	102
M4200	Alarm Monitor	Monitoring of digital alarm signals	Programmable LED color, 8 channels	BV, DNV, LRS, RMRS, RRR	103
M4500	Alarm Indicator	Remote alarm indication	6 channels	RRR	104
M4600	Alarm Indicator	Remote alarm indication	8 channels	RRR	104
M4700	Alarm Indicator	Remote alarm indication	20 channels. Versions with Modbus communication available.	RRR	104
H4000 Series	HMI Panels	Visualisation system with touch screen	Applications are built to customer specification	DNV, GL, RINA	105

GENERATOR & SINGLE-FUNCTION PROTECTION

GENERATOR CONTROL

ENGINE CONTROL

ENGINE DIAGNOSTICS

ALARM SYSTEMS

ALPHANUMERIC INDEX

White Papers & Technical Information

An expanded Technical Application Guide, White Papers, and a library of technical information is available online at **www.littelfuse.com/technicalcenter**. Littelfuse can help you address application and circuit protection challenges while achieving regulatory compliance.

Introduction to Protection Relays and Applications

Lowering the Limits for Ground-Fault Protection

The Importance of Effective Motor and Motor Circuit Protection

Ground-Fault Protection with VFDs

Selecting an Arc Flash Relay

Why NGRs Need Monitoring

Transformer Protection

Littelfuse Literature is in the App Store!

Our free Littelfuse Catalogs and Literature App keeps our products and technical resources at your finger tips, wherever you are. Find products and technical specifications you need, quickly and easily!

Let us Help you Build a Safe Electrical System

Contact our protection relay and safety experts today at **1-800-832-3873** or **www.littelfuse.com/relayscontrols** to find out what Littelfuse can do for you.

WWW.LITTELFUSE.COM/RELAYSCONTROLS

Application Support

Littelfuse's staff of professional engineers assists customers with the application of protection relays and generator controls. 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 assisting with product setup. As systems grow in terms of power and physical size, some products and settings may need to be adjusted. If so, our engineers are available to answer any questions that arise when modifying these applications.

Online Tools and Relay Software

Featuring easy to use navigation, search and selection tools as well as in-depth product details, **www.littelfuse.com/relayscontrols** 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 products and services enhance the safety and productivity of electrical systems. Along with protection relays, generator controls and alarm monitors, we offer current-limiting fuses to decrease Arc-Flash exposure, and fuse holders and fuse covers to reduce incidental contact and improve safety.

- **Protection Relays**
- **Generator Control and Protection**
- **Alarm Annunciators and Indicators**
- **Engine Control**
- **Engine Diagnostics**
- **Custom Power Centers**
- **Fuses and Fuse Holders**

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For 85 years, Littelfuse electrical safety products have helped OEM engineers, consulting engineers and end-users select the right products to protect critical electrical equipment—all supported by our full line of product catalogs and reference materials.

Arc-Flash Relay Brochure Littelfuse offers one of the fastest Arc-Flash Protection relays on the market. The PGR-8800 can detect a developing arc flash extremely fast and send a trip signal before any significant damage occurs.

Motor Protection Relay Brochure Littelfuse provides a range of multi-function motor protection products that reliably protect small, medium and large motors.

Generator Controls and Alarm Panels Littelfuse Selco provides generator control, diagnostics and protection products as well as alarm annunciation and indication panels.

Fuses and Fuse Holders 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.

To request catalogues for the entire Littelfuse portfolio of products, please contact your authorized Littelfuse sales representative or visit our website at **www.littelfuse.com/catalogs**

Scan with your mobile device for www.littelfuse.com/relayscontrols.

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