Generator Protection

COOPER Power Systems

Electrical Apparatus

150-52

MG30 Generator Protection Relay

The MG30 Generator Protection Relay is a member of Cooper Power Systems' **Edison**® Series of microprocessor based protective relays and provides comprehensive protection and metering for small, medium or large generators. The MG30 can be matched with the MD32G Generator Differential relay for complete generator protection. The MG30 unit offers the following functions:

- Two levels of under-impedance (21U).
- Two levels of over-excitation (24).
- Two levels of over/under voltage (27/59).
- Reverse power (32).
- Underpower (37).
- Loss of field (40).
- Two levels of negative sequence to detect current unbalance (46).
- Thermal overload (49).
- Inverse and definite time phase overcurrent elements with or without voltage restraint. (50/51 or 50V/51V).
- Inadvertent energization detection (50/27).
- Breaker failure (51BF).
- PT Fuse Failure to detect loss of potential (60FL).
- Two levels of stator 95% stator fault protection (64S).
- One level of 100% stator ground fault protection which monitors the 3rd harmonic component of the neutral voltage (64S-100%).
- Two levels of over/under frequency (81).
- Blocking inputs and outputs for protective zone interlocking.
- Three programmable Form C (SPDT) output contacts and one Form A/B contact. Up to 12 additional output contacts may be added through the use of REX8 output contact expansion modules.

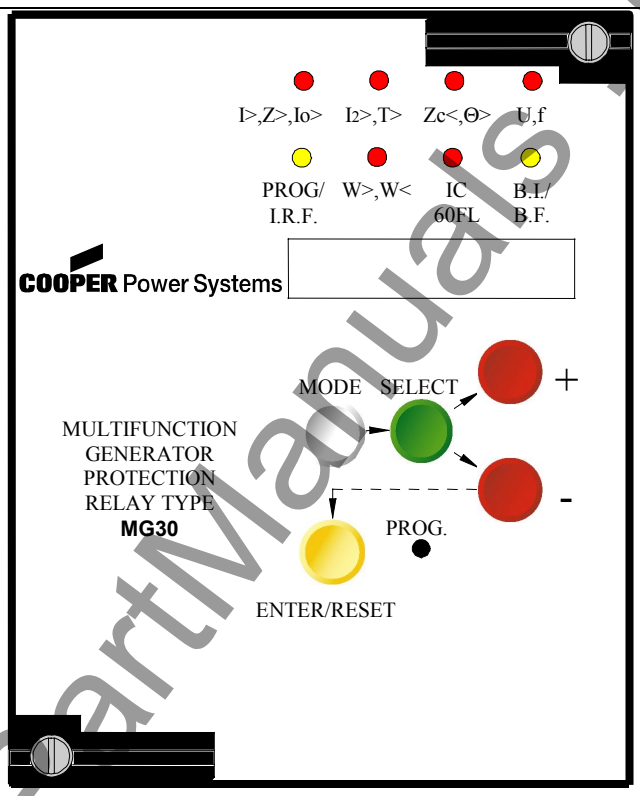

Figure 1: Front View of the MG30 Generator Protection Relay

The MG30 also shares the following features common to all Edison Series relays:

- Simple five button man machine interface (MMI) allows access to all functions, settings, and stored data without the need for a computer.
- Bright electroluminescent display easily visible even in brightly lit environments.
- Draw-out design permits relay testing without disturbing connections to case.
- Modbus communication protocol and RS485 terminal on rear.
- Modular design allows the draw-out module to be fitted to a variety of space saving cabinet styles.
- Programmable reset characteristics.
- Dedicated power supply/relay fail output contacts.
- Basic event records.
- Cumulative trip counters.
- Auto-ranging power supplies.

APPLICATIONS

The MG30 is ideally suited for the protection of small and medium generators, or as the core of a protection package for medium or large generators. The MG30 provides all of the basic protective functions required for generator protection. The MG30 may be used with the SPM21 Automatic Synchronizer relay to bring a generator into synch with the power system and initiate closing. For larger generators requiring differential protection, the MD32G Rotating Machine Differential relay may be used.

UNDERIMPEDANCE (21)

Two levels of under-impedance are provided for backup protection of the high voltage system including the unit transformer and transmission system. See Figure 2.

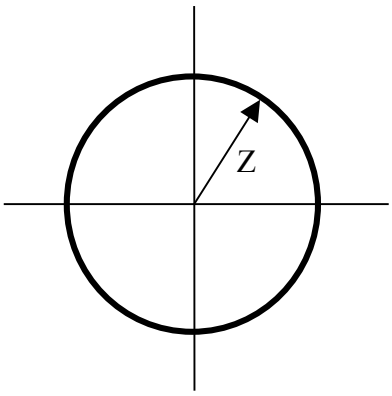

Figure 2: Underimpedance Element Characteristic of the MG30

OVEREXCITATION (24)

The MG30 includes both definite time and inverse time over-excitation elements which provides protection against over-fluxing of the generator and the generator transformer. See Figure 3.

VOLTAGE PROTECTION (27/59)

Two separate voltage elements can be each be configured to operate in either under, over, or the combination of under and over voltage mode.

REVERSE POWER (32)

A reverse active power element provides anti-motoring protection. The reverse power element may be set as low as 2% of the generator rated input current.

UNDERPOWER (37)

The underpower element is used to trip the generator off-line or issue an alarm in the event the power output drops below a preset value. This element can be used to trip the generator during an orderly shutdown. This element can be useful for alarming when expensive peaking units are operating at low power levels.

LOSS-OF-FIELD (40)

An offset mho characteristic is used to sense the loss of generator excitation current. See Figure 4.

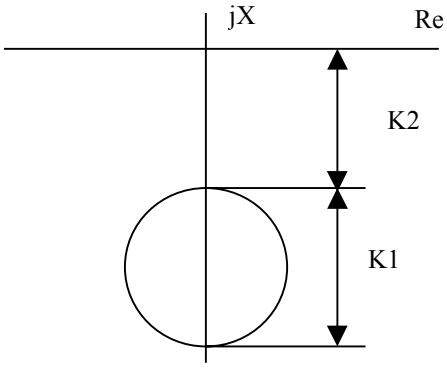

Figure 4: Loss of Field Characteristic of the MG30 Relay

CURRENT UNBALANCE (46)

The MG30 utilizes a programmable I^2t constant to model rotor heating when negative sequence current is flowing in the stator. A linear cooling time constant is used to model machine cooling after momentary current unbalance conditions. An unbalance alarm is also included with adjustable pickup and time delay levels.

STATOR THERMAL IMAGE (49)

The relay computes a thermal image of the machine based upon the ratio of the RMS value of the current flowing in each phase as compared to the full load rated current of the generator.

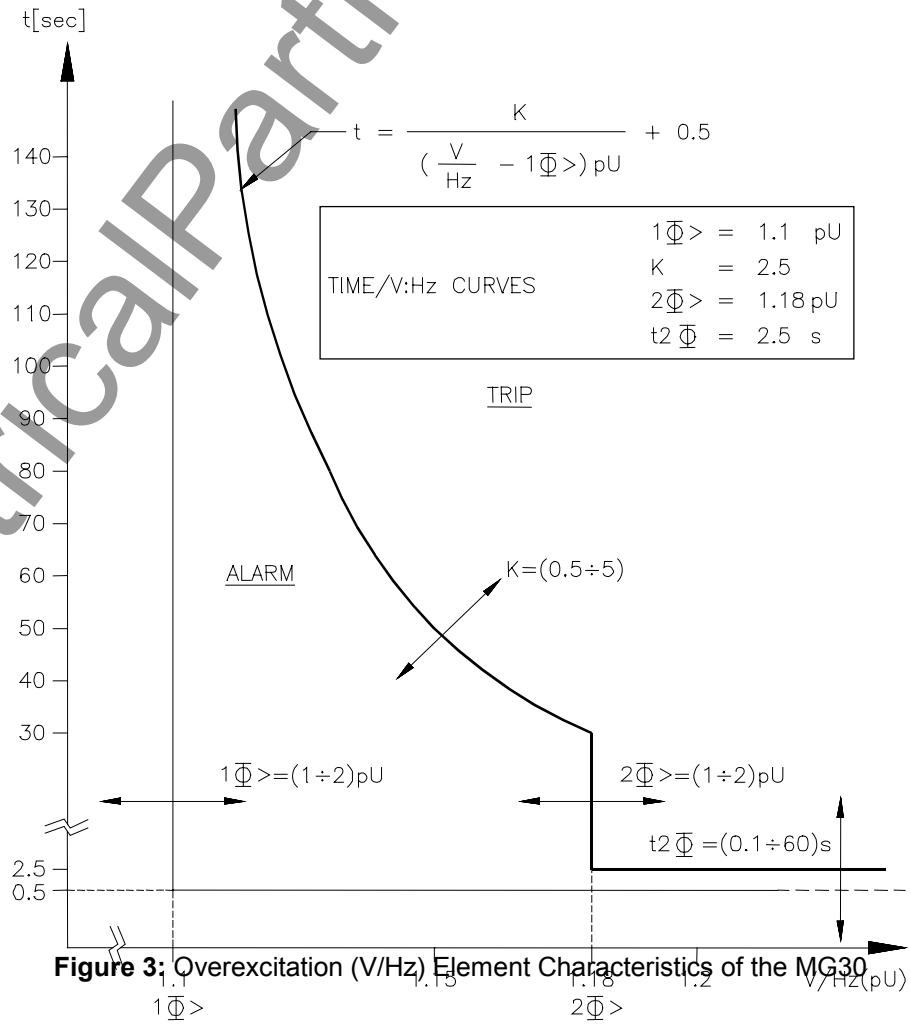

Figure 3: Overexcitation (V/Hz) Element Characteristics of the MG30

OVERCURRENT PROTECTION (50/51, 50V/51V)

The MG30 comes with low and high set phase voltage restraint overcurrent elements. This allows the generator to be protected from the effects of slow or failed system fault clearing. The low set element may be set to either definite time or inverse time characteristics which provides protection against generator overloads and coordination for contributions into faults. The voltage restraint function may be disabled.

INADVERTENT ENERGIZATION (50/27)

This logic protects against accidentally energizing the generator while it is not fully operational. A special low set overcurrent element is supervised by an undervoltage, tripping the generator offline immediately in the event this overcurrent element trips.

BREAKER FAILURE (50BF)

A programmable time delay can be set equal to the breaker clearing time. If the fault is then not cleared (i.e., the trip element has not dropped out), before this timer expires, a breaker failure is indicated. The breaker failure function may be assigned to operate one or more of the output relays.

PT FUSE FAILURE (60FL)

To protect against mis-operation of any elements which depend upon the presence of voltage signals from potential transformers, the MG30 can be set to block the operation of these elements when a PT fuse failure is detected.

STATOR GROUND FAULT (64S)

The MG30 provides two stator ground fault elements. The first element monitors the fundamental frequency component of the generator's neutral to ground voltage. For 100% stator ground fault protection, the second element monitors the third harmonic component of the neutral to ground voltage. This element senses the collapse of the 3rd harmonic voltage between neutral and ground when a fault close to the generator's neutral is experienced.

FREQUENCY PROTECTION (81)

Two separate frequency elements can each be configured to operate in either under, over, or the combination of under and over frequency mode. This will allow protection for not only under frequency operations but also for the similarly damaging over frequency operating conditions.

TRIP COUNTERS

A counter is maintained for each protective element which tallies the cumulative total number of trips each element has experienced.

TARGETS

Eight bright LED targets provide targeting for all protective elements, relay status and external blocking inputs.

RESET CHARACTERISTICS

The output relays may be programmed to reset in one of two manners.

- Instantaneously upon the input or calculated quantities dropping below the pickup value.
- Manual reset (by front panel or computer command) only.

EVENT RECORDS

For the most recent five protective element trips the MG30 records the time of trip, cause of trip and values of all the three phase currents and voltages, phase power factors, watts, system frequency, negative sequence current, and fundamental and 3rd harmonic components of the zero sequence voltage.

MEASUREMENTS

The MG30 measures the following instantaneous quantities:

- Phase currents
- Phase-to-phase voltages
- Thermal heating as a percent of full load steady state
- Phase angle between phase voltages and currents
- Three phase active power
- System frequency
- Negative sequence current
- Fundamental and 3rd harmonic frequency components of the zero sequence voltage

The maximum measured values during the first 100msec after closing of the tie breaker of each of the following is also recorded:

- Phase currents
- Three phase active power
- Negative sequence current
- Fundamental and 3rd harmonic frequency components of the zero sequence voltage

OUTPUT ELEMENTS AND CONTACTS

The MG30 has five output contacts, four of which are programmable. The fifth contact is dedicated to relay failure. If more than four output contacts are required, one or two REX8 contact output extension modules may be connected to the MG30. These modules may be located anywhere within the control cabinet

The REX-8 modules are for protrusion mounting on standard DIN mounting rails. They are controlled by the MG30 via a dedicated RS485 serial port over twisted pair wire. See Figure 5.

The REX-8 module includes eight user programmable contacts plus one output contact for diagnostics.

The MG30 can therefore control a total of sixteen output contact per the following:

- 4 contacts in the MG30

- 8 contacts in the first optional REX-8 module
- 4 contacts from a second optional REX-8 module

The second unit REX-8 is configured by an internal DIP-switch to operate the eight relays two-by-two in parallel (only four user programmable outputs with double number of available contacts)

Any of the functions featured by the MG30 relay can be programmed to control up to four out of the sixteen user programmable output relays

Any of the following functions may be programmed to these output relays:

- Pickup of each of the phase overcurrent, unbalance, over-excitation, stator ground fault and under-impedance elements.
- Trip of any of these elements.
- Operation of the either unbalance element, reverse power, loss-of-field, thermal alarm or thermal trip, loss-of-potential and inadvertent energization elements.

BLOCKING INPUTS

Three dry contact inputs provide the ability to block most protective elements.

DIAGNOSTICS

Complete memory and circuit diagnostics are run upon powering the relay. The revision level of the firmware is displayed at this time.

The relay provides two manual test routines which may be run at any time. The first routine performs the same 15 minute test an in addition checks the target LEDs and the control circuitry to the output relays without operating the output relays.. The second test is identical but also operates the output relays.

During normal operation the relay suspends operation every 15 minutes for 7 msec and runs a comprehensive set of diagnostics that includes memory checksum, test of the A/D converters by injection of an internally generated reference voltage, and a check of the ALU.

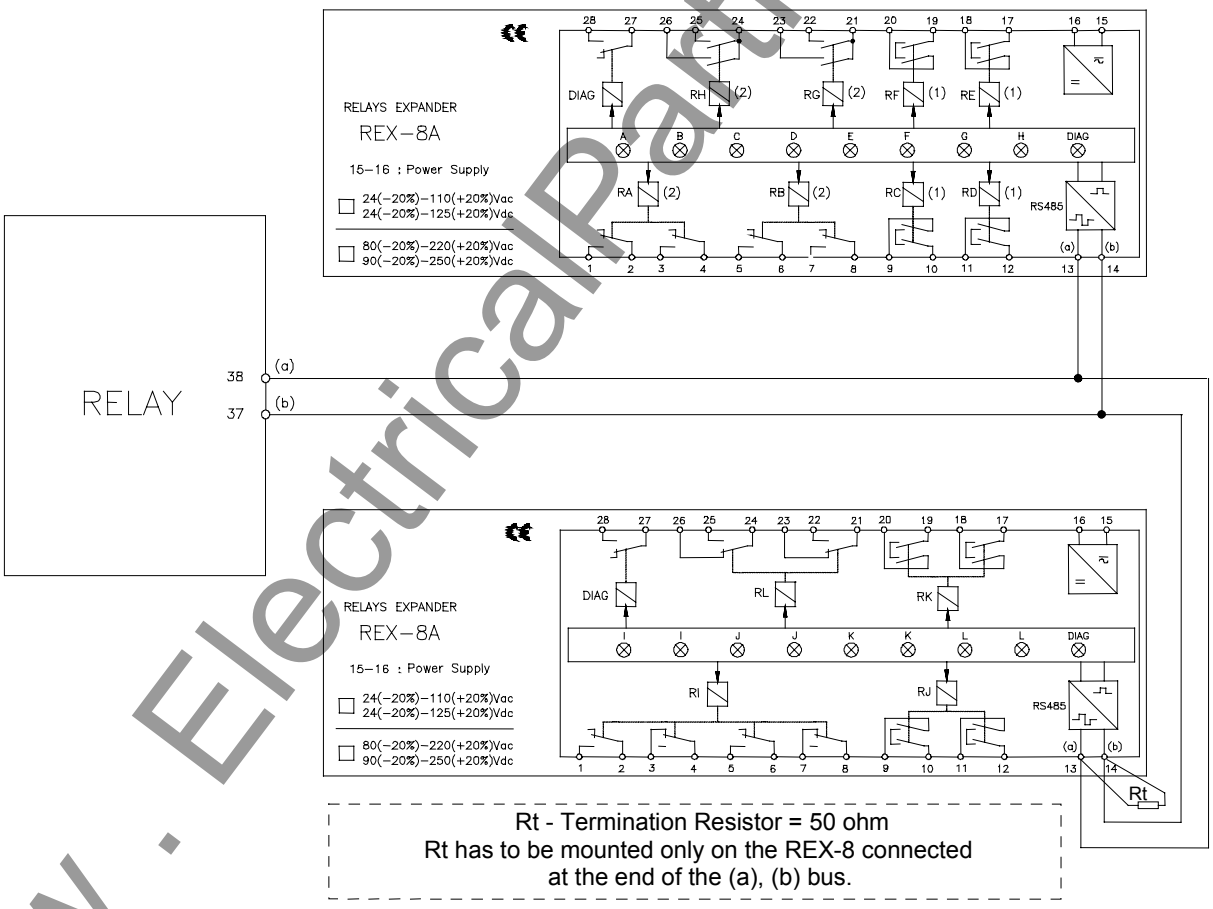

Figure 5: REX8 Contact Output Extension Module Wiring Diagram

Table 1: Functional Specifications

NOMINAL SYSTEM FREQUENCY SETTING RANGE	50 or 60 Hz
RATED PRIMARY INPUT CURRENT OF PHASE AND NEUTRAL CTS	1 - 9999A in 1A steps
RATED PRIMARY SYSTEM PHASE-TO-PHASE VOLTAGE OF PTS	2 – 655 kV in .0.1 kV steps
RATED PT SECONDARY LINE-TO-LINE VOLTAGE	50 – 125 V in 1 V steps
LOW SET OVERCURRENT ELEMENT	
Characteristic:	Definite time or inverse
Pickup:	1.0 – 2.5 pu of rated generator current
Time delay:	0.05 – 30.0 seconds (at 5pu Igen)
HIGH SET OVERCURRENT ELEMENT	
Characteristic:	Definite time
Pickup:	1.0 – 9.9pu of rated generator current
Time delay:	0.05 – 3.0 seconds (at 5pu Igen)
CURRENT UNBALANCE ELEMENT	
Maximum negative sequence current rating;	0.05 – 0.5pu of rated generator current
Time multiplier of I_2^2t curve	5 – 80 seconds
Cooling time to rated	10 – 1800 seconds
Alarm level pickup	0.03 – 0.5pu generator current
Alarm level time delay	1 – 100 seconds
REVERSE POWER ELEMENT PICKUP	0.02 to 0.2pu rated generator current
Time delay	1 – 100 seconds
LOSS OF FIELD ELEMENT	
Mho circle size	50 – 300% of rated generator impedance
Mho offset	5 – 50% of rated generator impedance
Time delay	0.2 – 60 seconds
Integration time	0 – 10 seconds
VOLTAGE ELEMENTS	
Characteristic	Over, Under or Over+Under
Pick-up level	1 – 50% change from rated voltage
Time delay	0.1 – 60.0 seconds
FREQUENCY ELEMENTS	
Characteristic	Over, Under or Over+Under
Pick-up level	0.05 – 9.99Hz from nominal
Time delay	0.1 – 60.0 seconds
THERMAL IMAGE ELEMENT	
Trip level	Fixed at 110% rated
Thermal time constant of alternator	1 – 400 minutes
Pre-alarm level	50 – 110% of rated
UNDERPOWER ELEMENT PICKUP LEVEL	0.05 – 1.00 of rated power output
Time delay	0.1 – 60.0 seconds
UNDERIMPEDANCE ELEMENTS	
Pickup level	01 – 1.0 pu rated impedance
Time delay	0.02 – 9.99 seconds
FIRST LEVEL OVEREXCITATION ELEMENT	
Characteristic	Inverse
Pickup level	1.0 - 2.0 pu
Time multiplier	0.5 – 5.0
SECOND LEVEL OVEREXCITATION ELEMENT	
Characteristic	Definite time
Pickup level	1.0 - 2.0 pu
Time multiplier	0.1 – 60.0 seconds
95% STATOR GROUND FAULT ELEMENTS	
Pickup level	5 – 99% Rated zero sequence voltage
Time delay	0.05 – 99.0 seconds
100% STATOR GROUND FAULT ELEMENT	
3rd Harmonic Pickup level	1 – 30% Rated zero sequence voltage
Time delay	0.05 – 99.0 seconds

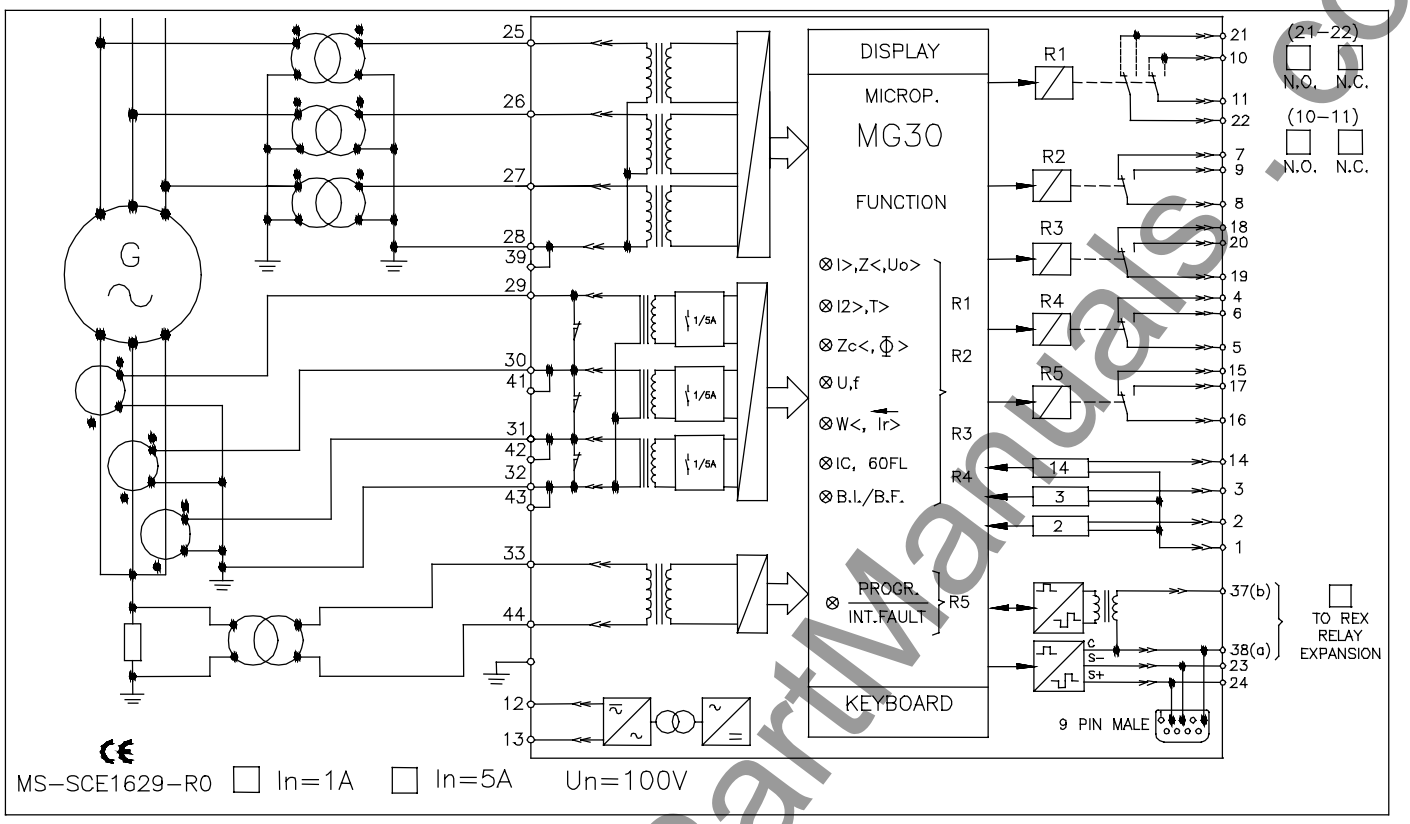

Figure 6: Wiring Diagram for the MG30 Relay

ORDERING INFORMATION

Construct the catalog number from the following table:

Base Relay Model	Power Supply[1]		Rated CT Input		Case Style[2]	
	Code	Description	Code	Description	Code	Description
PRMG30J	L	24-110V AC/DC	1	1A	D	Draw-out relay only, no cabinet supplied
	H	90-220V AC/DC	5	5A	S	Single case
					N	19” rack mount
					C2 C3 C4	Denotes mounting position in either a double case or 19” rack along with other relays ordered at the same time.

Example: PRMG30JL5S is an MG30 with low range power supply, 5A CT inputs, in a single relay case.

If ordering two or more relays to be fit in a common case, the first relay ordered should indicate the case style desired. This relay will be located in the leftmost bay of the case. Subsequent relays should use the C2, C3, or C4 suffixes to denote their position in the case using the leftmost bay as a “C1” reference.

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[1] The power supplies are user replaceable and interchangeable. See catalog section 150-99.

[2] The relay itself may be drawn out of any of the listed cases and plugged into any of the other case styles. The catalog number specified during ordering denotes the type of cabinet in which the relay will be shipped.