Generator Differential Relay

COOPER Power Systems

Electrical Apparatus

150-32

MD32G Rotating Machine Differential Relay

The MD32G Rotating Machine Differential Relay is a member of Cooper Power Systems' Edison® line of microprocessor based protective relays. The MD32G relay offers the following functions:

- Differential elements (87G) for each phase with multi-slope bias characteristics and selectable slope breakpoint. Trip response time of less than 2 cycles. The MD32G is suitable for protecting generators or other rotating machines.
- Phase overcurrent for stator protection (51P).
- Restricted ground fault element.
- Instantaneous and low set ground fault protection. Depending upon the input circuit configuration, either stator ground fault (51GN) or sensitive ground fault (87N) protective functions may be implemented.
- Breaker fail (50BF).
- 16 cycle oscillographic records of trip events. An oscillographic record may also be triggered externally.

The MD32G also shares the following features common to all Edison® 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.

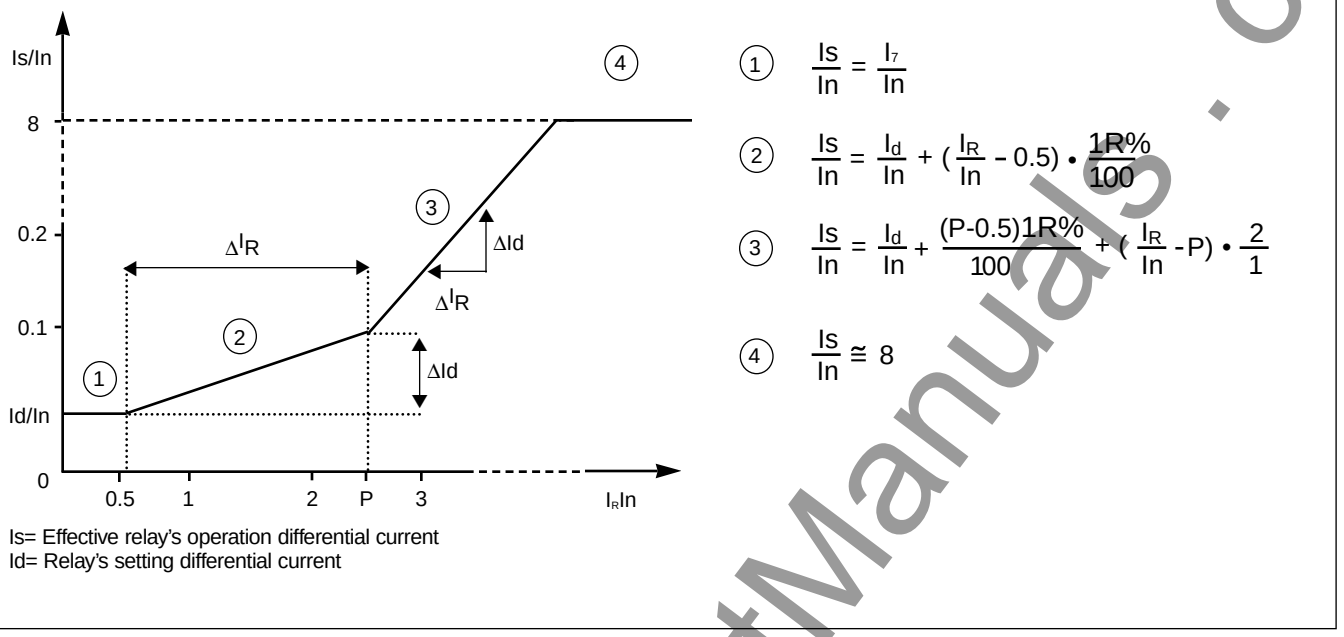
Figure 1.
Front View of the MD32G Generator Differential Relay

- 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.
- Three programmable Form C (SPDT) output contacts and one Form A/B contact.
- Pick-up (start-time) elements.
- Programmable reset characteristics.
- Dedicated power supply/relay fail output contacts.

Applications

The MD32G is ideally suited for the protection of generators and large motors against two or three phase internal faults, inter-turn faults, and ground faults in equipment with low-impedance or solidly grounded neutrals. Its multi-slope percentage bias characteristic allows for compensation of CT ratio error mismatch and differences in CT response.

For autotransformer-started motors, some differential protection schemes include the autotransformer in the zone of protection. In this case rotating machine differential relays such as the MD32G are not suitable as the 2nd and 5th harmonic restraint functions common to transformer differential relays are required. For this application, the MD32T relay should be used.



$$R\% = 100\,\frac{\Delta I_d}{\Delta I_R} = 100\,\frac{\Delta(I_1 - I_2)}{\Delta(I_1 - I_2)/2}$$

① $\frac{Is}{In} = \frac{I_7}{In}$

② $\frac{Is}{In} = \frac{I_d}{In} + \left(\frac{I_R}{In} - 0.5\right) \bullet \frac{1R\%}{100}$

③ $\frac{Is}{In} = \frac{I_d}{In} + \frac{(P-0.5)1R\%}{100} + \left(\frac{I_R}{In} - P\right) \bullet \frac{2}{1}$

④ $\frac{Is}{In} \cong 8$

Figure 2.
Dual Slope Bias Characteristic of the MD32G Differential Relay

Multi-slope Biased Differential Element

Each phase is provided with its own differential element having a characteristic as shown in Figure 2. The relay internally calculates the RMS value of the differential current compensated for any CT ratio and phase angle mismatch.

The minimum differential current required for operation is adjustable between 0.02 and 0.2 pu of the machine's rated current. This setting is fixed up to 0.5 pu of the machine's rated current. Above 0.5 pu compensation of the set point is required for CT saturation which may occur at higher current levels. The slope of each of the two sloping portions of the characteristic are adjustable, as is the breakpoint between the two slopes. The first slope may be adjusted from 2% to 20%, and applies from 0.5 pu of the machine's rated current, up to the breakpoint, which may be set from 1 to 3 pu. Above the setpoint the slope of the differential element is adjustable between 5% and 50%.

Overcurrent Protection

A single definite time delay phase overcurrent element is provided to act as overload backup protection.

Ground Fault Protection

To provide greater coverage for ground faults, the MD32G monitors the fundamental frequency component of current fed into the ground element inputs. Depending upon the connection, this element can perform:

- Sensitive ground fault protection (87GN).
- Neutral current protection (stator ground fault) (51N).

The 87GN connection is suitable for large generators, or for situations where a number of smaller generators are connected in parallel through a common step up transformer. This connection (shown in Figure 3) allows for very sensitive settings to be made and restricts the element to operate within the zone of the differential element. This ground fault element consists of a definite time high set element.

Breaker Fail

A programmable time delay is set equal to the breaker clearing time. If the fault is not cleared (i.e., the trip element has not dropped out), before this timer expires, a breaker fail is indicated. The breaker fail element may also be programmed to monitor any combination (or none) of the following elements; differential, phase overcurrent, or ground fault. The breaker fail function may be assigned to operate one or more of the output relays.

Targets

Eight bright LED targets are provided as follows:

- One red LED for each of the three phase differential elements.
- One red LED for the restricted ground fault element.
- One red LED for the breaker fail element.
- One red LED for the phase overcurrent element.

For all of the above, the LEDs flash when the element is picked up, and constantly illuminate upon trip. In addition, one yellow LED is provided which illuminates when the blocking input is active. A second yellow LED flashes when the relay is in programming mode, and illuminates constantly upon relay or power supply failure.

Blocking Input

An opto-isolated programmable blocking input is provided. This input may be programmed so that when activated, any combination of the differential, phase overcurrent, or ground fault elements may be blocked.

While the blocking input is active, the pickup of any element associated with the blocking input is prevented. Sensing of the input quantities and the countdown of any timers begins only when the blocking is removed.

Reset Characteristic

The programmable 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.

Measurements and Inrush Values

The following quantities are continuously monitored and are available for display at the relay and are accessible by software:

- RMS values of each phase's differential current.
- Fundamental frequency component of the neutral current in per unit of the rated phase current.
- RMS values of the three high side currents.
- RMS values of the three low side currents.

In addition, the maximum values of each of these quantities during the first 100 msec after transformer energization is also recorded. This makes it convenient to quickly review the inrush currents associated with the most recent energization.

Last Trip Record

The following parameters are stored in non-volatile memory, providing details of the last five trip events:

- Which element was the cause of the last trip.
- The values of all measured currents at the time of trip.
- In addition, the relays keep a cumulative total of the cause of all breaker trips.

Oscillography

The MD32G stores two oscillographic records which are made available for downloading to a PC for graphing. All six input phase currents are recorded. Each oscillographic record consists of 8 pre-trigger and 8 post-trigger cycles, for a total of 16 cycles. The waveform is sampled at 12 samples per cycle. Storage of an oscillographic record may be programmed to occur automatically every time a protective element trips, or to occur only upon an external trigger.

Output Elements

The following functions may be programmed to one or more of the output relays. The only limitation is that pick-up and time delay functions may not be assigned to operate the same output relay(s).

- Differential element.
- Phase overcurrent pickup element.
- Phase overcurrent time delayed element.
- Ground fault pickup element.
- Ground fault time delayed element.
- Breaker fail element.

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 runs a comprehensive set of diagnostics every 15 minutes that includes memory checksum, test of the A/D converters by injection of an internally generated reference voltage, and a check of the ALU.

The relay provides two manual test routines which may be run at any time. The first routine performs the same 15 minute test and 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.

Dimensions and Electrical Specifications

See Catalog Section 150-05 for electrical specifications and dimensional information on all Edison® relays.

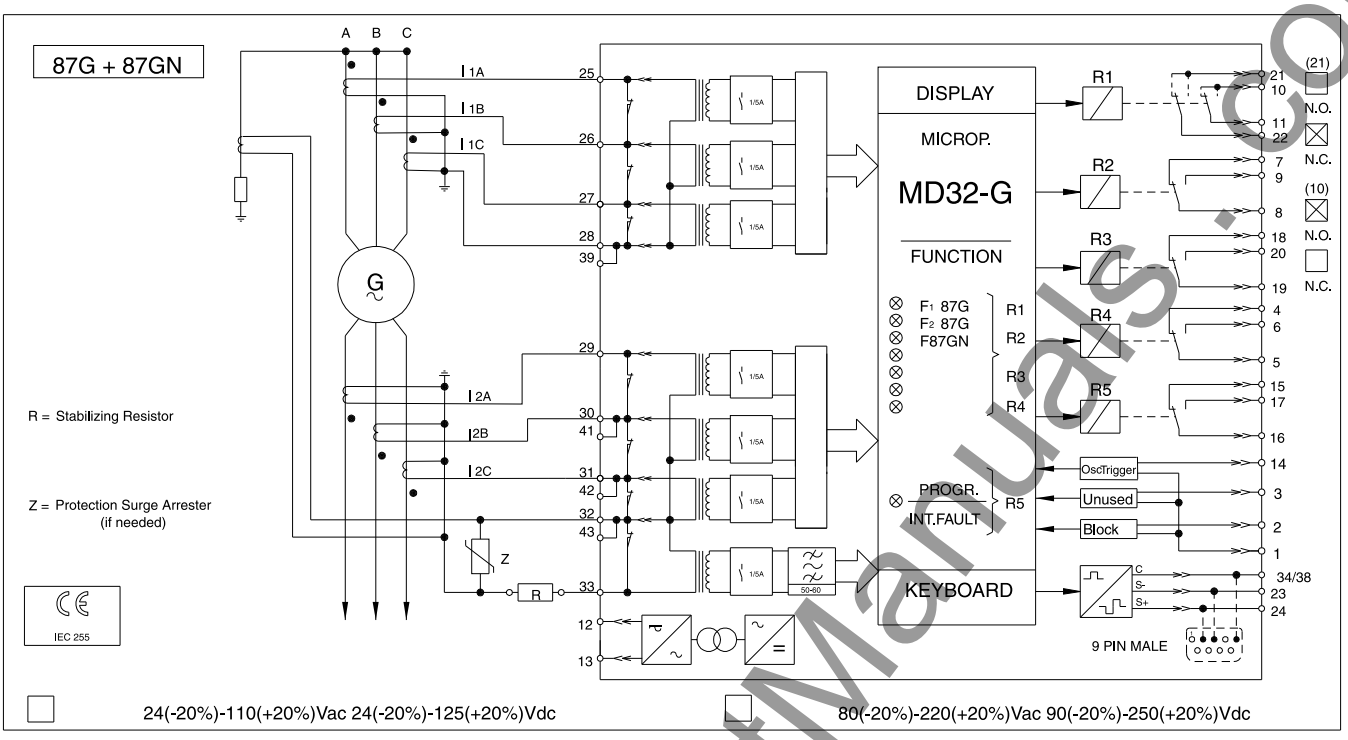


Figure 3.
Wiring Diagram for the MD32G Rotating Machine Differential Relay used for 87G and 87GN Protection

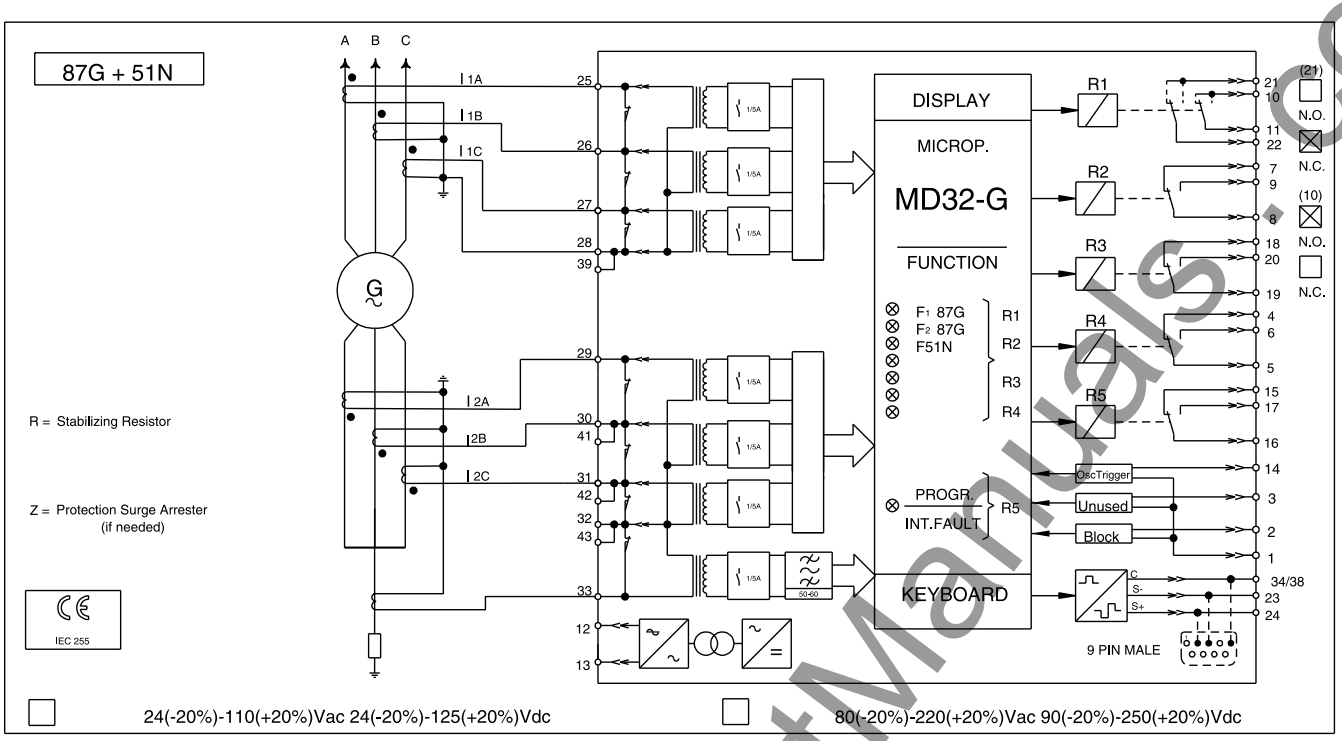


Figure 4.
Wiring Diagram for the MD32G Rotating Machine Differential Relay used for 87G and 51N Protection

TABLE 1
Functional Specifications

Nominal system frequency setting range	50 or 60 Hz
Programmable rated primary input current of phase CTs	1 - 9999A in 1A steps
Breaker fail (50BF) time delay	0.05 to 1.00 seconds in 0.01 second steps
Differential Element (87G)	
Minimum pick-up level of low set differential element	0.02 to 0.20 pu of rated CT current in 0.01 pu steps
Bias percentage slope from 0.5 pu to "P" pu of rated CT current	2 - 20% in 1% steps
Bias percentage slope at greater than "P" pu of rated CT current	5 - 50% in 1% steps
Bias slope break point "P"	1.00 to 3.00 pu of rated CT current in 0.01 pu steps
Overcurrent Element (51P)	
Minimum pick-up level	0.50 to 10.00 pu of rated CT current in 0.01 pu steps
Time delay	0.05 to 99.00 seconds in 0.01 second steps
Ground Fault Element	
Minimum pick-up level	0.01 to 1.00 pu of rated CT current in 0.01 pu steps
Time delay	0.02 to 9.99 seconds in 0.01 second steps

Ordering Information

Construct catalog number from Table 2.

Example: MD32GL5JS is an MD32G 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.

TABLE 2
Catalog Numbers

Description	Catalog Number
Base Relay	MD32G
To the above add one each of the following applicable suffixes	
Power Supply[1]	
24-110V AC/DC	L
90-220V AC/DC	H
Rated CT Input	
1A	1
5A	5
Modbus Protocol	J
Case Style[2]	
Draw out relay only, no cabinet supplied	D
Single relay case	S
Double relay case	T
19" Rack mount cabinet	N
Mounting Position	
Denotes mounting position in either a double case or 19" Rack along with other relays ordered at the same time.	C2 C3 C4

[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.

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