Generator Protection

Cooper Power Systems

Electrical Apparatus

150-50

IM30G Generator Protection Relay

The IM30G Generator Protection Relay is a member of Cooper Power Systems' Edison® line of micro-processor based protective relays. The IM30G offers in a compact package all of the basic protection required by small and medium sized generators.

- Time and instantaneous phase overcurrent elements (50/51).
- Current unbalance (negative sequence) with programmable constant I_2^2t characteristics (46I2T).
- Current unbalance alarm level (46A).
- Stator ground fault (64G).
- Reverse power (32).
- Alternator loss-of-field or out-of-step element (40).
- Breaker failure.

The IM30G 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.
- 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.
- Four fully programmable Form C (SPDT) output contacts.
- Pick-up (start-time) elements.
- Programmable reset characteristics.

Figure 1.
Front View of the IM30G Generator Protection Relay

- Dedicated power supply/relay fail output contacts.
- Event records.
- Cumulative trip counters.
- Auto-ranging power supplies.

Applications

The IM30G is ideally suited for the protection of small generators, or as the core of a protection package for either medium or large generators. The IM30G provides all of the basic protective functions required for generator protection. The IM30G may be used with the SPM21 Automatic Synchronizer relay to bring a generator in synch with the power system and initiate closing. For larger generators requiring differential protection, the MD32G Rotating Machine Differential relay may be used. The UM30 Frequency & Voltage relay may also be added for additional protective functions.

Phase Overcurrent Protection

The IM30G comes with low and high set phase overcurrent elements. The low set element may be set to either a definite time or an inverse time characteristic which allows protection against generator overloads and time coordinations for it's fault contributions into network faults. If a voltage restrained overcurrent element is required, use the IM3GV relay.

Current Unbalance

The IM30G utilizes a programmable I_2^2t 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.

Ground Fault

A definite time ground fault element provides protection against ground faults. The input may be supplied directly by a ground CT, or calculated internally by the relay from the three phase currents.

Reverse Power

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

Loss-of-field

An offset mho characteristic is used to sense the loss of generator excitation current. See Figure 2.

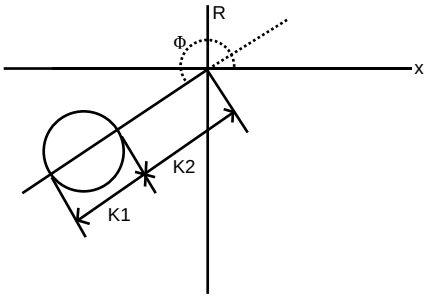

Figure 2.
Loss-of-Field Characteristic

In Figure 2, K1 is the mho element diameter, K2 is the offset, and Φ is the characteristic angle.

Breaker Failure

A programmable time delay can be 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, then a breaker failure is indicated. The breaker failure function may be assigned to operate one or more of the output relays.

Targets

Eight bright LED targets are provided as follows:

- Five red LEDs, one for each of the phase overcurrent, negative sequence, reverse power, ground overcurrent, and loss-of-field elements.
- One red LED for the breaker failure 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 or any protective functions are disabled via programming. A second yellow LED flashes when the relay is in programming mode, and illuminates constantly upon relay or power supply failure.

Blocking Input

Two opto-isolated programmable blocking inputs are provided. These inputs may be programmed so that when activated, any combination of the phase or ground overcurrent, loss of field, or reverse power 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 whenever the input or calculated quantities drop below the pickup value.
- Manual reset (by front panel or by computer command).

Measurements And Inrush Values

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

- RMS phase currents.
- RMS ground current.
- Voltage as a percentage of rated PT secondary voltage.
- RMS negative sequence current.
- Phase displacement.

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 initiated the last trip.
- The values of all measured currents at the time of the trip.
- The values of the voltages at the time of the trip.

Additionally, the relay keeps a cumulative total of the causes of all breaker trips.

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).

- Low set phase overcurrent pick-up.
- Low set phase overcurrent trip.
- High set phase overcurrent pick-up.
- High set phase overcurrent trip.
- Ground fault pick-up.
- Ground fault trip.
- Unbalance alarm.
- Unbalance trip.
- Reverse power trip.
- Loss-of-field trip.
- Breaker failure element.

Diagnostics

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

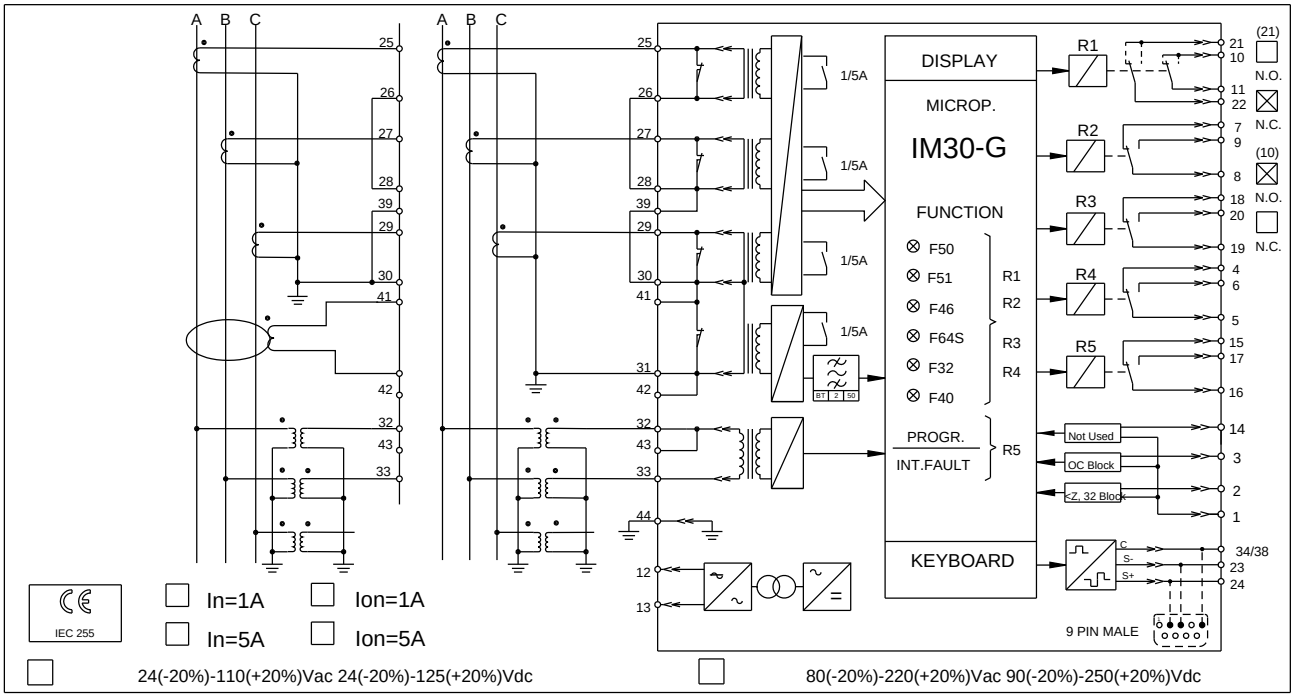

Figure 3.
Wiring Diagram for the IM30G Generator Protection Relay

The relay runs a comprehensive set of diagnostics every 15 minutes which 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 can be run at any time. The first routine not only performs the same previously mentioned 15 minute test but additionally 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.

Dimensional and Electrical Specifications

Catalog Section 150-05 should be consulted for all electrical specifications and dimensional information for each Edison® relay.

Ordering Information

Construct catalog number from Table 1.

Example: IM30GJL5S is an IM30G with low range power supply, 5A CT inputs, in a single relay case.

TABLE 1
Catalog Numbers

Description	Catalog Number
Base Relay	IM30G
To the above add one each of the following applicable suffixes	
Modbus Protocol	J
Power Supply[1]	
24-110V AC/DC	L
90-220V AC/DC	H
Rated CT Input	
1A	1
5A	5
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.

If ordering two or more relays to be fit into 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 be suffixed C2, C3 or C4 to denote their position in the case with the leftmost bay referenced as C1.

TABLE 2
Functional Specifications

Nominal frequency setting range	50 or 60Hz
Programmable rated primary input current of phase CTs	1 - 9999A in 1A steps
Programmable rated primary input current of neutral CT	1 - 9999A in 1A steps
Programmable rated primary PT secondary voltage	100 - 125 V (phase to phase) in 1V steps
Rated generator current	0.5 - 1.1 pu of phase CT rated current in 0.1 pu steps
Breaker fail (50BF) time delay	0.05 to 0.50 seconds in 0.01 second steps
Low Set Overcurrent Element (51P)	
Characteristics	Definite Time (D) or Normal Inverse Time (SI)
Minimum pick-up level	1.0 - 2.5 pu of rated generator current in 0.01 pu steps, or disable
Time delay (definite time delay mode)	0.05 to 30.00 seconds in 0.01 second steps
Time delay (normal inverse time mode)	$t = [(5^{0.02} - 1)Ts] \div [(I_{input} \div I_{pickup})^{0.02} - 1]$ Where: t is the trip time in seconds, Ts is the trip time delay at a pickup multiple of 5.
High Set Overcurrent Element (51P)	
Characteristics	Definite Time
Minimum pick-up level	1.0 - 12.0 pu of rated generator current in 0.1 pu steps, 1 pu steps above 10, or disable
Time delay (definite time delay mode)	0.05 to 3.00 seconds in 0.01 second steps
Stator Ground Fault (64N)	
Characteristics	Definite Time
Minimum pick-up level	0.02 to 0.40 pu of rated primary input current of the neutral CT in 0.01 pu steps, or disable
Time delay	0.05 to 30.00 seconds in 0.01 second steps
Current Unbalance (46I2T)	
Continuous negative sequence current pickup level	0.05 - 0.50 pu of generator rated current in 0.01 pu steps, or disable
Time delay characteristic	Constant I_2^2t $t = Ks \div (I_2 \div I_b)^2$ Where: t is the actual trip time delay in seconds, I_b is the rated generator current, Ks is the trip time delay at $I_2 = I_b$, I_2 is the actual negative sequence current.
Time multiplier	5 - 80 seconds in 1 second steps
Cooling time constant	10 - 1800 seconds in 1 second steps
Current Unbalance Alarm (46A)	
Continuous negative sequence current pickup level	0.03 - 1.00 pu of generator rated current in 0.01 pu steps, or disable
Characteristic	Definite time
Time delay	1 - 100 seconds in 1 second steps
Reverse Power (32)	
Minimum pickup level	0.02 - 0.20 pu of rated phase CT input current in 0.01 pu steps, or disable
Time delay	0.1 - 60 seconds in 0.01 second steps
Loss-of-Field (40) - See Figure 2	
Impedance characteristic angle Φ	0° - 330° in 30° steps
Circle diameter, K1	50 - 300% of generator base impedance in 1% steps
Circle offset, K2	5% to 50% of generator base impedance in 1% steps
Time delay	0.2 - 60.0 seconds in 0.1 second steps
Integration time	0 - 10.0 seconds in 0.1 second steps
Undervoltage inhibition	Enabled for voltage below 0.3 pu of rated PT voltage
Undercurrent inhibition	Enabled for phase current below 0.2 pu of rated CT current

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