Generator Protection

COOPER Power Systems

Electrical Apparatus

150-51

IM3GV Generator Protection Relay

The IM3GV Generator Protection Relay is a member of Cooper Power Systems' Edison® line of protective relays. The IM3GV offers in a compact package all of the basic protection requirements for small to large sized generators.

- Stator Thermal Imaging (49).
- Time and instantaneous phase overcurrent elements (50/51) with or without voltage restraint.
- Current unbalance (negative sequence) with programmable constant I_2^2t characteristics (46).
- Two separate voltage elements (27/59).
- Two separate frequency elements (81).
- Loss of field (40).
- Reverse active power (32).
- Underpower (37).

As members of the Edison relay family, these relays also share the following features:

- 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.

Figure 1.
Front View of the IM3GV Generator Protection Relay

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

Applications

The IM3GV is ideally suited for the protection of small generators, or as the core of a protection package for medium or large generators. The IM3GV provides all of the basic protective functions required for generator protection. The IM3GV 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. The UM30 Frequency/ Voltage relay may also be added for additional voltage protective functions.

Stator Themal Imaging

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.

Phase Overcurrent Relay

The IM3GV 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.

Current Unbalance

The IM3GV 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.

Voltage Protection

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

Frequency Protection

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.

Loss-of-Field

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

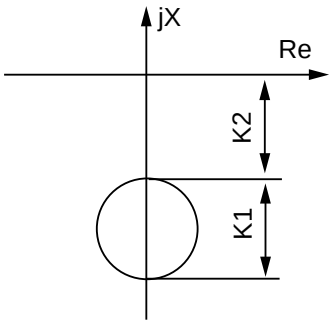

Figure 2.
Loss-of-Field Characteristic

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

Reverse Active Power

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

This function can be activated if desired, for the unusual condition of needing to have interruption of generation of a particular unit at a given power output level.

Breaker Failure

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.

Targets

Eight bright LED targets are provided as follows:

- One red LED flashes when the temperature exceeds the thermal imaging prealarm temperature setting and illuminates constantly when the temperature exceeds the trip level.
- Three red LEDs, one each for the phase overcurrent, negative sequence and loss-of-field elements.
- One red LED for any voltage or frequency element operation.
- One red LED for either reverse power or for underpower.

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 flashes when a blocking signal is active and illuminates constantly when the breaker failure function operates. 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 Characteristics

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:

- Actual thermal status as percentage of the steady full load status temperature.
- RMS phase currents.
- Voltage as a percentage of rated PT secondary voltage.
- Phase displacement.
- Three phase active power as a percentage of the generator's rated power.
- System frequency.
- RMS negative sequence current as a percentage of the generator's rated current.

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, voltages and phase displacements at the time of the trip.
- Values for frequency, negative sequence current and three phase active power at the time of the trip.

In addition the relays keep a cumulative total of the cause 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.
- Thermal image alarm.
- Thermal image trip.
- Undervoltage trip.
- Overvoltage trip.
- First frequency element trip.
- Second frequency element trip.
- Negative sequence alarm.
- Negative sequence trip.
- Loss-of-field trip.
- Reverse active power trip.
- Underpower trip.
- Breaker failure element.

TABLE 1
Catalog Numbers

Description	Catalog Number
Base Relay	IM3GV
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 whichthe relay will be shipped.

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.

Dimensional and Electrical Specifications

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

Ordering Information

Construct catalog number from Table 1.

Example: IM3GVJL5S is an IM3GV 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.

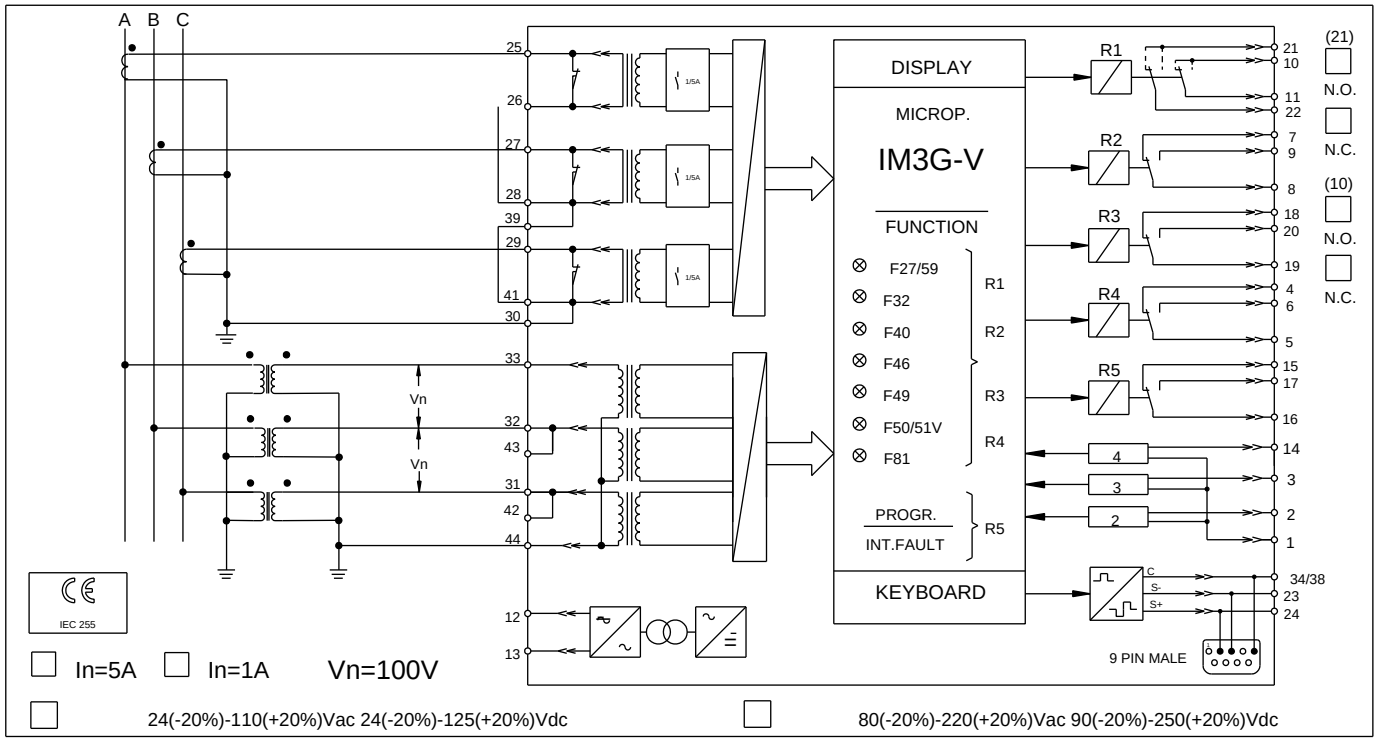

Figure 3.
Wiring Diagram for the IM3GV Generator Protection Relay

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
Programmable rated primary PT secondary voltage	100 - 125 V in 1V steps
Rated generator current	0.5 - 1.1 pu of phase CT rated current in 0.1 pu steps
Breaker failure time delay (50BF)	0.05 - 0.50 second in 0.01 second steps
Stator Thermal Imaging (49)	
Warming-Up time constant	1 - 400 minutes in 1 minute steps
Over temperature alarm level	50 - 110% of full load rated operating temperature in 1% steps
Low Set Voltage Restrained Overcurrent Element (51P)	
Automatic voltage restraint	ON - OFF
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 3.00 seconds in 0.01 second steps
Time delay in inverse time mode	t = (0.033 x Ts) ÷ [$(I\ input \div I\ pickup)^{0.02}$ -1] Where: t is the trip time in seconds, T_S is the trip time delay at a pick-up multiple of 5.
High Set Voltage Restrained Overcurrent Element (51P)	
Automatic voltage restraint	ON - OFF
Minimum pick-up level	1.0 - 12.0 pu of rated generator current in 0. 1 pu steps, or Disable
Time delay (definite time delay mode)	0.05 to 3.00 seconds in 0.01 second steps
Current Unbalance (46)	
Continuous negative sequence current pick-up 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
Voltage Elements (27/59)	
Quantity	2
Characteristic	Selectable between Under (27), Over (59), Under/Over (27/59) or Disable
ΔVoltage setting	5 - 50% PT's secondary rated voltage in 1% steps
Time delay	0.1 - 60 seconds in 0. 1 second steps
Frequency Elements (81)	
Quantity	2
Characteristic	Selectable between Under (81U),Over (81O), Under/Over (81U/81O) or Disable
ΔFrequency setting[1]	0.05 - 9.99 Hz in 0.01 Hz steps
Time delay	0.1 - 60 seconds in 0.01 second steps
Loss-of-Field (40) - See Figure 2	
Circle diameter, K1	50 - 300% of generator base impedance in 1% steps, or Disable
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 generator current
Reverse Active Power (32)	
Minimum pick-up Level	0.02 - 0.20 pu of generator rated current in 0.01 pu steps, or Disable
Time delay	0.1 - 60 seconds in 0.01 second steps
Underpower (37)	
Minimum pick-up level	0.05 - 1.00 pu of generator rated power in 0.05 pu steps, or Disable
Time delay	0.1 - 60 seconds in 0.1 second steps

[1] The setting is made based upon the change from the system base frequency. Whether a negative, positive or absolute value change will be acted upon is dependent upon the operational mode selected: under, over, under/over.

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