Generator Protection

COOPER Power Systems

Electrical Apparatus

150-55

SPM21 Generator Synchronizing Relay

The SPM21 is a member of the of Cooper Power Systems' Edison® line of protective relays. The SPM21 offers the following functions:

- Synchronization of a generator to its reference bus with fast synchronization.
- Live and Dead bus operation.
- Anti-motoring control.
- Kicker pulse control.

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.
- Event records.
- Cumulative trip counter.
- Auto-ranging power supplies.

Applications

The SPM21 is for use in bringing a spinning generator into synchronism with the power system. The relay will ensure the generator and bus are within programmable voltage, frequency, and phase angle ranges, then will issue a close signal to the connecting circuit breaker. The breaker closing time is taken into account in this process.

Figure 1.
Front View of the SPM21 Synch Check Relay

The SPM21 also provides for dead bus operation, whereby the ability to connect the generator to a dead bus may be controlled.

The SPM21 may also be used as a voltage and frequency regulator by disconnecting the bus voltage input, the circuit breaker status input, and setting the DEAD BUS operation mode on. In this mode, the SPM21 will regulate the generator according the set rated system voltage and system frequency.

Normal (Dead Bus Not Permitted) Operation

When a valid operating condition exists (the bus voltage and frequency are within programmed limits) the relay continuously compares the bus' and generator's voltage and frequency against the programmed difference limits. After the voltage and frequency have been within the limits for a programmable period of time, the relay begins to check phase angle displacement.

When the phase angle displacement is within limits and decreasing for a programmable period of time, the relay then begins to monitor the phase angle displacement between the bus and the generator. A breaker close signal will be issued when the phase displacement is also within limits. The breaker closing time is input as a setting, and the relay will automatically adjust the output contact closing time to take into account this breaker closing time.

As protection against repeated connection of the generator to the bus, after the breaker has been opened, the issuance of another close command is blocked for the duration of an internal timer or for as long as an external blocking input is present.

Dead Bus Operation

In addition to normal conditions where the bus voltage and

frequency are within limits, this mode of operation, when selected, also allows closing when the bus voltage is less than 5% of nominal bus voltage.

The bus “reference” voltage and frequency are then set equal to the set nominal system voltage and frequency.

Synchronization

The SPM21 provides voltage regulator control when the generator voltage is below or above the bus voltage by more than the allowed limits. The control is issued as a series of output pulses from a dry contact. The pulse duration is proportional to the measured voltage difference.

Similarly a speed control is provided to adjust the generator’s speed when the generator frequency is above or below the bus frequency by more than the allowed limits. To avoid a motoring condition, the SPM21 prevents closing of the breaker unless the frequency of the generator is higher than the bus frequency.

As with the voltage control, the speed control is issued as a series of output pulses from a dry contact. The pulse duration is proportional to the measured frequency difference.

Kicker Pulse

If the slip frequency is very small or equal to zero, yet the phase displacement between the generator and the bus are not within the programmed limits, the SPM21 will issue a short "increase speed" pulse even if the generator frequency is within limits. This is done to force the phase displacement into range, allowing for more rapid closing of the generator to the bus.

Targets

Eight bright LED targets are provided as follows:

- Four red LEDs (V↑, V↓, f↓, and f↑) which indicate voltage and frequency increase or decrease requirements.
- One red LED (ΔV) which indicates if the bus-generator voltage difference is within limits for closing.
- One red LED (Δf) which indicates if the bus-generator frequency difference is within limits for closing.
- One yellow LED (SX/α) which is illuminated if the breaker is closed, and flashes if the breaker is open and the phase angle displacement between the bus and generator is out of limits.

In addition, one yellow LED is provided which flashes when the relay is in programming mode, and illuminates constantly upon relay or power supply failure. Operation of all output relays is blocked automatically upon an internal relay fault.

Blocking Inputs

Two opto-isolated blocking inputs are provided. One is dedicated to blocking the operation of the SPM21 speed and frequency control output relays. The other is dedicated to blocking operation of the breaker closing relay.

Measurements

The following measurements are available for display on the relay and are accessible by software:

- Generator and bus voltages and frequencies.
- Voltage and frequency differences between the generator and bus.
- Phase angle difference between the generator and bus.

Last Trip Record

At the time of the tie breaker closing, the measured values described above are stored in non-volatile memory, providing details of the last event.

In addition, the relay keeps a cumulative counter of all breaker close operations.

Diagnostics

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

During normal operation the relay suspends operation every 15 minutes for 10 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.

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.

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: SPM21JLS is an SPM21

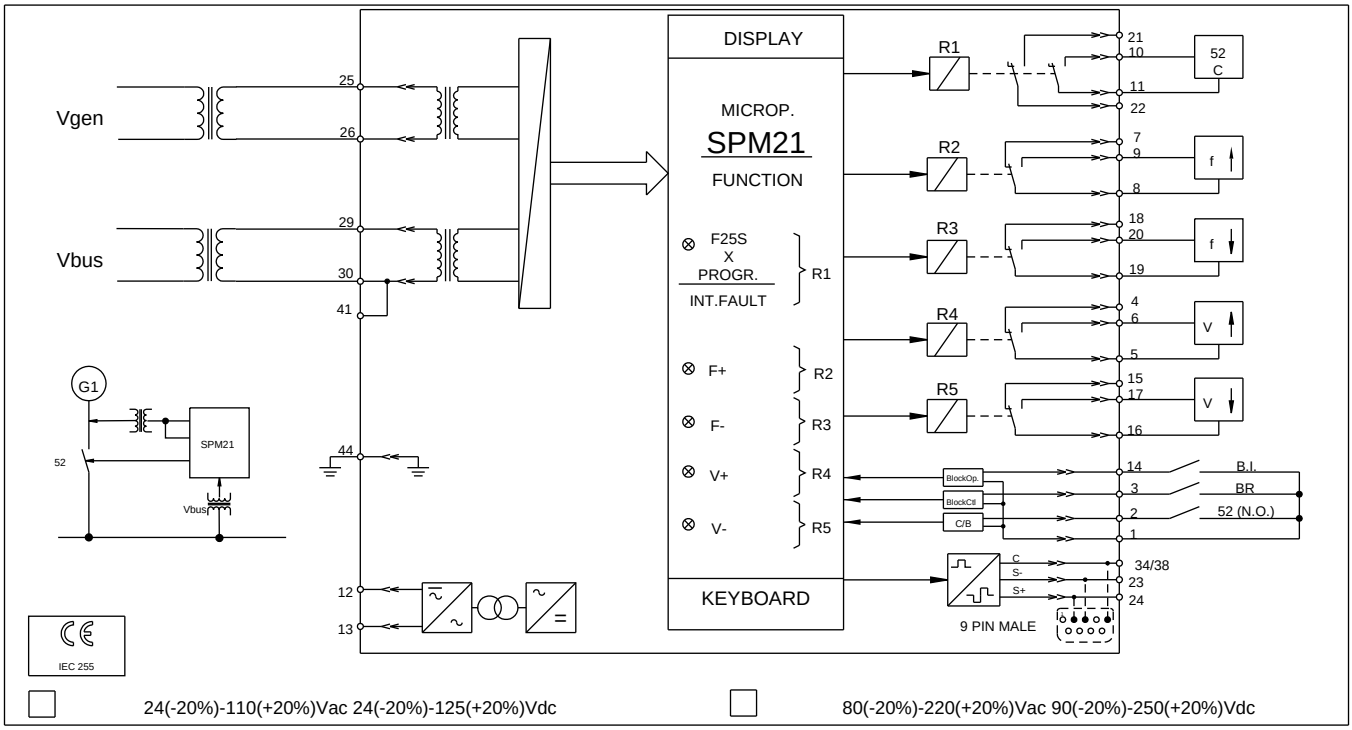

Figure 2.
Wiring Diagram for the SPM21 Relay

with low range power supply in a single relay draw-out case.

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.

Example: An SPM21JxN and an IM30GJxxC2 consist of an SPM21 relay in the leftmost bay of a 19" rack case, with an IM30G relay in the second bay from the left. The third and fourth bays will be empty and will be covered with blank faceplates.

TABLE 1
Catalog Numbers

Description	Catalog Number
Base Relay	SPM21
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
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.

TABLE 2
Functional Specifications

Nominal system frequency setting range	50 or 60Hz
Rated input voltage (PT secondary voltage)	100 - 125V in 1V steps
Dead Bus Operation Mode	ON or OFF
Synchronized Functions	
Minimum Bus voltage to allow breaker closure	15 - 120% of rated input voltage in 1% steps
Maximum Bus voltage to allow breaker closure	20 - 150% of rated input voltage in 1% steps
Minimum Bus frequency to allow breaker closure	45 - 60Hz in 0.1Hz steps
Maximum Bus frequency to allow breaker closure	50 - 65Hz in 0.1Hz steps
Maximum permissible generator/bus voltage difference	1 - 20% in 1% steps
Maximum permissible generator/bus frequency difference	0.05 - 0.60Hz in 0.01Hz steps
Maximum permissible generator/bus phase angle difference	3 - 30° in 1° steps
Minimum time for voltage and frequency conditions to be met before phase angle is monitored	0 - 60 seconds in 0.1 second steps
Programmable circuit breaker closing time	0.01 - 0.50 seconds in 0.01 second steps
Reclose time delay	0 - 600 seconds in 1 second steps
Voltage and Frequency Control	
Voltage regulator pulse duration	0.5 - 60.0 seconds in 0.1 second steps
Minimum voltage pulse duration	0.1 - 60.0 seconds in 0.1 second steps
Maximum voltage pulse duration	0.1 - 60.0 seconds in 0.1 second steps
Gain for proportional voltage pulse duration	0 - 9.9 Volts/second in 0.1 Volts/second steps
Speed regulator pulse duration	0.5 - 60.0 seconds in 0.1 second steps
Minimum speed pulse duration	0.1 - 30.0 seconds in 0.1 second steps
Maximum speed pulse duration	0.1 - 30.0 seconds in 0.1 second steps
Gain for proportional speed pulse duration	0 - 9.9 Hz/second in 0.1 Hz/second steps

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