Synchro-Check Relay for Parallel Operation

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Abstract— This Synchro check relay can be used to assist in the semi-automatic paralleling of two ac power systems. It is the intention of this presentation to provide an explanation of the automatic synchronizing process, to explore the considerations involved and to look at some synchronizing applications for selection of the proper synchronizer. Synchronizing, in its simplest form, is the process of electrically connecting additional Generators to an existing bus. Paralleling protector provides Manual /automatic switching of generator to bus bar without damage or disturbance to the system. The volt - free relay contacts change state when the voltage level, phase relationship and frequency are within the selected synchronizing limits. Connecting two electrical systems that are not closely matched can cause expensive damage and disturbance to the electrical system. Using this relay will ensure that damage will not occur.

Key words: Laboratory Prototype, Generator Protection, Numerical Relay Settings, Various Fault/abnormal Conditions

I. INTRODUCTION

TheTypeSLJ21Aisastaticsynchro-nismcheck relaywhichisdesignedtopermitclosingofabreakeronlyifthe anglebetween the voltages on the line and bus sides of the breaker is less than a set angle for a set period of time.

The SCM21 is a member of the of Cooper Power Systems' Edison® line Control of one or two lines against a common bus.

- Check of voltage, frequency, and phase displacement between each of the lines and the bus.
- Programmable dead line and dead bus operation.
- Definite time bus over- and under- voltage inhibit functions.
- Definite time bus over- and under- frequency inhibit functions.
- The SCM21 relay also shares the following features common 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.
- Three fully programmable Form C (SPDT) output contacts and one Form A/B contact set.
- Pick-up (start-time) elements.
- Programmable reset characteristics.
- Dedicated power supply/relay fail output contacts.
- Event records.
- Cumulative trip counters.
- Auto-ranging power supplies

Fig. 1: Front View of the SCM21 Synch-Check Relay

II. APPLICATIONS

The SCM21 is ideally suited as a supervisory relay on lines subject to reclosing where the possibility that the open line or lines may be out of synchronism with the common bus. Reclosing the lines on to the bus under this condition may possibly cause equipment damage or exacerbate system stability concerns.

The SCM21 may also be used as a supervisory relay for industrial or co-gen operations to ensure that the plant generators are in synchronism with the local utility

Before closing the tie breaker. Note, the SCM21 does not provide synchronizing functions. If this is required, please refer to synchronizing relay SPM21 described in Catalog Section 150-55.

The SCM21 also provides for dead bus and dead line operation, whereby the ability to re-energize a line or bus may be controlled.

III. OPERATION

When a valid operating condition exists (one or two lines open and the bus voltage and frequency are within programmed limits) the relay continuously compares the bus' and line(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 breaker close signal is enabled. The breaker closing time is

able to be input as a setting, and the relay will automatically adjust

After the relay has issued a close command, the issuance of another close command is blocked for the duration of an internal timer.

A. Dead Line Operation:

In addition to normal conditions where both line and bus voltages are within limits, this mode of operation, when selected, also allows closing when the following conditions are met:

− The line voltage is less than 5% of nominal bus voltage;
− Bus voltage and frequency within programmed limits.

B. Dead Bus Operation:

In addition to normal conditions where both line and bus voltages are within limits, this mode of operation, when selected, also allows closing when the following conditions are met:

− The bus voltage is less than 5% of nominal bus voltage;
− Line voltage and frequency limits are within programmed limits.

Both dead bus and dead line operation modes may be activated simultaneously. If both modes are selected, closing is blocked in the case that both lines and the bus are dead.

C. Targets:

Eight bright LED targets are provided as follows:

One red LED (VBUS RANGE) which monitors the bus voltage against the acceptable range defined by the bus over- and under- voltage inhibit elements. When both lines are isolated from the bus, the LED flashes if the bus voltage is within the set limits. This signifies a permissive condition.

If one or both of the lines are connected to the bus, the LED remains dark if the bus voltage is within the set limits. The LED will flash if the bus voltage exceeds either the bus under- or over- voltage inhibits elements (i.e. pickup).

The LED will illuminate continuously after the set time delay (i.e. trip).

− One red LED (V) which compares the difference between the bus and line voltages against the predefined limits to permit closing. The LED is off if both line breakers are closed. The LED flashes if the delta voltage between the bus and an open line or lines is low, and illuminates constantly if high.
− One red LED (f) which compares the difference between the bus and line frequencies against the predefined limits to permit closing. The LED is off if both line breakers are closed. The LED flashes if the delta frequency between the bus and an open line or lines is low, and illuminates constantly if high.
− One red LED (BUS RANGE) which monitors the bus voltage against the acceptable range defined by the bus over- and under- voltage inhibit elements. When both lines are isolated from the bus, the LED flashes if the bus voltage is within the set limits. This signifies a permissive condition. The flashing or constant illumination pattern of the LEDs follows the same logic as the VBUS RANGE LED.
− Two red LEDs which indicate the condition of the phase angle displacement between the bus and the lines and the

breakers (CLOSED/SYNCH LINE 1 and CLOSED/SYNCH LINE 2). When the breaker for the respective line is closed, the LED are constantly illuminated. When the breakers are open, the LEDs flash of the phase angle displacement is within limits, and is dark if out of limits.

− In addition, one yellow LED is provided which illuminates when any function has been disabled via programming.
− A second yellow LED flashes when the relay is in programming mode, and illuminates constantly upon relay or power supply failure.

D. Blocking Inputs:

One onto-isolated blocking input is provided and is dedicated to blocking the operation of the relay's output contacts. Note, this does not block operation of the relay logic.

E. Output Functions:

The following output functions are available which may be assigned to any or all of the programmable output contacts. Note that pick-up and time delayed elements may not be assigned to the operate the same output contact(s).

− Closing command of line 1 breaker (all synch conditions are met).
− Closing command of line 2 circuit breaker (all synch conditions are met).
− Time delayed bus.
− Time delayed bus overvoltage.
− Time delayed under frequency.
− Time delayed over frequency.

F. Reset Characteristics:

Each of the four programmable output relays except those assigned to close the line 1 or line 2 circuit breakers may be programmed to reset in one of three manners.

− Instantaneously upon the input or calculated quantities dropping below the pickup value.
− Automatically, but with a time delay adjustable between 0.1 and 9.9 seconds in 0.1 second steps.
− Manual reset (by front panel or computer command) only.

Output relays assigned to close the circuit breakers automatically reset 10ms after the circuit breakers close signal is detected.

G. Measurements:

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

− Line and bus voltages and frequencies.
− Voltage and frequency differences between each line and the common bus.
− Phase angle difference between each line and the common bus.

H. Last Trip Record:

At the time of any pick-up event, the measured values described above are stored in non-volatile memory, providing details of the last event. A record is kept of the initiating event.

In addition, the relay keeps a set of counters associated with the operation of each protective element.

I. 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.

Description	Catalog Number
Base Relay	SCM21
To the above add one each of the following applicable suffixes	
Modbus Protocol	J
Power Supply[1] 24-110V AC/DC	L H
Case Style[2] Draw out relay only, no cabinet supplied Single relay case Double relay case 19" Rack mount cabinet	D S T 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

Table 1: Catalog Numbers

J. Dimensional and Electrical:

Specifications:

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

K. Ordering Information:

Construct catalog number from Table 2.

Example: A SCM21JxN and an IM30AJxxC2 consist of a SCM21 relay in the leftmost bay of a 19" rack case, with an IM30A relay in the second bay from the left. The third and fourth bays will be empty and will be covered with blank face plate
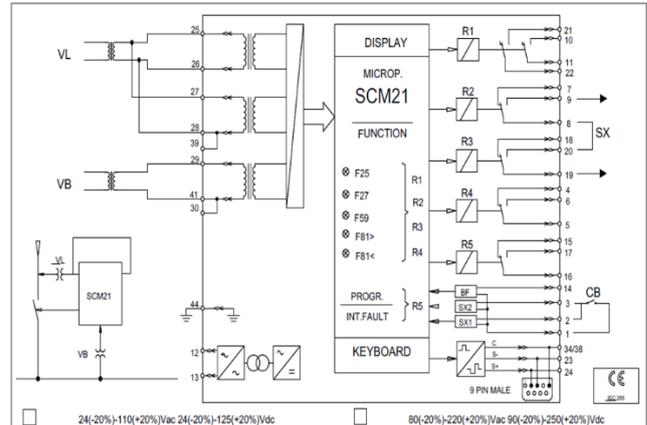

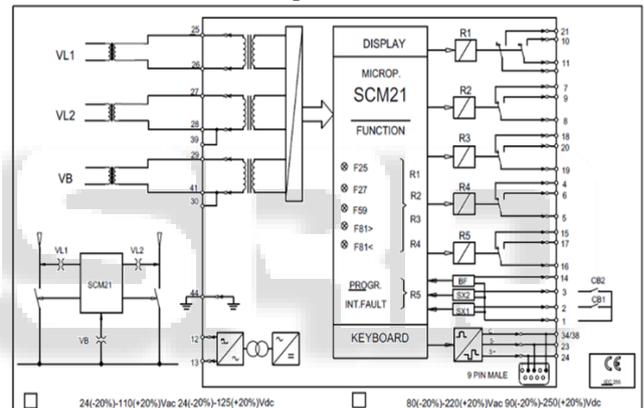Fig. 2: Wiring Diagram of SCM21 for 1 line Synch-Check Operation

Fig. 3: Wiring Diagram of SCM21 for 2 line Synch-Check Operation

Nominal frequency setting range	50 or 60Hz
Rated input voltage (PT secondary voltage)	100 - 125V in 1V steps
Minimum Bus voltage to allow breaker closure	15 - 120% of rated input voltage in 1% steps
Trip time delay for bus under voltage	0.1 - 30 seconds in 0.1 second steps
Maximum bus voltage to allow breaker closure	20 - 150% of rated input voltage in 1% steps
Trip time delay for bus over voltage	0.1 - 30 seconds in 0.1 second steps
Minimum bus frequency to allow breaker closure	45 - 60Hz in 0.1Hz steps
Trip time delay for bus under frequency	0.1 - 30 seconds in 0.1 second steps
Maximum bus frequency to allow breaker closure	50 - 65Hz in 0.1Hz steps
Trip time delay for bus over frequency	0.1 - 30 seconds in 0.1 second steps
Maximum permissible line/bus voltage difference	1 - 20% in 1% steps
Maximum permissible line/bus frequency difference	0.02 - 0.50Hz in 0.01Hz steps
Maximum permissible line/bus phase angle difference	3 - 30° in 1° steps
Minimum time for voltage and frequency conditions	

Table 2: Functional Specifications

IV. CONCLUSION

The voltage check function is used when a disconnected bus/line is to be connected to an energized section of a network. The synchro- check function allows circuit breaker closing only if the voltages on both sides of the circuit breaker fulfill the preset conditions as to magnitude, phase and frequency difference. SCM21 is a voltage measuring relay designed to be used when two power systems are to be connected together. ... The synchro- check function allows circuit breaker closing only if the voltages on both sides of the circuit breaker fulfill the preset conditions as to magnitude, phase and frequency difference. A synchro-check or synch-check relay electrically determines if the difference in voltage magnitude, frequency and phase angle falls within allowable limits. The allowable limits will vary with the location on the power system. ... A synch-check relay decides internally whether its conditions for closing are satisfied.

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