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SE-2SCR-LC MANUAL

DIGITAL SCR CONTROL

MAY 1997

PRELIMINARY

Publication: SE-2SCR-LC-M
Document: S95-2SCR-00000
Printed in Canada.

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1. GENERAL

Each Startco solid-state starter uses one control module to control the power applied to three-phase, squirrel-cage induction motors in one-, two-, three-, or four-motor configurations. The SE-2SCR-LC LOAD CONTROL module replaces the SE-2SCR, and SE-1SCR control modules.

A silicon-controlled rectifier (SCR) is an electrically operated switch that can be gated into conduction by applying a trigger pulse to its gate terminal. Once a SCR is gated on, it will remain on until current drops below a low value called the holding current. In ac applications, this happens each cycle on the negative zero crossing; consequently, SCR's can be used to control ac voltage by triggering the SCR's into conduction once each cycle. The portion of the cycle in which current flows is called the conduction angle. In Startco solid-state starters, conduction angle signals from the control module initiate SCR trigger pulses generated by firing boards in the power modules.

A Startco power module with a SCR and a diode in a parallel, back-to-back configuration is used in each line to control three-phase power to a motor. The SE-2SCR-LC uses either current (TORQUE) or tachometer feedback to adjust SCR conduction angles during a start to bring a load smoothly up to speed. Once full conduction is reached, the SCR's are gated full-on so that currents are the same as they would be if the power modules were replaced by contacts.

2. TORQUE OR CURRENT FEEDBACK

A toggle switch on the back of the control is used to select torque (current) or tachometer feedback. In torque feedback, the ACCELERATION and TORQUE LIMIT HOLD potentiometers on the front panel are operational.

Six red LED’s provide a visual indication of the conduction angle applied to the motor. These red LED’s have a binary weighting of 32, 16, 8, 4, 2, and 1 from left to right. When the drive is off, the conduction angle LED’s will be off. At the beginning of the start sequence, the left four LED’s on the conduction angle indicator will turn on. This corresponds to a count of 60 which is the number of steps used to apply full voltage to the motor. Upon completion of the sixty steps, all red LED’s on the conduction angle counter will be off and the green LED indicating FULL CONDUCTION will be on.

2.1 ACCELERATION ADJUSTMENT

The ACCELERATION control sets the rate at which the conduction angle counter will be clocked from 60 down to full conduction. The ACCELERATION control is calibrated from 1 to 5. When the ACCELERATION control is set to 1, it will take approximately 25 seconds to count from 60 down to full conduction. As the acceleration control is advanced clockwise, the time to reach full conduction will decrease by 5 seconds for each division so that at maximum acceleration (5) the conduction angle will count from 60 to full conduction in 5 seconds.

2.2 TORQUE LIMIT ADJUSTMENT

The TORQUE LIMIT adjustment is also calibrated on a scale from 1 to 5. Each unit on this scale corresponds to full-load current of the motor. For example, if the TORQUE LIMIT is set on 3 for a 200-hp, 600-Vac motor, the torque limit would be 600 A or 300%.* During a start, the conduction angle will increase at a rate controlled by the ACCELERATION setting; however, if the ACCELERATION rate is too high or if the load is sufficient to cause the motor current to increase to 600 A, the torque limit hold light will come on and the conduction angle will not advance until the motor current falls below 300%. As the motor accelerates, the current will decrease and the conduction angle will then continue to advance toward full conduction. During the interval that the SCR control is in TORQUE LIMIT HOLD condition, the clock pulses that would normally be used to advance the conduction angle are accumulated in a trip counter. If the load is too large, acceleration setting is too high, or the torque limit setting is too low; the starter will trip, indicating a torque limit trip, if 24 of these pulses accumulate in the trip counter during the start. Should this occur, either the ACCELERATION should be decreased or the TORQUE LIMIT should be increased. The TORQUE LIMIT HOLD indicator should flicker once or twice during a heavily loaded start.

* If requested by the customer, the feedback current transformers can be changed so that the scale of 1 to 5 will correspond to 1.5 to 7.5 times full-load current. This scale change also applies to the instantaneous overcurrent trip adjustment.

2.3 INITIAL TORQUE ADJUSTMENT

Two adjustments on the back of the SCR control allow the initial torque and the instantaneous overcurrent trip to be adjusted. Adjusting the INITIAL TORQUE potentiometer clockwise increases the conduction angle applied when a run signal is received. Normally, a setting slightly less than midscale will be sufficient for most applications. The INITIAL TORQUE should be set so that torque is applied smoothly and shaft rotation begins without delay. If the initial torque setting is too high, the starter will trip on overcurrent at the beginning of the start sequence.

2.4 INSTANTANEOUS TRIP ADJUSTMENT

The instantaneous overcurrent trip potentiometer is calibrated from 100% FLA (ccw) to 500% FLA (cw). This control is normally left in the fully clockwise position so that the starter will trip if the instantaneous current exceeds 500%.

3. JOG TEMPERATURE INDICATOR

The four amber LED's labeled JOG TEMPERATURE indicate the recent starting history of the starter. The LED's have a binary weighting of 8, 4, 2, and 1 from left to right. The number in the jog temperature counter is obtained by adding the binary value of the LED's that are on. Values assigned to this counter are: zero is cold, four is normal run and fourteen is trip. Two clocks are used to change the number in the counter. A fast clock is used to increase the count during starting at approximately one count every 5 seconds, and a slow clock is used to decrease the count to four when running or down to zero when stopped. The down count rate is approximately 1 count every 66 seconds. This allows two successive minimum acceleration starts if the drive is stopped on normal run; however, if a third start is attempted, the anti-jog circuit will trip at a count of 14 and it will not allow a reset until it has counted down to four. This will take approximately 11 minutes.

4. PHASE LOSS INDICATOR

The phase loss indicator serves two functions. During initial hook-up, the phase loss trip will not allow a reset if the phase sequence of the supply is reversed. A phase sequence of A B C from left to right is required. Once the correct sequence has been established, the phase loss circuit will lock out the SCR control if any one or all of the phases are interrupted. Both conditions require a manual reset and are indicated by the phase loss trip LED.

5. TACHOMETER FEEDBACK

The tachometer feedback circuit* is designed to accept an analog output from a dc tachometer connected to one of the drive motors. A 5PY59JY23 tachometer which provides 100 Vdc/1000 rpm is recommended. On-board jumper pins are provided so that the tachometer circuit can be programmed for 1800, 1200, or 900 rpm motors. Normally the SCR control will be jumpered for 1800 rpm operation. The negative terminal of the tachometer should be connected to the starter chassis and positive terminal to the TACH input on the board. To operate with tachometer feedback, the toggle switch on the rear of the SCR Control must be set to "TACH". The TORQUE LIMIT control should be adjusted between 4 and 5 (400% - 500% current).

When the drive is started with tachometer feedback, the TORQUE LIMIT control is inhibited because the conduction angle and hence the current will be adjusted automatically to the level required for the drive to follow a speed ramp. Consequently, the conduction angle indicator will remain with a 60 count until the motor reaches 90% of full speed. At this time, the conduction angle control will take over and clock toward full conduction to guarantee that the SCR's are full-on during normal run. The clocking time is internally fixed at 5 seconds and is independent of the ACCELERATION control setting.

Two adjustments are provided in tachometer feedback. The TACHOMETER RAMP potentiometer adjusts the acceleration time from 10 seconds (ccw) to 20 seconds (cw). Increasing the acceleration time is recommended for heavy loads or long conveyor belts. The STABILITY ADJUSTMENT potentiometer should be set midscale. If hunting or oscillating of the drive is observed, the stability adjustment can be turned slightly counter clockwise until hunting is no longer observed.

In the tachometer feedback mode, the function of the INITIAL TORQUE potentiometer is changed. In tachometer feedback, the INITIAL TORQUE adjustment is used to limit the maximum conduction angle so that the motor current will not exceed 500% and cause an overcurrent trip during the start sequence. In tachometer feedback, the INITIAL TORQUE potentiometer should be increased to the 12 o'clock position; however, a further increase to 2 o'clock may be necessary if the drive seems to falter or hesitate between 1/3 to 2/3 of full speed due to the droop in the torque speed characteristic of the motors. If the INITIAL TORQUE potentiometer is set correctly, the motors will be allowed to draw between 400% and 450% full-load current. The current level can be observed during starting by decreasing the TORQUE LIMIT control on the front panel to make the torque limit hold light come on. This technique can be used to manually track the current during starting; however, care must be taken not to keep the torque limit light on too long and trip the drive off on torque limit trip. Also, remember to leave the torque limit control at about 450% so that the torque limit hold light does not come on during a normal start.

* SE-2SCR-LC used with Red Lion Controls (magnetic pick-up and pulse rate to analog converters) are modified as follows:

- 10 kΩ resistor designated R238 is removed.
- 4.7 μF capacitor designated C124 is removed.
- Required input: 10 Vdc @ full speed.

6. LOAD REGULATION CONTROL

The SE-2SCR-LC has provisions for driving 4 SCR banks. These banks are controlled by the load control circuit. Four rocker switches on the board are used to select the banks that are to be controlled by the load regulation circuit. With a switch in the up or OFF position, the selected bank will not be allowed to drop-out. When in the down or ON position, that particular bank will be under the control of the load regulation circuit.*

The load regulation circuit monitors the motor current obtained from the phase A feedback CT of each bank of SCR's. Two potentiometers on the board adjust the current level at which the motor will be shed (DROP OUT) and pick-up (PULL IN). The shed level is 50 to 75 percent of rated motor current and the pick-up level is 80 to 100 percent of rated current.

With the motor currents below the DROP OUT level, the SCR banks will be sequentially turned off starting with bank 4. The drop-out rate is one motor per 5 minutes and the pick-up rate is 20 to 40 seconds.

*** Note that at least one switch must be in the OFF position to guarantee that one motor remains on. If all switches are set to allow shedding, all motors may be shed when the conveyor belt is running unloaded. This is followed by an EMERGENCY TRIP (SE-3ETC) due to no motor current being sensed when a run signal is applied. In addition, unused inputs to the load regulation circuit must be grounded to 260.**

7. SOLID-STATE STARTER TROUBLESHOOTING TIPS

Reference: Startco Blueprint SE2SCR-4.CDR

- - - C A U T I O N - - -

Power modules, heat sinks, and motor cables can be energized even if a motor is not running. If a motor is stopped, diodes in the power modules provide half-wave rectification with respect to ground. If a motor is disconnected, current through snubber networks in the power modules is sufficient to be lethal. Use the same precautions and safety procedures for both line-side and load-side measurements and service.

In the event of a control problem with a solid-state starter, the following list of troubleshooting tips can be used to isolate the problem using only a dc voltmeter.

1. Check the SCR Control panel for fault indication. i.e. overcurrent trip, etc.

2. If all indication is normal, depress the lamp test switches to ensure that all annunciation is operational.

3. If this fails to locate the problem, disconnect the gate drives to the SCR's (white wires) and make the following measurements with a dc voltmeter.
   – The voltage on terminal 202 must be 12 Vdc. If this voltage is 0 Vdc, the SCR Control is indicating a tripped condition.
   – If a run signal is being generated, a 12 Vdc signal on terminal 201 should be present whenever the run signal LED is on.

4. If the SCR Control has the tachometer feedback option, put the tachometer feedback switch in the TORQUE position (down position). When a run signal is generated, the conduction angle counter should clock down from a count of 60 to full conduction at a rate controlled by the acceleration control. If full conduction is not achieved, measure the voltages on signal terminals 211, 212, and 210 to ground. Starting at the upper right hand terminal 211 and working clockwise toward terminal 238 and 230, the dc voltages should be 12, 5, 0, 12, 5, 0, 12, etc. Odd numbered terminals are 12 Vdc, even numbered terminals are 5 Vdc except for terminals ending with a zero which are 0 Vdc.* The voltage on even numbered terminals should drop to 0 Vdc when the run signal is removed.

5. With the SCR Control in full conduction, check the input signals to the firing boards which should also be 12 Vdc, 5 Vdc, and 0 Vdc. If the SCR Control outputs are normal but do not appear at the firing boards, then the shielded cable is defective. If the inputs to the firing boards are normal, each firing board can be checked by placing a 1-k ohm resistor between the gate and cathode terminals on the firing board (SCR disconnected). The voltage across this resistor should be 6 Vdc when the SCR Control is in full conduction and 0 Vdc when the SCR Control is off.

6. In order to check the SCR and the Diode, the shorting bar on the split heat sink should be removed. The diode can be checked in the conventional manner and the SCR can be checked with the simple circuit shown on the blueprint.*

* See troubleshooting blueprint.