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**4922c**

*Instruction Manual  
Publication 189 SCR  
March 1995*

# ***Silicon Controlled Rectifier***

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# Silicon Controlled Rectifiers

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The primary SCR bridge is an SCR/Heat Sink assembly with the power SCRs connected in inverse parallel. The function of the SCR bridge is to control the amount of voltage applied to the motor. The SCR, silicon controlled rectifier, is similar to standard rectifiers in that it will allow current to flow in one direction while blocking current in the reverse direction. However, SCRs will conduct current only when turned ON. When two SCRs are connected as shown a controllable AC switch or contact is formed that will carry current in either direction but only when GATED ON. SCRs can react very quickly to gating signals, quickly enough to be able to control portions of half cycles of standard AC power. When the gating or firing signal is presented to the SCR very late in the half cycle, the SCR will block all of the cycle up to the time of firing. At the time the gating signal is applied, the SCR will turn ON and conduct the remaining portions of the half cycle to the load.

As the firing signal is presented earlier in the half cycle, the SCR will conduct more and more of the cycle on to the load. The extremes will be maximum firing when the SCR bridge passes all of the AC power on to the motor, and lock out, zero firing, when the SCR bridge blocks all of the AC power.

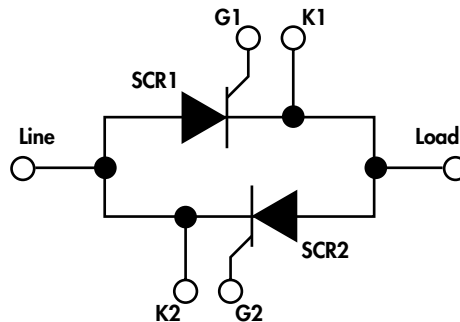
In static reversing controllers, the SCR bridges also perform a directional control function as well. As can be seen in Figures 4 & 5 (on pages 13 & 14), there are five SCR bridges, two Hoist bridges, two

Lower bridges, and one Common bridge. When a Hoist operation is required, adjustable voltage three phase power is supplied to the motor via the two Hoist bridges and the Common bridge. The three phase relationship of the applied motor power determines the direction of developed motor torque and rotation.

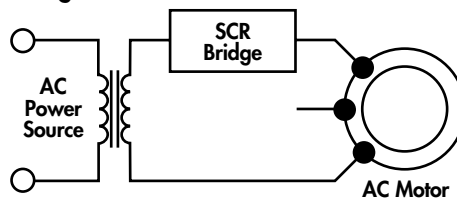
A Lower operation will be performed in one of two ways depending upon mechanical losses and the weight of the suspended load. First, adjustable voltage power is supplied to the motor via the two Lower bridges and the Common bridge to produce a driving lower operation. If the loading is such as to continue to require a driving lower torque, system will supply lowering adjustable voltage power to meet the commanded speed condition. If an overhauling condition exists, a counter-torque lowering operation will occur where the Hoist SCR bridges and the Common bridge provide motor power. True motor and power system regeneration can be used, if desired, to lower overhauling loads at full speed. For this condition, the system turns the Lower SCR bridges and the Common SCR bridge fully on to supply full lowering voltage to the motor.

The transition from driving lower to counter-torque lower is automatic and is determined by the mechanical loading presented to the motor. Full voltage regenerative lowering will produce lowering speeds 10% to 15% greater than full load hoisting speeds.

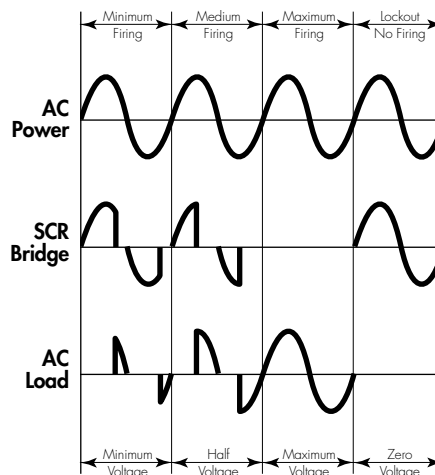
**Inverse Parallel SCR Bridge Circuit**



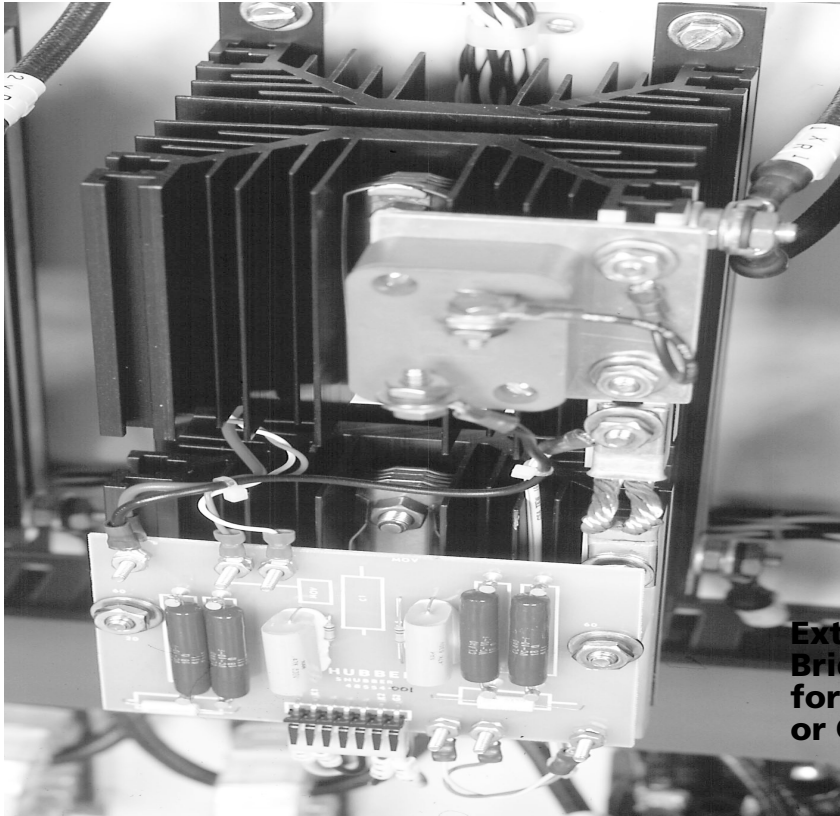
**Primary SCR Bridge Schematic**



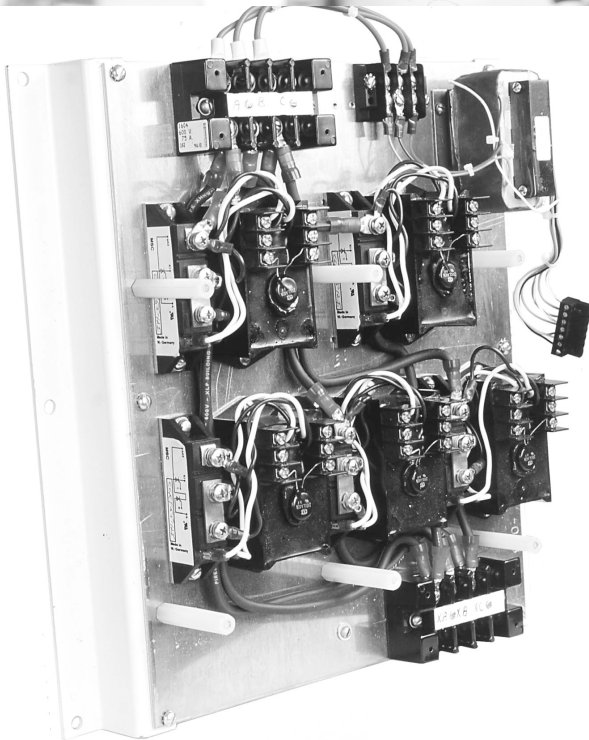
**SCR Firing Cycle Waveforms**



## Major Components



**External SCR Bridge Assemblies for 50 hp (460V) or Greater**

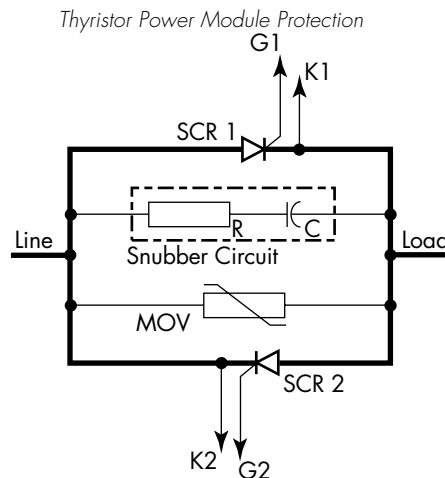


**Compact SCR Bridge Assembly for 40 hp (460V) or Less**

## Thyristor Power Module Protection

Thyristor power modules (TPM's) are SCR/SCR, full wave assemblies available in several horsepower ratings from 10–500 hp in ambients up to 140°F (60°C). Each assembly is configured as an inverse parallel bridge with snubbing circuit and voltage transient protection as shown in the illustration. The TPM's are the units that control the applied motor voltage on primary thyristor controls.

The snubbing circuit, comprised of a capacitor and a resistor, is connected in parallel with the SCR's across the bridge. The function of the snubbing circuit is to limit the rate of rise of applied voltage. Transient voltage protection is provided by a metal oxide varistor, MOV, which is also connected in parallel across the bridge. The MOV is a nonlinear resistive device that will limit or clamp the transient voltage to a safe level. The snubbing circuit in conjunction with the MOV provides complete transient voltage protection for the TPM's.



# Troubleshooting

Inverse parallel SCR bridges control AC power by providing a method of adjusting applied voltage as in the case of Primary Motor Control. The AC Power is handled on a half cycle basis by one of two SCR's. Refer to the Primary SCR Bridge figure provided. SCR1 can conduct power on the first half of the cycle and SCR2 can conduct during the remaining half of the cycle thereby providing balanced currents. Ammeter readings of motor primary currents at low motor speeds should produce balanced readings.

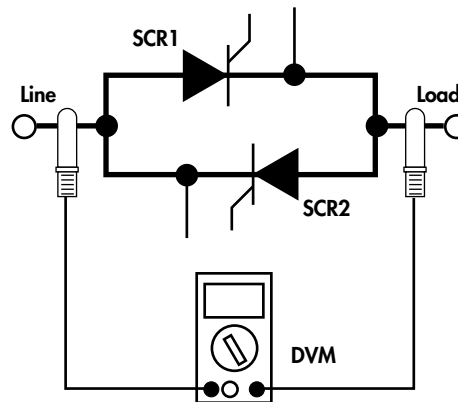
If one of the SCR's fails to conduct, the controlled power becomes unbalanced with a DC component which can saturate common motor loads and lead to higher than normal operating currents. If one of the SCR's becomes shorted, the SCR Bridge supplies full conduction for that phase resulting in unbalanced phase voltages and currents in Primary Control.

The operating condition of an inverse parallel SCR Bridge can be determined easily with a digital DVM. A simple continuity test can be performed with the power removed from the motor circuit. In most Primary Control systems, when the power is removed and the directional or main contactor is open, the SCR Bridge is isolated and continuity measurements can be made directly at the bridge. A shorted SCR will result in a very low or "Zero"

ohmmeter reading. A good SCR Bridge will result in a ohmmeter reading of 200K to 300K ohms.

An open or nonconducting SCR as well as a shorted SCR can also be located by taking a set of AC and DC readings across each SCR Bridge and comparing the values. Again, normal readings will be balanced from phase to phase with the "odd" reading indicating a problem. By looking at the SCR Bridge waveforms on the figures supplied, normal operation is indicated by equal periods of positive and negative voltage. With the motor operating at minimum speed, approximately 50% voltage will be supported across each SCR Bridge, and an AC measurement across each bridge should yield balanced voltages. A "Zero" or very low AC voltage reading indicates a shorted SCR. With the DVM set to read DC, voltage measurements across each bridge should yield a low DC value indicating equal periods of positive and negative voltage. A typical DC voltage encountered in this measurement will be less than 10 volts. A reading substantially higher than 10 volts indicates unbalanced firing. The unbalanced condition will affect the readings on the remaining two phases, therefore, the highest unbalanced voltage when compared to the remaining readings, indicates the problem phase.

## SCR Readings



Connecting a DVM as shown above, test an SCR for the two conditions listed below. If either of the test conditions fail the SCR will need to be replaced.

### 1. Power Off Condition

Set the DVM to Ohms and measure the resistance across the SCR. It should read 200k–300k $\Omega$ . If it reads 0 $\Omega$ , then the SCR is shorted. It needs to be replaced.

### 2. Power On Condition (Motor Running at minimum speed)

Set the DVM to read 600VAC. If the DVM reads between  $\approx$ 200–300VAC for a 460V system configuration, the SCR is acting normal with all phases balanced. If the DVM reads 0V, the SCR is shorted. It needs to be replaced.

Now set the DVM to 600VDC. If the DVM read  $\pm$ 5 to  $\pm$ 10VDC, the SCR is running normally with all phases balanced. If the DVM reads  $>$  $\pm$ 20VDC, the SCR is conducting current as a diode or is not firing. It needs to be replaced.

## SCR Firing Cycle Waveforms

