SPECIAL SUPPLEMENT

CAPACITORS FOR SCR COMMUTATION

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The silicon controlled rectifier (SCR) is a three-terminal pnpn semiconductor device with characteristics similar to those of a thyratron. The application of SCRs in industrial and commercial power control systems has grown considerably in India in the last few years. High-voltage high-power controlled rectifiers have created a new concept of solidstate power control systems. Conventional AC/DC

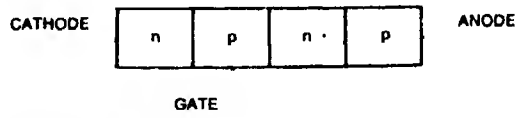

Fig. 1: PNPN SCR structure

general-purpose capacitors are unsuitable for these applications. Capacitors for these applications require high peak and RMS current ratings, high insulation resistance, low power factor and low inductance.

SCR operation

The function of the pnpn structure (Fig. 1) is that of controlling power by serving as a switch. The SCR acts like a diode (Fig. 2) in the reverse direction, blocking current from cathode to anode. In the forward direction, the current is blocked until it is turned on by a pulse between the gate and the cathode. The 'on' state is characterised by an

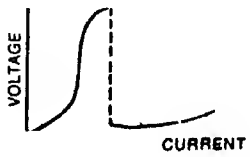

Fig. 2: SCR V/I characteristics

extremely low forward impedance and the current flow is limited only by the external circuit.

Capacitor switching

The SCRs can trigger on large currents with very small gate current levels. However, the controlled rectifier loses the gate control of the anode current after the conduction begins. The SCR must be turned off by reducing the anode current flow below the device holding current. For AC applications this problem does not exist because the device turns off at the end of the conduction half-cycle when the anode voltage becomes zero.

A fast turnoff is normally desired in high frequency operations. This is achieved by the use of a charged capacitor delivering energy into the SCR when allowed to reverse bias SCR in the conducting state. The device will conduct a high reverse current, discharging the capacitor. Fig. 3 shows a typical capacitor switching the SCR circuit.

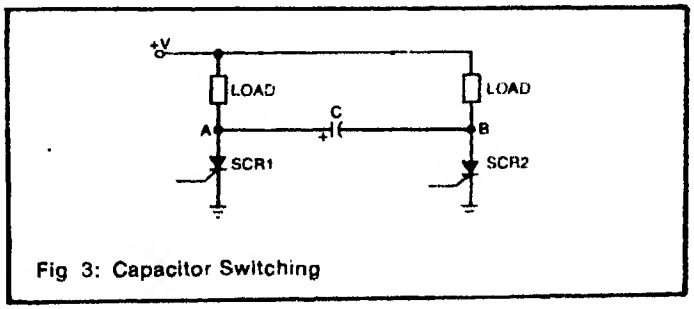

Fig 3: Capacitor Switching

SCR1 is assumed to be 'on' and SCR2 is assumed to be 'off' with on gating signals applied. Because SCR1 is conducting, the voltage level at point A is nearly zero and with SCR2 'off' the voltage at point B will be very close to +V. The capacitor C is charged to +V. If a gating signal is applied to SCR2, it will turn on virtually instantaneously. The voltage at point B will drop to zero and a negative voltage pulse is seen at A, putting a reverse voltage across SCR1. This discharges the capacitor through the SCR, resulting in SCR1 being turned off.

High power SCR applications

Industrial uses of high power SCRs include power conversion, frequency conversion, power and process control functions in chemical, steel and petroleum industries. Fig. 4 shows a typical chopper circuit for DC motor speed control. The effect of the chopper is to release power in short bursts, the duration of each burst controlling the speed of the motor.

The solidstate motor controls are a big improvement over auto transformers, potentiometers or variable gear trains because of their better torque characteristics. The chopper circuits allow a smooth variation of the average

armature voltage and there is no loss of power at low speeds and no dissipation of energy in the control resistors as in the conventional method of speed control.

Capacitors for SCR commutation

The commutating capacitor is a vital part of SCR circuits. The losses in the capacitor have to be kept as low as

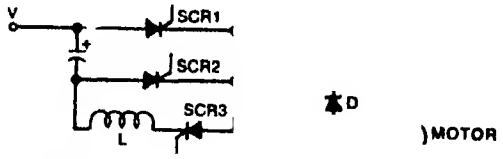

Fig. 4: Chopper circuit for D.C. motor speed control

possible to maintain high overall efficiency of SCR circuits and to avoid shortened life owing to high internal temperatures. In India, conventional AC/DC general-purpose capacitors have been used for these applications due to non-availability of the specialised components. The very short turn-on times needed for maximum efficiency require capacitors capable of discharging large peak currents up to 1000 amperes in very short periods. These factors make general-purpose capacitors unsuitable for SCR applications.

The use of paper dielectric capacitors in commutation of SCRs has limitations due to increased losses at higher frequencies, which can cause a rapid increase in the dielectric temperature leading to a capacitor breakdown. There is also a point at which the dissipation factor of paper rises with temperature at such a rate that a breakdown is inevitable.

Commutation capacitors need to have a low inductance, a low equivalent series resistance and a high current rating. They need to be vibration proof and may be used in high humidity and temperature conditions. Metallised polycarbonate is the normal dielectric used for these applications due to its high insulation resistance, low power factor and excellent stability. In some applications metallised polyester may be used because even though it is inferior to polycarbonate, it is still greatly superior to paper.

The nature of the voltage, current and frequency applied to commutating capacitors varies greatly with circuits and applications. A degree of individual tailoring of the capacitors to match the circuit requirement is needed and recommended. □