Source: Power Electronics book by M.D.Singh & K.B.Khanchandani

GATE CHARACTERISTICS OF SCR:

In a thvristor, the gate is connected to the cathode through a PN junction and resembles a diode. Therefore, the V-I characteristic of a gate is similar to a diode but varies considerably in units.

The circuit which supplies firing signals to the gate must be designed so that the gate voltage voltage should not exceed the maximum voltage, and power capabilities of the gate.

Figure 2.7 shows the gate characteristics of a typical SCR. Here, positive gate to cathode voltage Vg, and positive gate to cathode current Ig represent d.c. values. Applying gate drive increases the minority carrier density in the inner P layer and thereby facilitate the reverse breakdown of the junction J2.

In Fig. 2.7 curves ON and OM corresponds to the possible spread of the characteristic for SCRs of the same rating. For best results, the operating point S, which may change from S1 to S2, must be as close as possible to the permissible

There are maximum and minimum limits for gate voltage and gate current to prevent the permanent destruction of the junction and to provide reliable triggering. Similarly, there is also a limit on the maximum instantaneous gate power dissipation (Pgmax = Vg Ig).

With pulse firing, a larger amount of instantaneous gate power-dissipation can be tolerated if the average-value of Pg, is within the permissible limits. Hence, the gate can be driven harder (greater Vg and Ig) when pulse tiring is used.

This provides for reliable and faster turn-on ot- the device. All possible safe operating points for the gate are bounded by the low and high current limits for the V-I characteristics, maximum gate voltage, and the hyperbola representing maximum gate power. Within these boundaries there are three regions of importance.

(I) The first region OA lies near the origin (shown hatched) and is defined by the maximum gate voltage that will not trigger any device. This value is obtained at the maximum rated junction temperature (usually 125°C).

(II) The second region is further defined by the minimum value of gate-voltage and current required to trigger all devices at the minimum rated junction temperature. This region contains the actual minimum tiring points of all devices.

(III) The third region is the largest and shows the limits on the gate-signal for reliable firing.

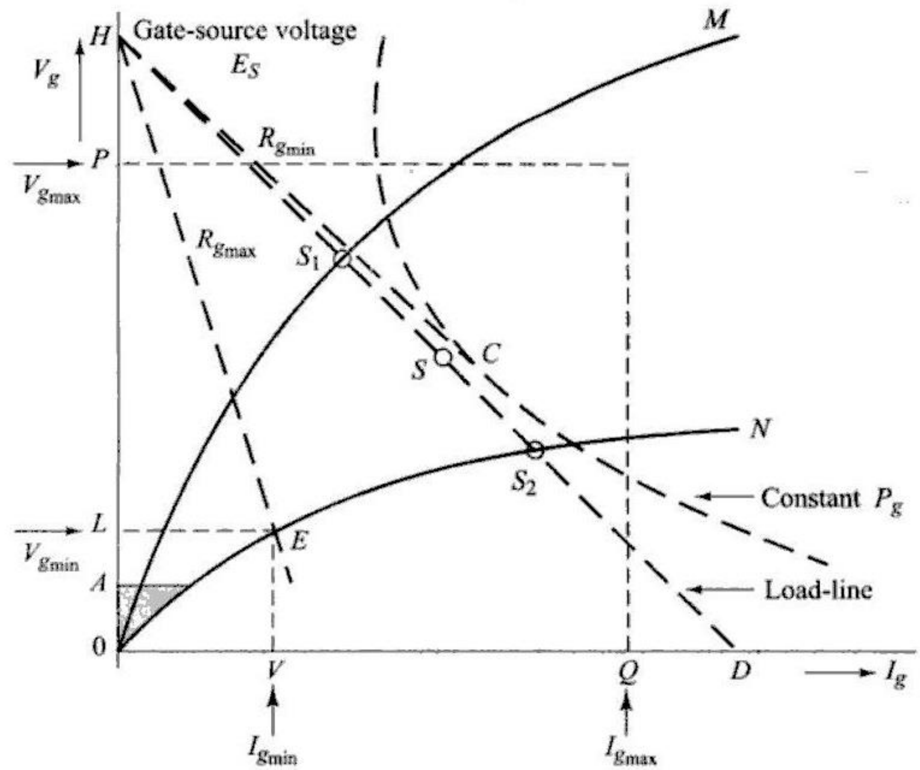

Fig. 2.7 *Gate characteristics*

For selecting the operating point, usually a load line of the gate source voltage Es=OH is drawn as HD. The gradient of the load line HD (=OH/OD) will give the required gate source resistance R. The maximum value of this series resistance is given by the line HE where E is the point of intersection of lines indicating the minimum gate voltage and gate current. The minimum value agate source series resistance is obtained by drawing a line HC tangential to Pg curve.

When the thyristor is triggered using gate pulses, it should he ensured that pulse width is sufficient to allow the anode current to exceed the latching current, In practice, the gate pulse width is usually taken as equal to or greater than SCR turn-on time t_{on}. If T is the pulse width as shown in Fig. 2.8. then $T \geq t_{on}$

For Fig. 2.8 pulses, the duty cycle $\delta = T/T1$. Then, the Average power Pavg is related to the maximum instantaneous power Pmax by

Pavg = Pmax.δ

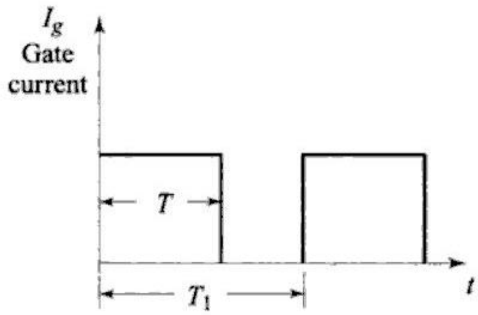

Fig. 2.8 *Pulse gating*

Gate Circuit Parameters:

The Gate Cathode circuit with different circuit parameters is shown in Fig.2.9.

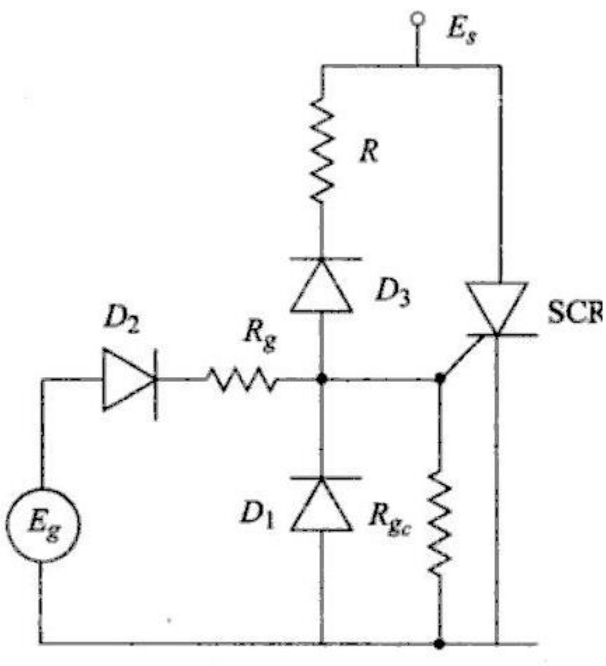

Fig. 2.9 *Gate circuit*

The shunt resistor Rgc, is introduced to bypass the thermally generated leakage current across junction when the device is in the blocking state, in order to improve the thermal-stability of the device.

Diode D1 applies a negative voltage between the gate and the cathode when a reverse voltage is applied across the device. It also serves to limit the reverse voltage applied between the cathode and the gate, if the gate, source voltage Eg is alternating.

A series diode D2 in the circuit will prevent the negative source current. D3 is connected as shown in the figure to block the positive gate current coming from the supply when the device is forward biased.

A shunt capacitor may be connected across gate to cathode to improve the dv/dt capability. However, pulse firing results in a larger portion of the gate drive being bypassed by the capacitor which will increase the delay time and consequently the di/dt rating cif the device is also lowered. Further, when the device is turned ON, the gate acts as a voltage source and charges the capacitor. This charge can provide enough gate current after the anode current has stopped thereby increasing the turn-off time of the SCR and commutation may fail.

If an inductance is connected across gate to cathode, the negative gate current is maintained by the inductance even after the anode-current has stopped, and this will facilitate faster turn-off. However, when pulse firing is used, the negative gate current that continues to flow out of the gate can possibly turn-off the thyristor.