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TURN-OFF MECHANISM (TURN-OFF CHARACTERISTIC)

Once the SCR is turned-on and an appreciable forward current is flowing through it, the gate has no control on it and the device can be brought back to the blocking state only by reducing the forward current to a level below that of the holding current.

Process of turn-off of SCR is is also called as Commutation.

However, if' a forward voltage is applied immediately after reducing the anode current to zero, it will not block the forward voltage and will start conducting again, although it is not triggered by a gate pulse. It is, therefore, necessary to keep the device reverse biased for a finite period before a forward anode voltage can be reapplied.

The turn-off time of the thyristor is defined as the minimum time interval between the instant at which the anode current becomes zero, and the instant at which the device is capable of blocking the forward voltage.

The turnoff time is illustrated by the waveforms shown in Fig. 2.11. The total turn-off time is divided into two time intervals the reverse, recovery time t_{rr} and the gate recovery time t_{gr}.

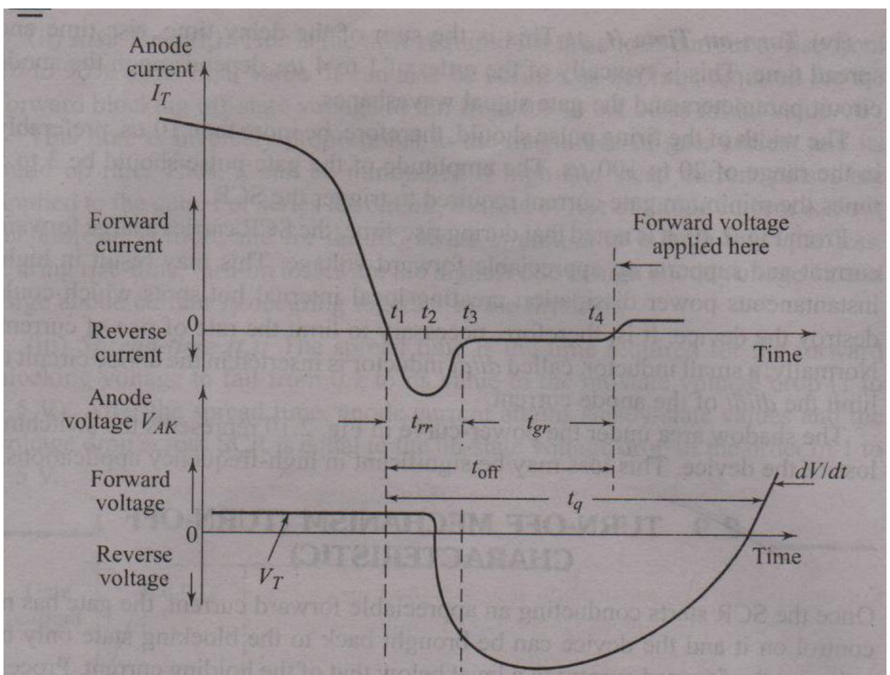


Fig. 2.11 *Waveforms during SCR turn-off*

At the instant t_1, the anode forward current becomes zero. During the reverse recovery time, t_1 to t_3, the anode current flows in the reverse direction. At the instant t_2 a reverse anode voltage is developed and the reverse recovery current continues to decrease,

At t_3 junction J_1 and J_3 are able to block a reverse voltage. However, the thyristor is not yet able to block a forward voltage because carriers, called *trapped charges* , are still present at the junction J_2. During the interval t_3 to t_4, these carriers recombine. At t_4 the recombination is complete and therefore, a forward voltage can he reapplied at this instant.

The SCR turn-off time is the interval between t_4 and t_1. In an SCR, this time varies in the range 10 to 100 μs. Thus, the total turn-off time (t_q) required for the device is the sum of the duration for which the reverse recovery current flows after the application of reverse voltage, and the time required for the recombination of all excess carriers in the inner two layers of the device.

Turn-Off Methods

The term commutation in SCRs is to transfer current from one thyristor to another. A thyristor itself cannot turn off once it is conducting. The circuit in which it is connected should reduce the thyristor current to zero to turn it off.

The two methods by which a thyristor can be commutated are as follows:

1. Natural Commutation

This is the most simplest and widely used method as it uses a.c. voltage to effect the current transfer. In an a.c. supply, the current passes through zero at every half cycle.

At the end of every positive half cycle, the anode current reaches zero. As it passes through natural zero, a reverse voltage will appear across the thyristor which immediately turn-off the device. This process is called *Natural Commutation* as no external source is required to turn-off the device. This method may use a.c. mains supply voltages or the voltages generated by local rotating machine.

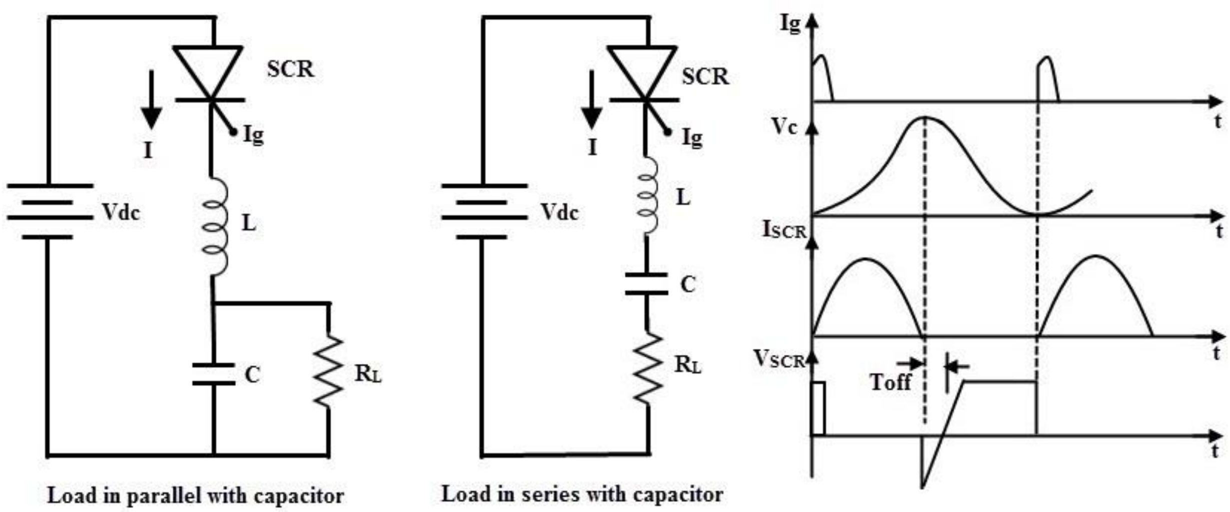
2. Forced Commutation

In the case of d.c. circuits, for switching off thyristor, forward current must be forced to zero. This can only be done with the help of an external circuit. The external circuit required for commutation is called *commutation circuits* and the components used are called *commutation components* namely inductance and capacitance. With the help of this circuit, reverse voltage will appear across the thyristor which will make the device to turn-off.

Based on the arrangement of the commutation components and the manner in which zero current is achieved, it is classified into various types.

Class A - Self Commutation by Resonating the Load
This is also known as Resonant Commutation. LC components are used where either (i) load resistance is in parallel with Capacitor as shown in Fig. 2.12a or (ii) it is in series with the Capacitor as shown in Fig. 2.12b.

The load resistance RL and the other components are chosen such that their combination forms an underdamped resonant circuit.



(a) Load in parallel with Capacitor (b) Load in series with Capacitor (c) Waveforms for Load in parallel with capacitor

Fig. 2.12 Class A Commutation Circuit.

When the thyristor is triggered by applying a gate pules, the forward current suddenly increases. This current starts charging the capacitor.
As the voltage across capacitor starts building up, the SCR cathode voltage increases as a result the net voltage across SCR decreases and current also starts decreasing. When the capacitor voltage reaches the maximum supply Vdc, anode current becomes zero and SCR is turned off. since the potential difference between anode and cathode is zero at this point.

Now capacitor starts discharging through the load and reaches zero voltage gradually. Again to switch on SCR a gate pulse has to be applied.