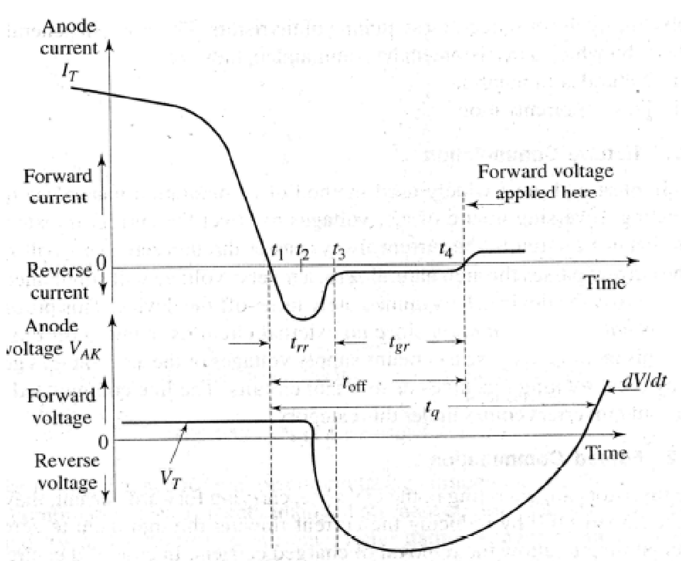
COMMUTATION

Once the SCR starts conducting an appreciable forward current, 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 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. 1. The total turn-off time **t_{off}** is divided into two time intervals the reverse, recovery time **t_{rr}** and the gate recovery time **t_{gr}**.

At the instant **t_l,** 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 thereverse 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 be 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.



In practical applications, the turn-off time required to the SCR by the circuit, called the circuit turn-off time t_q, must be greater than the device turn-off time t_{off} by a suitably safe margin, otherwise the device will turnon at an undesired instant a process known as **commutation failure***.* Thyristor having large turn-off time (50-100 μs) are called as slow switching or phase control type thyristors (or converter grade thyristors), and those having low turn-off time (l0-50 μs) are called fast switching or inverter type thyristors. In high frequency applications, the required circuit turn-off time consumes an appreciable portion of the total cycle time and therefore, inverter grade thyristors must be used.

Turn-Off Methods:

The term commutation basically means the transfer of current from one path to another. In thyristor circuits, this term is used to describe process of transferring current from one thyristor to another. As explained earlier, it is not possible, for a thyristor to turn itself OFF; the circuit in which it is connected must reduce the thyristor current to zero to enable it to turn-off. 'Commutation' is the term to describe the methods of achieving this.

Commutation is the one of the fundamental principles in behind the use of thyristors for control purposes. A thyristor can only operate in two modes: it is either in the OFF state. i.e., open circuit, or in the ON state. i.e., short circuit. By itself it cannot control the level of current or voltage in a circuit. Control can only be achieved by variation in the time thyristors when switched ON and OFF, and commutation is central to this switching process. All thyristor circuits, therefore, involve the cyclic or sequential switching of thyristors.

There are, in general, two methods by which a thyristor can be commutated, they are

(1)Natural commutation

(2) Forced commutation.

Natural Commutation:

The simplest and most widely used method of commutation makes use of the alternating, reversing nature of a.c. voltages to effect the current transfer. We know that in a.c. circuits, the current always passes through zero every half cycle. As the current passes through natural zero, a reverse voltage will simultaneously appear across the device. This immediately turns-off the device. This process is called as **natural commutation** since no external circuit is required for this purpose. This method may use a.c. mains supply voltages or the a.c. voltages generated by local rotating machines or resonant circuits. The line commutated converters and inverters come under this category.

Forced Commutation:

Once thyristors are operating in the ON state, carrying forward current, they can only be turned OFF by reducing the current flowing through them to zero for sufficient time to allow the removal of charged carriers. In case of D.C. circuits, for switching off the thyristors, the forward current should be forced to be zero by means of some external circuits. The process is called **forced commutation** and the external circuits required for it are known as commutation circuits. The components (inductance and capacitance) which constitute the commutating circuits are called as commutating components. A reverse voltage is developed across the device by means of a commutating circuit that immediately brings the forward current in the device to zero, thus turning off the device. Producing reliable commutation is a difficult problem to be tackled whole designing chopper and inverter circuits. The most important stage in the designing process is choosing a forced turn-off method and deciding its components. The classification of the methods of forced commutation is based on the arrangement of the commutating components and the manner in which zero current is obtained in the SCR. There are six basic methods of commutation by which thyristors may be turned OFF**.**