Thyristor Commutation Techniques

To turn On a Thyristor, there are various triggering methods in which a trigger pulse is applied at its Gate terminal. Similarly, there are various **techniques to turn Off a Thyristor**, these techniques are called **Thyristor Commutation Techniques**. It can be done by bringing the Thyristor back into the forward blocking state from the forward conduction state. To bring the Thyristor into forward blocking state, forward current is reduced below the holding current level. For the purpose of power conditioning and power control a conducting Thyristor must be commutated properly.

There are mainly two techniques for Thyristor Commutation: Natural and Forced. The Forced commutation technique is further divided into five categories which are Class A, B, C, D, and E.

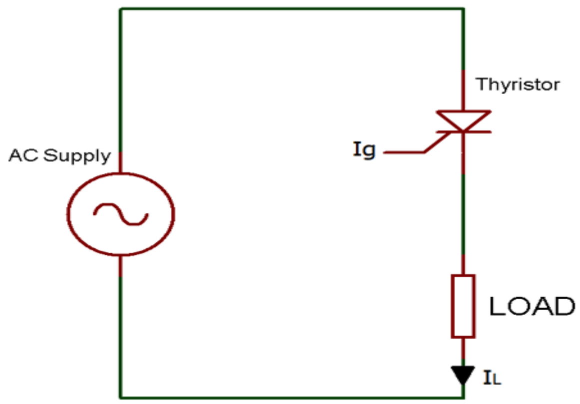
Below is the Classification:

- Natural Commutation
- Forced Commutation
  - Class A: Self or Load Commutation
  - Class B: Resonant-Pulse Commutation
  - Class C: Complementary Commutation
  - Class D: Impulse Commutation
  - Class E: External Pulse Commutation

Natural Commutation

Natural Commutation occurs only in AC circuits, and it is named so because it doesn't require any external circuit. When a positive cycle reaches to zero and the anode current is zero, immediately a reverse voltage (negative cycle) is applied across the Thyristor which causes the Thyristor to turn OFF.

A Natural Commutation occurs in AC Voltage Controllers, Cycloconverters, and Phase Controlled Rectifiers.

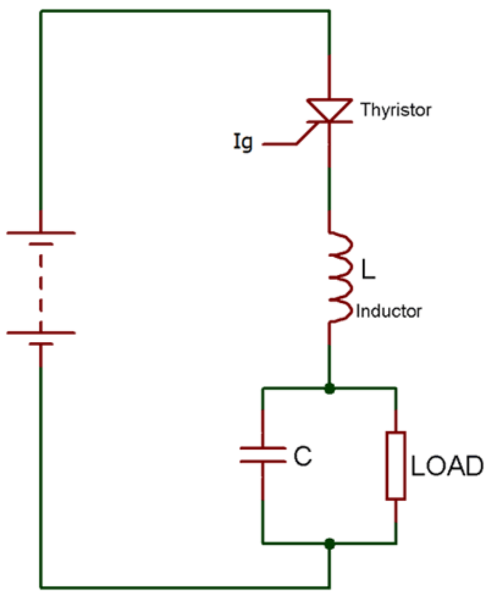


Forced Commutation

As we know there is no natural zero current in DC Circuits like as natural commutation. So, Forced Commutation is used in DC circuits and it is also called as **DC commutation**. It requires commutating elements like inductance and capacitance to forcefully reduce the anode current of the Thyristor below the holding current value, that's why it is called as **Forced Commutation**. Mainly forced commutation is used in Chopper and Inverters circuits. Forced commutation is divided into six categories, which are explained below:

1. Class A: Self or Load Commutation

Class A is also called as "Self-Commutation" and it is one of the most used technique among all Thyristor commutation technique. In the below circuit, the inductor, capacitor and resistor form a second order under damp circuit.

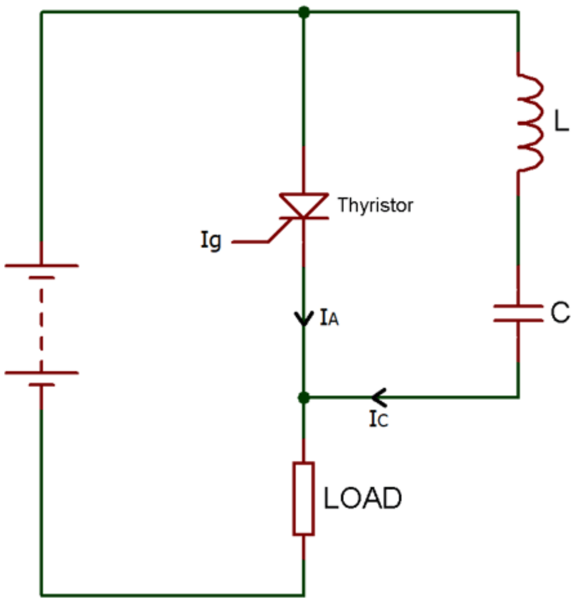


When we start supplying the input voltage to the circuit the Thyristor will not turn ON, as it requires a gate pulse to turn ON. Now when the Thyristor turns ON or forward biased, the current will flow through the inductor and charges the capacitor to its peak value or equal to the input voltage. Now, as the capacitor gets fully charged, inductor polarity gets reversed and inductor starts opposing the flow of current. Due to this, the output current starts to decrease and reach to zero. At this moment the current is below the holding current of the Thyristor, so the Thyristor turns OFF.

2. Class B: Resonant-Pulse Commutation

Class B commutation is also called as Resonant-Pulse Commutation. There is only a small change between Class B and Class A circuit. In class B LC resonant circuit is connected in parallel while in Class A it's in series.

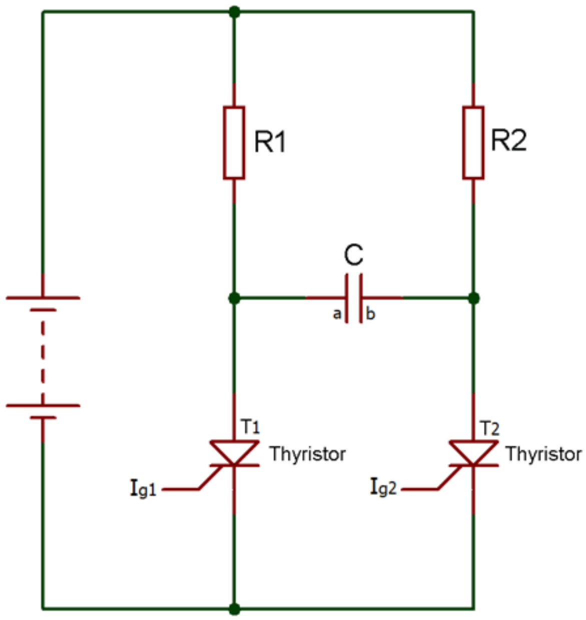
Now, as we apply the input voltage, the capacitor starts charging upto the input voltage (Vs) and Thyristor remains reversed biased until the gate pulse is applied. When we apply the gate pulse, the Thyristor turns ON and now the current start flowing from both the ways. But, then the constant load current flows through the resistance and inductance connected in series, due to its large reactance.



Then a sinusoidal current flow through the LC resonant circuit to charge the capacitor with the reverse polarity. Hence, a reverse voltage appears across the Thyristor, which causes the current Ic (commutating current) to oppose the flow of the anode current I_A. Therefore, due to this opposing commutating current, when the anode current is getting lesser than the holding current, Thyristor turns OFF.

3. Class C: Complementary Commutation

Class C commutation is also called as Complementary Commutation. As you can see the circuit below, there are two Thyristor in parallel, one is main and another is auxiliary.

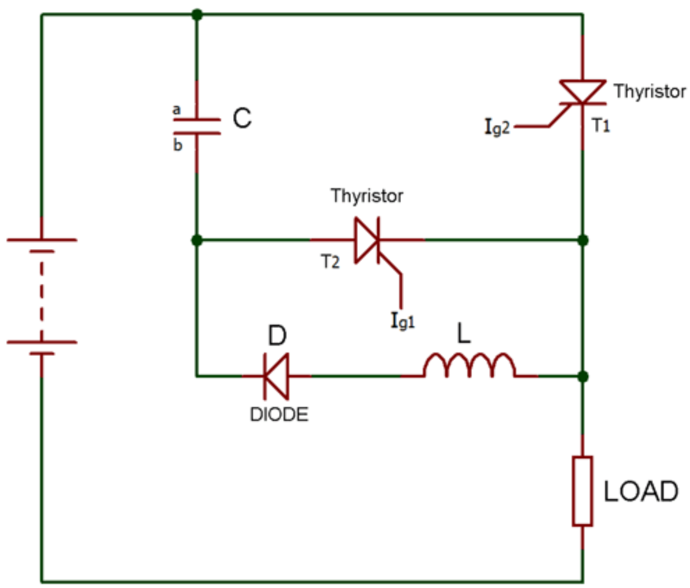


Initially, both the Thyristor are in OFF condition and the voltage across capacitor is also zero. Now, as the gate pulse is applied to the main Thyristor, the current will start flowing from two paths, one is from R1-T1 and second is R2-C-T1. Hence, the capacitor also starts charging to the peak value equal to the input voltage with the polarity of plate B positive and plate A negative.

Now, as the gate pulse is applied to the Thyristor T2, it turns ON and a negative polarity of current appear across the Thyristor T1 which cause T1 to get turn OFF. And, the capacitor starts charging with the reverse polarity. Simply we can say that when T1 turns ON it turns OFF T2 and as T2 turns ON it turns OFF T1.

4. Class D: Impulse Commutation

Class D commutation is also called as Impulse Commutation or Voltage Commutation. As Class C, Class D commutation circuit also consists of two Thyristor T1 and T2 and they are named as main and auxiliary respectively. Here, diode, inductor, and auxiliary Thyristor form the commutation circuit.



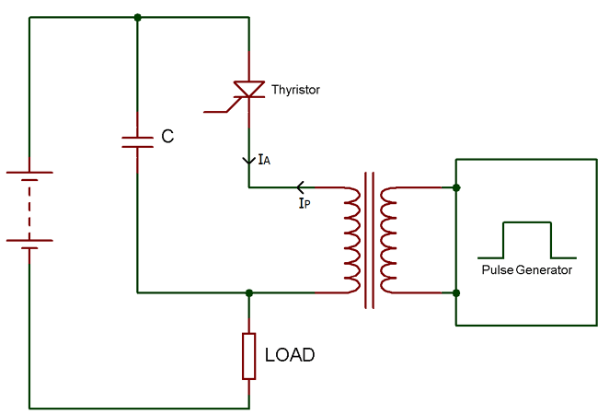
Initially, both the Thyristor are in OFF state and voltage across capacitor C is also zero. Now as we apply the input voltage and trigger the Thyristor T1 the load current starts flowing through it. And, the capacitor starts charging with polarity of plate A negative and plate B positive.

Now, as we trigger the auxiliary Thyristor T2, the main Thyristor T1 turns OFF and the capacitor starts charging with the opposite polarity. When it gets full-charged, it causes the auxiliary Thyristor T2 to turn OFF, because a capacitor does not allow the flow of current through it when it gets fully charged.

Therefore, the output current will also be zero because at this stage because of both the Thyristors are in OFF state.

5. Class E: External Pulse Commutation

Class E commutation is also called External Pulse Commutation. Now, you can see in the circuit diagram, the Thyristor is already in forward bias. So, as we trigger the Thyristor, the current will appear at the load.



The capacitor in the circuit is used for the dv/dt protection of the Thyristor and the pulse transformer is used to turn OFF the Thyristor.

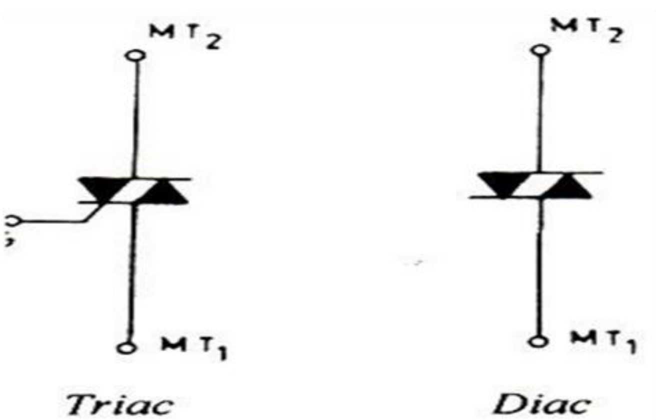
Now, when we give pulse through the pulse transformer an opposite current will flow in the direction of the cathode. This opposite current oppose the flow of the anode current and if $I_A - I_P < I_H$ Thyristor will turn OFF.

Where I_A is Anode current, I_P is pulse current and I_H is holding current.

Difference between DIAC and TRIAC: Working & Their Characteristics

There are several applications where it is preferred to regulate the power fed to a load. For instance: using electrical methods controlling the speed of a motor or fan. But, these methods do not allow fine control over the flow of power in a system additionally; there is an extensive wastage of power. In the present day, such devices have been developed which can allow fine control over the flow of large blocks of power in a system. These devices perform as controlled switches and can complete the duties of controlled rectification, regulation, and inversion of power in a load. The essential semiconductor switching devices are UJT, SCR, DIAC, and TRIAC. Earlier we have studied the basic electrical and electronic components such as transistors, capacitors, diodes, etc. But, to understand the switching devices like SCR, DIAC and triac we have to know about the thyristor. A thyristor is one type of semiconductor device that includes three or more terminals. It is unidirectional similar to a diode but switched like a transistor. Thyristors are used to control high voltages and currents in motors, heating, and lighting applications.
Difference between Diac and Triac

The differences between DIAC and triac mainly include what are a DIAC and TRIAC, construction of TRIAC and DIAC, working, characteristics and applications. The symbols of DIAC and TRIAC are shown below.



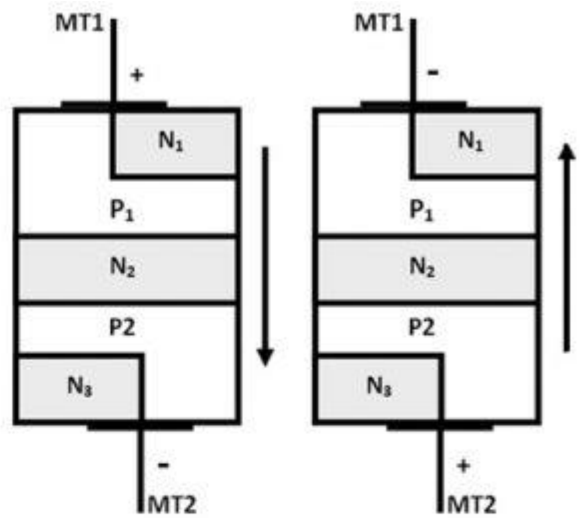
What are DIAC and TRIAC?

We know that thyristor is a half-wave device like a diode and that will supply only half power. A Triac device comprises two thyristors that are connected in opposite directions but in parallel but,

it is controlled by the same gate. Triac is a 2-dimensional thyristor that is activated on both halves of the i/p AC cycle using + Ve or -Ve gate pulses. The three terminals of the Triac are MT1; MT2 & gate terminal (G). Generating pulses are applied between MT1 and gate terminals. The 'G' current to switch 100A from triac is not more than 50mA or so.
The DIAC is a bi-directional semiconductor switch that can be switched on in both polarities. The full form of the name DIAC is a diode alternating current. DIAC is connected back to back using two Zener diodes and the main application of this DIAC is, it is widely used to help even activating of a TRIAC when used in AC switches, dimmer applications, and starter circuits for fluorescent lamps.

Construction and Operation of DIAC

Basically, the DIAC is a two-terminal device; it is a combination of parallel semiconductor layers that allows activating in one direction. This device is used to activating the device for the triac. The basic construction of DIAC consists of two terminals namely MT1 and MT2. When the MT1 terminal is designed +Ve with respect to the terminal MT2, the transmission will take place to the p-n-p-n structure that is another four-layer diode. The DIAC can be performing for both the direction. Then the symbol of the DIAC looks like a transistor.



DIAC Construction

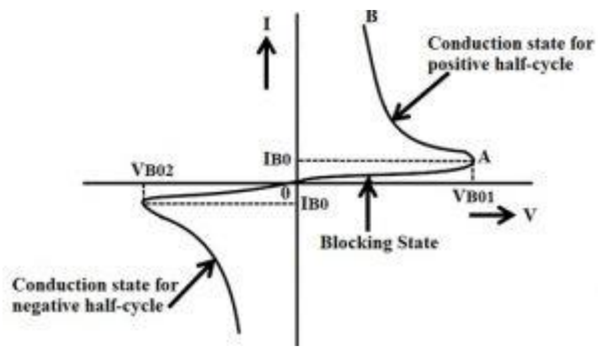
The DIAC is basically a diode that conducts after a 'break-over voltage, selected VBO, and is exceeded. When the diode surpasses the break-over voltage, then it goes into the negative dynamic resistance of the region. This causes a reduction in the voltage drop across the diode with rising voltage. So there is a quick increase in the current level that is mannered by the device.

The diode leftovers in its transmission state until the current through it falls below, what is termed the holding current, which is usually chosen by the letters IH. The holding current, the DIAC reverts to its non-conducting state. Its behavior is bidirectional and thus its function takes place on both halves of an alternating cycle.

Characteristics of DIAC

V-I characteristics of a DIAC are shown below.

The volt-ampere characteristic of a DIAC is shown in the figure. It looks like a letter Z due to symmetrical switching characteristics for each polarity of the applied voltage.

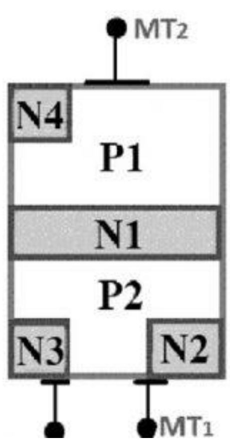


DIAC Characteristics

The DIAC performs like an open-circuit until its switching is exceeded. At that position, the DIAC performs until its current decreases toward zero. Because of its abnormal construction, doesn't switch sharply into a low voltage condition at a low current level like the triac or SCR, once it goes into the transmission, the diac preserves an almost continuous –Ve resistance characteristic, which means, voltage reduces with the enlarge in the current. This means that, unlike the triac and the SCR, the DIAC cannot be estimated to maintain a low voltage drop until its current falls below the level of holding current.

Construction and Operation of TRIAC

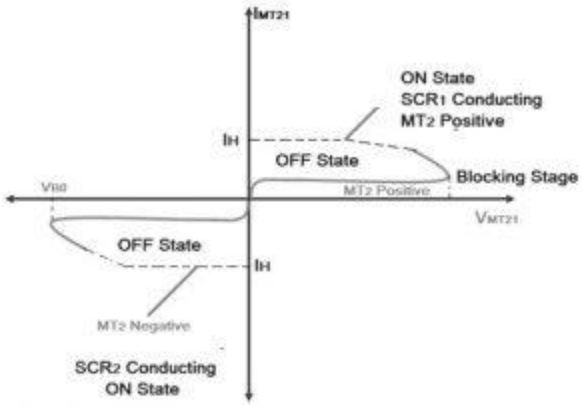
TRIAC is a three-terminal device and the terminals of the triac are MT1, MT2, and Gate. Here the gate terminal is the control terminal. The flow of current in the triac is bi-directional which means current can flow in both directions. The structure of TRIAC is shown in the below figure. Here, in the structure of triac, two SCRs are connected in the antiparallel and it will act as a switch for both directions. In the above structure, the MT1 and gate terminals are near to each other. When the gate terminal is open, the triac will obstruct both the polarities of the voltage across the MT1 & MT2.



TRIAC Construction

Characteristics of TRIAC

The V-I characteristics of TRIAC are discussed below.



TRIAC Characteristics

The triac is designed with two SCRs which are fabricated in the opposite direction in a crystal. The operating characteristics of triac in the 1st and 3rd quadrants are similar but for the direction of flow of current and applied voltage.

The V-I characteristics of triac in the first and third quadrants are basically equal to those of an SCR in the first quadrant.

It can function with either +Ve or –Ve gate control voltage but in typical operation generally, the gate voltage is +Ve in the first quadrant and -Ve in the third quadrant.

The supply voltage of the triac to switch ON depends upon the gate current. This allows utilizing a triac to regulate AC power in a load from zero to full power in a smooth and permanent manner with no loss in the device control.