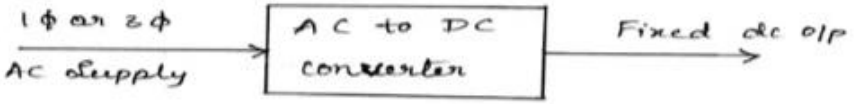
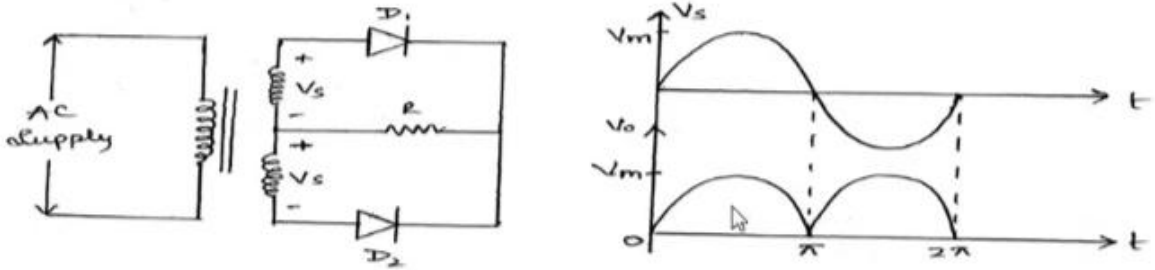
Types of Power Electronic Circuits

The power electronics circuits can be classified into six types:

1. Diode rectifiers
2. ac–dc converters (controlled rectifiers)
3. ac–ac converters (ac voltage controllers)
4. dc–dc converters (dc choppers)
5. dc–ac converters (inverters)
6. Static switches

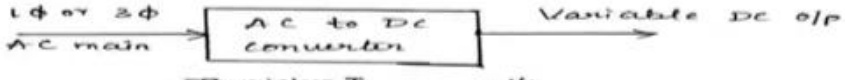
1> Diode Rectifiers

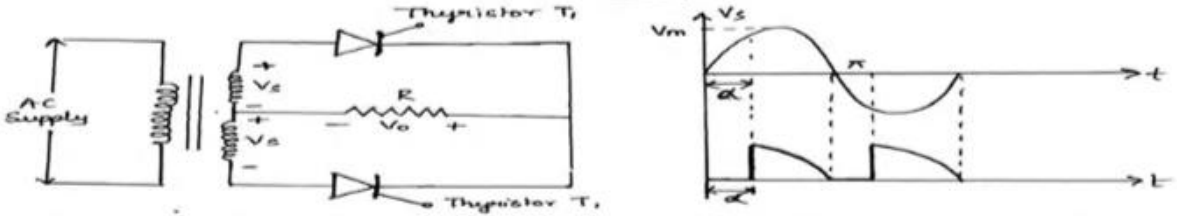




* A diode Rectifier circuit converts AC voltage into fixed DC voltage as shown in figure.
* The I/p voltage to the Rectifier Vi could be either single phase or 3 phase.

2> AC – DC Converter [Controlled Rectifier]





* The input voltage is available from the main source (Input voltage is fixed AC voltage)
* The o/p of the converter is variable dc o/p i.e o/p is controlled dc voltage & currents.
* The control rectifiers mainly use SCR's. The average value of the o/p voltage can be controlled by varying the firing angle 'α'.
* The SCR are turned off by natural commutation

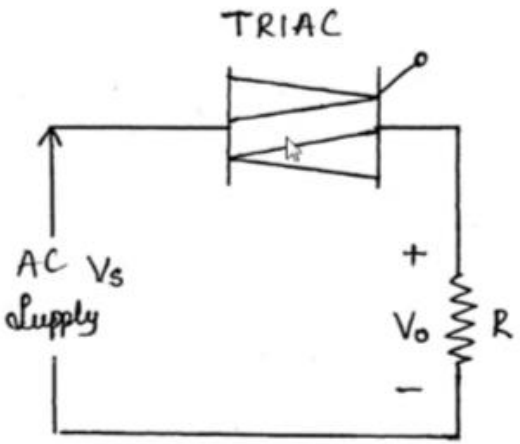
Applications :

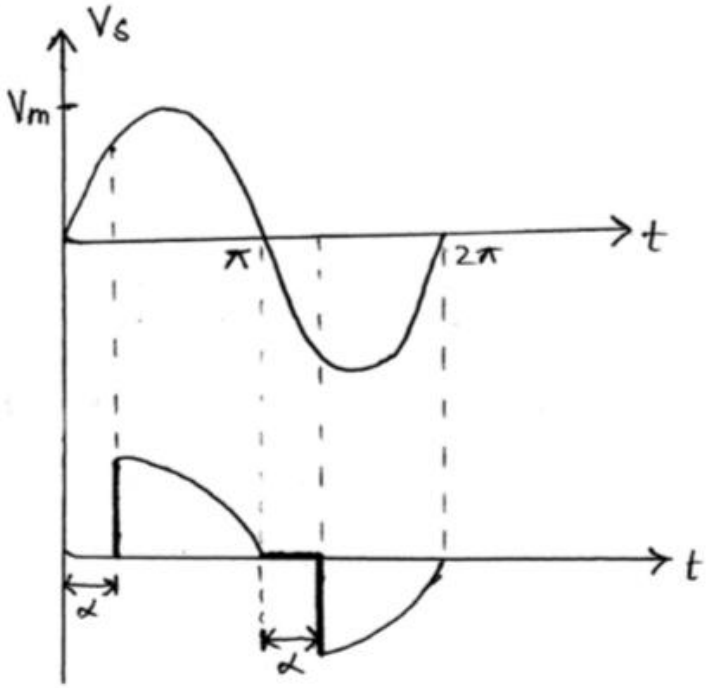
i> DC Motor drives
ii> Regulated DC power supplies
iii> Battery charger ckts etc

Note:

- Commutation is the process of turning off a conducting thyristor
- There are two methods for commutation viz. natural commutation and forced commutation.
- Natural commutation: It occurs in AC circuits i.e. when supply voltage is AC. Due to this, SCR turns off when negative voltage appears across the SCR. As there are no special circuits needed to turn off the SCR (thyristor), this type of commutation is known as **natural commutation**.
- **Forced Commutation:** It is Applied to dc circuits. Forced Commutation is achieved by reverse biasing SCR device or by reducing SCR current below the holding current value.

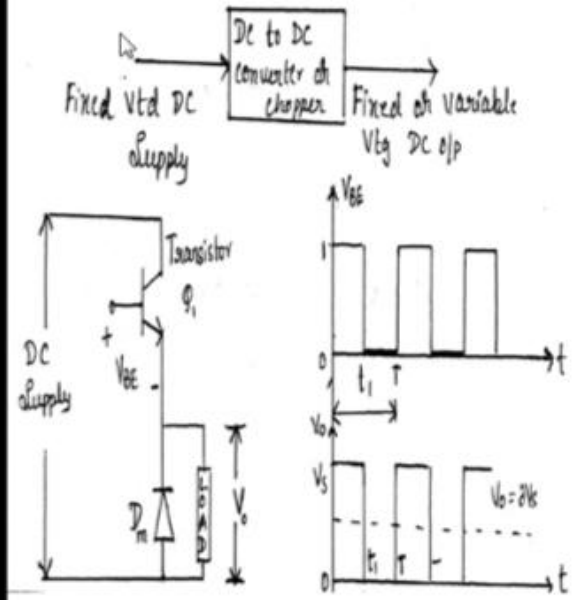
3. ac–ac converters (ac voltage controllers)





These converters are used to obtain a variable ac output voltage from a fixed ac source and a single-phase converter with a TRIAC is shown in Fig. The output voltage is controlled by varying the conduction time of a TRIAC. These types of converters are also known as *ac voltage controllers*.

4) DC - DC Converters [choppers] :-



* A DC-DC converter is also known as a chopper or Switching Regulator.

Fig shows transistor chopper.

* The average o/p is controlled by varying the conduction time 't_1' of transistor Q_1.

* The duty cycle ∂ of the chopper is given by

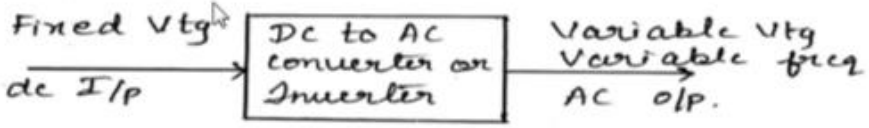
$$\partial = \frac{t_1}{T}$$

* The converter use TRIAC as shown in the fig. The o/p Vtg is controlled by varying the firing angle of TRIAC ie 'α'.

Applications

Widely used for lighting control, Speed control of fans, pumps etc.

5> DC – AC converters :-



* A DC – AC converter is also known as an Inverter

The I/p to the inverter is fixed DC Vtg usually obtained from battery

The o/p of the inverter is the fixed or variable frequency ac voltage. Inverter are used Whenever mains are not available

Applications :-

1> Inverter
2> UPS
3> HVDC etc

6> Static Switches

Since the power devices can be operated as static switches or contactors, the supply to these switches could be either ac or dc and the switches are called as *ac static switches* or *dc switches*.

Principle of operation of SCR

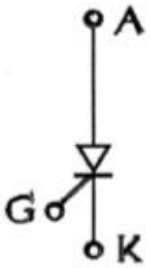
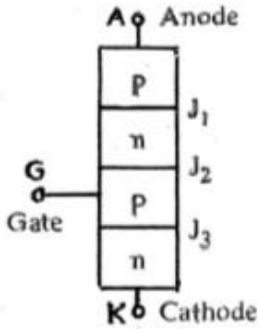


Fig a.: Symbol



A thyristor is a four (4) layer, three junction, three terminal semiconductor device. The terminals are **Anode (A)**, **Cathode (K)** and **Gate (G)**. Thyristors are operated as bistable switches, operating from OFF state to ON state. Thyristor is also called as **Silicon Controlled Rectifier (SCR)**.

Characteristics of Thyristor :-

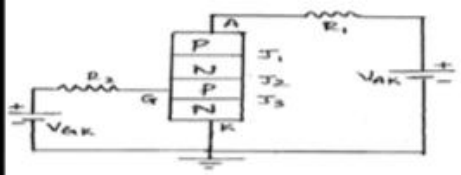


Fig 2a. Circuit Diagram.

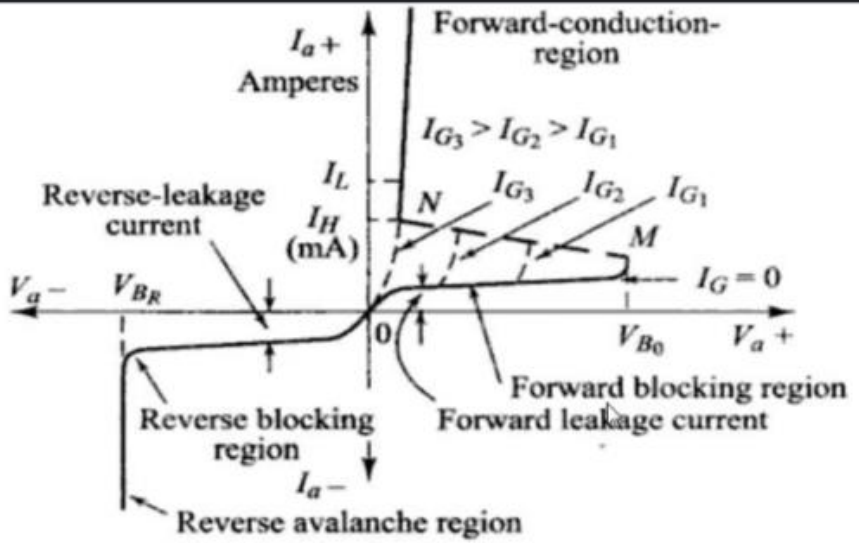


Fig 2b. V-I Characteristics

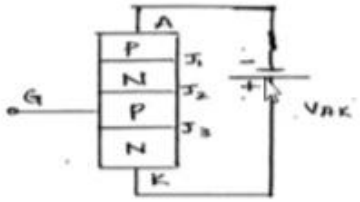
* When the anode voltage is made +ve wrt to the cathode, the junction J_1 & J_3 are forward biased The junction J_2 is reverse biased. Hence forward Vlg is to be hold by junction J_2.

  A very small current flows from anode to cathode. This current is called as forward leakage current The thyristor in then said to be in forward blocking mode.

  The thyristor is treated as an open switch.

* A thyristor can be turned ON by applying a gate pulse between gate & cathode and is called as forward conduction mode.

  In this mode thyristor is in ON condition and behaves as a closed switch.



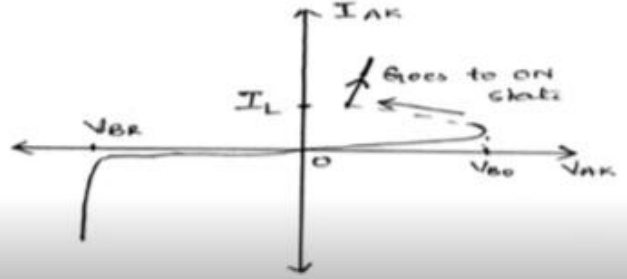
* When anode Vtg is made -ve wrt to cathode, the thyristor is reverse biased Junction J_1 & J_3 are reverse biased where as Junction J_2 is forward biased.

A very small current flows from cathode to Anode. This current is called <u>reverse leakage current</u> & this mode is called <u>reverse blocking mode</u>.

* At reverse breakdown vtg (V_{BR}), the reverse current increases rapidly. At the same time reverse break-down, the high vtg is present across the thyristor & heavy current flows through it. Hence large power dissipation takes place in the thyristor. Due to this dissipation the thyristor will damage.

Latching Current :-

Latching current is the minimum forward current that flows through the thyristor to keep it in forward conduction mode (ie ON state) at the time of Triggering.

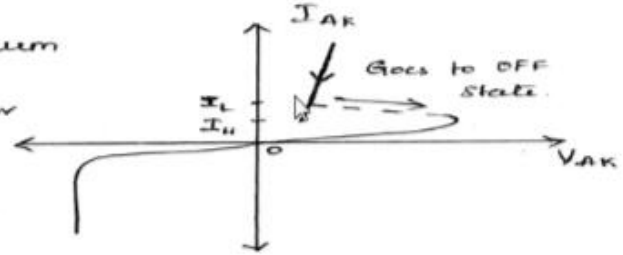


* If forward current is less than latching current, thyristor doesnot turn-ON.
  ie $I_{AK} < I_L$

After triggering $I_{AK} \geq I_L$ for thyristor to remain in ON state. The latching current is of the order of 10 to 15mA.

Holding Current :-

* Holding current is minimum forward current that flows through the thyristor to keep it in forward conduction mode. When forward current reduces below holding current thyristor turns-OFF



* The holding current of the thyristor is of order 8 to 10mA.

Break over Voltage (V_{BO}) :-

When gate is open & if anode to cathode voltage exceeds forward Breakover voltage 'V_{BO}', the SCR is driven into forward conduction.

In other words V_{BO} is the maximum vtg that SCR can withstand in forward direction.