Unit-1

1) Introduction of Industrial Automation...

- Automation is a set of technologies that results in operation of machines and system without significant human intervention and achieves performance superior to manual operation.
- The word "auto" (self) and "Motars" moving. Automation is the mechanism for system that "moves by itself".
- The usage of automation technology started when work done by labour/worker was started replace by machine. Technology development process continuous improve Unit human started introduce the usage of robatic, CAD/CAM, Flexible manufacturing system and other technology to increase human quality of life and increase productivity in the industrial.

Advantages of Automation...

1. To increase Labor Productivity.
2. To reduce Labor cost.
3. To migrate the effect of Labour shortage.
4. To reduce of eliminate routine manual and clerical task.
5. To improve worker safety.
   → The safety and physical well being of the worker has become a national objective with the enactment of occupational safety and health Act (OSHA) in 1970. This has provided an impetus for Automation.
6. To improve product quality.
7. To reduce manufacturing lead time.
8. Accomplish proceses that can't be done manually.

i.e – include certain integrated circuit fabrication operations, rapid prototyping processes based on computer graphics (CAD) models, and the machining of complex.

⑨ To avoid the high cost of not automatically.

Disadvantage of Automation...

① Higher start-up cost and the cost of operation.
② Higher cost of maintenance.
③ Obsalescence / Depreciation cost.
④ Unemployment
⑤ Not economically justifible for small scale production.

Types of Automation System...

① Fixed automation
② Programmable automation
③ Flexible automation

Features of Power diodes...

Power diodes are designed for high current and high voltage application in power electronics circuits.

Power diodes are used mainly in high-power applications. They are built with large P-N junction in order to pass large amounts of current and dissipate large amount of heat.

★ Types of Power diodes :-

- High current diodes
- High voltage diodes
- PIN Power diodes
- RF Power diodes
- Switching Power diodes
- Rectifier Power diodes.

- Basic power p diodes consist of a diode built into a chip.
- Power diode arrays are composed of multiple, discrete and usually unconnected devices on a single silicon chip.

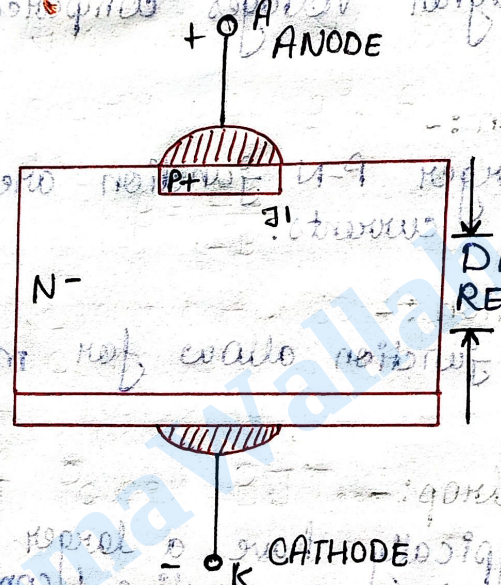
* Key features

- High current and voltage Handling :-
  Power diodes are designed to handle larger current and withstand higher voltages compared to regular diodes.
- Large P-N junction :-
  They have a larger P-N junction area to enable the passage of higher currents.
- Thicker P-N Junction :-
  The thicker P-N junction allow for more efficient heat dissipation.
- Forward voltage drop :-
  Power diodes typically have a larger forward voltage drop (0.8 - 1V) when conducting compared to regular diodes.
- Reverse Bias :-
  They can withstand high reverse bias voltage.
- Fast switching :-
  some power diodes are designed for fast switching speeds making them suitable for high speed application.
- Reverse Recovery Time :-
  Power diodes have a reverse recovery Time, which is the here it takes for the diode to return to its reverse bias state after being switched off.
- Reverse leakage current :-
  Power diodes exhibit a certain amount of reverse leakage current in the reverse bias region.

- Temperature dependence :-
The reverse leakage current and forward voltage drop can be affected by tempeture.
- Construction :-
Power diodes are typically large then regular diodes to a accommodate the larger P-N junction and dispate heat more efficiently.

Symbol of power diodes...

Fig (a)

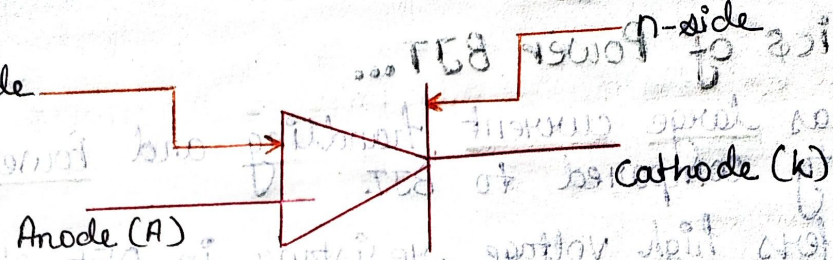


(a) Basic structure

Fig (b)

(b) Circuit Symbol

Fig (c)



(c) Symbol of Power diode

(i) It can be used as a rectifier in converter circuits, voltage regulation circuit, flyback / freewheeling diode reverse voltage protection etc...

(ii) Switching speed of power diode is now as compared to that of the low power diode

Need for power devices...

Power BJT...

★ Basics of Power BJT...

- It has large current handling and Power handling capacity compared to BJT.
- It offers high voltage resistance in OFF state then BJT.
- It offers high current handling in ON state then BJT.
- It has vertically oriented structure.
- High gain is maintained by enhancing doping level of emitter several times that of base.
- Due to more emitter doping, β current gain will decrease.

$$\beta = \frac{I_C}{I_B}$$

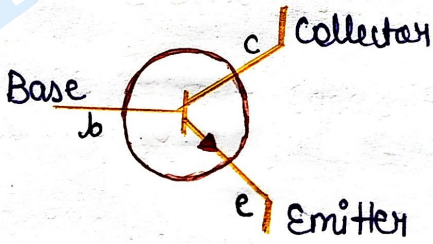
- It handles more current, so it has large metallic body to dissipate power as heat.

★ Structure of Power BJT...

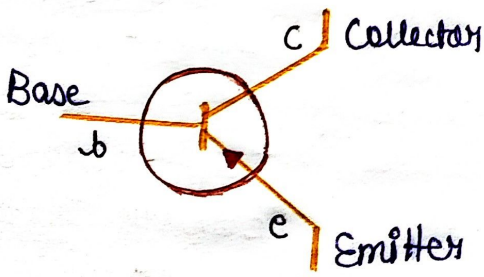
- It has n⁻ region that is collector drift region.
- This n⁻ region will increase voltage blocking capacity of power BJT.

Symbol of BJT :-

NPN Transistor



PNP Transistor



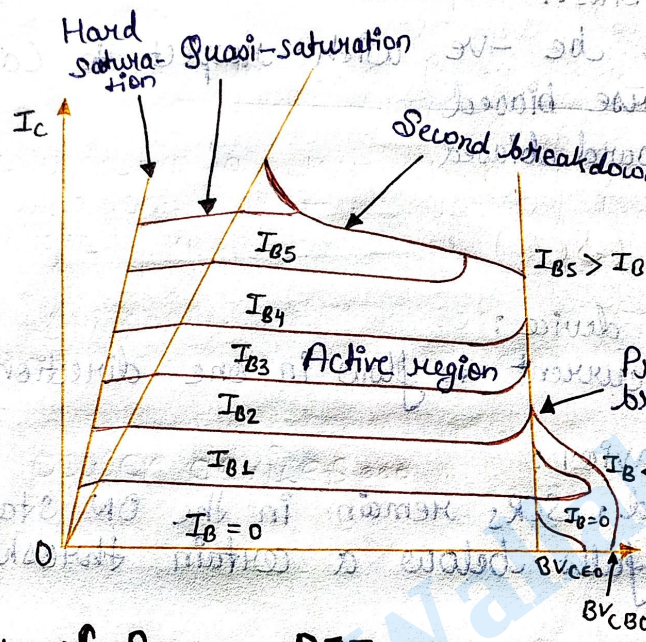
★ Modes of Power BJT...

- Cut OFF mode [Base Emitter and Collector Base junction in Reverse Bias].
- Active mode [Base Emitter junction in forward bias and Collector Base junction in reverse bias].
- Quasi Saturation [Base Emitter and Collector Base junction in

Forward Bias].

- Hard saturation [Base Emitter and collector Base junction in forward bias].

★ VI Characteristics of Power BJT...

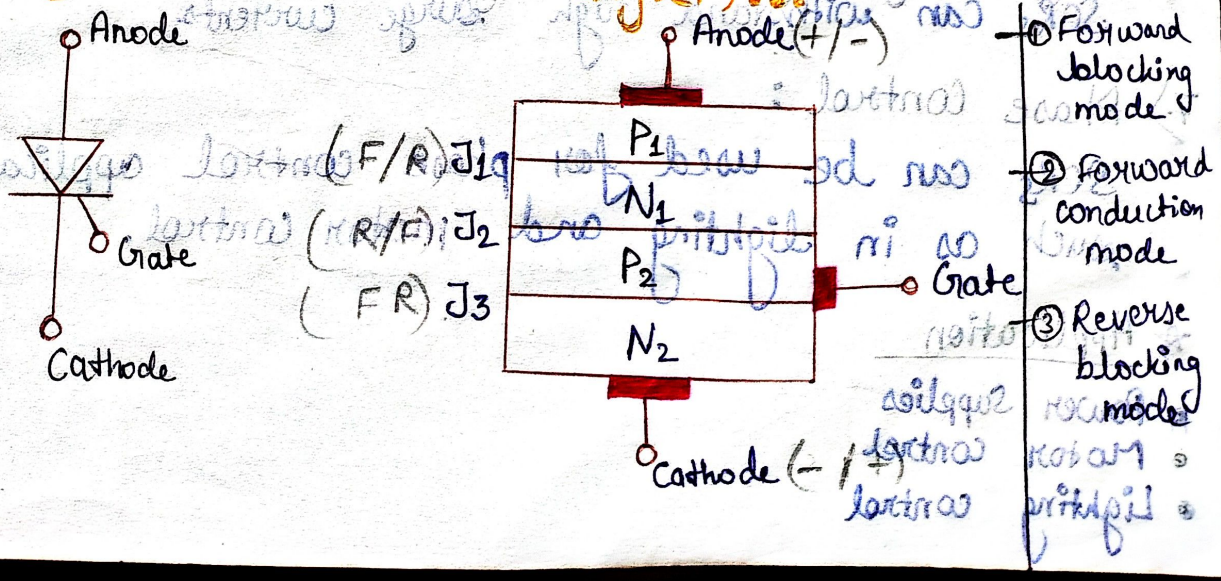


★ Application of Power BJT...

- SMPS
- Power Amplifier
- DC to AC Inverters
- Relay
- Power Control circuit

2.) Features of SCR...

SCR (Silicon Controlled Rectifier)...



→ For Forward bias
- Anode should be +ve with respect to Cathode.
- J_1 & J_3 Forward Biased
- J_2 Reverse biased

→ For Reverse bias..
- Anode should be -ve with respect to Cathode.
- J_1 & J_3 Reverse biased
- J_2 is in Forward biased

Features... (SCR)

1.) Unidirectional device:
SCRs allow current to flow in one direction only.

2.) Latching behavior:
Once triggered, SCRs remain in the ON state until the current falls below a certain threshold (holding current).

3.) Gate Control: SCRs can be triggered into the ON state by applying a gate signal.

4.) High Current handling Capability:
SCRs can handle high currents and voltages.

5.) Low gate power requirement:
SCRs require low power to trigger the gate.

6.) High surge current capability:
SCRs can withstand high surge currents.

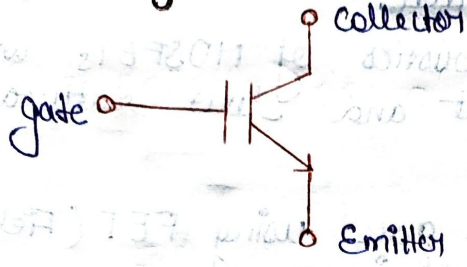
7.) Phase Control:
SCRs can be used for phase control applications, such as in lighting and motor control.

★ Application

- Power supplies
- Motor control
- Lighting control

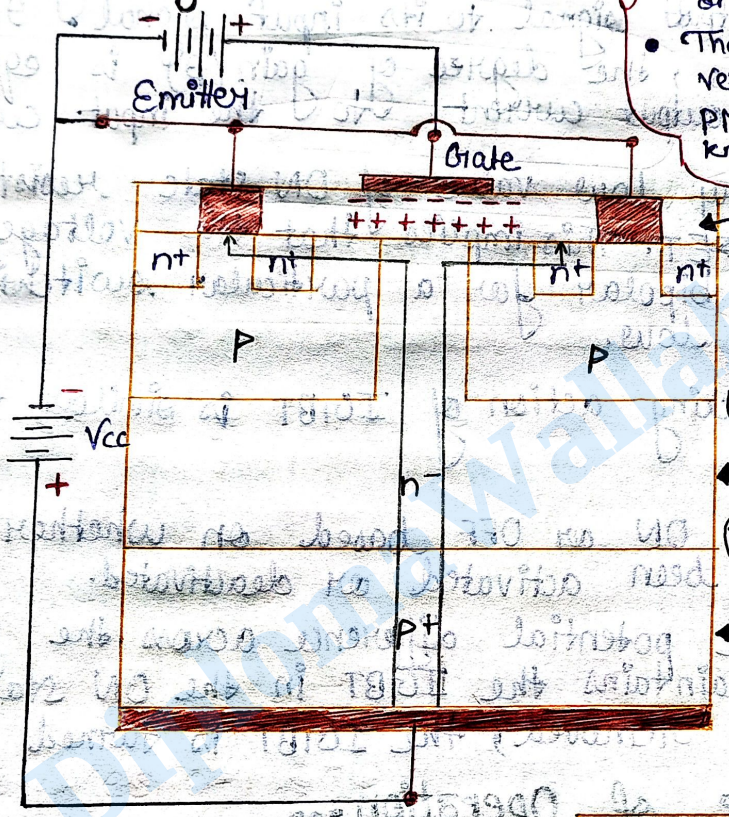
IGBT ... (Instructed Gate Bipolar Transistor)

★ Symbol of IGBT

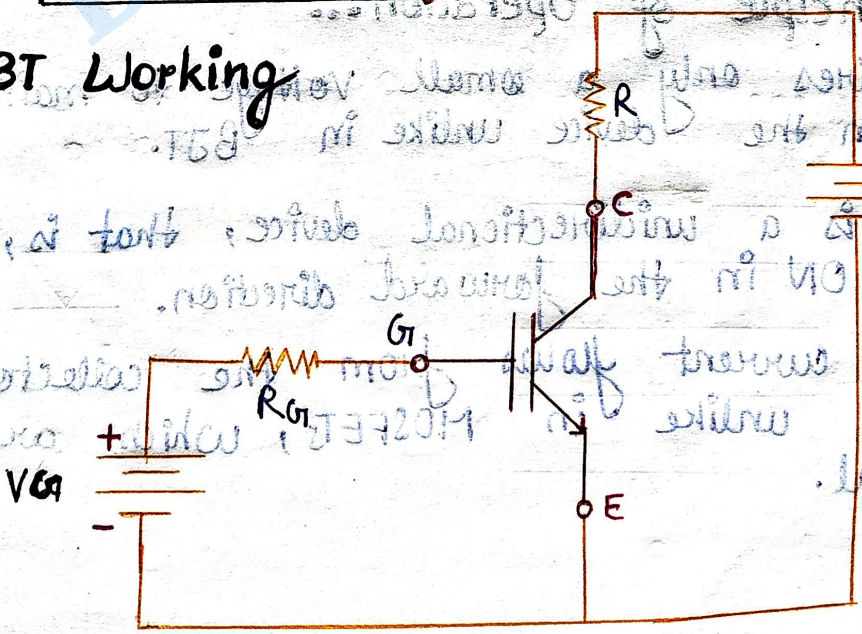


- Like a PMOSFET, an IGBT has thousands of basics MOS cell connected on a single silicon chip.
- The structure of IGBT is very similar to that of PMOSFET except one layer known as injection layer which is p+ unlike n+ substrate in PMOSFET.

★ Structure of IGBT



★ IGBT Working



- The insulated gate bipolar transistor (IGBT) is a semiconductor device with three terminals and is mainly used as an electronic switch.
- IGBT combines the characteristics of MOSFETs and BJTs to attain high current and low saturation voltage capacity respectively

  It integrates an isolated gate using FET (Field Effect Transistor) to obtain a control input.
- The amplification of an IGBT is computed by the ratio of its output signal to its input signal. In conventional BJTs, the degree of gain (β) is equal to the ratio of its output current to the input current.
- IGBT has a very low value of ON state resistance (R_{ON}) than a MOSFET. This implies that the voltage drop (I^2R) across the bipolar for a particular switching operation is very low.
- The forward blocking action of IGBT is similar to that of a MOSFET.
- IGBT is switched ON or OFF based on whether its gate terminal has been activated or deactivated.
- A constant positive potential difference across the gate and the emitter maintains the IGBT in the ON state. When the input signal is removed, the IGBT is turned OFF.

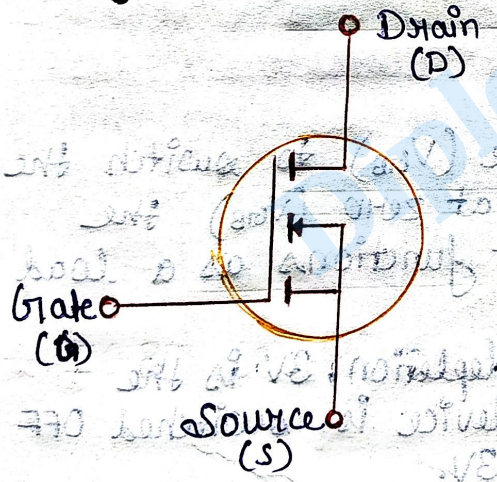
★ IGBT Principle of Operation...

- IGBT requires only a small voltage to maintain conduction in the device unlike in BJT.
- The IGBT is a unidirectional device, that is, it can only switch ON in the forward direction.
- This means current flows from the collector to the emitter unlike in MOSFETs, which are bi-directional.

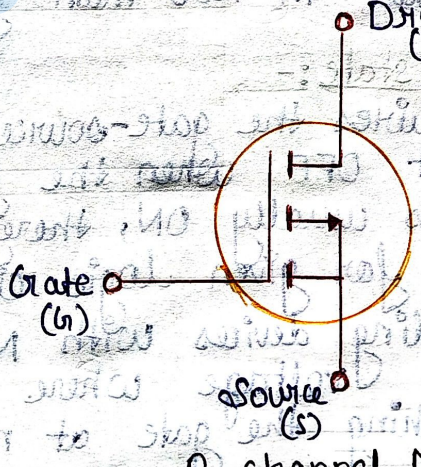
Power MOSFET...

- Metal Oxide Semiconductor Field Effect Transistor (MOSFET) is a type of transistor used to switch electronic signals.
- It has four terminals namely, Source (S), Drain (D), Grate (G) and Body (B).
- The MOSFETs body is normally connected to the terminal of the source (S), which results in three-terminal device similar to other field effect transistor (FET).
- Since these two main terminals are usually interconnected via short circuit, only three terminals are visible in electrical diagrams.
- It is the most common device in circuits that are both digital and analogue. Compared to the regular transistor, a MOSFET needs low current (less than one mill-ampere) to switch ON.

★ Symbol of Power MOSFET.



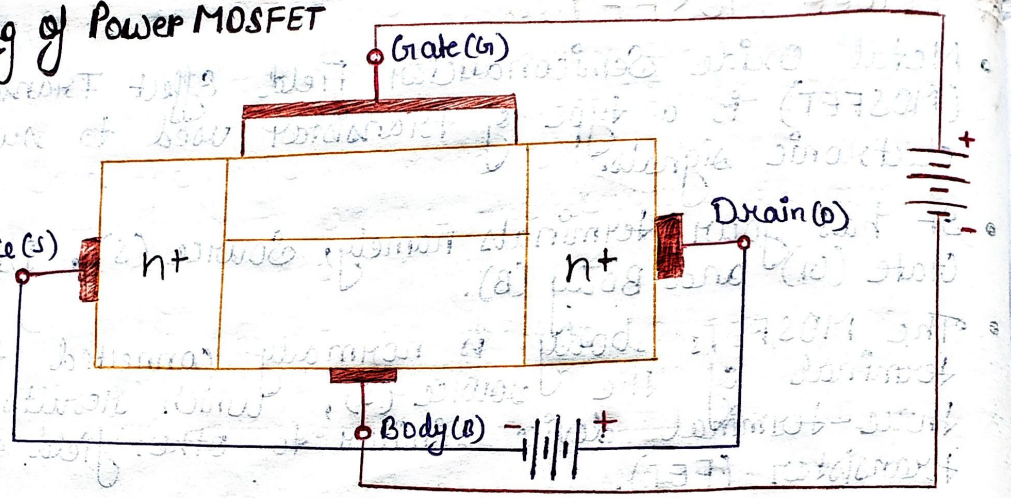
N-Channel MOSFET



P-Channel MOSFET

★ Working of Power MOSFET

★ Working of Power MOSFET



★ Operation of a MOSFET

- MOSFET has a thin layer of silicon dioxide, which acts as the plate of a capacitor. The isolation of the controlling gate raises the resistance of the MOSFET to extremely high levels. (almost infinite).
- The gate terminal is barred from the primary current pathway, thus, no current leaks into the gate.

MOSFET exist in two main forms -

* Depletion state :-

- This requires the gate-source voltage (V_{GIB}) to switch the component OFF. When the gate is at zero (V_{GIB}) the device is usually ON, therefore, it functions as a load resistor for given logic circuits.
- For loading devices with N-type depletion, 3V is the threshold voltage where the device is switched OFF by switching the gate at negative 3V.

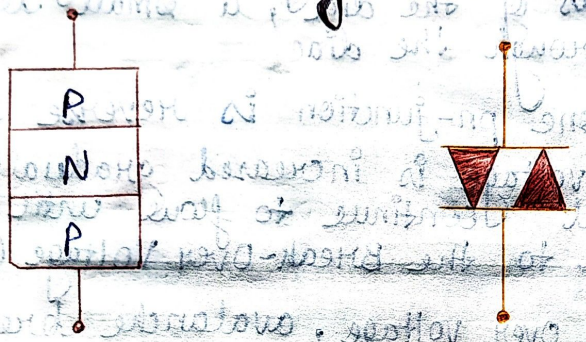
* Enhancement state :-

- The gate-source voltage (V_{GIB}) is required in this state to switch the component ON.
- When the gate is at zero (V_{GIB}) the device is usually OFF and can be switched ON by ensuring the gate voltage is higher than the source voltage.

3.) DIAC ...

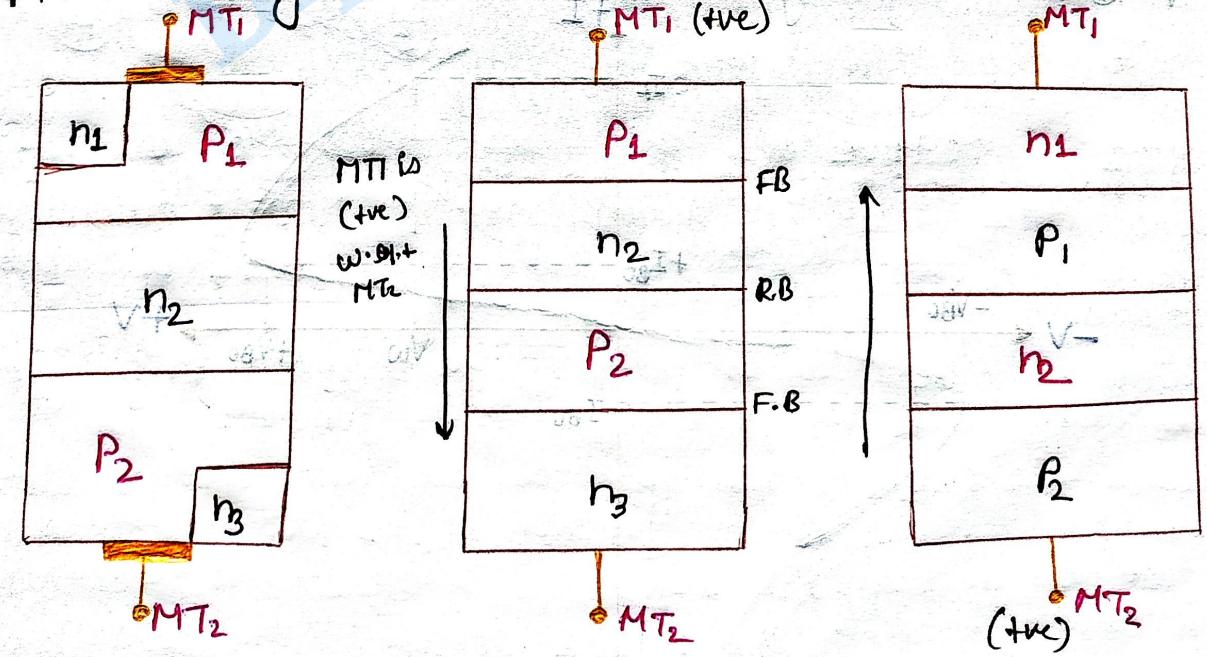
- A diac is a two-terminal, three-layer, bidirectional device which can be switched from OFF state to ON state for both positive and negative polarity of the supply voltage.
- Diode Alternating Current.

★ Constructional details of the DIAC



- The basic structure of a Diac is similar to a BJT transistor. The only difference is that there is no base terminal in case of Diac.
- The terminals of the diac are taken from the two p-regions of silicon that are separated by an n-region. The concentrations are identical in all layers to give the device symmetrical properties.

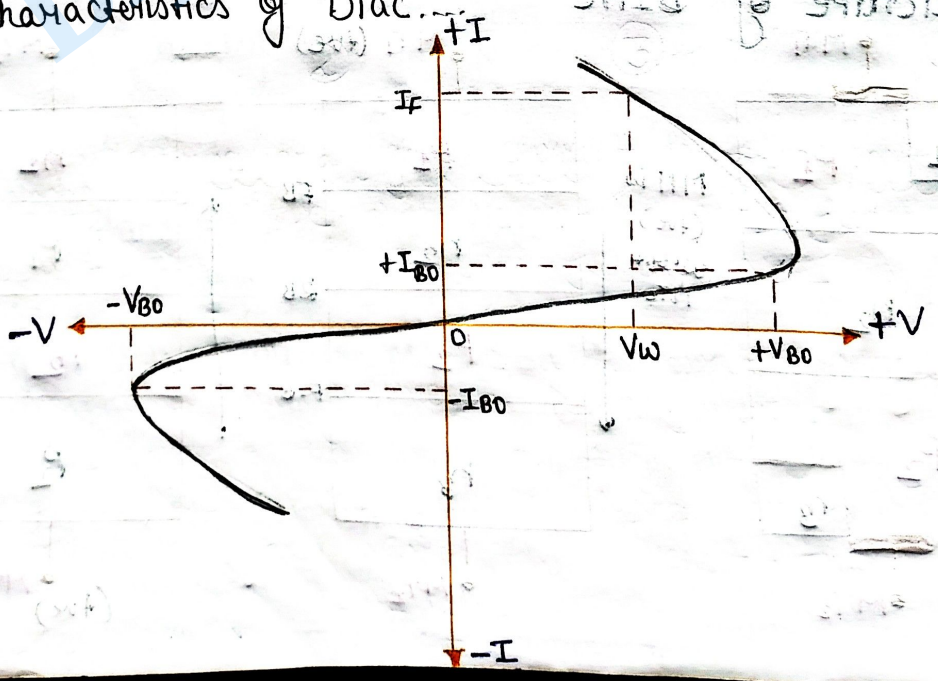
★ Structure of DIAC



★ Operation of DIAC

- The amount of voltage required across the terminals of the diac to switch it ON is called the Break-Over Voltage (I_{BO}). Once the diac is made ON, the only way to switch it off is to reduce the current to zero by isolating it from the supply.
- When a small positive or negative voltage is applied across the terminals of the diac, a small leakage current IBO will flow through the diac.
- This is because one pn-junction is reverse biased.
- When the applied voltage is increased gradually, the leakage current will continue to flow until the voltage attains value equal to the Break-Over Voltage (I_{BO}).
- At point of break over voltage, avalanche breakdown occurs on the reverse biased junction and the current through the diac increases with the decreasing value of applied voltage.
  The voltage across the diac drops to the Break-Back Voltage (Vw).
- When the applied voltage is equal to or greater than the breakdown voltage, the diac starts to conduct and the voltage drop across it becomes a few volts.

★ V-Characteristics of Diac.



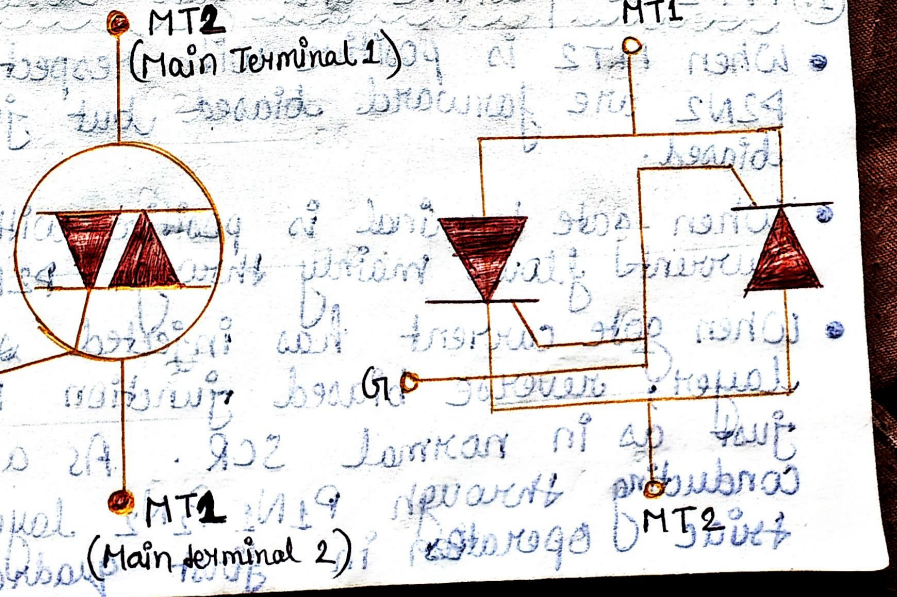
★ Application of DIAC

- Diacs are primarily used in the triggering circuits of the Triacs.
- Lamp dimmer circuits.
- Heat control circuits.
- Speed Control of universal motors.

TRIAC ...

- The word TRIAC is derived from combination of capital letters TRIode and AC. It is a low power semiconductor device acting as a switch.
- TRIAC is a bipolar blocking and bi-directional conducting device. It is a pulse triggered switch.
- A SCR is a unidirectional device as it can conduct from anode to cathode. It has reverse blocking characteristics and current cannot flow from cathode to anode direction.
- But in some application, particularly in AC circuit, the bidirectional current flow is required.
- For this two thyristors can be integrated into a single chip as this device is called a TRIAC (triode ac switch).
- TRIAC can conduct in both directions. Hence, TRIAC is a bi-directional thyristor and it is extensively used for AC controller circuits.

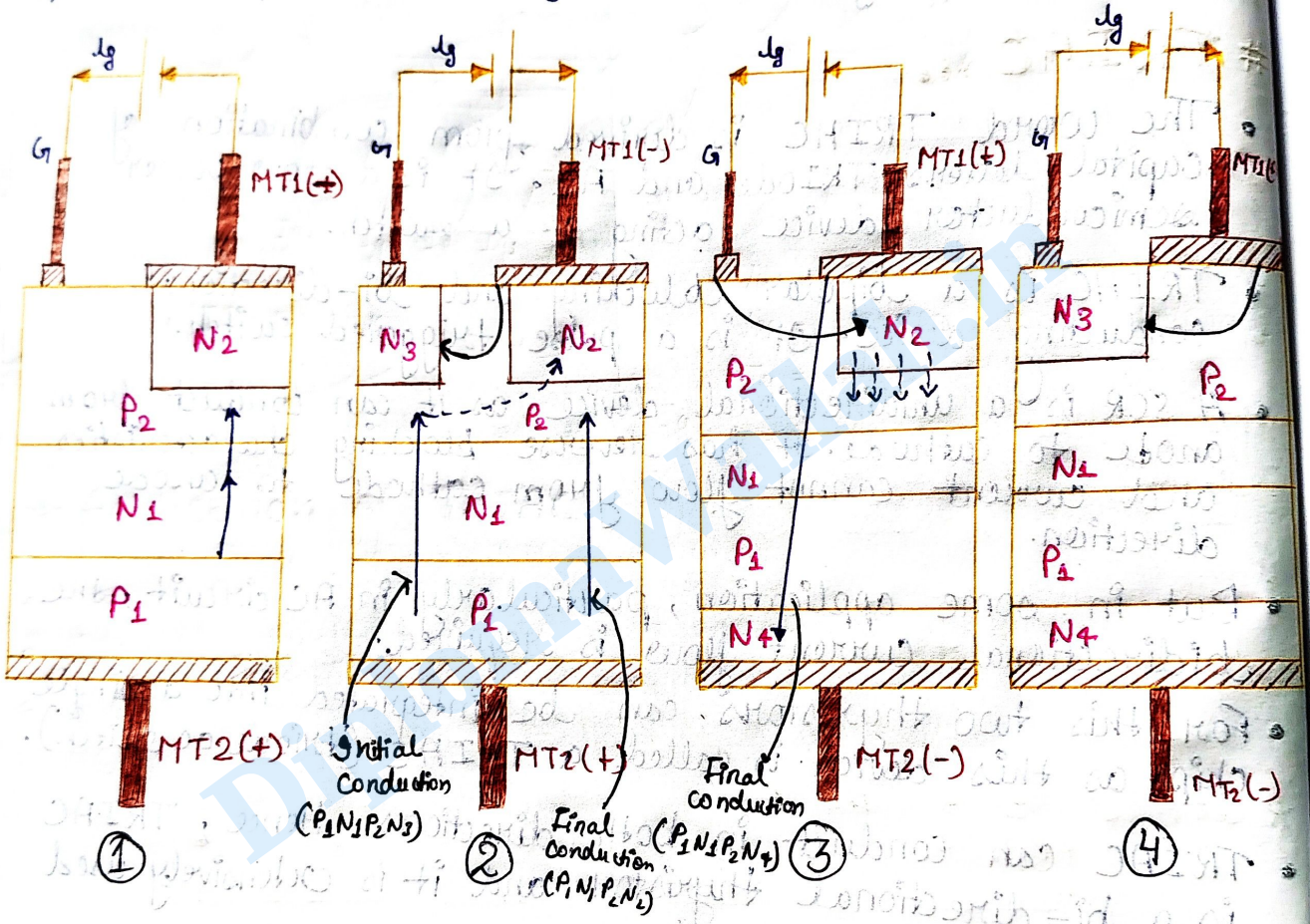
Symbol of TRIAC



★ Modes of Operation of TRIAC

TRIAC under go four modes of operation:-

1) MT2 is positive and gate current is also positive.
2) MT2 is positive but gate current is negative.
3) MT1 is positive and gate current is also positive.
4) MT1 is positive but gate current is negative.



(1.) MT2 is positive and gate current is also positive:-

- When MT2 is positive with respect to MT1, junction P1N1, P2N2 are forward biased but junction N1P2 is reverse biased.
- When gate terminal is positive with respect to MT1, gate current flows mainly through P2N2 junction.
- When gate current has injected sufficient charge into P_2 layer, reverse biased junction N_1P_2 breaks down just as in normal SCR. As a result, triac starts conducting through $P_1N_1P_2N_2$ layers. Under this condition, triac operates in first quadrant.

② MT2 is positive but gate current is negative :-

- When gate terminal is negative with respect to MT1, gate current flows through P_2N_3 junction, and reverse biased junction N_1P_2 is forward biased as in a normal thyristor.

  As a result, triac starts conducting through $P_1N_1P_2N_3$ layer initially.

- With the conduction of $P_1N_1P_2N_3$, the voltage drop across this path falls but potential of layer between P_2N_3 raises towards anode potential of MT2.

③ MT1 is positive and gate current is also positive :-

- The gate current I_g forward biased P_2N_2 junction. Layer N_2 injects electron into P_2 layer.

  As a result, junction N_1P_1 breaks down as in a conventional thyristor.

- Eventually the structure $P_2N_1P_1N_4$ is completely turned on. As usual, the current after turn-on is limited by the external load.

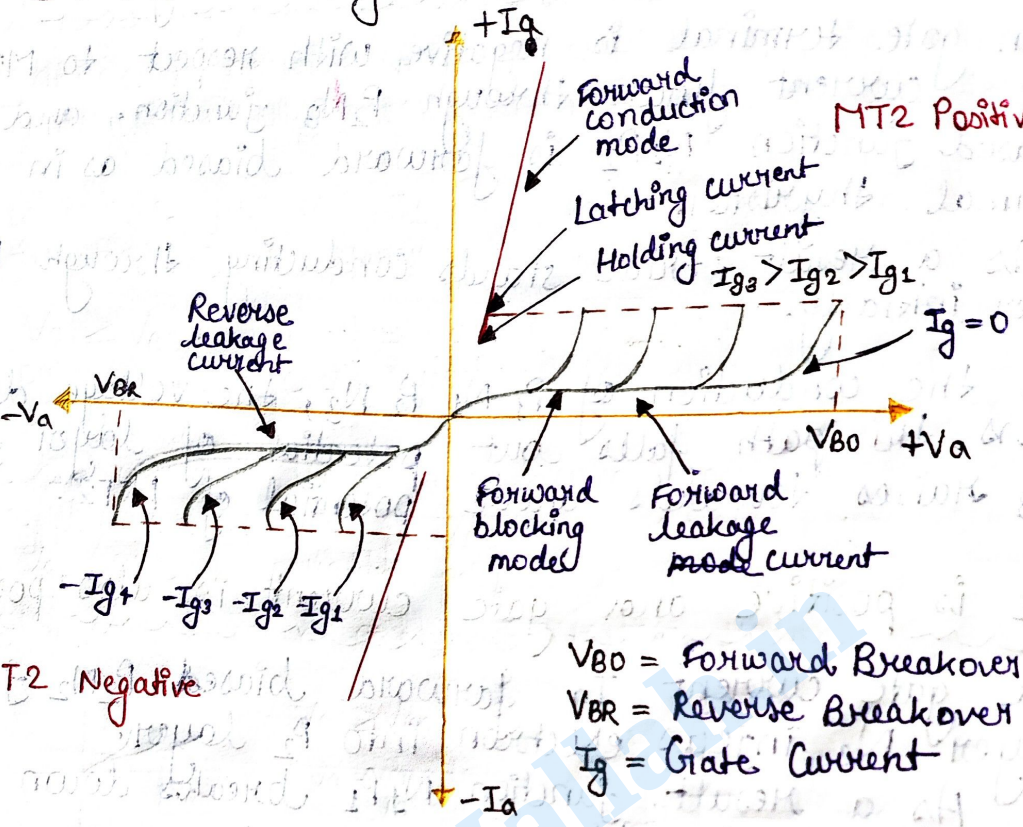
- As the triac is turned on by remote gate N_2, the device is less sensitive in the third quadrant with positive gate current.

④ MT1 is positive but gate current is negative :-

- In this mode, N_3 acts as a remote gate. The gate current I_g flows from P_2 to N_3 as in a normal thyristor.

- Reverse-biased junction N_1P_1 is broken and finally, the structure $P_2N_1P_1N_4$ is turned on completely.

★ V-I Characteristics of TRIAC



V_{BO} = Forward Breakover Voltage
V_{BR} = Reverse Breakover Voltage
I_g = Gate Current

★ Application of TRIAC

- Lamps Control.
- Speed Control of fans
- Chopper
- AC phase Control.