

UNIT - 1

Electrical
is an branch
not a branch

POWER ELECTRONICS DEVICE :-

- power electronics device is a control & conversion of high power application.
- power semiconductor device is also used to control the magnitude of high power.

* Following power electronics device :-

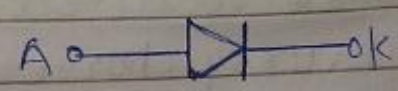
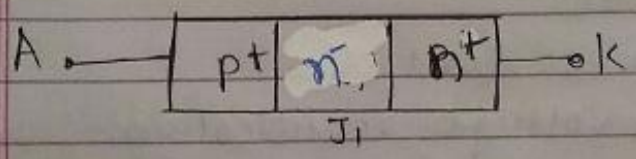
- ① power diode (uncontrol switch)
- ② power transistor (fully control)
- ③ power Thyristor (semi-control)

POWER DIODE :-

- A power diode is a type of diode that is commonly used in power electronics circuit.
- power diode is a simple semiconductor device.
- It is a 3-layer, 2-terminal and 1-junction diode device.
- power diode is uni-directional or uncontrol device.

* Construction :-

Symbol :-

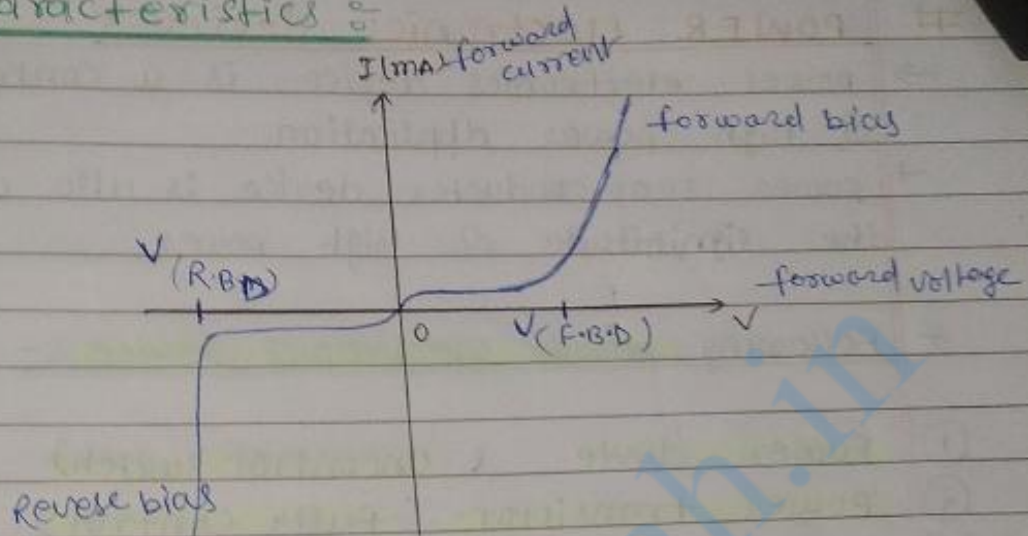


P-Diode

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* I-V characteristics :-



working :-

① forward biased condition :-

(Anode \rightarrow +ve wr. to cathode)

(forward current \uparrow & $V \uparrow$)

(diode is conducts)

② Reverse biased condition :-

(cathode \rightarrow +ve wr. to anode)

diode does not conduct.

* Application :-

① 3- ϕ rectifiers & inverter

② battery chargers, power controller.

③ snubber ckt & high voltage rectification.

POWER Transistor : construction, working, I-v characteristics and its application.

* POWER TRANSISTOR :-

→ The three terminal device which is designed specially for control high-current-voltage rating and handle a large number of power levels in a device or a circuit, is called power transistor.

* Classification of power Transistor :-

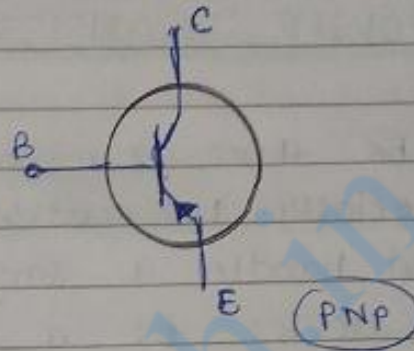
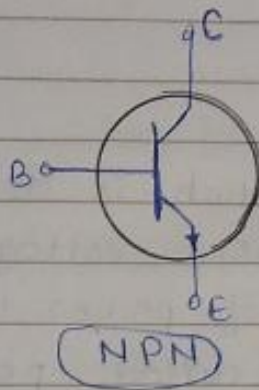
- (i) power BJT.
- (2) Power MOSFET.
- (3) power IGBT.

1: Power BJT

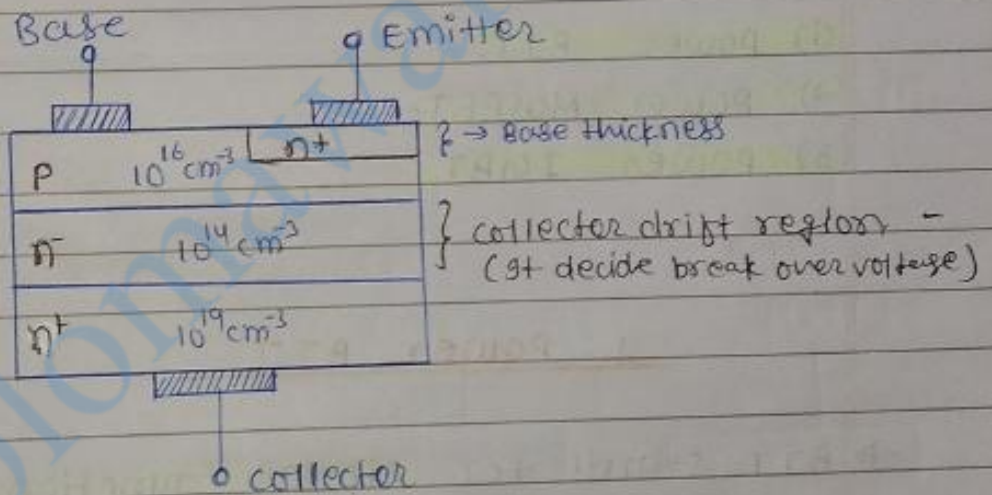
- BJT stands for Bipolar Junction transistor.
- It is a current controlled device.
- It is either used as an amplifier or as a switch.
- In BJT, Emitter is heavily doped.
- There is a three terminal device (Collector, Base and Emitter), 3-layer and 2-junction semiconductor device.
- BJT is of two types -
 - (i) NPN
 - (2) PNP
- BJT have high breakdown voltage.
- BJT is mainly seen in high power application.

P-BJT

* Symbol of BJT



* Construction of BJT



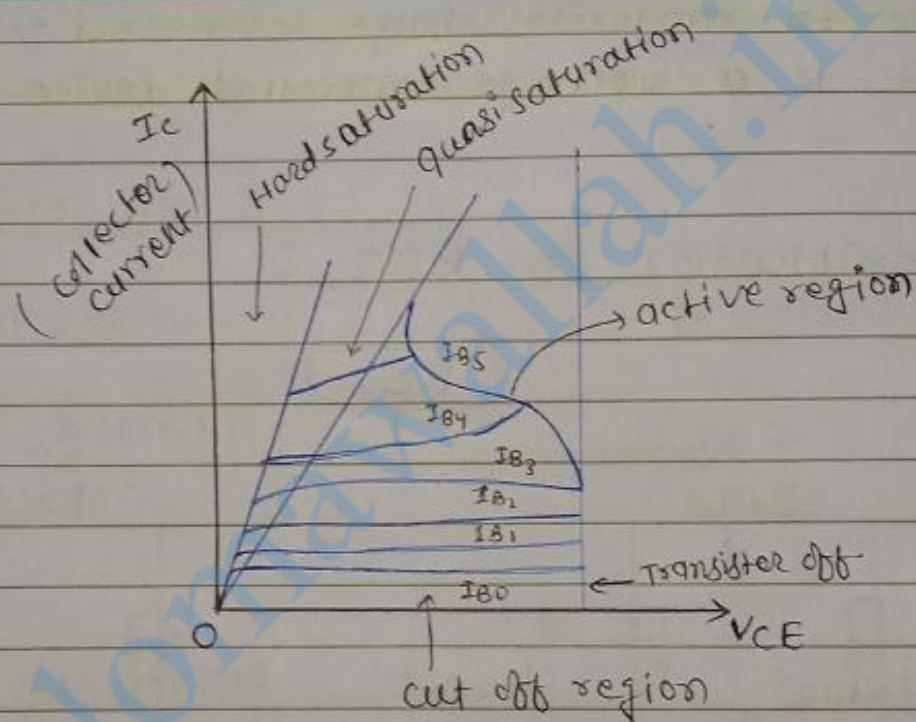
* Mode of operation of BJT

→ Power BJT is operates in four (4) region-

- 1) Cut off mode :- Base, Emitter and collector base junction in reverse bias.
- 2) Active mode :- Base Emitter junction in forward bias and collector base junction in reverse bias.
- 3) Quasi saturation :- Base Emitter and collector Base junction is forward bias.
- 4) Hard saturation :- Base Emitter and collector Base junction in forward bias but in quasi saturation region.

offers lower power working of saturation with power BJT while hard saturation region explains higher power working with given power BJT.

* I-V characteristics of power BJT :-



* application of power BJT :-

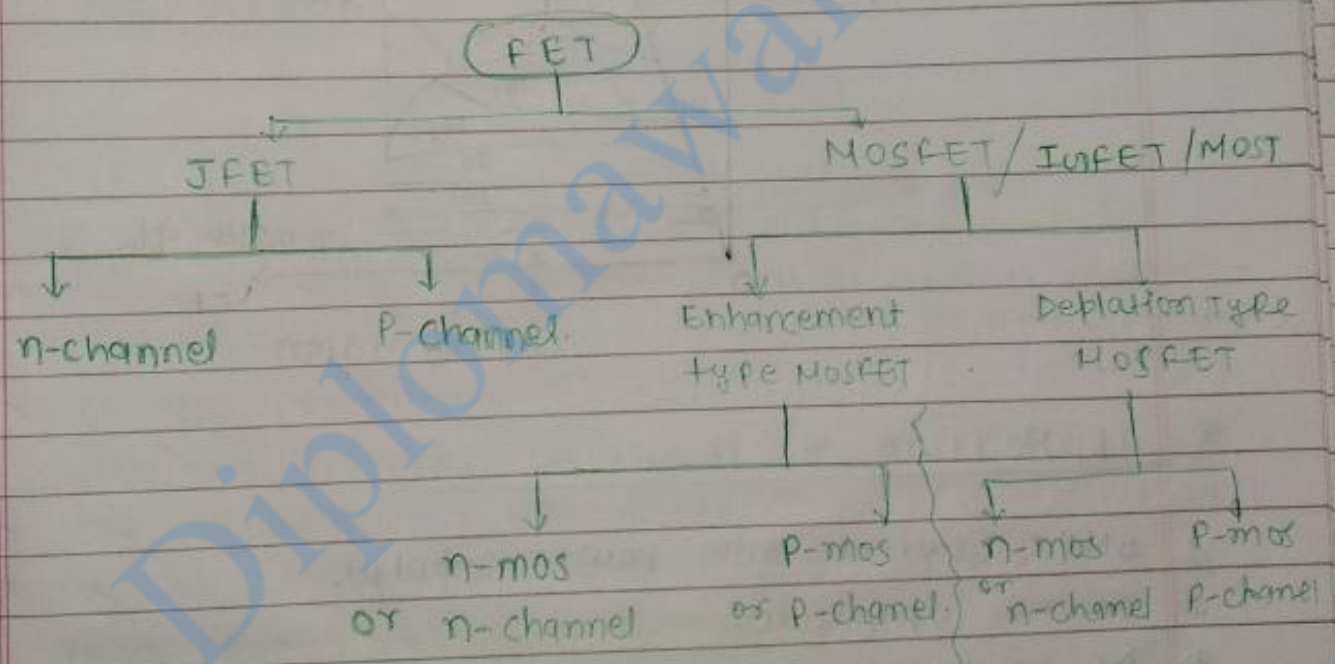
1. SMPS (switch mode power supply).
2. power amplifier.
3. DC to A.C inverters.
4. Relay.
5. power control circuit.

FET

FET (Field Effect Transistor)

- #
 - fET stands for **field effect transistor**.
 - fET is a device in which current flow in conducting region is **controlled by Electric field** is called fET.
 - **gt** is a **uni-polar device** because **conduction is only due to majority charge carriers** i.e, holes or electrons.
 - **gt** is a **voltage controlled device**.

* classification of FET :-



JFET

classmate

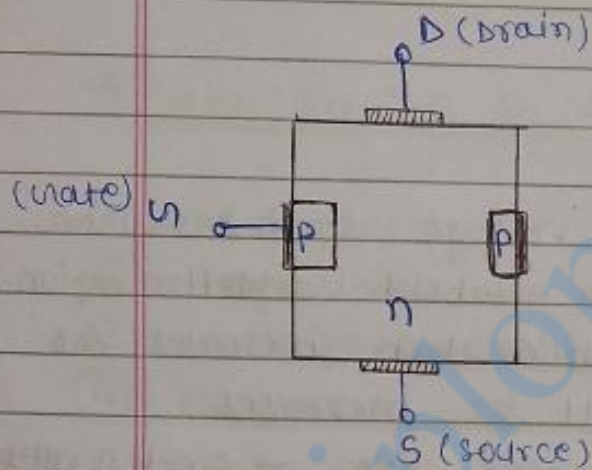
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JFET :-

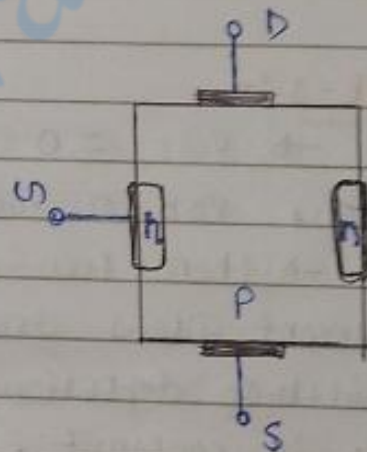
- JFET stand for **Junction field Effect transistor.**
- It is a **three terminal device** in which current conduction take place due to **majority charge carrier.**
- It is a **uni-polar transistor device.**
- It is a **voltage controlled device.**

* construction of JFET :-

n-channel JFET

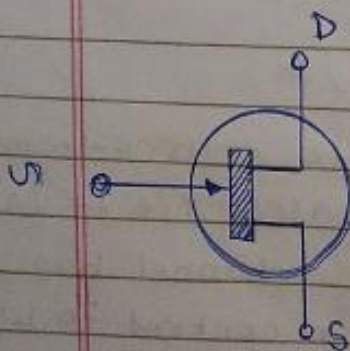


p-channel JFET

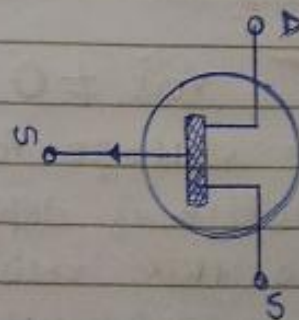


* Symbol :-

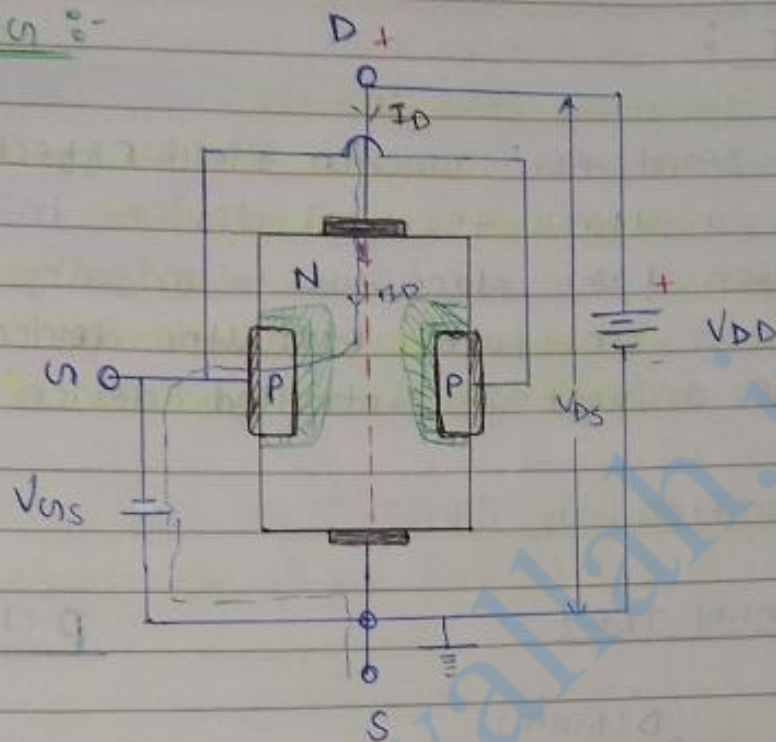
N-channel JFET



P-channel JFET



* WORKING :-



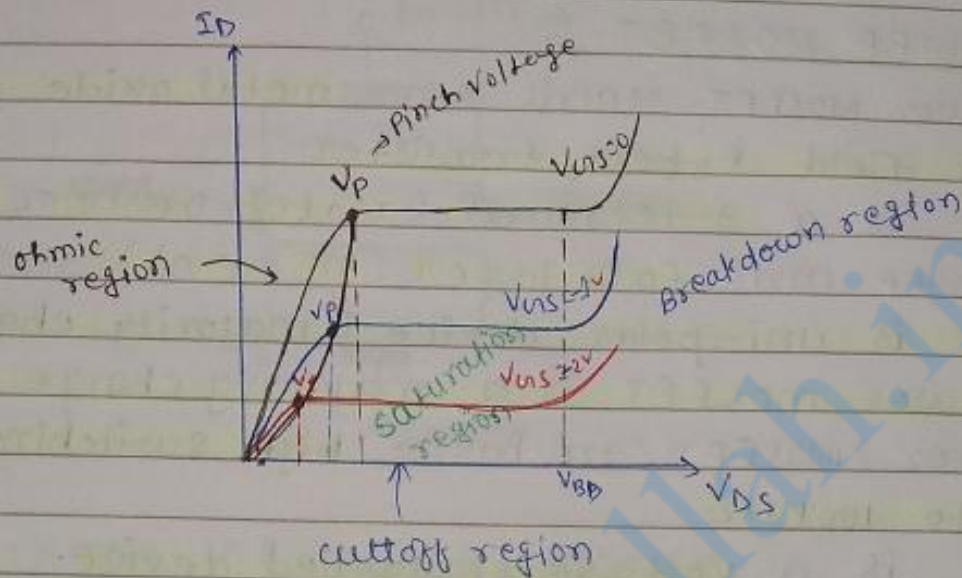
Case - I :-

- $V_{gs} = 0$
- when V_{DD} or V_{ds} applied voltage drain & source.
- then two p-n junction establish depletion region.
- current flow drain & to source then increases V_{DD} width of depletion layer will be increases.
- I_D is constant, we increases V_{DD} . → pinch of voltage
- if we apply more voltage after pinch of voltage then breakdown and high amount of current flow from n-channel to p-type s.c.

Case - II :-

$$V_{gs} \neq 0$$

- reverse voltage. V_{gs} apply - gate to source terminal.
- the width of depletion region increases due to V_{gs} .
- Due to this resistance increases in channel bar.
- we need few voltage of V_{DD} , we can control I_D by changing in V_{gs} .

* I-V characteristics :-* Application of JFET :-

- ① chopper
 - ② amplifier
 - ③ voltage control resistor
 - ④ buffer
- etc.

- short working case of JFET :-case-1

$$V_{GS} = 0$$

$$V_{DS} = V_{DD}$$

case-2

$$V_{GS} = -ve \text{ voltage.}$$

I_D constant and $V_{DD} \uparrow \uparrow$ increases.

P-MOSFET

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POWER MOSFET : Construction, working & I-V char.

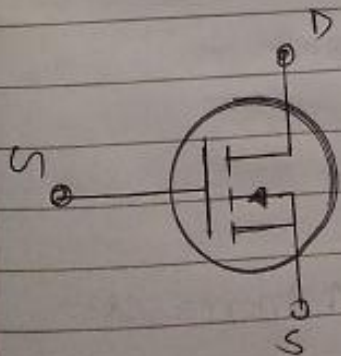
* POWER MOSFET :

- power MOSFET stands for metal oxide semiconductor field effect transistor.
- It is a 3-terminal (gate, drain or source) device and four layer (n^+p-n^+) device.
- It is uni-polar device (majority charge carrier).
- power MOSFET is a majority charge device.
- power MOSFET are having high switching frequency upto 100kHz .
- It is a voltage controlled device.

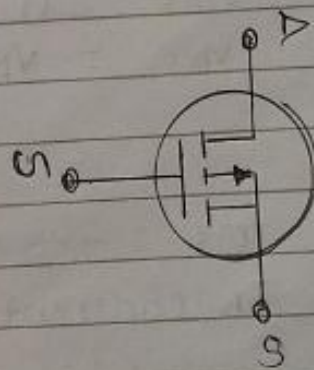
* FEATURES OF POWER MOSFET :

- low input current.
- It is a voltage controlled device.
- high switching speed.
- high input impedance.
- Active device.
- They do not have problem of second breakdown.

* Symbol of power MOSFET :

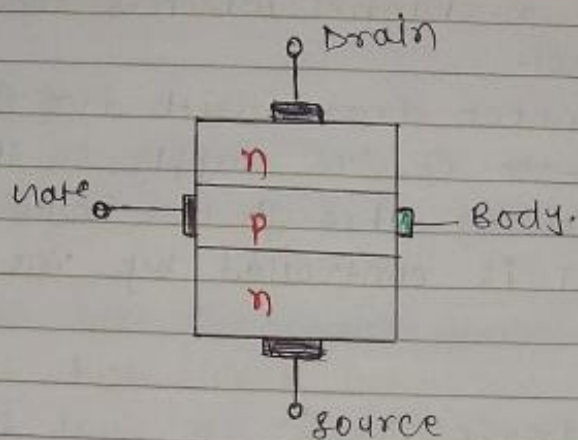


n-channel

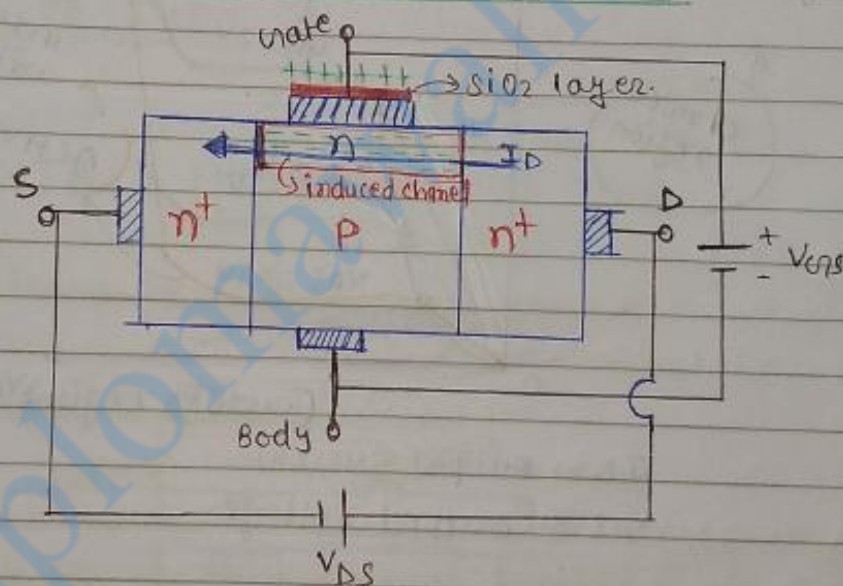


p-channel.

* Structure of P-MOSFET :-



* WORKING OF POWER MOSFET :-

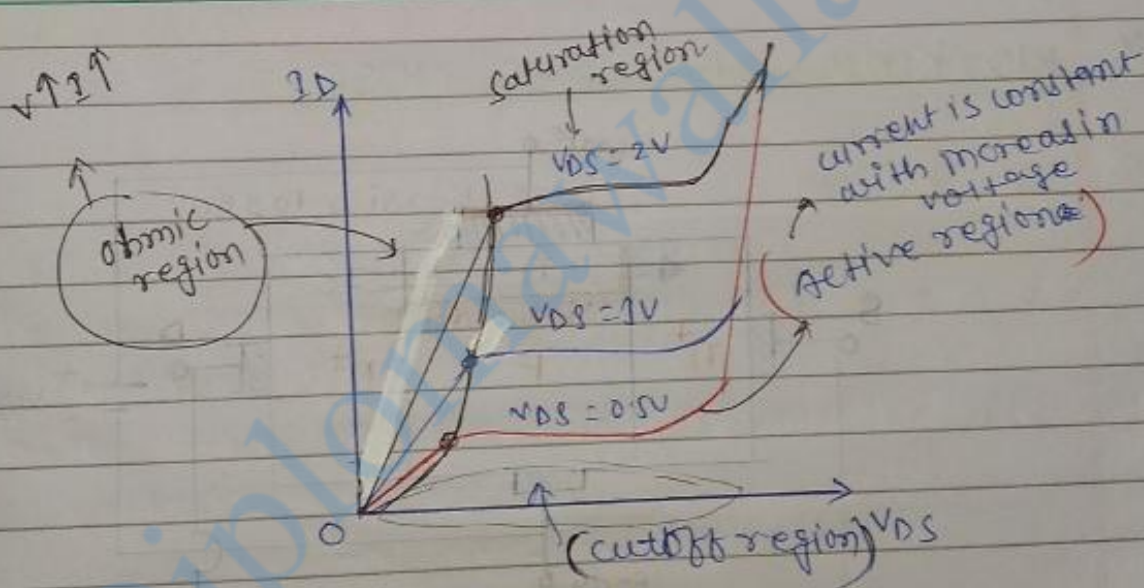


✓ → We have to connect gate with +ve terminal of V_{GS} and body is connected to -ve terminal of the V_{GS} . Then gate act as a capacitor due to SiO_2 layer with upper plates is positive short-

✓
 gate → +ve terminal w.r. to body of V_{GS} .
 gate is act capacitor. due to SiO_2 layer

- when we increase V_{gs} -ve charge is increases. so it create n-channel which is known as induced channel.
- Now we connect drain with +ve of V_{DS} and source with -ve of V_{DS} supply, so the current I_D start flowing through the induced channel.
- power MOSFET is controlled by V_{gs} voltage (gate voltage).

* I-V characteristics :-



I_D → output current
 V_{DS} → output voltage.

* Application of power MOSFET :-

- UPS (uninterruptible power supplied)
- small motor control.
- switch mode power supplies (SMPS)
- power-over-Ethernet (PoE).
- solar inverter.

(IGBT)

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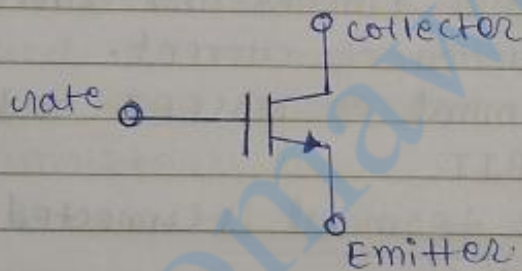
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IGBT : construction • working & I-V characteristics and symbol :-

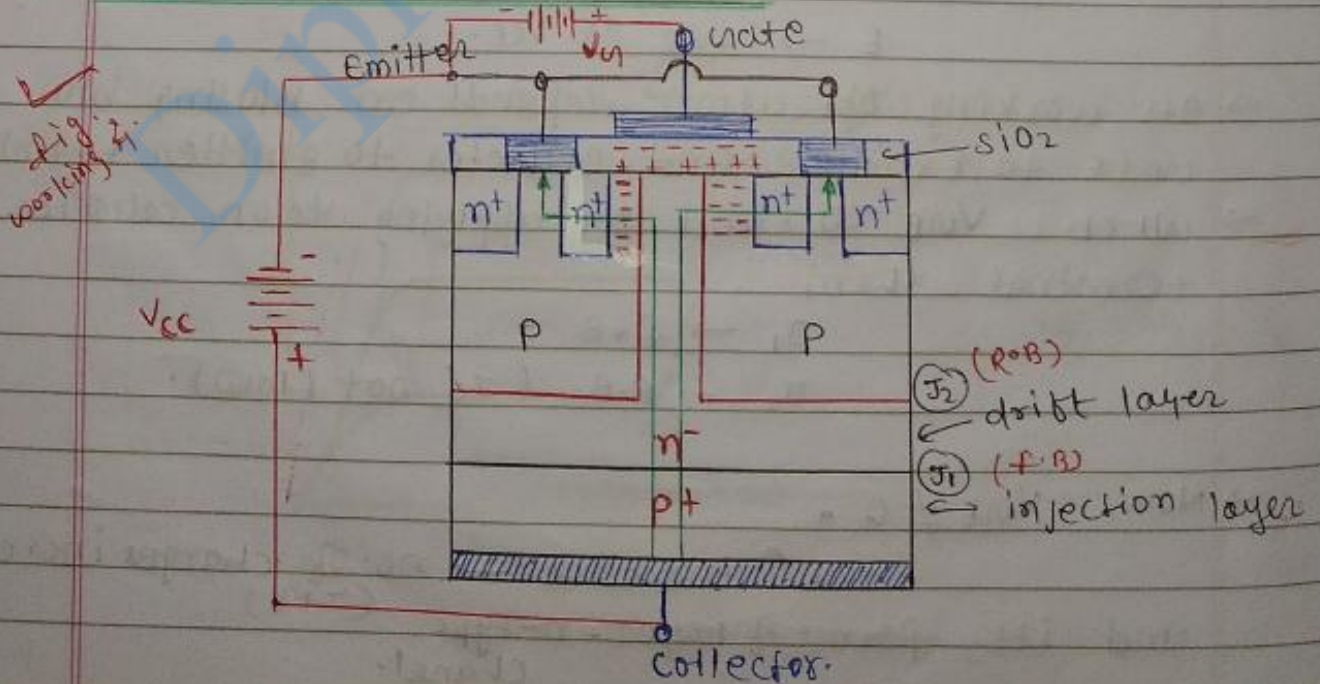
* IGBT :-

- IGBT stands for insulated-gate bipolar transistor.
- It has 3-terminal (gate, emitter and base) device.
- It has best combination quality of BJT and MOSFET.
- It has high input impedance like MOSFET.
- It has low on state power loss as in BJT.

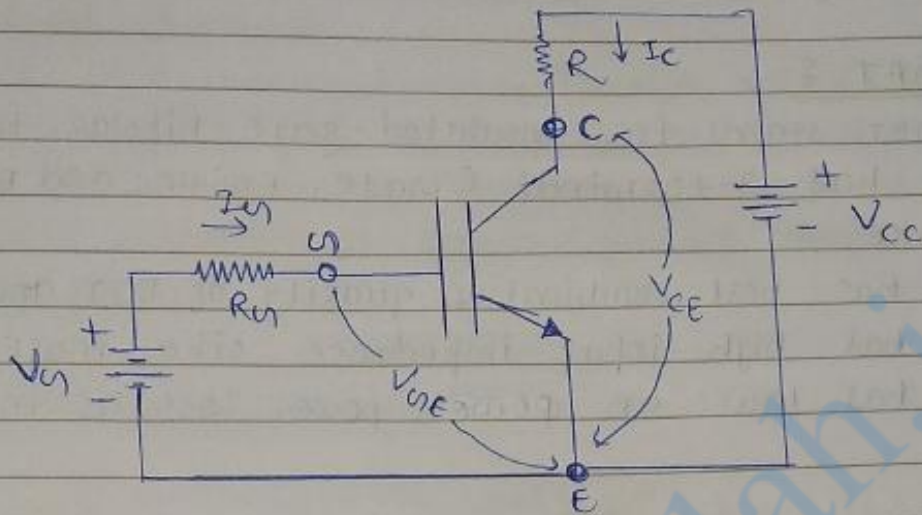
* Symbol of IGBT :-



* STRUCTURE OF IGBT :-



* JMPT WORKING :-



- In JMPT gate terminal is used for controlling the device (i.e. JMPT) and emitter and collector terminal is used for conduction of current.
- gate is input terminal of MOSFET and E & C is o/p terminal of BJT.
- collector & emitter terminal is connected through o/p voltage i.e. 'V_{CC}'.
- C → +ve of V_{CC}
- E → -ve of V_{CC}.
- Its working operation depends on biasing b/w gate to emitter and collector to emitter terminal.
- When V_{BE} = 0, and by applying V_{CC} on collector terminal then,
 - J₁ → f.o.B
 - J₂ → R.B. (I_c not flow).
- Now, V_{BE} ≠ 0.
- V_{BE} ↑ increase → no. of charges increases. (-ve)
- and its forms of layer - n-type channel.

→ Emitter is emits charge carrier from n^+ region to drift region. and holes in injected to drift region from p^+ .

Hence,

• magnitude of charge carrier in drift region is increases so, conductivity is also increases.

→ Therefore, flow of current (I_c) from collector to emitter.

* Application of IGBT :-

- ① SMPS (switch mode power supply).
- ② It is used in UPS (uninterruptible power supply)
- ③ AC and DC motor, speed control.
- ④ chopper and inverter.
- ⑤ solar inverters.

* I-V characteristics of IGBT :-

