Sumedh

- Topics

PN - Junc
BJT
JFET
MOSFET
IGBT
SCR
Powr Convrs
SMPS
KMAP

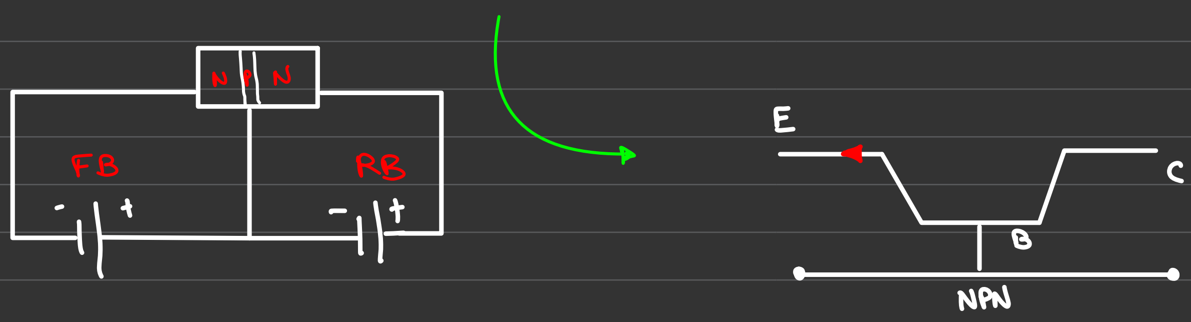
- BJT

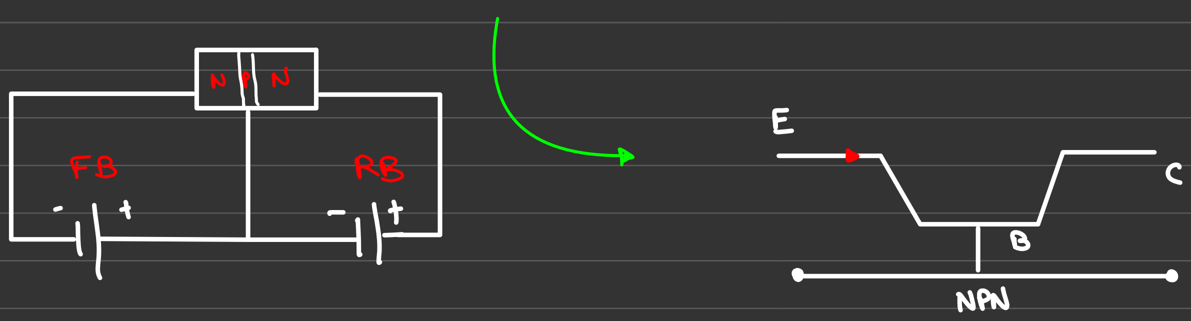
Bipolar Junction Transistor is a three terminal semiconductor device. Depends on both majority and minority carriers

Used as amplifier & Oscillator in circuits.

- Transistor biasing

Emittor - base junction is forward biased & Collected base junction is reverse biased. I_E flows to the base then into the collector





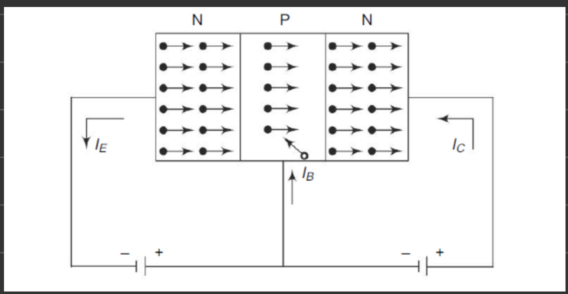
① NPN Transistor

When forward biasing is applied to the emittor-base junction, it causes a lot of e⁻s from the emittor region to crossover the base region

The base region size is very small & hence very less number of e⁻ combine with holes

The majority e⁻ then crossover to the collector region constituting a collector current.

Summed to give $I_E = I_C + I_B$

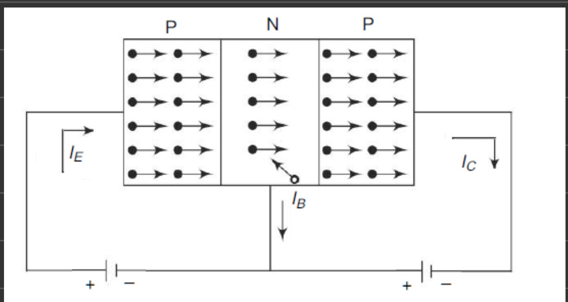


② PNP Transistor

When FB applied to E-B junc, holes frm emitter region to crossover to the base region (lighty doped N-type imp)

no of e⁻ in base is less, hence only few combine and make I_B, rest go to collected region & make I_C

$\therefore \; I_E = I_C + I_B$



- **FET**

A device in which flow of current thru conducting region is Controlled by elec. fld

A unipolar device

JFET MOSFET

- **N - channel JFET**

made of N-type bar made of silicon

Construction : i) Source (S) : Connected to -ve of the battery
e^- are maj cars . they enter here

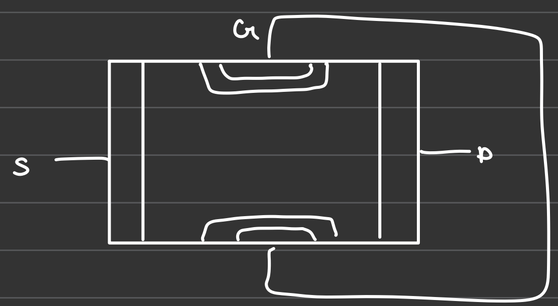
ii) drain (D) : Connected to +ve pole of the bat
maj cars leave frm here

iii) Gate (G) : Both terminals joined here
Heavy dope P-type Si diffused on both sides

Operation :-

Case - 1 : $V_{GS} = 0$ & $V_{DS} = 0$

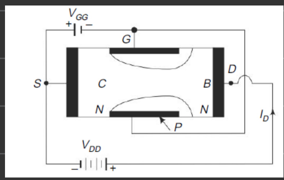
- No Volt b/w D, S, G
- Thickness of dep region is uniform



Case - 2 : $V_{DS} = 0$, $V_{GS} < 0$

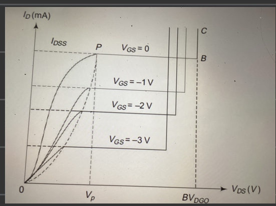
- PN junc RB
- As V_{GS} dec frm 0 , rev Vol inc .
- The thickness of dep reg inc until two meet
- The channel cutoff at Volt V_C

Case - 3 : $V_{GS} = 0$, $V_{DS} > 0$



- Drain is +ve
- maj cars (e^-s) flow frm S → D with I_D (D → S)
- Becoz R and V_{DS} , -ve pot inc (S → D)
- ∴ rev volt also inc , hence thick inc in wedge shape
- as V_{DS} ↑ , cross - sectional area ↓
- when becomes min , it called V_P (pinch off voltage)

Case - 4 : $V_{GS} < 0$, $V_{DS} > 0$



- When G is (-ve) , rev volt ↑
- ∴ same plot for $V_{GS} = 0$

- **JFET vs BJT**

JFET	BJT
i) Only operates on maj cars	i) Operates on both maj + min cars
ii) less noisy	ii) more noisy
iii) High impedance (> 100 MΩ)	iii) less compared
iv) less sensitive to temp	iv) more
v) easy to fabricate	v) hard
vi) less Volt , high signal distortion	

- **MOSFET**

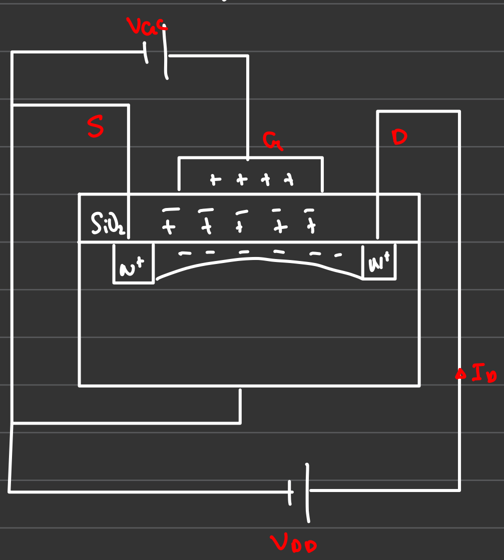
It's a common term of Insulated Gate Fld Effect Transt

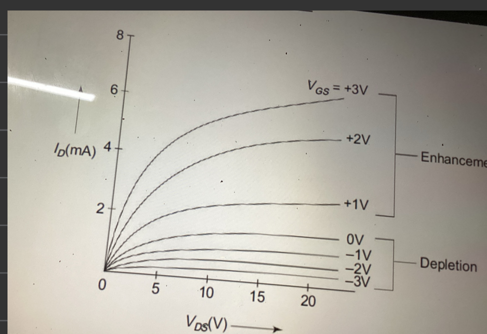
(Enchancement MOSFET)   Depletion MOSFET

Principle : By applying transverse elec fld across an insulator depositing on semi mat , the thickness / R can be controlled

Construction:
i) Two highly doped N^+ diffused in lighly doped substrate
ii) One N^+ region called S & other D
iii) A thin SiO_2 insulating layer on surface
iv) The metal area , SiO_2 layer form a ||el plate capacitor
v) This is called insulated gate FET

Operation:
i) If substrate grounded & +ve voltage applied at gate
ii) The +ve on G induces eq (-ve) charge b/w S & D
iii) Thus, elec fld prod b/w S & D
iv) directn is ⊥ to plates of oxide
v) The -ve charge on e⁻s (min cars) in P-type form an inversion layer
vi) As (+ve) Volt of G inc , induced (-ve) charge in semi inc.
vii) Hence cond ↑ & I flows (S → D





• Insulated Gate Transistor (IGBT)

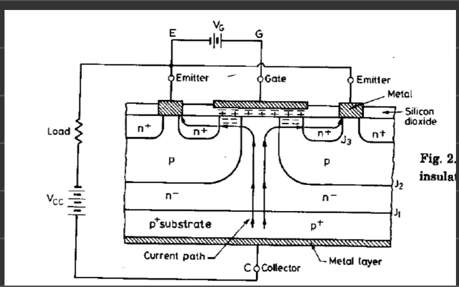
- Has high input impedance of a MOSFET & low on stable power loss in a BJT
- p^+ layer at drain is called collector
- When gate is +ve w.r.t emitter & gate - emitter volt > threshold Voltage, n-channel formed in the p- region
- N^- channel short circuit n^- with n^+ emitter region causing e^- movement in n-channel, eventually forward I est.
- Three layers : p^+ n^-, p (PNP Trans)
  $p^+ \rightarrow E$, $n^- \rightarrow B$, $p \rightarrow C$

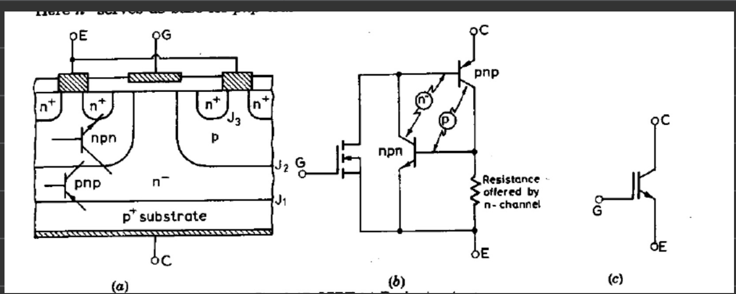
  if n^-, p, n^+ (npn trans)
  $n^- \rightarrow C$

- Output Chars : plot of I_C vs V_{CE}
  (VI same as BJT)

- Tranfer Chars : plot I_C vs V_{GE}
  similar to MOSFET
  when $V_{GE} < V_{thres}$, $V_{GET} \rightarrow$ IGBT is off-state

App : DC & AC motor drives, UPS
more efficient due to small size





• Silicon Controlled Rectifier (SCR)

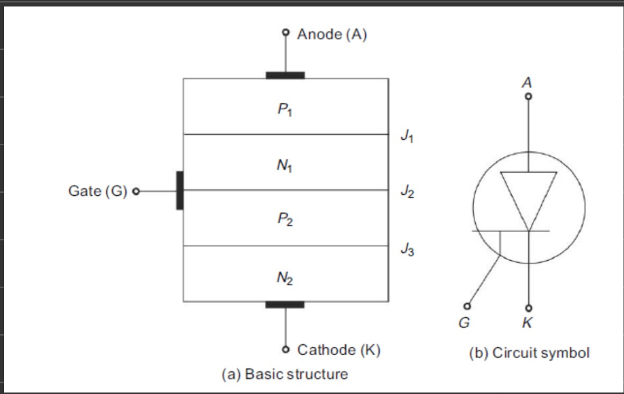
- four-layer, 3-terminal device
- end P-layer act as anode
  N   cathode
- Acts as a switch when FB

- When $I_G = 0$, SCR similar to PNPN diode
  $I_G < 0$, RB at J_2 ↑, V_{BV} (Brk down V) ↑
  $I_G > 0$, RB at J_2 ↓, V_{BV} ↑

- With large +ve I_G, brkdwn may occur at low volt
  so char of SCR similar to PN

- As SCR switched off, it can be controlled by I_G,
  commonly called controlled switch

Apps: used in relay control, motor control, invertor, battery charges

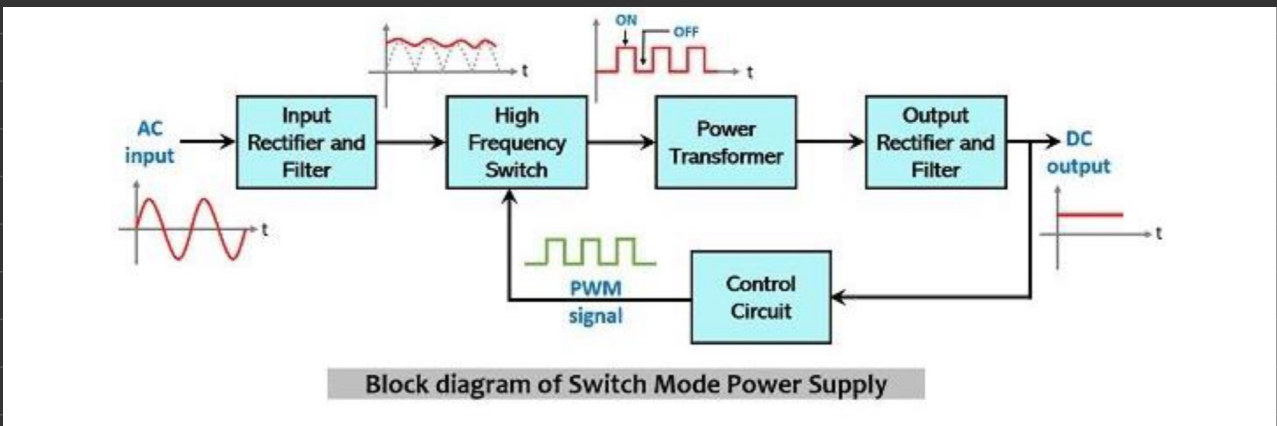


(a) Basic structure
(b) Circuit symbol

- SMPS (Switched Mode Power Supply

- Used to obtain regulated dc output by semicon switching methods
- highly efficient : power consumption ↓, heat dissipation ↓
- Includes switching trans (power MOSFET)
  dc signal goes thru chopping (switching)
- when trans is switched on → fully conducts curr
  off → completely blocks flow of curr
- Operates at high freq → size ↓ , weigh ↓

Working :



Block diagram of Switch Mode Power Supply

i) unregulated ac sig frm source $\xrightarrow[\text{rect}]{\text{input}}$ dc signal

ii) Power transformers acts as a high freq switch, here dc signal undergoes chopping (switching)

iii) high volt sig $\xrightarrow[\text{step ↓ trans}]{\text{Power Transformer}}$ low volt level

iv) Output rect removes unwanted sig, providing a regulated signal

v) Compares obtained dc volt w refrence value
dc output > ref value → chopping freq ↓ , dc volt ↓
dc output < ref value → ↑ ↑

Adv : i) highly efficient ; 60% – 95%
ii) Small size / less bulky

Dis Adv : i) complex circuit
ii) Volt regulatn tricky
iii) prop filtration for noise

Apps : used in motor drives, security system, television sets.

- Power Convertors

1) AC – DC

i) Diode Rect :-
- ac input volt → fixed dc voltage
- single-phase / 3-phase ac sig at input
- Used in electrochem processes like electroplating

ii) Phase Controlled rectifiers
- fixed ac → variable dc
- 1 / 3 phase ac
- line voltage operates the rect
- Used in dc drives, compensator

2) DC → DC

i) Chopper :-
- fixed dc → variable dc
- Output dc has diff ampli, controlled by low power sig
- used in SMPS, trolley trucks
- MOSFET used for fabrication

3) DC → AC

i) Invertor :-
- fixed dc → ac volt. of variable freq
- MOSFET, IGBT, etc used for fabrication
- used in induction heating supplies
- thyristor : used in high power apps

4) AC → AC

i) Cycloconverters
- fixed ac → variable ac
- input freq $<$ output freq
- used in ac motor drives

ii) AC voltage regu
- fixed ac → var ac
- some inp/out freq
- two thyristors used in $||^{el}$
- used in lightning control

- Convertors

AC → DC
- Diode Rec
- Phase Cont Rect

DC → DC → DC input → Dc Chopper → Variable DC output

DC → AC → (Invertor)

AC → AC
- Cycloconverter (Fixed to Variable)
- AC Volt regu

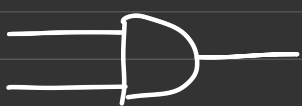
- Commutation

└ process of turning off a conductg thyristor

Natural
└ i at Anode = 0

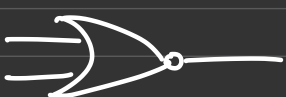
Forced
└ forcing Circuit (ext)
$i_{thy} \to 0$

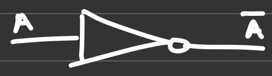
- logic gates

AND  $Y = AB$

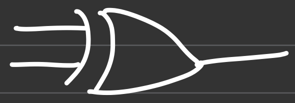
NAND  $Y = \overline{AB}$

OR  $Y = A+B$

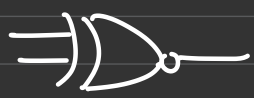
NOR  $Y = A+B$

NOT 

(Buffer)

EX- OR 

$E = xy' + x'y$

EX - NOR 

$E = xy + x'y'$

eg implement logical expression using logic gates

$F = ABC + ABC' + A'BC'$

A B C