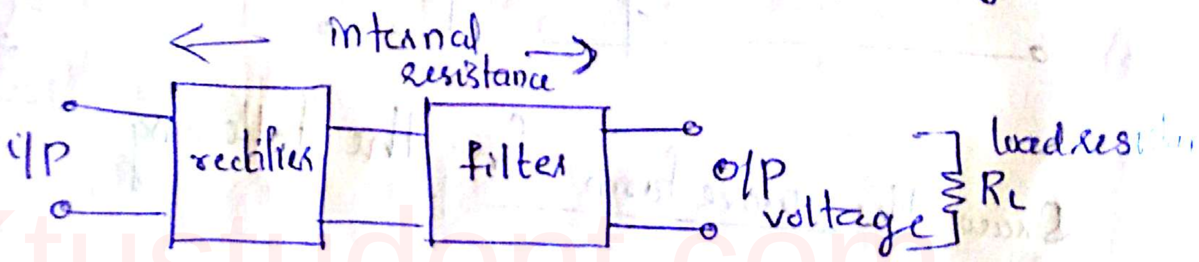
Power \ Supplies

Module - II

Power Supplies

1. Regulated Power supply
2. Unregulated power supply.

1) $\boxed{\text{Rectifier} \rightarrow \text{filter}}$: unregulated power supply.



dis adv

1) According to R_L varies, V_o also varies.

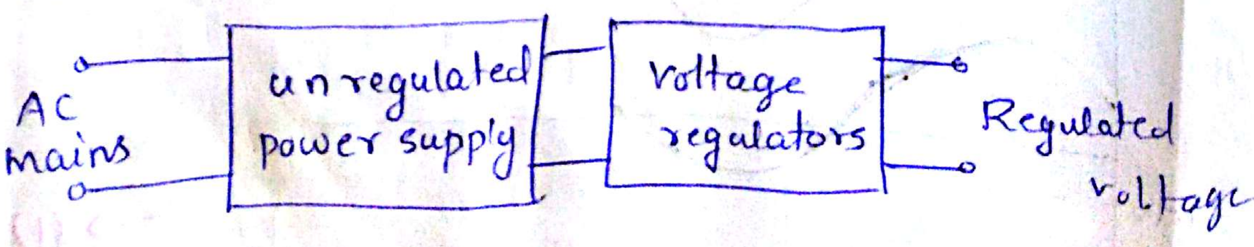
$R_L \uparrow \ V_o \uparrow$

$R_L \downarrow \ V_o \downarrow$

2) Fluctuation in i/p signal varies the o/p signal.

3) internal resistance.

Regulated Power supply

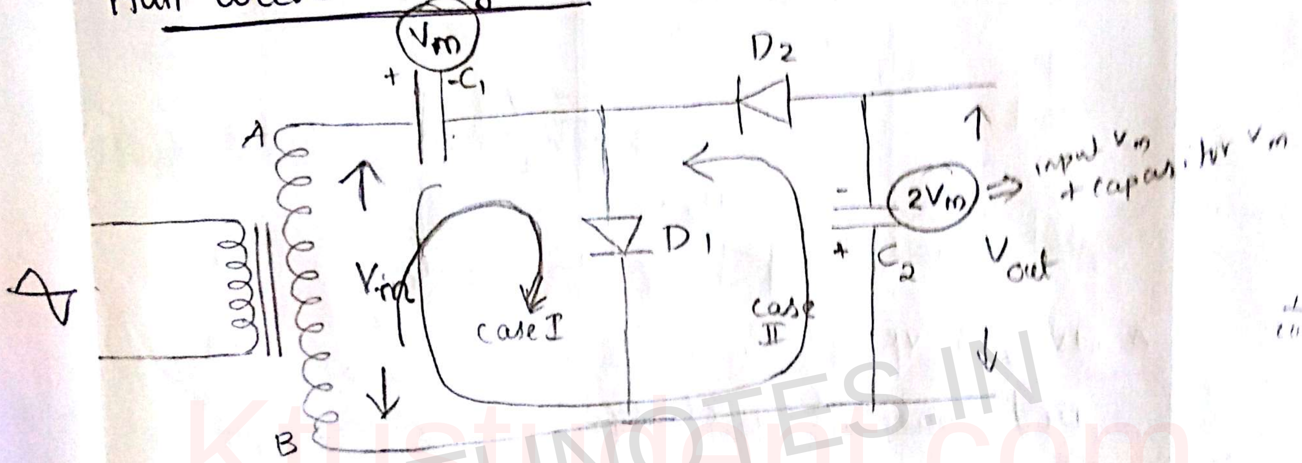


Voltage Multiplier

Voltage Doubler

→ Half wave voltage doubler
→ full wave voltage doubler

Half wave voltage doubler



case I A : +ve, B −ve

D_1 → forward biased

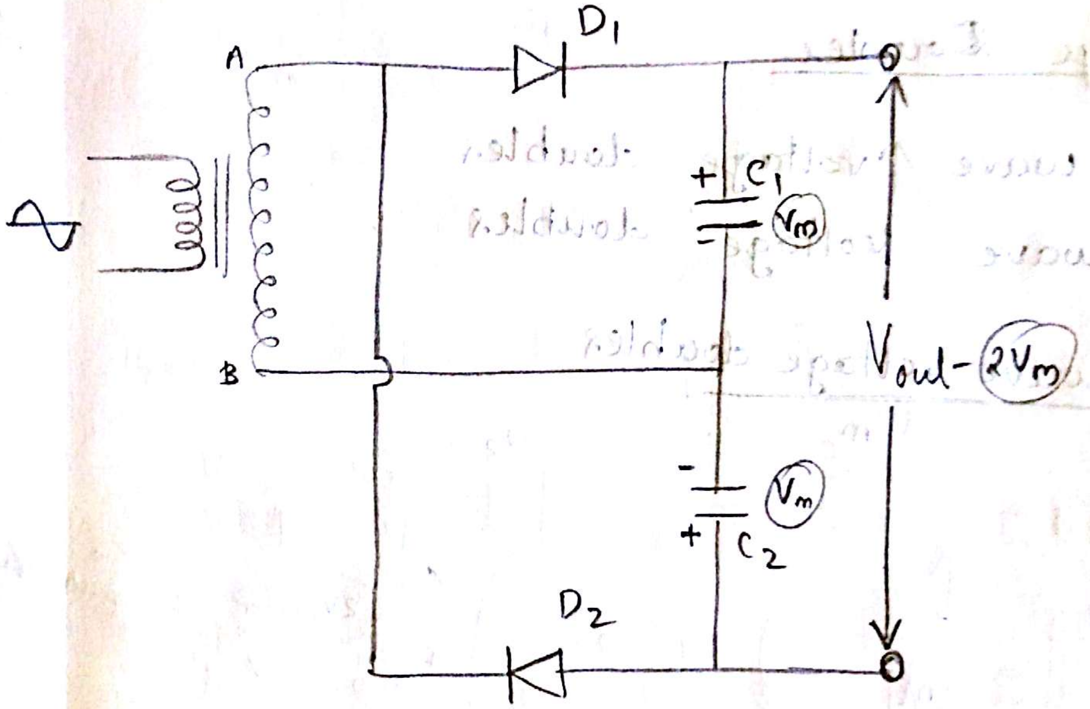
D_2 → reverse , C_1 charges

case II A : −ve, B +ve

D_1 → reverse

D_2 → forward , C_2 charges

Full wave voltage doubler



A → +ve , B − ve

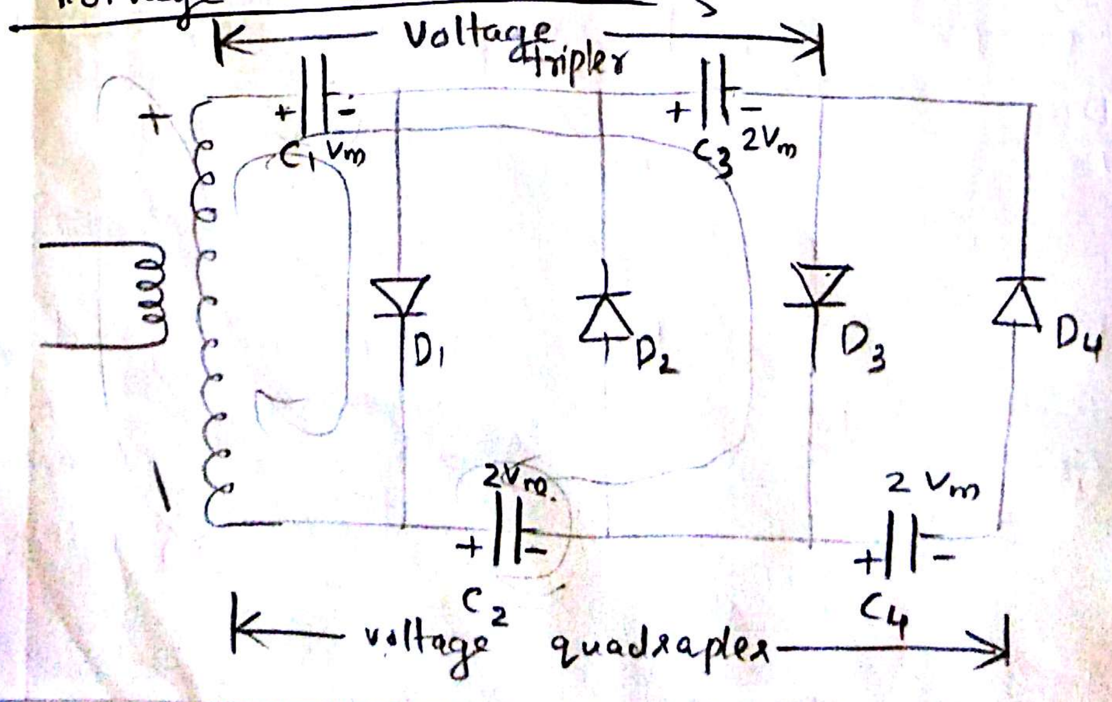
D_1 forward, C_1 charges

A → −ve , B +ve

D_2 C_2 charges

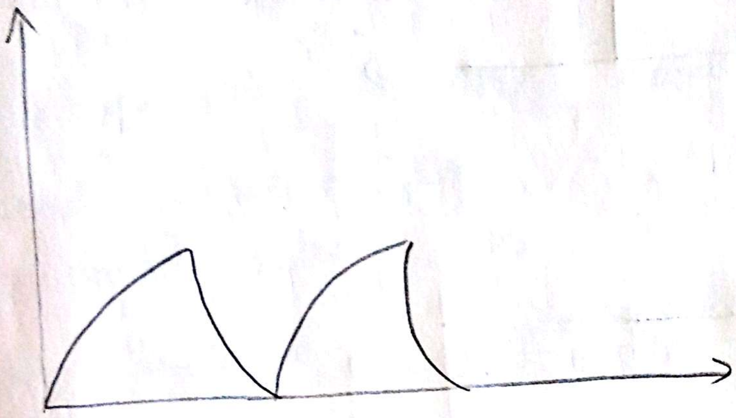
Vout across C_1 & C_2 ∴ Vout = V_m $V_m + 2V_m - V_m$

Voltage tripler Circuit

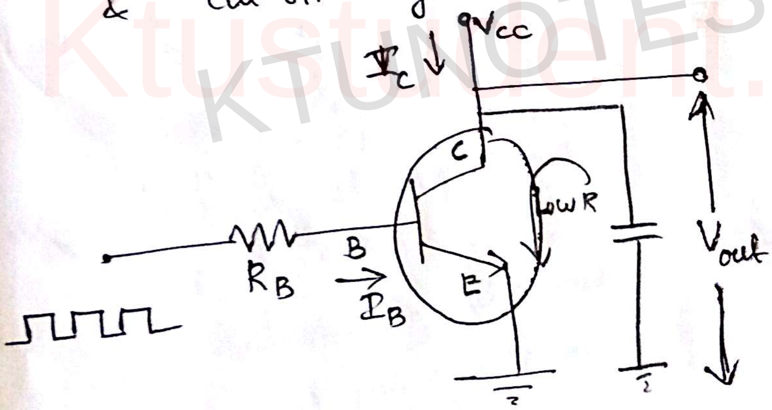


(2)

Sweep Circuit



Transistor works in
saturation region
& cut-off region in a sweep circuit



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

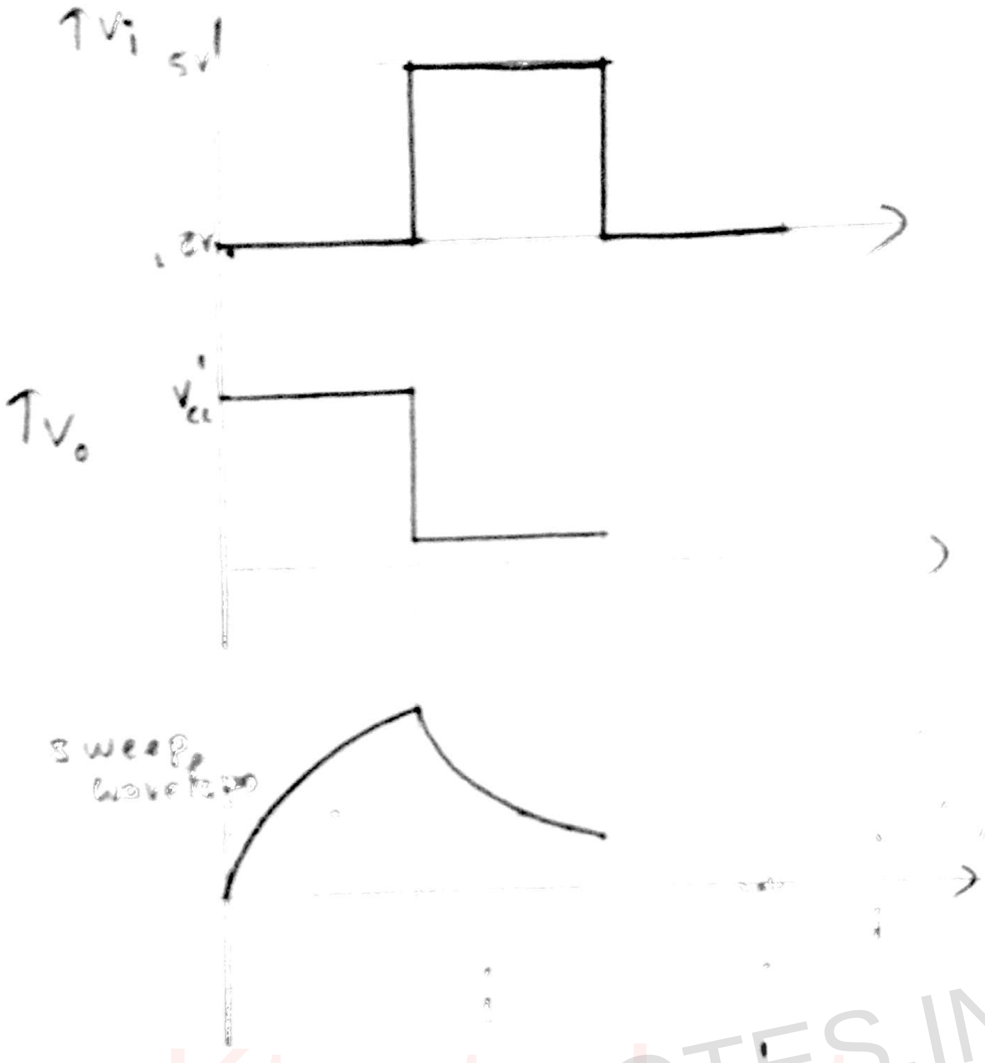
$$V_o = V_{cc} - I_c R_c$$

when $I_B = 0$, $I_c = \beta I_B = 0$

$$\therefore V_o = V_{cc} - 0 \times R_c$$

$$V_o = V_{cc}$$

(3)



(4)

Series voltage regulator

Shunt voltage regulator

Characteristics of voltage regulator

1) Load regulation (LR)
2) Minimum (load) resistance R_{Lmin}
3) Lin Regulation or source regulation (SR)
4) output impedance
5) Ripple Rejection.

Load regulation (LR)

$$LR = V_{NL} - V_{FL}$$

V_{NL} - Voltage at no load

i.e., $R_L = \infty$

V_{FL} = Voltage at full load

i.e., R_L is minimum.

$I = \frac{V}{R}$

in ideal case $LR = zero$

Minimum Resistance (R_{Lmin})

It is the load resistance when load current is maximum.

$$R_{L(min)} = \frac{V_{FL}}{I_{L(max)}}$$

Line Regulation or Source Regulation

$$SR = V_{HL} - V_{LL}$$

V_{HL} = maximum source voltage

V_{LL} = minimum source voltage

$$SR\% = \frac{V_{HL} - V_{LL}}{V_{HL}}$$

Output impedance

Resistance offered by the circuit.

Ripple Rejection

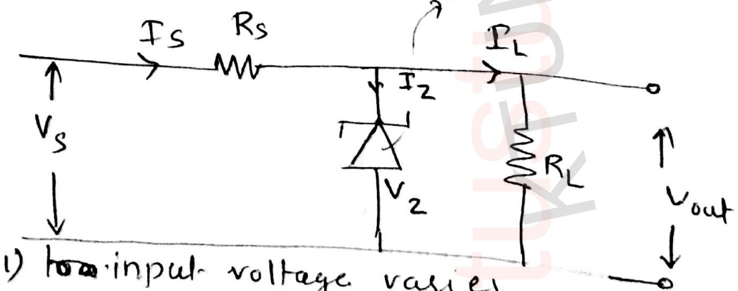
ripples zero.

V_Z constant

$V_Z = I_Z \cdot R$

Zener Regulation

internal resistance ↓ when V_{in} ↑



1) ~~for~~ input voltage varies

$V_{in}\uparrow$

$$I_{S\uparrow} = I_{Z\uparrow} + I_{L} \text{ constant}$$

$V_{in}\downarrow$

I_S

$I_L R_L$ = constant

$\therefore I_L$ is constant

2) R_L varies

$R_L \uparrow$

$$I_S = I_Z + I_L$$

$$\boxed{R_S = \frac{V_S - V_Z}{I_S}}$$

For the circuit shown $R_S = 20\Omega$, $V_Z = 18$ $R_L = 200\Omega$. If V_{in} can vary from 20V

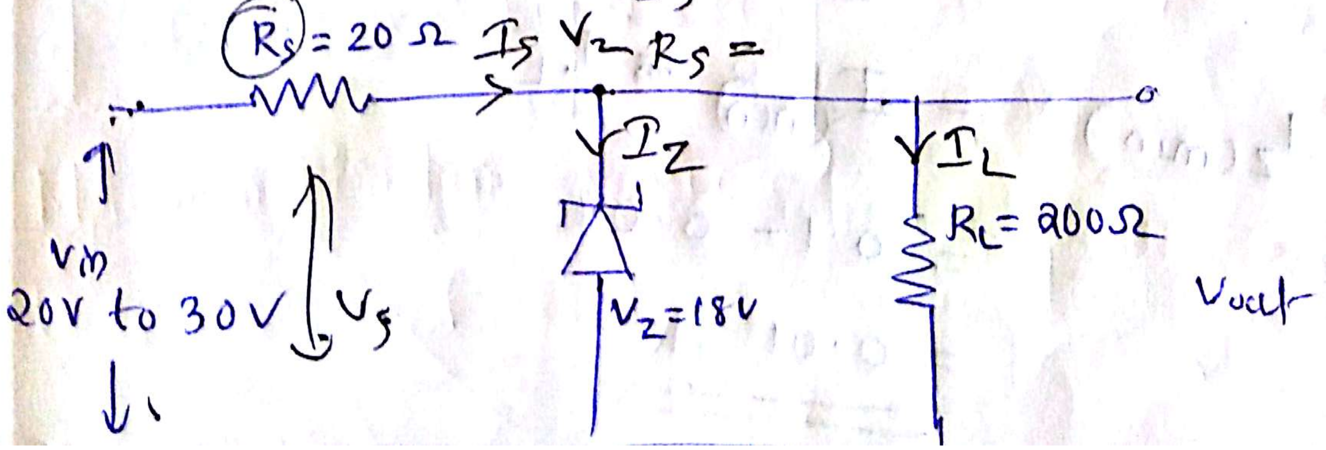
Find 1) The minimum & maximum curre in zener diode

2) The min & max. power descipatted diode

3) The maximum rated power descipa that R_S should have.

$\frac{V_S - V_Z}{I_S}$

$I_S = I_Z + I_L$



$V_{in(min)} = 20V$ $\quad R_S = 20\Omega$ $\quad V_Z = 18V$

$V_{in(max)} = 30V$ $\quad R_L = 200\Omega$

$$I_{S(min)} = \frac{V_S - V_Z}{R_S} = \frac{20-18}{20} = \frac{2}{20} = 0.1\ A$$

$$I_{S(max)} = \frac{V_S - V_Z}{R_S} = \frac{30-18}{20} = \frac{12}{20} = \frac{6}{10} = 0.6A$$

$$I_S = I_Z + I_L \Rightarrow I_Z = I_S - I_L$$

$$V_{out} = V_Z$$

$$\therefore I_L = \cancel{R_L \cdot V_{out}}\ \frac{V_{out}}{R_L} = \frac{\cancel{18}^{9}}{\cancel{200}} = 0.09\ A$$

$$= \cancel{200 \times 18 = 3600}\ A$$

$$I_{Z(max)} = I_{S(max)} - I_L$$

$$= \cancel{0.09} \; 0.6 - 0.09$$

$$= \underline{\underline{0.51\ A}}$$

$$I_{Z(min)} = I_{S(min)} - I_L$$

$$= 0.1 - 0.09$$

$$= \underline{\underline{0.01\ A}}$$

b) min power, $P_{min} = I_Z \cdot V_Z = 0.01 \times 18 = \underline{\underline{0.18\ W}}$

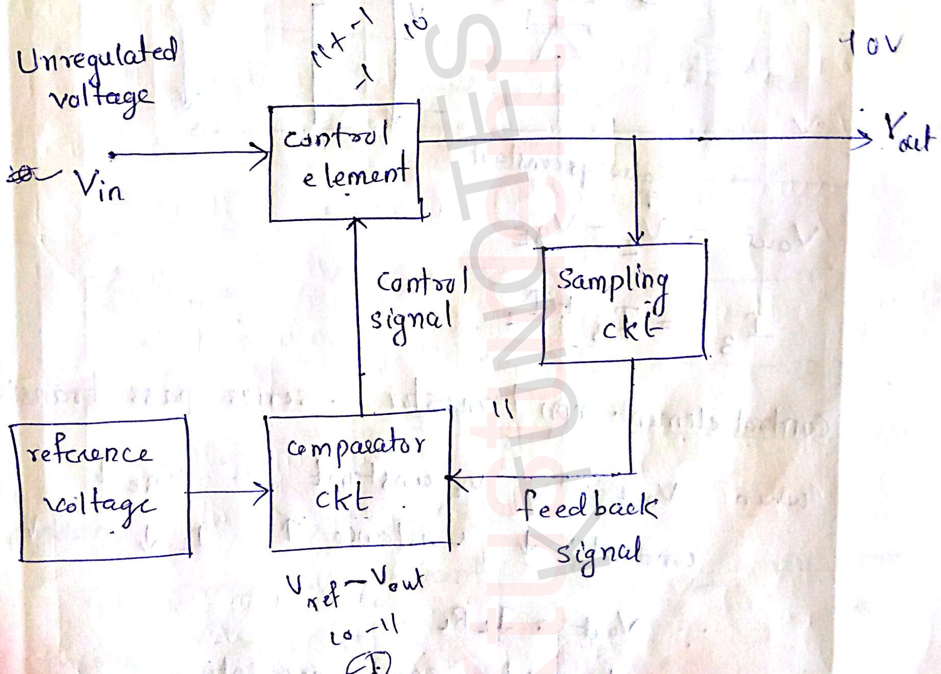
max power, $P_{max} = 0.51 \times 18 = \underline{\underline{9.18\ W}}$

$$P_s = I^2 R = I_{s(max)}^2 \cdot R_s$$

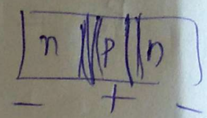
$$= 0.6^2 \times 20 = \underline{7.2\ W}$$

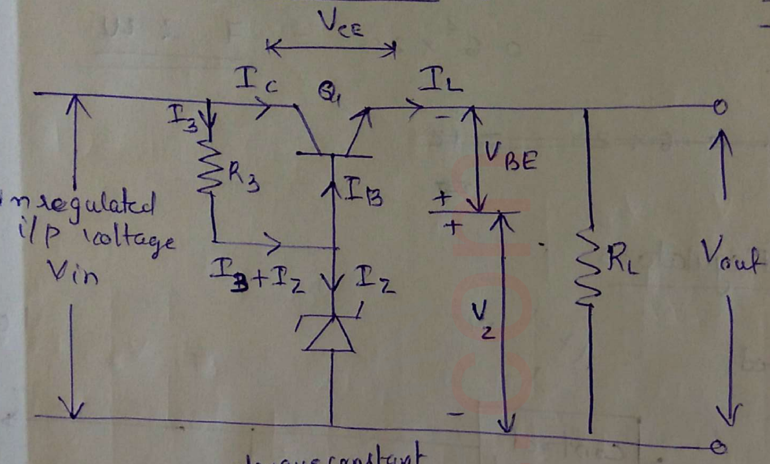
~~$IV = 0.6 \times 20 = 12$~~

Series Regulators



Transistor Series Regulation





always constant

$V_{out} = V_Z - V_{BE}$

$I_3 = I_B + I_Z$

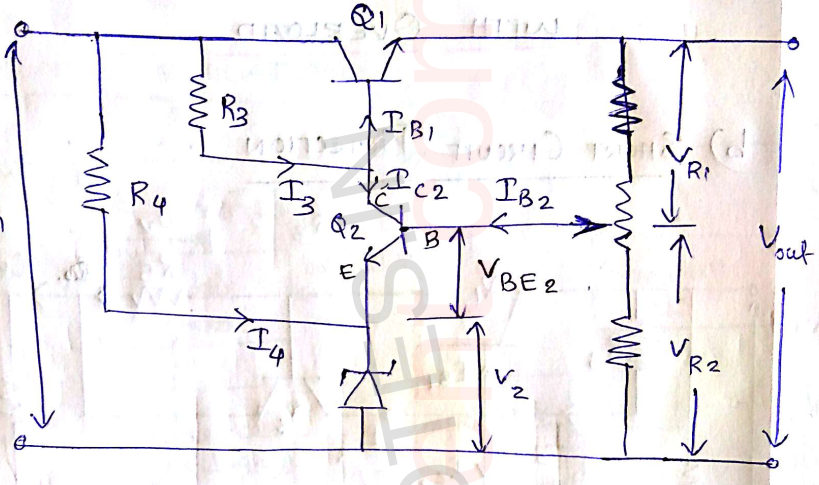
Control element npn transistor – series pass transistor

when $V_{out} \uparrow$ V_Z constant $\therefore V_{BE} \downarrow$

$\therefore$ conduct^n $\downarrow$ resistance $\uparrow$ $I_L \downarrow$ $\therefore V_{out} \downarrow$

$\because V_{out} = I_L R_L$

Controlled transistor series regulation



31/08/16

$$\cancel{V_{RR}} \neq \quad V_{R_2} = V_{BE_2} + V_z \quad \text{——— (1)}$$

$$V_{out} = V_{R_1} + V_{R_2} \quad \text{——— (2)}$$

$$I_3 = I_{B_1} + I_{C_2} \quad \text{——— (3)}$$

When $V_{out} \uparrow$, $V_{R_2} \uparrow$

since V_z constant $V_{BE_2} \uparrow$, conduction through transistor $\uparrow$. $\therefore I_{C_2} \uparrow$.

since I_3 is almost constant

(3) ⇒ ∴ ~~acc~~ Acc. (3) $I_{B_1} \downarrow$

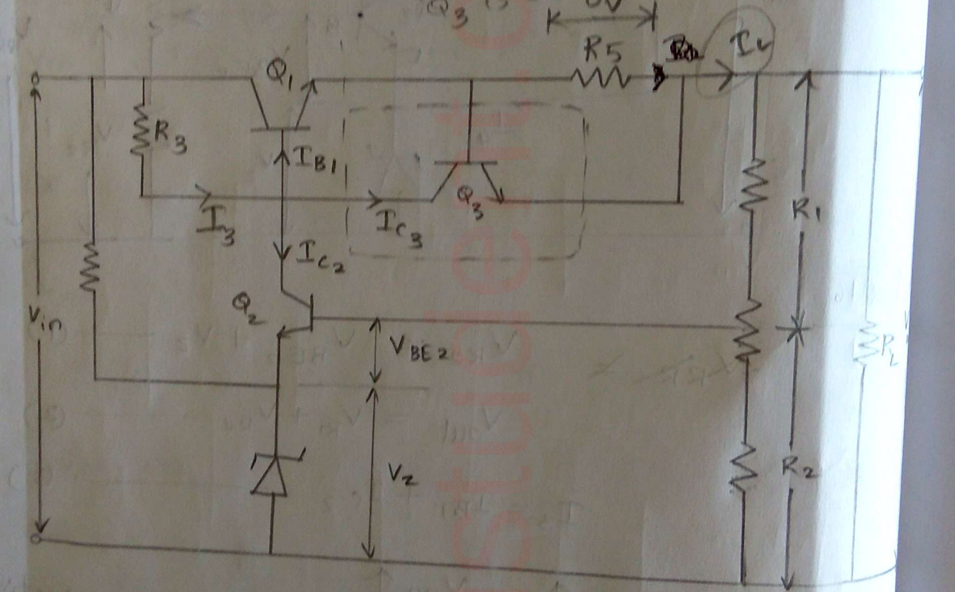
$\therefore V_{R_1} \downarrow$

$\therefore V_{out}$ become constant.

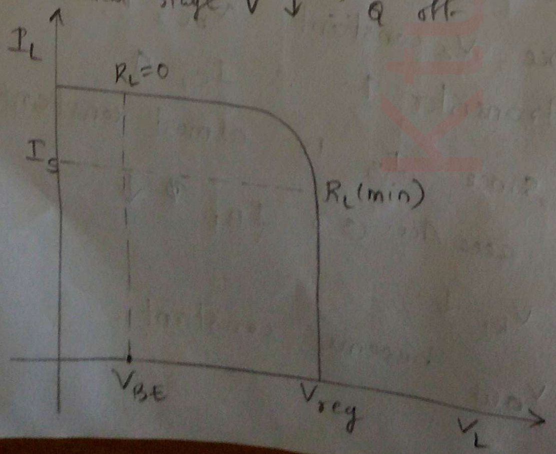
CONTROLLED TRANSISTOR SERIES REGULATOR WITH OVERLOAD

b) SHORT CIRCUIT PROTECTION

Q_3 is only only when I_L is large

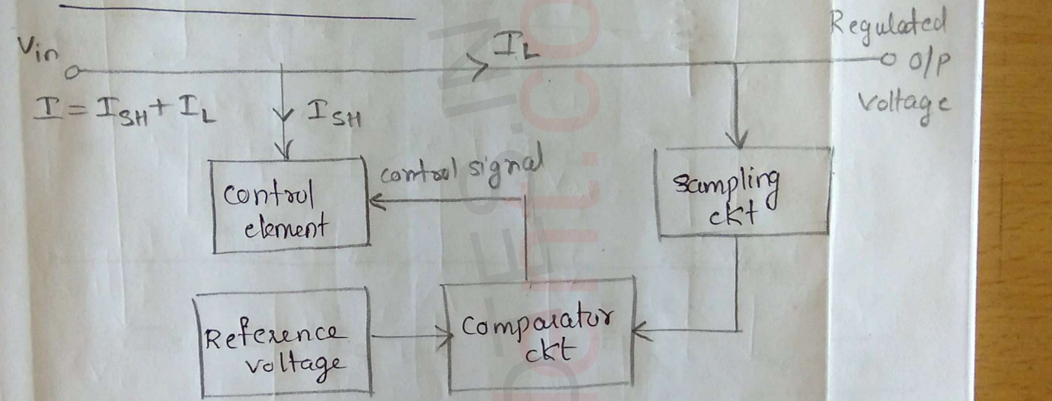


at normal stage V ↓ ∴ Q off

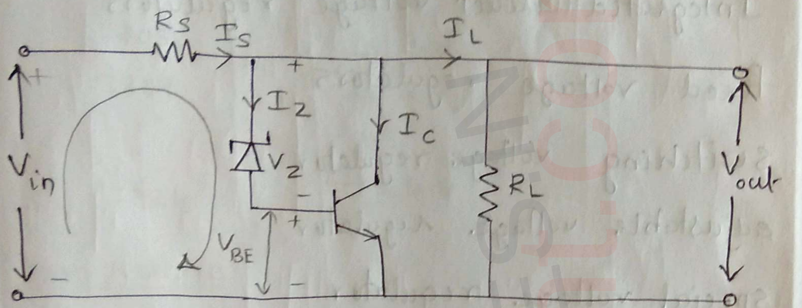


~~SHUND~~

SHUNT REGULATION



SHUNT REGULATION



$$V_{in} - I_S R_S - V_Z - V_{BE} = 0$$

$$\boxed{V_{in} - I_S R_S = V_Z + V_{BE}}$$

$$I_S = I_Z + I_C + I_L$$

$$V_{out} = V_Z + V_{BE}$$

$$= V_{in} - I_S R_S$$

$V_{in} \uparrow$

$V_{in} \uparrow$

$V_{in} - I_S R_S \uparrow$

V_Z constant

$V_{BE} \uparrow$

$V_{out} \uparrow$

when $V_{in} \downarrow$

$V_{in} - I_S R_S \downarrow$

V_Z constant

$V_{BE} \downarrow$

$V_{out} \downarrow$

IC Regulators

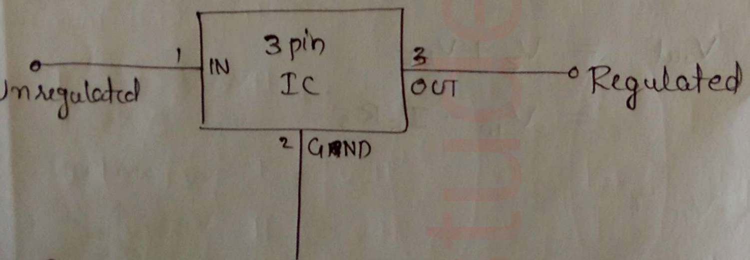
Integrated Circuit voltage regulators

fixed voltage regulators

switching voltage regulator

adjustable voltage regulator

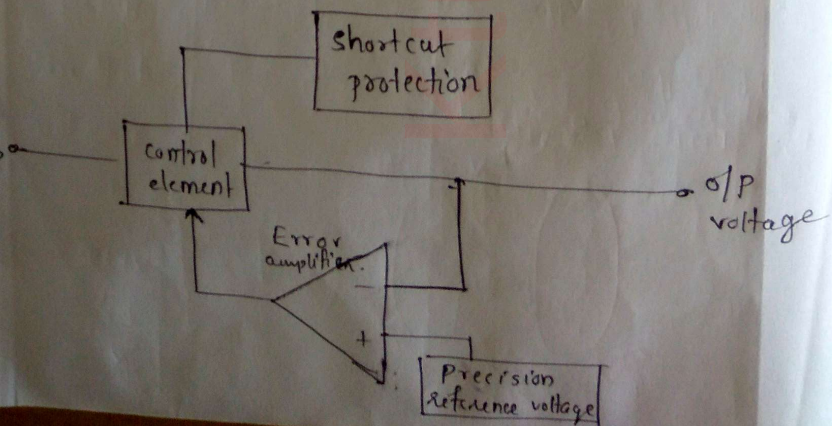
special voltage regulator



Coupling Capasitors

100mA − 5A

Fixed voltage regulator



Positive Voltage regulators

IC 78xx series   5 to 24V.

7805 → 5 V

7809 → 9 V

⋮

7824 → 24 V

Drop voltage

min. 2 volt

7805 min i/p v = 7V

max i/p v = 35 V

Negetive voltage regulators

IC 79xx series

7905 → −5V

⋮

7924 → −24V

7902 → −2V

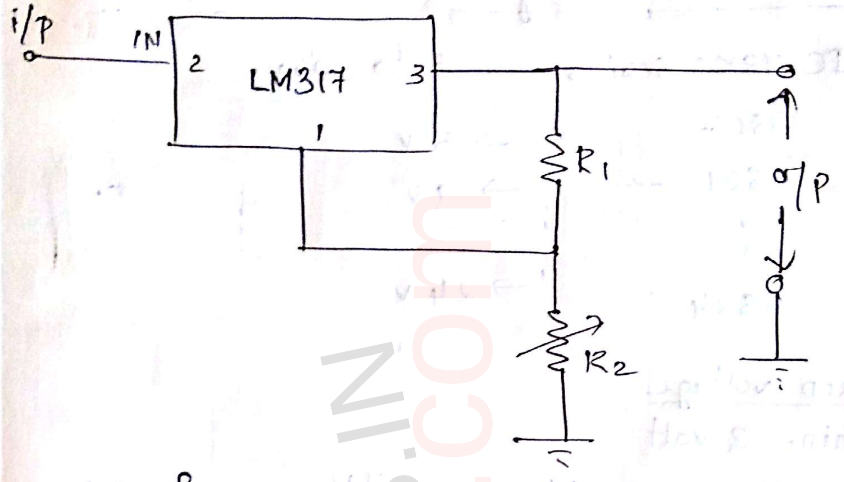
7905·2 → −5·2

Adjustable voltage regulator

1) Adjustment terminal

2) i/P

2) o/P



varies from 1.2 – 3.7

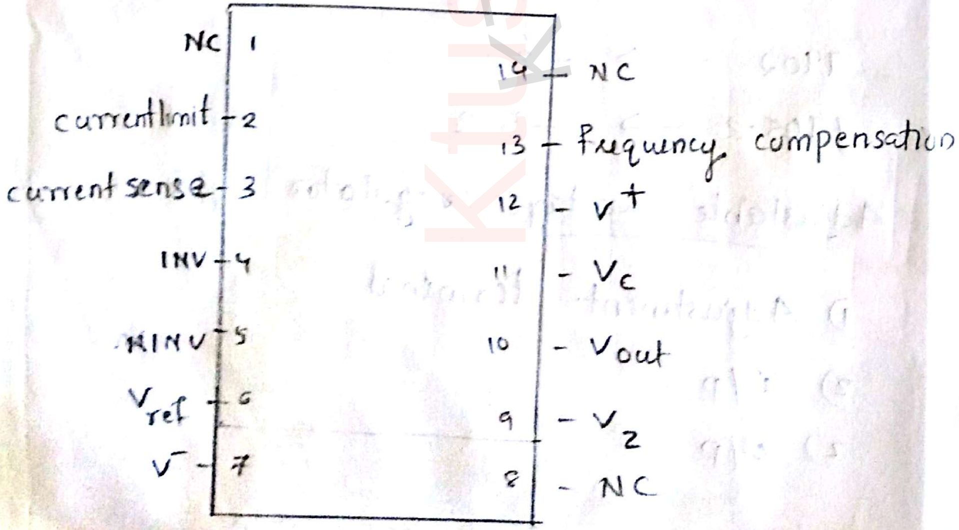
05/09/16

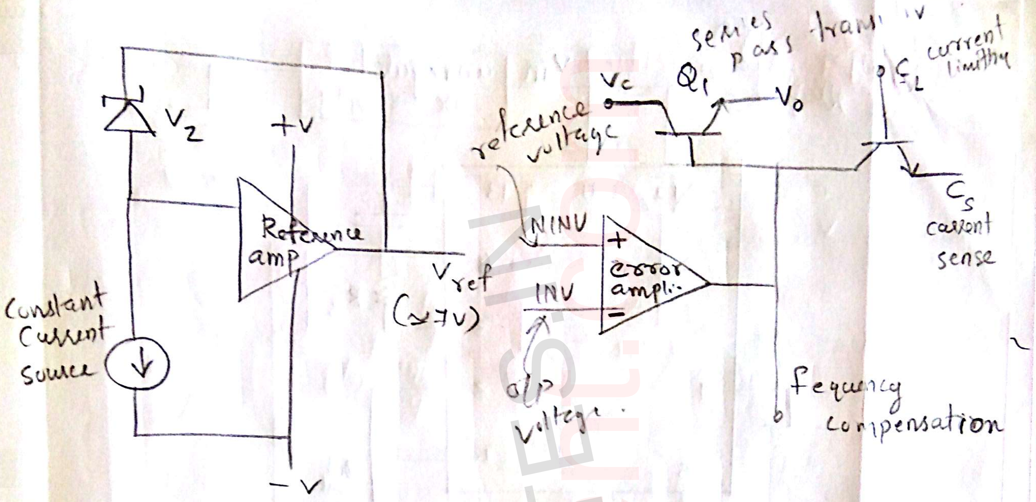
IC-723 voltage regulator

2V to 7V : low voltage regulator

>7V : High voltage regulator

14 pin IC





NC – no connection

INV – inverting terminal

NINV – noninverting terminal

V_{ref} – reference voltage

V^- – -ve voltage

NC – no connect?

V_z – zener voltage

V_{out} – output votage

V_c – internal voltages

V^+ – +ve voltage

13 – compensate frequency variations

14 – No connection

low V regulation

High V regulator

shunt regulator.

SWITCH MODE POWER SUPPLY

Linear regulator – power consumption is high

SMPS – " " low

SMPS – transistor is either in saturation region or in cutoff region.

∴ power consumptn low, efficiency high

on state : saturatn region

off state : cutoff region

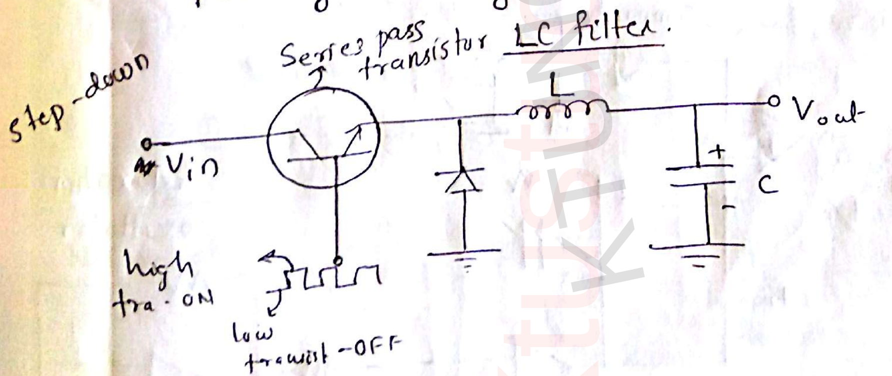
transistor

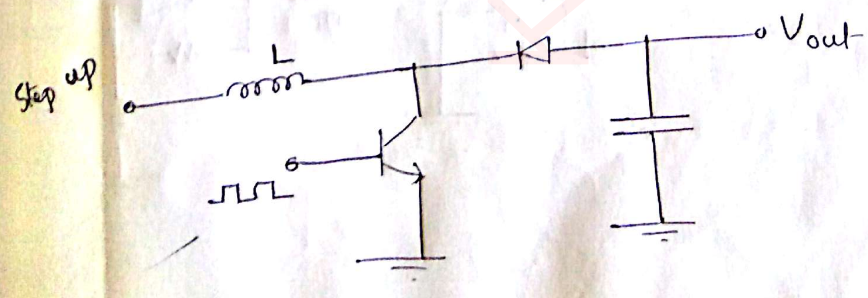
trx

→ step-down version

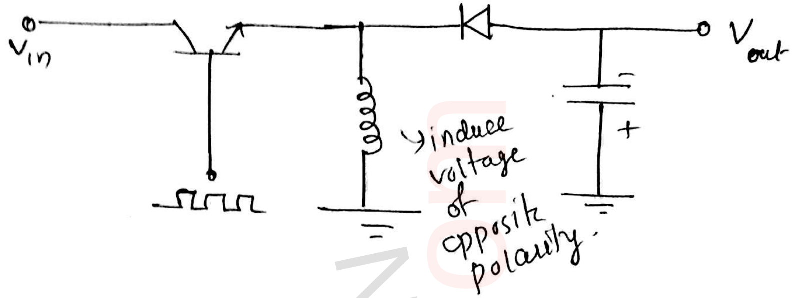
→ step up "

→ Polarity inverting "

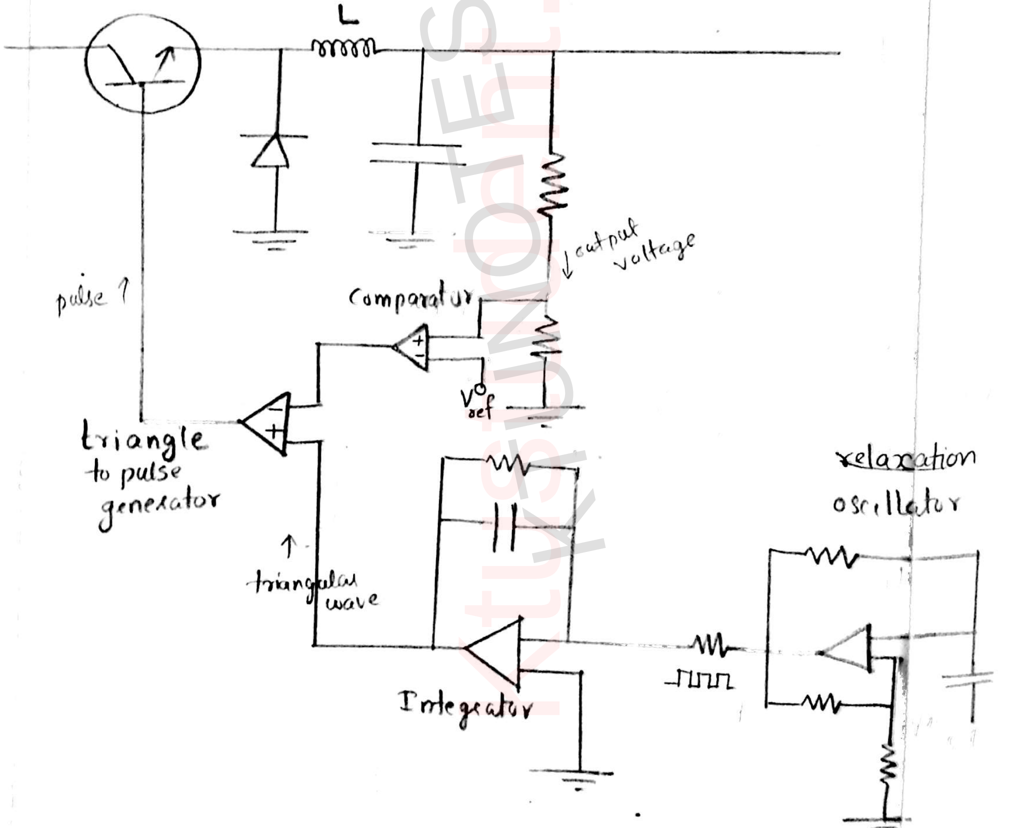




Polarity inverting



Step down



Field Effect Transistors (FET)

Conduction is due to electric field

1) Source
2) Drain
3) Gate

FET is a uni polar device.

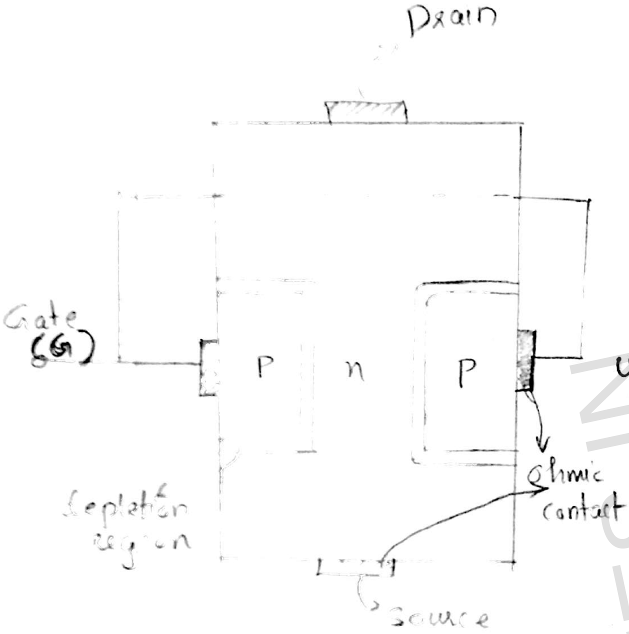
FET is stable at higher temp.

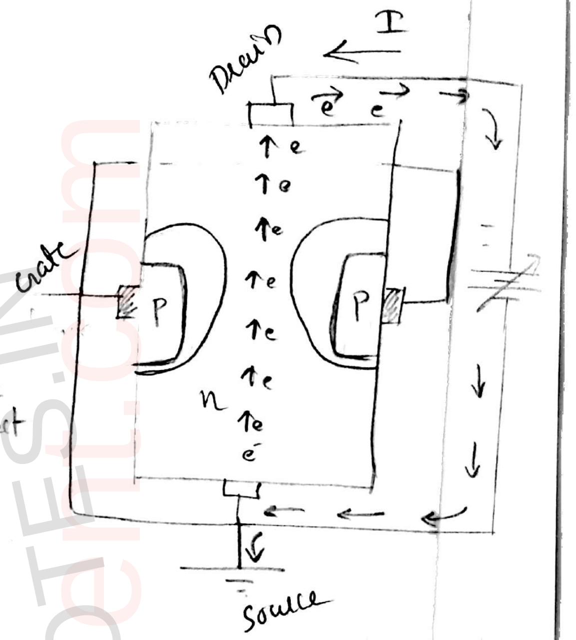
BJT → current controlled device

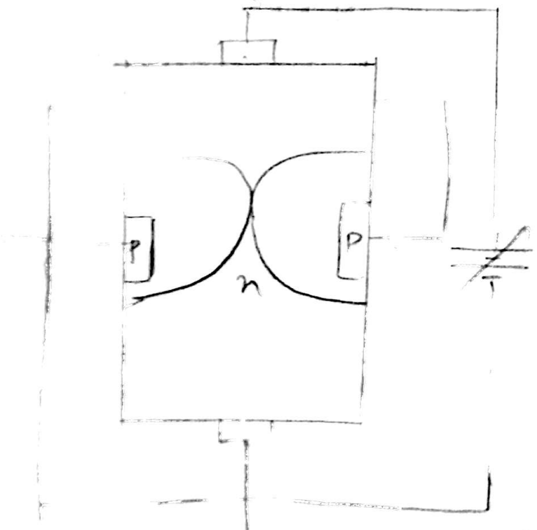
FET → voltage controlled device

FET

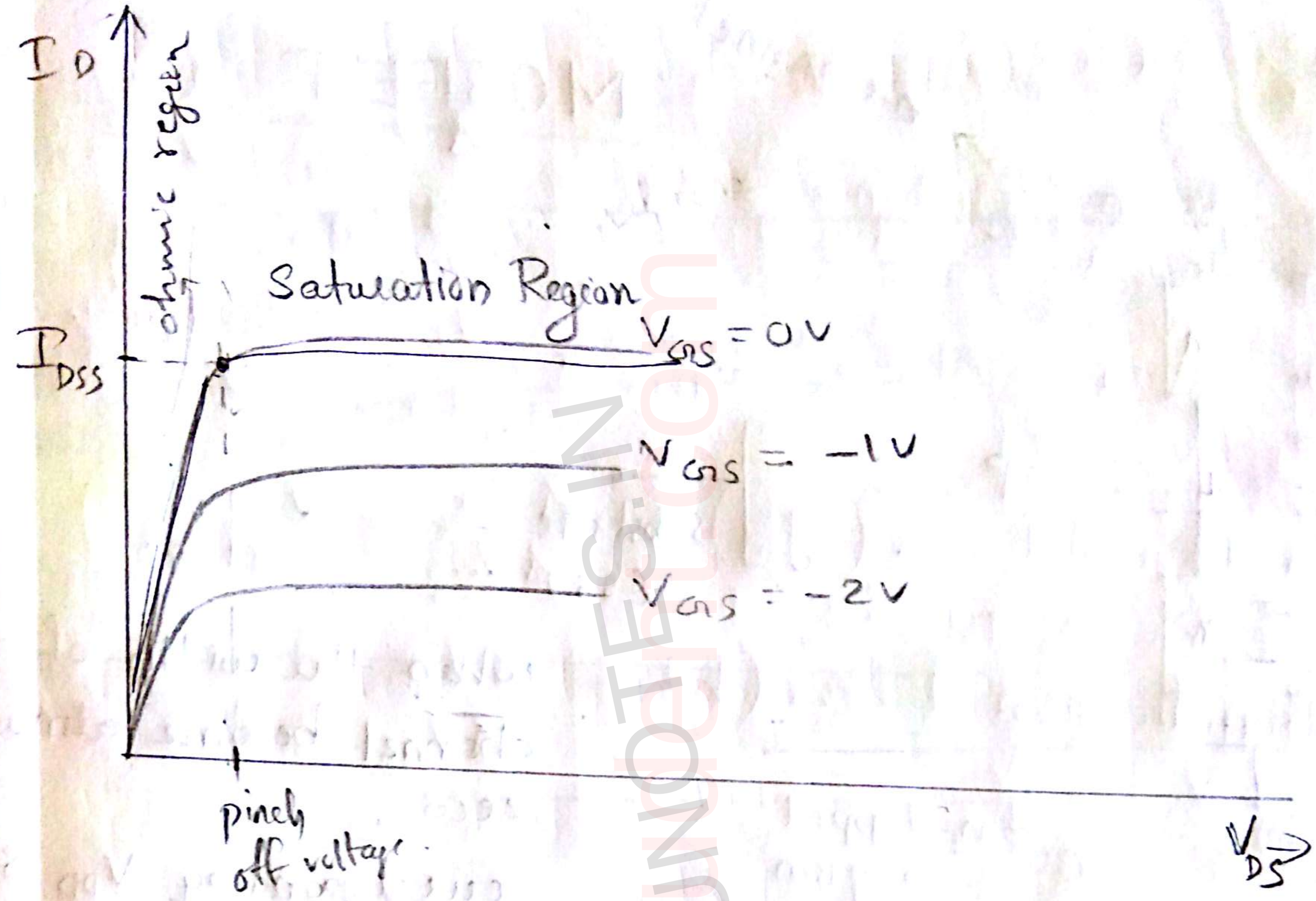
- Junction FET
  Junction Field Effect Transistor (JFET)
  - N-channel JFET
  - P-channel JFET
- ~~Metal oxide sei~~
  Metal oxide Semiconductor FET (MOSFETS)
  - Depletion MOSET
    - N-Channel
    - P-channel
  - Enhancement MOSET
    - N-channel
    - P-channel

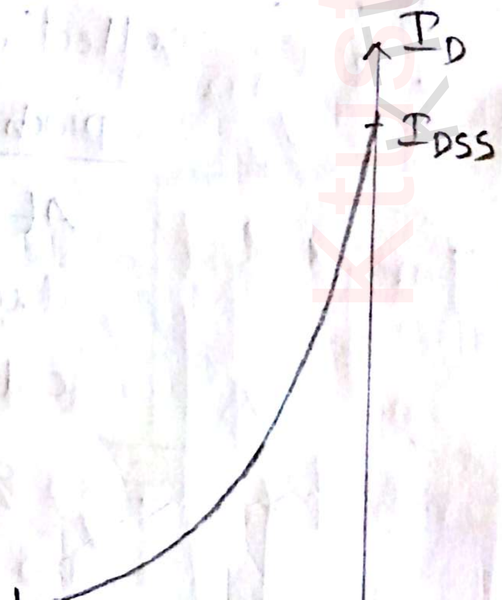






V= pinch off voltage





$I_D = I_{DSS}\left(1-\right.$

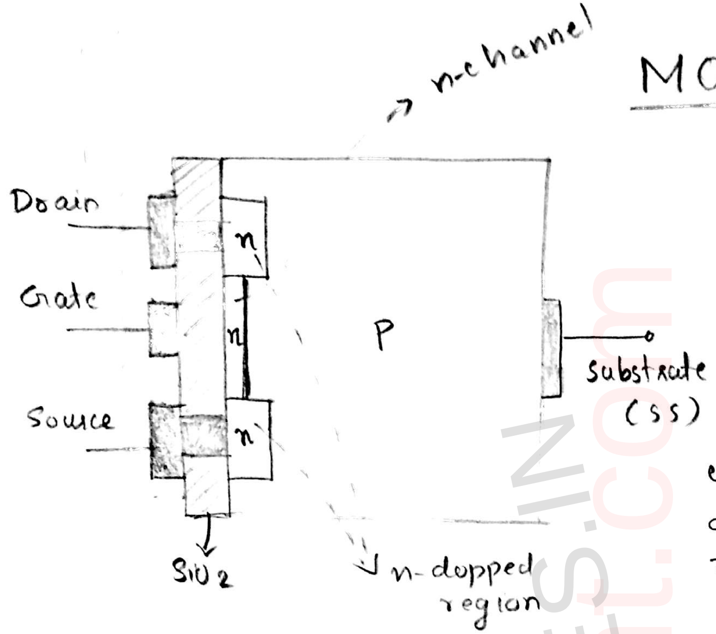
$V_{GS} = V_P$

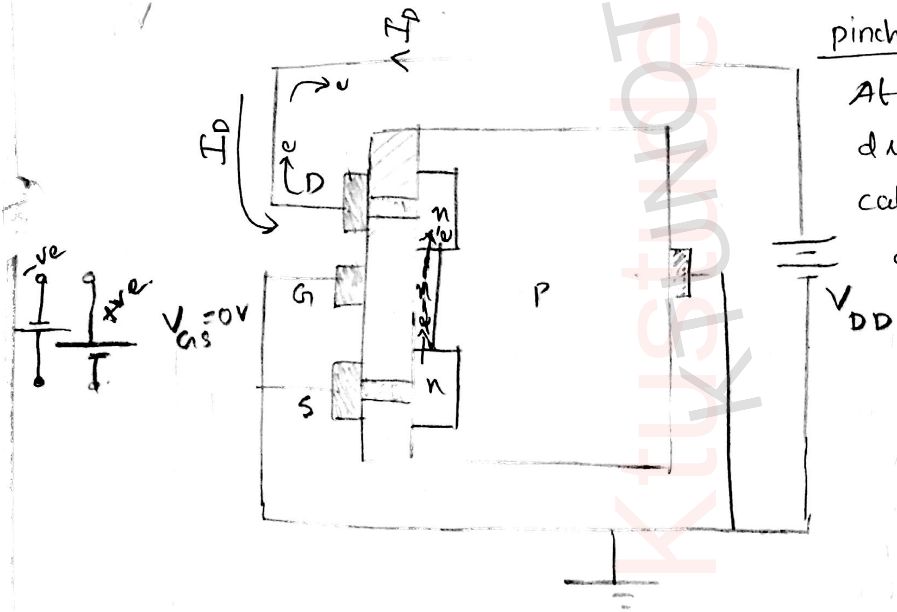
$I_D = 0$

$V_{GS} = 0$

$I_D = I_{D}$

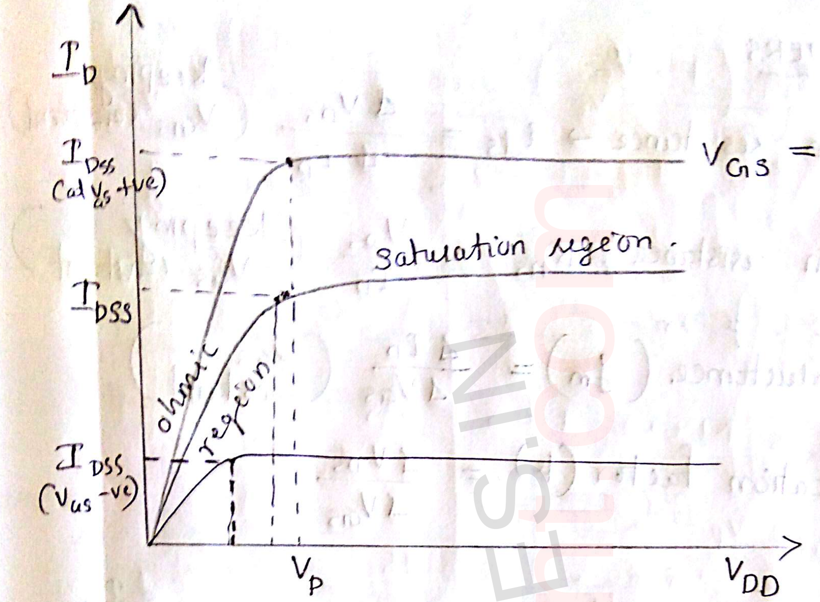
MOSFET





when the width of channel become almost zero, corresponding V_{DD} is called <u>pinch-off voltage</u> (V_p)

At that time; the drain current is called <u>saturation drain current</u> (I_{DSS})

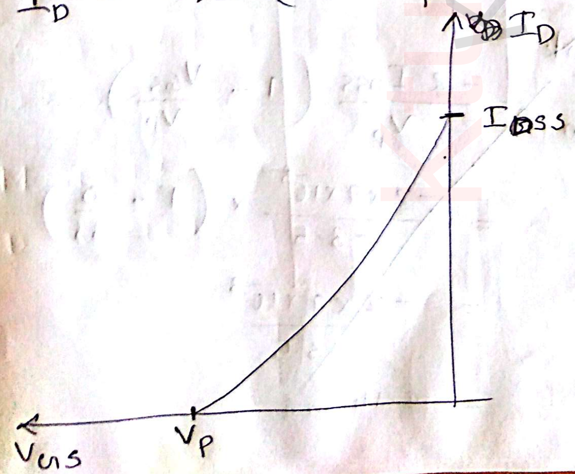


attract $\bar{e}$s from n and ~~ēs fr.~~ minority carriers ($\bar{e}$s) from p-type.

V_{GS} -ve

it pushes the electrons to p-region and majority carriers in p-region (holes) and these $\bar{e}$s combine. ∴ $\bar{e}$s ↓ses ∴ drain current ↓

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_p}\right)^2$$



* PARAMETERS

1) AC drain resistance → $r_{ds} = \frac{\Delta V_{DS}}{\Delta I_D}$ (keeping V_{GS} constant)

2) DC drain resistance, $R_{DS} = \frac{V_{DS}}{I_D}$ (keeping V_{GS} constant)

3) Transconductance $(g_m) = \frac{\Delta I_D}{\Delta V_{GS}}$ (V_{DS} constant)

4) Amplification factor $(\mu) = \frac{\Delta V_{DS}}{\Delta V_{GS}}$

~~Drain~~ Transconductance $\quad d\, I_D.$

$$g_m = \frac{-2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$\mu = g_m \times r_{ds}$$

1) Q: Given $I_{DSS} = 9\,mA$ and $V_P = -3.5\,V$. Determine I_D when $V_{GS} = 0\,V$ and $V_{GS} = -2\,V$

~~Drain current~~

$$g_m = \frac{-2 I_{DSS}}{V_P}\left(1 - \frac{V_{GS}}{V_P}\right)$$

$$= \frac{-2 \times 9 \times 10^{-3}}{-3.5} \times \left(1 - \frac{0}{-3.5}\right)$$

$$= \frac{-2 \times 9 \times 10^{-3}}{-3.5}$$

$$= 5.14\, mA$$

ans

$$g_m (V_{GS}) = \cancel{\frac{-2 \times 9\times10^{-3}}{-3.5}} \left(1 - \frac{-2}{-3.5}\right)$$

$= 1.$

2) A JFET has pinch off voltage as $-1.5V$ $I_{DSS} = 10mA$ and $I_D = 2.5mA$. Determine the transconductance.

ans 1) $I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)$

$V_{GS} = 0V$

$= 9\times10^{-3} \times 1 = 9mA$

$I_D = I_{DSS}\left(1 - \frac{\cancel{+3.5}-2}{\cancel{+}3.5}\right)$

$(V_{GS} = -2V)$

$= 9\times10^{-3}\left(1 - \frac{2}{3.5}\right)^2$

$= \underline{1.65 \text{ mA}}$

I_D

2) $V_P = -1.5V$

$I_{DSS} = 10mA$

$I_D = 2.5mA$

$\cancel{g_m} =$

$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$

$1 - \frac{V_{GS}}{V_P} = \frac{I_D}{I_{DSS}} = \left(\frac{2.5}{10}\right)^2$

$= (0.25)^2 = 0.0625$

$\frac{V_{GS}}{V_P} = 1 + 0.0625 = \cancel{0.625}$

$= 1.0625$

$V_{GS} = V_P \times \cancel{0.625}\ 1.0625$

$= -1.5 \times \cancel{0.625}\ 1.0625$

$= \cancel{-1.875}$

$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

ans
$V_{GS} = 2.25$
$g_S = 2.2\,mA$

$$\left(1 - \frac{V_{GS}}{V_P}\right)^2 = \frac{I_D}{I_{DSS}} = \frac{2.5}{10} = 0.25$$

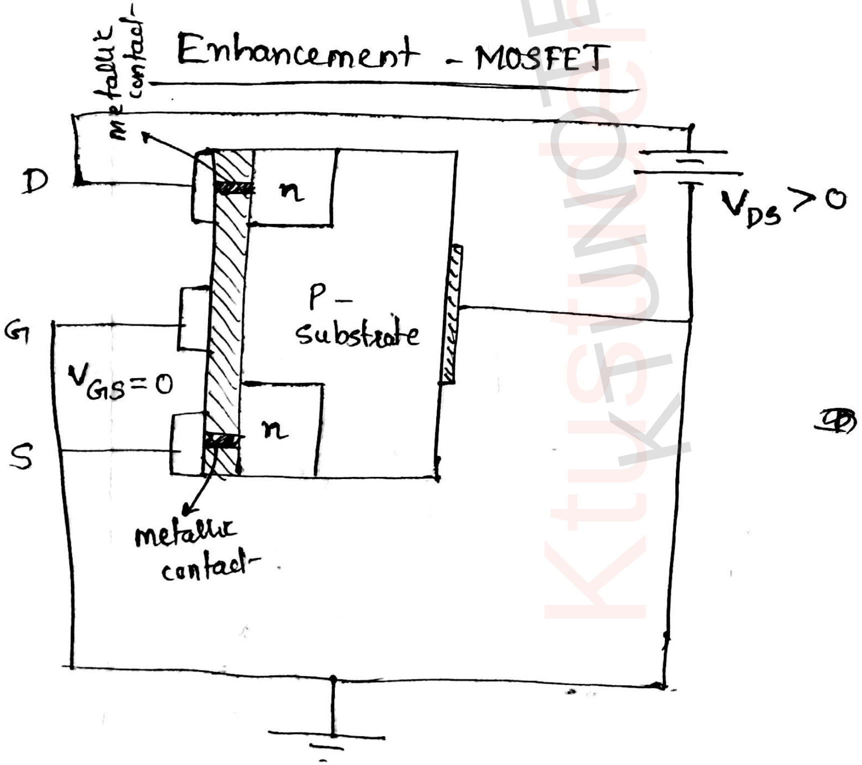
$$1 - \frac{V_{GS}}{V_P} = \sqrt{0.25} = 0.5$$

$$\frac{V_{GS}}{V_P} = \cancel{1+0.5}\ 1-0.5 = 0.5$$

$$V_{GS} = V_P \times 0.5$$

$$= -1.5 \times 0.5 = 0.75$$

Enhancement - MOSFET

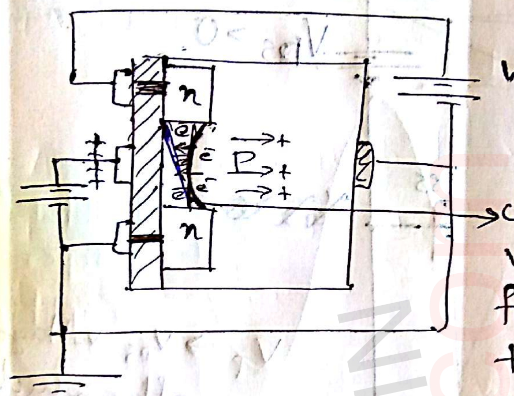


2.25

2.2 mA

$I_D = 0$

$V_{GS} > 0$



$V_{DS} = 5V$ (fixed)

channel formed

V_{GS} at which channel is formed, it is called threshold voltage (V_T)

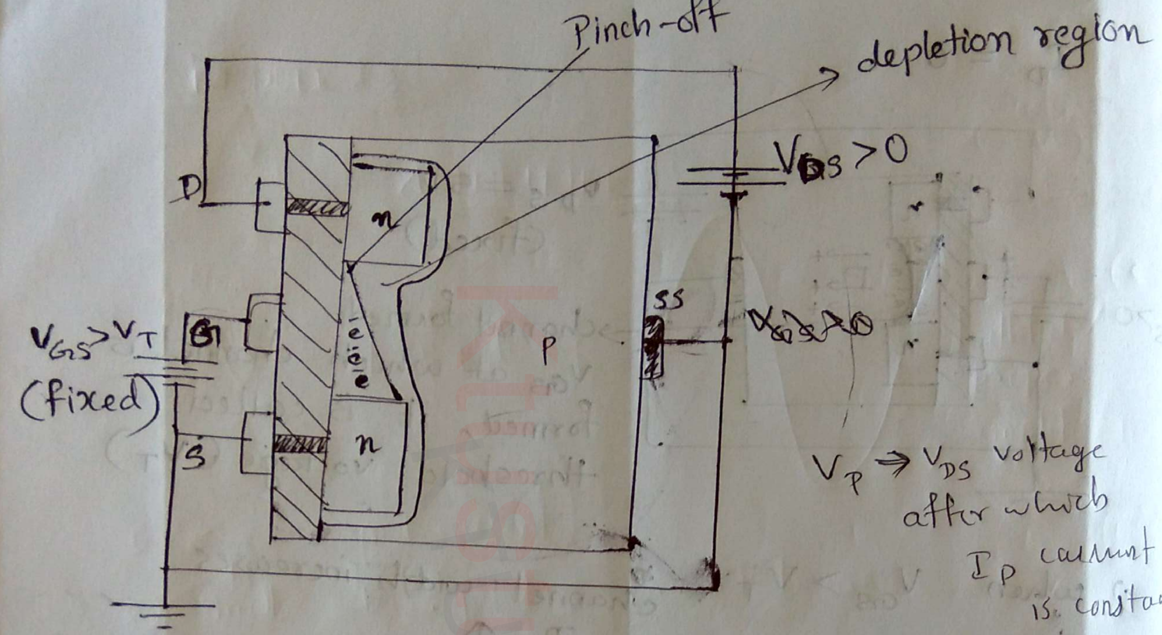
1) when $V_{GS} > V_T$ channel width increases

when V_{GS} ↑ses, I_D ↑.

2) V_{GS} constant channel width is constant ~~and V_{DS}>0 increases~~. channel ~~width is~~

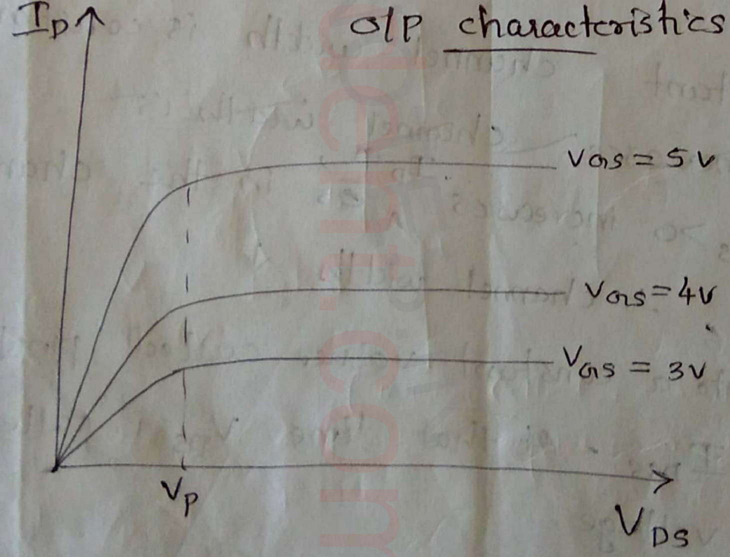
whe $V_{DS} > 0$ increases, I_D ↑, $\bar{e}$s in the channel decreases, ∴ channel width ↓

I_D ↓ upto a constant value called pinch-off current I_{DSS}. At that time V_{DS} is called pinch-off voltage.

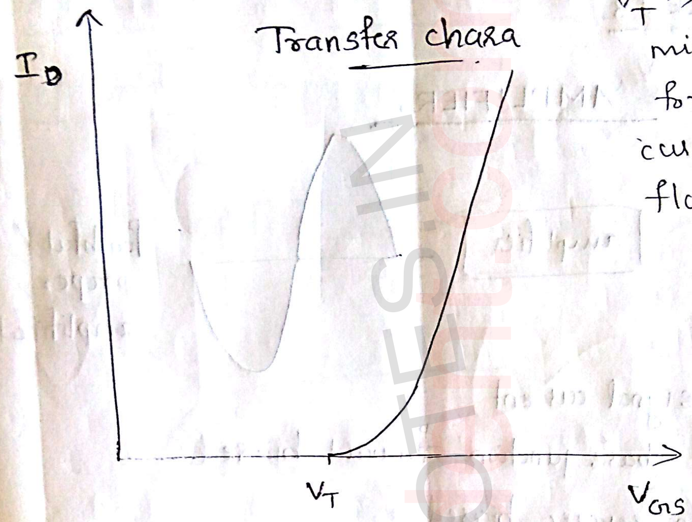


$V_P \Rightarrow V_{DS}$ voltage after which I_D current is constant

o/p characteristics



Transfer chara



$V_T \rightarrow$ threshold voltage
min. V_{GS} voltage for which I_D current starts to flow.

$$I_D = k\left(V_{GS} - V_T\right)^2$$

$$K = \frac{I_{D(on)}}{\left(V_{GS(ON)} - V_T\right)^2}$$

$$V_{GD} = V_{DS} - V_{GS}$$

In Enhancement MOSFET
Initially no channel. Enhanced is creating the channel. But in depletion MOSFET ~~the~~ the channel is already present.