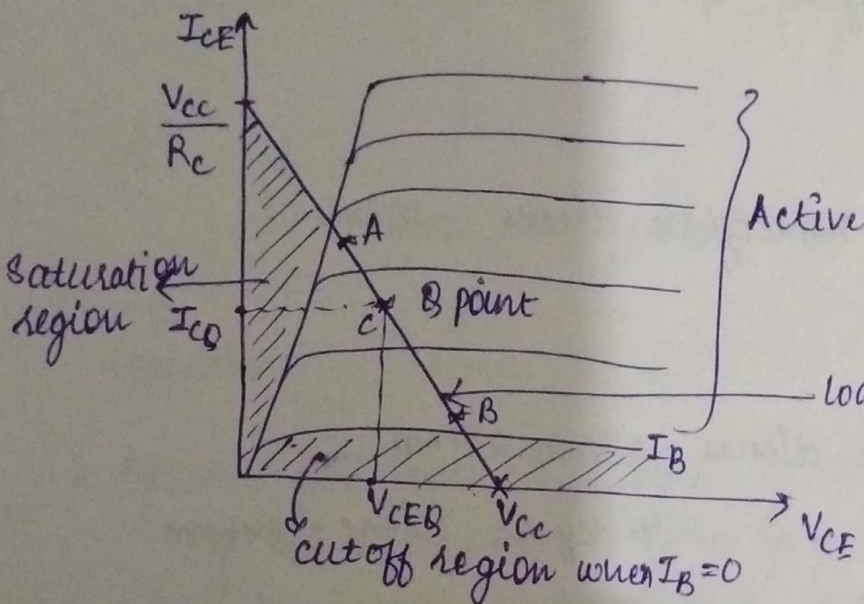
DC biasing - BJT:

→ Selection of Operating Point (selected on Load line)



Calculation of operating point ≅ value of V_{CE} and I_C

Active Region:

EB → FB (forward bias)
CB → Reverse bias

* when operating point is selected near saturation point the current signal get clipped in the +ive half and the voltage signal gets clipped in the -ive half.

* when the operating point is selected near cutoff region current signal gets clipped in -ive part and voltage signal clipped in positive part

* Operating point must be selected at the middle of load line.

* when collector current varies operating point changes.

$$\boxed{I_C = \beta I_B + (\beta+1) I_{CBO}} \longrightarrow I_{CBO} \equiv \text{reverse leakage current}$$

for common base confi

10°C Rise in temp

$I_{CBO} \Rightarrow$ Double

$$\boxed{I_C = \beta I_B + I_{CEO}}$$

common emitter config.

→ Stability Factor:

rate of change of collector current wrt. I_{CBO} at constant V_{BE} & β.

$$S = \left.\frac{dI_C}{dI_{CBO}}\right|_{\text{const. } V_{BE}\ \&\ \beta}$$

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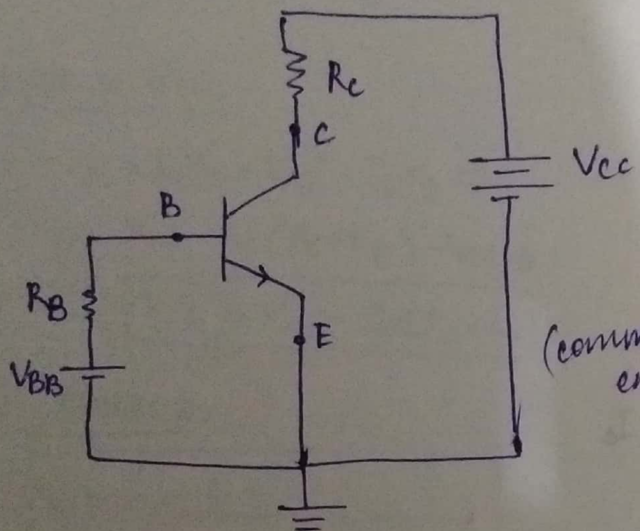
$$S' = \left.\frac{dI_C}{dV_{BE}}\right|_{\text{const. } I_{CBO} \,\&\, \beta}$$

$$S'' = \left.\frac{dI_C}{d\beta}\right|_{\text{const. } I_{CBO} \,\&\, V_{BE}}$$

$\boxed{\text{lower the value of S, stabler the system}}$

→ Fixed Bias Circuit: / Base Bias circuit



(common emitter config.)

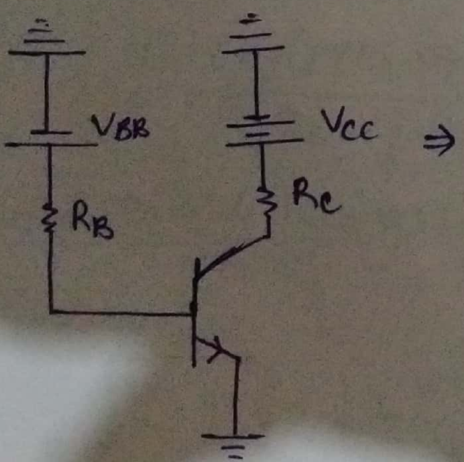
I_B, I_C, V_{CE}

R_B is selected in such a way so as to make V_{BE} equal to

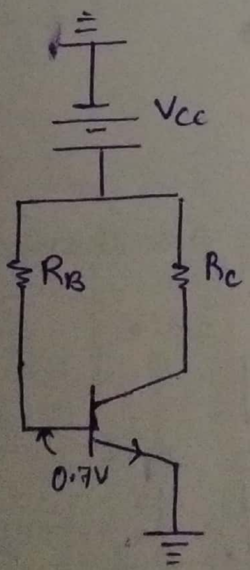
$0.7V \xrightarrow{\text{for}}$ silicon.

$0.3V \xrightarrow{\text{for}}$ Germanium

⇓ since 2 batteries are not pratically applied thus we modify it.



⇒



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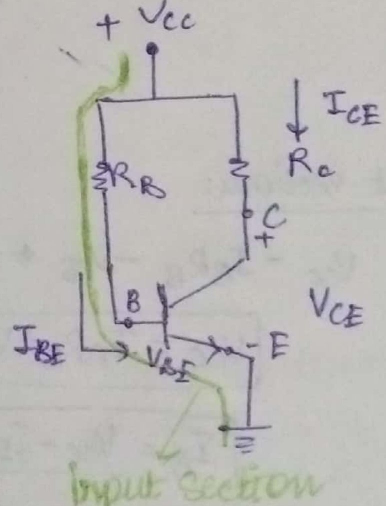


I (input section)

$$+V_{CC} - I_B R_B - V_{BE} = 0.$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{R_B}}$$

$$\boxed{I_B \simeq \frac{V_{CC}}{R_B}}$$

$$I_C = \beta I_B + I_{CEO}$$

$$I_C \simeq \beta I_B.$$

$$\boxed{I_C \simeq \beta\left(\frac{V_{CC} - V_{BE}}{R_B}\right)}$$

Output section:

$$+V_{CC} - I_C R_C - V_{CE} = 0.$$

$$\boxed{V_{CE} = V_{CC} - I_C R_C}$$

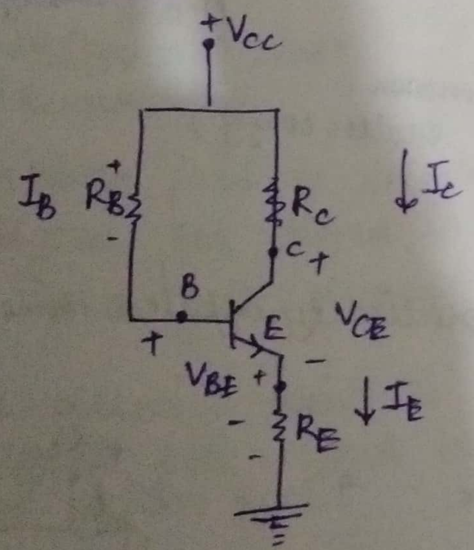
→ **Stability factor:** (Fixed Bias Circuit)

$$\boxed{S = \beta + 1}$$

general equation that can be used for any system.

$$S = \frac{\beta + 1}{1 - \beta \frac{dI_B}{dI_C}}$$

→ **Emitter Bias circuit:**



input section:

$$V_{CC} - I_B R_B - V_{BE} - I_E R_E = 0.$$

$$\boxed{V_{CC} = I_B R_B + V_{BE} + I_E R_E}$$

$$\boxed{I_B = \frac{V_{CC} - I_E R_E - V_{BE}}{R_B}}$$

$T\uparrow \Rightarrow I_{CBO}\uparrow \Rightarrow I_{CEO}\uparrow \Rightarrow I_C\uparrow \rightarrow I_E\uparrow \Rightarrow I_E R_E\uparrow \Rightarrow I_B\downarrow \Rightarrow I_C\downarrow$

$\Rightarrow I_C \uparrow$ and $\downarrow$

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$V_{cc} - I_B R_B - V_{BE} - I_E R_E = 0$

$I_E = I_B + I_C$

$V_{cc} - I_B R_B - V_{BE} - (\beta+1) I_B R_E = 0$

$I_E = (\beta+1) I_B$

$V_{cc} - I_B \left[R_B + (\beta+1) R_E \right] - V_{BE} = 0$

$$\boxed{I_B = \frac{V_{cc} - V_{BE}}{R_B + (\beta+1) R_E}}$$

$$I_C = \beta I_B = \beta \left[\frac{V_{cc} - V_{BE}}{R_B + (\beta+1) R_E} \right]$$

output section:

$V_{cc} - I_C R_C - V_{CE} - I_E R_E = 0$

$V_{cc} - I_C (R_C + R_E) - V_{CE} = 0$

$I_C \simeq I_E$ as I_B is in μA.

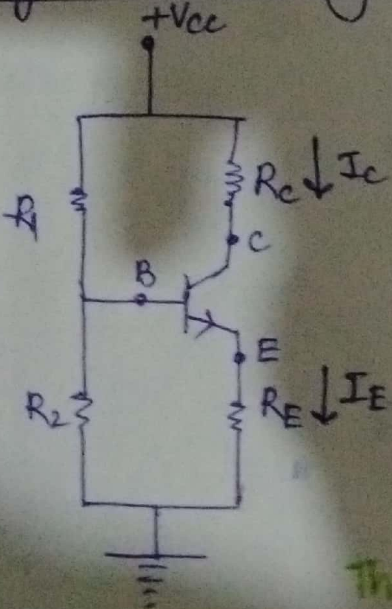
$$\boxed{V_{CE} = V_{cc} - I_C (R_C + R_E)}$$

* Stability factor:

$$\boxed{S = \frac{\beta+1}{1 + \beta\left(\frac{R_E}{R_B + R_E}\right)}}$$

$$S = \frac{(\beta+1)(R_B + R_E)}{R_B + (\beta+1) R_E}$$

→ Voltage Divider Biasing: (indepedent of β)



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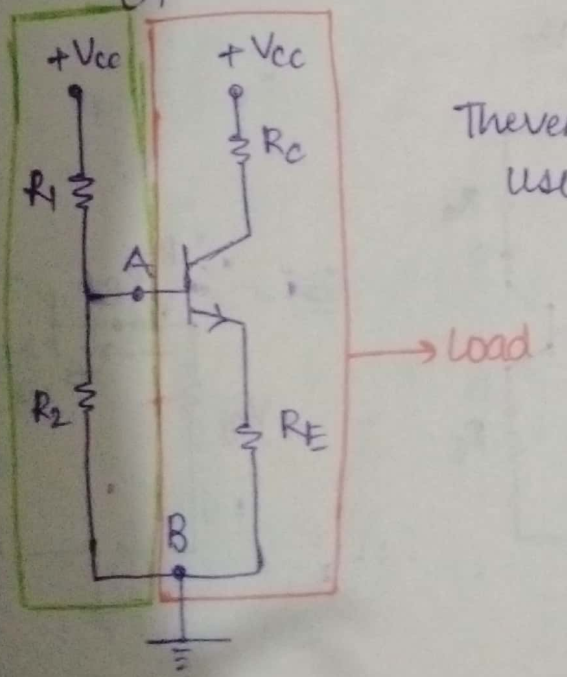
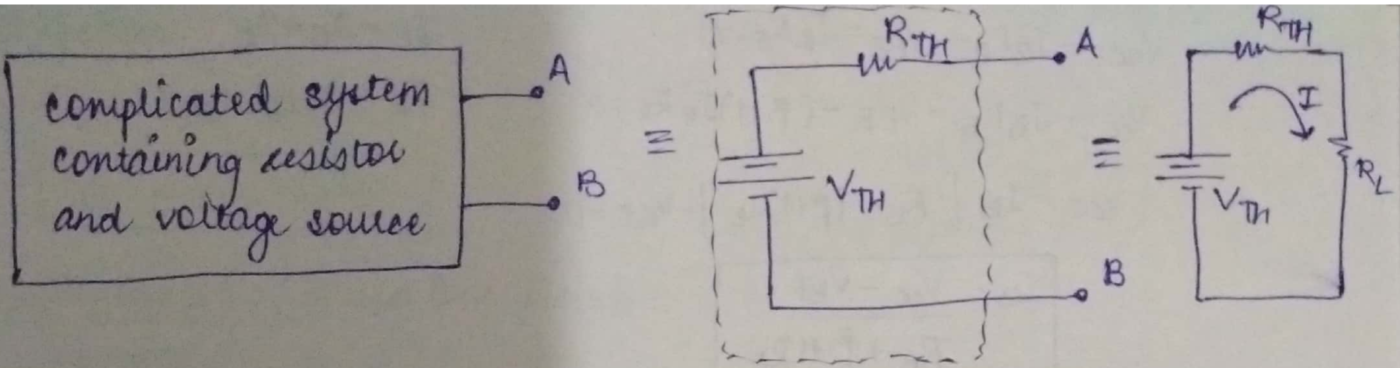


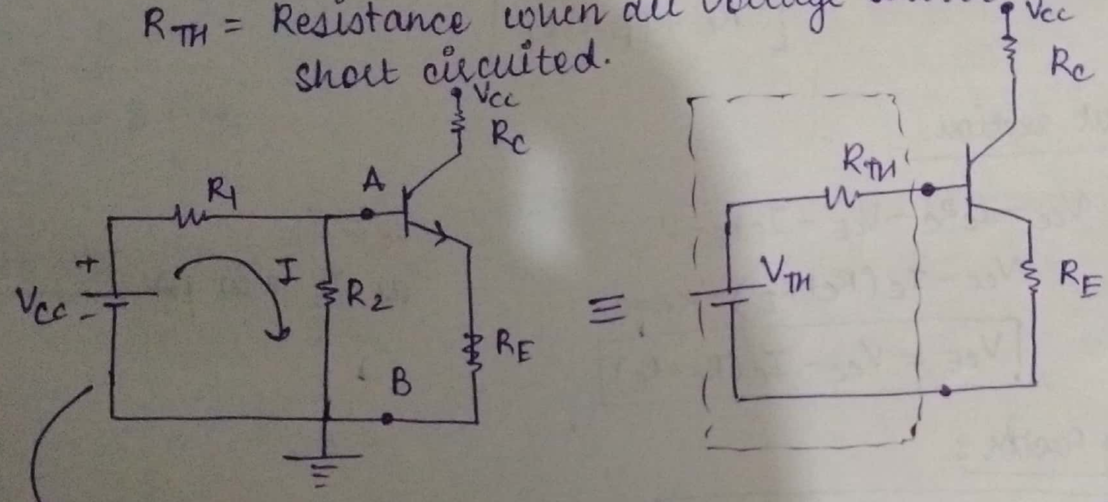
Thevenin part

Thevenin theorem used.



V_{TH} = Thevenin voltage across A,B

R_{TH} = Resistance when all voltage source are short circuited.

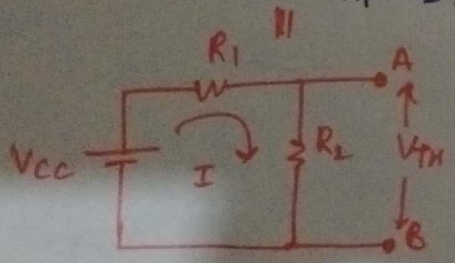


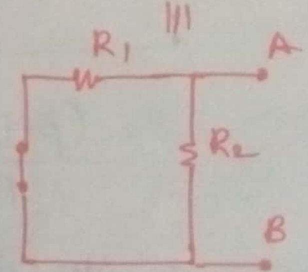
current $I = \dfrac{V_{cc}}{R_1+R_2}$

$V_{TH} \equiv R_2 \times I$

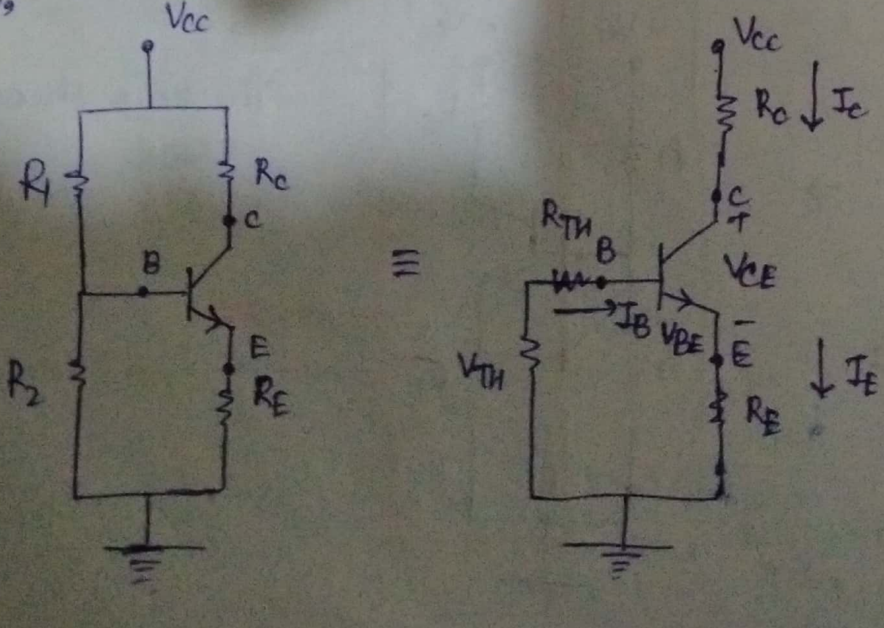
$V_{TH} = \dfrac{R_2 \times V_{cc}}{R_1+R_2}$

$R_{TH} \equiv \dfrac{R_1 R_2}{R_1+R_2}$





now,



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Input section:

$$V_{TH} - R_{TH} I_B - V_{BE} - I_E R_E = 0.$$

$$V_{TH} - R_{TH} I_B - V_{BE} - (\beta+1) I_B R_E = 0.$$

$$V_{TH} - I_B (R_{TH} + (\beta+1) R_E) - V_{BE} = 0.$$

$$\boxed{I_B = \frac{V_{TH} - V_{BE}}{R_{TH} + (\beta+1) R_E}} \qquad \boxed{I_C = \beta \left[\frac{V_{TH} - V_{BE}}{R_{TH} + (\beta+1) R_E} \right]}$$

output section:

$$I_E \simeq I_C.$$

$$V_{CC} - I_C R_C - V_{CE} - I_E R_E = 0.$$

$$V_{CC} - I_C R_C - V_{CE} - I_C R_E = 0.$$

$$\cancel{\boxed{I_C = \frac{V_{CC} - V_{CE}}{R_C + R_E}}} \qquad \boxed{V_{CE} = V_{CC} - I_C (R_C + R_E)}$$

now, $$I_C = \beta \left[\frac{V_{TH} - V_{BE}}{R_{TH} + (\beta+1) R_E} \right]$$

$$I_C \simeq \beta \left[\frac{V_{TH} - V_{BE}}{R_{TH} + \beta R_E} \right]$$

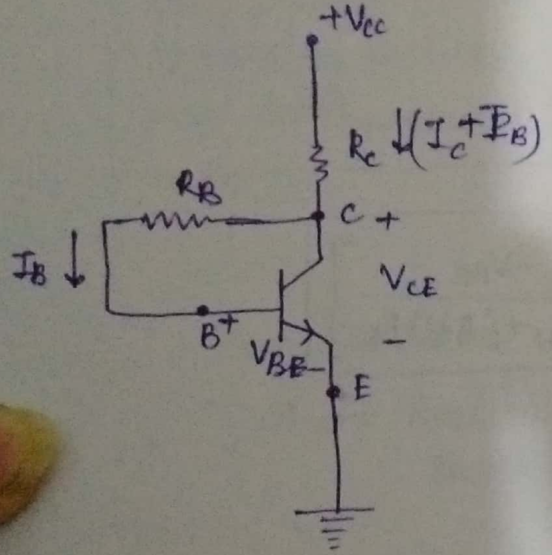
when $R_{TH} \ll \beta R_E$

$$I_C \simeq \cancel{\beta} \left[\frac{V_{TH} - V_{BE}}{\cancel{\beta} R_E} \right]$$

* Stability Factor:

$$\boxed{S = \frac{\beta+1}{1 + \beta \frac{R_E}{R_{TH} + R_E}}}$$

→ Collector Feedback Configuration:



Input section:

$$V_{CC} - R_C(I_C + I_B) - I_B R_B - V_{BE} = 0.$$

$$V_{CC} - I_B(R_C + R_B) - I_C R_C - V_{BE} = 0.$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE} - I_C R_C}{R_C + R_B}} \quad -③$$

$$\boxed{I_C = \beta\left[\frac{V_{CC} - V_{BE} - I_C R_C}{R_C + R_B}\right]} \quad -①$$

Output section

$$V_{CC} - R_C(I_C + I_B) - V_{CE} = 0. \quad (\because I_B \ll I_C)$$

$$V_{CC} - R_C I_C - V_{CE} = 0.$$

$$\boxed{V_{CE} = V_{CC} - I_C R_C} \quad -②$$

put eq ② in ① & ③.

$$\boxed{I_B = \frac{V_{CE} - V_{BE}}{R_C + R_B}} \qquad \boxed{I_C = \beta\,\frac{V_{CE} - V_{BE}}{R_C + R_B}}$$

$T\uparrow \Rightarrow I_{CBO}\uparrow \Rightarrow I_C\uparrow \Rightarrow V_{CE}\downarrow \Rightarrow I_B\downarrow \longrightarrow I_C\downarrow$

$\Rightarrow I_C \uparrow \& \downarrow$ simultaneously. hence provides stability.

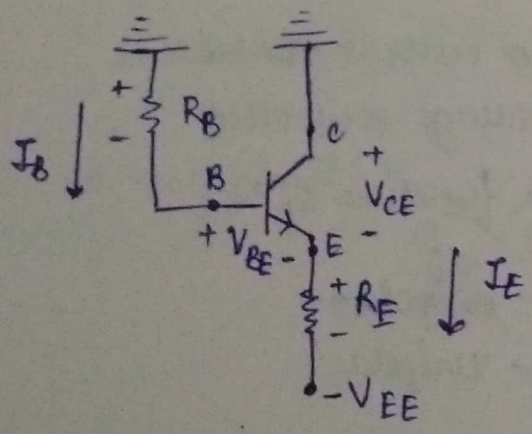
$$V_{CC} - I_B(R_C + R_B) - I_C R_C - V_{BE} = 0.$$

$$V_{CC} - I_B(R_C + R_B) - \beta I_B R_C - V_{BE} = 0.$$

$$V_{CC} - I_B((\beta+1)R_C + R_B) - V_{BE} = 0.$$

$$\boxed{I_B = \frac{V_{CC} - V_{BE}}{(\beta+1)R_C + R_B}}$$

→ Emitter-Follower Configuration:



Input section:

$$-I_BR_B - V_{BE} - I_ER_E + V_{EE} = 0.$$

$$-I_BR_B - V_{BE} - (\beta+1)\overset{I_B}{R_E} + V_{EE} = 0.$$

$$-I_B(R_B + (\beta+1)R_E) - V_{BE} + V_{EE} = 0.$$

$$\boxed{I_B = \frac{V_{EE} - V_{BE}}{R_B + (\beta+1)R_E}}$$

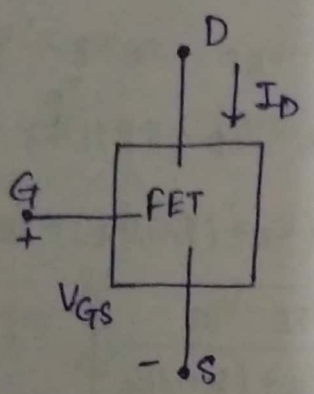
$$\boxed{I_C = \beta I_B}$$

Output section:

$$-V_{CE} - I_ER_E + V_{EE} = 0.$$

$$\boxed{V_{CE} = V_{EE} - I_ER_E}$$

Field Effect Transistor:



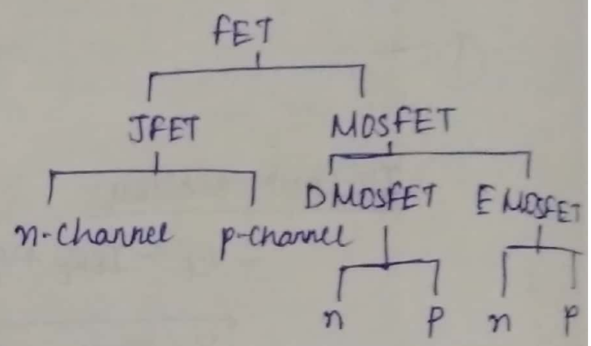
BJT → ~~co~~ current controlled

FET → voltage controlled.

I_D is a function of V_{GS}

BJT → bipolar

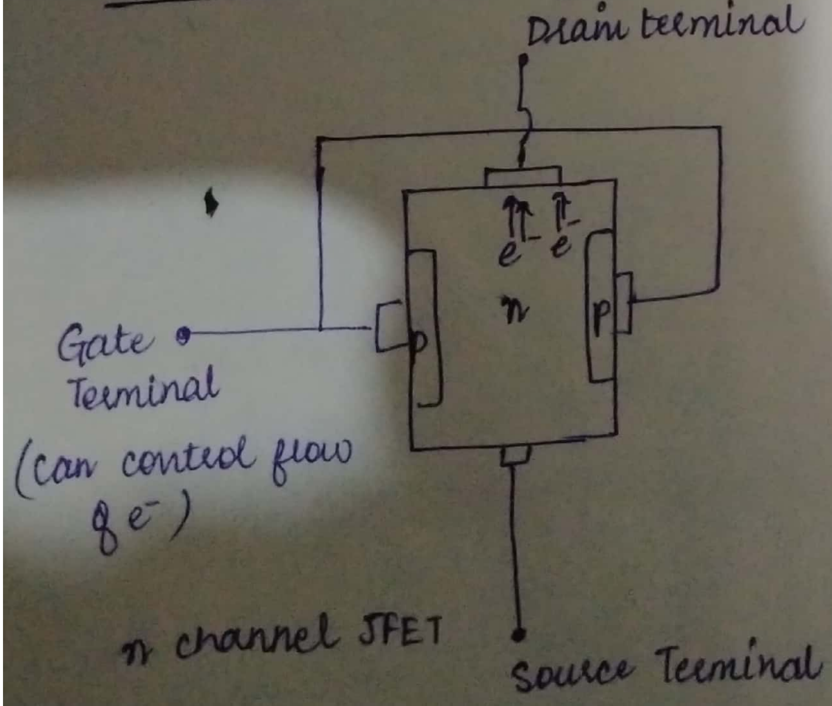
FET → unipolar



→ FET for amplification & switching.

→ FET • have high input impedance
- more temp. stable
- smaller in size
- less sensitive for input signals.

→ construction & working of JFET:



JFET → has 2 p-n junctions.

↓

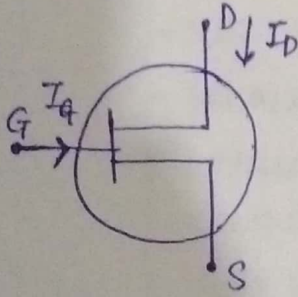
2 depletion region

cause of e^- flow = voltage diff. b/w D & S.

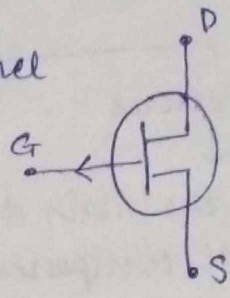
when $V_{GS}=0 \Rightarrow$ voltage of G and S are same and $V_{DS} > 0V$

e^- goes in drain

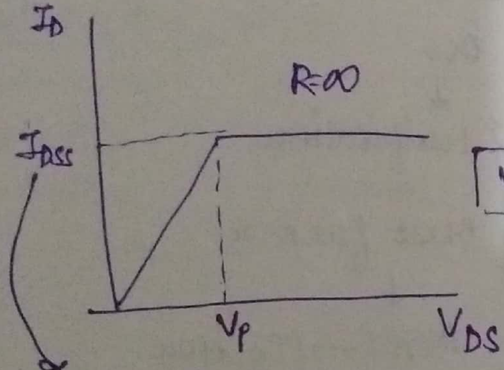
n channel JFET



p-channel



→ pinch off voltage:



max drain current.

$\boxed{V_{GS}=0}$ $\boxed{V_D > |V_P|}$

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

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

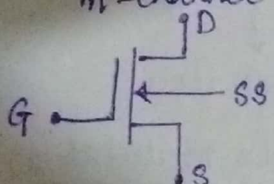
$$r_d = \frac{r_o}{(1-V_{GS}/V_P)^2}$$

$P_D = V_{DS} I_D$

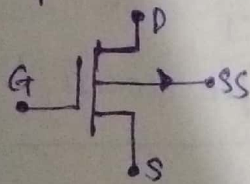
$I_D = I_S$, $I_G \cong 0A$

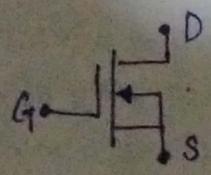
→ MOSFET:

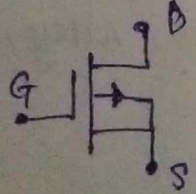
n-channel



p-channel







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

$V_{DS(sat)} = V_{GS} - V_T$

$I_D = K(V_{GS}-V_T)^2$

$V_T = V$ at which $I_D \cong 0A$