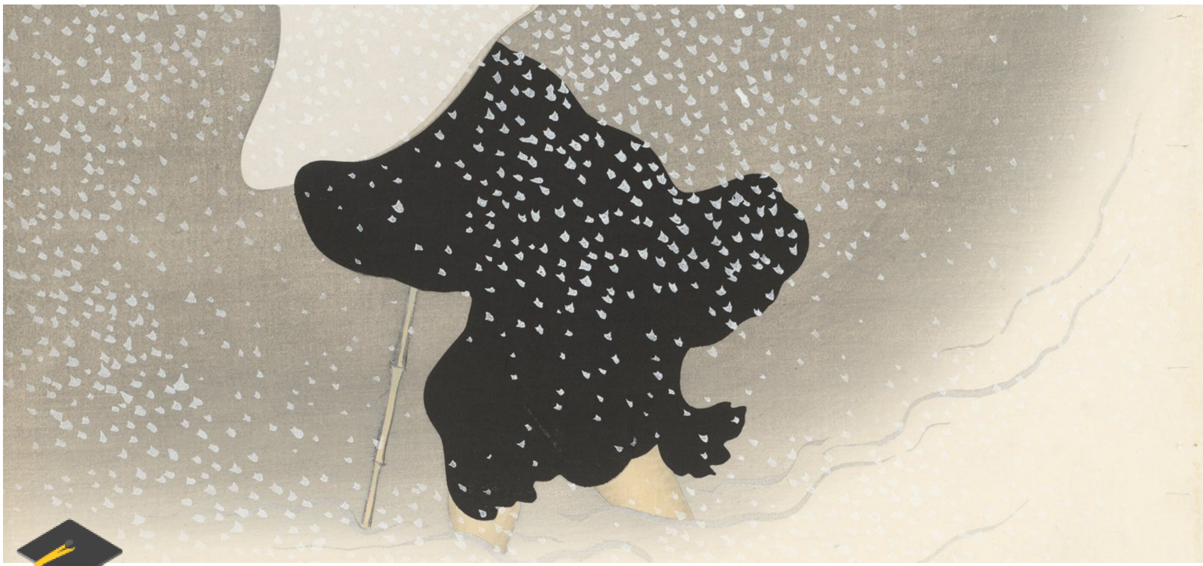

BJT

Created	@December 9, 2022 2:36 PM
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By	Sagoor

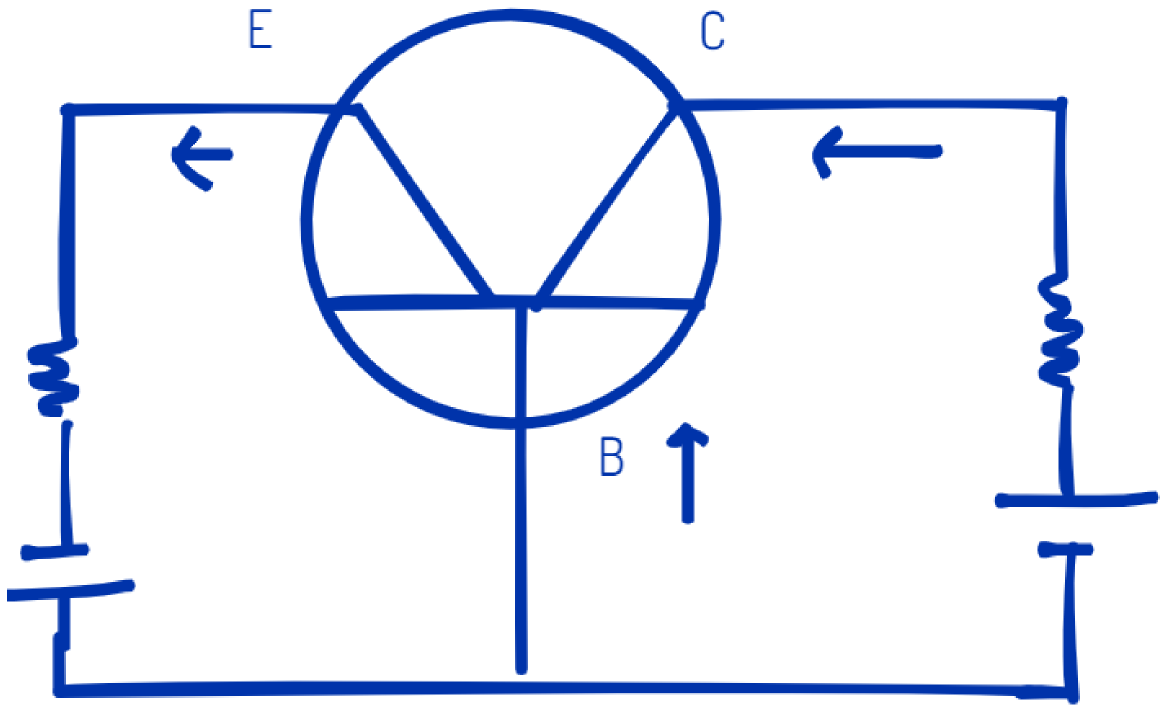
References:

- https://www.youtube.com/watch?v=p3ccfbyyDSQ&list=PLgwYQr3eNLspqSJN26drjIWFZhCgBFf-i&index=2&ab_channel=ElectricalEngineeringSolution

Basic Configuration of transistor:

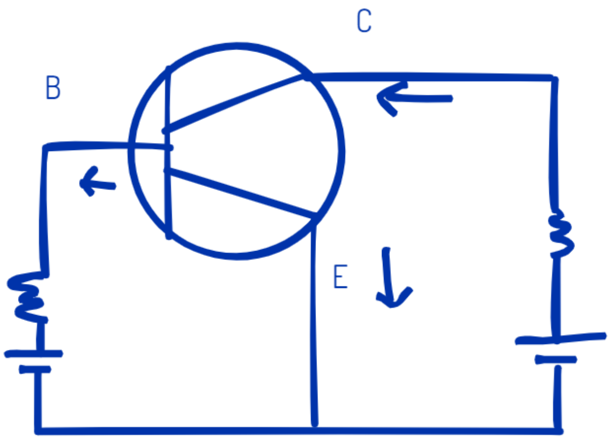
Configuration:

Common Base:



IE = IC+IB
Amplification factor, alpha = IC/IE
IC = alpha*E + ICBO (reverse saturated current) (prefectly)
IC = alpha*E (If we ignore ICBO)

Common Emitter:



IE = IB+IC

IC = alpha*IE + ICBO
=> IC = alpha(IB+IC)+ICBO
=> IC(1-alpha)=alpha*IB+ICBO
=>IC = IB (alpha/1-alpha) + ICBO/1-alpha
=> IC =beta * IB + (beta+1)*ICBO

IE=IB+IC
Amplification factor, beta = IC/IB = alpha/1-alpha
IC = beta*IB + ICEO (reverse saturated current)

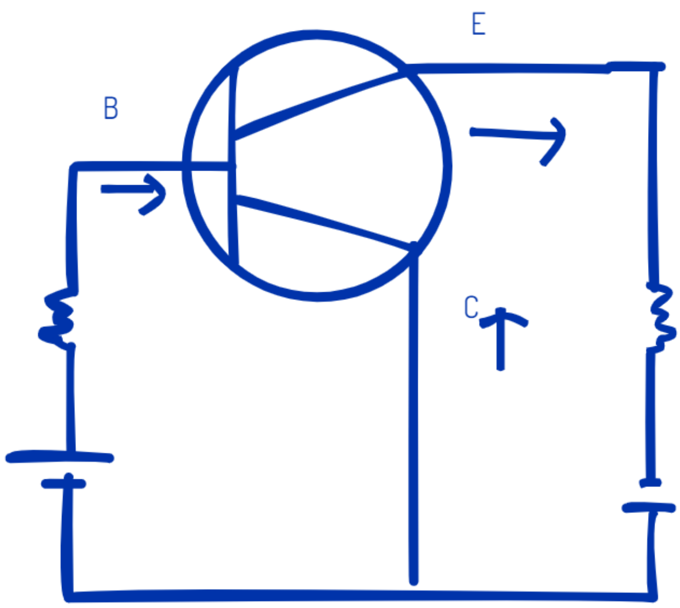
$$\alpha = \frac{I_C}{I_E} \qquad \beta = \frac{I_C}{I_B}$$

$$= \frac{I_C}{I_E - I_C}$$

$$= \frac{I_C/I_E}{1 - I_C/I_E}$$

$$= \frac{\alpha}{1-\alpha}$$

Common Collector:



IC = IB*gamma + gamma*IBEO
gamma = 1+beta=1/1-alpha

$$\gamma = \frac{I_E}{I_B}$$

$$= \frac{I_E}{I_E - I_C} \quad \left[\text{dev. by } I_E\right]$$

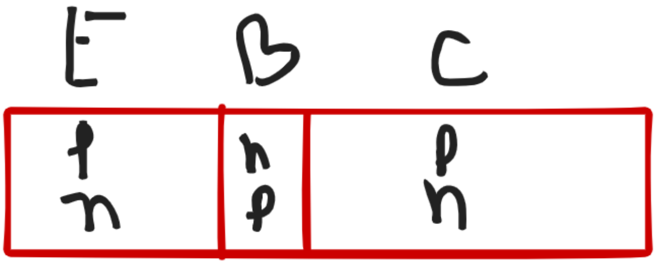
$$= \frac{1}{1-\alpha}$$

$$= \frac{1-\alpha+\alpha}{1-\alpha}$$

$$= \beta + 1$$

BJT

BJT → Bipolar Junction Transistor



3 Part:

- Base → width→ light, doping → minimum
- Emitter → width→ medium, doping → maximum
- Collector → width → large, doping → medium

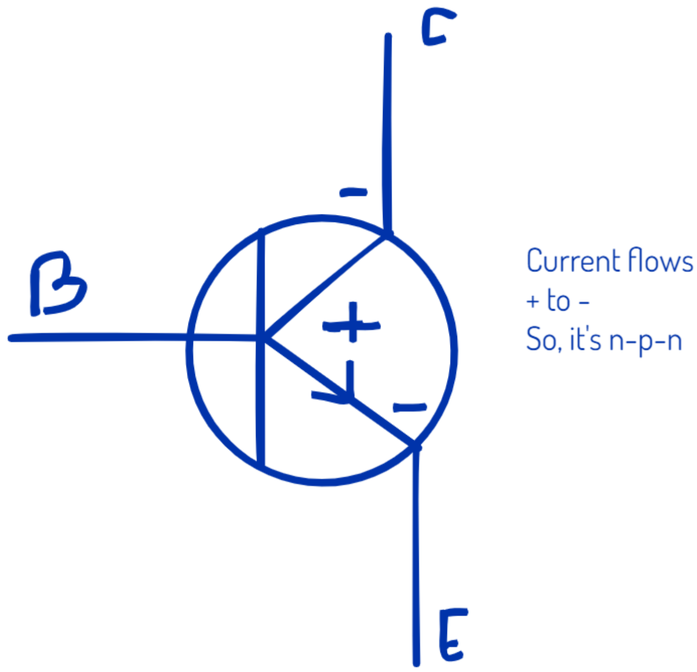
Width : C > E > B

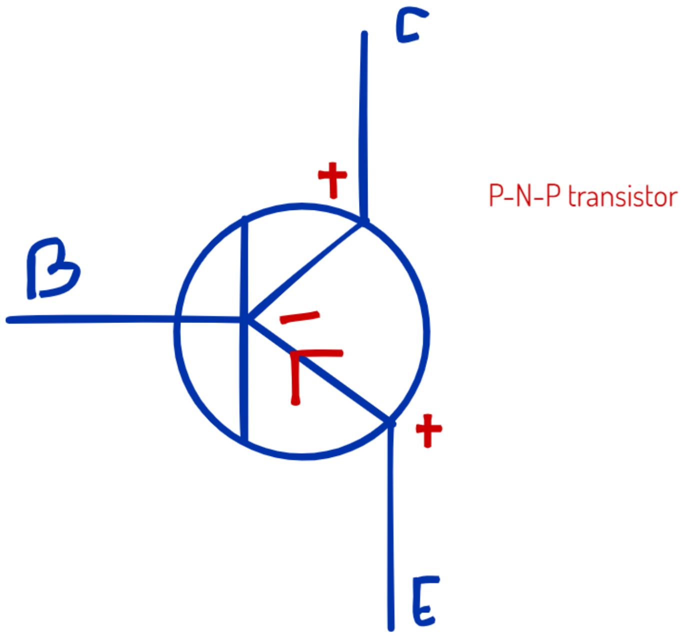
Doping: E > C > B

Can be n-p-n or p-n-p.

How to recognize that ?

→ By observing the direction of flowing of the current. Current flows from **positive to negative.**



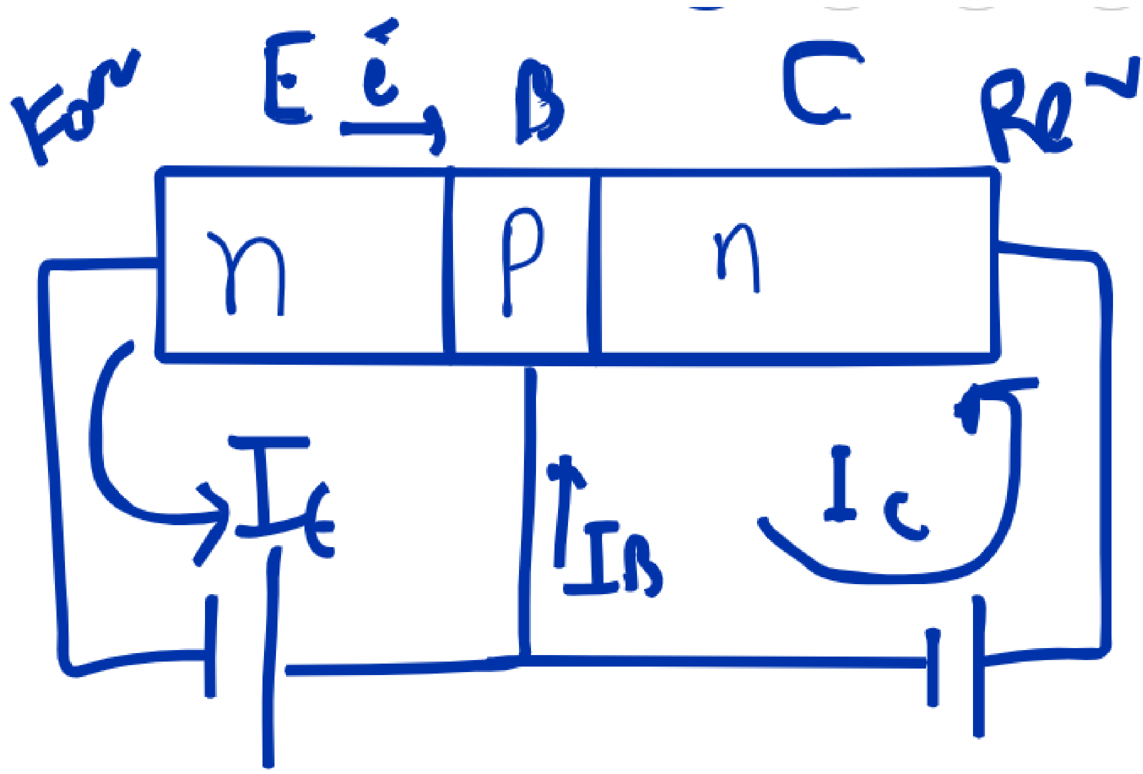


BJT Working:

- n-p-n uses more than p-n-p (commercially)
  - n-p-n has
    - more electron
    - more movability

Junction 1 (E-B)	Junction 2 (C-B)	Mode
Forward	Reverse	Active (amplifier)
Forward	Forward	Saturated
Reverse	Reverse	Cut off
Reverse	Forward	Inverted/ Reverse active (rare use)

Active mode :



$$I_B + I_C = I_E$$

$$I_E \cong I_C$$

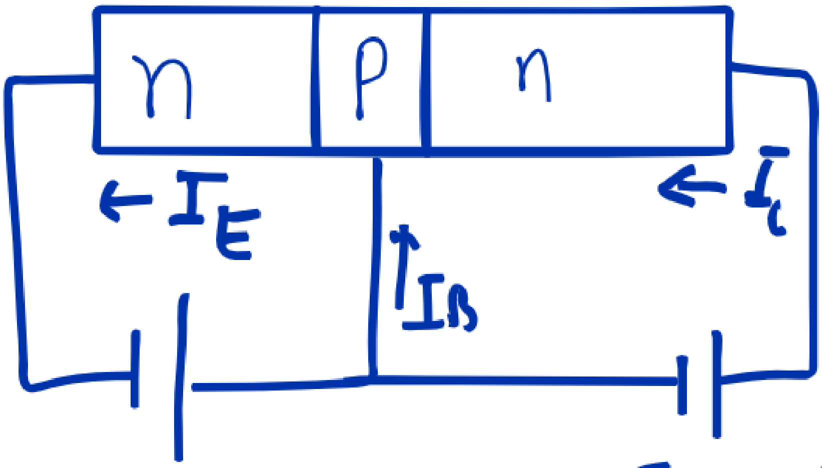
$$I_B + I_C = I_E$$

$I_E = I_C$

BJT as an amplifier :

- E-B → input

- C-B → Output



$$I_c = I_B = I$$

$$V_i = V_{EB} = I R_{EB} \quad \dots (i)$$

$$V_o = V_{CB} = I R_{CB} \quad \dots (ii)$$

$$\Rightarrow \frac{V_o}{V_i} = \frac{R_{CB}}{R_{EB}} \qquad R_{CB} >> R_{EB}$$

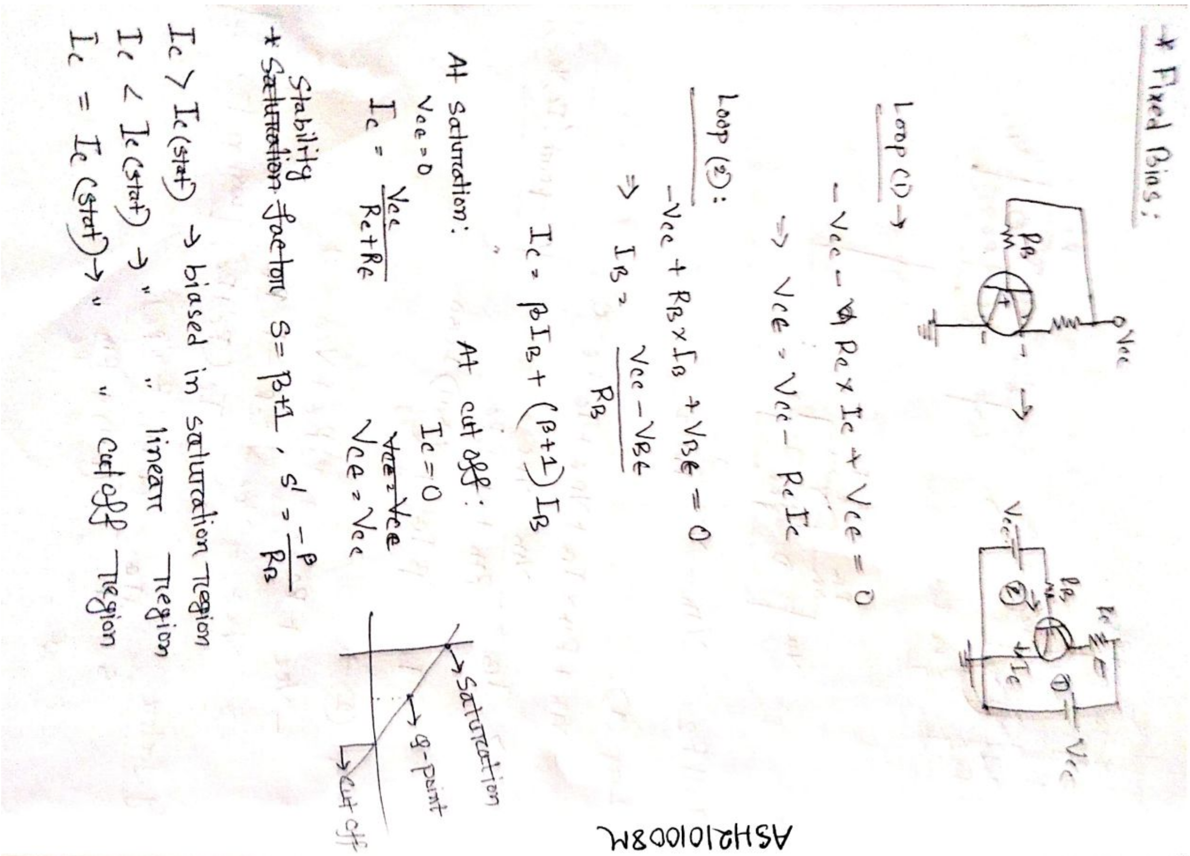
$$V_o >> V_i$$

BJT as a switch:

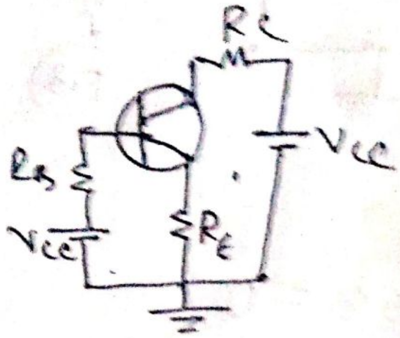
....

…

DC Biasing


* Fixed Bias:
Vcc
RB
Loop (1) →
− Vcc − Rc × Ic + Vce = 0
⇒ Vce = Vcc − Rc Ic
Loop (2):
−Vcc + RB × IB + VBE = 0
⇒ IB = (Vcc − VBE) / RB
Ic = βIB + (β+1) IB
At saturation:
Vce = 0
Ic = Vcc / (Rc+RE)
At cut off:
Ic = 0
Vce = Vcc
Saturation
Q-point
cut off
* Stability factor S = β+1 , S' = −β/RB
Ic > Ic(sat) → biased in saturation region
Ic < Ic(sat) → " " linear region
Ic = Ic(sat) → " " cut off region

* Emitter Bias :



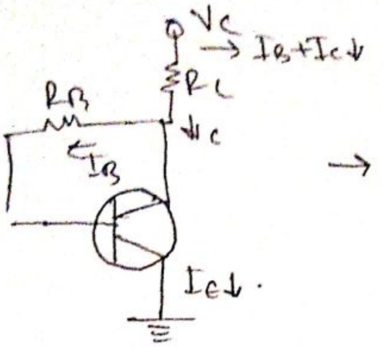
$$-V_{CC} + R_C I_C + R_E I_E + V_{CE} = 0$$

$$\Rightarrow V_{CE} = V_{CC} - R_C I_C - R_E I_E$$

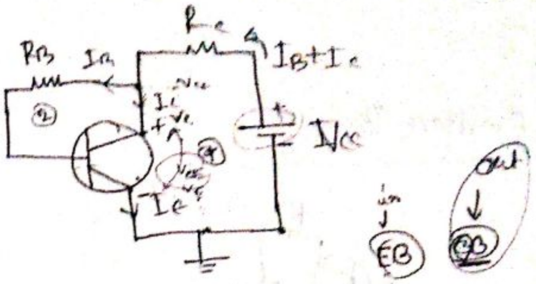
$$-V_{CC} + I_B R_B + V_{BE} + I_E R_E = 0$$

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

* Collector feedback:



→

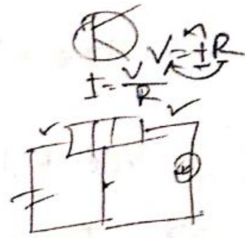


Loop (1) →

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

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

Loop (2) →



$$-V_{CC} + (I_B+I_C)R_C + V_{CE} = 0$$

$$\Rightarrow -V_{CC} + I_B(1+\beta)R_C + V_{CE} = 0$$

$$\Rightarrow V_{CE} = V_{CC} - I_B R_C(1+\beta)$$

$$V_{CE} = V_{CC} - (I_C R_C) \quad (\beta >> 1)$$

~~$-V_{CC} + R_C(I_C+I_B)$~~

* β_{DC} → varies directly with temperature

V_{BE} → varies inversely with temperature

$T\uparrow \quad \beta_{DC}\uparrow \quad I_C\uparrow \quad R_C\uparrow$ → Not sure

$T\uparrow \quad V_{BE}\downarrow \quad I_B\uparrow \quad R_B\downarrow$

* ~~Saturation factor~~ Stability

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

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

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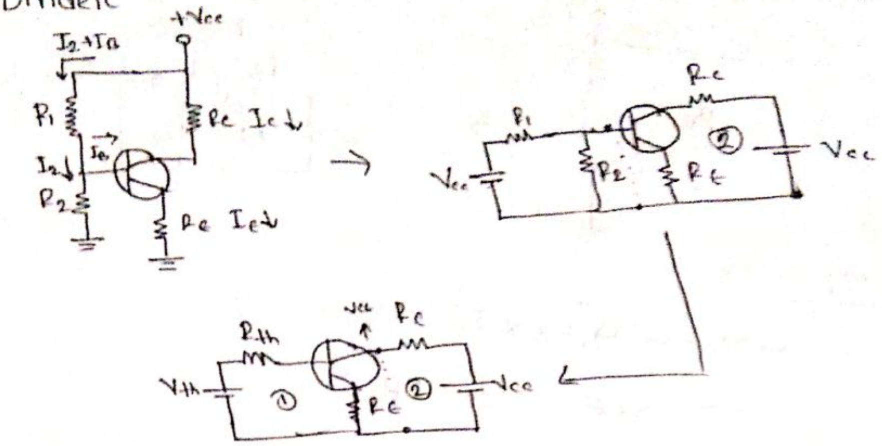
* Voltage Divider



$R_{th} = R_1 \| R_2$ $\quad V_{th} = V_{cc}\dfrac{R_2}{R_1+R_2}$

KVL in Loop (1).

$$-V_{th} + R_{th}\times I_B + V_{BE} + I_E \times R_E = 0$$

$$\Rightarrow I_B = \frac{V_{th} - V_{BE}}{R_{th} + (\beta+1)R_E}$$

$\boxed{\text{Q-point } (I_C, V_{CE})}$

$$I_C = \beta I_B + (\beta+1) I_{CBO}$$

KVL in Loop (2)→

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

$$\Rightarrow V_{CE} = V_{CC} - I_C R_C - I_E R_E$$

$$= V_{CC} - I_C(R_C + R_E) \quad [\text{when } \beta >> 1$$

Stability factor:

$$S = \frac{dI_B}{dI_C} = \frac{(\beta+1)(R_{th}/R_E)}{(\beta+1) + \frac{R_{th}}{R_E}}$$

S'

Stability Factor:

The rate of change of **collector current w.r.t** to the leakage current of constant input voltage and amplification factor is called stability factor.

$$S = \frac{dI_C}{dI_{CBO}}$$

$$S' = \frac{dI_C}{dV_{BE}}$$

$$S'' = \frac{dI_C}{d\beta}$$