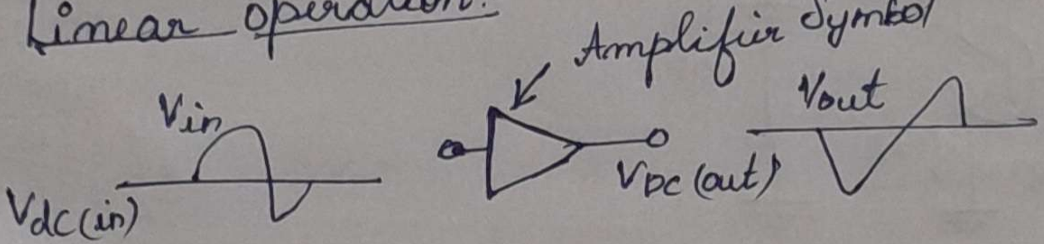
03/10/2023
Tuesday

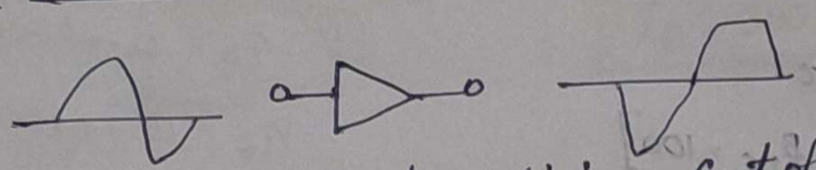
Transistor

- Used to amplify the weak Signals.

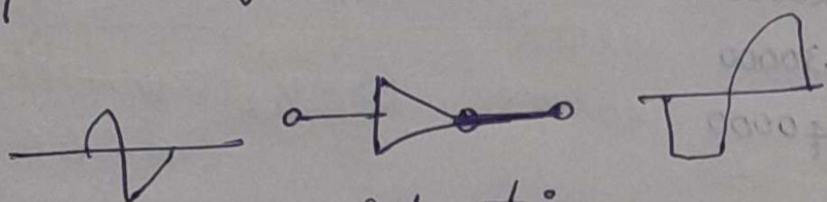
Linear operation:-



Non- Linear:



Output voltage (clipped) by cutoff



clipped by Saturation.

Analysis of a Transister

→ Knowledge of both DC and AC.

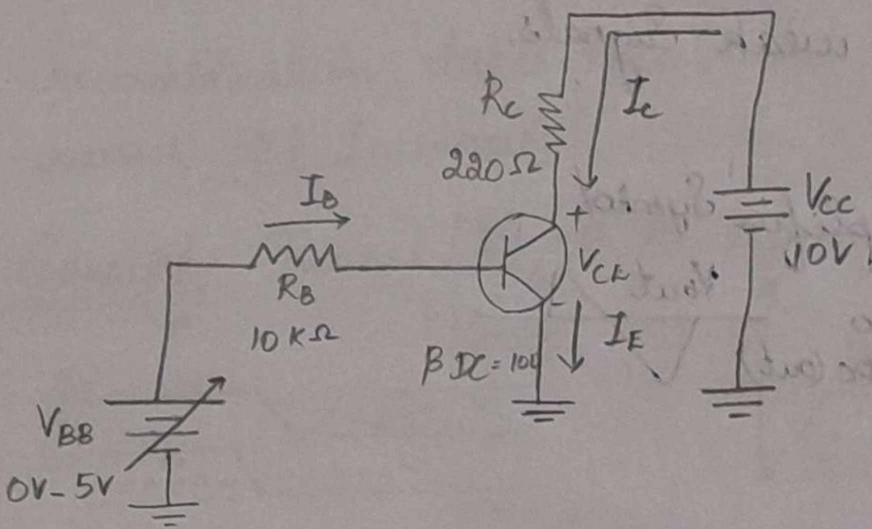
→ DC level of Operation.

- Setting a desired dc voltage and current
- Set up a point where the transistor Operates.
- A network must be constructed that will

establish
- the desired operating point.
- → External dc Supply → [Biasing circuits]

Operating point → Q-point

Q → [Quiescent point]



20000
× 220
00000
40000
40000
4400000

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

$$I_C = \beta_{DC} I_B \quad [\beta_{DC} = 100]$$

$I_B = 200\,\mu A$; $I_C = 20000 = 20 \times 10^{-3}$

$I_B = 300\,\mu A$; $I_C = 30000 = 30 \times 10^{-3}$

$I_B = 400\,\mu A$; $I_C = 40000 = 40 \times 10^{-3}$

① $V_{CE} = 10 - \cancel{20000}\,20\,(220)$

$V_{CE} = 10 - 4400000$

$V_{CE} = 10 - 4.4 = 5.6$

② $V_{CE} = 10 - 30(220)$

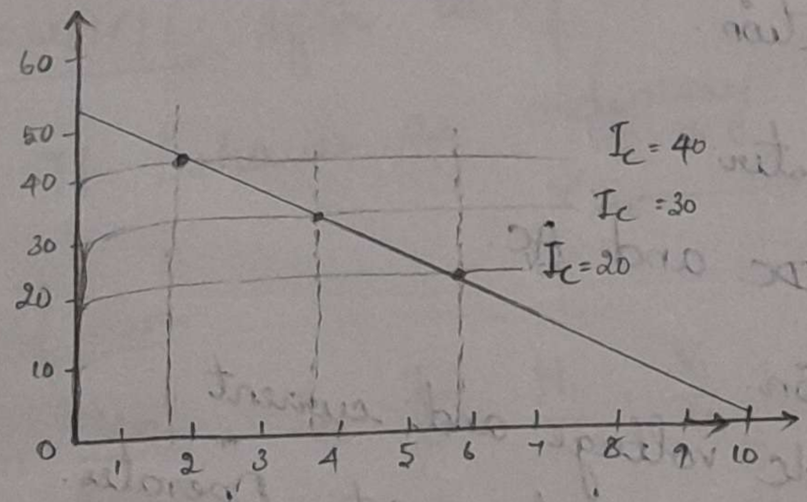
$= 10 - 6.6$

$V_{CE} = 3.4$

③ $V_{CE} = 10 - 40(220)$

$= 10 - 8.8$

$V_{CE} = 1.2$



Simpler way: (DC Load line)

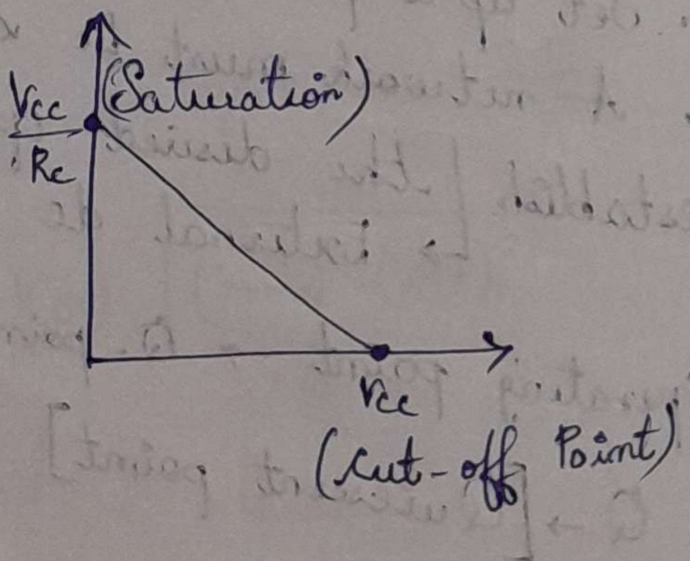
$$V_{CE} = V_{CC} - I_C R_C$$

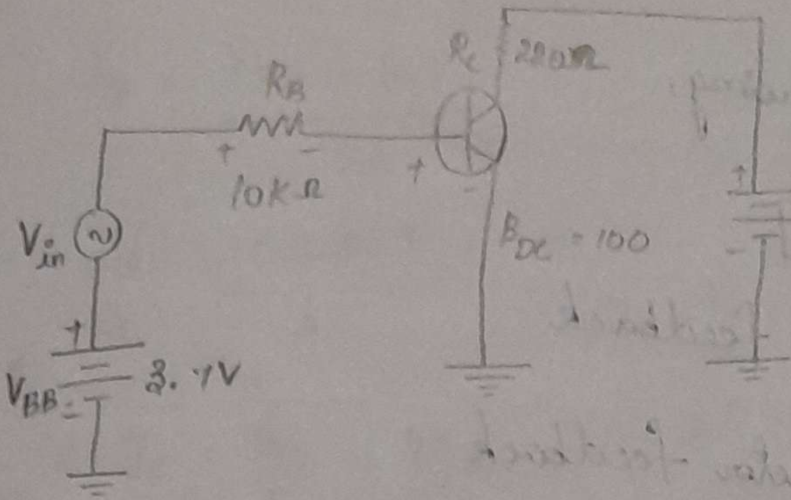
$$0 = V_{CC} - I_C R_C$$

$$I_C = \frac{V_{CC}}{R_C}$$

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

$$V_{CE} = V_{CC}$$





$I_B = V_{BB} - 0.7 / R_B$ $\qquad I_B = \frac{3.7 - 0.7}{10} = \frac{3}{10} = 0.3 K\Omega$
$= 300\,\Omega$

$I_B = 3.7 - 0.7$

$I_B = 3\,K\Omega$

$I_B = 3000\,\Omega$

$\boxed{I_B = 300\,\Omega}$

04/10/2023
Wednesday

Variations in Q-Point

Thermal Runaway:

- For every 10° rise in temperature the leakage current (I_{CBO} & I_{CEO}) double. [Leakage current depends on temperature]
- Power = Voltage × Current
- Dissipation repleased in the form of heat.

$$T \uparrow \longrightarrow I_{CBO} \uparrow - I_C \uparrow \rightarrow P_D$$

$$I_c = \beta I_B + I_{CEO} = \beta I_B + (1 + \beta) I_{CO}$$

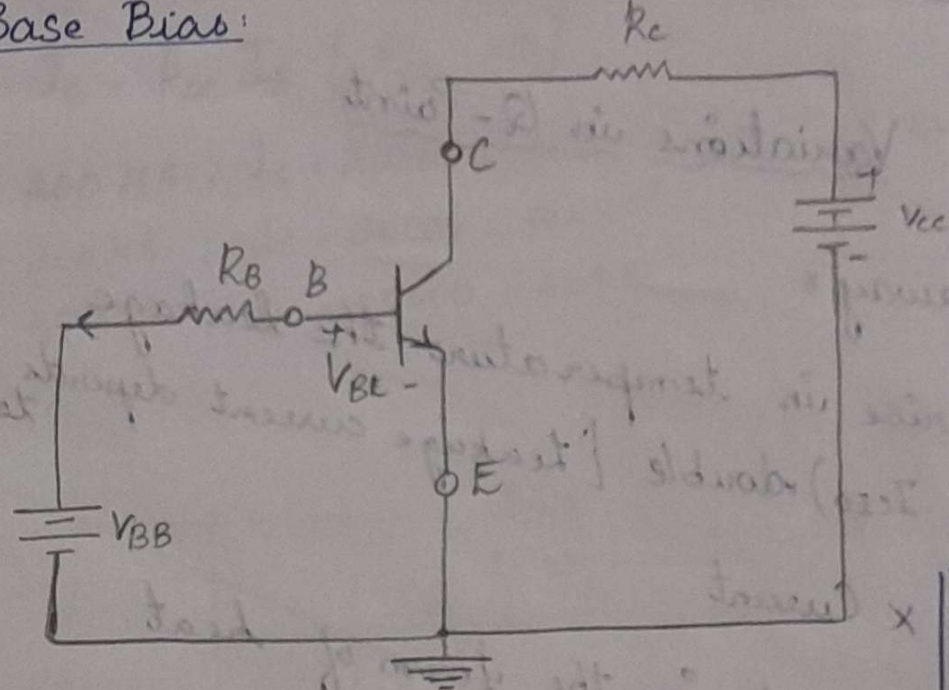
Stability factor:

$$\boxed{S = \frac{dI_c}{dI_{CO}}}$$

Types of Transistor biasing:

- → Base Bias [Fixed Bias]
- → Base Bias with Emitter feedback
- → Base Bias with collector feedback
- → Voltage divider Bias (Self bias)
- → Emitter Bias

① Base Bias:



$\boxed{I_c = 38000}$

38×10^{-3}

$V_{BB} = 10V$

$R_B = 47 K\Omega$

$R_C = 330\Omega$

$V_{CC} = 20V$

$\beta_{DC} = 200$

$I_c = \beta_{DC} I_B$

$= 200 (\cancel{0.197})$ 190

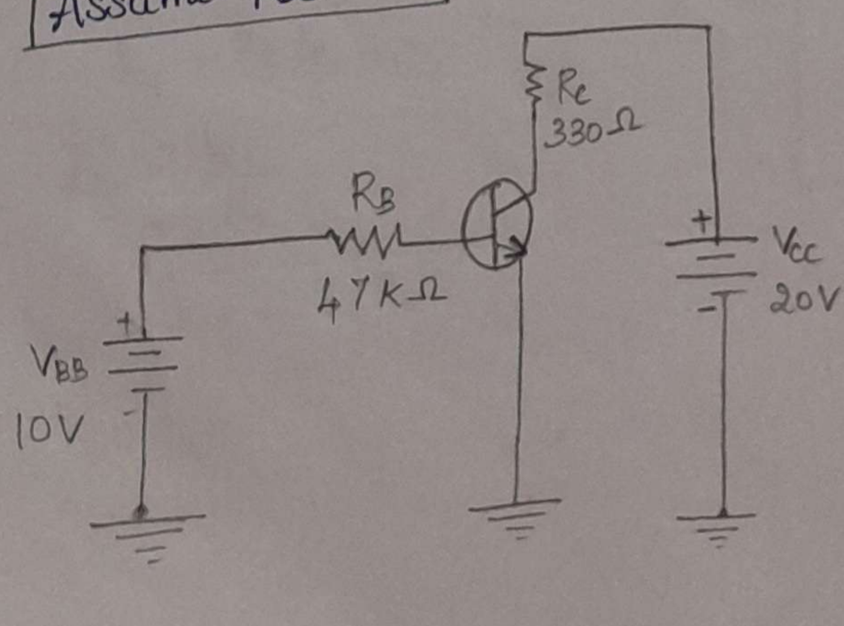
× $I_c = \frac{V_{cc}}{R_c} = \frac{20}{330}$

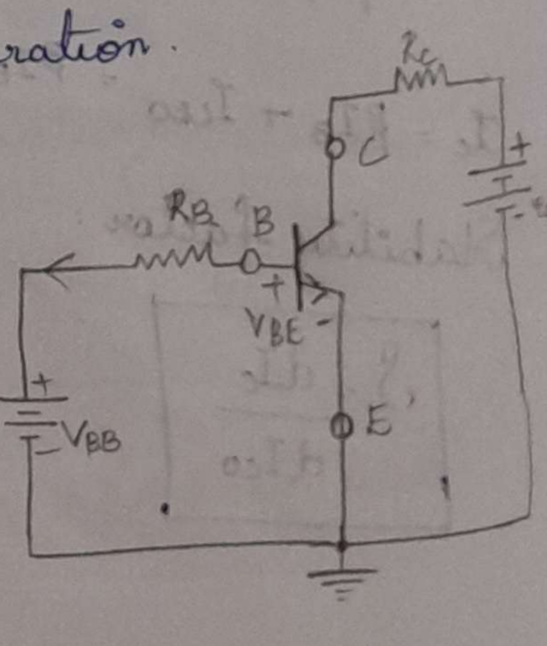
$I_c = 0.06$

PROBLEMS:

① Determine the Q point of the circuit and draw the DC load line. Find the maximum peak value of Base Current (I_B) for linear operation.

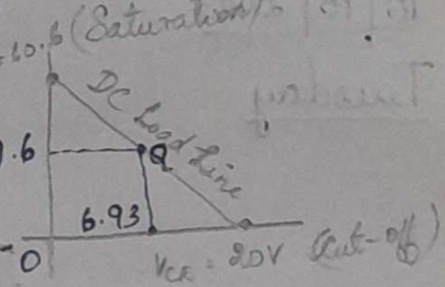
$\boxed{\text{Assume } \beta_{DC} = 200}$





$$I_B = \frac{V_{BB} - 0.7}{R_B}$$

$$I_B = \frac{10 - 0.7}{47} = \frac{9.30}{47 \times 10^{-3}} = 0.19\,mA = 190\,\Omega$$



DC Line $\leftarrow$ $I_c = \frac{V_{cc}}{R_c} = \frac{20}{330} = 0.06\,mA$ (or) $60.6\,mA$

$$V_{CE} = V_{cc} - I_c R_c$$
$$= 20 - (0.06)(330)$$
$$= 20 - 19.8$$
$$V_{CE} = 0.2$$

9/10/23

Q-Point

Input Loop:

$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{10 - 0.7}{47}$$

$$\boxed{I_B = 198\,\mu A}$$

$$I_c = \beta_{DC} I_B = (200)(198)$$

$$\boxed{I_c = 39.6}$$

Output Loop:

$$V_{CE} = V_{cc} - I_c R_c$$
$$= 20V - 13.07V = 6.93V$$

$$\boxed{V_{CE} = 6.93V}$$

$$I_c(sat) - I_{CQ} = 60.6\,mA - 39.6\,mA = 21.0\,mA$$

$$I_b = \frac{I_c}{\beta_{DC}} = \frac{21.0\,mA}{200} = 105\,\mu A$$

$$\boxed{I_b(peak) = 105\,\mu A}$$

$\boxed{V_{CE} = V_{cc}}$ $\leftarrow$ DC line

$V_{CE} = 20V$.

0.19×10^{3}
$= 190\,\Omega$

9/10/23

Stability factor:

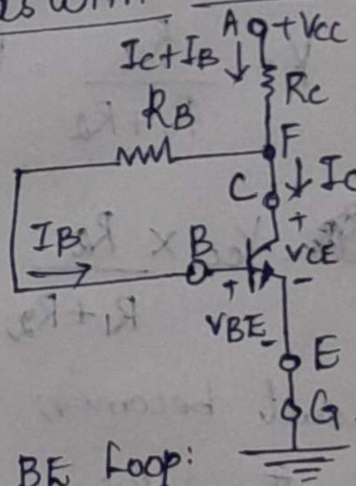
$$S = \frac{dI_c}{dI_{co}} \; ; \; I_c = \beta \cdot I_B + (1+\beta) I_{co}$$

$$= \beta \times \frac{dI_B}{dI_c} + (1+\beta)\frac{dI_{co}}{dI_c}$$

$$= \beta \times \frac{dI_B}{dI_c} + (1+\beta)\frac{1}{S}$$

$$\boxed{S = \frac{1+\beta}{1 - \beta\left(\frac{dI_B}{dI_c}\right)}}$$

Base Bias with Collector feedback:



(i) KVL to BE Loop:

$$V_{BE} - V_{cc} + (I_B + I_c) R_c + I_B \cdot R_B = 0$$

$$\boxed{\because I_c = \beta I_B}$$

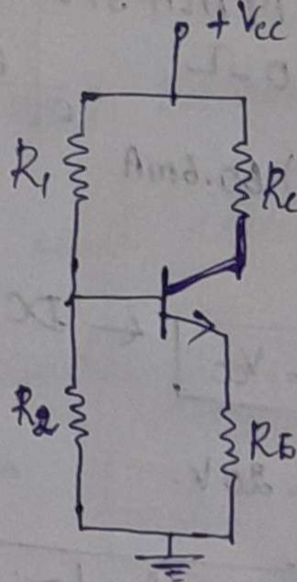
$$I_B = \frac{V_{cc} - V_{BE}}{R_B + (\beta+1) R_c} = \frac{V_{cc} - V_{BE}}{R_B + \beta \cdot R_c}$$

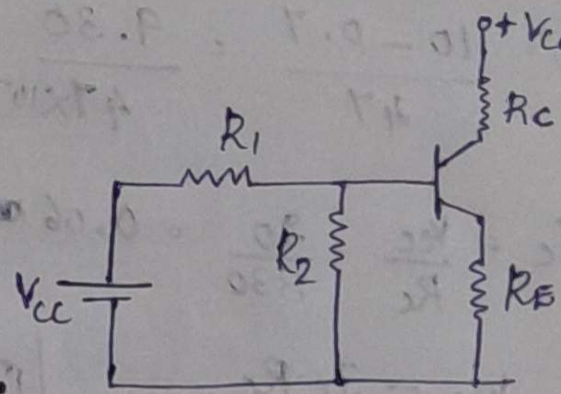
$$I_c = \beta \cdot I_B = \frac{V_{cc} - V_{BE}}{R_c + R_B/\beta} = \frac{V_{cc}}{R_c + R_B/\beta}$$

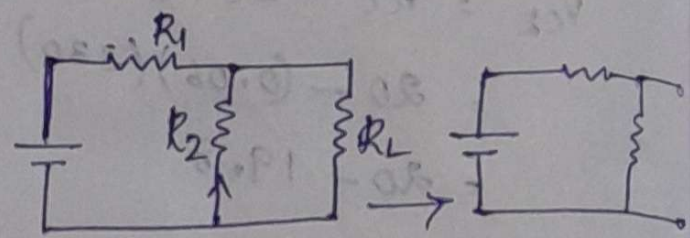
$(\because V_{cc} >> V_{BE})$

10/10/2023
Tuesday

Voltage divider Bias







Thevinins Theorem:

Remove the Load Resistance (R_L) and find the open circuit voltage.

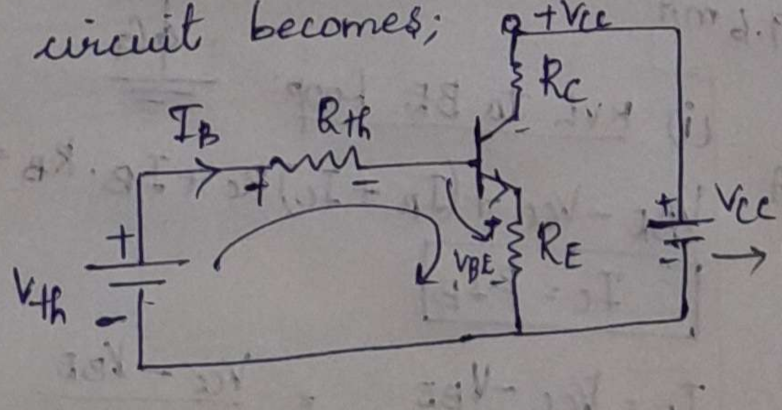
Voltage divider rule:-

Total Supply voltage × $\frac{\text{Resistance}}{\text{Total resistance}}$ = Voltage

$$V = \frac{R_2}{R_1 + R_2} = V_2$$

$$V_{th} = V_{cc} \times \frac{R_2}{R_1 + R_2} \quad ; \quad R_{th} = \frac{R_1 R_2}{R_1 + R_2}$$

The circuit becomes;



$V_{th} = I_B R_{th} + V_{BE} + I_C R_E + I_B R_E$

$I_B = \frac{V_{th} - V_{BE} - I_C R_E}{R_{th} + R_E}$

→ output loop ⇒ $V_{CC} = I_C R_C + V_{CE} + I_E R_E$

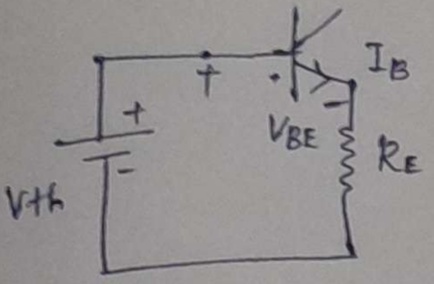
$\boxed{\because I_E = I_C + I_B}$

$$V_{th} = I_B R_{th} + V_{BE} + I_E R_E$$

$$V_{th} = I_B R_{th} + V_{BE} + (I_C + I_B) R_E$$

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

$$I_B = \frac{V_{th} - V_{BE} - I_C R_E}{R_{th} + R_E}$$



$$V_{th} = V_{BE} + I_E R_E$$

$$I_E = \frac{V_{BE} - V_{th}}{R_E}$$

Output loop:

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

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

$$= V_{CC} - I_C R_C - I_C R_E$$

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

$$S = \frac{1+\beta}{1-\beta\left(\frac{dI_B}{dI_C}\right)}$$

$$I_B = \frac{V_{th} - V_{BE} - I_C R_E}{R_{th} + R_E}$$

$$\frac{dI_B}{dI_C} = \frac{1}{R_{th}+R_E} \cdot \frac{d}{I_C}\left(\overset{0}{\cancel{V_{th}}} - \overset{0}{\cancel{V_{BE}}} - I_C R_E\right)$$

$$\frac{dI_B}{dI_C} = \frac{-R_E}{R_{th}+R_E} \Rightarrow S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_{th}+R_E}\right)}$$

$[R_{th} <<< R_E]$

$$S = \frac{1+\beta}{1+\beta \cdot \frac{1}{\left(\frac{R_{th}}{R_E}+1\right)}} = \frac{1+\beta}{\frac{1\left(1+\frac{R_{th}}{R_E}\right)+\beta}{1+\frac{R_{th}}{R_E}}} = \frac{(1+\beta)\left(1+\overset{0}{\cancel{\frac{R_{th}}{R_E}}}\right)}{1+\beta+\overset{0}{\cancel{\frac{R_{th}}{R_E}}}}$$

$[R_{th} <<< R_E]$

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

$S = 1 \rightarrow$ circuit more stable

$[R_{th} <<< R_E]$

9/10/23

Base bias with collector feedback Contd:-

(ii) KVL to CE Loop:

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

$$V_{CE} = V_{CC} - I_C \cdot R_C \quad [I_C = mA,\ I_B = mA]$$

Stability factor:

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

$$I_B = \frac{V_{CC} - V_{BE} - I_C \cdot R_C}{R_C + R_B}$$

$$S = \frac{1+\beta}{1-\beta\left(\frac{dI_B}{dI_C}\right)}$$

$$= \frac{1+\beta}{1-\beta\left[\frac{-R_C}{R_C+R_B}\right]} = \frac{1+\beta}{1+\beta\left[\frac{R_C}{R_C+R_B}\right]}$$