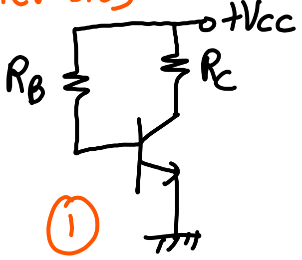
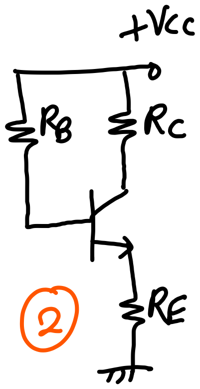
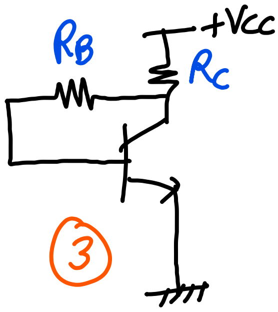
AEC lec 8 3/8/23

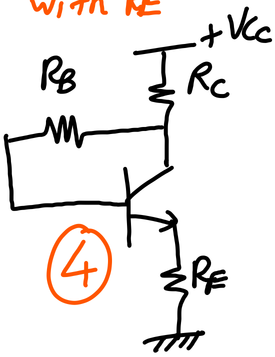
BJT Biasing ckts:

1. Fixed bias
2. Emitter bias
3. Collector to base bias
4. C to B bias with R_E





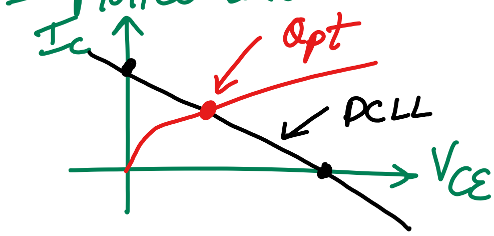




Forward-Active mode
B-E J^n: F.B
B-C J^n: R.B

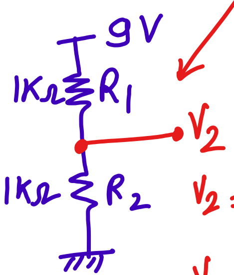
"DC Analysis" → Qpt ≡ (V_{CEQ}, I_{CQ})
→ S

– Plotted load line



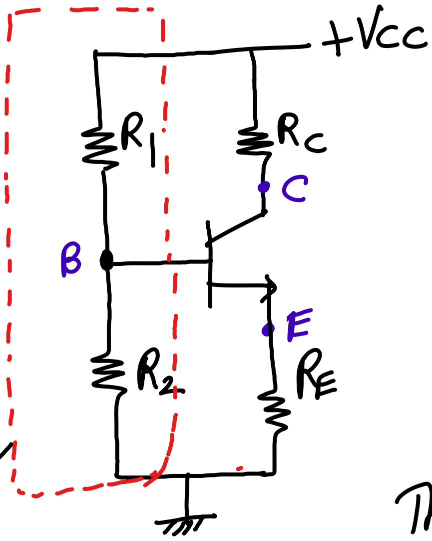
⑤ Voltage-divider biasing:

$R_1 - R_2$ form of voltage-divider



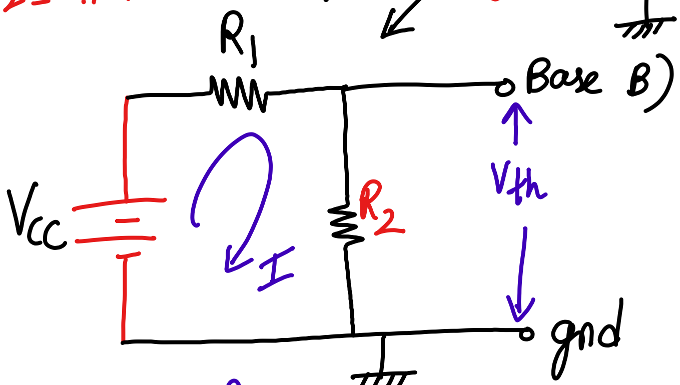
$V_2 = \frac{R_2}{R_1+R_2} \times V_{CC}$

$V_2 = 4.5V$



R_1 & R_2 divides the V_{CC} vtg at the base
↓
VDB

Thevenin's thm



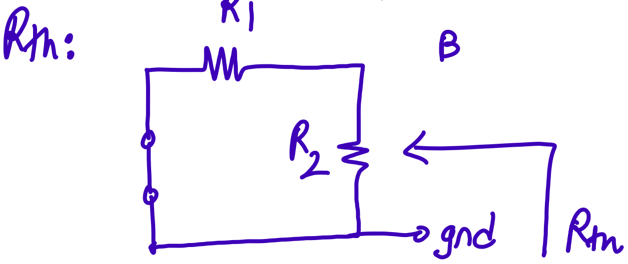
Thevenin's thm at B & gnd
Vth Rth

$I = \frac{V_{CC}}{R_1+R_2}$

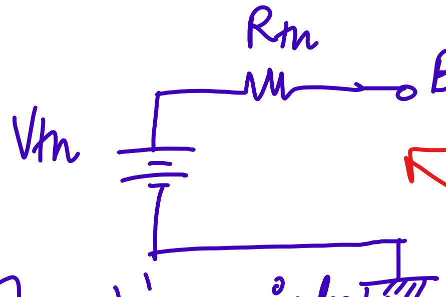
$V_{th} = I R_2$

$$\boxed{V_{th} = \frac{R_2}{R_1+R_2} V_{CC}}$$

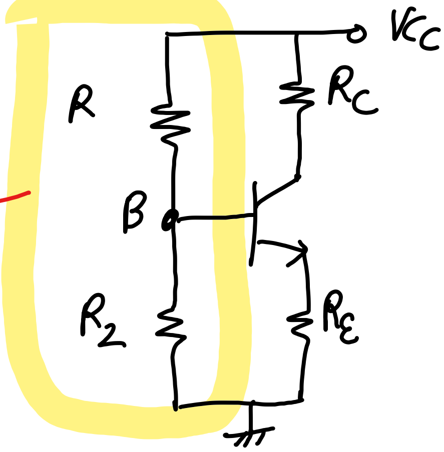
Rth:

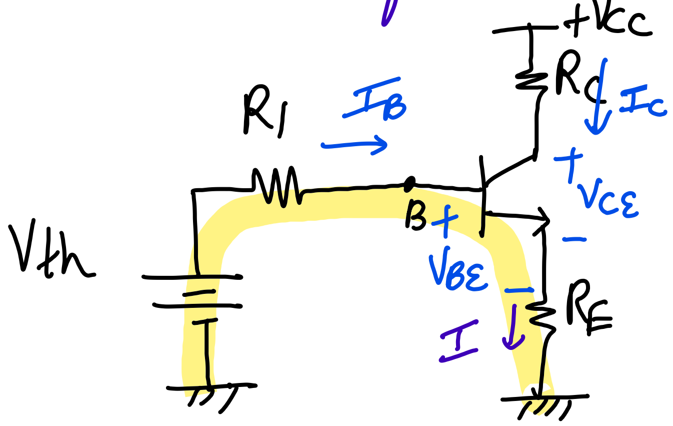


$R_{th} = R_1 \| R_2 = \frac{R_1 R_2}{R_1+R_2}$



Thevenin's equivalent ckt at Base of BJT





$$V_{th} = \frac{R_2}{R_1+R_2} V_{cc}$$
$$R_{th} = R_1 \parallel R_2$$

KVL to I/P (B−E) loop,

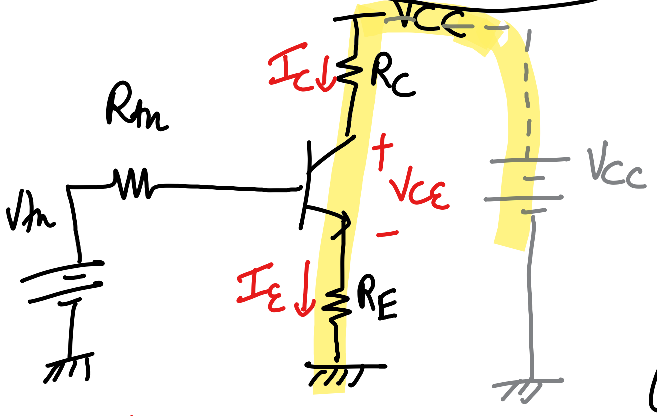
$$V_{th} - I_B R_{th} - V_{BE} - (1+\beta) I_B R_E = 0$$

$$V_{th} - V_{BE} = I_B\left[R_{th} + (1+\beta)R_E\right]$$

$$I_E = I_C + I_B = \beta I_B + I_B$$
$$I_E = (1+\beta) I_B$$

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

$$I_Q = \beta I_{BQ}$$



KVL to o/p (CE) loop,

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

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

$$Q_{pt} \equiv (V_{CEQ}, I_{CQ})$$

$$I \approx I_C \quad I_E = \frac{I_C}{\alpha}$$
$$I_C = \alpha I_E$$

Stability factor $S = \dfrac{\partial I_C}{\partial I_{CO}}$; $S = \dfrac{1+\beta}{1-\beta\left(\dfrac{\partial I_B}{\partial I_C}\right)}$

$$\frac{\partial I_B}{\partial I_C} = ?$$

KVL to I/P, $V_{th} - I_B R_B - V_{BE} - (I_C + I_B) R_E = 0$

Differentiate w.r.t I_C,

$$0 - \frac{\partial I}{\partial I_C} R_{th} - 0 - R_E - \frac{\partial I_B}{\partial I_C} R_E = 0$$

$$-R_E = \frac{\partial I_B}{\partial I_C}(R_E + R_{th})$$

$$\boxed{\frac{\partial I_B}{\partial I_C} = -\frac{R_E}{R_E + R_{th}}}$$

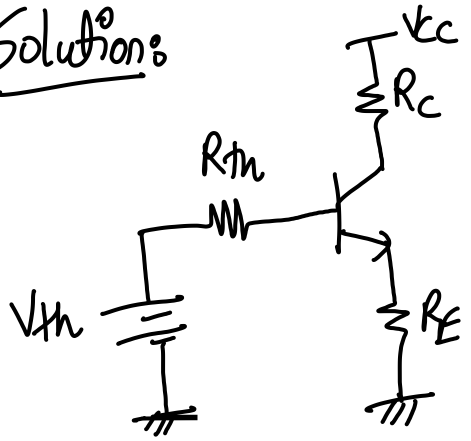
$$\boxed{S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_E + R_{th}}\right)}}$$

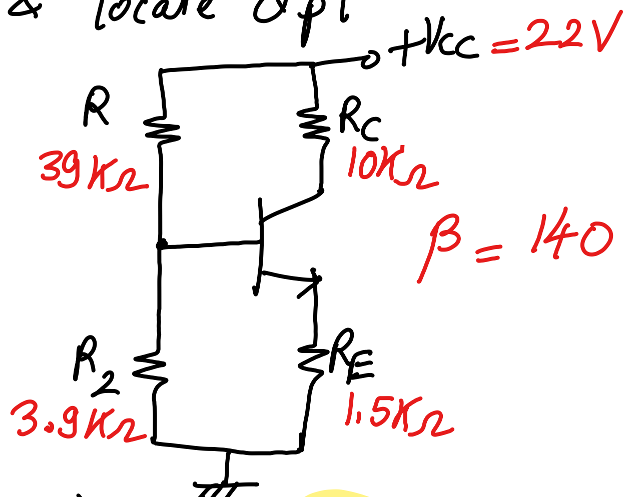
VDB

"Best biasing technique"

Numerical 8: Find V_{CEQ}, I_{CQ} and S for the ckt shown below. Also plot DC load line & locate Q pt

Solution:





① $V_{th} = \left(\frac{R_2}{R_1+R_2}\right)V_{CC} = \left(\frac{3.9}{3.9+39}\right)22 = 2V$

② $R_{th} = R_1 \| R_2 = 39K\Omega \| 3.9K\Omega = 3.545 K\Omega$

③ $I_{BQ} = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta)R_E} = \frac{2-0.7}{3.545\times10^3 + 141\times1.5\times10^3}$

$V_{BE} = 0.7V$ (Assume)

$I_{BQ} = 6.04 \mu A$

④ $I_{CQ} = \beta I_{BQ} = 140\times6.04\times10^{-6} = 0.846mA$

⑤ $V_{CEQ} = V_{CC} - I_C(R_C + R_E) = 22 - 0.846\cancel{\times10^{-3}}(10+1.5)\cancel{\times10^{3}}$

$V_{CEQ} = 12.27V$

⑥ $S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_{th}+R_E}\right)} = \frac{141}{1+140\times\left(\frac{1.5}{3.545+1.5}\right)} = 3.308$

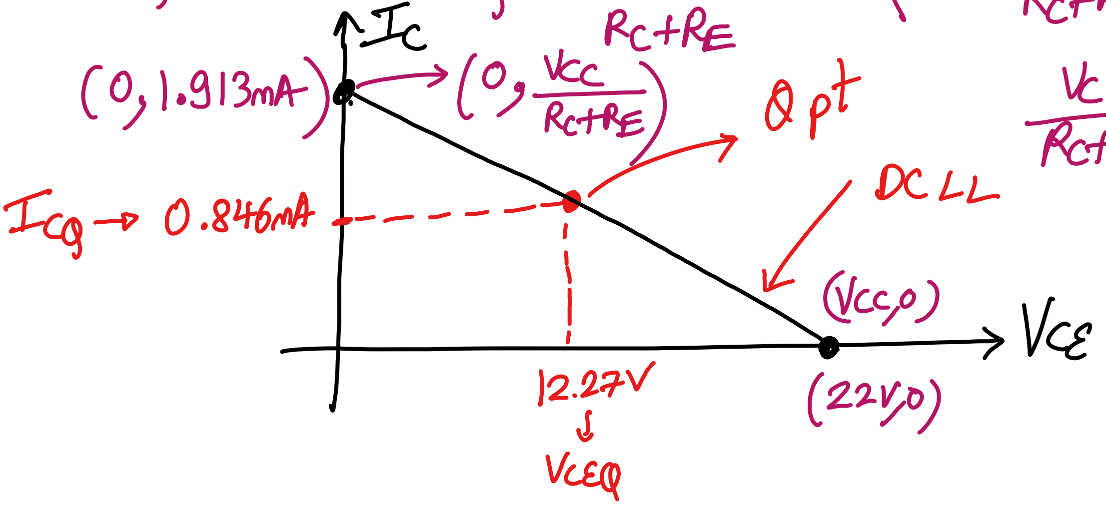
$S = \frac{\partial I_C}{\partial I_{CO}}$ → Lesser the value of S → better is the stability of the ckt

Plotting of DC load line:

$V_{CEQ} = V_{CC} - I_{CQ}(R_C + R_E)$ → load line eqⁿ

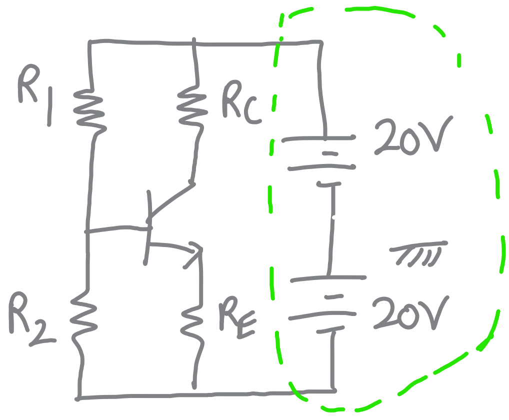
a) Put $I_{CQ} = 0$ → $V_{CEQ} = V_{CC}$ → $(V_{CC}, 0)$

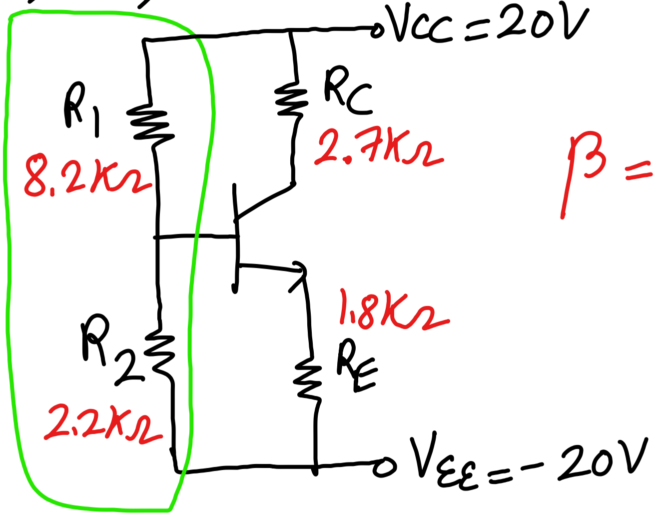
b) Put $V_{CEQ} = 0$ → $I_{CQ} = \frac{V_{CC}}{R_C + R_E}$ → $\left(0, \frac{V_{CC}}{R_C + R_E}\right)$



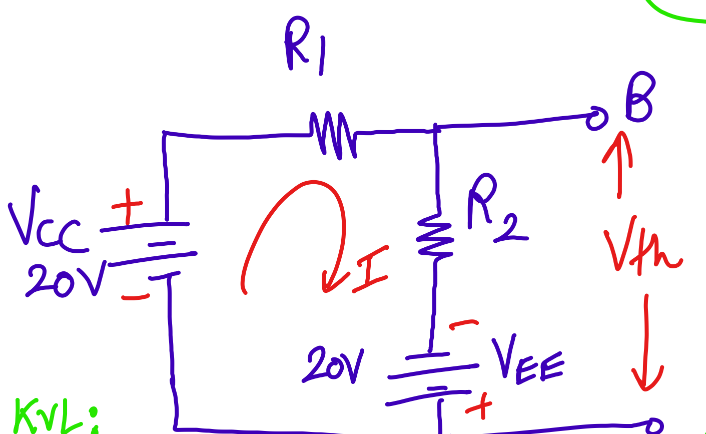
$\frac{V_{CC}}{R_C + R_E} = \frac{22}{(10+1.5)K}$

Numerical 9: Find V_{CEQ}, V_C, V_B, and I_{CQ} for ckt shown below:





$\beta = 120$



KVL:
$V_{CC} - IR_1 - IR_2 + V_{EE} = 0$

$I = \frac{V_{CC} + V_{EE}}{R_1 + R_2}$

$I = \frac{20 + 20}{8.2K + 2.2K} = 3.85mA$

$$V_{th} = IR_2 - V_{EE} = 3.85\times10^{-3} \times 2.2\times10^{3} - 20$$

$$V_{th} = -11.53\,V$$

$$R_{th} = R_1 \parallel R_2 = 8.2k \parallel 2.2k\Omega = 1.73\,k\Omega$$

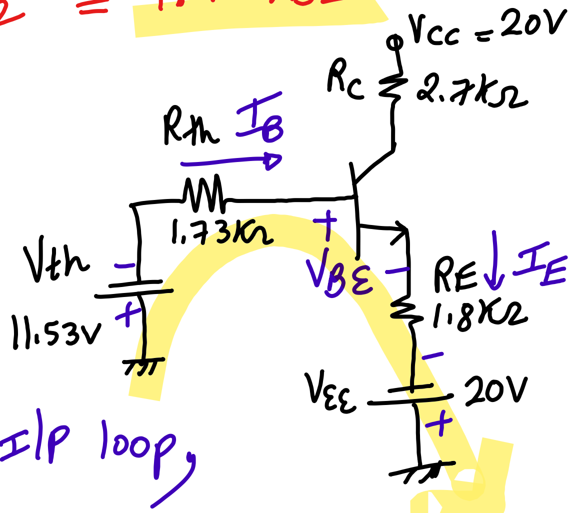
7, 85, 25, 24, 38 72,
45, 33, 11, 22, 44, 67,
41, 6, 26, 8, 50, 64,
40, 42, 39

Attendance (AEC lec 8)
(4/8/23)

$$V_{BE(on)} = 0.7V$$

assume

$$I_E = (1+\beta) I_B$$



→ KVL to I/P loop,

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

i.e $$-11.53 - I_B R_{th} - V_{BE} - (1+\beta) I_B R_E + 20 = 0$$

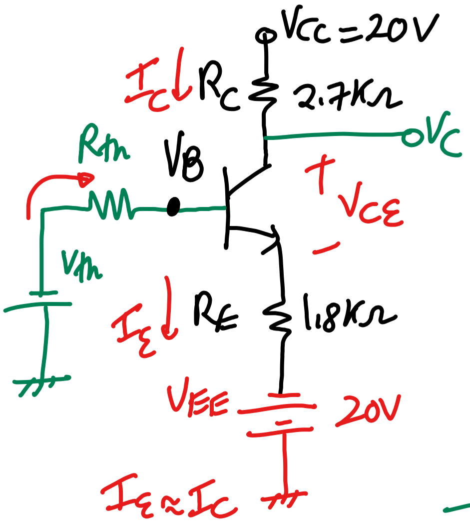
V_{th} ↓, ↓ 0.7V, ↑ V_{EE}

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

i.e $$I_{BQ} = \frac{20 - 11.53 - 0.7}{1.73\times10^3 + 121\times1.8\times10^3}$$

i.e $$I_{BQ} = 35.39\,\mu A$$

$$\rightarrow I_{CQ} = \beta I_{BQ} = 120 \times 35.39\times10^{-6} = 4.25\,mA$$



KVL to o/p loop,

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

$$V_{CEQ} = V_{CC} + V_{EE} - I_C (R_C + R_E) \qquad I_E \approx I_C$$

$$V_{CEQ} = 20 + 20 - 4.25\times\cancel{10^{-3}} (2.7 + 1.8)\times\cancel{10^{3}}$$

$$V_{CEQ} = 20.875\,V$$

$I_E \approx I_C$

$$\rightarrow I_C = \frac{V_{CC} - V_C}{R_C} \qquad \rightarrow V_C = V_{CC} - I_C R_C$$

$$V_C = 20 - 4.25\times\cancel{10^{-3}} \times 2.7\times\cancel{10^{3}}$$

$$V_C = 8.53\,V$$

$$V_B = -V_{th} - I_B R_{th}$$

$$\rightarrow I_B = \frac{-V_{th} - V_B}{R_{th}}$$

$$I_B R_{th} = -V_{th} - V_B$$

$$V_B = -11.53 - 35.39\times10^{-6} \times 1.73\times10^{3} \Rightarrow V_B = -11.59\,V$$