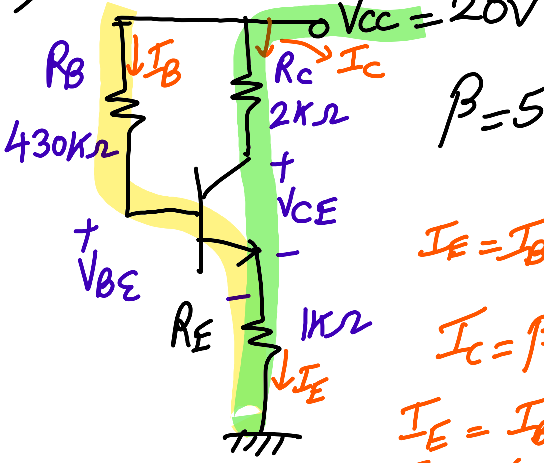
AEC lec 7 2/8/23

Numerical 4: For the following circuit, find I_B, I_C & V_{CE}, S



$\beta = 50$

$I_E = I_B + I_C$

$I_C = \beta I_B$

$I_E = I_B + \beta I_B$

$I_E = (1+\beta) I_B$

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

"Emitter bias"

Solution:

a) KVL to i/p loop (B-E): → I_B expression

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

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

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

$$\boxed{I_{BQ} = \frac{V_{CC} - V_{BE}}{R_B + (1+\beta) R_E}} \quad \mu A$$

i.e $I_{BQ} = \left(\dfrac{20 - 0.7}{430\times10^3 + 51 \times 1\times10^3}\right) = \underline{40.12}\ \mu A$

i.e $I_{CQ} = \beta I_{BQ} = 50 \times 40.12\mu A = \underline{2.01\ mA}$

V_{CEQ}: KVL to o/p loop (B-C),

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

$$\boxed{V_{CEQ} = V_{CC} - I_C R_C - I_E R_E}$$

$I_E \approx I_C$ $\quad (I_B + I_C)$

$$I_E = I_B + I_C$$

(mA = μA + mA)

$$V_{CEQ} = 20 - (2.01\times\cancel{10^{-3}} \times 2\times\cancel{10^{3}}) - (40.12\times10^{-6} + 2.01\times10^{-3}) \times 1\times10^3$$

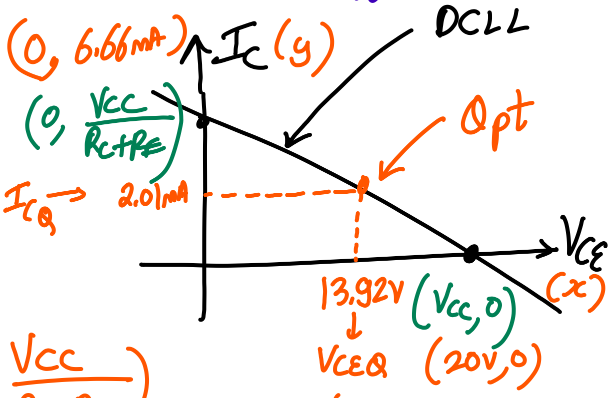
$$V_{CEQ} = \underline{13.92}\ V$$

Plot of DC load line:

$V_{CE} = V_{CC} - I_C(R_C + R_E)$ → load line eq^n

① Put $I_C = 0$, $V_{CE} = V_{CC}$ → $(V_{CC}, 0)$

② Put $V_{CE} = 0$, $I_C = \dfrac{V_{CC}}{R_C + R_E}$ → $\left(0, \dfrac{V_{CC}}{R_C+R_E}\right)$



Q pt = (V_{CEQ}, I_{CQ})

$$\underset{(y)}{I_C} = \frac{-V_{CE}^{(x)}}{\underset{\downarrow\, m}{R_C+R_E}} + \frac{V_{CC}^{(c)}}{R_C+R_E} \qquad (y = mx + c)$$

$$m = \frac{-1}{R_C+R_E} \qquad (y = mx+c)$$

$$c = \frac{V_{CC}}{R_C+R_E}$$

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

KVL to i/p, $\boxed{V_{CC} - I_B R_B - V_{BE} - (I_B + I_C) R_E = 0}$ — ①

Diff eqⁿ ① w.r.t I_C,

$$0 - R_B \frac{\partial I_B}{\partial I_C} - 0 - R_E - R_E \frac{\partial I_B}{\partial I_C} = 0$$

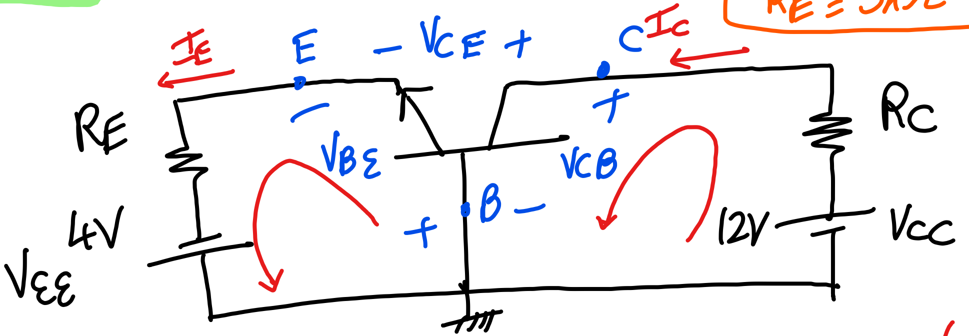
$$\frac{\partial I_B}{\partial I_C}(R_B + R_E) = -R_E$$

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

$$\boxed{S = \frac{1+\beta}{1+\beta\left(\dfrac{R_E}{R_B+R_E}\right)}} = \frac{1+50}{1+50\times\left(\dfrac{1K}{430K+1K}\right)} = \underline{45.69}$$

Numerical 5: Find R_C & R_E

$\boxed{R_C = 5.2K\Omega \quad R_E = 3K\Omega}$ → Answers



$\alpha = 0.99$

$I_E = 1.1mA$

$V_{CE} = 7V$

$V_{BE} = 0.7$ (assume)

Solution:

① KVL to I/p (B-E) loop, $V_{EE} - I_E R_E - V_{BE} = 0$

$$R_E = \frac{V_{EE} - V_{BE}}{I_E} = \frac{4-0.7}{1.1\times10^{-3}} = \underline{3K\Omega}$$

$$I_C = \alpha I_E = 0.99 \times 1.1mA = \underline{1.089\,mA}$$

② $V_{CB} = V_{CE} - V_{BE} = 7 - 0.7 = \underline{6.3V}$ ($V_{BC} = -6.3V \rightarrow$ B-C J^n is R.B)

③ KVL to the o/p (B-C) loop,

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

i.e $I_C R_C = V_{CC} - V_{CB}$

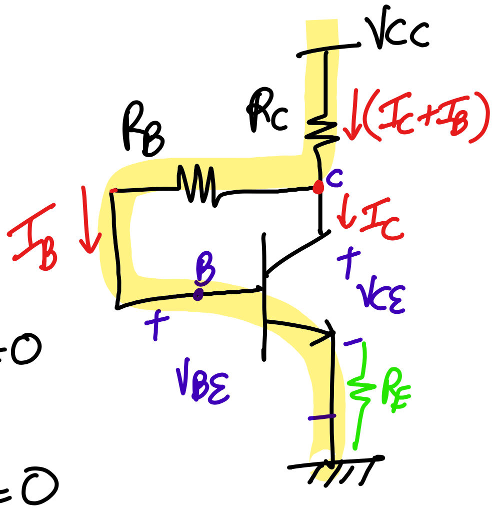
i.e $R_C = \dfrac{V_{CC} - V_{CB}}{I_C}$

i.e $R_C = \dfrac{12 - 6.3}{1.089 \times 10^{-3}}$

i.e $\boxed{R_C = 5.23 K\Omega}$

II Collector to base bias:

$\rightarrow$ Find Opt $\equiv (V_{CEQ}, I_{CQ})$



R_B bet^n C & B

① KVL to I/p loop, $\rightarrow I_{BQ}$

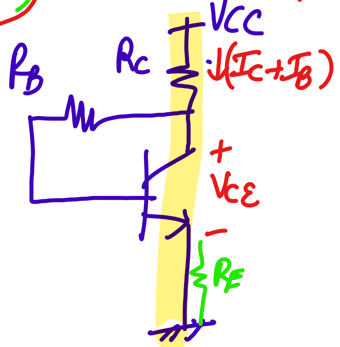
$$V_{CC} - (I_C + I_B)R_C - I_B R_B - V_{BE} = 0$$

$I_C \rightarrow \beta I_B$

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

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

; $I_{CQ} = \beta I_{BQ}$



② KVL to o/p loop,

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

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

③ $S = \dfrac{1+\beta}{1-\beta\left(\dfrac{\partial I_B}{\partial I_C}\right)}$ — ①

KVL to I/P, $V_{CC} - (I_C+I_B)R_C - I_B R_B - V_{BE} = 0$ — ②

Diff eqⁿ ② w.r.t I_C,

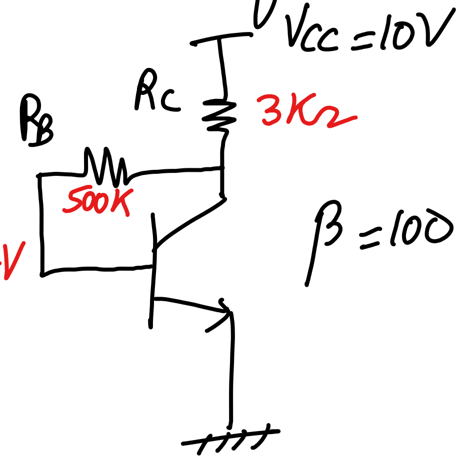
$$0 - R_C - \frac{\partial I_B}{\partial I_C}R_C - \frac{\partial I_B}{\partial I_C}R_B - 0 = 0$$

$$-\frac{\partial I_B}{\partial I_C}(R_C+R_B) = R_C$$

$$\boxed{\frac{\partial I_B}{\partial I_C} = -\frac{R_C}{R_C+R_B}}$$

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

Numerical 6: Find I_{BQ}, I_{CQ}, V_{CEQ} and S for ckt below,



KVL to I/p loop,

$$I_{BQ} = \frac{\overset{10V}{V_{CC}} - \overset{0.7}{V_{BE}}}{\underset{500\times10^3}{R_B} + \underbrace{(1+\beta)}_{101}\underset{3\times10^3}{R_C}}$$

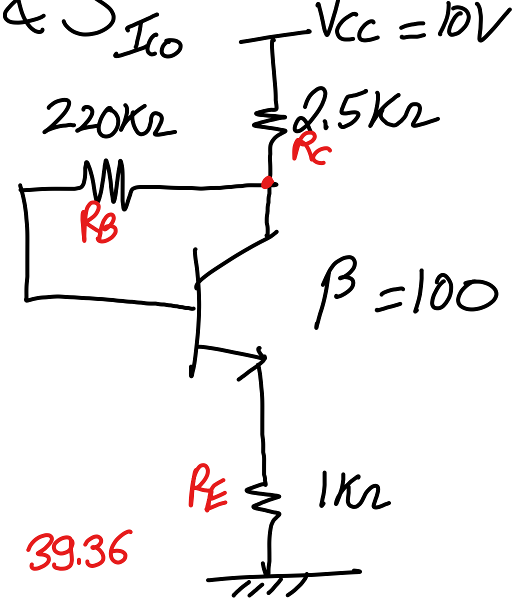
$I_{BQ} = \underline{11.58}\ \mu A$; $I_{CQ} = \underline{1.158}\ mA$

KVL to o/p loop,

$$V_{CEQ} = \overset{10V}{V_{CC}} - (\overset{1.158mA}{I_C} + \overset{11.58\times10^{-6}}{I_B})\underset{3k\Omega}{R_C}$$; $V_{CEQ} = \underline{6.49\,V}$

$$S = \frac{1+\beta}{1+\beta\left(\dfrac{R_C}{R_C+R_B}\right)} = \frac{101}{1+100\left(\dfrac{3}{500+3}\right)} = \underline{63.267}$$

Numerical 7: Find I_{CQ}, V_{CEQ}, & $S_{I_{CO}}$
(HW)



$I_{CQ} = 1.62mA$, $V_{CEQ} = 4.269V$, $S = 39.36$

Solution:

① $I_{BQ} = \dfrac{\overset{10V}{V_{CC}} - \overset{0.7}{V_{BE}}}{\underset{220K}{R_B} + \underbrace{(1+\beta)}_{101}(\underset{2.5K}{R_C} + \underset{1K\Omega}{R_E})} = \underline{16.216\mu A}$

② $I_{CQ} = \beta I_B = 100 \times 16.216\mu A = \underline{1.621mA}$

③ $V_{CEQ} = \underset{10V}{V_{CC}} - (\underset{16.216\mu A}{I_B} + \underset{1.621mA}{I_C})(\underset{2.5K}{R_C} + \underset{1K\Omega}{R_E}) = \underline{4.269V}$

④ $S = \dfrac{1+\beta}{1+\beta\left(\dfrac{R_C+R_E}{R_C+R_E+R_B}\right)}$

ie $S = \dfrac{101}{1+100\left(\dfrac{2.5+1}{2.5+1+220}\right)}$

$S = \underline{39.36}$

88, 93, 69, 40, 42, 39,
97, 100, 67, 41, 7, 45, 25,
16, 80, 85, 78, 50, 58, 44, 70, 46, 64

Attendance (AEC lec 7, 2/8/23)