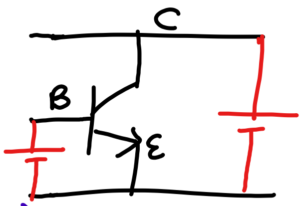
AEC lec 6 (online) 29/7/23

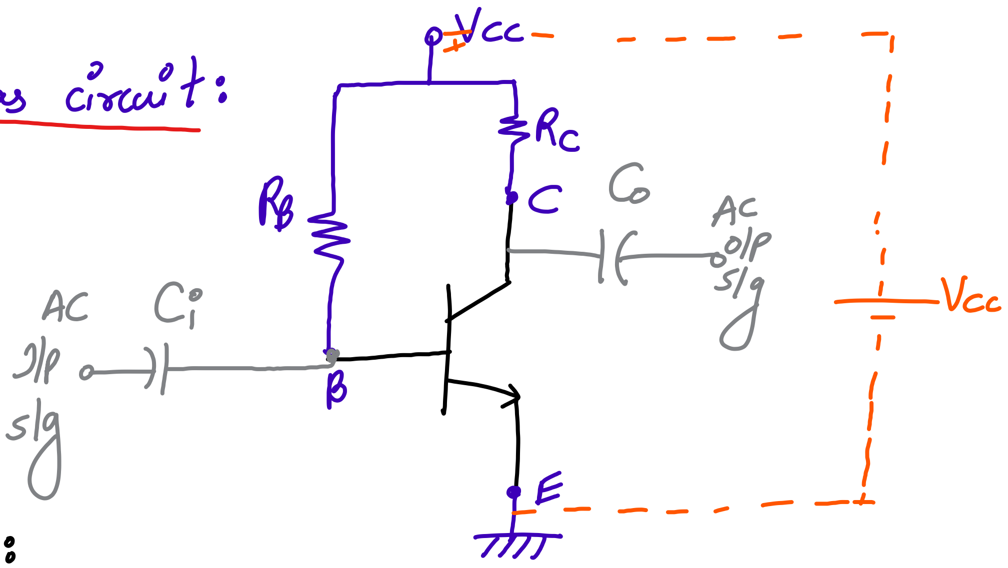
BJT biasing circuits: (eliminates need of additional power supply)



This requires 2 external supplies

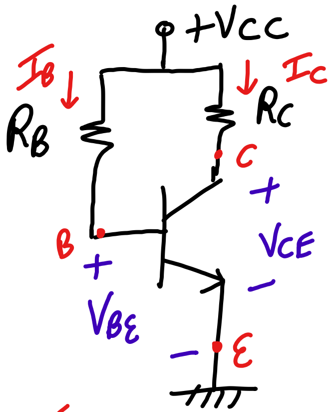
1. Fixed bias
   - ↳ Emitter bias (Fixed bias with emitter resistor)
2. Collector to base bias
   - ↳ (C to B bias with R_E)
3. Voltage-divider bias

I] Fixed bias circuit:



a) DC Analysis:

For dc → $f = 0$ → $X_C = \dfrac{1}{2\pi f C} = \infty$ → ∴ Capacitors acts as open ckt



Fixed-bias ckt

① Find Q-pt ≡ (V_{CEQ}, I_{CQ})
② Find Stability factor S or $S_{I_{co}}$
③ Plot Qpt on DC load line

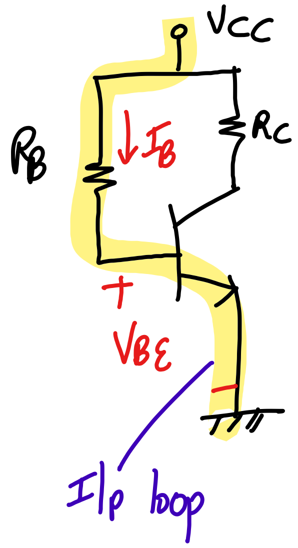
} Objectives

a) Q-point ≡ (V_{CEQ}, I_{CQ})

i) Apply KVL to i/p loop

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

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

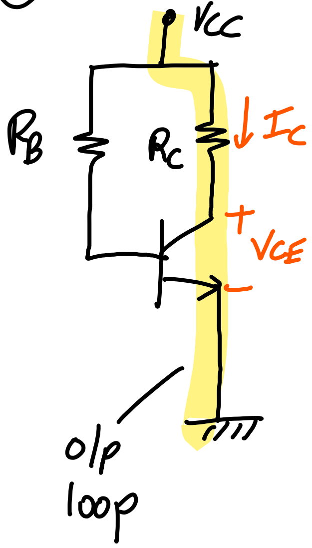


$$\boxed{I_C = \beta I_B}$$

$V_{BE_{ON}} \approx 0.7V$, $V_{CC} > 10V$, $V_{CC} >> V_{BE}$

$I_{BQ} \cong \frac{V_{CC}}{R_B}$ — V_{CC} fixed, R_B fixed } Hence, the name "fixed bias"

$$\boxed{I_{CQ} = \beta\left(\frac{V_{CC} - V_{BE}}{R_B}\right)} \quad \text{— (1)}$$



ii) Apply KVL to o/p loop,

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

$$\boxed{V_{CEQ} = V_{CC} - I_C R_C} \quad \text{— (2)}$$

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

b) Stability factor (S or $S_{I_{CO}}$)

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

KVL to i/p, $V_{CC} - I_B R_B - V_{BE} = 0$

Differentiate w.r.t I_C,

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

$$\boxed{S = 1+\beta} \text{ — Fixed bias ckt}$$

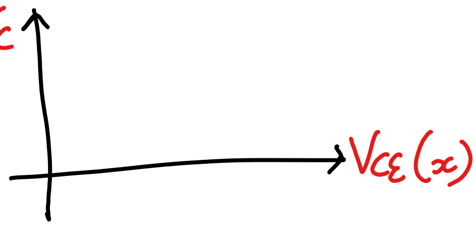
$$S = \frac{\partial I_C}{\partial I_{CO}}$$

If $\beta = 100$, $S = 101$

i.e If I_{CO} changes by 1% → I_C will change by 101%

Stability of ckt is very poor

c) Plotting of DC load line & locating Q pt on it



load line (KVL to o/p loop),

$$V_{CC} - I_C R_C - V_{CE} = 0 \quad \text{— (a)}$$

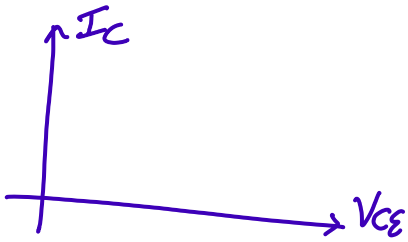
$$I_C R_C = V_{CC} - V_{CE}$$

$\to y = mx + c$

slope, y-intercept

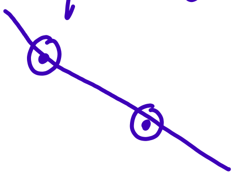
i.e. $$\boxed{I_C = -\frac{V_{CE}}{R_C} + \frac{V_{CC}}{R_C}}$$ → Eq^n of DC load line

'y' 'x'



Slope $= m = \frac{-1}{R_C}$, $c = \frac{V_{CC}}{R_C}$

To plot a straight line, we require 2 co-ordinates



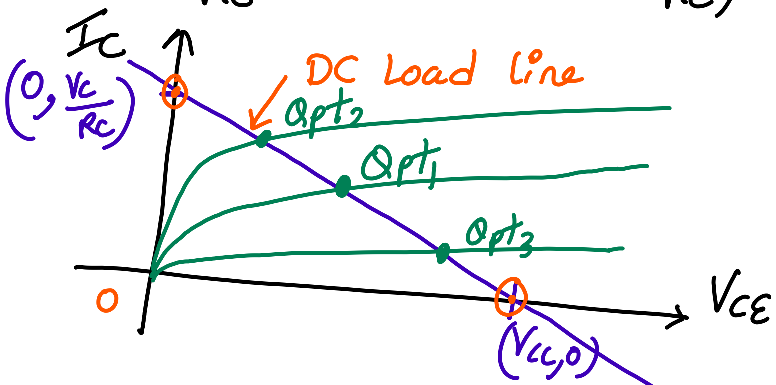
$$V_{CC} - I_C R_C - V_{CE} = 0$$

① Put $I_C = 0 \Rightarrow V_{CE} = V_{CC} \to$ 1st point: $(V_{CC}, 0)$

② Put $V_{CE} = 0 \Rightarrow I_C = \frac{V_{CC}}{R_C} \to$ 2nd point: $(0, \frac{V_{CC}}{R_C})$

Qpt$_1$ Qpt$_2$ Qpt$_3$

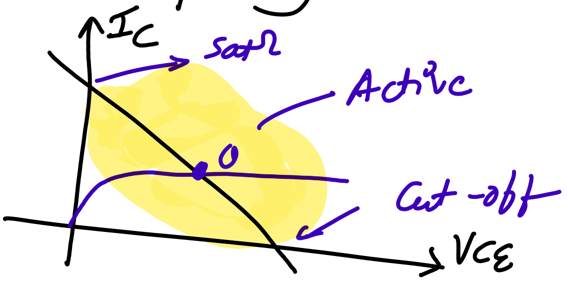
prefer this



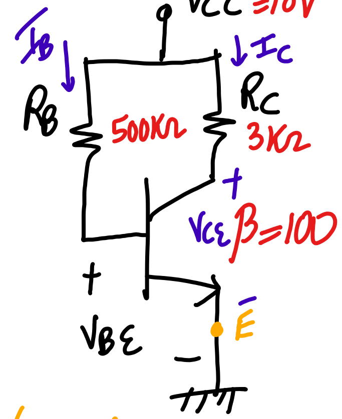
Intersection of o/p characteristics & DC load line is Qpt

Qpt → Operating point / Quiescent (Silent) point)

↳ guarantee's that bjt is operating in "Active region"



Numerical 1: For the circuit shown below, find I_{CQ}, V_{CEQ}, S, V_B, V_C & V_{BC}. Also comment on region of operation



$V_{BE} = V_B - V_E$ ↳ 0V

$V_{BE(on)} \approx 0.7V$ (Assume)

$K\Omega = 10^3 \Omega$

① $V_{CC} - I_B R_B - V_{BE} = 0$

$$I_{BQ} = \frac{V_{CC} - V_{BE}}{R_B} = \frac{10V - 0.7V}{500K\Omega}$$

$$I_{BQ} = \underline{18.6}\ \mu A$$

$\mu A = 10^{-6} A$

② $I_{CQ} = \beta I_{BQ} = 100 \times 18.6 \mu A$

$$I_{CQ} = \underline{1.86}\ mA$$

$mA = 10^{-3} A$

③ $V_{CC} - I_C R_C - V_{CE} = 0$

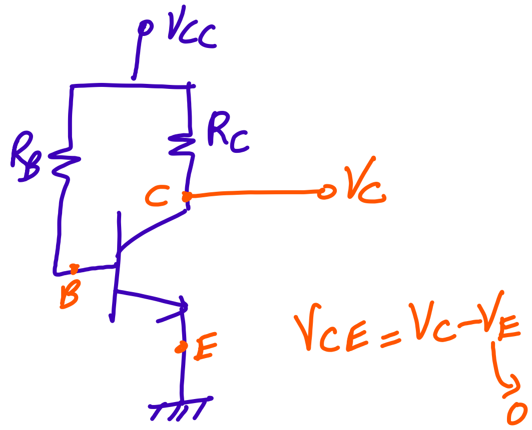
$\rightarrow V_{CEQ} = V_{CC} - I_{CQ} R_C = 10 - 1.86 \times \cancel{10^{-3}} \times 3 \times \cancel{10^{3}}$

$$V_{CEQ} = \underline{4.42}\ V$$

④ $S = 1 + \beta = 1 + 100 = \underline{101}$

⑤ $V_B = V_{BE} = \underline{0.7V}$ $(\because V_E = 0)$

⑥ $V_C = V_{CE} = \underline{4.42V}$

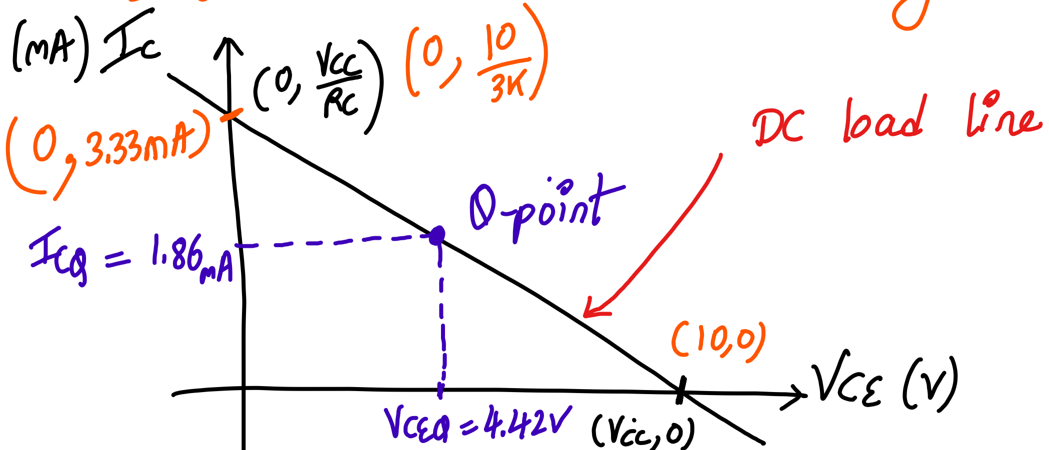


$V_{CE} = V_C - V_E$ ↳ 0

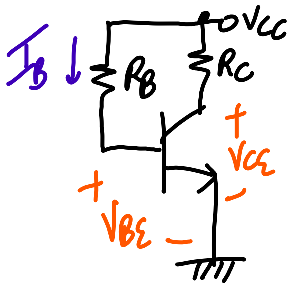
⑦ $V_{BC} = V_B - V_C = 0.7 - 4.42V$

$$\underline{V_{BC} = -3.72V}$$

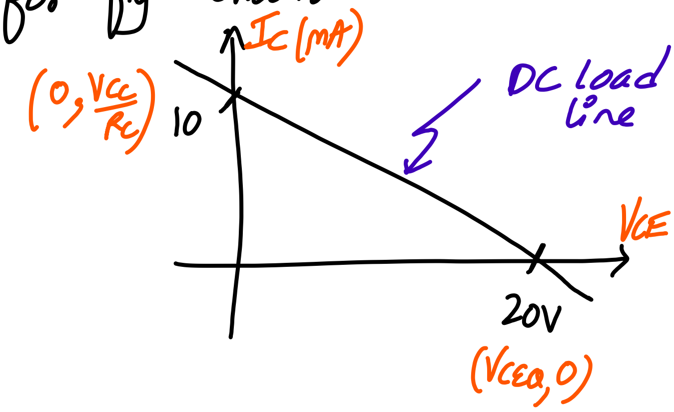
→ B-C J^n is R.B & BE J^n is F.B } BJT is operating in active region



Numerical 2: Find V_{CC}, R_C & R_B for fig shown



$\beta = 400$



Solution: a) $V_{CE} = V_{CC} = \underline{20V}$

b) $\frac{V_{CC}}{R_C} = 10mA \rightarrow R_C = \frac{V_{CC}}{10mA} = \frac{20}{10mA} = \underline{2K\Omega}$

c) KVL to I/P, $V_{CC} - I_B R_B - V_{BE} = 0$

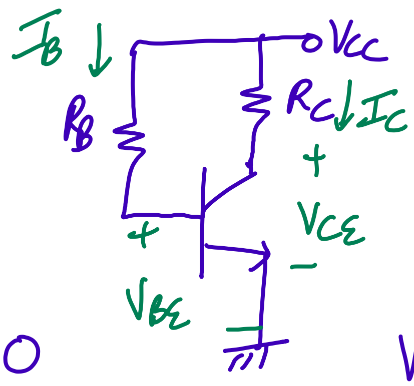
$$I_B = \frac{V_{CC} - V_{BE}}{R_B}$$

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

$$I_C = \beta I_B \Rightarrow I_B = \frac{I_C}{\beta} = \frac{10mA}{400} = \underline{25\mu A}$$

d) $R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{20 - 0.7}{25\mu A} = \underline{772}\ K\Omega$

Numerical 3: For the fixed-bias ckt, $\alpha = 0.98$, $I_{CBO} = 10\mu A$, $R_C = 3K\Omega$, $R_B = 820K\Omega$, $V_{CC} = 12V \rightarrow$ Find I_{CQ} & V_{CEQ}



Solution:

① $\beta = \frac{\alpha}{1-\alpha} = \frac{0.98}{1-0.98} = 49$

② KVL to I/P, $V_{CC} - I_B R_B - V_{BE} = 0$

$V_{BE} = 0.7V$

$$I_B = \frac{V_{CC} - V_{BE}}{R_B} = \frac{12 - 0.7}{820K\Omega} = \underline{13.78}\ \mu A$$

③ $I_{CQ} = \beta I_{BQ} + (1+\beta) I_{CBO}$

$I_{CQ} = 49 \times 13.78 \times 10^{-6} + 50 \times 10 \times 10^{-6}$

$I_{CQ} = \underline{1.175}$ mA

④ KVL to o/p loop, $V_{CC} - I_C R_C - V_{CE} = 0$

$\rightarrow V_{CEQ} = V_{CC} - I_C R_C$

$V_{CEQ} = 12 - 1.175 \cancel{\times 10^{-3}} \times 4 \cancel{\times 10^{3}}$

$\therefore V_{CEQ} = \underline{7.3}$ V

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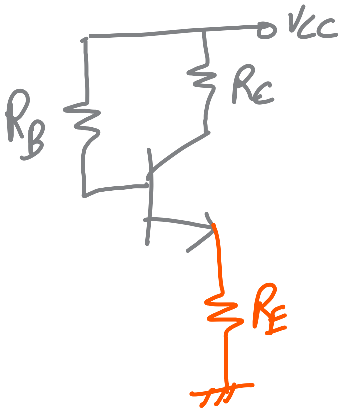
Next time: Emitter Bias (Fixed bias with R_E)

Investigate next lecture



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

b) S

c) Plot DC Load Line & locate Q pt