

①
Lec (8)

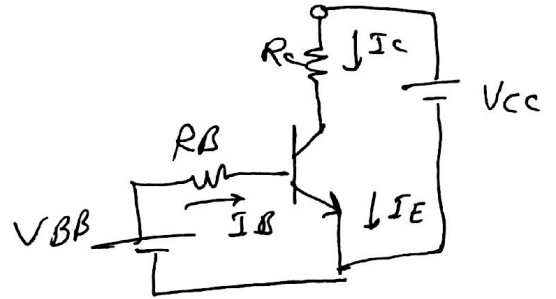
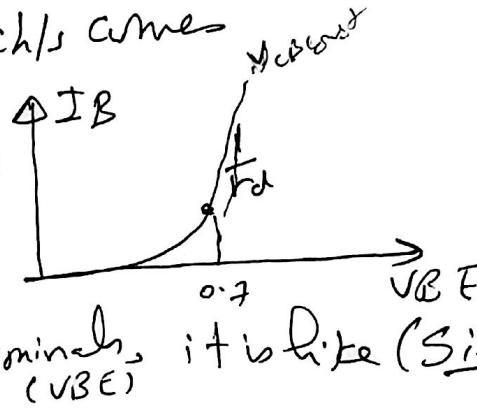
I Common emitter configuration

→ The most famous Technique used in design of Amplifiers.
 This Because The emitter is Common in input & o/p loops.

→ characteristics curve (ch/s curve)

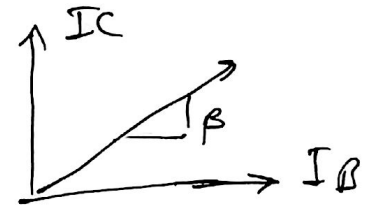
There are 3 - ch/s curves

I input ch/s
 (E-B ch/s)
 The relation between
 input current I_B &
 input voltage terminals
 (V_{BE})



II control ch/s

The relation between output current and input current (I_C, I_B), it is linear relation due to $I_C = \beta I_B$

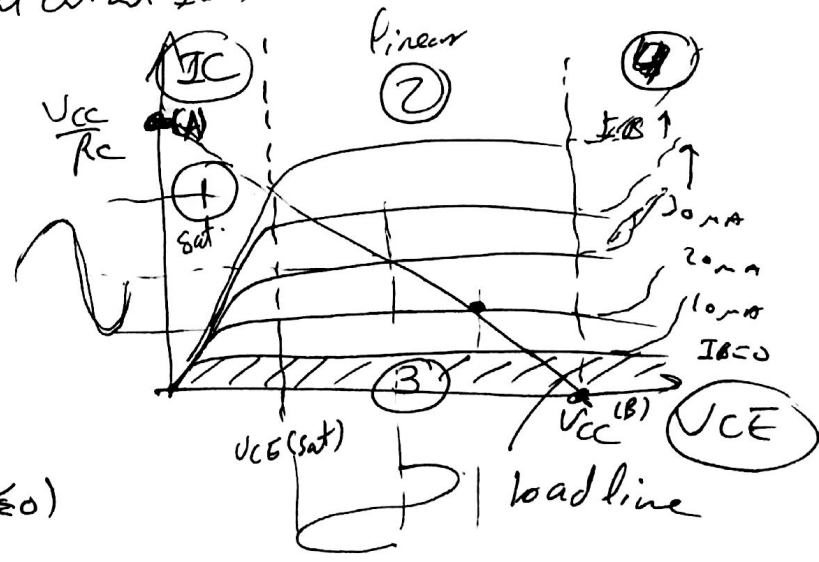


III output ch/s (transfer ch/s) (C-E ch/s)

→ it is measured between output current I_C & output voltage (V_{CE}) at constant values for (input current I_B)

→ The load line intersects the ch/s in 4 regions

- region ① Saturation Region
- region ② Linear Region
- region ③ Cut off region ($I_B \leq 0$)
- region ④ break down region



(2)

* For I/p chls (E-B chls)

- $I_B = I_0 e^{V_{BE}/nV_T}$ $\rightarrow \text{diode eqn}$
- $I_C = \beta I_B$, or $I_C = \beta I_0 e^{V_{BE}/nV_T}$
- dynamic resistance = $\frac{nV_T}{I_{BQ}} \approx \frac{n\beta V_T}{I_{CQ}}$

** For o/p chls (C-E chls)

i) Cutoff region $I_B = 0$ (Switch off)
 $I_C = I_{CBO} + \alpha I_E = I_{CBO} + \alpha [I_C + I_{CBO}]$

$$\begin{aligned} \therefore I_C - \alpha I_C &= I_{CBO} \\ I_C [1 - \alpha] &= I_{CBO} \end{aligned}$$

$$I_C = \frac{1}{1 - \alpha} I_{CBO}$$

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

\approx Very small current (neglected)

$$\approx V_{CE} = V_{CC} - I_C R_C \rightarrow \text{very small} \approx V_{CC}$$

$$\begin{aligned} \beta &= \frac{\alpha}{1 - \alpha} \\ \beta - \alpha\beta &= \alpha \\ \beta &= \alpha\beta + \alpha = \alpha(\beta + 1) \\ \alpha &= \frac{\beta}{\beta + 1} \\ \frac{1}{1 - \alpha} &= \frac{1}{1 - \frac{\beta}{\beta + 1}} = \frac{1}{\frac{\beta + 1 - \beta}{\beta + 1}} = \frac{1}{\frac{1}{\beta + 1}} = \beta + 1 \end{aligned}$$

at I/p cutoff $I_B = 0$, I_C neglected, $V_{CE} \approx V_{CC}$

(ii) Linear region $I_B \uparrow \rightarrow I_C \uparrow \rightarrow V_{CE} \downarrow$ (Amplifier)
 $\therefore V_{CE} = V_{CC} - I_C R_C$, $I_C = \beta I_B$

(iii) Saturation region $I_B \uparrow$ I_C (max) , V_{CE} (sat)
 $V_{CE}(\text{sat}) = V_{CC} - I_{Cmax} R_C \approx 0.2V$ (F.P. side)
 $I_C = I_{Csat} = I_{Cmax}$ (Switch)

(3)

(iv) Load line equation

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

at $I_C = 0 \rightarrow V_{CE} = V_{CC} \rightarrow$ Point (A)

at $V_{CE} = 0 \rightarrow I_C = V_{CC}/R_C \rightarrow$ Point (B)

\rightarrow @ Point P, I_C & V_{CE} \rightarrow operating point selected according to

The uses of transistor

(i) if it is used as Amplifier \rightarrow @ point selected in linear region

(ii) " " " " Switch \rightarrow " " " " Saturation region & (may be cutoff)

\rightarrow @ point selected by selecting (I_B)

EX(1) Find I_B, I_C with shown ch/s of $V_{BE} = 0.7V$ & calc β_{DC}

$V_{CE} = 6V$ & calc β_{DC}

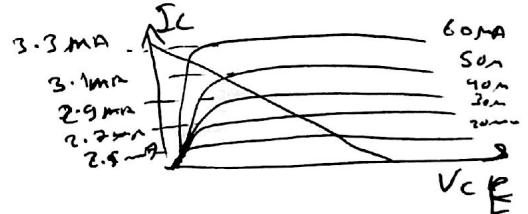
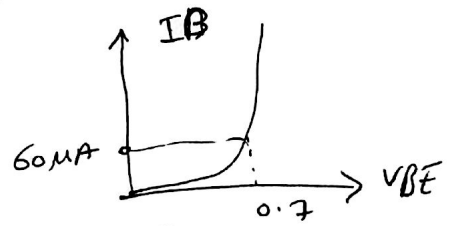
Sol \rightarrow From i/p ch/s curve

at $V_{BE} = 0.7 \rightarrow I_B \approx 60\mu A$

From o/p ch/s curve

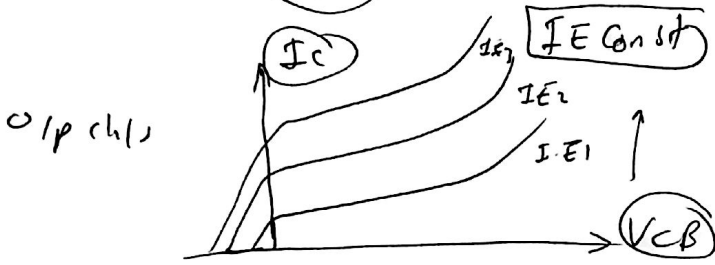
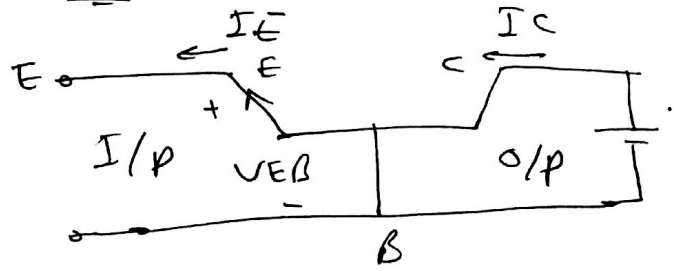
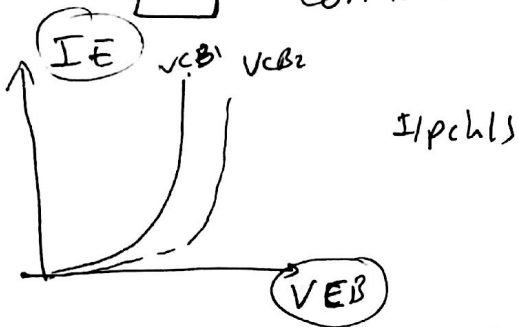
at $V_{CE} = 6V$ & $I_B = 60\mu A \rightarrow I_C \approx 3.3mA$

$$\therefore \beta_{DC} = \frac{I_C}{I_B} = \frac{3.3mA}{60\mu A} \approx 55$$

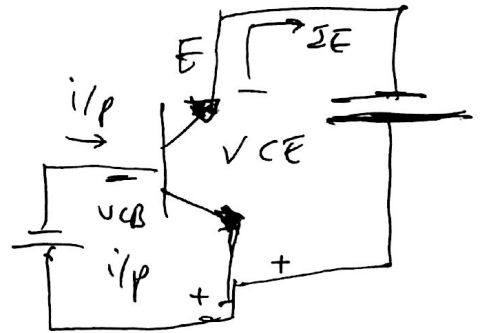
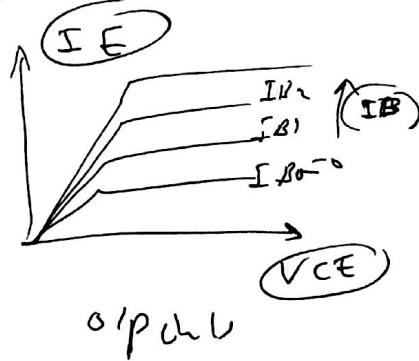
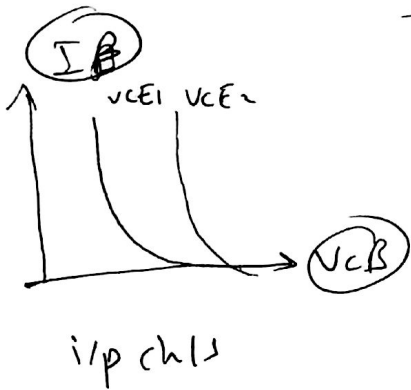


(4)

2 Common Base chls



3 Common collector chls



page 68

Biasing Circuits

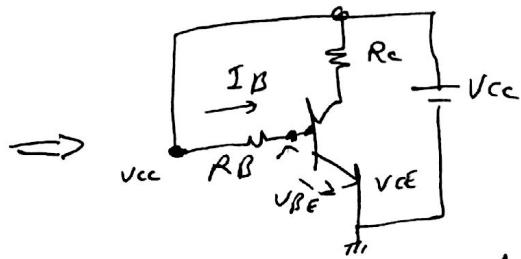
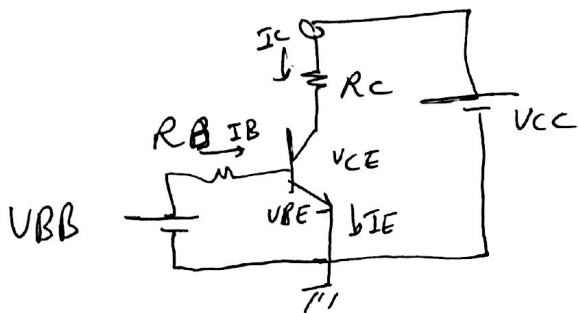
دوائر تغذية، استقرار

There are 4 types of Biasing circuits (to satisfy stability)

- 1- Base Bias [Fixed Current Bias]
- 2- Emitter Bias
- 3- Voltage doubler Bias
- 4- collector feedback Bias

(5)

1- Base Bias [Fixed Current Bias]



practical circuit
لتوفير البطارية

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

$$I_C = \beta I_B = \beta \left[\frac{V_{BB} - V_{BE}}{R_B} \right]$$

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

$$I_C = \beta I_B$$

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

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

disadvantage of this circuit

I_C dependent on β & V_{CE} dependent on β
& β depend on Temp (not stable circuit)

Ex(2) Find the percentage change in Q point for base bias circuit $R_C = 560 \Omega$, $R_B = 100 k\Omega$, $V_{CC} = 12V$ increase of temperature from $(25^\circ C, \text{ to } 75^\circ)$ make change for $\beta (100 \rightarrow 150)$ respectively

sol/ $I_C = \beta I_B = \beta \left[\frac{V_{BB} - V_{BE}}{R_B} \right] \Rightarrow$ $V_{CC} = V_{BB}$ (اعتبره)

at $25^\circ C \rightarrow I_C = 100 \left[\frac{12 - 0.7}{100k} \right] = 11.3 \text{ mA}$

$V_{CE} = V_{CC} - I_C R_C = 12 - 11.3 \times 10^{-2} \times 560 = 5.67 \text{ V}$

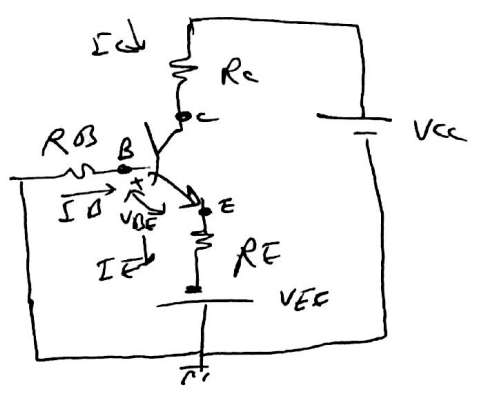
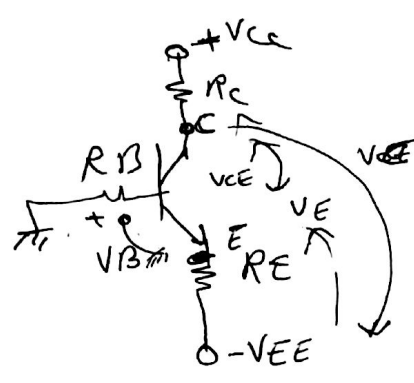
at $75^\circ C \rightarrow I_C = 150 \left[\frac{12 - 0.7}{100k} \right] = 17 \text{ mA}$

$V_{CE} = V_{CC} - I_C R_C = 2.48 \text{ V}$

$\Delta I_C = \frac{I_{75} - I_{25}}{I_{25}} \times 100 \% = \frac{17 - 11.3}{11.3} \times 100 = 50\%$
 $\Delta V_{CE} = \frac{V_{75} - V_{25}}{V_{25}} \times 100 \% = \frac{2.48 - 5.67}{5.67} \times 100 = -56.3\%$

(6)

2- Emitter Bias



$$V_{EE} = I_B R_B$$

$$V_{EE} - V_{BE} = I_B R_B + I_E R_E \quad (1)$$

$$I_C = \beta I_B = \alpha I_E \approx (I_E \text{ if } \alpha \approx 1)$$

$$\text{or } I_E = I_C = \beta I_B$$

$$\text{or } I_B = I_E / \beta$$

sub in (1) by $I_B = I_E / \beta$

$$V_{EE} - V_{BE} = \frac{I_E}{\beta} R_B + I_E R_E = I_E \left(R_E + \frac{R_B}{\beta} \right)$$

$$\text{or } I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B / \beta} \approx I_C \rightarrow (2)$$

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

$$V_{CE} = V_{CC} - I_C R_C - I_E R_E \quad \text{or}$$

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

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

copy

$$I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B / \beta}$$

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

$$V_E = -V_{EE} + I_E R_E \quad \text{or} \quad V_C = V_{CC} - I_C R_C \quad \text{or} \quad V_{CE} = V_C - V_E$$

Stability I_C, I_E depend on β & V_{BE}
 both β, V_{BE} depend on temperature

if $R_E \gg \frac{R_B}{\beta}$ & $V_{EE} \gg V_{BE}$
 or $I_E \approx \frac{V_{EE} - V_{BE}}{R_E + \frac{R_B}{\beta}} \approx \frac{V_{EE}}{R_E}$

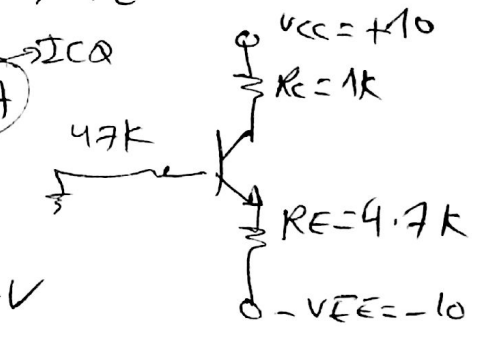
which now independent on β & V_{BE}
 So, emitter bias can provide stable @

Show how emitter bias circuit provides stable @

EX(3) Find I_E, I_C and V_{CE} for $\beta = 100, V_{BE} = 0.7$

sol $I_C = I_E \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{10 - 0.7}{4.7k + \frac{47k}{100}} = 1.8 \text{ mA}$

$V_{CE} = (V_{CC} + V_{EE}) - I_C(R_C + R_E)$
 $= 20 - 1.8 \times 10^{-3} (4.7 + 1) \times 10^3 = 9.74 \text{ V}$



→ cut off at $I_C = 0$

$V_{CE(off)} = V_{CC} + V_{EE} \approx 20 \text{ V}$

$\Delta I_{Cmax} = I_{Csat} - I_{CQ} = ?!$

→ saturation $I_{C(sat)} = \frac{V_{CC} + V_{EE}}{R_C + R_E} = 3.51 \text{ mA}$
 $V_{CE} = 0$

$\therefore \Delta I_{Cmax} = I_{Csat} - I_{CQ} = 3.51 \text{ mA} - 1.8 \text{ mA}$

$\Delta I_{Cmin} = I_{CQ} - I_{C(off)} \approx 1.8 \text{ mA}$

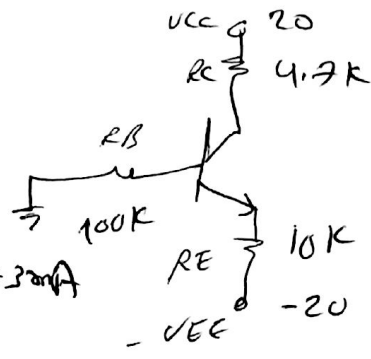
of Required
 sat. & cutoff
 Condition
 ΔI_{Cmax}
 ΔI_{Cmin}

8

EX(4) determine how much Q point will change over temp range (β) from 85 to 100 & V_{BE} from 0.7 to 0.6

in the \circ shown

Sol $\beta = 85, V_{BE} = 0.7$



$$I_C \approx I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{20 - 0.7}{(10 + \frac{100}{85})k} = 1.73mA$$

$$\begin{cases} V_C = V_{CC} - I_C R_C = 20 - 1.73 \times 10^{-3} \times 4.7 \times 10^3 = 11.9V \\ V_E = -V_{EE} + I_E R_E = -20 + 1.73 \times 10^{-3} \times 10 \times 10^3 = -2.7V \\ V_{CE} = V_C - V_E = 11.9 - (-2.7) = 14.6V \end{cases}$$

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

2 For $\beta = 100, V_{BE} = 0.6$

$$I_C \approx I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{20 - 0.6}{(10 + \frac{100}{100}) \times 10^3} = 1.76mA$$

$$V_{CE} = (V_{CC} + V_{EE}) - I_C (R_C + R_E) \approx 12.8V$$

$$\Delta I_C = \frac{I_{100} - I_{85}}{I_{85}} = \frac{1.76mA - 1.73mA}{1.73mA} \times 100 = 3.3\% \text{ increase}$$

$$DV_{CE} = \frac{V_{100} - V_{85}}{V_{85}} = \frac{12.8 - 14.6}{14.6} = -14\% \text{ decrease}$$

2014 2/2/2014

724-6