Lec(8)

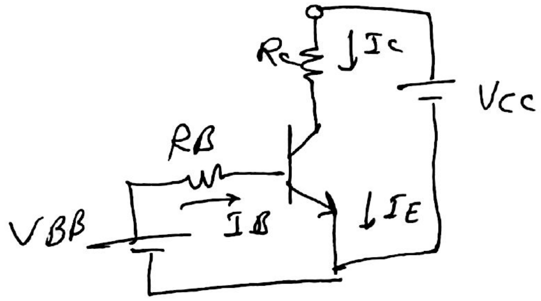
[I] Common emitter configuration

* The most famous Technique used in design of Amplifiers.

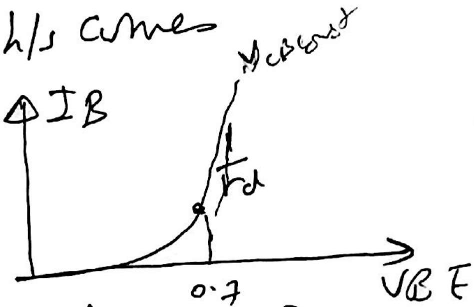
This Because The emitter is Common in input & o/p loops.

* characteristics curve (ch/s curve)

There are 3 - ch/s curves

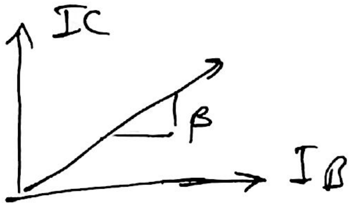


[I] input ch/s (E-B ch/s)



The relation between input current (IB) & input voltage terminals (VBE), it is like (Silicon) diode ch/s.

[II] control ch/s

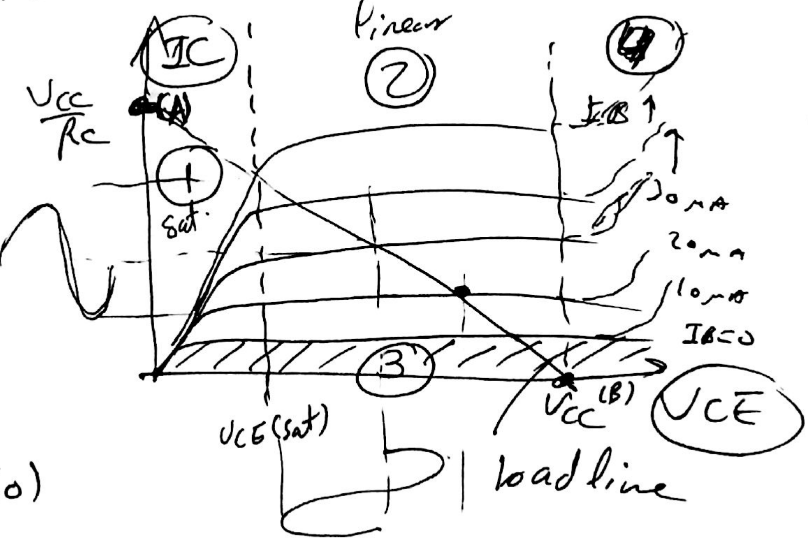


The relation between output current and input current (Ic, IB), it is linear relation due to $I_C = \beta I_B$

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

→ it is measured between output current (IC) & output voltage (VCE) at constant values for (input current IB)

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



region ① Saturation Region

region ② Linear Region

region ③ Cut of region ($I_B \leq 0$)

region ④ breakdown region

* for I/p ch/s (E-B ch/s)

- $I_B = I_o \, e^{V_{BE}/nV_T}$ معادلة تيار الدايود
- $I_C = \beta I_B$, or $I_C = \beta I_o e^{\frac{V_{BE}}{nV_T}}$
- dynamic resistance $= \dfrac{nV_T}{I_{BQ}} \simeq \dfrac{n\beta V_T}{I_{CQ}}$

** for o/p ch/s (C-E ch/s)

(i) → Cutoff region (Switch)

$I_B = 0$

$I_C = I_{CBO} + \alpha I_E = I_{CBO} + \alpha [I_C + \cancel{I_B}]$ ($I_B \to 0$)

∴ $I_C - \alpha I_C = I_{CBO}$

$I_C [1-\alpha] = I_{CBO}$

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

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

$\simeq$ very small current (neglected)

& $V_{CE} = V_{CC} - I_C R_C$ (very small) $\simeq V_{CC}$

$\beta = \dfrac{\alpha}{1-\alpha}$
∴ $\beta - \alpha\beta = \alpha$
$\beta = \alpha\beta + \alpha = \alpha(\beta+1)$
$\alpha = \beta / (\beta+1)$
∴ $\dfrac{1}{1-\alpha} = \dfrac{1}{1 - \dfrac{\beta}{\beta+1}} = \dfrac{1}{\frac{\beta+1-\beta}{\beta+1}} = \dfrac{\beta+1}{1}$

في ال cutoff: $I_B = 0$, I_C neglected, $V_{CE} \simeq V_{CC}$

(ii) linear region $I_B \uparrow\uparrow \longrightarrow I_C \uparrow\uparrow \longrightarrow V_{CE} \downarrow\downarrow$ (Amplifier)

∴ $V_{CE} = V_{CC} - I_C R_C$, $I_C = \beta I_B$

(iii) Saturation Region $I_B \uparrow$ I_C (max) , V_{CE} (Sat.)

$V_{CE}(\text{Sat}) = V_{CC} - I_{C\,max} R_C \simeq 0.2V$ (Fig. صغيرة) , $I_C = I_{C\,sat} = I_{C\,max}$ (Switch)

(iv) Load line equation $V_{CE} = V_{CC} - I_C R_C$

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

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

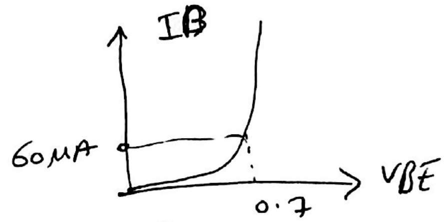
⟶ Q point نقطة التشغيل ⟶ operating Point selected according to The uses of transistor

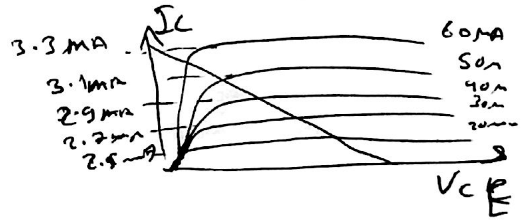
(i) If it is used as Amplifier ⟶ Q point selected in linear Region

(ii) " " " " " Switch ⟶ " " " saturation Region & (may be cutoff)

⟶ Q point Selected by selecting (I_B)

EX(1) Find I_B, I_C with shown ch/s if $V_{BE} = 0.7$ & $V_{CE} = 6V$ & calc β_{dc}





Sol معطي لينا 2 curves في السؤال

From I/p ch/s curve

at $V_{BE} = 0.7$ ⟶ $I_B \simeq 60\mu A$

— From o/p ch/s curve

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

∴ $\beta_{dc} = \frac{I_C}{I_B} = \frac{3.3mA}{60\mu A} \simeq 55$

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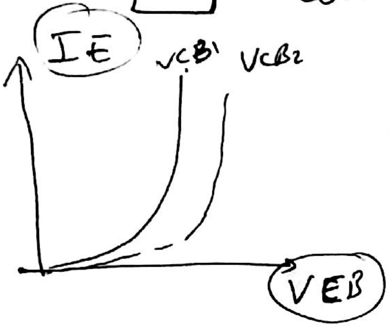
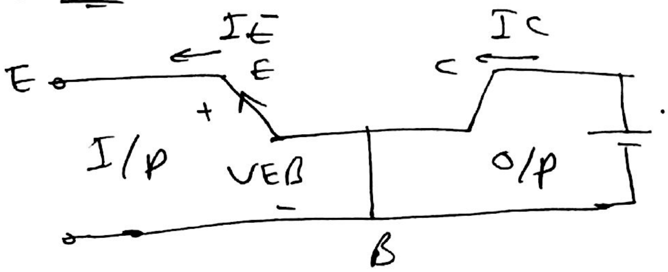
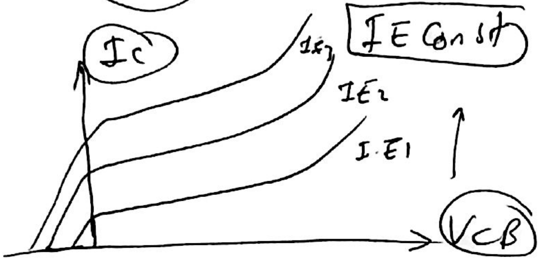
2 Common Base ch/s



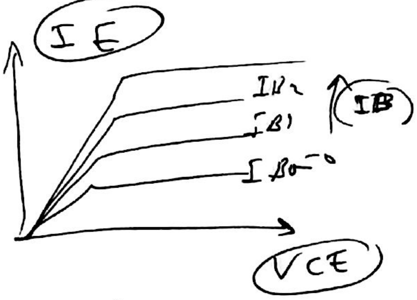
I/p ch/s

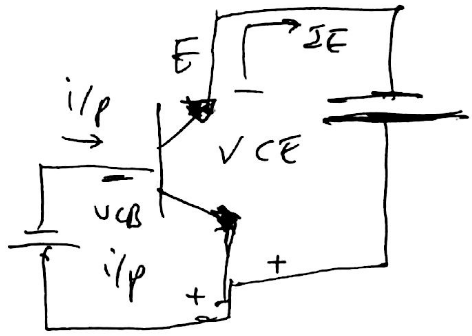


o/p ch/s



3 Common Collector ch/s





i/p ch/s

o/p ch/s

Page 68

Biasing Circuits دوائر تغذية انحياز للترانزستور

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

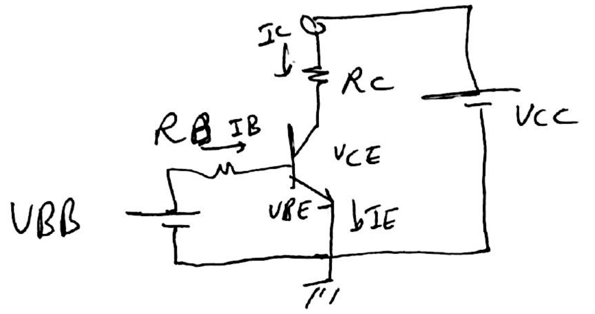
1- Base Bias [Fixed Current Bias]

2- Emitter Bias

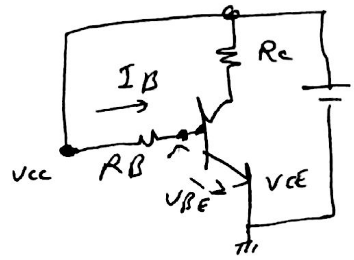
3- Voltage doubler Bias

4- Collector feedBack Bias

1- Base Bias [fixed current Bias]



⟹



practical circit
لتوفير البطاريات

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

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

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

$$I_C = \beta I_B$$

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

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

disadvantage of this circit

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

Ex(2) Find the percentage change in Q point for Base bias circit $R_C = 560\,\Omega$, $R_B = 100\,k\Omega$, $V_{CC} = 12\,V$ make change increase of teperature from (25°C, to 75°) for β (100 → 150) respectively

Sol/ $V_{CC} = V_{BB}$ اعتبرها

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

at 25°C → $I_C = 100 \left[\frac{12 - 0.7}{100k}\right] = 11.3\,mA$

$V_{CE} = V_{CC} - I_C R_C = 12 - 11.3 \times 10^{-3} \times 560 = 5.67\,V$

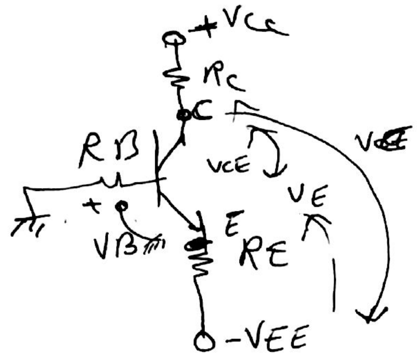
at 75°C → $I_C = 150 \left[\frac{12 - 0.7}{100k}\right] \cong 17\,mA$

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

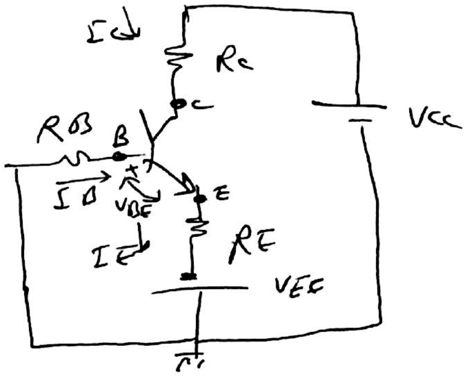
$\Delta I_C = \frac{I_{75} - I_{25}}{I_{25}} \times 100\,\% = \frac{17 - 11.3}{11.3} \times 100 = 50\%$

$\Delta V_{CE} = \frac{V_{75} - V_{25}}{V_{25}} \times 100\,\% = -56.3\,\%$

2- Emitter Bias



⟹



~~VEE = IBRB~~

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

$$I_c = \beta I_B = \alpha I_E \approx (I_E \text{ at } \alpha \simeq 1) \quad (2)$$

$\therefore I_E = I_C = \beta I_B$ or $I_B = I_E/\beta$

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

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

$$\therefore I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} \simeq I_C \longrightarrow (3)$$

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

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

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

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

الخلاصة

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

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

$V_E = -V_{EE} + I_E R_E$ || $V_C = V_{CC} - I_C R_C$ | $V_{CE} = V_C - V_E$

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

both β, V_{BE} depend on temperature

if $R_E \gg \frac{R_B}{\beta}$ & $V_{EE} \gg V_{BE}$

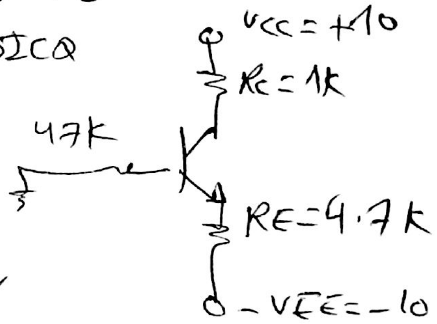
so $I_E \approx \frac{V_{EE} - V_{BE}}{R_E + \frac{R_B}{\beta}} \approx \frac{V_{EE}}{R_E}$

which now independent on β & V_{BE} [illegible]

So, emitter Bias can provide stable Q

| Show how emitter bias circuit provides stable Q [illegible]

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



Sol $I_C \approx I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{10 - 0.7}{4.7k + \frac{47k}{100}} \approx 1.8\,mA$ → I_{CQ}

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

$= 20 - 1.8 \times 10^{-3}(4.7 + 1)(10^3) = 9.74\,V$

→ Cut off at $I_C = 0$

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

$\Delta I_{C max} = I_{C sat} - I_{CQ} = ?!$

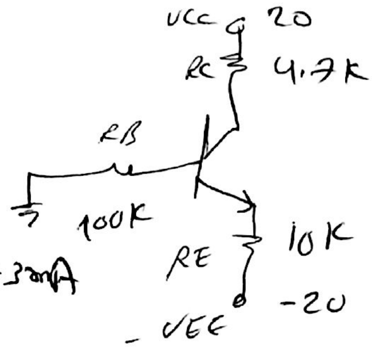
saturation → $I_{C(sat)} \Big|_{V_{CE}=0} = \frac{V_{CC} + V_{EE}}{R_C + R_E} = 3.51\,mA$

$\therefore \Delta I_{C max} = I_{C sat} - I_{CQ} = 3.51\,mA - 1.8\,mA$

$\Delta I_{C min} = I_{CQ} - I_{C cutoff} \approx 1.8\,mA$ ($I_{C cutoff} = 0$)

If Required sat & cutoff condition ($\Delta I_{C\,max}$, $\Delta I_{C\,min}$)

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 ckt shown



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

(1)

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

[illegible]

$$V_C = V_{CC} - I_C R_C = 20 - 1.73\times10^{-3} \times 4.7\times10^{3} = 11.9\,V$$

$$V_E = -V_{EE} + I_E R_E = -20 + 1.73\times10^{-3} \times 10\times10^{3} = -2.7\,V$$

$$V_{CE} = V_C - V_E = 11.9 - (-2.7) = 14.6\,V$$

[illegible]

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

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

$$I_C \simeq I_E = \frac{V_{EE} - V_{BE}}{R_E + R_B/\beta} = \frac{20 - 0.6}{(10 + \frac{100}{100})\times10^3} = 1.76\,mA$$

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

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

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

[illegible]

[illegible]