Section 1
دوائر الكترونية

For electronic circuits' analysis, we make :-

DC analysis

* ac Voltage source is replaced with short circuit (s.c)
* ac current source → open circuit (o.c)
* any Capacitor $X_C = \frac{1}{jwC}$ → (o.c)

because $w = 0$

← How →

AC analysis

* DC Voltage source → (s.c)
* DC current source → (o.c)
* any capacitor → (s.c)

where $X_C = \frac{1}{jwC} \simeq 0$

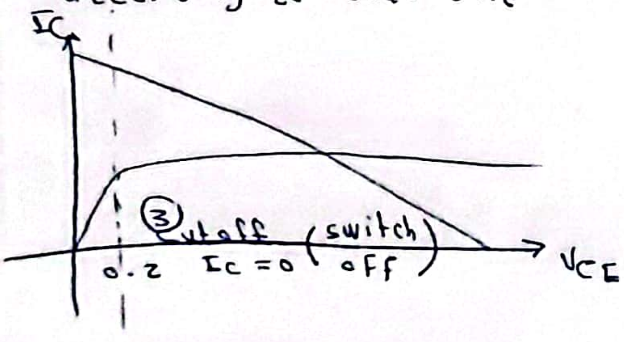
لذلك يوجد مصطلح يسمى frequency responce
يتم ضبطه التردد حيث أجعل المكثفات في
حالة الـ ac analysis ← s.c
حيث أحصل على الـ responce الطبيعي
للدائرة

Why

DC analysis

* Compute DC Voltages :- (V_B, V_C, V_E, V_{BE}, V_{BC}, V_{CE}) and DC currents :- (I_C, I_B, I_E) then Compute
  - $r_e = \frac{26\,mV}{I_E}$
  - $r_o = \frac{V_A}{I_E}$

  DC Parameters of Ac model
* Determine Q Point of transistor to know in any applications (amplifier, switch → on / off) the transistor will act as.
* Q Point is determined according to load line



② Saturation
- V_{BE} (F)
- V_{BC} (F)
- application switch on

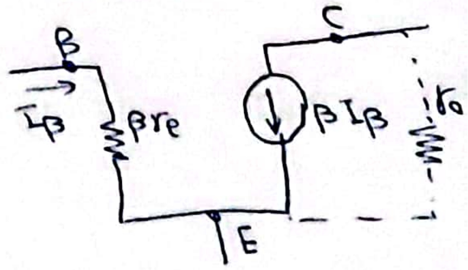
① active region
- → V_{BE} (Forward) and V_{BC} (Reverse)
- → $V_{CE} > 0.2$ and $I_C \neq 0$

application :- amplifier → CE, CC, CB

Ac analysis

* Voltage gain (Av) and current gain (Ai) For three types of amplifiers → CE, CC, CB
* input & output impedances Z_{in} & Z_{out}

where they are useful concerned the cascade circuit with multi stages in order to avoid Power Loss during its transferring from one stage to another.



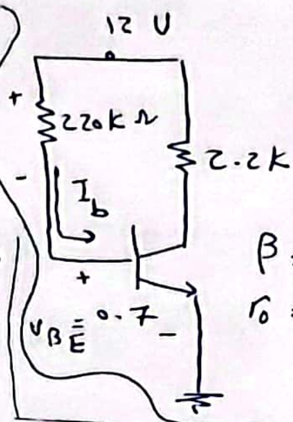
DC Analysis of sheet 1

[1]

$V_i(ac) \longrightarrow S.C$

$C \longrightarrow O.C$

Left loop



$\beta = 60$

$r_o = 40k\,\Omega$

* مطلوب ايجاد الـ r_e والى بتمثل المقاومة الداخلية للـ AC model والى هستخدمها فيما بعد لإيجاد gain , Zin , Zout

* فى أول المسألة تفترض وجودها فى active region لوضع

$V_{BE} = 0.7\ V$

وفى آخرها ضرورى نتأكد من الفرض ده

apply kvl at left loop:-

$$12 - 220k\, I_b - 0.7 = 0$$

$$I_b = \frac{12 - 0.7}{220k} = 0.051\,mA = 51.4\,\mu A$$

$$I_E = I_b + I_c = I_b + \beta I_b = (\beta + 1)\, I_b$$

$$I_E = (60 + 1) * 0.05 = 3.05\ mA$$

$$r_e = \frac{26\,mV}{I_E} = \frac{26\,mV}{3.05\,mA} = 8.5\,\Omega$$

$$\boxed{r_e = 8.5\,\Omega}$$

أخيرا أتأكد من فرض الـ active region بطريقتين.

$$V_C = 12 - (2.2k * \underbrace{60 * 0.05m}_{I_C}) = 5.4\ V$$

$$V_E = 0$$

$$V_{CE} = V_C - V_E = 5.4 - 0 = 5.4 > 0.2$$

and $I_C = 3mA \neq 0$

$\longrightarrow I_C \neq 0$, $V_{CE} > 0.2$

$\longrightarrow V_{BE} \geq 0.7 \longrightarrow$ Forward Junction

and $V_{BC} < 0.7 \longrightarrow$ reverse Junction.

$\therefore$ $I_C \neq 0$ and $V_{CE} > 0.2\,V$

$\therefore$ The assumption, considered is correct and transistor is located in active region.

other method $\longrightarrow$

$V_{BE} = 0.7\,V$ (Forward)

$V_{BC} = V_B - V_C = 0.7 - 5.4 = -4.7\,V < 0.7$ (reverse)

$\longrightarrow$ active region

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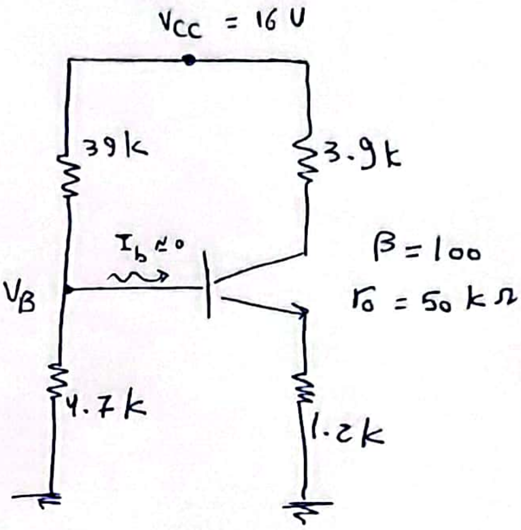
For determining re $\longrightarrow$ make DC analysis

assume transistator is located in active region ($V_{BE} = 0.7$)



∵ base current is so small, hence V_B can be obtained by applying Voltage divider at base Point as follows:-

$$V_B = \frac{16 * 4.7k}{39k + 4.7k} = 1.7 \text{ Volt.}$$

$$V_{BE} = V_B - V_E$$

$$0.7 = 1.7 - V_E \longrightarrow V_E = 1 \text{ Volt.} \longrightarrow I_E = \frac{V_E}{R_E} = \frac{1}{1.2k}$$

$$I_E = 0.83 \text{ mA}$$

$$r_e = \frac{26 \text{ mV}}{I_E} = \frac{26 \text{ mV}}{0.83 \text{ mA}}$$

$$\boxed{r_e = 31 \ \Omega}$$

خطوة مهمة $\longrightarrow$ check assumption
عليها درجات

طريقة 1

$$\left.\begin{aligned} I_C &= \beta I_B \simeq I_E = 0.83m \neq 0 \\ V_{CE} &= 16 - 0.83mA[3.9k + 1.2k] \end{aligned}\right\} \longrightarrow \text{active region}$$

$$= 11.8 \text{ volt.} > 0.2 \text{ Volt}$$

طريقة 2

$$\left.\begin{aligned} V_{CE} &= V_C - V_E \\ 11.8 &= V_C - 1 \\ V_C &= 12.8 \text{ V} \end{aligned}\right\} \quad \left.\begin{aligned} &V_{BE} \geq 0.7 \text{ (Forward)} \\ &V_{BC} = 1.7 - 12.8 = -11.1 < 0.7 \text{ (Reverse)} \end{aligned}\right\} \longrightarrow \text{active region.}$$

CamScanner

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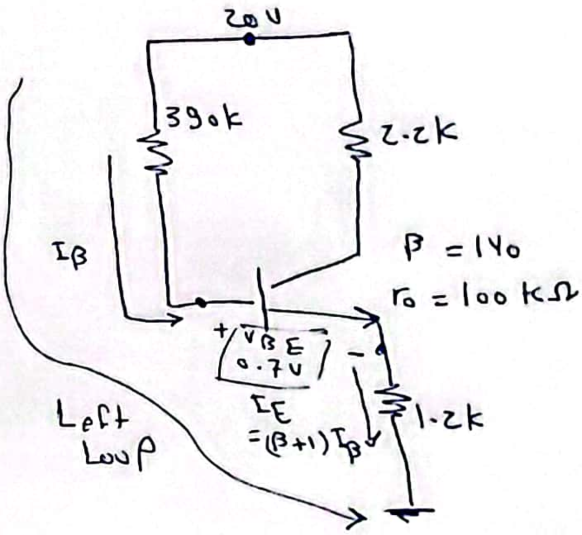
r_e is computed from DC analysis to be used in AC analysis as follows:- $\boxed{\text{assume } V_{BE} = 0.7 \text{ (active region) then check}}$

Apply KVL at left loop:-



$$20 - 390k * I_\beta - 0.7 - 1.2k(\beta+1) I_\beta = 0$$

$$I_\beta = \frac{20 - 0.7}{390k + (1.2k * 141)} = 0.0345 \text{ mA}$$

$$= 34.5 \mu A$$

$$I_E = (\beta+1) * I_\beta = (140+1) * 0.0345$$

$$I_E = 4.9 \text{ mA}$$

$$r_e = \frac{26 \text{ mV}}{I_E} = \frac{26 \text{ mV}}{4.9 \text{ mA}} = 5.3 \Omega$$

$\boxed{r_e = 5.3 \Omega}$ تستخدم في العكس التام

Finally → check active region assumption.

$$V_{CE} = 20 - 4.9[2.2k + 1.2k] = 3.34 \text{ Volt} > 0.2$$

and $I_C \simeq I_E = 4.9 \text{ mA} \neq 0$

→ active region

$V_E = I_E R_E$

$V_B = V_{BE} + V_E$

$V_C = V_{CE} + V_E$

(Forward) V_{BE}

(Reverse) V_{BC}

أو بطريقة

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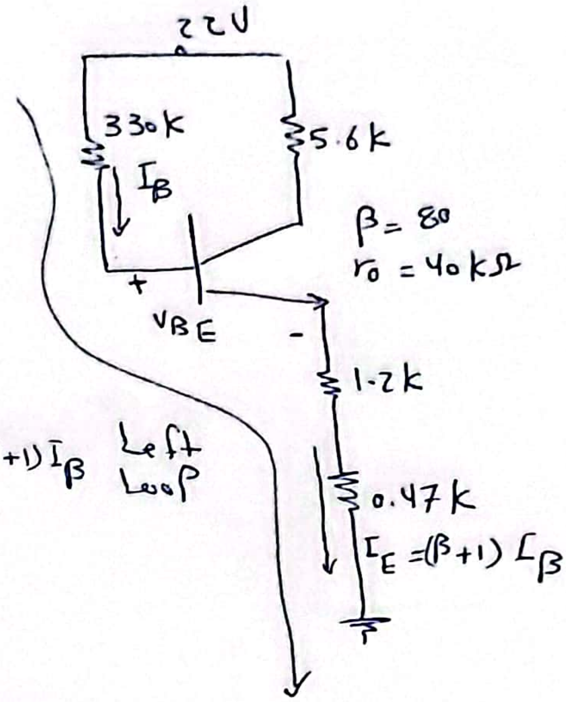
* DC analysis to compute r_e



* assume $V_{BE} = 0.7$ V, considering transistor region is active

$$22 - 330k * I_B - 0.7 - \underbrace{(1.2 + 0.47)}_{1.67k} k * (\beta+1) I_B = 0$$

$$I_B = \frac{22 - 0.7}{330k + \underbrace{(81 * 1.67k)}_{135.27k}}$$

$$I_B = 0.0458 \text{ mA}$$
$$= 45.8 \mu A$$

$$I_E = (\beta+1) * I_B = (80+1) * 0.0458$$

$$I_E = 3.7 \text{ mA}$$

$$r_e = \frac{26 \text{ mV}}{I_E} = \frac{26 \text{ mV}}{3.7 \text{ mA}} \rightarrow \boxed{r_e = 7 \Omega}$$

Finally → check the assumption :-

$I_C \simeq I_E \simeq 3.7$ mA $\neq 0$

kvl at right loop:-

$$V_{CE} = 22 - 3.7 \text{ mA} [5.6k + 1.2k + 0.47k]$$

$$V_{CE} = -4.9 \text{ Volt.}$$

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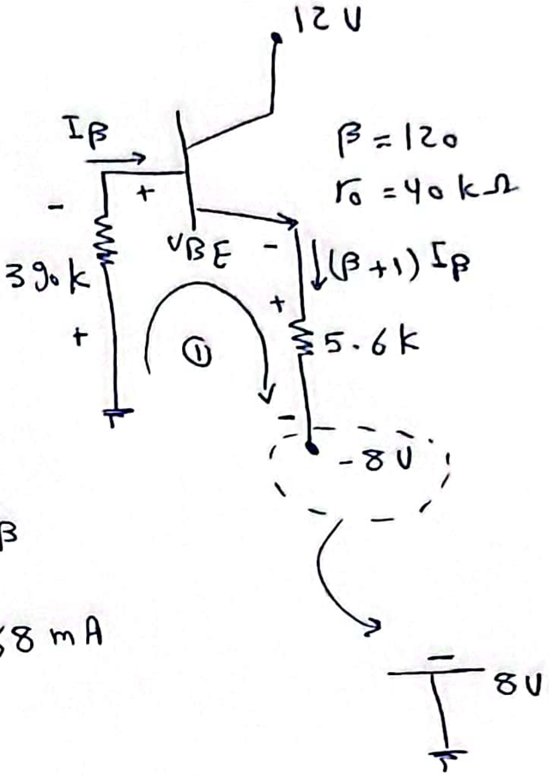
assume transistor is in active region $\xrightarrow{\text{hence}}$ $V_{BE} = 0.7V$



apply KVL at Loop 1 :-

$$-390k * I_\beta - 0.7 - 5.6k * (\beta+1) I_\beta \underbrace{=0}_{+8}$$

$$-0.7 + 8 = [390 + (121 * 5.6)] I_\beta$$

$$I_\beta = \frac{-0.7 + 8}{1068k} = 0.0068 mA$$

$$I_\beta = 6.8 \mu A$$

$$I_E = (\beta+1) * I_\beta$$

$$= (120+1) * 0.0068$$

$$I_E = 0.8 mA$$

$$r_e = \frac{26 mV}{I_E} = \frac{26 mV}{0.8 mA} = 32.5 \Omega$$

$$\boxed{r_e = 32.5 \Omega}$$

$\longrightarrow$ check assumption (active region) $\rightarrow$ $I_C \neq 0$, $V_{CE} > 0.2$; V_{BE} (F), V_{BC} (R)

* $I_C \simeq I_E = 0.8 mA \neq 0$

* $V_{CE} = 12 - 0.8 mA * 5.6k + 8$

$V_{CE} = 15.5$ volt, $> 0.2V$

active region

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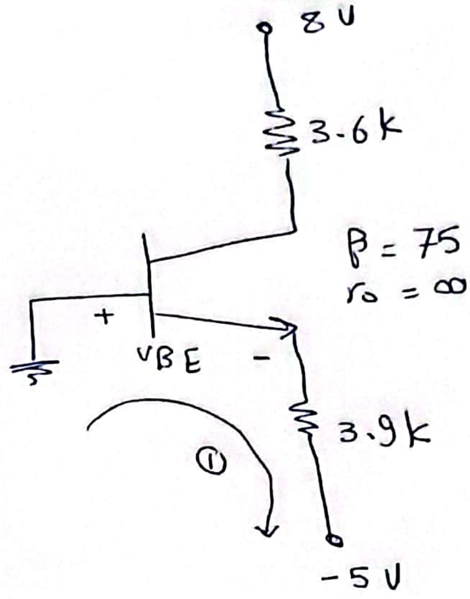

* DC analysis to compute $\boxed{r_e}$

* assume transistor is in active region $\xrightarrow{\text{hence}}$ $V_{BE} = 0.7V$
then check this assumption finally.

apply KVL at Loop ① :-

$$-0.7 - 3.9k * I_E + 5 = 0$$

$$I_E = \frac{-0.7 + 5}{3.9k} = 1.1 \, mA$$

$$r_e = \frac{26 \, mV}{1.1 \, mA}$$

$$\boxed{r_e = 23.6 \, \Omega}$$

→ check whether the first assumption is true or false

$$I_C \approx I_E \approx 1.1 \, mA \neq 0 \longrightarrow \boxed{1}$$

apply KVL at right Loop :-

$$8 - 1.1 \, mA * [3.6k + 3.9k] + 5 = V_{CE}$$

$$V_{CE} = 4.75 > 0.2 V \longrightarrow \boxed{2}$$

from 1 and 2
transistor is in active region and the previous assumption is correct.

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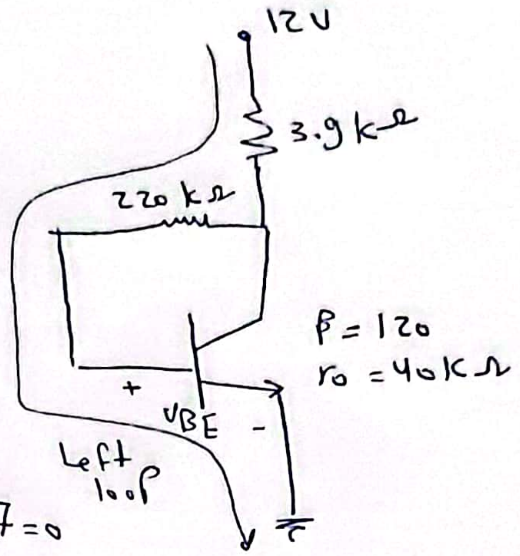

DC analysist to compute re

→ assume active region ($V_{BE} = 0.7V$)

apply kvl at left loop :-

$$12 - 3.9k * \underbrace{(\beta + 1)}_{121} I_B - 220k * I_B - 0.7 = 0$$

$$I_B = \frac{12 - 0.7}{[3.9k * 121] + 220k} = 0.0163 \ mA$$

$$= 16.3 \ \mu A$$

$$I_E = (\beta + 1) * I_B = (120 + 1) * 0.0163$$

$$I_E = 1.97 \ mA$$

$$r_e = \frac{26 \ mV}{I_E} = \frac{26 \ mV}{1.97 mA}$$

$$\boxed{r_e = 13.19 \ \Omega}$$

→ check the first assumption, concerned the transistor region.

$I_C \simeq I_E \simeq 1.97 \ mA \neq 0$ → ①

apply kvl at right loop :-

$V_{CE} = 12 - 3.9k * 1.97 mA$

$= 4.3 V > 0.2$ Volt → ②

→ assumption is correct and transistor is in active region.

or check by another method :- VBE Forward
VBC Reverse