9.00

ELJOKER

أولى حاسبات

ELECTRONICS

SHEET 6

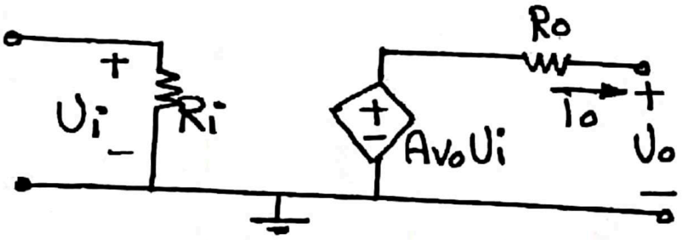
م.ايمان

Summary for Sheet 6

Some important Notes

amplifier types

① Voltage amplifier

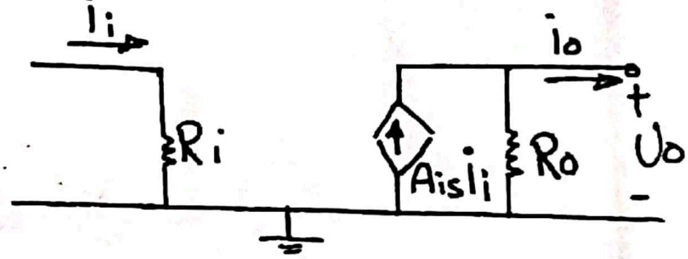


- open circuit Voltage Gain

$$A_{vo} = \frac{V_o}{V_i}\Big|_{i_o=0} \quad (V/V)$$

- $R_i = \infty$
- $R_o = 0$

② Current amplifier



- Short-Circuit current Gain

$$A_{is} = \frac{i_o}{i_i}\Big|_{V_o=0} \quad (A/A)$$

- $R_i = 0$
- $R_o = \infty$

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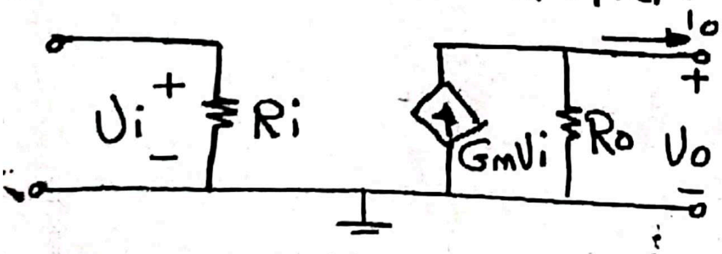
③ transconductance amplifier

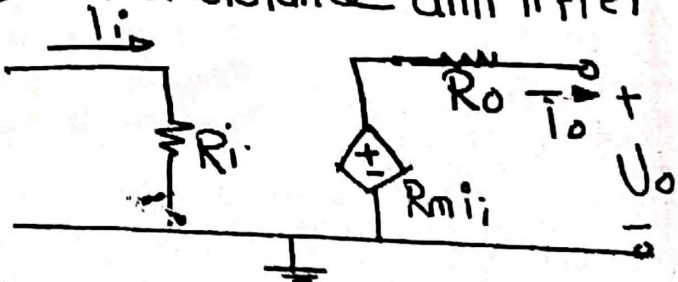


short-circuit transconductance

$$G_m = \frac{i_o}{V_i}\Big|_{V_o=0} \quad (A/V)$$

- $R_i = \infty$
- $R_o = \infty$

④ transresistance amplifier



- open circuit transresistance

$$R_m = \frac{V_o}{i_i}\Big| \quad (V/A)$$

- $R_i = 0$
- $R_o = 0$

Ema
②

analysis of BJT :-

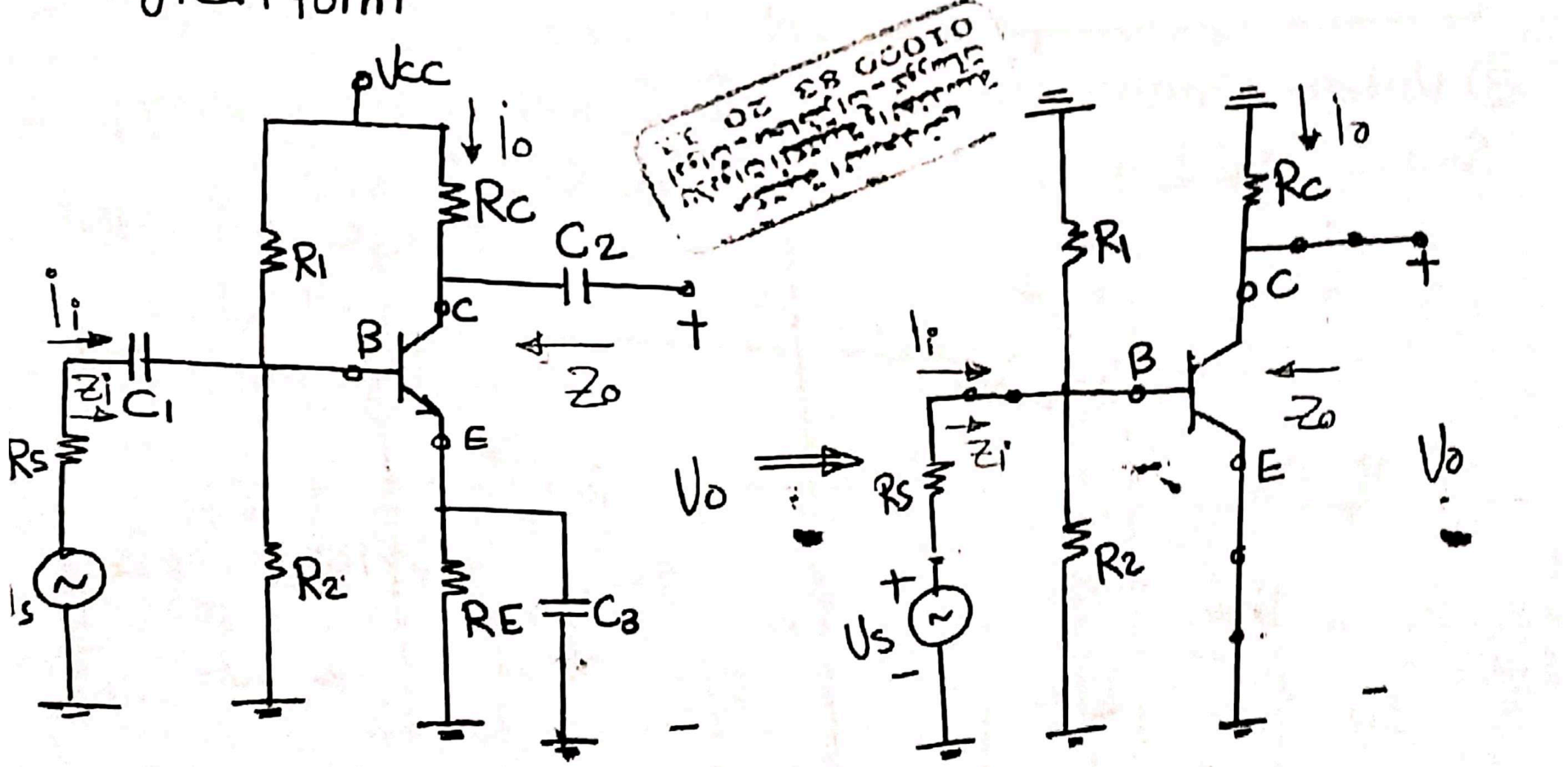
the ac equivalent of a transistor Network is obtained by

① Setting all dc Sources to zero and replacing them by a sort-circuit equivalent

② Replacing all capacitors by a short circuit equivalent

③ Removing all elements by passed by the short-circuit equivalents introduced by step ① and ②

④ Redrawing the Network in more convenient and logical form



⑤ Replacing the BJT with appropriate model

→ r_e transistor model

or → Hybrid model (hybrid π model)

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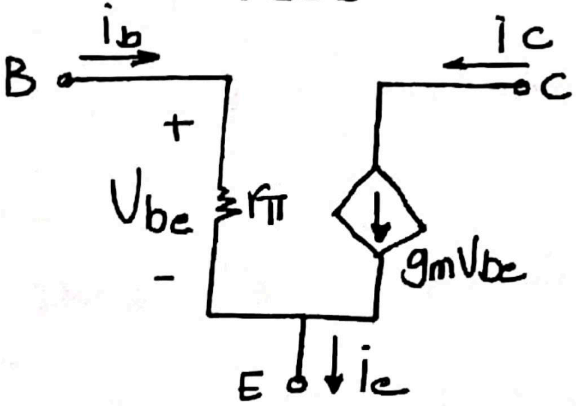
* Hybrid π model :-

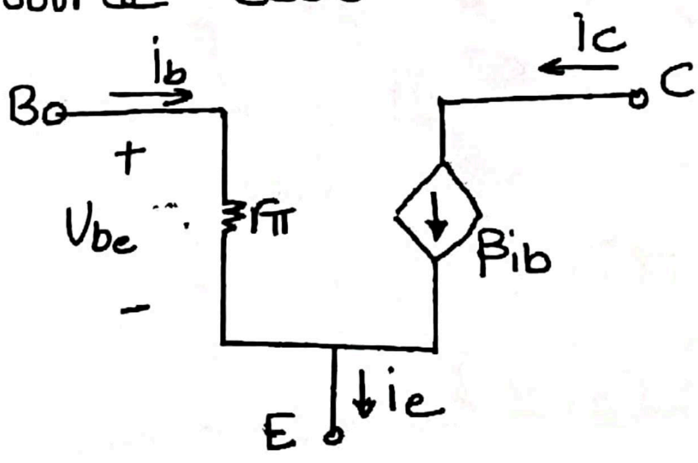
① Voltage Controlled Current Source "VCCS"



• $g_m = \dfrac{I_C}{V_T}$

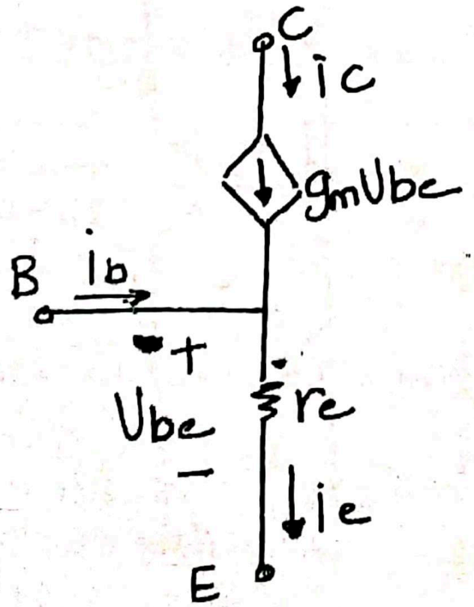
• $r_\pi = \dfrac{V_T}{I_B}$

② Current Controlled Current Source "CCCS"



• $r_\pi = \dfrac{\beta}{g_m}$

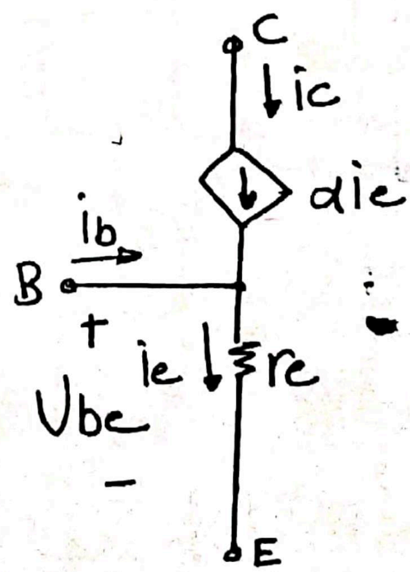
③ Voltage Controlled Current Source "VCCS"



$g_m = \dfrac{I_C}{V_T}$

$r_e = \dfrac{V_T}{I_E}$

④ Current Controlled Current Source "CCCS"



$r_e = \dfrac{\alpha}{g_m}$

$g_m = \dfrac{I_C}{V_T}$

Steps for solving AC analysis of BJT

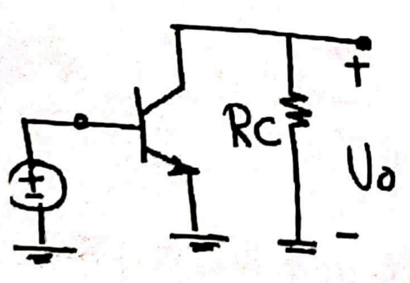
First DC analysis

Using the DC analysis to calculate the parameters of small signal model g_m, r_π and r_e

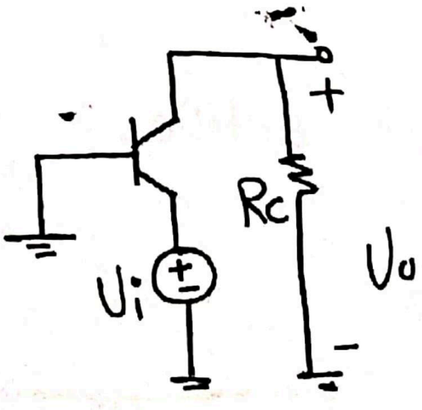
Second AC analysis

1) replace all capacitors by S.C (Short Circuit)
   replace all inductors by O.C (open circuit)
2) replace the DC voltage source by S.C
   replace the DC current source by O.C
3) replace the BJT by the small signal model
4) analyze the circuit to determine the amplifier gain

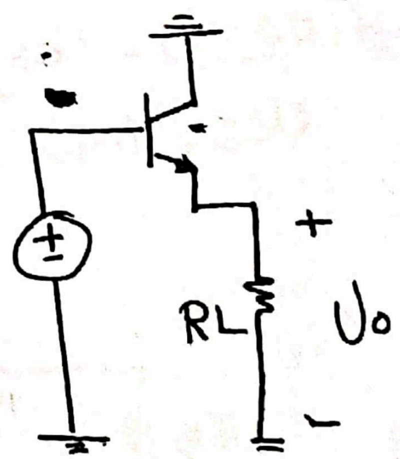
BJT Configuration



CE



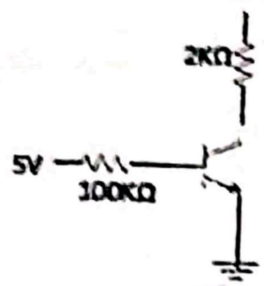
CB



CC

Sheet 6

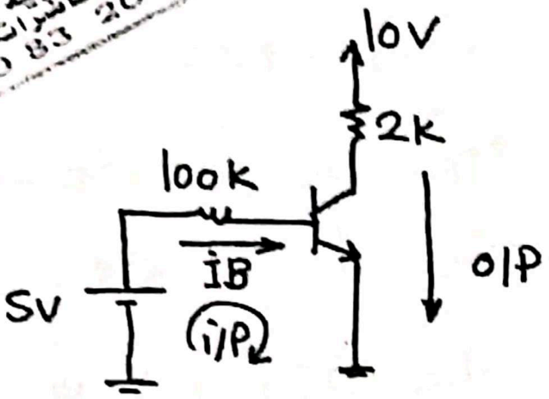
1- For the circuits shown, draw the equivalent AC circuit model. Denote on your schematic the values of r_π and r_o. ($\beta = 100$, VA = 100 V)



Sol :-

→ Dc analysis

i/P loop



$5 - I_B(100) - V_{BE} = 0$

$5 - I_B(100) - 0.7 = 0$

$I_B = 0.043\,mA$

$I_C = \beta I_B = 4.3\,mA$

$I_E = (1+\beta) I_B = 4.343\,mA$

o/P loop

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

$10 - (4.3)(2) - V_{CE} = 0$

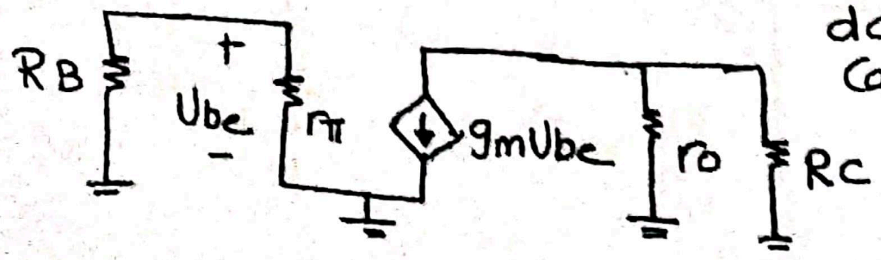
$V_{CE} = 1.4 > V_{BE}$ active

• Ac

dc Volt Source S.C

dc current Source O.C

Capacitors S.C



$\rightarrow g_m = \dfrac{I_C}{V_T} = \dfrac{4.3\times10^{-3}}{0.025} = 0.172 \text{ A/V}$

$= 172 \text{ mA/V}$

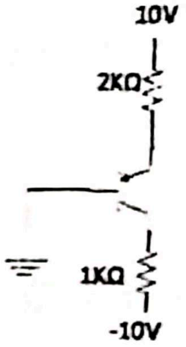
$\rightarrow r_\pi = \dfrac{V_T}{I_B}$

$= \dfrac{0.025}{0.043} = 581.39\ \Omega$

$\rightarrow r_o = \dfrac{V_A}{I_C}$

$= \dfrac{100}{4.3\times10^{-3}} = 23.25\ \text{K}\Omega$

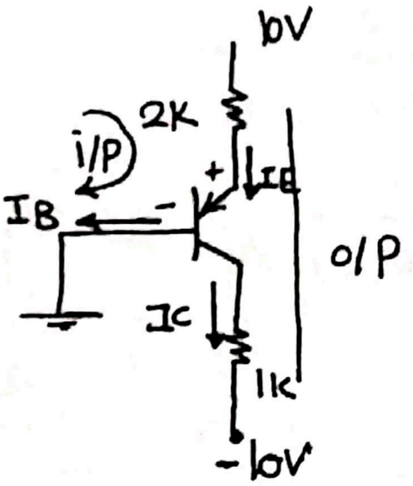
2- For the circuits shown, draw the equivalent AC circuit model. Denote on your schematic the values of r_π and r_o . ($\beta = 100$, $V_A = 100$ V)



Sol:-

→ Dc analysis

input loop



$10 - I_E(2) - V_{EB} = 0$

$10 - I_E(2) - 0.7 = 0$

$I_E = 4.65$ mA

$I_B = 0.046$ mA

$I_C = 4.603$ mA

output loop

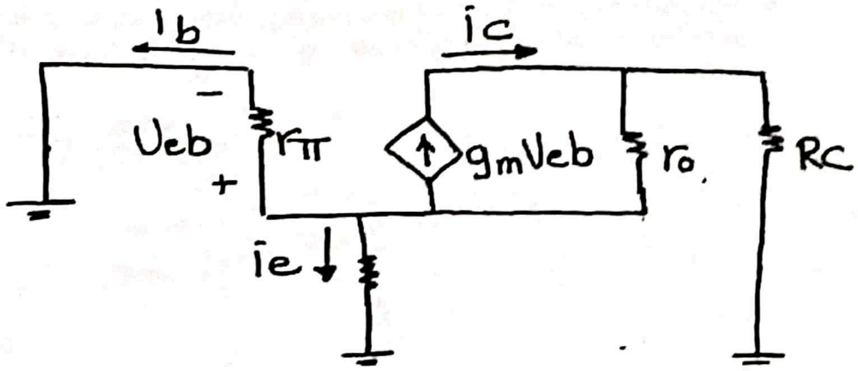
$10 - I_E(2) - V_{EC} - I_C(1) + 10 = 0$

$10 - (4.65)(2) - V_{EC} - (4.603)(1) + 10 = 0$

$V_{EC} = 6.097 > V_{EB}$ active

AC equivalent Circuit

Dc volt source s.c
Dc Current source o.c
Capacitors s.c

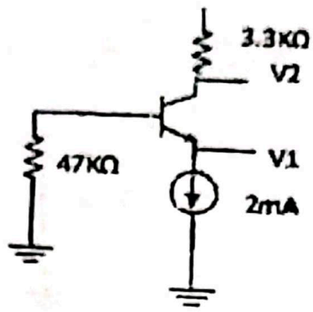


$$\rightarrow g_m = \frac{I_C}{U_T} = \frac{4.603 \times 10^{-3}}{0.025}$$
$$= 184.12 \text{ mA/V}$$

$$\rightarrow r_\pi = \frac{U_T}{I_B} = \frac{0.025}{0.046 \times 10^{-3}}$$
$$= 543.47\ \Omega$$

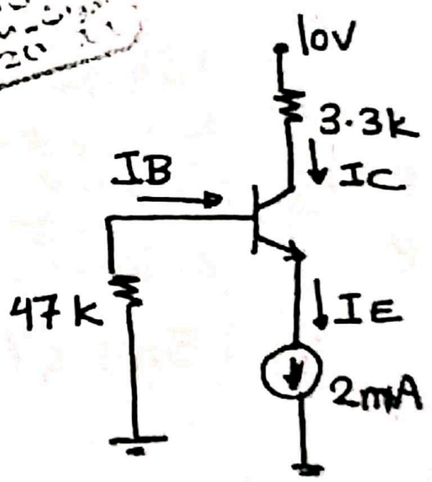
$$\rightarrow r_o = \frac{U_A}{I_C} = \frac{100}{4.603 \times 10^{-3}}$$
$$= 21.72\ k\Omega$$

3. For the circuits shown, draw the equivalent AC circuit model. Denote onyour schematic the values of $r\pi$ and ro. ($\beta = 100$, $VA = 100$ V)



Sol:-

→ Dc analysis



$\because I_E = 2mA$

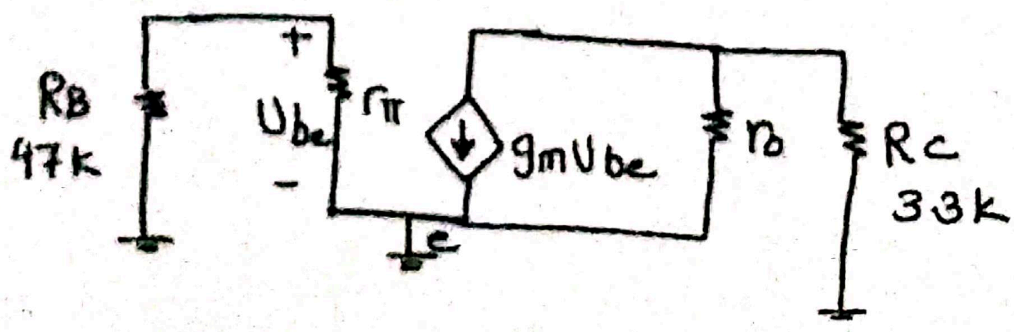
$\therefore I_B = \dfrac{I_E}{1+\beta} = \dfrac{2mA}{101}$

$= 0.0198 \, mA$

$I_C = I_B \, \beta = 1.98mA$

- Ac equivalent circuit

- Dc voltage source s.c
- Dc current source o.c
- Capacitors s.c



$$g_m = \frac{I_C}{V_T}$$

$$= \frac{1.98}{0.025} = 79.2 \ mA/V$$

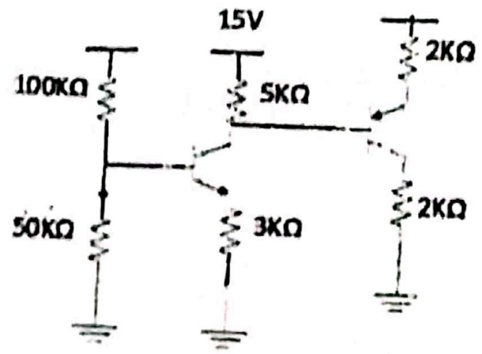
$$\rightarrow r_\pi = \frac{V_T}{I_B}$$

$$= \frac{0.025}{0.0198 \times 10^{-3}} = 1262.6 \ \Omega$$

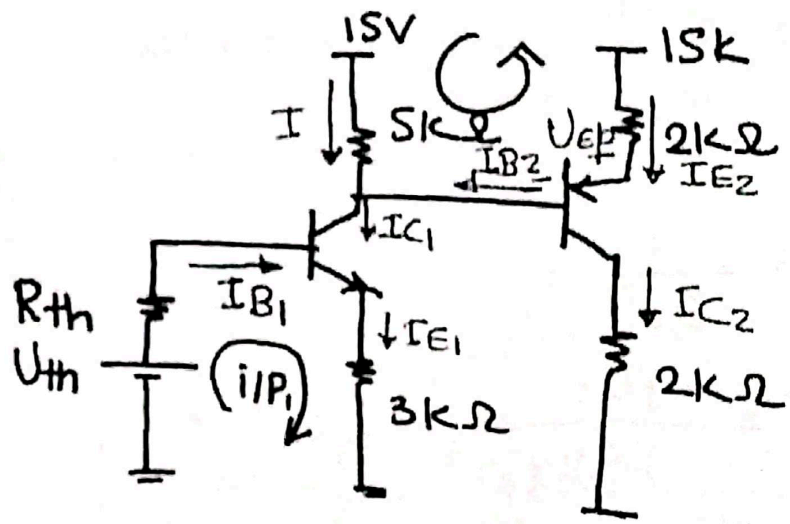
$$\rightarrow r_o = \frac{V_A}{I_C}$$

$$= \frac{100}{1.98 \times 10^{-3}} = 50.5 \ k\Omega$$

4- For the circuits shown, draw the equivalent AC circuit model. Denote on your schematic the values of $r\pi$ and ro. ($\beta = 100$, VA = 100 V)



Sol:-



$$V_{th} = \frac{15 \times 50}{50+100} = 5V$$

$$R_{th} = \frac{100 \times 50}{100+50} = 33.3\ k\Omega$$

i/p loop₁

$$V_{th} - I_{B_1}(R_{th}) - V_{BE_1} - I_{E_1}(R_E) = 0$$

$$5 - I_{B_1}(33.3) - 0.7 - (1+\beta) I_{B_1}(3) = 0$$

$$\therefore I_{B_1} = 0.01278\ mA$$

$$I_{C_1} = \beta I_{B_1} = 1.278\ mA$$

$$I_{E_1} = (1+\beta) I_{B_1} = 1.291\ mA$$

$$I + I_{B_2} = I_{C_1}$$

$$I = I_{C_1} - I_{B_2}$$

$+5 - I(5) + V_{Eb} + I_{E2}(2) - 15 = 0$

$-[(I_{C1} - I_{B2})(5)] + 0.7 + (1+\beta)I_{B2}$

$-(5)I_{C1} + (5)I_{B2} + 0.7 + (101)(2)I_{B2} = 0$

$-(5)(1.278) + (5)I_{B2} + 0.7 + (101)(2)I_{B2} = 0$

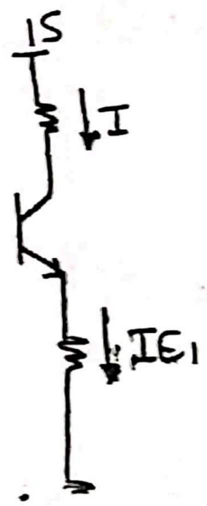
$I_{B2} = 0.0275 \text{ mA}$

$\therefore I_{C2} = 2.75 \text{ mA}$

$\therefore I_{E2} = 2.77 \text{ mA}$

$\therefore I = I_{C1} - I_{B2} = 1.25 \text{ mA}$

o/p loop 1



$15 - I(5) - V_{CE_1} - I_{E1}(3) = 0$

$15 - 1.25(5) - V_{CE_1} - (1.291)(3) = 0$

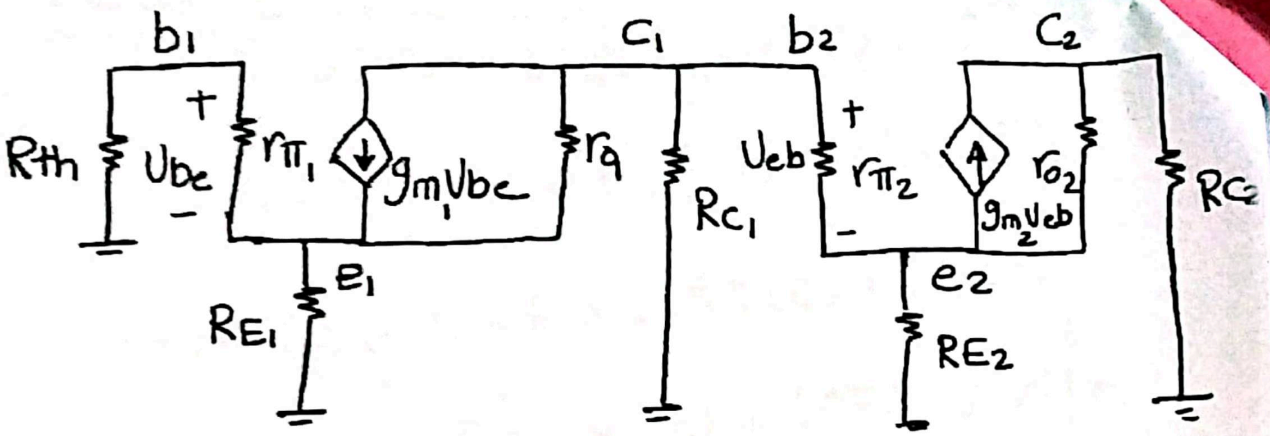
$V_{CE_1} = 4.877 > V_{BE}$

o/p loop 2

$15 - I_{E2}(2) - V_{EC2} - I_{C2}(2) = 0$

$V_{EC2} = 3.96 > V_{EB}$

→ AC equivalent circuit



$$g_{m_1} = \frac{I_{C1}}{V_T} = \frac{1.278}{0.025} = 51.12\ mA/V$$

$$r_{\pi_1} = \frac{V_T}{I_{B_1}} = \frac{0.025}{0.01278\times10^{-3}} = 1956.18\ \Omega$$

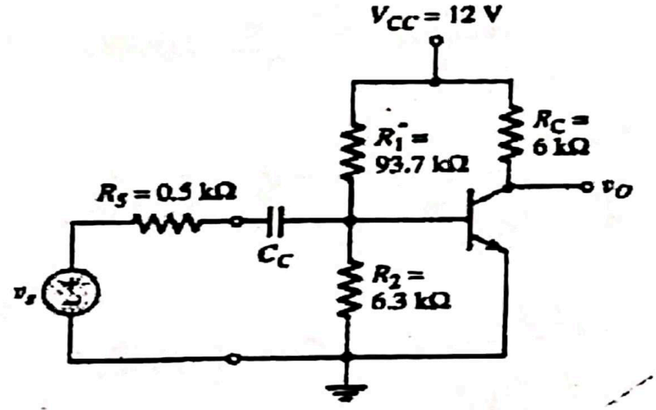
$$r_{o_1} = \frac{V_A}{I_{C1}} = \frac{100}{1.278} = 78.24\ k\Omega$$

$$g_{m_2} = \frac{I_{C2}}{V_T} = \frac{2.75}{0.025} = 110\ mA/V$$

$$r_{\pi_2} = \frac{V_T}{I_{B2}} = \frac{0.025}{0.0275\times10^{-3}} = 909.09\ \Omega$$

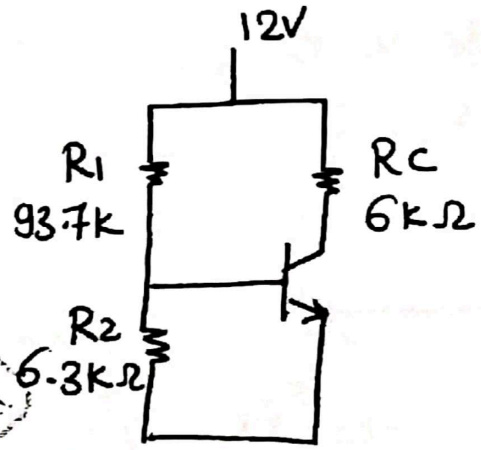
$$r_{o2} = \frac{V_A}{I_{C2}} = \frac{100}{2.75} = 36.36\ k\Omega$$

5- Determine the small-signal voltage gain, input resistance, and output resistance of the circuit shown. Assume the transistor parameters are: $\beta=100$, $V_{BE(on)}=0.7V$, and $V_A=100V$



Sol:-

→ Dc analysis



$$U_{th} = \frac{12 * R_2}{R_1 + R_2}$$

$$= 0.756 V$$

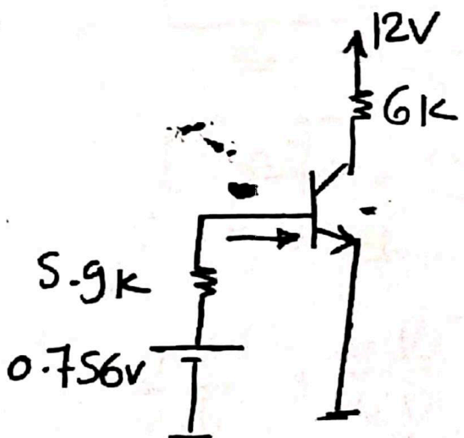
$$R_{th} = \frac{R_1 R_2}{R_1 + R_2}$$

$$= 5.9 K\Omega$$

i/P loop

$$0.756 - I_B(5.9) - U_{BE} = 0$$

0.7



$$I_B = 9.49 \mu A$$

$$I_C = 0.949 mA$$

$$I_E = 0.958 mA$$

o/P loop

$$12 - 6 I_C - U_{CE} = 0$$

$$U_{CE} = 6.3 > U_{BE}$$

- Ac analysis

$$g_m = \frac{I_C}{V_T} = \frac{0.949}{0.025} = 37.96 \text{ mA/V}$$

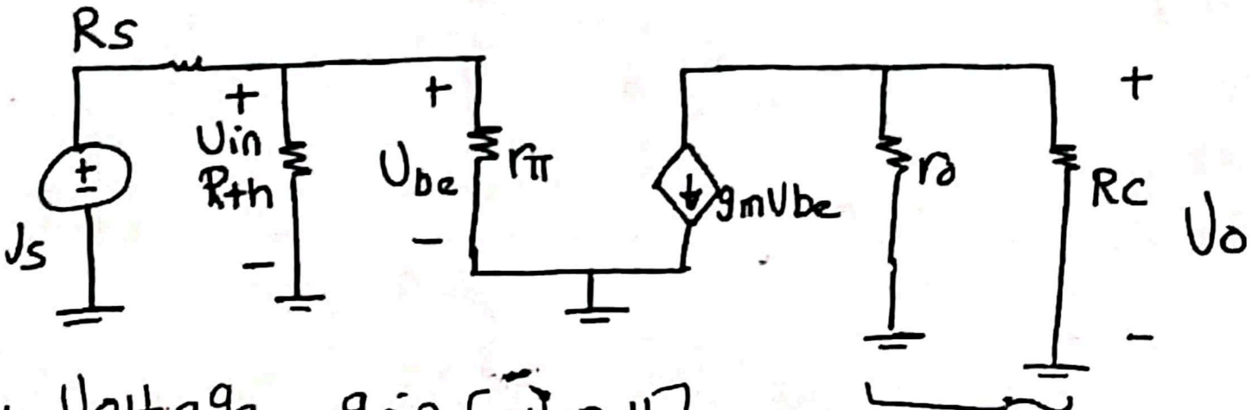
$$r_\pi = \frac{V_T}{I_B} = \frac{0.025}{9.49 \times 10^{-6}} = 2634.3\ \Omega$$

$$r_o = \frac{V_A}{I_C} = \frac{100}{0.949} = 105.4\ \text{k}\Omega$$

- Ac equivalent circuit

Dc Voltage Source S.C

Capacitors S.C



$R_L = r_o \| R_C$

- Voltage gain [overall]

$$G_V = \frac{V_o}{V_s}$$

$$= \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{in}} * \frac{V_{in}}{V_s}$$

$$V_o = -g_m V_{be} R_L$$

$$\frac{V_o}{V_{be}} = -g_m R_L$$

ut resistance

$R_{in} = R_{th} \parallel r_\pi$

$$V_{be} = V_{in}$$

$$V_{in} = V_s \frac{R_{in}}{R_{in} + R_s}$$

$$\frac{V_{in}}{V_s} = \frac{R_{in}}{R_{in} + R_s}$$

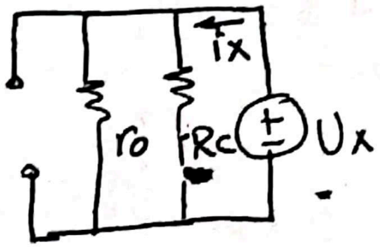
$$G_V = \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{in}} * \frac{V_{in}}{V_s}$$

$$G_V = [-g_m R_L] \left[\frac{R_{in}}{R_{in} + R_s}\right]$$

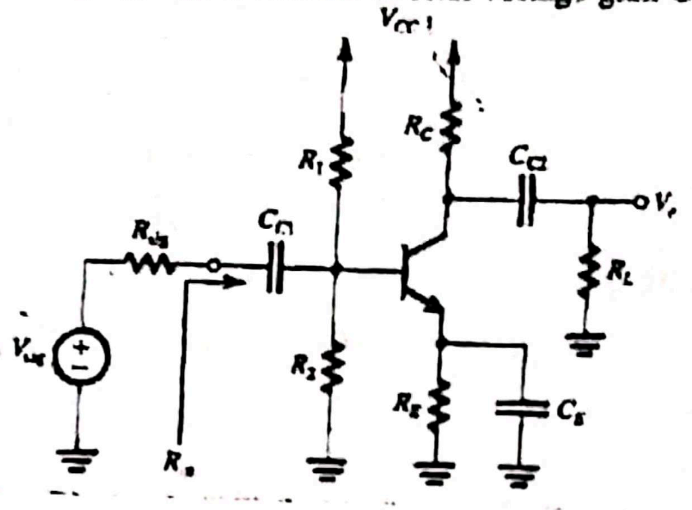
* output resistance

$$R_{out} = \frac{V_x}{i_x}$$

$$= R_C \parallel r_o$$



6- For the common-emitter amplifier shown, let $V_{CC} = 15$ V, $R_1 = 27$ kΩ, $R_2 = 15$ kΩ, $R_E = 2.4$ kΩ, and $R_C = 3.9$ kΩ. The transistor has $\beta = 100$. Calculatethe dc bias current I_C. If the amplifier operates between a source for which $R_{sig} = 2$ kΩ and a load of 2 kΩ, replace the transistor with its hybrid-π model, and find the values of R_{in}, R_v, A_{vo}, A_v and the overall voltage gain G_v (v_o/v_{sig}).



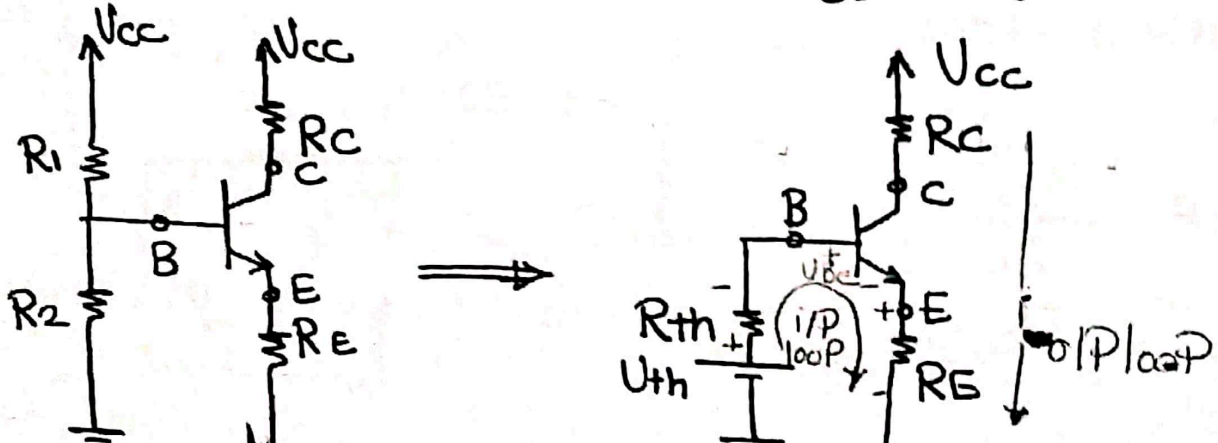
Sol8-

$U_{cc} = 15V$, $\beta = 100$

$R_1 = 27\,k\Omega$, $R_2 = 15\,k\Omega$, $R_C = 3.9\,k\Omega$, $R_E = 2.4\,k\Omega$

① Calculate dc bias Current I_C

from Dc analysis all Capacitors o.c So ....



• $R_{th} = \dfrac{R_1 R_2}{R_1 + R_2} = \dfrac{27 * 15}{27 + 15} = 9.64\,k\Omega$

• $U_{th} = U_{cc} * \dfrac{R_2}{R_1 + R_2} = \dfrac{15 * 15}{15 + 27} = 5.36V$

iP loop

$V_{th} - I_B R_{th} - V_{BE} - I_E R_E = 0$

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

$5.36 - (9.64k) I_B - 0.7 - (101)(2.4k\Omega) I_B = 0$

$I_B = 0.01848 \text{ mA}$

$I_E = (1+\beta) I_B = 1.867 \text{ mA}$

$I_C = \beta I_B = 1.848 \text{mA}$ ✓

from o/P loop

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

$15 - (1.84)(3.9) - V_{CE} - (1.867)(2.4) = 0$

$V_{CE} = 3.3432 > V_{BE}$ active

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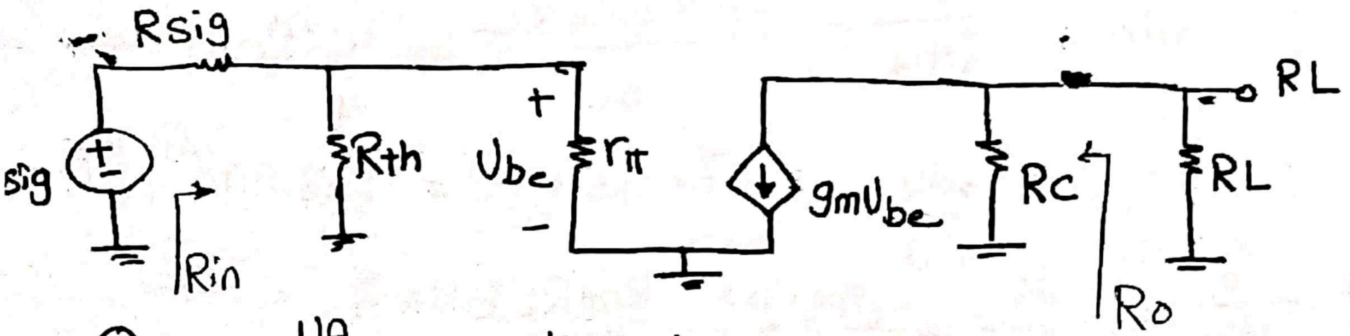
② if $R_{sig} = 2k\Omega$, $R_L = 2k\Omega$ replace Tr by π hybrid model then find R_{in}, R_{out}, A_{vo}, A_v and G_v (V_o/V_{sig}) → overall Voltage gain

all Cap SC, Dc V.S S.C, Dc CS O.C



① $r_o = \frac{V_A}{I_C}$ V_A not given so neglect r_o

② $g_m = \frac{I_C}{V_T} = \frac{1.848}{0.025} = 73.9 \text{ mA/V}$ ← room temp

③ $r_\pi = \frac{\beta}{g_m} = \frac{V_T}{I_B} = 1.35 k\Omega$

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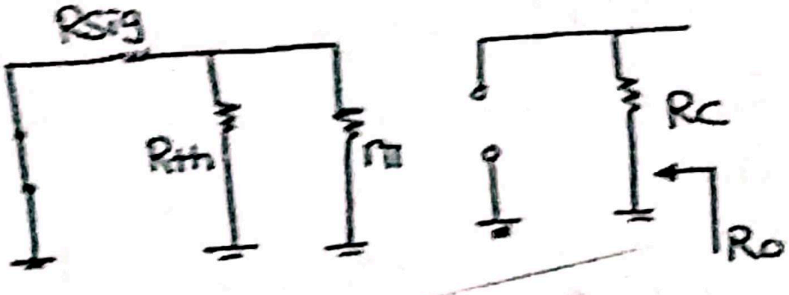
→ input resistance

$$R_{in} = R_{th} \parallel r_\pi = \frac{9.64 * 1.35}{9.64 + 1.35} = 1.187\,k\Omega$$

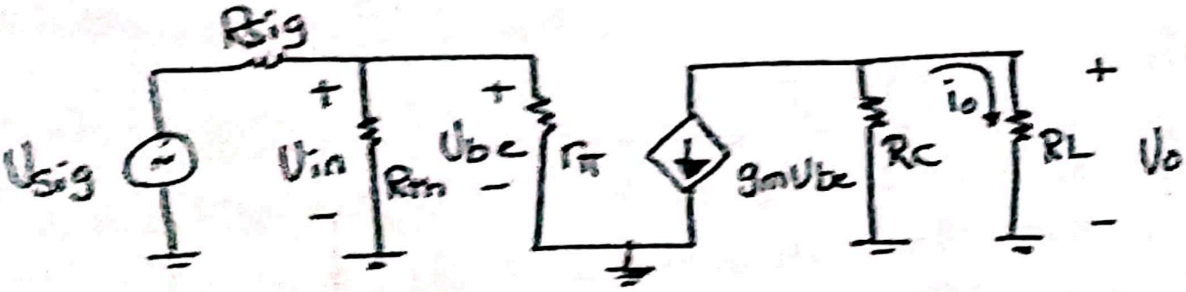
→ output resistance

$R_o = R_C = 3.9\,k\Omega$



→ $A_{vo} = \frac{V_o}{V_{in}} = \frac{V_o}{V_{be}}$

→ Called Voltage gain without RL



$$A_{vo} = \frac{V_o}{V_{in}} = \frac{V_o}{V_{be}} = \frac{-g_m V_{be} * R_C}{V_{be}} = -g_m R_C$$

$$= -73.96 * 3.9 = -288.444\ V/V$$

→ $A_v = \frac{V_o}{V_{in}} = \frac{V_o}{V_{be}} = \frac{-g_m V_{be} (R_C \parallel R_L)}{V_{be}}$

→ Voltage gain with RL

$$= -73.96 * \left(\frac{2 * 3.9}{2 + 3.9}\right) = -97.77$$

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$$= \frac{V_o}{V_{sig}} = \frac{V_o}{V_{in}} * \frac{V_{in}}{V_{sig}}$$

↳ overall Voltage gain

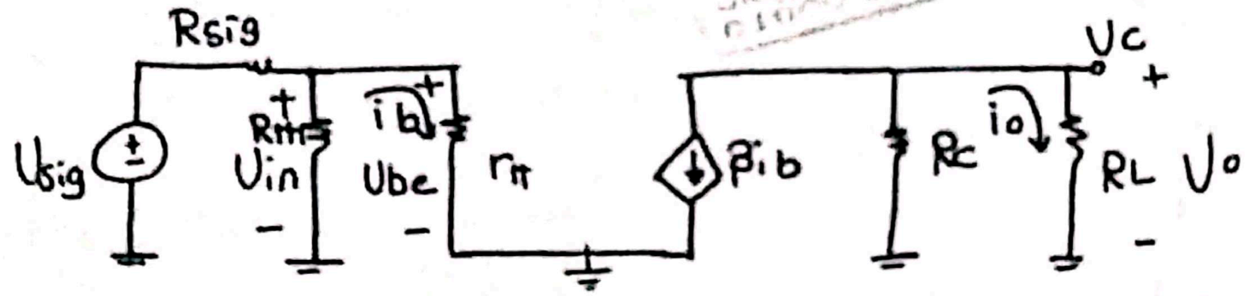
$$= \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{sig}}$$

$$V_{be} = V_{sig} * \frac{R_{in}}{R_{in}+R_{sig}} \quad , \quad \frac{V_{be}}{V_{sig}} = \frac{R_{in}}{R_{in}+R_{sig}} = 0.374$$

$$\therefore G_V = \left[-g_m (R_C \parallel R_L)\right] \left[\frac{R_{in}}{R_{in}+R_{sig}}\right]$$

$$= -97.77 * 0.374 = -36.414 \text{ V/V}$$

another Solution



→ $R_{in} = R_{th} \parallel r_\pi = 1.187 \text{ k}\Omega$

→ $R_{out} = R_C = 3.9 \text{ k}\Omega$

→ $A_{Vo} = \frac{V_o}{V_{in}} = \frac{V_o}{i_b} * \frac{i_b}{V_{be}} * \frac{V_{be}}{V_{in}}$

$$\frac{V_o}{i_b} = -\beta * R_C = -100 \times 3.9 = -390$$

$$\frac{i_b}{V_{be}} = \frac{1}{r_\pi} = \frac{1}{1.35} = 0.740$$

$$\frac{V_{be}}{V_{in}} = 1$$

$$A_{Vo} = -288.8 \text{ V/V}$$

$\rightarrow A_V = \frac{V_o}{V_{in}} = \frac{V_o}{i_b} * \frac{i_b}{V_{be}} * \frac{V_{be}}{V_{in}}$

$\frac{V_o}{i_b} = -\beta(R_C \| R_L) = -100\left(\frac{2*3.9}{2+3.9}\right) = -132.2$

$\frac{i_b}{V_{be}} = \frac{1}{r_\pi} = 0.740$

$\frac{V_{be}}{V_{in}} = 1$

$\therefore A_V = -97.8 \; V/V$

$\rightarrow G_V = \frac{V_o}{V_{sig}} = \frac{V_o}{i_b} * \frac{i_b}{V_{be}} * \frac{V_{be}}{V_{in}} * \frac{V_{in}}{V_{sign}}$

$\frac{V_o}{i_b} = -\beta \; (R_C \| R_L) = -132.2$

$\frac{i_b}{V_{be}} = \frac{1}{r_\pi} = 0.74$

$\frac{V_{be}}{V_{in}} = 1$

$\frac{V_{in}}{V_{sig}} = \frac{R_{in}}{R_{in}+R_{sig}} = 0.372$

$G_V = -36.392 \; V/V$

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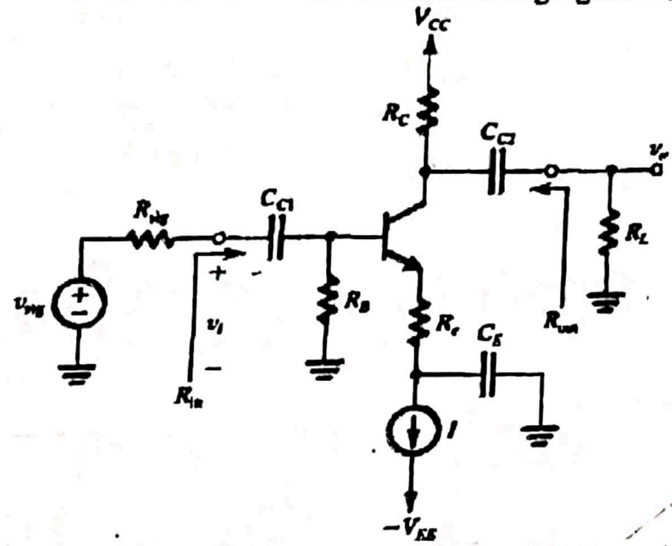
7- **For the common-emitter amplifier with an Emitter resistance shown. Find the equations of R_{in}, R_o, A_{vo}, A_v and the overall voltage gain G_v (v_o/v_{sig}).**



Sol:-

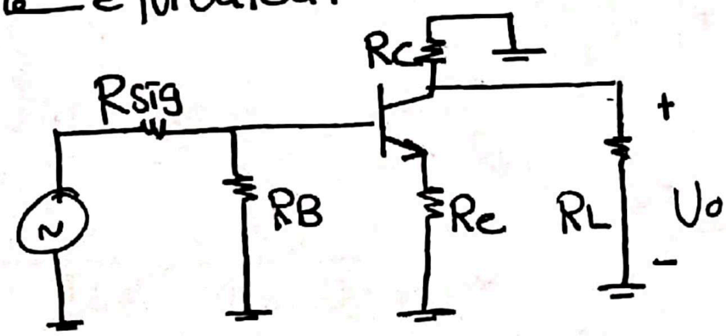
for ac analysis

① all Capacitors S.C

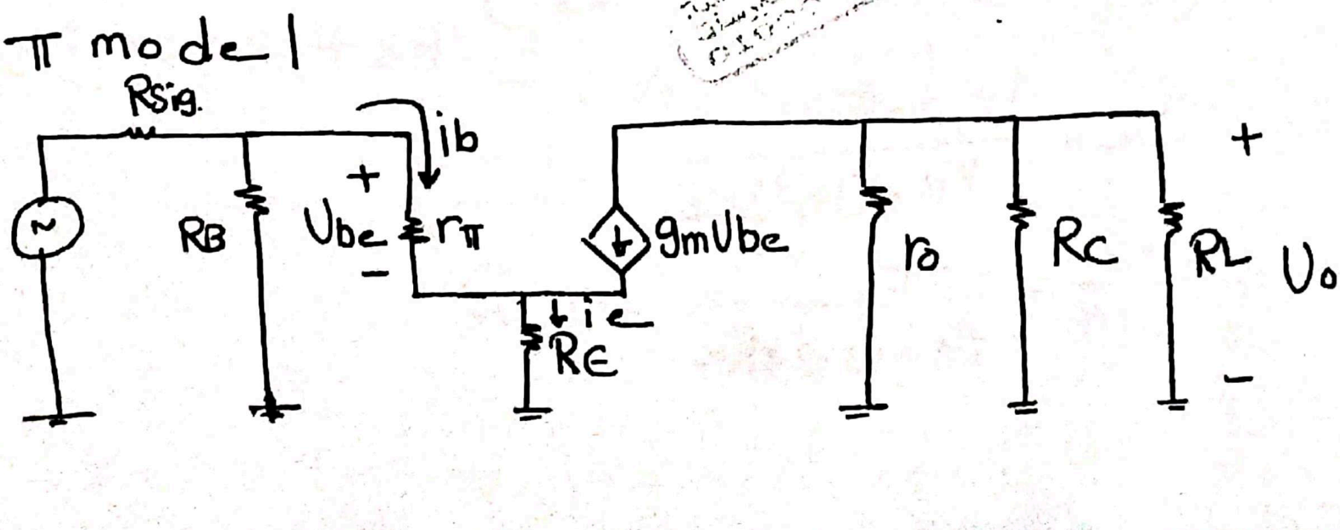
② Dc Voltage Source S.C

③ Dc current Source O.C

the equivalent circuit



Using π model

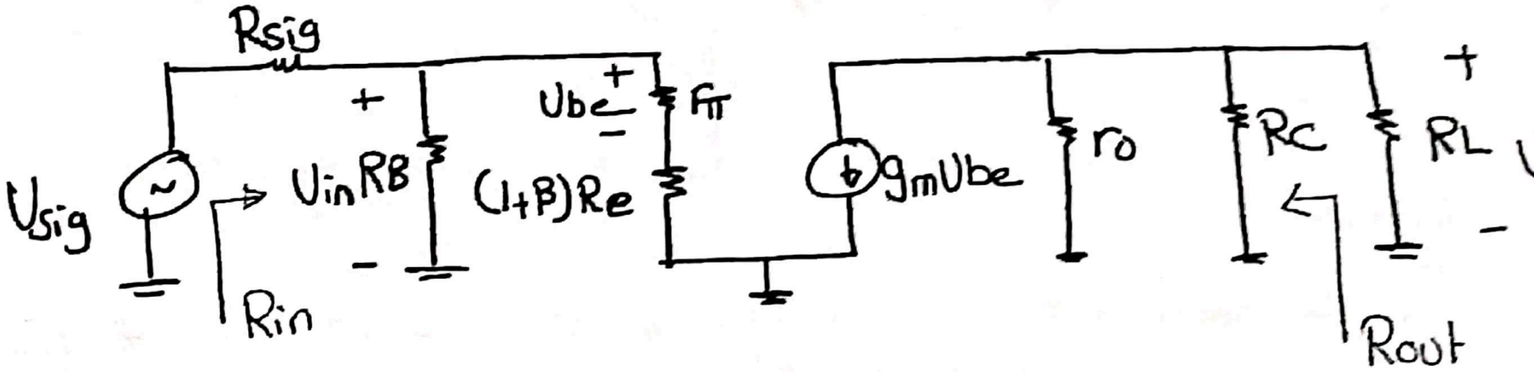


$r_o = \frac{V_A}{I_C}$, $r_\pi = \frac{V_T}{I_B}$, $g_m = \frac{I_C}{V_T}$

Note that

$\therefore i_e = (1+\beta) i_b$

the equivalent circuit can be simplified



$\rightarrow R_{in} = R_B \parallel (r_\pi + (1+\beta) R_e)$

$V_{be} \neq V_{in}$

$\rightarrow R_{out} = r_o \parallel R_C$

$\rightarrow A_{vo} = \frac{V_o}{V_{in}} = \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{in}}$

↓ without RL

$V_o = -g_m V_{be} * (r_o \parallel R_C)$

$\frac{V_o}{V_{be}} = -g_m (r_o \parallel R_C) \rightarrow (1)$

$V_{be} = \frac{V_{in} * r_\pi}{r_\pi + (1+\beta) R_e}$

$\frac{V_{be}}{V_{in}} = \frac{r_\pi}{r_\pi + (1+\beta) R_e} \rightarrow (2)$

$$V_o = [-g_m (r_o \| R_C)]\left[\frac{r_\pi}{r_\pi+(1+\beta)R_e}\right]$$

$$\to A_V = \frac{V_o}{V_{in}} = \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{in}}$$

$\downarrow$

With RL

$$V_o = -g_m V_{be} (r_o \| R_C \| R_L)$$

$$\frac{V_o}{V_{be}} = -g_m \; (r_o \| R_C \| R_L)$$

$$\frac{V_{be}}{V_{in}} = \frac{r_\pi}{r_\pi + (1+\beta) R_e}$$

$$A_v = [-g_m (r_o \| R_C \| R_L)]\left[\frac{r_\pi}{r_\pi+(1+\beta)R_e}\right]$$

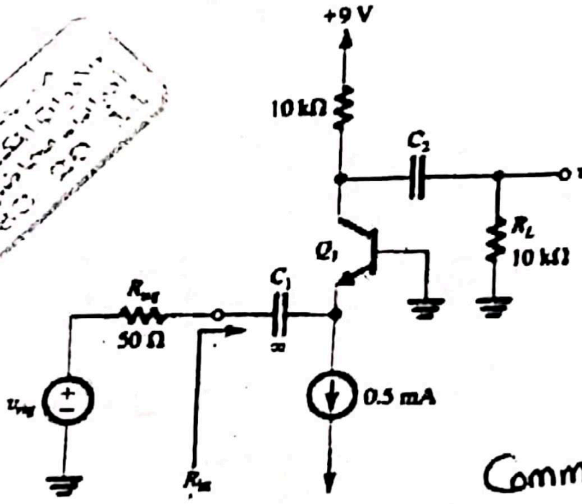
$$\to G_V = \frac{V_o}{V_{sig}} = \frac{V_o}{V_{be}} * \frac{V_{be}}{V_{in}} * \frac{V_{in}}{V_{sig}}$$

$$V_{in} = V_{sig} \; \frac{R_{in}}{R_{in}+R_{sig}}$$

$$\frac{V_{in}}{V_{sig}} = \frac{R_{in}}{R_{in}+R_{sign}}$$

$$G_V = [-g_m (r_o \| R_C \| R_L)]\left[\frac{r_\pi}{r_\pi+(1+\beta)R_e}\right]\left[\frac{R_{in}}{R_{in}+R_{sig}}\right]$$

8- For the circuit shown, draw a complete small-signal equivalent circuit (use α= 0.99). Your circuit should show the values of all components, including the model parameters. What is theinput resistance R_{in}? Calculate the voltage gain (v_o/ v_{sig}).



Common Base

Sol8-

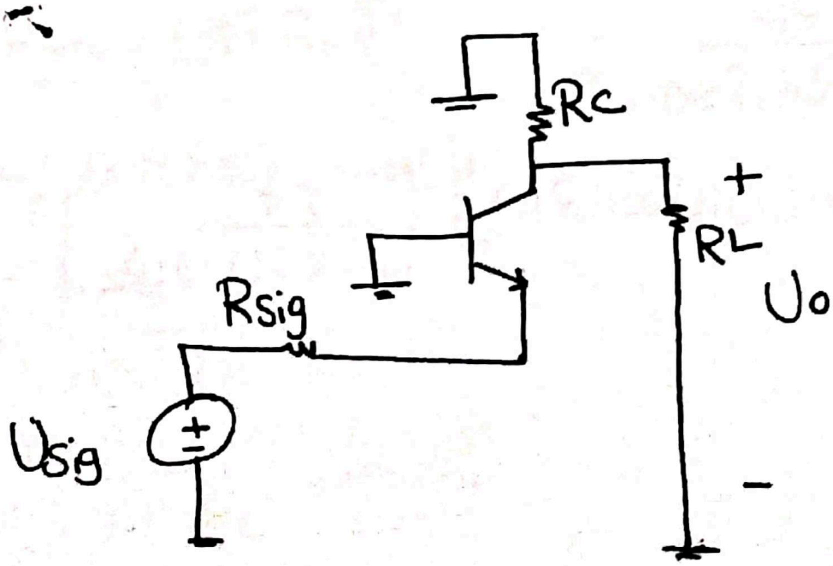
in ac analysis

① all Capacitors S.C

② Dc Voltage Source S.C

③ Dc current source O.C

the equivalent circuit



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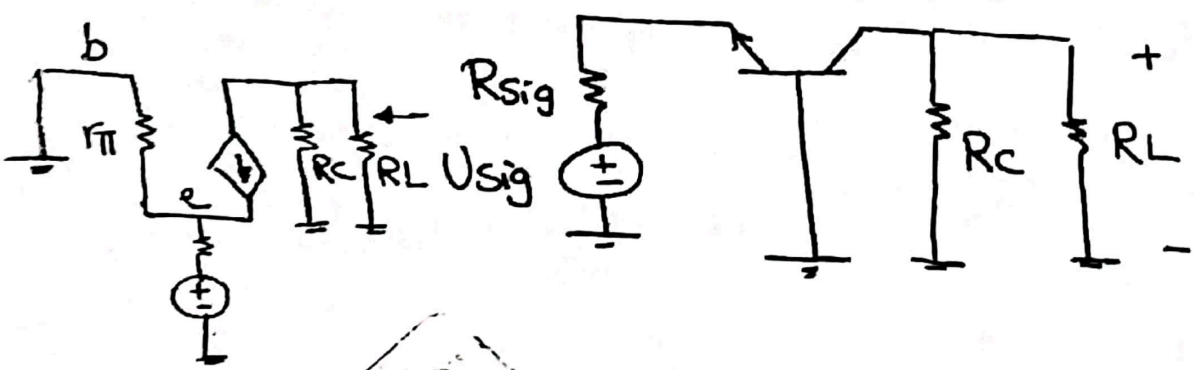
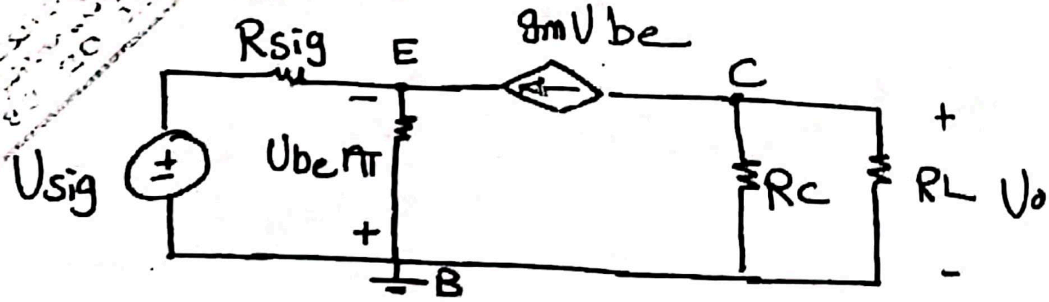
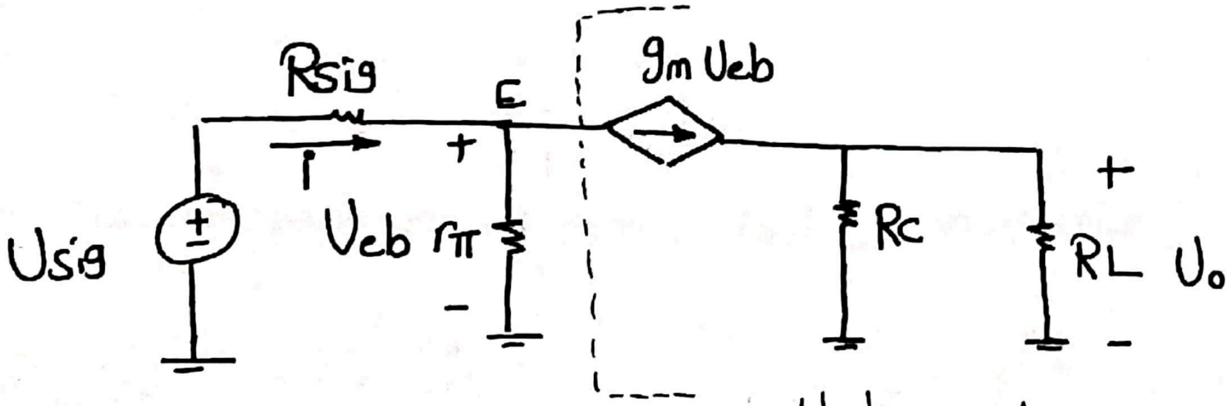






$$R = \frac{V_{eb}}{g_m V_{eb}} = \frac{1}{g_m}$$

$$R_{in} = r_\pi \,//\, R$$

$$i = \frac{V_{eb}}{r_\pi} + g_m V_{eb}$$

$$i = V_{eb}\left[\frac{1}{r_\pi} + g_m\right]$$

$$R_{in} = \frac{V_{eb}}{i} = \frac{1}{\frac{1}{r_\pi} + g_m} = \frac{1}{\frac{1 + g_m r_\pi}{r_\pi}} = \frac{r_\pi}{1 + g_m r_\pi}$$

$$= r_\pi \,//\, \frac{1}{g_m} \simeq \frac{1}{g_m}$$

$$G_V = \frac{V_o}{V_{sig}} = \frac{V_o}{V_{eb}} * \frac{V_{eb}}{V_{sig}}$$

$$\Rightarrow \quad V_o = g_m V_{eb} (R_c // R_L) \rightarrow \boxed{\frac{V_o}{V_{eb}} = g_m (R_c // R_L)}$$

$$\Rightarrow \quad i = \underline{V_{eb} \left[\frac{1}{r_\pi} + g_m\right]}$$

$$\Rightarrow \quad V_{sig} = i R_{sig} + V_{eb}$$

$$\Rightarrow \quad V_{sig} = V_{eb} \left[\frac{1}{r_\pi} + g_m\right] R_{sig} + V_{eb}$$

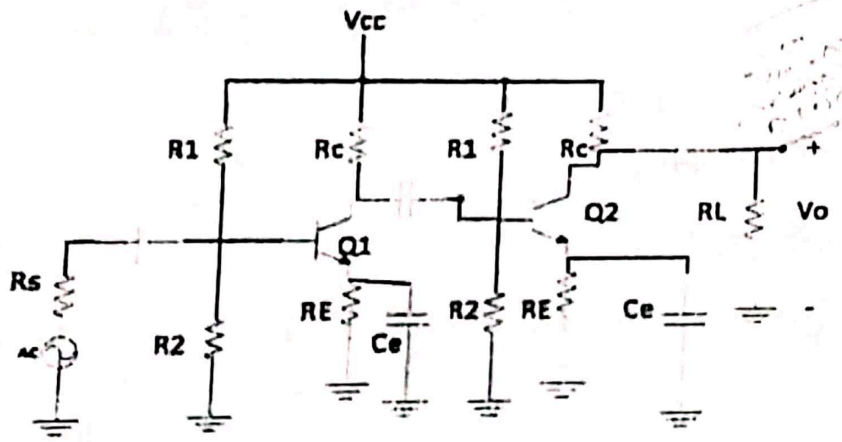
$$\Rightarrow \quad \boxed{\frac{V_{eb}}{V_{sig}} = \left(\frac{1}{r_\pi} + g_m\right) R_{sig} + 1}$$

$$\Rightarrow G_V = \frac{V_o}{V_{eb}} * \frac{V_{eb}}{V_{sig}} = \left[\left(\frac{1}{r_\pi} + g_m\right) R_{sig} + 1\right] \left[g_m (R_c // R_L)\right]$$

9- The amplifier consists of two identical common-emitter amplifiers connected in cascade. Observe that the input resistance of the second stage, R_{in2}, constitutes the load resistance of the first stage.

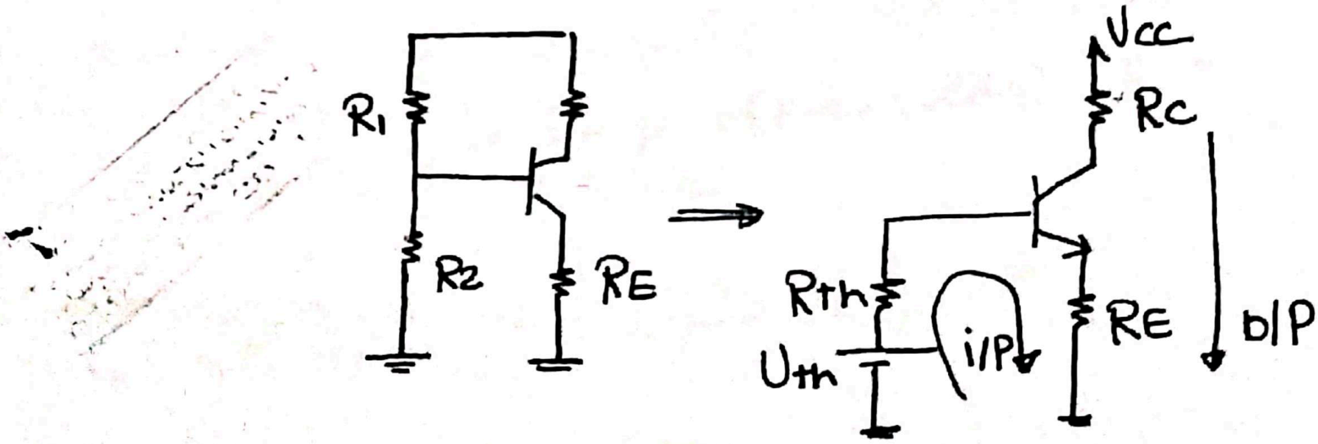
(a) For $V_{CC} = 9$ V, $R_1 = 100$ kΩ, $R_2 = 47$ kΩ, $R_E = 3.9$ kΩ, $R_C = 6.8$ kΩ, and $\beta = 100$, determine the dc collector current and dc collector voltage of each transistor.

(b) Draw the small-signal equivalent circuit of the entire amplifier and give the values of all its components.



Sol:-

1] Dc analysis for each one [Same identical transistor]



$$U_{th} = \frac{9 * 47}{47 + 100} = 2.87\text{V}$$

$$R_{th} = \frac{R * R_2}{R_1 + R_2} = 32\text{k}\Omega$$

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for i/p loop

$V_{th} - I_B R_{th} - V_{BE} - I_E R_E = 0$

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

$9 - I_B(32) - 0.7 - (101)(3.9) I_B = 0$

$I_{B_1} = 6.66\ \mu A$

$I_{E_1} = 0.672\ mA$

$I_{C_1} = 0.666\ mA$

for o/p loop

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

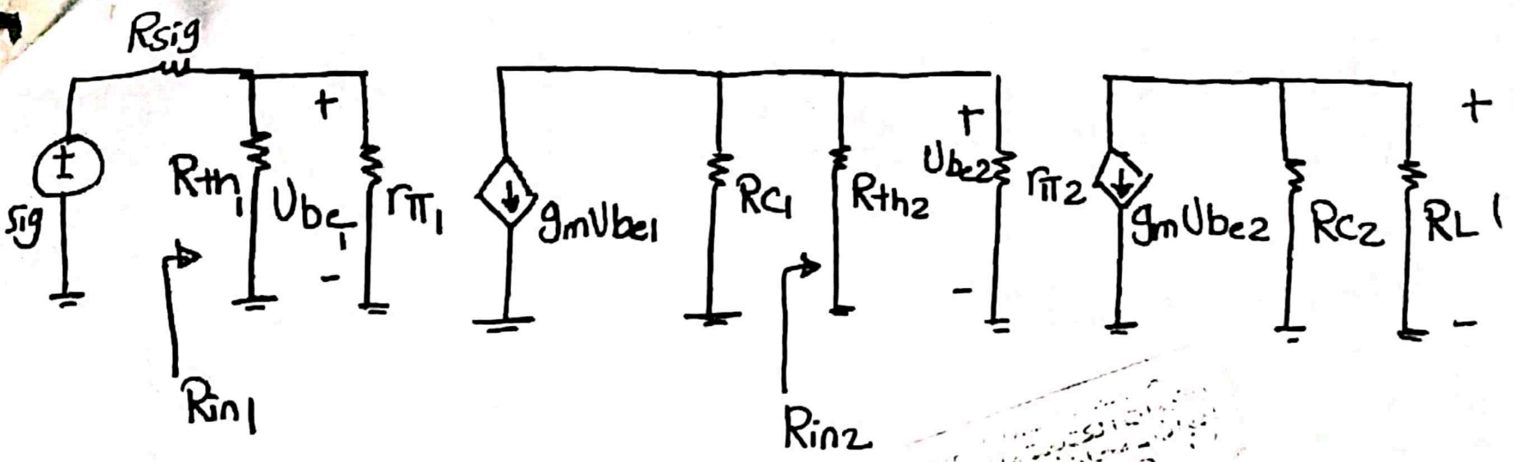
$V_{CE} = 1.8 > V_{Be}$ active

$V_C = V_{CC} - I_C R_C$

$= 9 - (0.666)(6.8) = 4.47\ V$

وال Tr التانى زيه بالظبط

Small Signal analysis



$R_{th1} = R_{th2} = 32\,k\Omega$

$g_{m1} = g_{m2} = \frac{I_C}{V_T} = \frac{0.666}{0.025} = 26.64\ mA/V$

$r_{\pi1} = r_{\pi2} = \frac{\beta}{g_m} = \frac{V_T}{I_B} \simeq 3.75\ k\Omega$

$R_{C1} = R_{C2} = 6.8\,k\Omega$

$r_{o1} = r_{o2} = \infty$

شوية مطاليب مكسم تنطلب

$R_{in1} = R_{th1} \parallel r_{\pi1} = 2.4\,k\Omega$

$R_{in2} = R_{th2} \parallel r_{\pi2} = 2.4\,k\Omega$

$$\frac{V_o}{V_s} = \frac{V_o}{V_{be2}} * \frac{V_{be2}}{V_{be1}} * \frac{V_{be1}}{V_s}$$

- $V_o = -g_{m2} V_{be2} (R_{C2} \parallel R_L)$

$\frac{V_o}{V_{be2}} = -g_{m2} (R_{C2} \parallel R_L)$

$$, U_{be2} = -g_{m1} U_{be1} (R_{C1} \parallel R_{in2})$$

$$\frac{U_{be2}}{U_{be1}} = -g_{m1} (R_{C1} \parallel R_{in2})$$

$$U_{be1} = U_s \frac{R_{in1}}{R_s + R_{in1}}$$

$$\frac{U_{be1}}{U_s} = \frac{R_{in1}}{R_s + R_{in1}}$$

$$\frac{U_o}{U_s} = \left[\frac{R_{in1}}{R_{in1} + R_s}\right] \left[-g_{m1} (R_{C1} \parallel R_{in2})\right] \left[-g_{m2} (R_{C2} \parallel R_L)\right]$$

تم بحمد الله