Faculty of Engineering
Benha university
Electrical Eng.Dept.
Dr Hossam Labib Zayed

Electronic Circuits (a) (E1203)
Final-Term Exam (corrective)
Date: 1/1/2017
Time: 3 Hours

Answer the following questions:

Q1: (a) Find the values of I and V in the circuits shown in Fig. (1).

(b) Fig.(2) shows a simpler way to draw a transistor circuit. What are collector-emitter voltage and the transistor power dissipation?

Q2: (a) In fig.(3), $V_i = 20\sin(wt)$ V. Sketch the output waveform. Assume the diode is actual.

(b) The transistor parameters for the circuit in Figure (4) are $\beta_1 = 120$, $\beta_2 = 80$, $V_{BE1}(on) = V_{BE2}(on) = 0.7$ V. Determine the quiescent collector current in each transistor.

Q3: The 6.8V zener diode in the circuit of Fig. (5) is specified to have $V_Z = 6.8$V at $I_Z = 5$mA, $r_z = 20\Omega$, and $I_{zk} = 0.2$ mA. The supply voltage V^+ is nominally 10V but can vary by ±1 V.

(a) Find V_O with no load and with V^+ at its nominal value.

(b) Find the change in V_O resulting from the ±1 V change in V^+.

(c) Find the change in V_O when $R_L = 2$ kΩ.

(d) What is the minimum value of R_L for which the diode still operates in the breakdown region?

Q4: For the circuit shown in Fig. (6), draw a complete small-signal equivalent circuit utilizing an appropriate T- model for the BJT. Your circuit should show the values of all components, including the model parameters. Find R_{in}, R_o, the voltage gain (v_o/v_{sig}) and the current gain (i_o/i_i). Assume that the transistor β = 100.

Q5: The parameters of the circuit shown in Fig.(7), are $V^+ = 3.3$V, $V^- = -3.3$V, $R_B = 100$kΩ, $R_E = 15$KΩ, $R_c = 10$ KΩ, $R_L = 2$KΩ, and $R_S = 2$KΩ. The transistor parameters are β = 120, and $V_A = \infty$. Determine the dc emitter current I_E and V_{CE}. Find using hybrid-π -model the values of R_i, the output resistance R_o, the voltage gain (v_o/v_s), and the current gain (i_o/i_i).

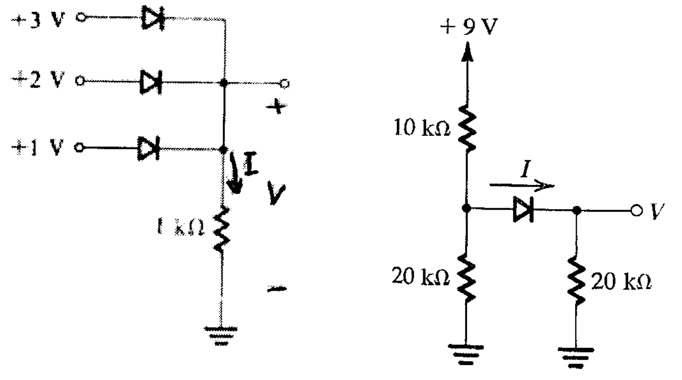


Fig.(1)

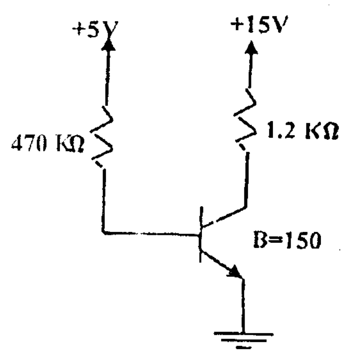


Fig.(2)

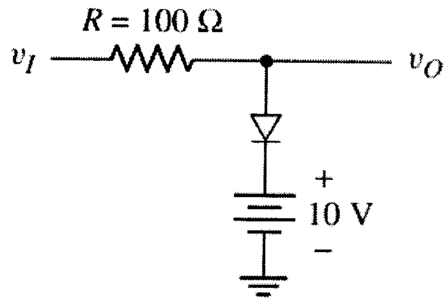


Fig.(3)

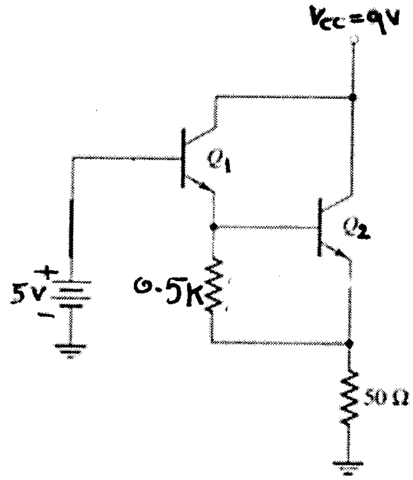


Fig.(4)

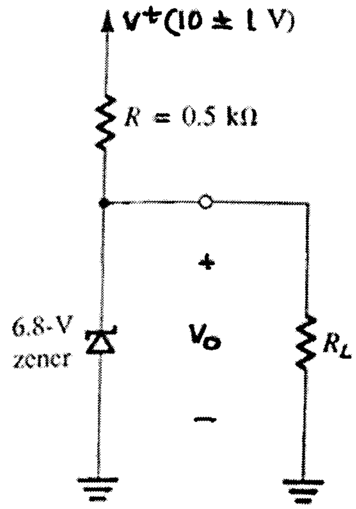


Fig.(5)

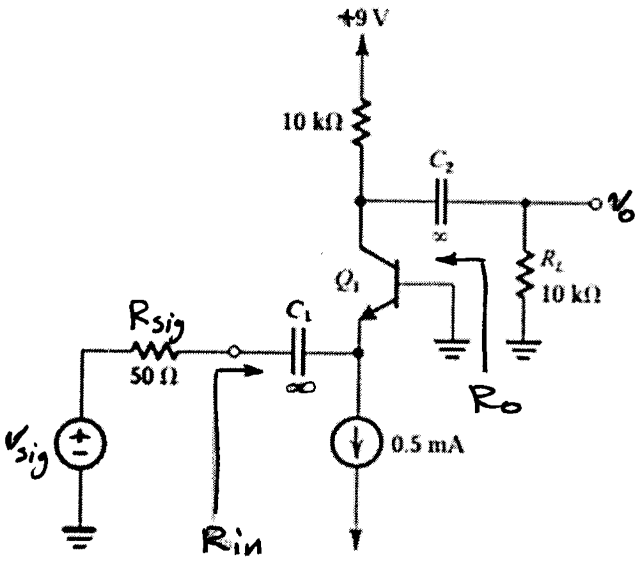


Fig.(6)

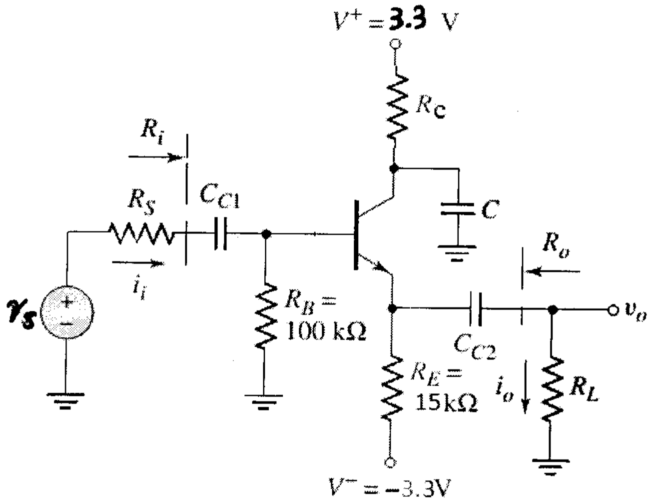
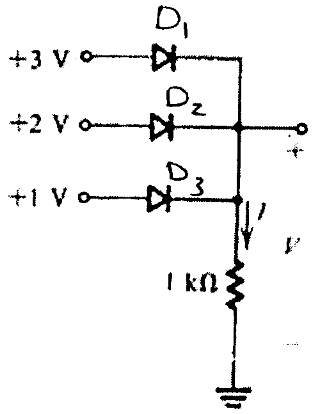


Fig.(7)

BEST WISHES

Hossam Labib

Q1 (a) Find the values of I and V in the circuits shown in Fig. (1).



(a)

For Fig. (a))

For D_1 on $\xrightarrow{V=3V}$ D_2 and D_3 are off

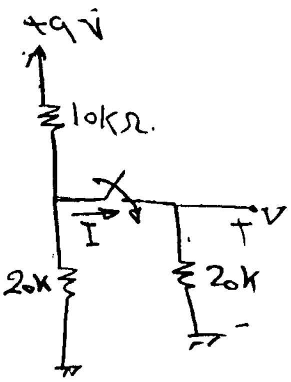
$\therefore V = 3\ V$

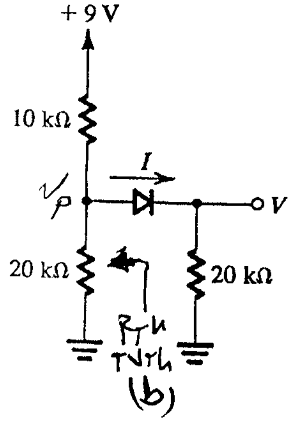
$$I = \frac{V}{R} = \frac{3}{1K\Omega} = 3mA$$

For Fig. (b)

$$V_p = \frac{9 * 20K}{10K + 20K} = 6\ V$$

Then Diode is on and replaced by S.C





(b)

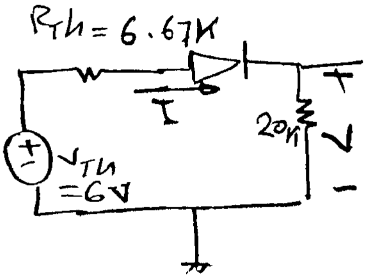
$$V = \frac{9 * (20K // 20K)}{10 + (20K // 20K)}$$

$$= \frac{9 * 10K}{20K} = 4.5\ V$$

$$I = \frac{V}{20K} = \frac{4.5}{20K} = 0.225\ mA$$

Another Solution

Using Thevenin the circuit becomes



$$V_{Th} = \frac{9 * 20K}{10K + 20K} = 6\ V \quad ; \quad R_{Th} = 10K // 20K = 6.67K$$

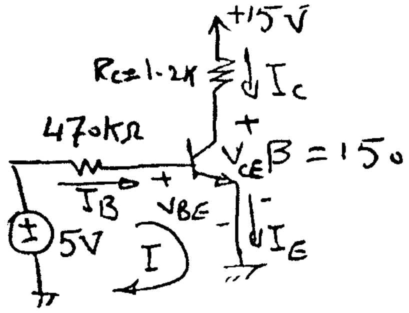
$\because V_p > V_n \Rightarrow$ Diode on

$$\therefore V = \frac{6 * 20K}{6.67K + 20K} = 4.5\ V$$

$$I = \frac{6}{6.67K + 20K} = 0.225\ mA$$

Q1 (b) (points)

Fig.(2) shows a simpler way to draw a Transistor circuit. what are collector emitter voltage and the Transistor power dissipation?



Solution

Let Transistor in Active Region

Loop (I)

$$5 = 470K\, I_B + V_{BE}$$

$$I_B = \frac{5 - 0.7}{470K} = 9.15\ \mu A$$

$\because I_C = \beta I_B = 150 * 9.15\mu = 1.3725\ mA$

$V_{CE} = V_{CC} - I_C R_C = 15 - 1.3725 * 1.2 = 13.353\ V$

$\because V_E = 0\ V$, $\because V_{BE} = V_B - V_E$

$\therefore V_B = V_{BE} = 0.7\ V$; $V_C = V_{CE} = 13.353\ V$

$\because V_B > V_E \Rightarrow$ BEJ Forward bias

$\because V_B < V_C \Rightarrow$ BCJ Revirse bias

$\therefore$ Transistor in Active Region

$\therefore V_{CE} = 13.353\ V$; $I_C = 1.3725\ mA$

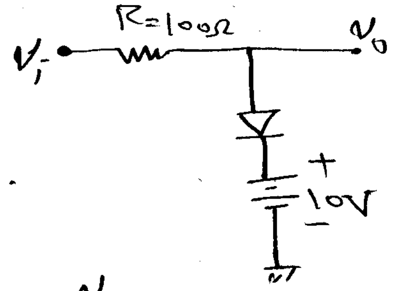
$P_{diss} = I_{CQ} V_{CEQ}$

$= 1.3725 * 10^{-3} * 13.353 = 0.0183\ w$

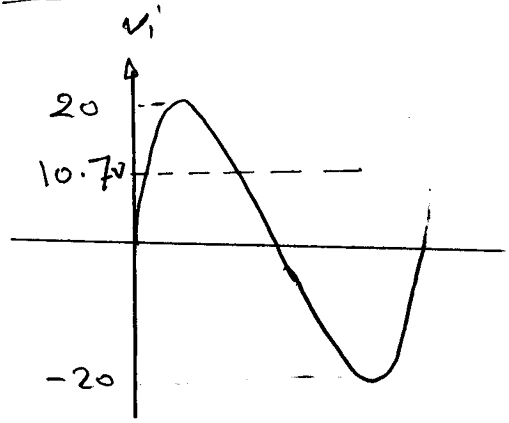
$= 18.3\ mw$

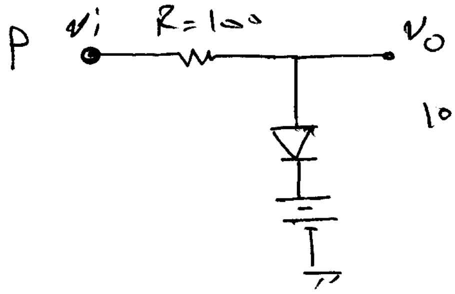
Q2 : (a)

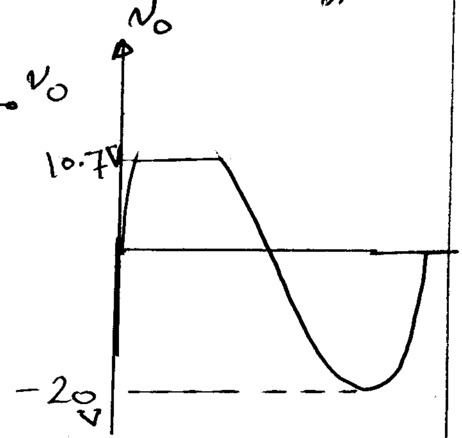
In Fig.(3) $v_i = 20\sin(\omega t)$ V. sketch the o/p waveform. Assume the diode is actual.



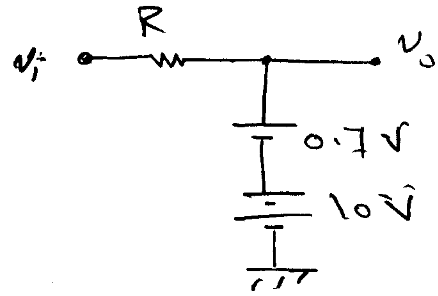
Solution







For +ve half cycle



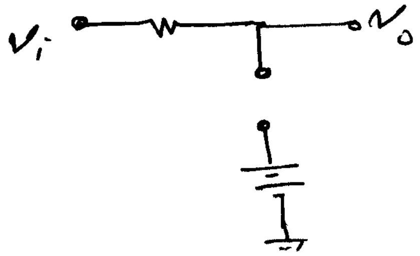
For $v_i > 10.7 \Rightarrow$ diode is on

Then $v_o = 10.7$

For $v_i < 10.7 \Rightarrow$ diode is off

$\therefore v_o = v_i$

For −ve half cycle

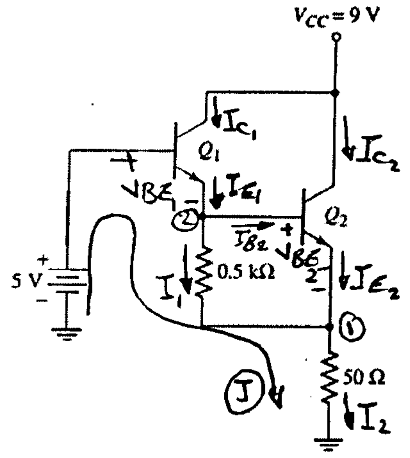


diode is off

$\therefore v_o = v_i$

Q2:

(b) The transistor parameters for the circuit in Figure (2) are $\beta_1 = 120$, $\beta_2 = 80$, $V_{BE1}(on) = V_{BE2}(on) = 0.7$ V. Determine the quiescent collector current in each transistor.



Solution

Loop (J)

$$-5 + V_{BE_1} + V_{BE_2} + 50 * I_2 = 0$$

$$I_2 = \frac{5 - V_{BE_1} - V_{BE_2}}{50}$$

$$= \frac{5 - 0.7 - 0.7}{50} = \frac{3.6}{50} = 72\text{ mA}$$

$$I_1 = \frac{V_{BE_2}}{0.5K} = \frac{0.7}{0.5K} = 1.4\text{ mA}$$

at node (1)

$$I_1 + I_{E_2} = I_2 \Rightarrow I_{E_2} = I_2 - I_1$$

$$I_{E_2} = (72 - 1.4)\,m = 70.6\text{ mA}$$

$$I_{B_2} = \frac{I_{E_2}}{1 + \beta_2} = \frac{70.6m}{81} = 871.605\ \mu A$$

$$I_{C_2} = \beta_2 I_{B_2} = 871.605\,\mu * 80 = 69.728\text{ mA}$$

at node (2)

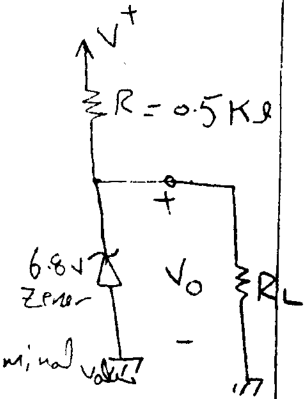
$$I_{E_1} = I_{B_2} + I_1 = 871.605\,\mu + 1.4m = 2.272\text{ mA}$$

$$I_{C_1} = \alpha_1 I_{E_1} = \frac{\beta_1}{1 + \beta_1} I_{E_1}$$

$$= \frac{120}{121} * 2.272m = 2.253\text{ mA}$$

Q3:- (12 POINTS)

The 6.8V Zener diode in the circuit shown is specified to have $V_Z = 6.8\,V$ at $I_Z = 5\,mA$, $r_Z = 20\,\Omega$, and $I_{ZK} = 0.2\,mA$. The supply voltage V^+ is nominally 10 V but can vary by $\pm 1V$.



(a) Find V_o with no load and with V^+ at its nominal value

$\because V_Z = V_{Z_0} + r_Z I_Z$

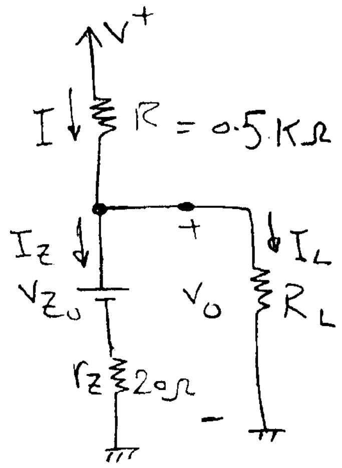
$6.8 = V_{Z_0} + 20 * 5*10^{-3}$

$\therefore V_{Z_0} = 6.8 - 0.1 = 6.7\,V$

with no load i.e $R_L = \infty$

$$I = I_Z = \frac{V^+ - V_{Z_0}}{R + r_Z}$$

$$= \frac{10 - 6.7}{0.5K + 20} = 6.35\,mA$$



$\therefore V_o = V_{Z_0} + I_Z r_Z$

$= 6.7 + 6.35 * 20 = 6.83\,V$

(b) Find the change in V_o resulting from the $\pm 1V$ change in V^+.

The change in V_o can be found from

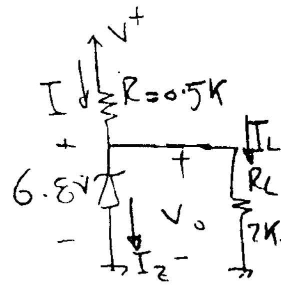
$$\Delta V_o = \Delta V^+ \frac{r_Z}{R + r_Z}$$

$$= \pm 1 * \frac{20}{0.5K + 20} = \pm 38.5\,mV$$

(C) Find the change in V_o when $R_L = 2K\Omega$

If $R_L = 2K\Omega$ is connected

$$\therefore I_L \simeq \frac{V_Z}{R_L} \simeq \frac{6.8}{2K} = 3.4\,mA$$



$$I = \frac{10 - 6.8}{0.5K} = 6.4\,mA$$

$\because I = I_Z + I_L \Rightarrow I_Z\big|_{Loaded} = I - I_L =$

$I_Z\big|_{Loaded} = 6.4m - 3.4m = 3\,mA$

Q3: (cont.)

change in Zener current $\Delta I_Z = I_Z|_{Load} - I_Z|_{No-Load}$

$\Delta I_Z = 3 - 6.35 = -3.4\,mA$

$\therefore$ change in $V_o \Rightarrow \Delta V_o = \Delta I_Z\, r_Z$

$\Delta V_o = -3.4m \times 20 = -68\,mV$

(d) what is the min. value of R_L for which the diode still operates in the breakdown region?

For the Zener at edge of the breakdown region then

$I_Z = I_{ZK} = 0.2\,mA$ and $V_{Zo} \simeq V_{ZK} \simeq 6.7\,V$

$\therefore$ At this point the lowest current supplied through R is

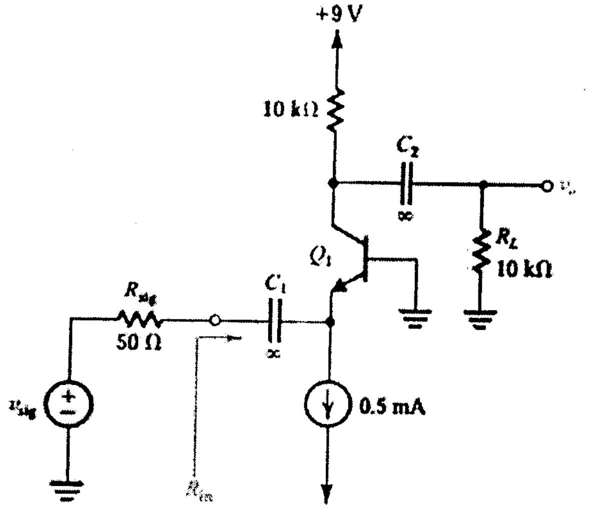
$$I = \frac{V^+ - V_{ZK}}{R}$$

$$= \frac{9 - 6.7}{0.5k} = 4.6\,mA$$

$\because I_L = I - I_Z = 4.6 - 0.2 = 4.4\,m$

$$R_L|_{min} = \frac{V_o}{I_L} \simeq \frac{V_Z}{I_L}$$

$$= \frac{6.7}{4.4m} = 1.5\,K\Omega$$

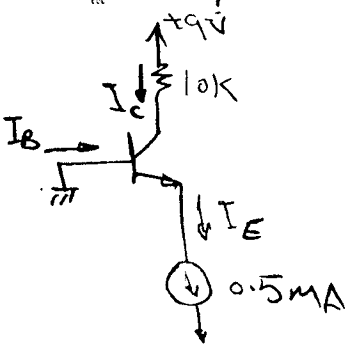


Q4: For the circuit shown in Fig. (5), draw a complete small-signal equivalent circuit utilizing an appropriate T- model for the BJT (use α = 0.99). Your circuit should show the values of all components, including the model parameters. Find R_{in}, R_o, the voltage gain (v_o/v_{sig}) and the current gain (i_o/i_i).

Solution

DC Analysis

- All capacitors are o.c
- reduce AC sources



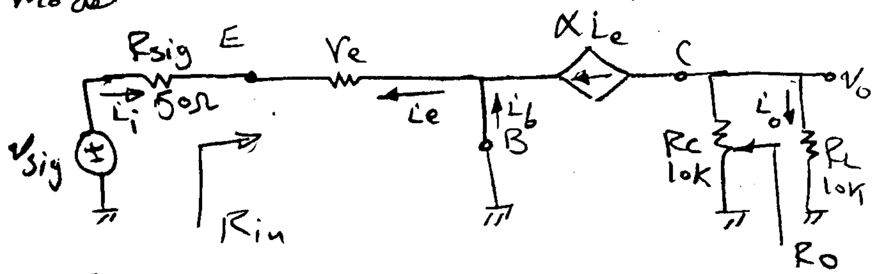
$I_E = 0.5\,mA$

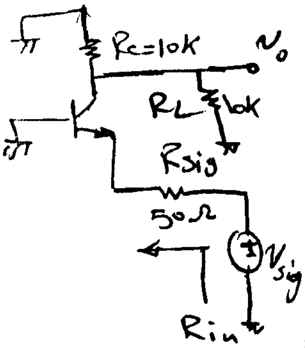
$r_e = \frac{V_T}{I_E} = \frac{25\,mV}{0.5\,mA} = 50\,\Omega$

AC Analysis

- All capacitors are s.c ; reduce DC sources i.e V.S = s.c & C.S = o.c

Using T-model





$R_{in} = r_e = 50\,\Omega$

$R_o \big|_{v_{sig}=0} = R_C = 10\,K\Omega$

$v_o = -\alpha i_e (R_C \| R_L)$

$i_e = -i_i = \frac{-v_{sig}}{R_{sig} + r_e}$

$\therefore v_o = \frac{+\alpha v_{sig} (R_C \| R_L)}{R_{sig} + r_e}$

$\therefore A_v = \frac{v_o}{v_{sig}} = \frac{\alpha (R_C \| R_L)}{R_{sig} + r_e}$

$A_v = \frac{0.99\,(10K \| 10K)}{50 + 50} = \frac{0.99 * 5K}{100} = 49.5\ V/V$

Q4: (Cont.)

To find $A_i = \frac{i_o}{i_i}$

$$i_o = -\alpha i_e \frac{R_C}{R_C + R_L}$$

$$i_i = -i_e$$

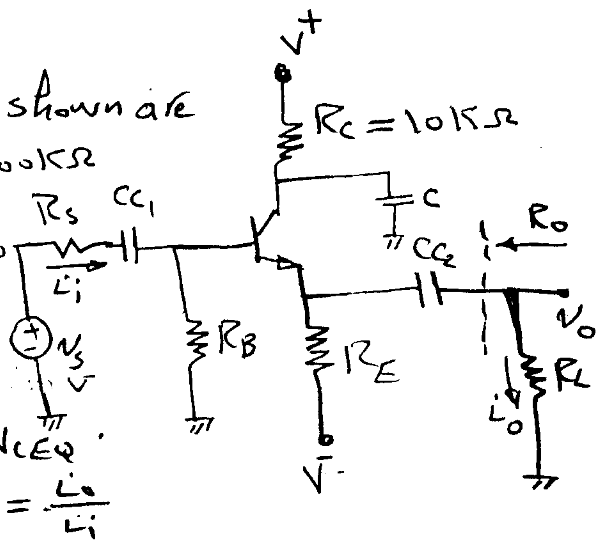
$$\therefore A_i = \frac{i_o}{i_i} = \frac{\alpha R_C}{R_C + R_L}$$

$$= \frac{0.99 * 10k}{10k + 10k} = \frac{0.99}{2} = 0.495 \text{ A/A}$$

Q5: (15 points)

The parameters of the circuit shown are $V^+ = 3.3\ V$, $V^- = -3.3\ V$, $R_B = 100K\Omega$, $R_E = 15K\Omega$, $R_L = 2K\Omega$, $R_S = 2K\Omega$, and $R_C = 10K\Omega$. The transistor parameters are $\beta = 120$ and $V_A = \infty$. (a) Determine I_{EQ} and V_{CEQ}.

(b) Find R_i, R_o, $A_v = \frac{v_o}{v_s}$, and $A_i = \frac{i_o}{i_i}$

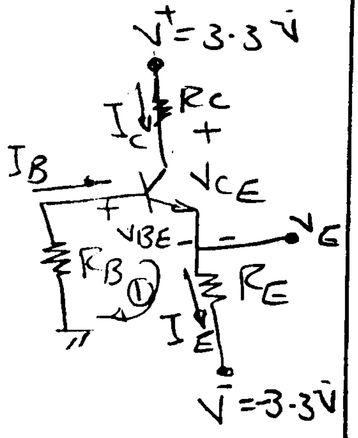


Solution:

DC Analysis

All capacitor are o.c and reduce AC sources

Loop ①



$$I_B R_B + V_{BE} + I_E R_E + V^- = 0$$

$$\because I_B = \frac{I_E}{1+\beta}$$

$$\therefore \frac{I_E R_B}{1+\beta} + V_{BE} + I_E R_E + V^- = 0$$

$$I_E \left(\frac{R_B}{1+\beta} + R_E \right) = -V^- - V_{BE}$$

$$I_{EQ} = \frac{-V^- - V_{BE}}{R_E + \frac{R_B}{1+\beta}} = \frac{3.3 - 0.7}{15K + \frac{100K}{121}} = 0.164\ mA$$

$$V_E = I_E R_E + V^- = 0.164 * 15 - 3.3\ V = -0.84\ V$$

$$V_{CEQ} = V_C - V_E \quad ; \quad V_C = V^+ - I_C R_C = 1.674\ V$$

$$V_{CEQ} = 1.674 - (-0.84) = 2.514\ V$$

$$I_C = \alpha I_E = \left(\frac{\beta}{1+\beta} \right) I_E = \frac{120}{121} * 0.164m = 0.1626\ mA$$

$$g_m = \frac{I_C}{V_T} = \frac{0.1626\ m}{25\ m} = 6.504\ mA/V$$

$$r_e = \frac{V_T}{I_E} = \frac{25m}{0.164m} = 152.44\ \Omega$$

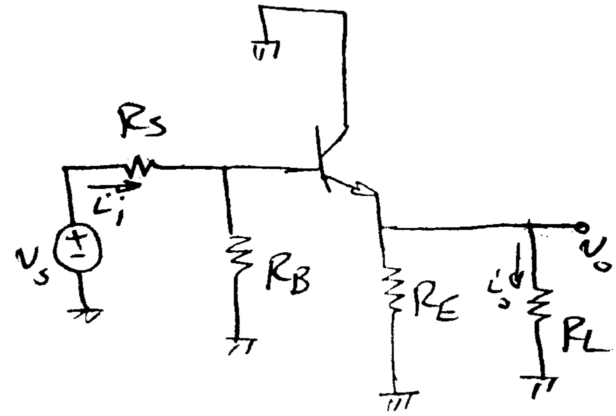
$$\because V_A = \infty \Rightarrow r_o = \infty$$

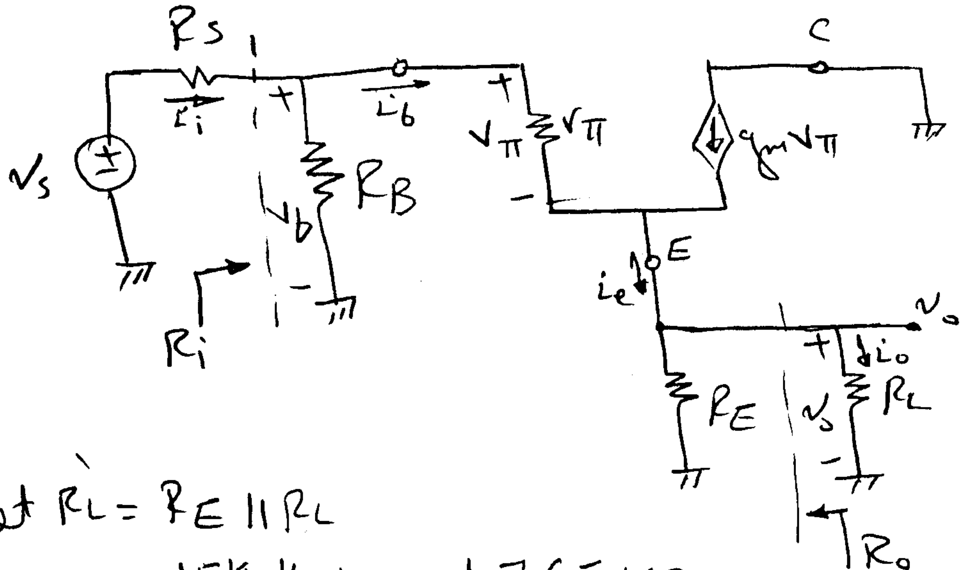
$$r_\pi = \frac{\beta}{g_m} = \frac{120}{6.504m} = 18.45\ K\Omega.$$

AC Analysis

- All capacitors are s.c
- reduce DC sources

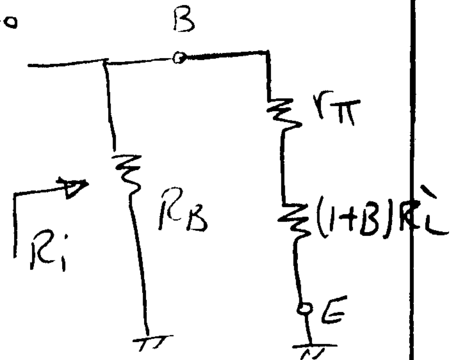
using π-model





let $R_L' = R_E \parallel R_L$

$= 15K \parallel 2K = 1.765\ K\Omega.$



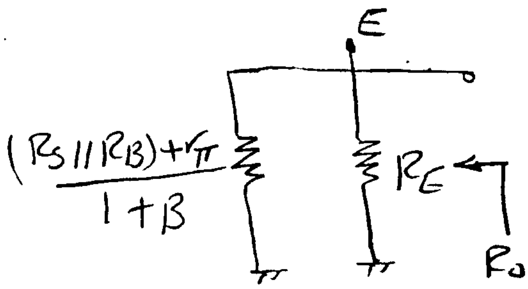
To find R_i

$$R_i = R_B \parallel [r_\pi + (1+B)R_L']$$

$$= 100K \parallel [18.45K + (121) * 1.765K]$$

$$= 100K \parallel (232.015K) = 69.88\ K\Omega$$

To find R_o

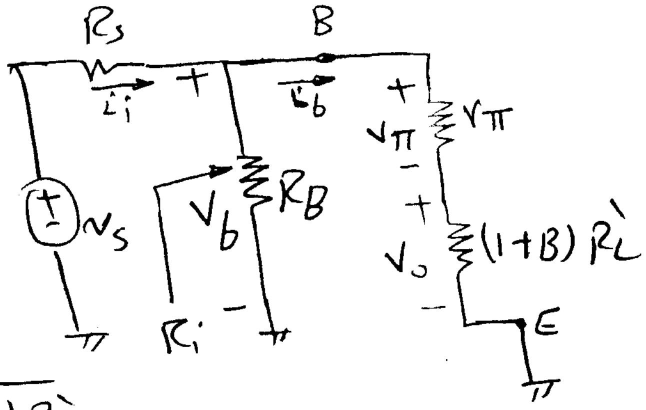


$$R_o\Big|_{v_s=0} = R_E \parallel \left[\frac{(R_S \parallel R_B) + r_\pi}{1+B}\right]$$

$$= 15K \parallel \left[\frac{(2K \parallel 100K) + 18.45K}{121}\right]$$

$$= 15K \parallel 168.68 = 166.8\ \Omega$$

To find $A_v = \frac{v_o}{v_s}$



$$v_b = v_s \frac{R_i}{R_s + R_i}$$

$$v_o = v_b \frac{(1+\beta) R_L'}{r_\pi + (1+\beta) R_L'}$$

$$\therefore v_o = v_s \frac{R_i}{R_s + R_i} * \frac{(1+\beta) R_L'}{r_\pi + (1+\beta) R_L'}$$

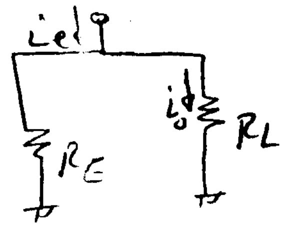
$$\therefore A_v = \frac{v_o}{v_s} = \frac{R_i}{R_s + R_i} * \frac{(1+\beta) R_L'}{r_\pi + (1+\beta) R_L'}$$

$$= \frac{69.88K}{2K + 69.88K} * \frac{121 * 1.765K}{18.45K\Omega + 121 * 1.765K}$$

$$= 0.9722 * 0.9205$$

$$= 0.895 \quad V/V$$

To find $A_i = \frac{i_o}{i_i}$



$$i_o = i_e \frac{R_E}{R_E + R_L}$$

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

$$i_b = i_i \frac{R_B}{R_B + r_\pi + (1+\beta) R_L'}$$

$$\therefore i_o = (1+\beta) i_i \frac{R_B}{R_B + r_\pi + (1+\beta) R_L'} \frac{R_E}{R_E + R_L}$$

$$\therefore A_i = \frac{i_o}{i_i} = (1+\beta) \frac{R_B}{R_B + r_\pi + (1+\beta) R_L'} * \frac{R_E}{R_E + R_L}$$

$$= (1+120) \frac{100K}{100K + 18.45K + 121 * 1.765K} * \frac{15K}{15K + 2K}$$

$$= 121 * 0.3012 * 0.8824$$

$$= 32.17 \quad A/A$$