Faculty of Engineering
Benha university
Electrical Eng.Dept.
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Electronic Circuits (a) (E1203)
Final-Term Exam (Corrective)
Date: 3/1/2016
Time: 3 Hours

Answer the following questions:

Q1: (a) Assuming that the diodes in the circuit of Fig.(1) are ideal, find the values of the labeled voltage, V, and current, I.

(b) In fig.(2), the firs transistor Q_1 has a current gain of 100 and the second transistor Q_2 has a current gain of 50, what is the base current in the first transistor?

Q2: (a) Determine and sketch the output waveform for the network of Fig. (3).

(b) What is the output voltage in Fig.(4). Let β of the two transistors are very high.

Q3: The 6.8V zener diode in the circuit of Fig.(5) is specified to have V_z= 6.8V at I_z=5mA, r_z=20Ω, 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: In the circuit of Fig.(6), v_{sig} is a small sine-wave signal with zero average value. For V_{CC}=15V, R_1= R_2=100KΩ, R_E=200 Ω, R_C=R_L=20 KΩ, and β = 100. Find using hybrid-π model the values of R_{in}, R_o, the voltage gain (v_o/v_{sig}), and the current gain (i_o/i_i).

Q5: For the universal BJT amplifier configuration as shown in fig. (7), let R_B = 100 KΩ, R_C = R_E =10 KΩ, V_{CC} = V_{EE} = 10V, β =100, and I_C = 0.838 mA. If the amplifier is connected in the common base configuration draw the complete circuit of the amplifier and then find using T-model the values of R_i, R_o, A_v, and A_i for R_S = R_L = 10 KΩ.

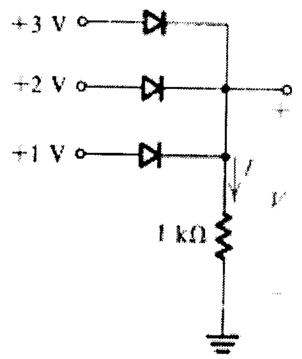


Fig.(1)

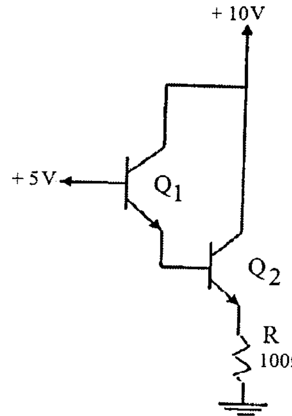


Fig.(2)

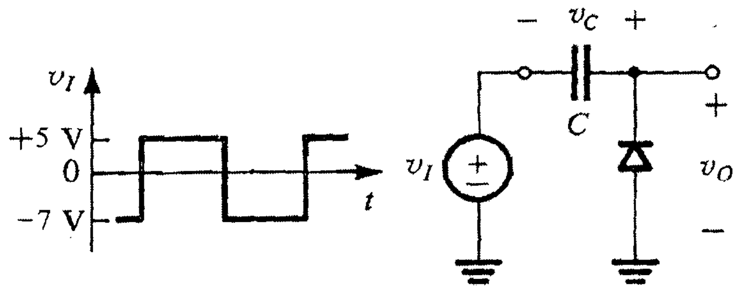


Fig.(3)

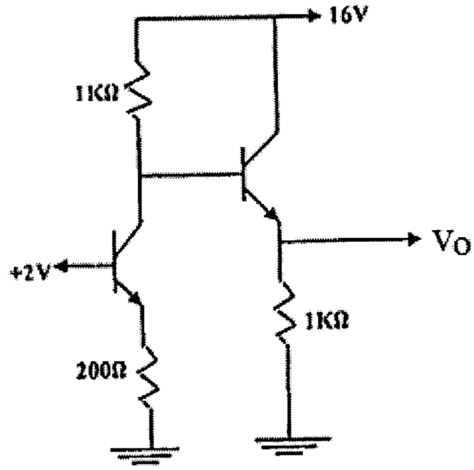


Fig.(4)

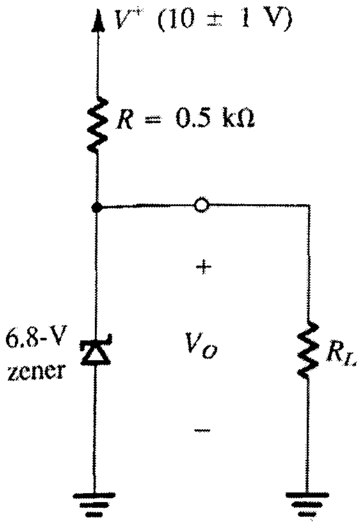


Fig.(5)

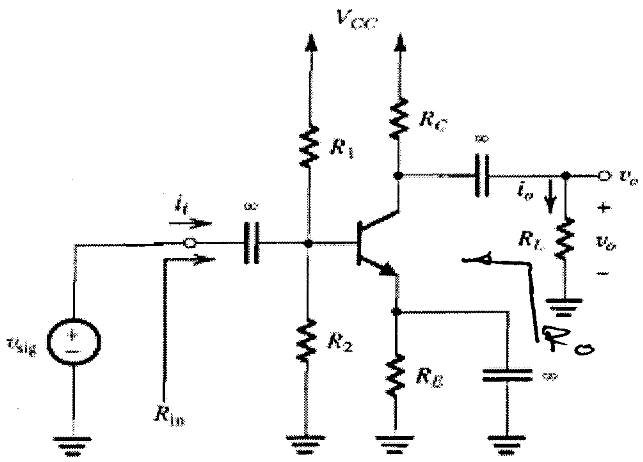


Fig.(6)

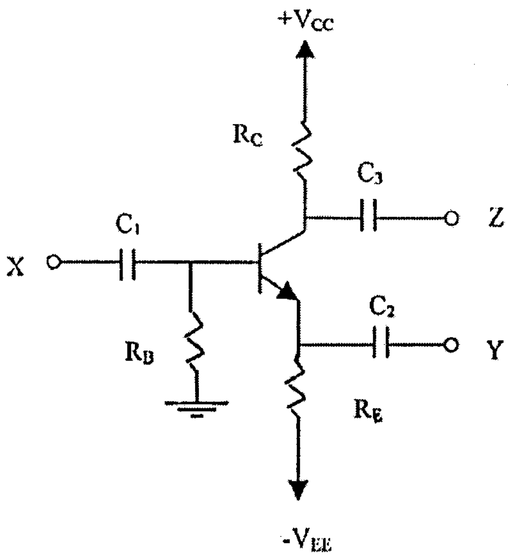


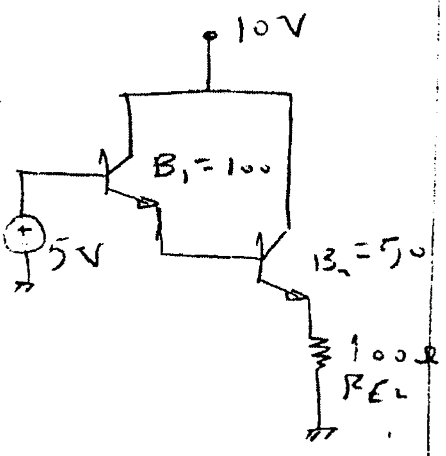
Fig.(7)

BEST WISHES

Hossam Labib

Q1:(b)

The first transistor has a current gain of 100 and the second transistor has a current gain of 50, what is the base current in the first transistor?

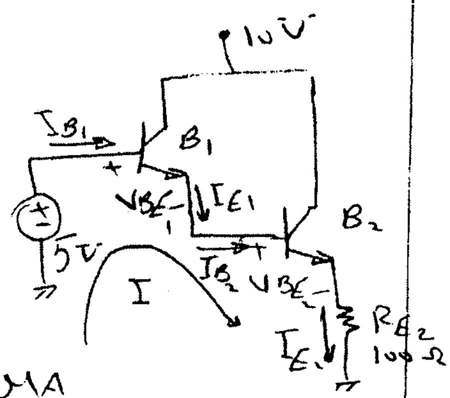


Solution

let 2-Transistor in Active region

Loop (I)

$$-5 + V_{BE_1} + V_{BE_2} + I_{E_2} R_{E_2} = 0$$



$$I_{E_2} = \frac{5 - 0.7 - 0.7}{100} = 36\,mA$$

$$I_{B_2} = \frac{I_{E_2}}{1+B_2} = \frac{36\,mA}{51} = 705.8\,\mu A$$

$$\because I_{E_1} = I_{B_2} = 705.8\,\mu A$$

$$\therefore I_{B_1} = \frac{I_{E_1}}{1+B_1} = \frac{705.8\,\mu A}{101} = 7\,\mu A.$$

$V_{B_1} = 5\,V$

$V_{E_1} = V_{B_2} = 5 - V_{BE_1} = 4.3\,V$

$V_{C_1} = V_{C_2} = 10\,V$

$V_{E_2} = I_{E_2} R_{E_2} = 36m \times 100 = 3.6$

$V_{B_1} > V_{E_1} \Rightarrow$ BEJ Forward

$V_{C_1} > V_{B_1} \Rightarrow$ BCJ reverse.

$\therefore Q_1$ in Active region

$V_{B_2} > V_{E_2} \Rightarrow$ BEJ Forward

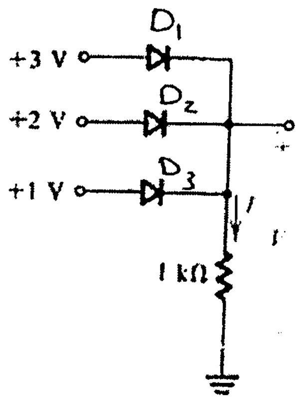
$V_{C_2} > V_{B_2} \Rightarrow$ BCJ reverse.

$\therefore Q_2$ in Active region

$\therefore$ Assumption True.

$\therefore I_{B_1} = 7\,\mu A$

Q$_1$ (a) Find the values of I and V in the circuits shown in Fig. (1).



For Fig. (a))

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

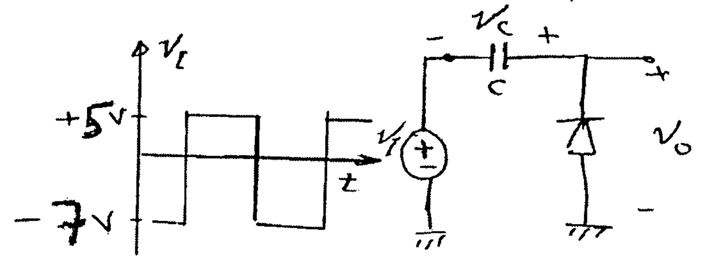
$\therefore V = 3\ V$

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

Q2: (a)

points!

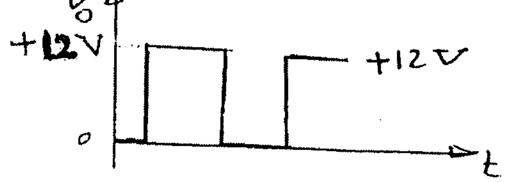
Q2: (a) Determine and sketch the output waveform for the network shown



$V_c = 7$ V

$V_o = V_i + V_c$ i.e $V_o = V_i$ + shifted by -ve half cycle

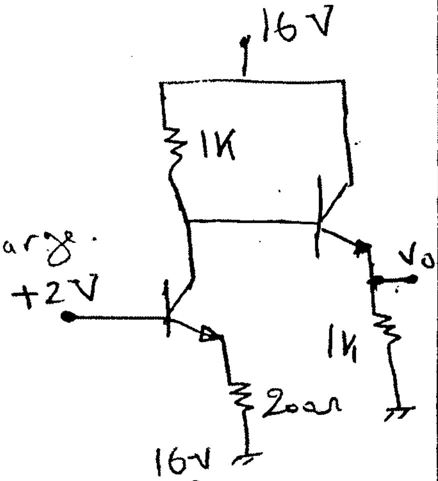
$= V_i + 7$



Q2(b)

what is the o/p voltage.

- Let β of the 2-transistors is very Large.

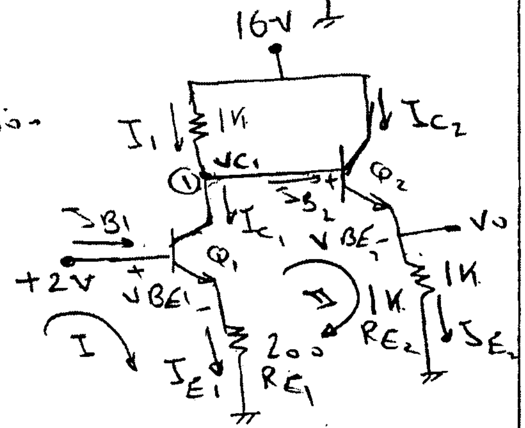


Solution

∵ β is very high

∴ $I_{B_1} = I_{B_2} \simeq 0$

let Q_1 and Q_2 in Active region



Loop (I)

$-2 + V_{BE_1} + I_{E_1} R_{E_1} = 0$

$I_{E_1} = \frac{2 - 0.7}{200} = 6.5 \text{ mA}$

$\therefore I_{C_1} = I_{E_1}$

∴ at node ① ⇒ $I_1 = I_{C_1} + I_{B_2}$; $I_{B_2} = 0$

$\therefore I_1 = I_{C_1} = 6.5 \text{ mA}$

$V_{C_1} = 16 - I_1 \times 1K = 16 - 6.5 \times 1 = 9.5 \text{ V} = V_{B_2}$

$V_{E_1} = I_{E_1} R_{E_1} = 6.5 \times 0.2 = 1.3 \text{ V}$

Loop (II)

$-V_{C_1} + V_{BE_2} + I_{E_2} R_{E_2} = 0$

$I_{E_2} = \frac{9.5 - 0.7}{1K} = 8.8 \text{ mA}$

$\therefore V_o = I_{E_2} R_{E_2} = 8.8 \times 1 = 8.8 \text{ V} = V_{E_2}$

$V_{C_2} = 16 \text{ V}$

for Q_1 ∵ $V_{B_1} > V_{E_1}$ ⇒ BEJ → Forward

$V_{B_1} < V_{C_1}$ ⇒ BCJ → Reverse

∴ Q_1 in Active region

for Q_2 ∵ $V_{B_2} > V_{E_2}$ ⇒ BEJ → Forward.

$V_{B_2} < V_{C_2}$ ⇒ BCJ → Reverse

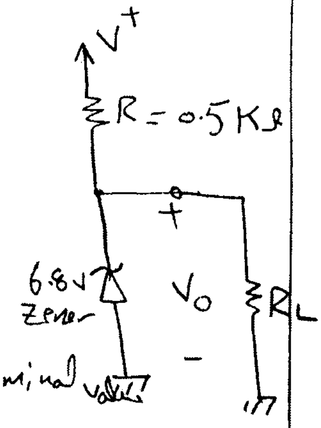
∴ Q_2 in Active region

∴ Assumption is True.

∴ $V_o = V_{E_2} = 8.8 \text{ V}$

Q3:-(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 $\pm 1V$.

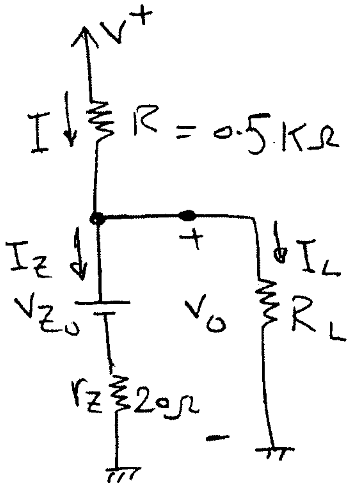


(a) Find V_o with no load and with V^+ at its nominal value.

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

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

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



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

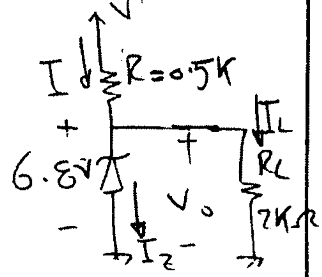
$$\Delta V_o = \Delta V^+ \frac{r_Z}{R + r_Z}$$

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

(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 $\Delta I_Z = I_Z\Big|_{Load} - I_Z\Big|_{No\text{-}Load}$

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

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

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

(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 $V_{Z_0} \simeq V_{ZK} \simeq 6.7\,V$

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

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

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

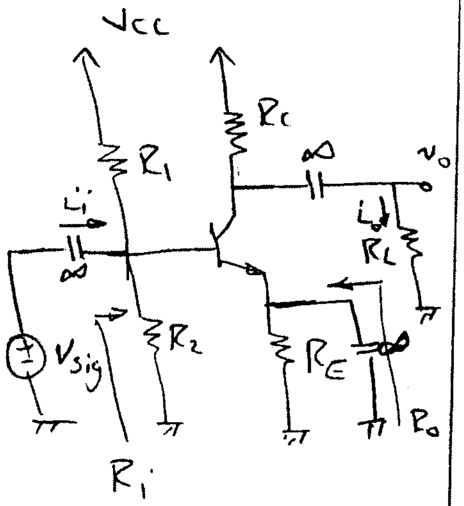
$\because I_L = I - I_Z = 4.6 - 0.2 = 4.4\,m$

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

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

Q4: (points)

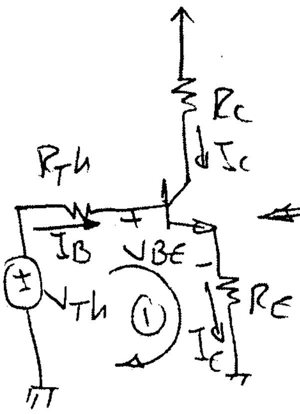
In The circuit of fig. ( ), v_{sig} is a small sine-wave signal with zero average value. For $V_{CC} = 15$ V, $R_1 = R_2 = 100\ K\Omega$, $R_E = 200\ \Omega$, $R_C = R_L = 20\ K\Omega$, and $\beta = 100$. Find using hybrid-π model the values of R_{in}, R_o, The voltage gain $\left(\frac{v_o}{v_{sig}}\right)$, and The current gain $\left(\frac{i_o}{i_i}\right)$.

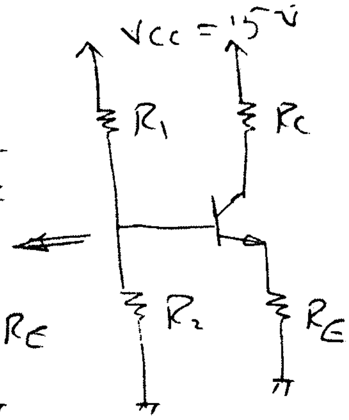


Solution

DC Analysis

- All cap. o.c
- reduce AC sources





$R_{Th} = R_1 \parallel R_2$

$= 100K \parallel 100K = 50\ K\Omega.$

$$V_{Th} = \frac{V_{CC}\ R_2}{R_1 + R_2} = \frac{15 * 100K}{100K + 100K} = 7.5\ V$$

Loop (1)

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

$\because I_E = (1+\beta) I_B$

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

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

$$I_B = \frac{V_{Th} - V_{BE}}{R_{Th} + (1+\beta) R_E} = \frac{7.5 - 0.7}{50K + 101 * 200} = 96.87\ \mu A$$

$I_C = \beta I_B = 100 * 96.87\ \mu A = 9.687\ mA$

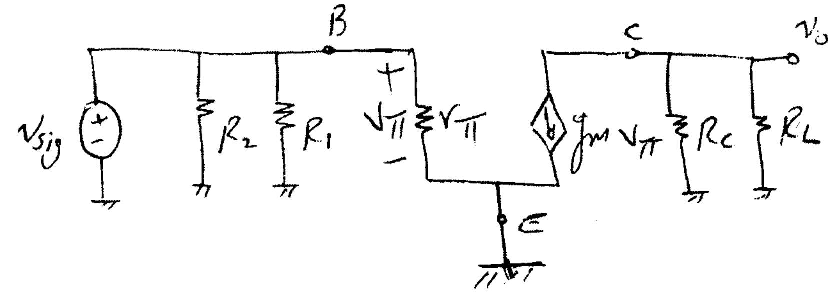
$$g_m = \frac{I_C}{V_T} = \frac{9.687m}{25m} = 0.388\ A/V$$

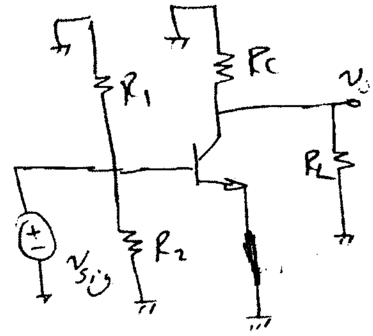
$$r_\pi = \frac{\beta}{g_m} = \frac{100}{0.388} = 258\ \Omega$$

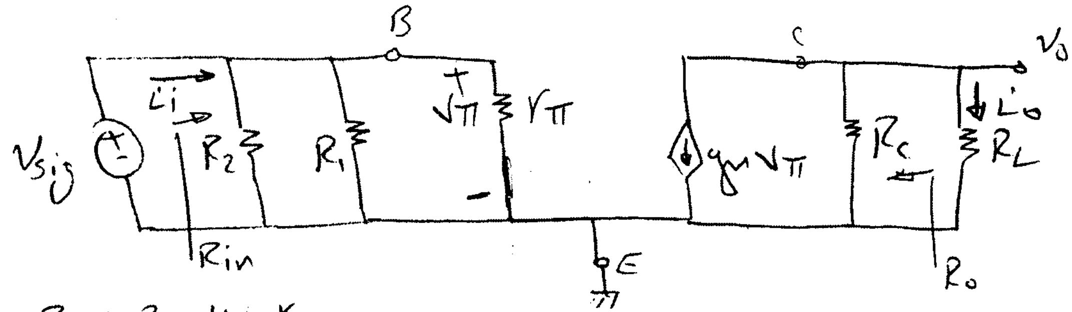
AC Analysis

- All cap. s.c & reduce DC sources

Q4: (Cont.)







$R_{in} = R_1 \| R_2 \| r_\pi$

$= 100K \| 100K \| 258$

$= 50K \| 258 = 256.68\ \Omega$

$R_o \big|_{v_{sig}=0} = R_C = 20\ K\Omega.$

$v_o = -g_m v_\pi (R_C \| R_L)$

$v_\pi = v_{sig}$

$v_o = -g_m v_{sig} (R_C \| R_L)$

$A_v = \frac{v_o}{v_{sig}} = -g_m (R_C \| R_L) = -g_m (R_C \| R_L)$

$= -0.388 * (20K \| 20K) = -3880\ V/V$

$i_o = -g_m v_\pi \frac{R_C}{R_C + R_L}$

$\because v_{sig} = i_i R_{in}$; $v_\pi = v_{sig}$

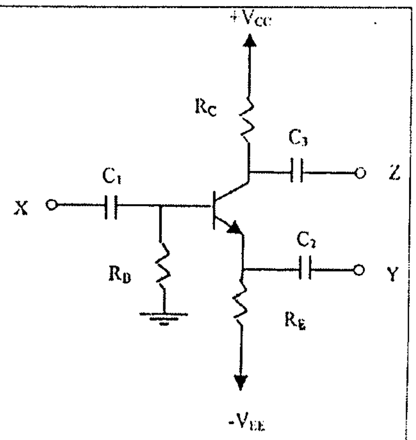
$\therefore v_\pi = i_i R_{in}$

$i_o = -g_m (i_i R_{in}) \left(\frac{R_C}{R_C + R_L} \right)$

$A_i = \frac{i_o}{i_i} = -g_m R_i \left(\frac{R_C}{R_C + R_L} \right) = -0.388 * 256.68 * \frac{20K}{40K}$

$= -49.8\ A/A$

Q5: For the universal BJT amplifier configuration as shown in fig. (7), let R_B = 100 KΩ, R_C = R_E =10 KΩ, V_{CC} = V_{EE} = 10V, β =100, and I_C = 0.838 mA. If the amplifier is connected in the common base configuration draw the complete circuit of the amplifier and then find using T-model the values of R_i, R_o, A_v, and A_i for R_S = R_L = 10 KΩ.



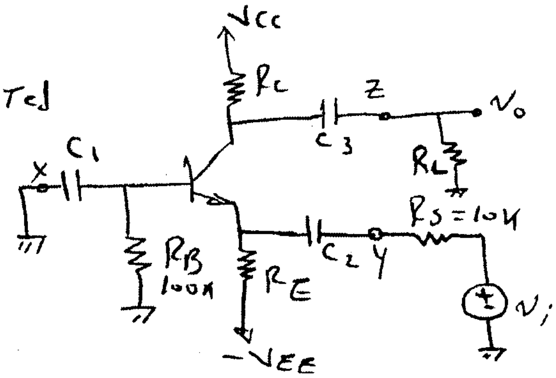
Solution

For I_C= 0.838 mA then

$$g_m = \frac{I_C}{V_T} = \frac{0.838m}{25m} = 33.52 \text{ mA/V}$$

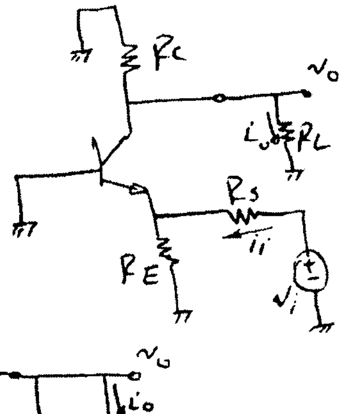
$$r_e = \frac{\alpha}{g_m} \simeq \frac{1}{g_m} = \frac{1}{33.52m} = 29.8\,\Omega$$

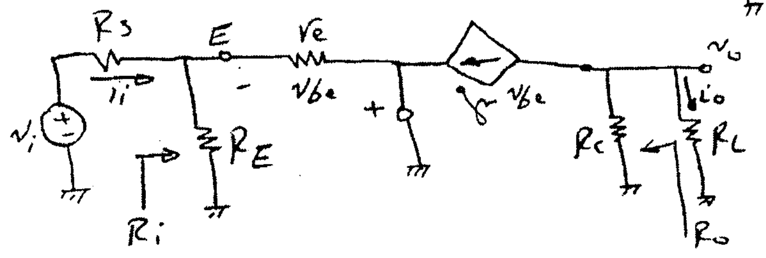
· If The amplifier is connected in C.B configuration
$R_S = R_L$ = 10 KΩ
The complete circuit is as shown ⟶



Ac Analysis
- ALL capacitor are S-C
- reduce DC sources

using T-model





$R_i = R_E \parallel r_e = 29.8 \parallel 10K \simeq 29.7 \cong r_e$

$R_o\big|_{v_i=0} = R_C = 10\ K\Omega$

<u>To find $A_v = \frac{v_o}{v_i}$</u>

$v_o = -g_m v_{be} (R_C \parallel R_L)$

$v_{be} = -v_i \left(\frac{R_E \parallel r_e}{R_E \parallel r_e + R_s}\right) = \frac{-v_i R_i}{R_i + R_s}$

$v_o = +g_m v_i \frac{R_i}{R_i + R_s} (R_C \parallel R_L)$

$A_v = \frac{v_o}{v_i} = g_m \frac{R_i}{R_i + R_s} (R_C \parallel R_L)$

$= 33.52 \times 10^{-3} \frac{29.7}{29.7 + 10K} (10K \parallel 10K) \simeq 0.5\ V/V$

<u>To find $A_i = \frac{i_o}{i_i}$</u>

$i_o = -g_m v_{be} \left(\frac{R_C}{R_C + R_L}\right)$

$v_{be} = -i_i R_i$

$i_o = +g_m i_i R_i \left(\frac{R_C}{R_C + R_L}\right)$

$A_i = \frac{i_o}{i_i} = g_m R_i \frac{R_C}{R_C + R_i}$

$= 33.52 \times 10^{-3} \times 29.7 \frac{10K}{10K + 10K}$

$= 0.5\ A/A$