**Faculty of Engineering**
**Benha university**
**Electrical Eng.Dept.**
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**Electronic Circuits (a) (E1203)**
**Final-Term Exam (corrective)**
**Data: 1/1/2015**
**Time: 3 Hours**

## Answer the following questions:

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

**(b)** For the circuit shown in Fig.(2) in which $|V_{BE}|= 0.7V$, find the voltages at nodes A, B, and C for $\beta = \infty$.

**Q2: (a)** Describe the output voltage of the circuit shown in Fig.(3). Assuming the diodes to be actual and $V_I = 10 \sin wt$. Sketch one cycle of the output voltage.

**(b)** Fig.(4) shows a simpler way to draw a transistor circuit. What are collector-emitter voltage and the transistor power dissipation?

**Q3:** The zener diode of Fig.(5) has a breakdown voltage of 12V. Determine:

(i) If the zener diode is disconnected, what is the load voltage?

(ii) Assume the supply voltage decreases from 20 to 0 V. At some point along the way, the zener diode will stop regulating. Find the supply voltage where regulation is lost.

(iii) Assuming a tolerance of ±10 percent in both resistors, what is zener current?

**Q4:** For the amplifier shown in Fig. (6), the signal source is directly coupled to the transistor base. If the dc component of $v_{sig}$ is zero, and $R_{sig}$=2.5 kΩ. For $R_E$=14.1 kΩ, $R_C$=10 kΩ, $R_L$=5kΩ find the dc emitter current. Assume $\beta$= 100, and $V_A$=100V. Find $R_{in}$, the voltage gain $v_o/v_{sig}$, the current gain $i_o/i_i$ , and the output resistance $R_{out}$.

**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, $\beta$ =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.

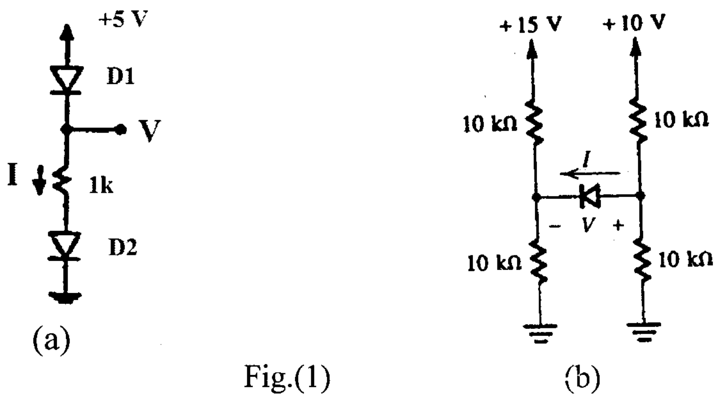



Fig.(1)

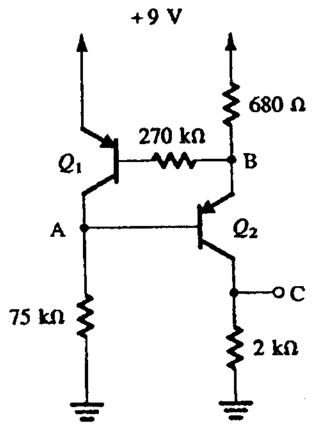



Fig.(2)

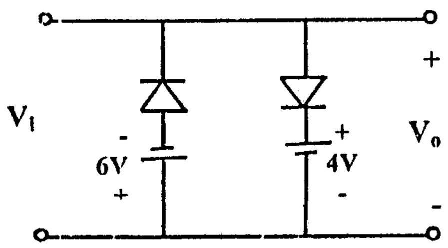



Fig.(3)

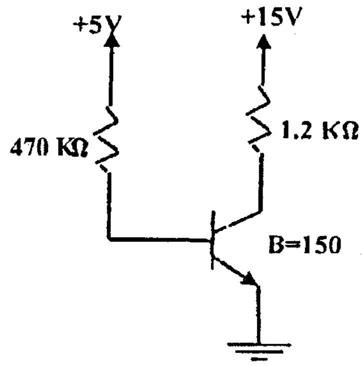



Fig.(4)

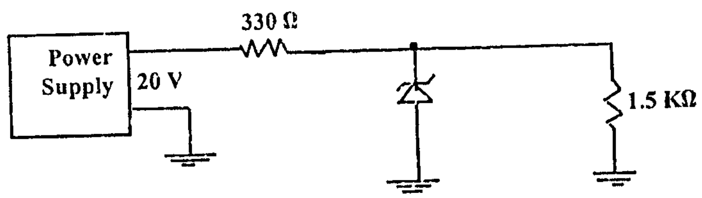



Fig.(5)

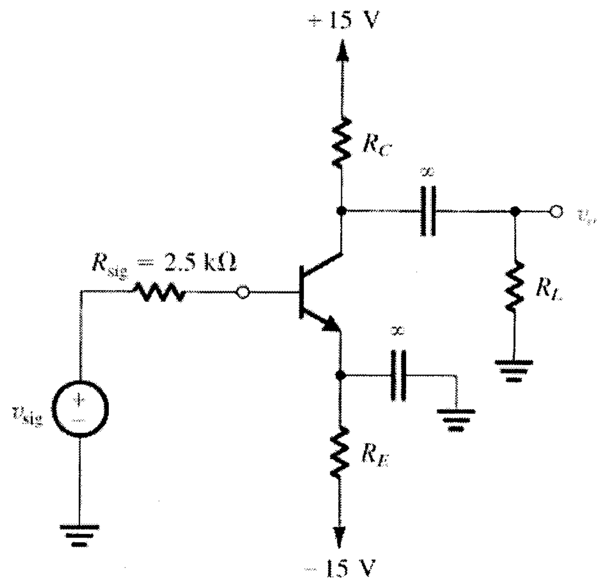



Fig.(6)

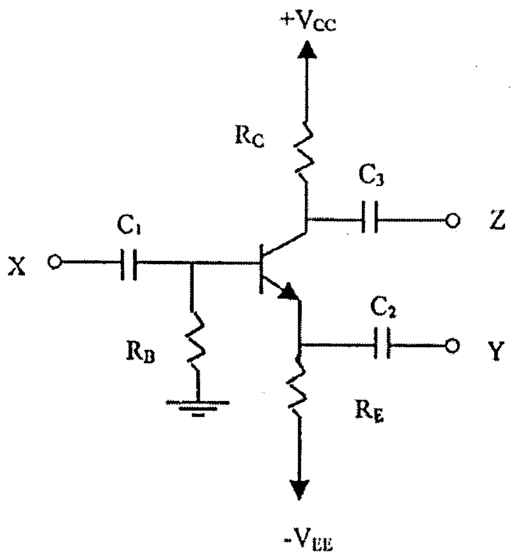



Fig.(7)

***BEST WISHES***

*Hossam Labib*

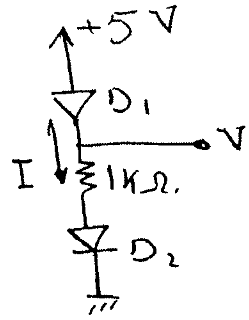
Model Answer

Q1: (15 points)

(a) Assuming that the diode in the circuits shown are ideal Find the values of labeled voltage, V, and current, I.

Solution

(a) For $D_1$ ; $V_{P_1} = 5V$




$\because V_{P_1} > V_{n_1} \Rightarrow D_1$ on $\rightarrow$ 1

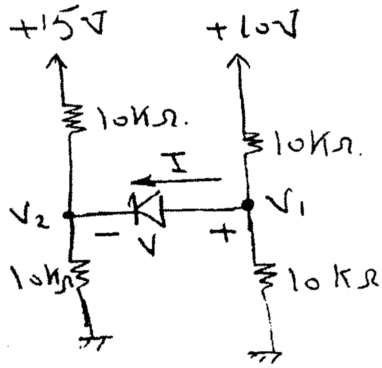
$\therefore V = 5V \rightarrow$ 2

$\because V_{n_2} = 0V \Rightarrow V_{P_2} > V_{n_2}$

$\therefore D_2$ on $\rightarrow$ 1

$I = \frac{5V}{1K\Omega} = 5mA \rightarrow$ 1

(b) $V_1 = \frac{10 * 10K}{(10+10)K} = 5V \rightarrow$ 1




$V_2 = \frac{15 * 10K}{(10+10)K} = 7.5V \rightarrow$ 1

$V_P = V_1 = 5V$

$V_n = V_2 = 7.5V$

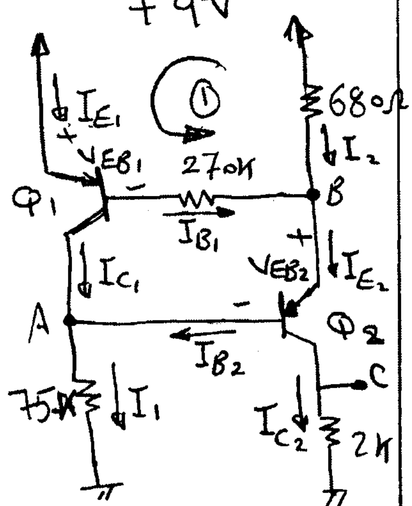
$\therefore V_P < V_n \Rightarrow$ Diode off $\rightarrow$ 1

$V = V_1 - V_2 = 5 - 7.5 = -2.5V \rightarrow$ 1

$\because$ Diode off $\Rightarrow I = 0 \rightarrow$ 1

Q1: (b)

For The circuit shown $|V_{BE}| = 0.7V$ find The voltage at nodes A, B and C for $\beta = \infty$.




Solution

let Q1 and Q2 in Active Region

for $\beta = \infty \Rightarrow$ Base currents $\simeq 0$

i.e $I_{B_1} = I_{B_2} = 0$ ⟶ ①

∴ AT Node A

$I_{C_1} = I_1$ ; $I_{E_1} = I_{C_1} = I_1$

at node B

$I_{E_2} = I_2$ ; $I_{E_2} = I_{C_2} = I_2$

Loop ①

$V_{EB_1} + 270K\, I_{B_1} - 680 I_2 = 0$ ($I_{B_1} = 0$)

$I_2 = \frac{V_{EB1}}{680} = \frac{0.7}{680} = 1.029\ mA = I_{E_2} = I_{C_2}$ ⟶ ①

∴ $V_B = 9 - I_2 * 680 = 9 - 0.7 = 8.3V$ ⟶ ②

or ($V_B = 9 - V_{EB_1} = 8.3V$)

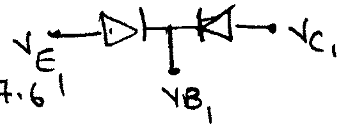
$V_C = I_{C_2} * 2K = 1.029 * 2 = 2.058V$ ⟶ ②

∵ $V_B = V_{EB_2} + V_A \Rightarrow V_A = V_B - V_{EB_2}$

$V_A = 8.3 - 0.7 = 7.6V$ ⟶ ②

$I_1 = \frac{V_A}{75K} = \frac{7.6}{75K} = 101.33\ \mu A = I_{C_1} = I_{E_2}$

for Q1




$V_{E_1} = 9V$ & $V_{B_1} = V_B = 8.3V$ & $V_{C_1} = V_A\ 7.6$

$V_{B_1} < V_{E_1} \Rightarrow$ EBJ Forward
$V_{B_1} > V_{C_1} \Rightarrow$ CBJ Reverse
} Then Q1 in Active Region ⟶ ①

for Q2

$V_{E_2} = V_B = 8.3V$ & $V_{B_2} = V_A = 7.6V$ & $V_{C_2} = V_C = 2.058$

$V_{B_2} < V_{E_2} \Rightarrow$ EBJ Forward
$V_{B_2} > V_{C_2} \Rightarrow$ CBJ Reverse
} Then Q2 in Active Region ⟶ ①

∴ The assumption is True.

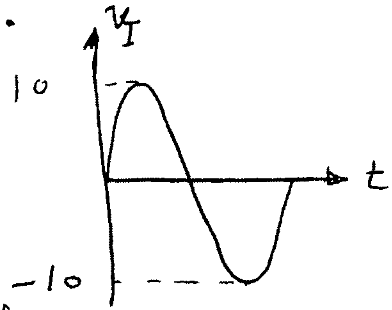
②

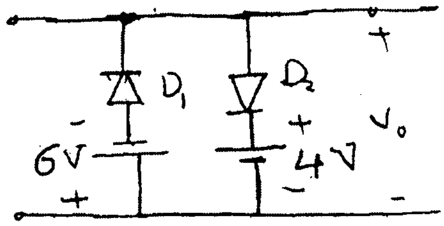
Q2: (15 points)

Q2 (a)

Describe the o/p voltage of the circuit shown. Assuming the diode to be actual and $v_I = 10 \sin \omega t$. Sketch one cycle of the o/p.

Solution:




for +ve half cycle

- for $v_i < 4.7$ V

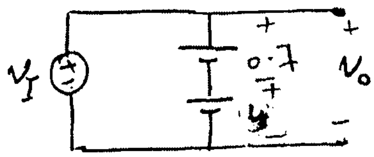
  $D_1$ and $D_2$ are off

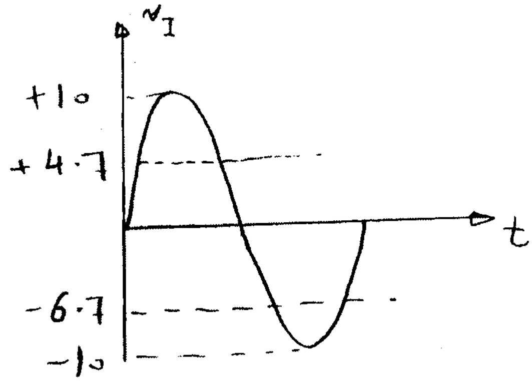
  $\therefore v_o = v_i$

- for $v_i > 4.7$ (2)

  $D_1$ off & $D_2$ on

  $\therefore V_o = 4.7$ V




for -ve half cycle

- for $v_i > -6.7$

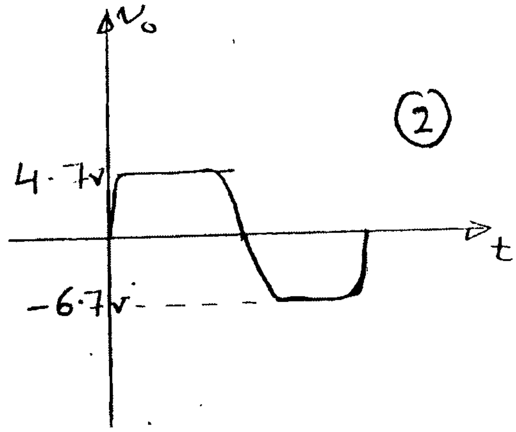
  $D_1$ off and $D_2$ off

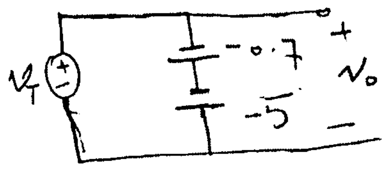
  $\therefore v_o = v_i$ (2)

- for $v_i < -6.7$

  $D_1$ on & $D_2$ off

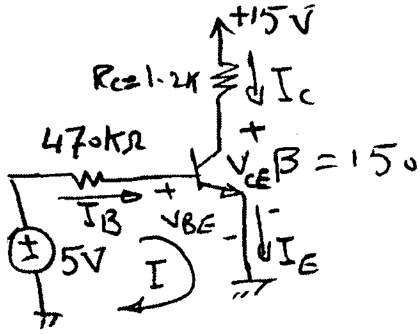
  $\therefore v_o = -6.7$



Q2 (b)

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

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

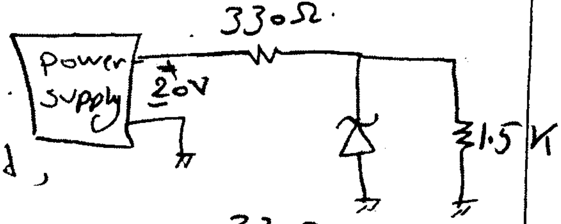
$P_{diss} = I_{CQ} V_{CEQ}$

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

$= 18.3\ mw$

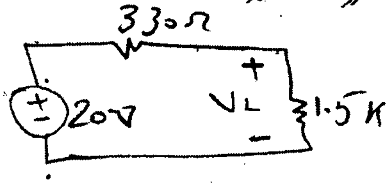
Q3: (15 points)

Q3: The Zener diode shown has breakdown voltage of 12 V. Determine:




(i) If the Zener diode is disconnected, what is the load voltage.

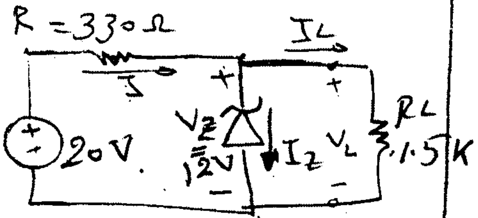
Solution




$$V_L = \frac{20 \times 1.5K}{1.5K + 330} = 16.4\ V$$

(ii) Assume the supply voltage decreases from 20 to 0V. At some point along the way, the Zener diode will stop regulating. Find the supply voltage where regulation is lost.

Solution




When Zener is operate

$$\therefore I_L = \frac{V_Z}{R_L} = \frac{12}{1.5K} = 8\ mA$$

$$I = I_Z + I_L$$

If regulation is lost $\Rightarrow I_Z = 0$

$$\therefore I = I_L = 8\ mA$$

$$\therefore V_{supply} = I(330 + 1500) = 8m \times 1830 = 14.64\ V$$

$\therefore$ regulation is lost when supply voltage $= 14.64\ V$

(iii) Assuming a tolerance of ±10 percent in both resistors, what is the max. Zener current?

Solution

$$I_Z\uparrow = I\uparrow - I_L\downarrow \quad ; \quad I\uparrow \text{ at } R\downarrow \quad ; \quad I_L\downarrow \text{ at } R_L\uparrow$$

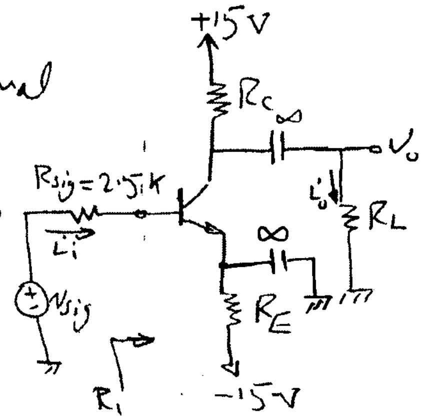
$$\therefore R_{min} = R - 10\% R = R(1 - 0.1) = 330 \times 0.9 = 297\ \Omega$$

$$R_L|_{max} = R_L + 10\% R_L = R_L(1 + 0.1) = 1.5K \times 1.1 = 1650\ \Omega$$

$$I_Z|_{max} = \left(\frac{20 - 12}{297}\right) - \left(\frac{12}{1650}\right) = 19.7\ mA$$

## Q4: (15 points)

For the amplifier shown in Fig. ( ), the signal source is directly coupled to the transistor base. If the dc component of $v_{sig}$ is zero, and $R_{sig} = 2.5\ K\Omega$. For $R_E = 14.1\ K\Omega$, $R_C = 10\ K\Omega$, $R_L = 5\ K\Omega$ find the dc emitter current. Assume $\beta = 100$, and $V_A = 100\ V$.



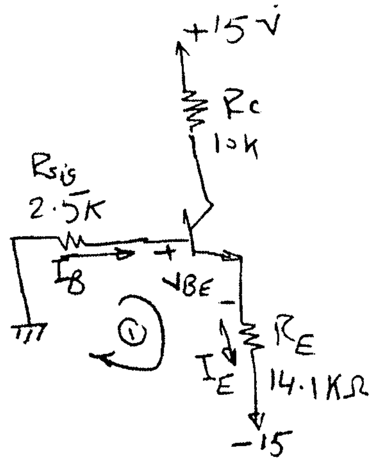

Find $R_{in}$, the voltage gain $v_o / v_{sig}$, the current gain $i_o/i_i$, and the output resistance $R_{out}$.

**Solution**

DC Analysis

All capacitor are o.c

reduce AC sources i.e $v_{sig}$ = s.c




Loop ①

$$I_B R_{sig} + V_{BE} + I_E R_E - 15 = 0$$

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

$$\frac{I_E}{(1+\beta)} R_{sig} + V_{BE} + I_E R_E - 15 = 0$$

$$I_E \left( \frac{R_{sig}}{1+\beta} + R_E \right) = 15 - V_{BE}$$

$$I_E = \frac{15-0.7}{\frac{R_{sig}}{1+\beta} + R_E} = \frac{15-0.7}{\frac{2.5K}{101} + 14.1K} = 1.012\ mA$$

$$I_C = \alpha I_E = \frac{100}{101} * 1.012\ mA \simeq 1\ mA$$

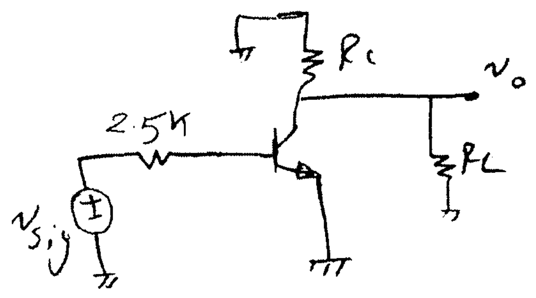
$$g_m = \frac{I_C}{V_T} = \frac{1\ mA}{25\ mV} = 0.04\ A/V$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{0.04} = 2.5\ K\Omega$$

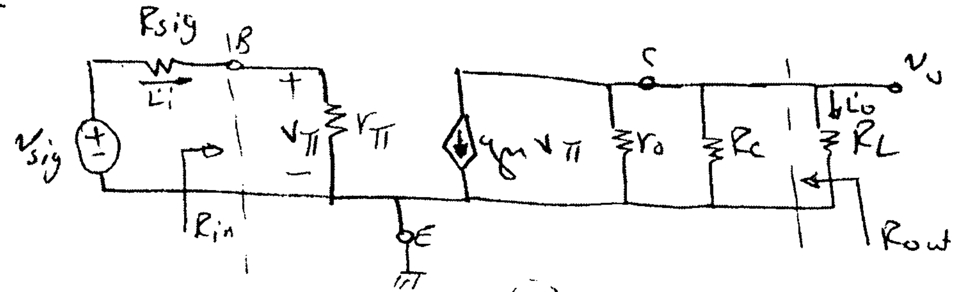
$$r_o = \frac{V_A}{I_C} = \frac{100}{1m} = 100\ K\Omega.$$

AC Analysis

- All cap. = s.c
- reduce DC sources



## $Q_4$: (Cont.)




$R_{in} = r_\pi = 2.5 \ K\Omega$. ⟶ ( )

$R_{out}\big|_{v_{sig}=0} = r_o \parallel R_C = (100K\Omega \parallel 10K\Omega) = 9.1 \ K\Omega$. ⟶ ( )

To find $A_v = \frac{v_o}{v_{sig}}$

$v_o = -g_m v_\pi (r_o \parallel R_C \parallel R_L)$ ⟶ ( )

$v_\pi = v_{sig} \frac{r_\pi}{R_{sig} + r_\pi}$ ⟶ ( )

$v_o = -g_m v_{sig} \frac{r_\pi}{R_{sig}+r_\pi} (r_o \parallel R_C \parallel R_L)$

$\therefore A_v = \frac{v_o}{v_{sig}} = -g_m \frac{r_\pi}{R_{sig}+r_\pi} (r_o \parallel R_C \parallel R_L)$

$= -0.04 \frac{2.5K}{2.5K + 2.5K} (100K \parallel 10K \parallel 5K)$

$= -0.04 * 0.5 * 3.226 K\Omega = -64.5 \ V/V$ ⟶ ( )

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

$i_o = -g_m v_\pi \frac{R_{out}}{R_{out}+R_L}$ ⟶ ( )

$\because v_\pi = i_i r_\pi$ ⟶ ( )

$i_o = -g_m i_i r_\pi \frac{R_{out}}{R_{out}+R_L}$

$A_i = \frac{i_o}{i_i} = -g_m r_\pi \frac{R_{out}}{R_{out}+R_L}$

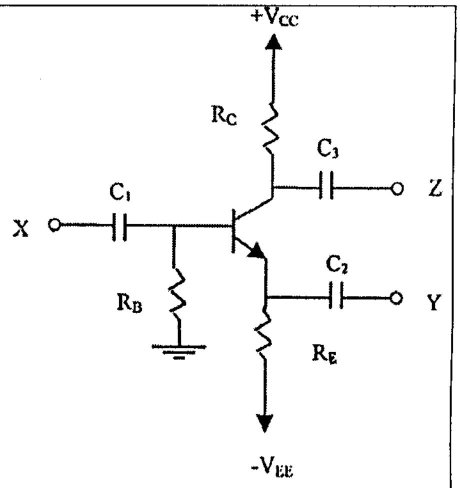
$= -g_m \frac{\beta}{g_m} \frac{R_{out}}{R_{out}+R_L} = -\beta \frac{R_{out}}{R_{out}+R_L}$

$A_i = -100 \frac{9.1K}{9.1K + 5K}$

$A_i = -64.5 \ A/A$ ⟶ ( )

Q5: (15 Points)

**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.



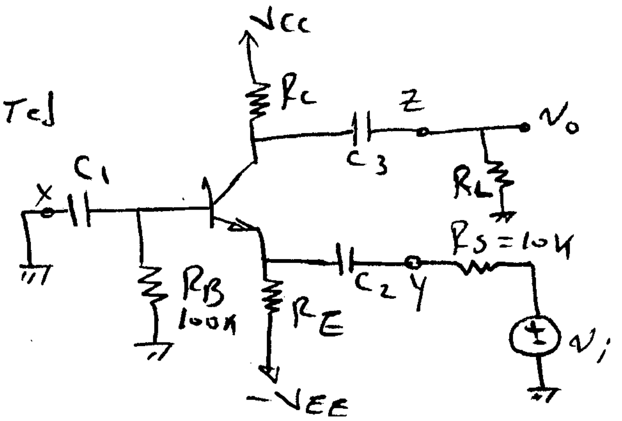

## Solution

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 →

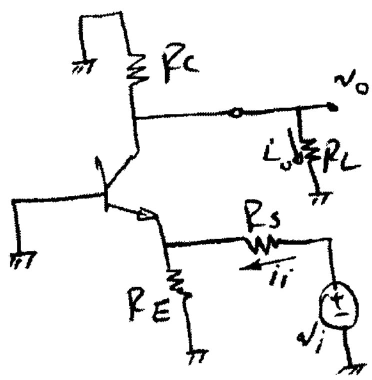


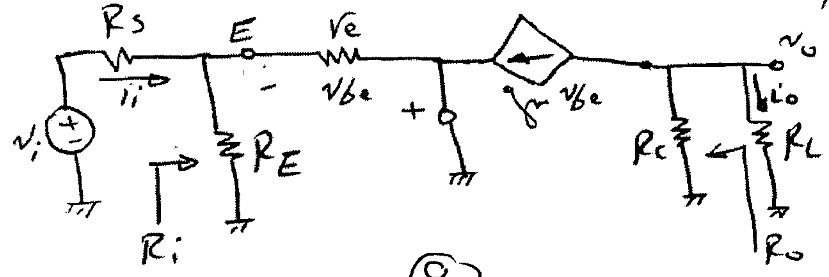

Q4: Cont

Ac Analysis

- All capacitor are S-C
- reduce DC sources

Using T-model



$R_i = R_E \,||\, r_e = 29.8 \,||\, 10K \doteq 29.7 \simeq r_e$

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

**To find $A_v = \frac{v_o}{v_i}$**

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

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

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

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

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

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

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

$v_{be} = -i_i R_i$

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

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

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

$= 0.5\ A/A$