Faculty of Engineering
Benha university
Electrical Eng.Dept.
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Electronic Circuits (a) (E1203)
Final-Term Exam
Date: 11/1/2017
Time: 3 Hours

Answer the following questions:

Q1: Complete the following sentences:

i. …………… is the boundary between p-type and n-type semiconductors in a diode.
ii. The PIV is the maximum voltage appearing across the diode in …………..
iii. The output frequency of a half-wave rectifier ………… the input frequency.
iv. Diode ………. cut off voltage above or below specified levels.
v. The DC value of a half wave rectifier voltage with a peak sinusoidal value of 10V is … .
vi. The ripple factor can be decreased by increasing the value of the ………….. .
vii. The ……….. operates in reverse breakdown region.
viii. The term ………. refers to two types of current: electron current and ……… current.
ix. The bias methods for discrete BJT circuit are using ….. , ….. , and …… .
x. A capacitor placed across the emitter resistor of CE amplifier is known as ………… .
xi. In ……….. amplifier, the input and output voltages are 180° out of phase.
xii. …………….. amplifier is known as an emitter-follower.

Q2: (a) Determine and sketch the output waveform for the network of Fig. (1).

(b) The Si Darlington transistor pair of Fig.(2) has $\beta_1 = \beta_2 = 50$ and $R_2 = 100\ k\Omega$. Find the values of R_1 and V_{CE1} needed to bias the circuit so that $V_{CE2} = 6V$.

Q3: Consider the circuit shown in Figure (3). Let $V_S = 12$ V, $V_{ZO} = 6.2$ V, and $r_z = 3\Omega$. The maximum power rating of the diode is P = 1 W.
(a) Determine $I_Z(max)$ and R_i for no load.
(b) If $I_Z(min) = 0.1\ I_Z(max)$, determine $R_L(min)$.

Q4: For the amplifier shown in Fig.(4), $\beta = 200$. (a) Determine the dc values of I_E and V_E. (b) Using the small signal hybrid π-model calculate the values of R_i, R_o, and the voltage gain (v_o/v_s).

Q5: Consider the ac equivalent circuit in Figure (5). The transistor parameters are $\beta_1 = 120$, $\beta_2 = 80$, $V_{A1} = V_{A2} = \infty$, and $I_{C1} = I_{C2} = 1$ mA.
(a) Calculate the input resistance R_i, and the output resistance R_o.
(b) Find the small-signal voltage gain $A_{v1} = V_{o1}/V_i$.
(c) Determine the small signal voltage gain $A_{v2} = V_{o2}/V_{o1}$.
(d) Find the overall small-signal voltage gain $A_v = V_{o2}/V_i$.
(e) Calculate the current gain $A_i = (i_o/i_s)$.

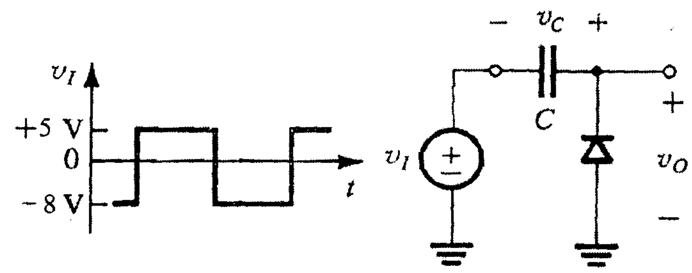


Fig.(1)

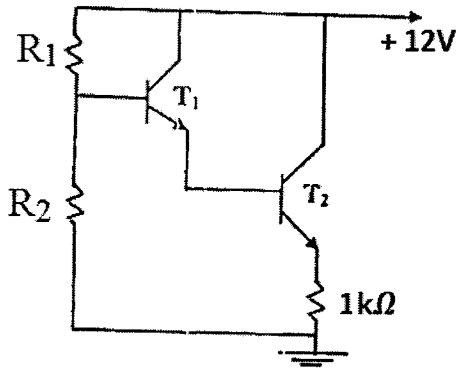


Fig.(2)

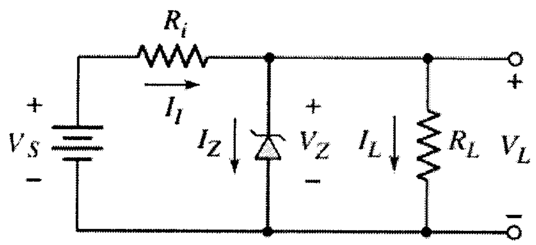


Fig.(3)

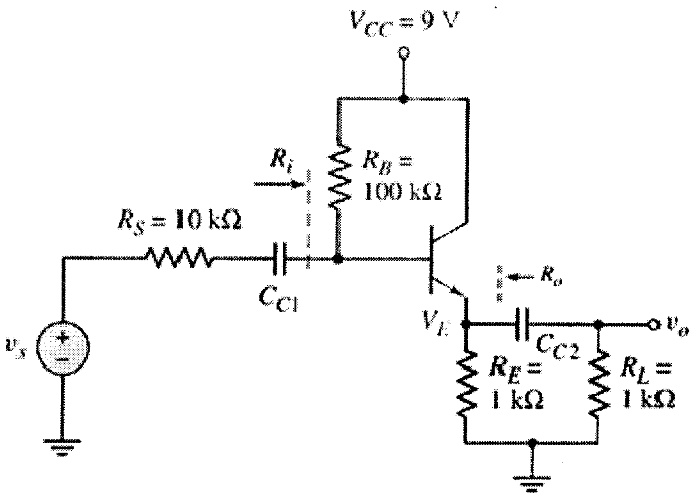


Fig.(4)

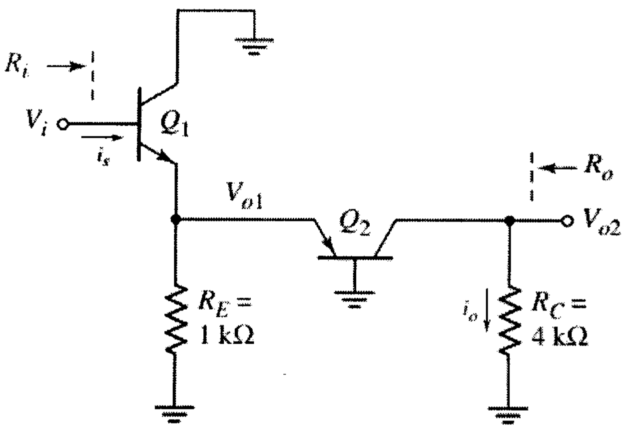


Fig.(5)

BEST WISHES

Hossam Labib

Answer the following questions:

Q1: Complete the following sentences:

i. *A pn junction* is the boundary between p-type and n-type semiconductors in a diode.

ii. The PIV is the maximum voltage appearing across the diode in *reverse bias*.

iii. The output frequency of a half-wave rectifier *equals* the input frequency.

iv. Diode *limiters* cut off voltage above or below specified levels.

v. The DC value of a half wave rectifier voltage with a peak sinusoidal value of 10V is *10/π=3.1831V*.

vi. The ripple factor can be decreased by increasing the value of the *filter capacitor*.

vii. The *zener diode* operates in reverse breakdown region.

viii. The term *bipolar* refers to two types of current: electron current and *hole* current.

ix. The bias methods for discrete BJT circuit are using *single power supply (voltage divider bias), using two power supplies, and using a collector-to- base feedback resistor, OR using constant current source.*

x. A capacitor placed across the emitter resistor of CE amplifier is known as *bypass capacitor.*

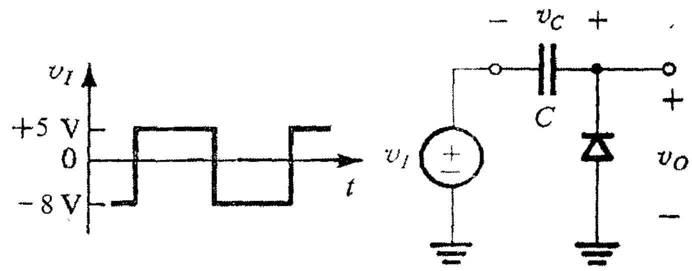
xi. In *common emitter* amplifier, the input and output voltages are 180 out of phase.

xii. A *common-collector* amplifier is known as an emitter-follower.

Q2 (a)

Determine and sketch the output waveform for the network of Fig. (1).

Solution:

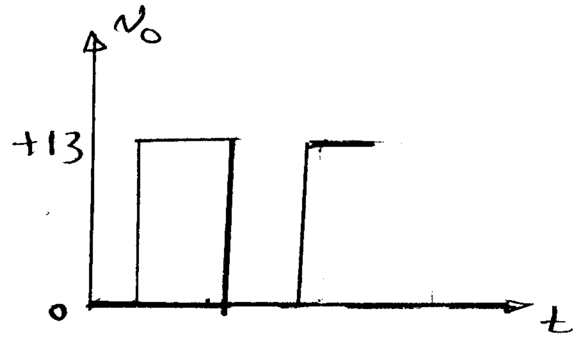


$V_c = 8V$

$V_o = V_i + V_c$

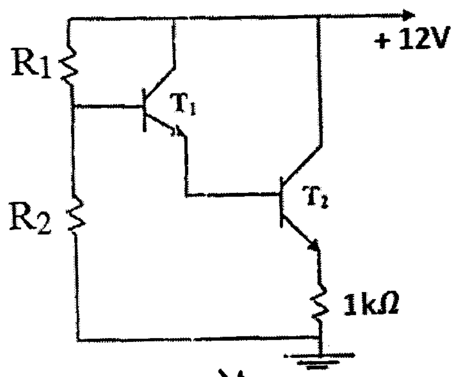
i.e $V_o = V_i$ shifted by −ve half cycle.

$\therefore V_o = V_i + 8V$

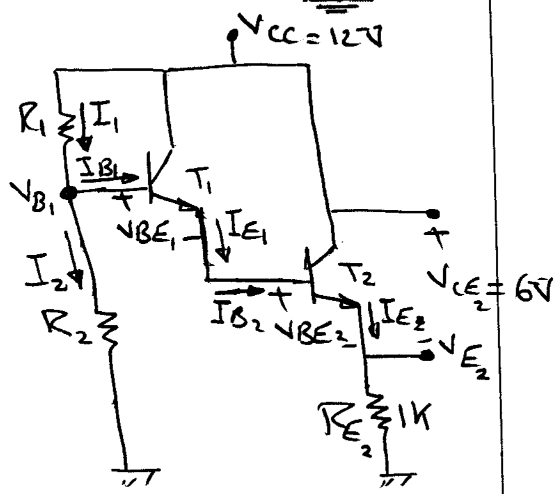


Q2 (b)

The Si Darlington transistor pair of Fig.(2) has $\beta_1 = \beta_2 = 50$ and $R_2 = 100\ k\Omega$. Find the values of R_1, and V_{CE1} needed to bias the circuit so that $V_{CE2} = 6V$.



Solution:



$V_{C_1} = V_{C_2} = V_{CC} = 12\ V$

$\because V_{CE_2} = 6\ V$

$\therefore V_{CE_2} = V_{C_2} - V_{E_2}$

$\therefore V_{E_2} = V_{C_2} - V_{CE_2}$

$= 12 - 6 = 6\ V$

$I_{E_2} = \dfrac{V_{E_2}}{R_{E_2}} = \dfrac{6}{1K} = 6\ mA$

$V_{B_1} = V_{BE_1} + V_{BE_2} + V_{E_2}$

$= 0.7 + 0.7 + 6 = 7.4\ V$

$I_2 = \dfrac{V_{B1}}{R_2} = \dfrac{7.4}{100k} = 74\ \mu A$

$I_{B_2} = I_{E_1} = \dfrac{I_{E_2}}{1+\beta_2} = \dfrac{6mA}{1+50} = 0.1176\ mA$

$I_{B_1} = \dfrac{I_{E_1}}{1+\beta_1} = \dfrac{0.1176m}{51} = 2.306\ \mu A$

$\therefore I_1 = I_{B_1} + I_2 = 2.306\mu + 74\mu = 76.306\ \mu A$

$R_1 = \dfrac{V_{CC} - V_{B_1}}{I_1}$

$= \dfrac{12 - 7.4}{76.306\mu} = 60.284\ k\Omega$

$V_{E_1} = V_{B_1} - V_{BE_1}$

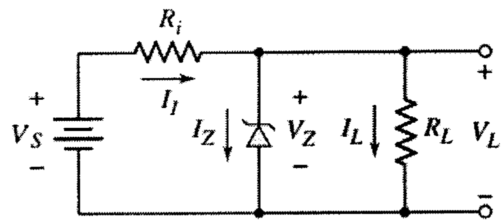
$= 7.4 - 0.7 = 6.7\ V$

$\therefore V_{CE_1} = V_{C_1} - V_{E_1}$

$= 12 - 6.7 = 5.3\ V$

Q3

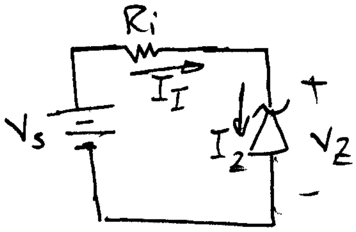
Consider the circuit shown in Figure ( ). Let $V_S = 12$ V, $V_{ZO} = 6.2$ V, and $r_z = 3$. The maximum power rating of the diode is $P = 1$ W. (a) Determine $I_Z(max)$ and R_i for no load. (b) If $I_Z(min) = 0.1\ I_Z(max)$, determine $R_L(min)$



Solution:

$V_S = 12\ V$; $V_{Z_o} = 6.2\ V$; $r_Z = 3\ \Omega$; $P_{Z_{max}} = 1\ W$

(a) find $I_{Z_{max}}$ and R_i for no Load



$V_Z = V_{Z_o} + I_Z r_Z$

$V_Z = 6.2 + 3 I_Z \longrightarrow (1)$

$\because P_Z = I_Z V_Z$

$1 = I_Z (6.2 + 3 I_Z)$

$1 = 6.2 I_Z + 3 I_Z^2 \Rightarrow 3 I_Z^2 + 6.2 I_Z - 1 = 0$

$\therefore I_Z = \dfrac{-6.2 \pm \sqrt{(6.2)^2 + 4 * 3 * 1}}{2 * 3} = -1.0333 \pm 1.1834$

$\therefore I_Z = -1.0333 + 1.1834 = 150\ mA$

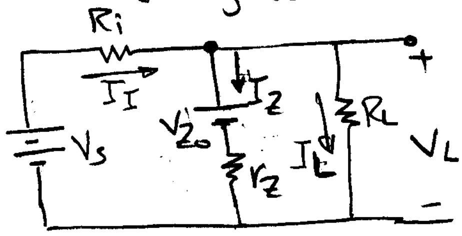
or $I_Z = -1.0333 - 1.1834 = -2.217$ ✗ rejected

$\therefore I_Z|_{max} = 150\ mA = I_I$

$V_Z = 6.2 + 3 * 150m = 6.65\ V = V_L|_{no\ Load}$

$R_i = \dfrac{V_S - V_Z}{I_I} = \dfrac{12 - 6.65}{150m} = 35.7\ \Omega$

(b) If $I_{Z_{min}} = 0.1\ I_{Z_{max}}$ find $R_L|_{min}$ and Load Regulation.



$I_{Z_{min}} = 0.1 * 150m = 15\ mA$

$V_Z = V_L = V_{Z_o} + I_Z|_{min} r_Z$

$= 6.2 + 15m * 3 = 6.245\ V$

$R_L|_{min} = \dfrac{V_L}{I_L} = \dfrac{V_Z}{I_L}$

$\because I_L = I_I - I_Z|_{min}$; $I_I = \dfrac{V_S - V_Z}{R_i} = \dfrac{12 - 6.245}{35.7} = 161.2\ mA$

$\therefore I_L = 161.2m - 15m = 146.2\ mA$

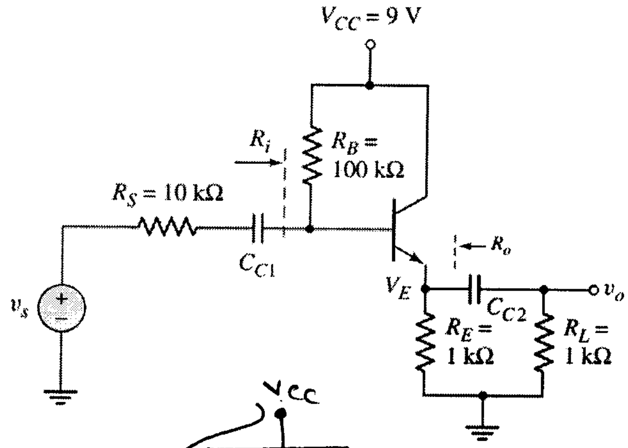
$\therefore R_L|_{min} = \dfrac{6.245}{146.2m} = 42.7\ \Omega$

Q4

For the amplifier shown in Fig.(4), $\beta = 200$.

(a) Determine the dc values of I_E and V_E.

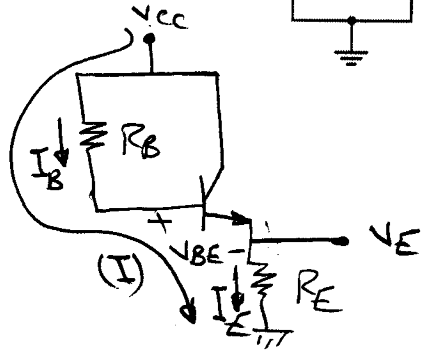
(b) Using the small signal hybrid π-model calculate the values of R_i, R_o, and the voltage gain (v_o/v_s).



Solution:

DC Analysis

- ALL capacitors are o.c
- reduce AC sources



Loop (I)

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

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

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

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

$$I_E = \frac{V_{cc} - V_{BE}}{\frac{R_B}{1+\beta} + R_E} = \frac{9 - 0.7}{\frac{100k}{201} + 1K} = 5.543\ mA$$

$$V_E = I_E R_E = 5.543m * 1K = 5.543\ V$$

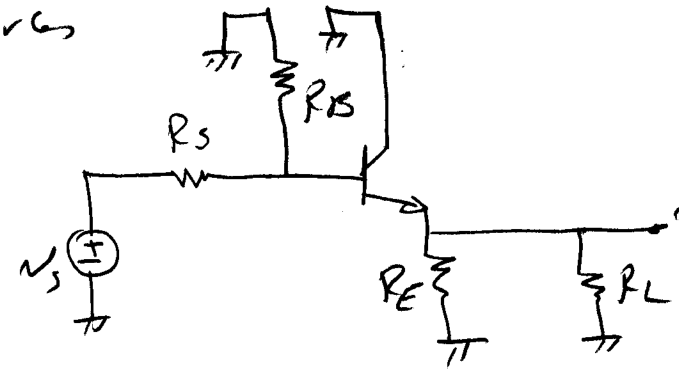
$$I_C = \alpha I_E = \frac{200}{201} * 5.543m = 5.515\ mA$$

$$g_m = \frac{I_C}{V_T} = \frac{5.515m}{25m} = 220.6\ mA/V$$

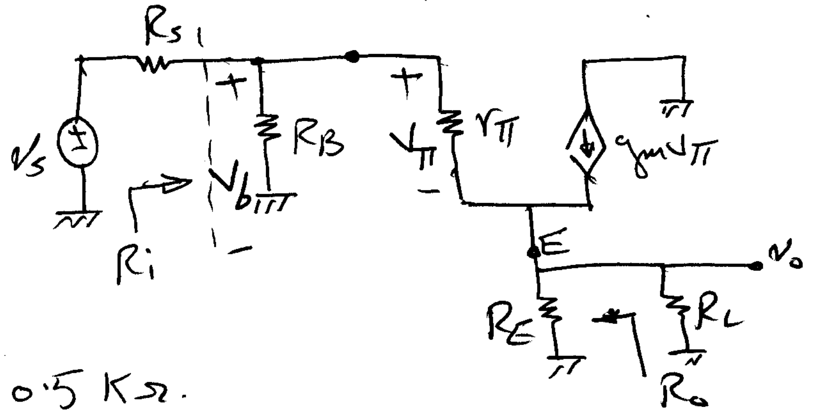
$$r_\pi = \frac{\beta}{g_m} = \frac{200}{220.6m} = 906.62\ \Omega$$

AC Analysis

- ALL capacitors are s.c
- reduce DC sources



Q4 (cont.)



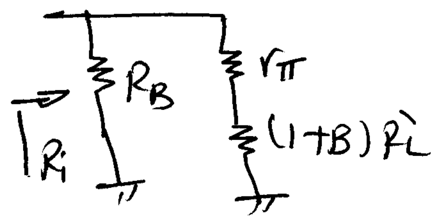
$R_L' = R_E \,||\, R_L$

$= 1K \,||\, 1K = 0.5\ K\Omega.$

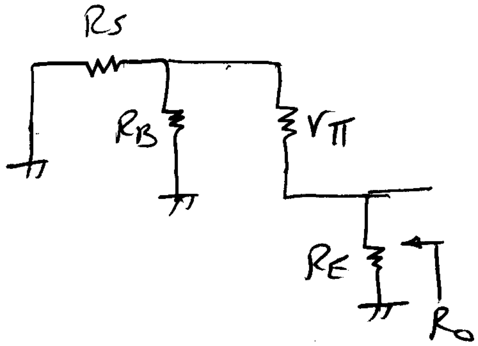
$R_i = R_B \,//\, [r_\pi + (1+B) R_L']$

$= 100K \,//\, [906.62 + (1+200) \times 0.5K]$

$= 100K \,//\, 101.41\ K = 50.35\ K\Omega.$



$R_o \Big|_{V_s=0} = \left[\dfrac{(R_S || R_B + r_\pi)}{1+B}\right] \,//\, R_E$



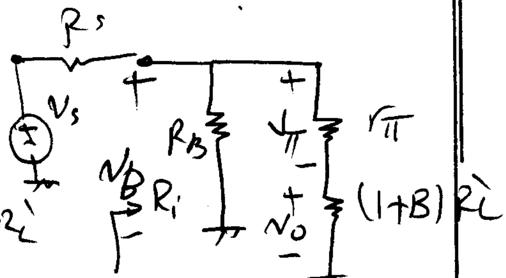
$= \left[\dfrac{(10K \,//\, 100K) + 906.62}{201}\right] \,||\, 1K$

$= 49.74 \,||\, 1K = 47.38\ \Omega$

- To find $A_V = \dfrac{V_o}{V_s}$

$V_b = \dfrac{V_s R_i}{R_i + R_s}$

$V_o = V_b \dfrac{(1+B) R_L'}{r_\pi + (1+B) R_L'} = \dfrac{V_s R_i}{R_i + R_s} * \dfrac{(1+B) R_L'}{r_\pi + (1+B) R_L'}$



$\therefore A_V = \dfrac{V_o}{V_s} = \dfrac{R_i}{R_i + R_s} \; \dfrac{(1+B) R_L'}{r_\pi + (1+B) R_L'}$

$= \dfrac{50.35K}{50.35K + 10K} \; \dfrac{201 * 0.5K}{906.62 + 201 * 0.5K}$

$= 1.002 * 0.9911 = 0.993\ V/V$

Q5

Consider the ac equivalent circuit in Figure (5). The transistor parameters are $\beta_1 = 120$, $\beta_2 = 80$, $V_{A1} = V_{A2} = \infty$, and $I_{C1} = I_{C2} = 1$ mA.

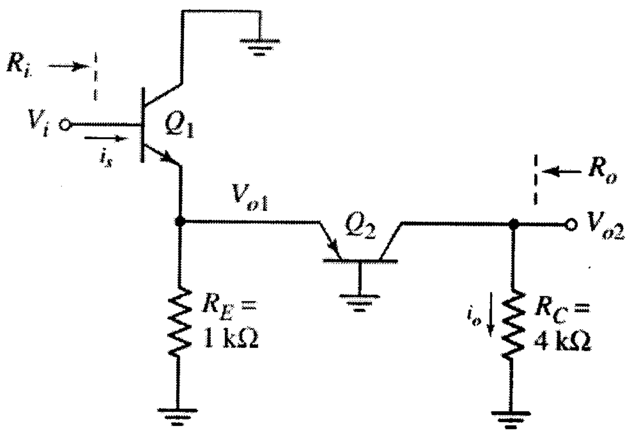
(a) Calculate the input resistance R_i, and the output resistance R_o.

(b) Find the small-signal voltage gain $A_{V1} = V_{o1}/V_i$.

(c) Determine the small signal voltage gain $A_{v2} = V_{o2}/V_{o1}$.

(d) Find the overall small-signal voltage gain $A_v = V_{o2}/V_i$.

(e) Calculate the current gain $A_i = (i_o/i_s)$.



Solution:

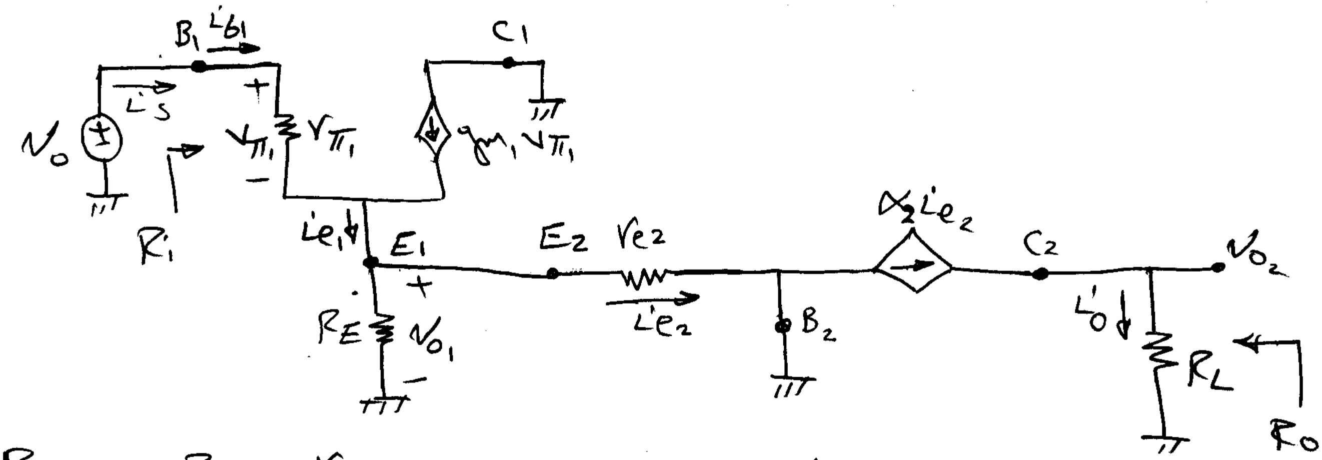
$\because I_{C1} = I_{C2} = 1mA = I_C$ (given)

$\therefore g_{m1} = g_{m2} = \frac{I_C}{V_T} = \frac{1m}{25m} = 40\ mA/V$

$r_{\pi 1} = \frac{\beta_1}{g_{m1}} = \frac{120}{40m} = 3K\Omega$

$r_{e2} = \frac{\alpha_2}{g_{m2}} \simeq \frac{1}{g_{m2}} = \frac{1}{40m} = 25\Omega$

Ac Analysis



(a) $R_{ET} = R_E \parallel r_{e2} = 1K \parallel 25 = 24.39\Omega$

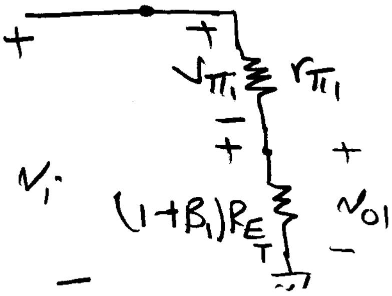
$R_i = r_{\pi 1} + (1+\beta_1) R_{ET}$

$= 3K + (1+120) * 24.39 = 5.95\ K\Omega$

$R_o \Big|_{V_i = 0} = R_C = 4\ K\Omega$

Q5 (cont.)

(b) To find $A_{v1} = \frac{v_{o1}}{v_i}$



$$v_{o1} = v_i \frac{(1+\beta_1) R_{E_T}}{r_{\pi_1} + (1+\beta_1) R_{E_T}}$$

$$\therefore A_{v_1} = \frac{v_{o1}}{v_i} = \frac{(1+\beta_1) R_{E_T}}{r_{\pi_1} + (1+\beta_1) R_{E_T}}$$

$$= \frac{(1+120) * 24.39}{3K + 121 * 24.39} = 0.496 \text{ V/V}$$

(c) To find $A_{v_2} = \frac{v_{o2}}{v_{o1}}$

$$v_{o2} = \alpha_2 i_{e2} R_C$$

$$i_{e2} = \frac{v_{o1}}{r_{e2}}$$

$$\therefore v_{o2} = \alpha_2 \frac{v_{o1}}{r_{e2}} R_C$$

$$\therefore A_{v_2} = \frac{v_{o2}}{v_{o1}} = \frac{\alpha_2}{r_{e2}} R_C = g_{m2} R_C$$

$$= 40m * 4K = 160 \text{ V/V}$$

(d) $A_v = \frac{v_{o2}}{v_i} = \frac{v_{o1}}{v_i} * \frac{v_{o2}}{v_{o1}} = A_{v_1} * A_{v_2}$

$$= 0.496 * 160 = 79.36 \text{ V/V}$$

(e) To find $A_i = \frac{i_o}{i_s}$

$$i_o = \alpha_2 i_{e2}$$

$$i_{e2} = i_{e1} \frac{R_E}{R_E + r_{e2}} \quad ; \quad i_{e1} = (1+\beta_1) i_{b1}$$

$$\because i_{b1} = i_s \Rightarrow i_{e1} = (1+\beta_1) i_s$$

$$\therefore i_{e2} = (1+\beta_1) i_s \frac{R_E}{R_E + r_{e2}}$$

$$\therefore i_o = \alpha_2 (1+\beta_1) i_s \frac{R_E}{R_E + r_{e2}}$$

$$\therefore A_i = \frac{i_o}{i_s} = \alpha_2 (1+\beta_1) \frac{R_E}{R_E + r_{e2}}$$

$$= 1 * 121 \frac{1K}{1K + 25} = 118.05 \text{ A/A}$$