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

**Electronic Circuits (a) (E1203)**
**Final-Term Exam**
**Date: 14/1/2016**
**Time: 3 Hours**

## Answer the following questions:

**Q1: Complete the following sentences:**

i. ……… is the maximum voltage appearing across the diode in reverse bias.
ii. The output frequency of a full-wave rectifier with a 60 Hz sinusoidal input is…..Hz
iii. Diode……. add a DC level to an AC voltage.
iv. If the load resistance of a capacitor filtered full wave rectifier is reduced, the ripple voltages ……..
v. The DC value of a full wave rectifier voltage with a peak value of 200 is……. .
vi. The PIV of the bridge rectifier is about…….the value for the center tapped transformer.
vii. A transistor can be operated as an electronic switch in ……. and……..region.
viii. The bias methods for discrete BJT circuit are using ….. , ….. , and …… .
ix. In common base amplifier, the input and output voltages are……. phase.
x. In common emitter amplifier the gain ……..with the emitter resistance.
xi. The maximum current gain is one in the ………. amplifier.
xii. The maximum voltage gain is one in the ………. amplifier.

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**Q2: (a)** In fig.(1), what is the maximum positive and negative output voltages with $V_i = 20\sin(wt)$ ?. Sketch the output waveform. Assume the diode is actual.

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

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**Q3:** The parameters of the zener diode for the voltage regulator circuit of Fig.(3) are $V_Z$=4.7 V at test current $I_{ZT}$ = 53 mA, $r_Z$ =8Ω, and $I_{ZK}$ = 1 mA. The supply voltage is $V_S = 12 \pm 2$ V, and Rs=220Ω.

a) Find the nominal value of the output voltage $v_O$ under no-load condition $R_L$.
b) Find the maximum and minimum values of the output voltage for a load resistance of $R_L$=470Ω.
c) Find the nominal value of the output voltage $v_O$ for a load resistance of $R_L$ =100Ω.
d) Find the minimum value of $R_L$ for which the zener diode operates in the breakdown region.

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**Q4:** For the amplifier shown in Fig.(4) , $\beta = 80$ and $V_A = 150$ V. (a) Determine the dc voltages at the base and emitter terminals. (b) Using the small signal hybrid π-model calculate the values of $R_{in}$, $R_o$, the voltage gain $(v_o/v_s)$ and the current gain $A_i = (i_o/i_s)$.

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**Q5:** The parameters of the amplifier circuit shown in Figure (5) are Vcc =15V, $R_{C1} = R_{C2}$ = 1kΩ, $R_1 = R_3$ = 65kΩ, $R_2 = R_4$ = 25kΩ, $R_{E1} = R_{E2}$ = 400Ω, $R_L$ = 20kΩ, and $C_1 = C_2 = C_3 = C_E \approx \infty$. Assume, identical transistors of β=100 and $V_A$=100 V. Calculate the input resistance $R_i$, the output resistance $R_o$, and the overall voltage gain $A_v = (v_o/v_s)$.

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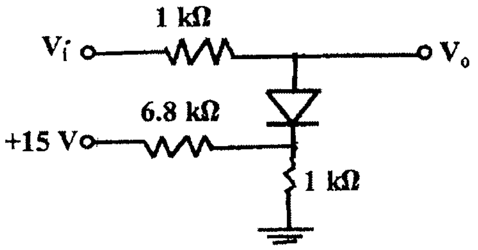


Fig.(1)

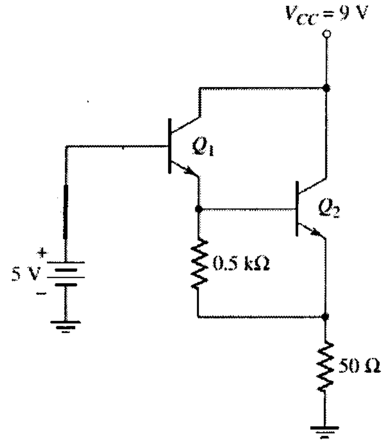


Fig.(2)

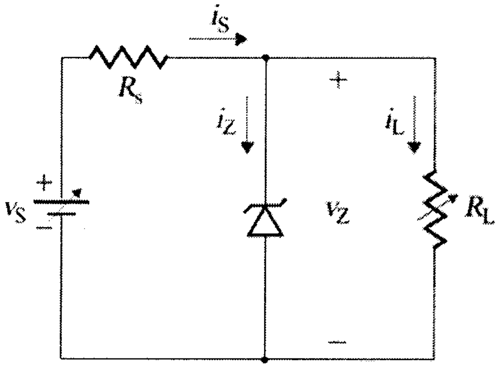


Fig.(3)

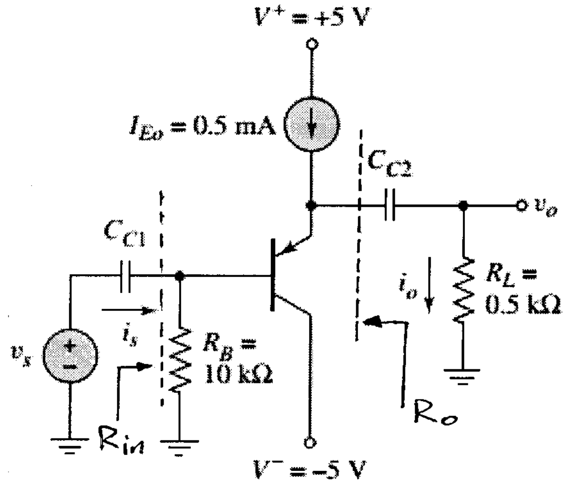


Fig.(4)

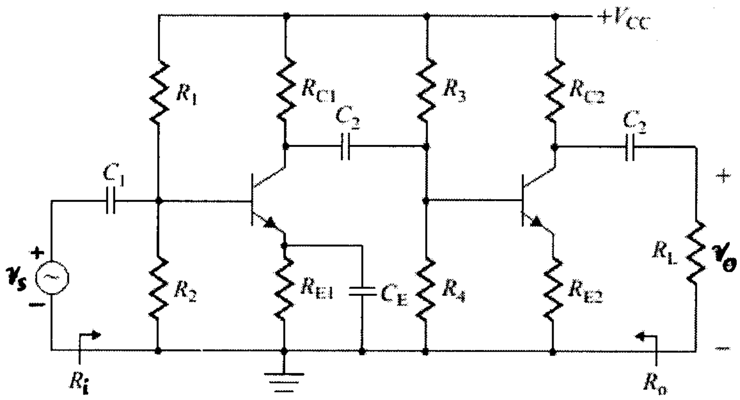


Fig.(5)

**BEST WISHES**

*Hossam Labib*

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## Answer the following questions:

**Q1: Complete the following sentences:**

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

ii. The output frequency of a full-wave rectifier with a 60 Hz sinusoidal input is ***120*** Hz

iii. Diode ***clampers*** add a DC level to an AC voltage.

iv. If the load resistance of a capacitor filtered full wave rectifier is reduced, the ripple voltages ***increase***.

v. The DC value of a full wave rectifier voltage with a peak value of 200 is ***($V_{dc}=2*V_m/\pi=400/\pi=127.324V$).***

vi. The PIV of the bridge rectifier is about ***half*** the value for the center tapped transformer.

vii. A transistor can be operated as an electronic switch in ***cut off*** and ***saturation*** region.

viii. 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.***

ix. In common base amplifier, the input and output voltages are ***in*** phase.

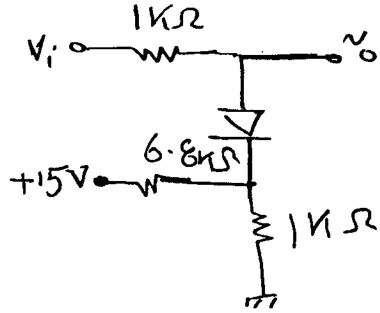
x. In common emitter amplifier the gain ***decreases*** with the emitter resistance.

xi. The maximum current gain is one in the ***common base*** amplifier.

xii. The maximum voltage gain is one in the ***common collector*** amplifier.

**Q2:**

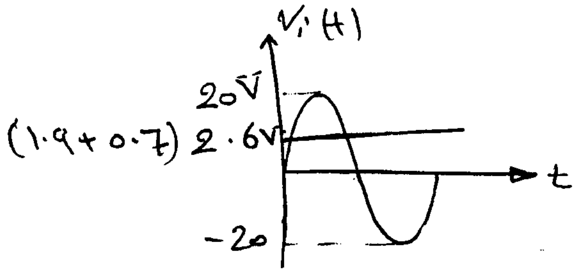
ⓐ In fig. shown what is the maximum positive and negative o/p voltages with $V_i = 20 \sin(\omega t)$ ?. Sketch the o/p waveform. Assume the diode is actual.

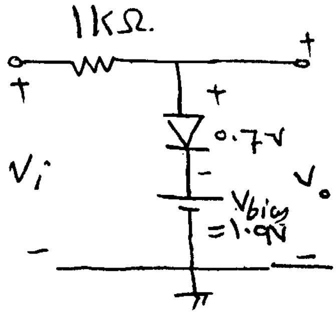



**Solution**

$$V_{bias} = \frac{15 * 1K}{(6.8+1)K} = 1.9\,V \longrightarrow ②$$

Then the circuit is +ve biased clipper



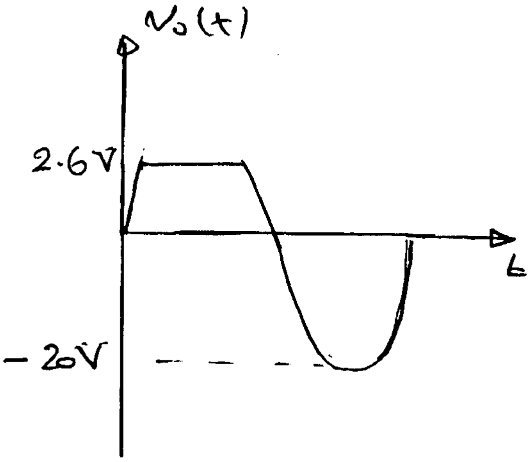




for $V_i < 2.6\,V \Rightarrow$ Diode is off $\Rightarrow V_o = V_i$ $\longrightarrow$ ①

for $V_i > 2.6\,V \Rightarrow$ Diode is on $\Rightarrow V_o = 2.6\,V$

$V_o|_{max_{+ve}} = 2.6\,V \longrightarrow$ (1.5)

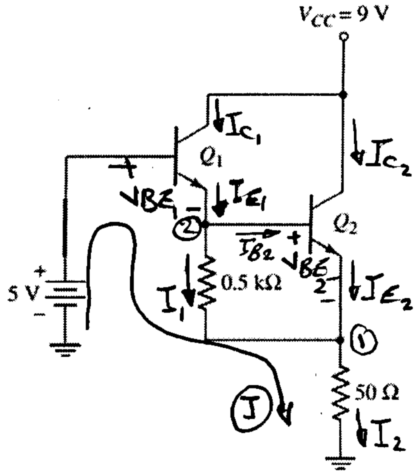
$V_o|_{max_{-ve}} = -20\,V \longrightarrow$ (1.5)




②

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)

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

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

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

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

at node (1)

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

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

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

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

at node (2)

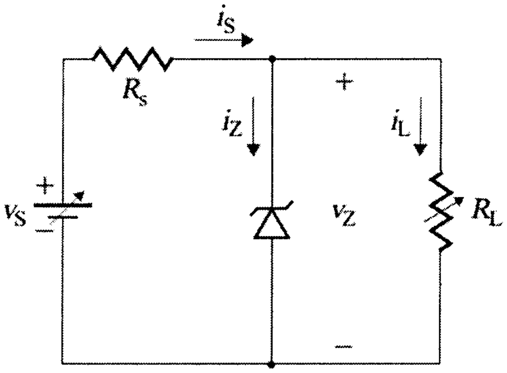
$$I_{E_1} = I_{B_2} + I_1 = 871.605\,\mu + 1.4\,m = 2.272\,mA$$

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

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

Q3:

The parameters of the zener diode for the voltage regulator circuit of Fig. ( ) are $V_Z$=4.7 V at test current $I_{ZT}$ = 53 mA, $r_Z$ =8Ω, and $I_{ZK}$ = 1 mA. The supply voltage is $V_S$ = 12 ± 2 V, and Rs=220Ω .




**(a)** Find the nominal value of the output voltage $v_O$ under no-load condition $R_L$.
**(b)** Find the maximum and minimum values of the output voltage for a load resistance of $R_L$=470Ω.
**(c)** Find the nominal value of the output voltage $v_O$ for a load resistance of $R_L$ =100Ω.
**(d)** Find the minimum value of $R_L$ for which the zener diode operates in the breakdown region.

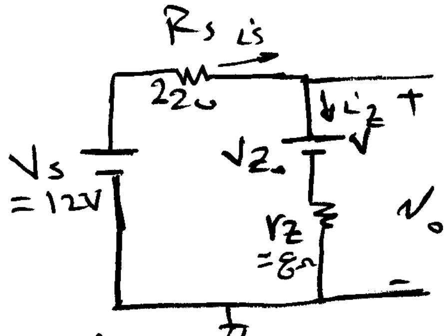
Solution

$V_Z = 4.7$ @ $I_{ZT} = 53mA$ ; $r_Z = 8\Omega$

$r_{ZK} = 500\Omega$ at $I_{ZK} = 1mA$

$V_S = 12 \pm 2V$ , and $R_S = 220\Omega$

1st find $V_{Z_0}$




$\because V_Z = V_{Z_0} + i_Z r_Z \Rightarrow V_{Z_0} = V_Z - i_Z r_Z$

$V_{Z_0} = 4.7 - 53m * 8 = 4.28 V$

(a) for no Load i.e $R_L = \infty$ find $V_o$ at nominal value of $V_s = 12V$

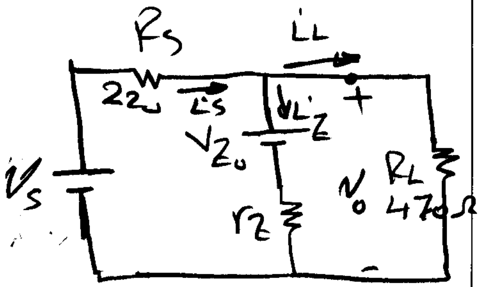
$i_S = i_Z = \frac{V_S - V_{Z_0}}{R_S + r_Z} = \frac{12 - 4.28}{220 + 8} = 33.86 mA$

$\therefore V_o = V_{Z_0} + i_Z r_Z = 4.28 + 33.86m * 8 = 4.55 V$

(b) find The max. and min. values of The o/p voltage for $R_L = 470\Omega$

The max. value $V_o|_{max}$ ocure at $V_s|_{max}$

$\therefore V_s|_{max} = V_s + 2V = 12 + 2 = 14 V$




– At $V_s = 12V$ (nominal value) and $R_L = 470\Omega$ is connected

$i_L = \frac{V_Z}{R_L} = \frac{4.7}{470} = 10 mA$

$i_s = \frac{V_S - V_Z}{R_S} = \frac{12 - 4.7}{220} = 33.2 mA$

$\therefore i_Z|_{Loaded} = i_S - i_L = 33.2m - 10m = 23.2mA$

$\therefore V_o = V_{Zo} + i_Z|_L r_Z$

$= 4.28 + 23.2 * 10^{-3} * 8 = 4.47\ V$

for $V_S|_{max} = 14\ V$ and $R_L = 470\ \Omega$ Connected.

$i_S = \frac{V_S - V_o}{220} = \frac{14 - 4.47}{220} = 43.32\ mA$

$i_L = \frac{V_o}{R_L} = \frac{4.47}{470} = 9.51\ mA$

$\therefore i_Z|_{max} = i_S - i_L = 43.32 - 9.51 = 33.81\ mA$

$\therefore V_o|_{max} = V_{Zo} + i_Z|_{max} r_Z$

$= 4.28 + 33.81m * 8 = 4.55\ V$

for $V_S|_{min} = 12 - 2 = 10\ V$

$i_S = \frac{V_S - V_o}{R_S} = \frac{10 - 4.47}{220} = 25.14\ mA$

$i_L = \frac{V_o}{R_L} = \frac{4.47}{470} = 9.51\ mA$

$i_Z|_{min} = i_S - i_L = 25.14 - 9.51 = 15.63\ mA$

$\therefore V_o|_{min} = V_{Zo} + i_Z|_{min} r_Z = 4.28 + 15.63m * 8 = 4.41\ V$

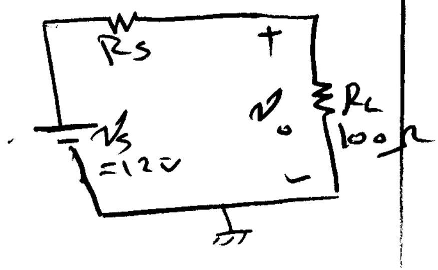
(c) for $R_L = 100$ at nominal value of $V_S$ find $V_o$

for $V_S = 12\ V \Rightarrow i_L = \frac{V_Z}{R_L} = \frac{4.7}{100} = 47\ mA$

$\because i_S = 33.2\ mA \Rightarrow i_L > i_S \quad (i_S = i_L + i_Z)$

$\therefore$ Zener must be off

$\therefore V_o = \frac{V_S R_L}{R_L + R_S} = \frac{12 \times 100}{100 + 220} = 3.75\ V$



(d) Find the min. value of $R_L$ for which the Zener operate in breakdown region

To operate in break down region $\Rightarrow$ Zener current $= I_{ZK}$

$= 1mA = i_Z = i_Z|_{min}$ ; $V_{ZK} \simeq V_{Z_0} = V_Z = 4.28V$

$\therefore i_S|_{min} = \dfrac{V_S|_{min} - V_{Z_0}}{R_S} = \dfrac{10 - 4.28}{220} = 26mA$

$\therefore i_L = i_S|_{min} - i_Z|_{min} = 26mA - 1mA = 25mA$

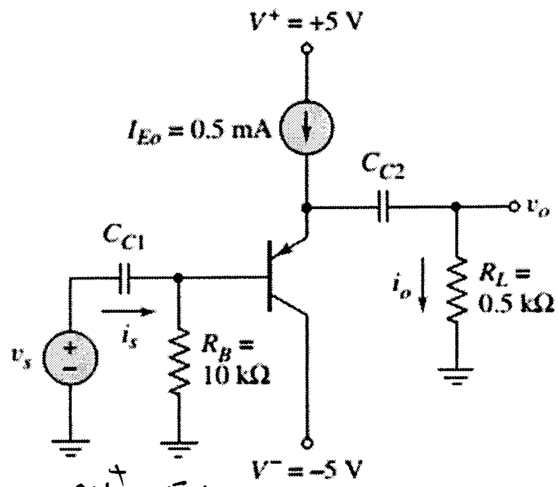
$\therefore R_L|_{min}$ to operate in breakdown region is given by

$R_L \geq \dfrac{V_Z}{i_L}$

$R_L|_{min} \geq \dfrac{4.28}{25m} = 171.2\Omega.$

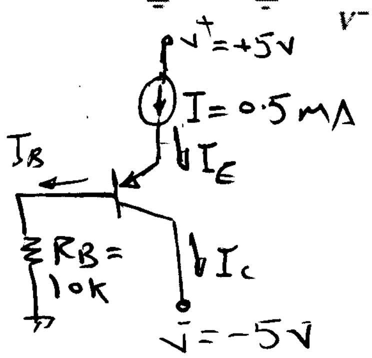
Q4:

For the amplifier shown in Fig.(4) , $\beta = 80$ and $V_A = 150$ V. (a) Determine the dc voltages at the base and emitter terminals. (b) Using the small signal hybrid π-model calculate the values of $R_{in}$, $R_o$, the voltage gain ($v_o/v_s$), and The current gain.( $i_o/i_s$).




Solution

Dc Analysis




$I_E = I = 0.5mA$

$$I_B = \frac{I_E}{1+\beta} = \frac{0.5mA}{1+80} = 6.173\ \mu A$$

$$I_c = \alpha I_E = \frac{\beta}{1+\beta} I_E$$

$$= \frac{80}{81} * 0.5mA = 0.494\ mA$$

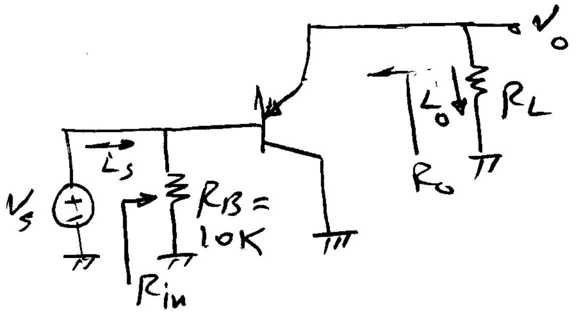
$$g_m = \frac{I_c}{V_T} = \frac{0.494m}{25m} = 19.76\ mA/V$$

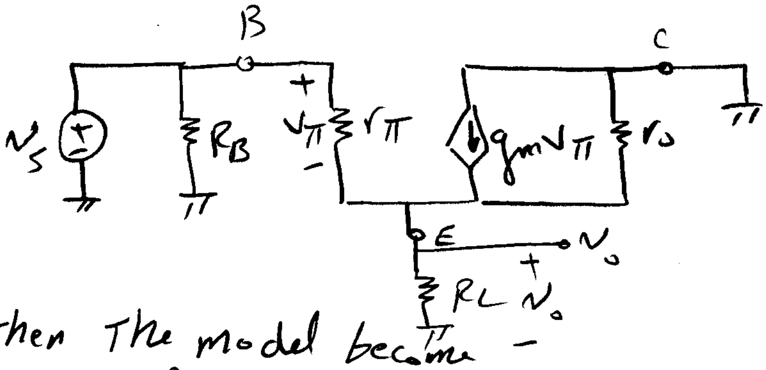
$$r_\pi = \frac{\beta}{g_m} = \frac{80}{19.76m} = 4.049\ K\Omega.$$

$$r_o = \frac{VA}{I_c} = \frac{150}{0.494m} = 303.644\ K\Omega.$$

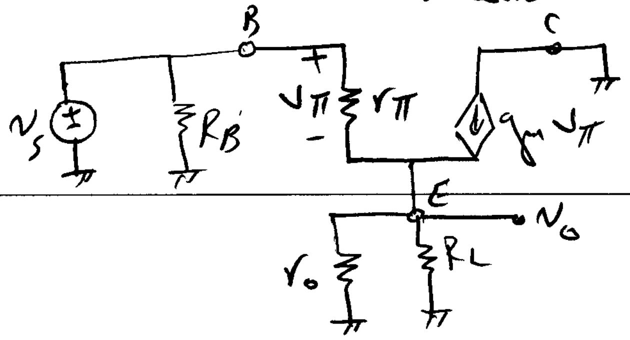
Ac Analysis

Using π- model

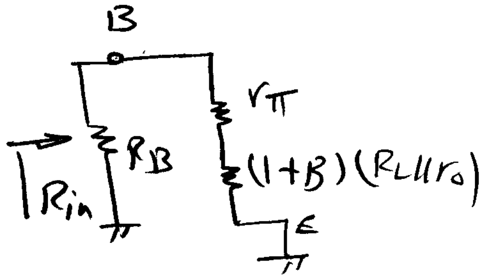



$r_o // R_L$ Then The model become -



## To find $R_i$



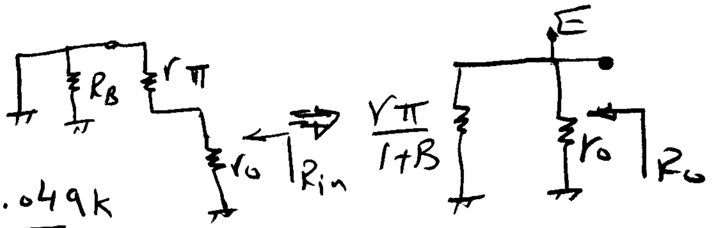

$R_L \| r_o = 0.5K \| 303.644k = 499.178\Omega$

$R_{in} = R_B \| [r_\pi + (1+B)(R_L \| r_o)]$

$= 10K \| [4.049K\Omega + (1+80)(499.178)]$

$= 10K \| 44.482K = 8.165 \; K\Omega$

## To find $R_o$

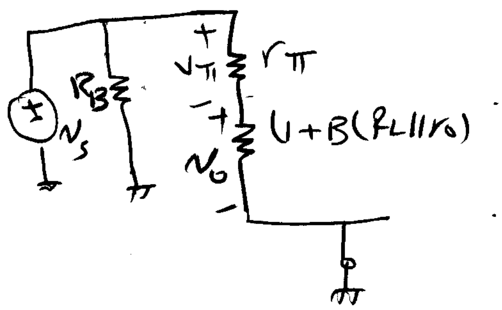



$R_o|_{v_s=0} \Rightarrow R_B \| s.c = 0$

$R_o = r_o \| \frac{r_\pi}{1+B} = 303.644K \| \frac{4.049k}{81}$

$= 303.644K \| 50 \simeq 50\Omega$

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



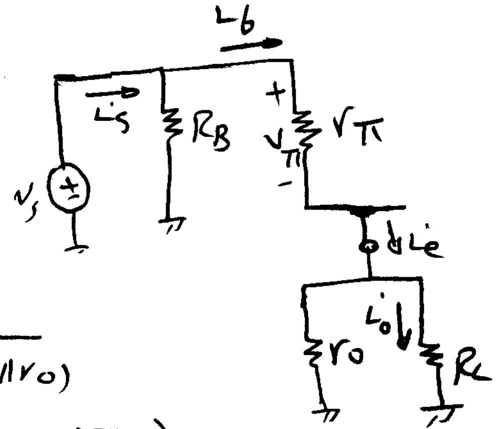

$v_o = \frac{v_s (1+B)(R_L \| r_o)}{r_\pi + (1+B)(R_L \| r_o)}$

$\therefore A_v = \frac{v_o}{v_s} = \frac{(1+B)(R_L \| r_o)}{r_\pi + (1+B)(R_L \| r_o)}$

$= \frac{81(499.178)}{4.049K + 81(499.178)}$

$= \frac{40.433K}{4.049K + 40.433K} = 0.91 \quad V|V$

## To find $A_i = \frac{i_o}{i_s}$




$i_o = i_e \frac{r_o}{r_o + R_L} = (1+B) i_b \frac{r_o}{r_o + R_L}$

$i_b = i_s \frac{R_B}{R_B + r_\pi + (1+B)(R_L \| r_o)}$

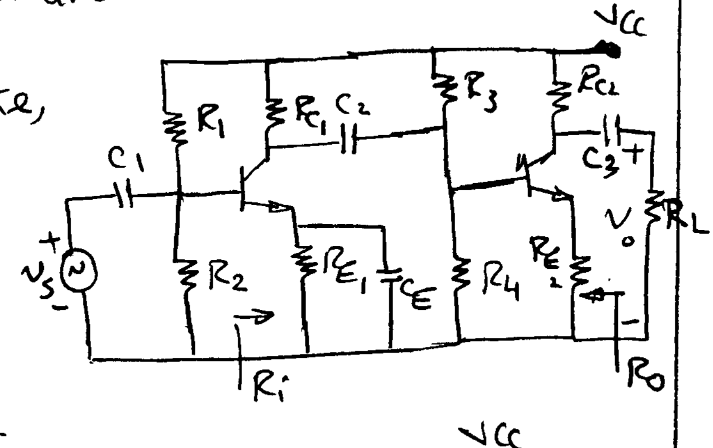
$A_i = \frac{i_o}{i_s} = (1+B)\left(\frac{r_o}{r_o + R_L}\right)\left(\frac{R_B}{R_B + r_\pi + (1+B)(R_L \| r_o)}\right)$

$= 81\left(\frac{303.644K}{303.644K + 0.5K}\right)\left(\frac{10K}{10K + 4.049K + 81 * 499.17}\right)$

$= 14.84 \; V|V$

Q5:

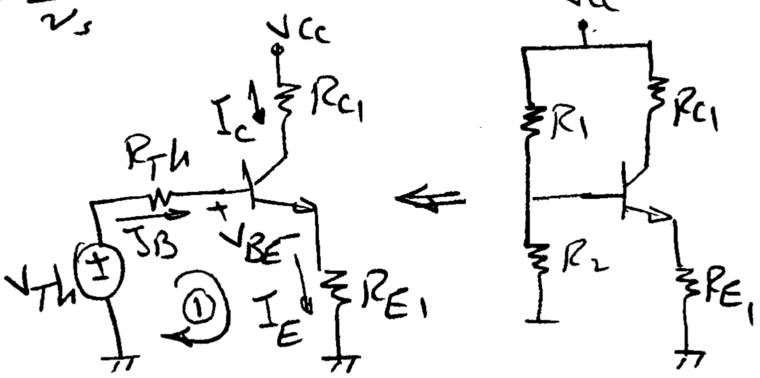
The parameters of The circuit shown are
$V_{cc} = 15\,V$, $R_{C_1} = R_{C_2} = 1\,K\Omega$,
$R_1 = R_3 = 65\,K\Omega$, $R_2 = R_4 = 25\,K\Omega$,
$R_{E_1} = R_{E_2} = 400\,\Omega$ ; $R_L = 20\,K\Omega$,
and $C_1 = C_2 = C_3 = C_E \simeq \infty$
Assume, identical Transistors of
$B = 100$ and $V_A = 100\,V$.
calculate $R_i$, $R_o$, and $A_v = \frac{v_o}{v_s}$




Solution

DC Analysis

ALL cap. o.c
for $Q_1$ and $Q_2$




$R_{Th} = R_1 // R_2 = 65K // 25K = 18.1\,K\Omega$ → ①,

$V_{Th} = \frac{V_{cc} R_2}{R_1 + R_2} = \frac{15 * 25K}{25K + 65K} = 4.17\,V$ →

Loop ①

$-V_{Th} + I_B R_{Th} + V_{BE} + I_E R_{E_1} = 0$ → ①

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

$I_B (R_{Th} + (1+B) R_{E_1}) = V_{Th} - V_{BE}$

$I_B = \frac{V_{Th} - V_{BE}}{R_{Th} + (1+B) R_{E_1}} = \frac{4.17 - 0.7}{18.1K + 101 * 400} = 59.32\,\mu A$ → ①

$I_C = B I_B = 5.932\,mA$ → (0.5)

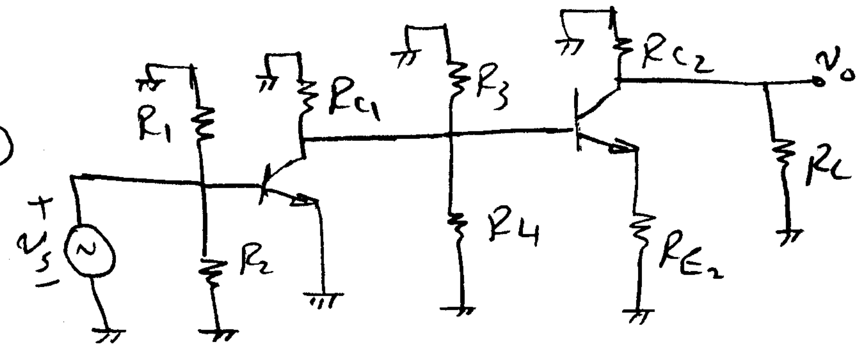
$\therefore g_{m_1} = g_{m_2} = g_m = \frac{I_C}{V_T} = \frac{5.932m}{25m} = 237.28\,mA/V$ → 0.5

$r_{\pi_1} = r_{\pi_2} = r_\pi = \frac{B}{g_m} = \frac{100}{237.28 * 10^{-3}} = 421\,\Omega$ → 0.5

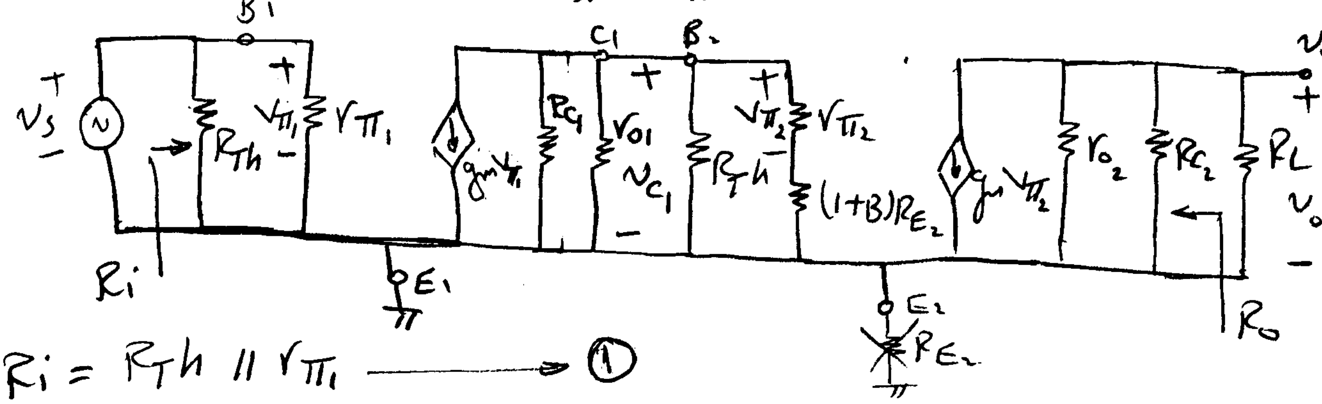
$r_{o_1} = r_{o_2} = r_o = \frac{V_A}{I_C} = \frac{100}{5.932m} = 16.86\,K\Omega$. → 0.5

## Ac Analysis

(1)




(3)




$R_i = R_{Th} \parallel r_{\pi_1}$ ⟶ (1)

$= 18.1\,K \parallel 421 = 411\,\Omega$ ⟶ (1)

$R_o|_{v_s=0} = r_{o2} \parallel R_{C2}$ ⟶ (1)

$= 16.86K \parallel 1K\Omega = 944\,\Omega$ ⟶ (1)

$R_{Leq} = r_{o2} \parallel R_{C_2} \parallel R_L = 16.86K \parallel 1K \parallel 20K = 901.5\,\Omega$

$R_{eq} = R_{C_1} \parallel r_{o_1} \parallel R_{Th} \parallel [r_{\pi_2} + (1+B)R_{E_2}]$

$= 1K \parallel 16.86K \parallel 18.1K \parallel [421 + 101 * 400]$

$= 1K \parallel 16.86K \parallel 18.1K \parallel 40.82\,K\Omega = 878\,\Omega$

$v_o = -g_m v_{\pi_2} R_{Leq}$ ⟶ (1)

$v_{c_1} = -g_m v_{\pi_1} R_{eq}$ ⟶ (1)

$$v_{\pi_2} = v_{c1} \frac{r_{\pi_2}}{r_{\pi_2} + (1+B) R_{E_2}}$$

$$v_{\pi_2} = -g_m v_{\pi_1} R_{eq} \frac{r_{\pi_2}}{r_{\pi_2} + (1+B) R_{E_2}}$$ ⟶ (1)

$\because v_{\pi_1} = v_s$ ⟶ (1)

$$v_{\pi_2} = -g_m v_s R_{eq} \frac{r_{\pi_2}}{r_{\pi_2} + (1+B) R_{E_2}}$$

$$v_o = +g_m g_m v_s R_{eq} \frac{r_{\pi_2}}{r_{\pi_2} + (1+B) R_{E_2}} R_{Leq}.$$

$$\therefore A_v = \frac{v_o}{v_s} = g_m g_m \cdot \frac{R_{eq}\, r_{\pi_2}\, R_{Leq}}{r_{\pi_2} + (1+\beta) R_{E_2}}$$

$$= (237.28 \times 10^{-3})^2 \cdot \frac{878 * 421 * 901.5}{421 + 101 * 400}$$

$$= 459.6 \text{ V/V} \longrightarrow (1)$$