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

Electronic Circuits (a) (E1203)
Final-Term Exam
Data: 12/1/2015
Time: 3 Hours

Answer the following questions:

Q1: Complete the following sentences:

i. The two basic types of full wave rectifier are ......and ....
ii. The output frequency of half wave rectifier is ......the input frequency.
iii. Diode....... add a DC level to an AC voltage.
iv. The......... operates in reverse breakdown.
v. The DC value of a full wave rectifier voltage with a peak value of 50 is....... .
vi. Diode .... cut-off voltage above or below specified levels.
vii. .... is the common base current gain of the transistors.
viii. The bias methods for discrete BJT circuit are using ..... , ... , and ....
ix. In common emitter amplifier, the input and output voltages are....... phase.
x. In common emitter amplifier the gain ....with the emitter resistance.
xi. In common collector amplifier, the input resistance is......, and the output resistance is ....

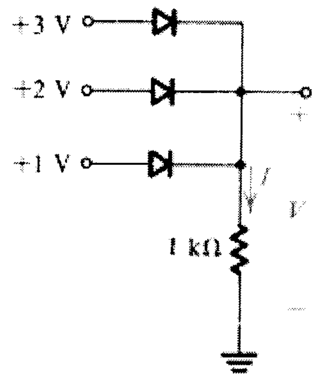
Q2: **(a)** Find the values of I and V in the circuits shown in Fig. (1).

(b) In fig.(2), the first transistor Q1 has a current gain of 100 and the second transistor Q2 has a current gain of 50, what is the base current in the first transistor?

Q3: A 6.8V Zener diode specified at 5mA to have V_z = 6.8V and r_Z = 20Ω with I_{Zk} = 0.2 mA, is operated in a regulator circuit shown in fig. (3). Using R_s= 200 Ω resistor and a 9 V supply. Estimate the knee voltage of the Zener. For no load, what is the lowest supply voltage for which the Zener remains in breakdown operation? For the nominal supply voltage, what is the maximum load current for which the Zener remains in breakdown operation? For half this load current, what is the lowest supply voltage for breakdown operation?

Q4: For the amplifier shown in Fig.(4) R_1=10kΩ; R_2=10kΩ; R_C=4.3kΩ; R_E=6.8kΩ; R_L=1kΩ; R_{sig}=500Ω; V_{cc}=15V; β=100 ; and V_A= 100. Calculate the dc bias current I_E. Replace the transistor with its hybrid-π model, and find 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 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).



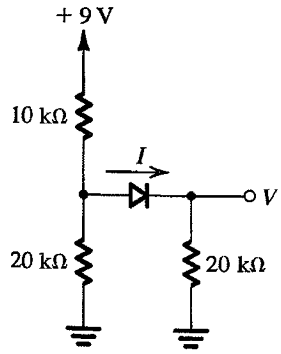


Fig.(1)

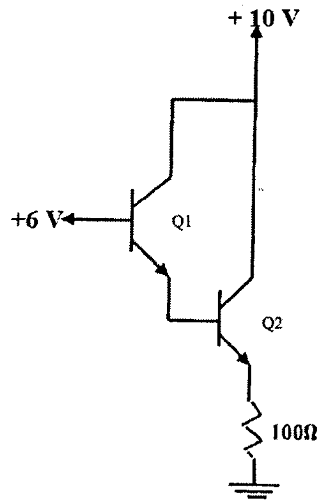


Fig.(2)

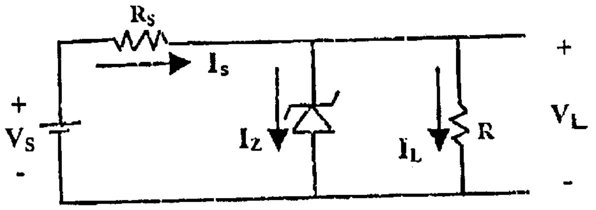


Fig.(3)

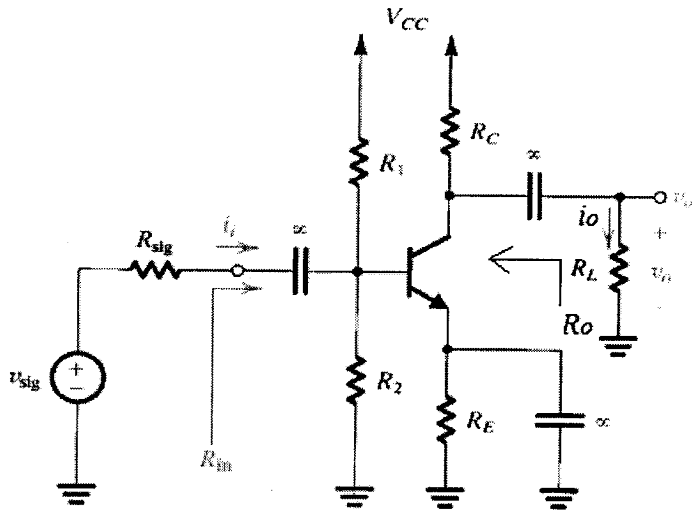


Fig.(4)

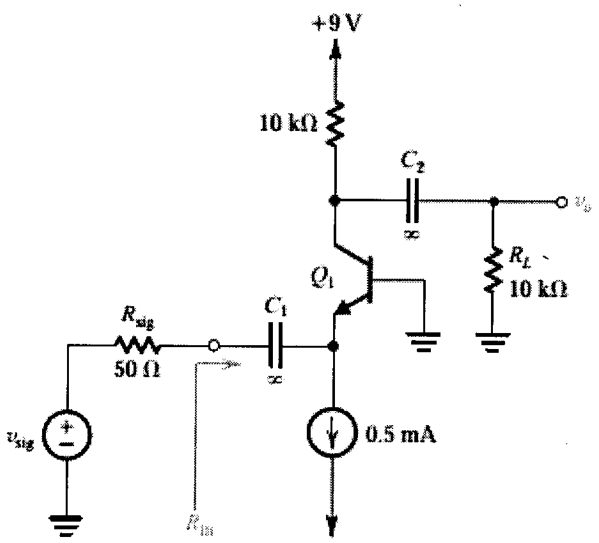


Fig.(5)

BEST WISHES

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Answer the following questions:

Q1: Complete the following sentences:

i. The two basic types of full wave rectifier are *center tapped* and *bridge*.

ii. The output frequency of half wave rectifier is *the same* the input frequency.

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

iv. The *zener diode* operates in reverse breakdown.

v. The DC value of a full wave rectifier voltage with a peak value of 50 is $(V_{dc}=2*V_m/\pi=100/\pi=31.831V)$.

vi. Diode *limiter* cut-off voltage above or below specified levels.

vii. α is the common base current gain of the transistors.

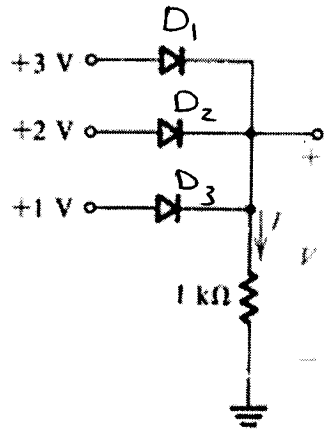
viii. The bias methods for discrete BJT circuit are using *single power supply (voltage divider bias), using two power supplies* ,and *using a collector-to- base feedback resistor,* OR *using constant current source*.

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

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

xi. In common collector amplifier, the input resistance is *high*, and the output resistance is *low* .

Q2 (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

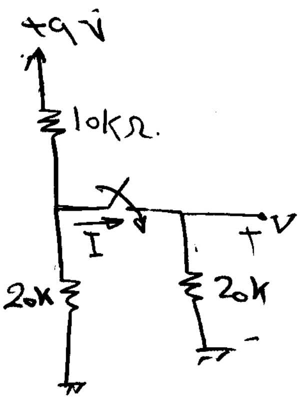
$\therefore V = 3 V$

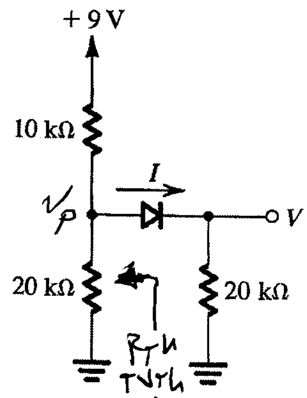
$$I = \frac{V}{R} = \frac{3}{1K\Omega} = 3mA$$

For Fig. (b)

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

Then Diode is on and replaced by s.c





(b)

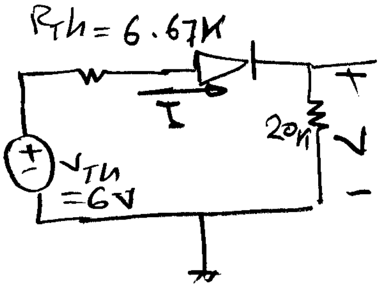
$$V = \frac{9*(20K // 20K)}{10+(20K // 20K)}$$

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

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

Another Solution

using Thevenin The circuit becomes



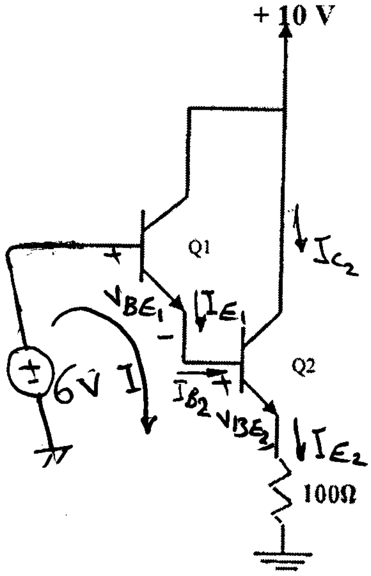
$$V_{Th} = \frac{9*20K}{10K+20K} = 6 V \quad ; \quad R_{Th} = 10K // 20K = 6.67K$$

$\because V_p > V_n \Rightarrow$ Diode on

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

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

Q2(b) In Fig.(2), the first transistor Q1 has a current gain of 100 and the second transistor Q2 has a current gain of 50, what is the base current in the first transistor?



Solution

let Q_1 and Q_2 in ACTive region

Loop (I) $\quad B_1 = 100$ & $B_2 = 50$

$$-6 + V_{BE_1} + V_{BE_2} + I_{E_2} * 100 = 0$$

$$I_{E_2} = \frac{6 - 0.7 - 0.7}{100} = \frac{6 - 1.4}{100}$$

$$I_{E_2} = 46 \text{ mA}$$

$$I_{B_2} = \frac{I_{E_2}}{1 + B_2} = \frac{46 \text{mA}}{51} = 902 \ \mu A = 0.902 \text{mA}$$

$$\because I_{E_1} = I_{B_2} = 0.902 \text{mA}$$

$$\therefore I_{B_1} = \frac{I_{E_1}}{1 + B_1} = \frac{0.902 \text{mA}}{101} = 8.93 \ \mu A$$

$$V_{B_1} = 6V$$

$$V_{E_1} = V_{B_2} = 6 - V_{BE_1} = 6 - 0.7 = 5.3 \text{ V}$$

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

$$V_{E_2} = I_{E_2} R_{E_2} = 46m * 100 = 4.6 \text{ V}$$

for Q_1

$V_{B_1} > V_{E_1} \Longrightarrow$ BE J is Forward

$V_{C_1} > V_{B_1} \Longrightarrow$ BC J is reverse

$\therefore$ Q_1 in ACTive Region

for Q_2

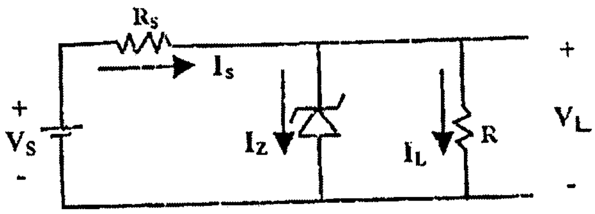
$V_{B_2} > V_{E_2} \Longrightarrow$ BE J is Forward

$V_{C_2} > V_{B_2} \Longrightarrow$ BC J is reverse

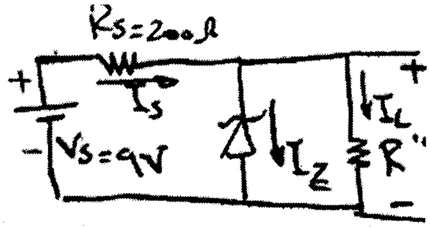
$\therefore$ Q_2 in ACTive region $\Longrightarrow$ $\therefore$ Assumption is True

$\therefore I_{B_1} = 8.93 \ \mu A$

Q3: A 6.8V Zener diode specified at 5mA to have $V_z = 6.8V$ and $r_Z = 20\Omega$ with $I_{Zk} = 0.2$ mA, is operated in a regulator circuit shown in Fig. (3). Using $R_s = 200\ \Omega$ resistor and a 9 V supply. Estimate the knee voltage of the Zener. For no load, what is the lowest supply voltage for which the Zener remains in breakdown operation? For the nominal supply voltage, what is the maximum load current for which the Zener remains in breakdown operation? For half this load current, what is the lowest supply voltage for breakdown operation?



Solution



$V_Z = 6.8\ V$; $I_Z = 5mA$; $I_{ZK} = 0.2mA$

$r_Z = 20\ \Omega$

$\because V_Z = V_{Z0} + I_Z r_Z$; $V_{Z0} = V_{ZK}$

$\therefore V_{Z0} = V_Z - I_Z r_Z = 6.8 - 5m \times 20 = 6.7V$

$\therefore$ Knee Voltage $= 6.7\ V$ ⟶ 2

- For no Load find Lowest V_S To operate in break down.

For edge of break down $\Rightarrow I_Z = I_{ZK} = 0.2\ mA$; $V_Z = V_{ZK} = V_{Z0} = 6.7V$ ⟶ 1

For $R = \infty \Rightarrow I_S = I_Z \Rightarrow I_S = I_{ZK}$

$\therefore \dfrac{V_S - V_{Z0}}{R_S} = I_{ZK} \Rightarrow V_S = V_{Z0} + I_{ZK} R_S$ ⟶ 1

$V_S = 6.7 + 0.2 \times 10^{-3} \times 200 = 6.74\ V \simeq 6.7V$ ⟶ 1

Then for no Load, break down is sustained To about supply VolTage $= 6.7V$

Q3: (Cont.)

- For nominal supply voltage i.e $V_s = 9V$ find $I_L|_{max}$ in which Zener remain in breakdown

$\because I_S = I_Z + I_L \Longrightarrow I_L|_{max} = I_S\uparrow - I_Z\downarrow_{=I_{ZK}}$; $V_Z = V_{Z_0}$, $I_Z = I_{ZK}$

$$\therefore I_L|_{max} = \frac{V_S - V_{Z_0}}{R_S} - I_{ZK} \longrightarrow 1$$

$$= \frac{9 - 6.7}{200} - 0.2m = 11.5m - 0.2m = 11.3\ mA \longrightarrow 2$$

- For $\frac{I_L|_{max}}{2} = \frac{11.3m}{2} = 5.65\ mA$ find lowest V_s for breakdown

$I_L = 5.65$; $I_Z = I_{ZK} = 0.2\ mA$; $V_Z = V_{Z_0} = 6.7\ V$

$$\because I_s = I_{ZK} + I_L = 0.2m + 5.65m = 5.85\ mA \longrightarrow 1$$

$$\because I_s = \frac{V_S - V_{Z_0}}{R_s} \Longrightarrow V_s = V_{Z_0} + I_s R_s \longrightarrow 1$$

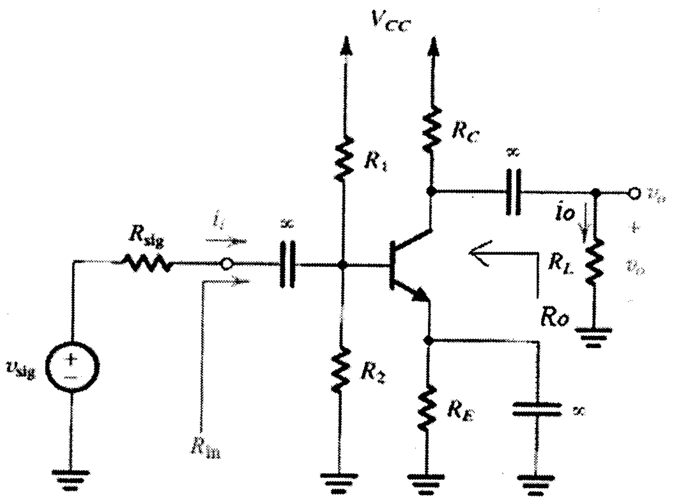
$$\therefore V_s|_{min} = V_{Z_0} + I_s R_s$$

$$= 6.7 + 5.85 \times 10^{-3} \times 200$$

$$= 7.87\ V \longrightarrow 2$$

Thus the lowest supply for regulation with half-max. Load current = 7.87 V

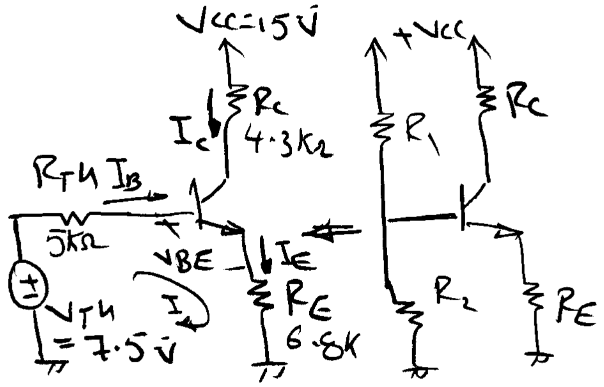
Q4: For the amplifier shown in Fig.(4) R_1=10kΩ; R_2=10kΩ; R_C=4.3kΩ; R_E=6.8kΩ; R_L=1kΩ; R_{sig}=500Ω; V_{cc}=15V; β=100 ; and V_A= 100. Calculate the dc bias current I_E. Replace the transistor with its hybrid-π model, and find the values of R_{in}, R_o, the voltage gain (v_o/v_{sig}) and the current gain (i_o/i_i).



Solution

DC Analysis

- All capacitors are o.c
- reduc AC sources



$$R_{Th} = R_1 \parallel R_2 = 10K \parallel 10K = 5k\Omega$$

$$V_{Th} = \frac{V_{cc} R_2}{R_1 + R_2} = \frac{15 * 10k}{20k} = 7.5\,V$$

Loop (1)

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

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

$$\therefore -V_{Th} + \frac{I_E}{1+\beta} R_{Th} + V_{BE} + I_E R_E = 0$$

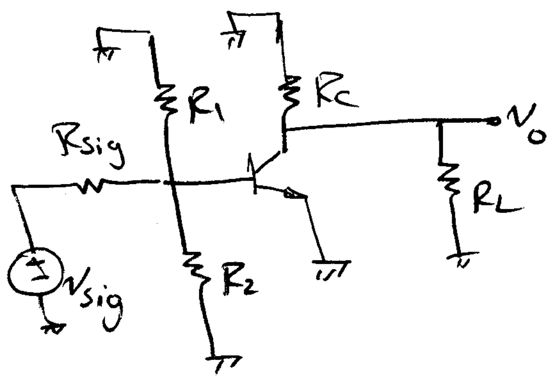
$$I_E\left(\frac{R_{Th}}{1+\beta} + R_E\right) = V_{Th} - V_{BE}$$

$$I_E = \frac{V_{Th} - V_{BE}}{\frac{R_{Th}}{1+\beta} + R_E} = \frac{7.5 - 0.7}{\frac{5k}{101} + 6.8k} = 0.993\ mA$$

$$I_C = \alpha I_E = \frac{\beta}{1+\beta} I_E = \frac{100}{101} * 0.993m = 0.983\,mA$$

AC Analysis

- All capacitors are s.c
- reduc DC sources i.e V.s = s.c



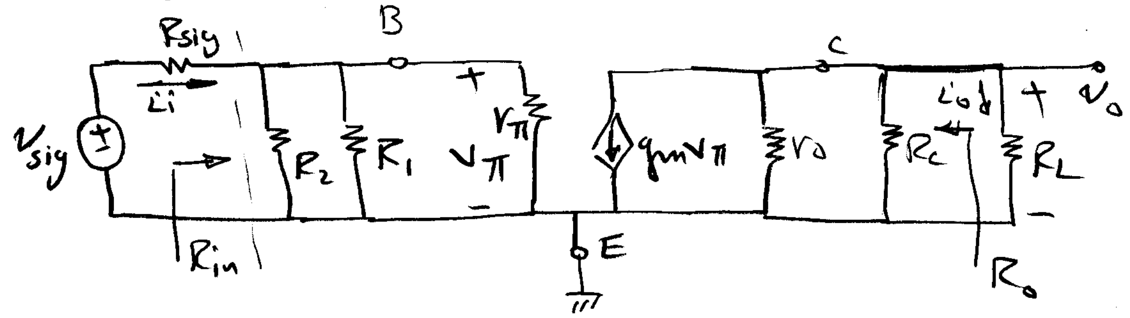
$$g_m = \frac{I_C}{V_T} = \frac{0.983mA}{25mV} = 39.32\ mA/V$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100}{39.32m} = 2.54\ K\Omega$$

$$r_o = \frac{V_A}{I_C} = \frac{100}{0.983m} = 101.73\ K\Omega.$$

Q4: (Cont.)

Using π– model



$R_{in} = R_1 \| R_2 \| r_\pi = 10K \| 10K \| 2.54 K\Omega$

$= 5K \| 2.54 K\Omega = 1.684 K\Omega.$

$R_o \big|_{v_{sig}=0} = R_C \| r_o$

$= 6.8K \| 101.73K = 6.374 K\Omega.$

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

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

$v_\pi = v_{sig} \frac{R_{in}}{R_{sig}+R_i}$

$v_o = -g_m v_{sig} \frac{R_i}{R_{sig}+R_i} (r_o \| R_C \| R_L)$

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

$= -39.32 * 10^{-3} \frac{1.684K}{0.5K + 1.684K} (101.73K \| 6.8K \| 1K)$

$= -39.32 * 10^{-3} * 771.06 * 10^{-3} * 864.39 = -26.21 \ V/V$

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

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

$v_\pi = i_i R_{in}$

$i_o = -g_m i_i R_i \frac{R_o}{R_o+R_L}$

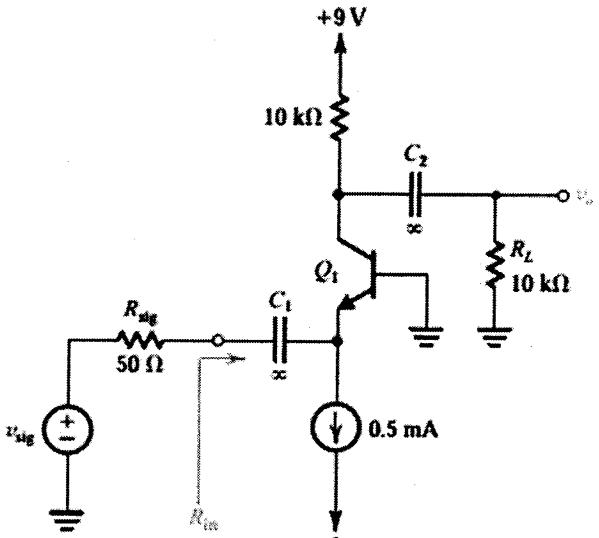
$A_i = \frac{i_o}{i_i} = -g_m \frac{R_i R_o}{R_o + R_L}$

$= -39.32 * 10^{-3} \frac{1.684K * 6.374K}{6.374K + 1K}$

$= -39.32 * 10^{-3} * 1455.63$

$A_i = -57.24 \ A/A$

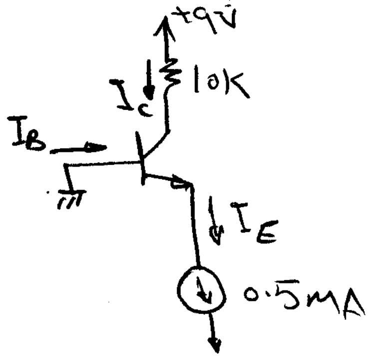
Q5: For the circuit shown in Fig. (5), draw a complete small-signal equivalent circuit utilizing an appropriate T- model for the BJT (use $\alpha = 0.99$). Your circuit should show the values of all components, including the model parameters. Find R_{in}, R_o, the voltage gain (v_o/v_{sig}) and the current gain (i_o/i_i).



Solution

DC Analysis

- All capacitors are o.c
- reduce AC sources



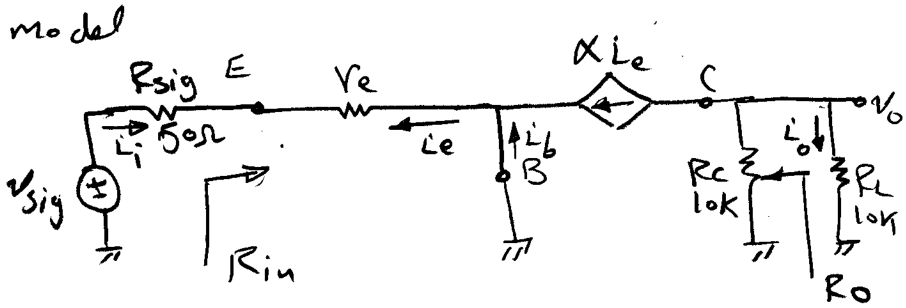
$I_E = 0.5\, mA$

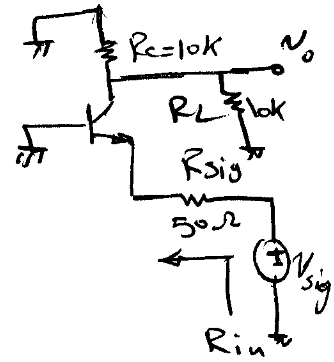
$r_e = \frac{V_T}{I_E} = \frac{25\, mV}{0.5\, mA} = 50\,\Omega$

AC Analysis

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

using T- model





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

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

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

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

$\therefore V_o = \frac{+\alpha\, V_{sig} (R_C \| R_L)}{R_{sig} + r_e}$

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

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

Q5: (Cont.)

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

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

$$i_i = -i_e$$

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

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