POSTAL BOOK PACKAGE 2025

MADE EASY PUBLICATIONS

ELECTRICAL ENGINEERING

CONVENTIONAL Practice Sets

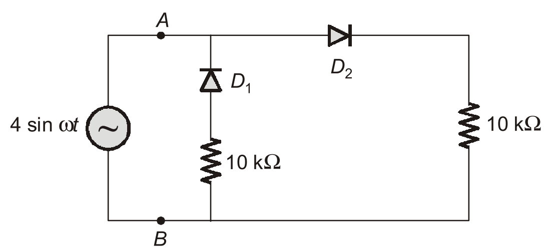
CONTENTS

ANALOG ELECTRONICS

1
CHAPTER

Diode Circuits

Q.1 A voltage source $V_{AB} = 4 \sin \omega t$, is applied across the terminals *A* and *B* of the circuit. The diodes are assumed to be ideal. Find the impedance offered by the circuit across the terminals *A* and *B* in kilo ohm.



Solution:

In +ve half cycle D_1 – off (R.B.)

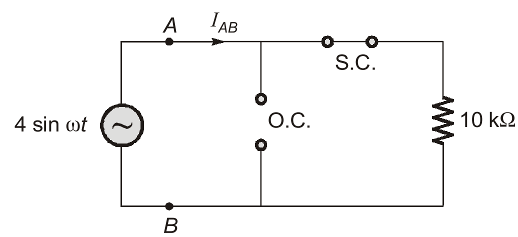
D_2 – on (F.B.)

∴ Equivalent circuit will be

$$V_{AB} = 4 \sin\omega t$$

$$I_{AB} = \frac{V_{AB}}{10\,\text{k}\Omega}$$

$$\therefore \quad R_i = \frac{V_{AB}}{I_{AB}} = 10\,\text{k}\Omega$$



For –ve half cycle,

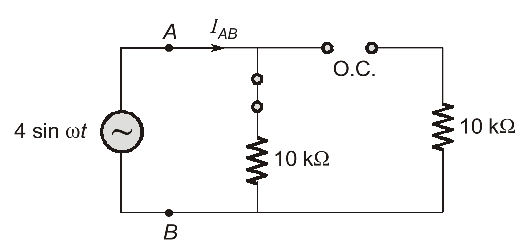
D_1 on, D_2 off

Equivalent circuit,

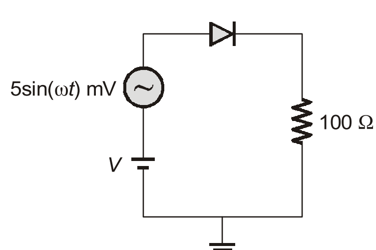
$$V_{AB} = 4 \sin\omega t$$

$$I_{AB} = \frac{4 \sin\omega t}{10\,\text{k}\Omega}$$

$$\therefore \quad \frac{V_{AB}}{I_{AB}} = R_i = 10\ \text{k}\Omega$$



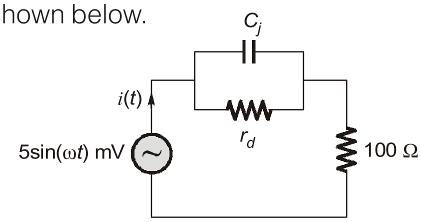
Q.2 A DC current of 26 μA flows through the circuit shown. The diode in the circuit is forward biased and it has an ideality factor of one. At the quiescent point, the diode has a junction capacitance of 0.5 nF. Its neutral region resistances can be neglected. Assume that the room temperature thermal equivalent voltage is 26 mV.



For $\omega = 2 \times 10^6$ rad/s, the amplitude of the small-signal component of diode current.

Solution:

The small-signal equivalent model of the given circuit can be drawn as shown below.



Given that,

$$\omega = 2 \times 10^6 \text{ rad/sec}$$
$$C_j = 0.5 \text{ nF}$$
$$I_{DC} = 26\ \mu\text{A}$$
$$V_T = 26 \text{ mV}$$
$$\eta = 1$$

Since, small signal incremental diode resistance, $r_d = \dfrac{\eta V_T}{I_{DC}} = \dfrac{26 \text{ mV}}{26\ \mu\text{A}} = 1\text{k}\Omega$

and impedance due to junction capacitance, $\dfrac{1}{\omega C_j} = \dfrac{1}{2 \times 10^6 \times 0.5 \times 10^{-9}}\ \Omega = 1\text{k}\Omega$

So, total impedance of the circuit will be,

$$Z = \left(r_d \| \frac{1}{j\omega C_j}\right) + 100\ \Omega$$

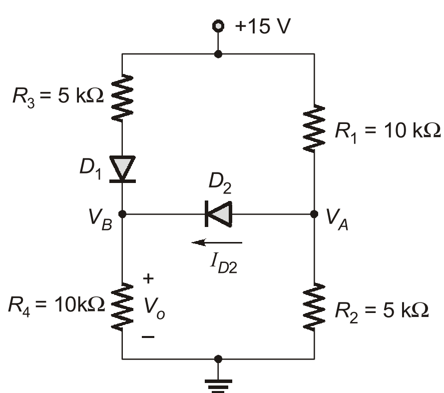
$$\left(r_d \| \frac{1}{j\omega C_j}\right) = \frac{(1000)(-j1000)}{1000 - j1000}\ \Omega = \frac{-j(1+j)}{2}\text{k}\Omega = \frac{1}{2}(1-j)\text{ k}\Omega = (500 - j500)\ \Omega$$

$$\therefore \quad Z = 600 - j500\ \Omega$$

$$|Z| = 100\sqrt{36+25} = 100\sqrt{61}\ \Omega$$

$$I_m = \frac{V_m}{|Z|} = \frac{5 \text{ mV}}{100\sqrt{61}\ \Omega} = \frac{50}{\sqrt{61}}\ \mu\text{A} = 6.40\ \mu\text{A}$$

Q.3 Determine the current I_{D2} and the voltage V_o in the multidiode circuit shown in the figure below. Assume that, cut-in voltage $V_\gamma = 0.7$ V for each diode.



Solution:

To begin, initially assume that, both the diodes D_1 and D_2 are in their conducting state.

By applying KCL at A and B nodes, we have

$$\frac{15 - V_A}{10} = I_{D2} + \frac{V_A}{5} \quad \text{...(i)}$$

and
$$\frac{15 - (V_B + 0.7)}{5} + I_{D2} = \frac{V_B}{10} \quad \text{...(ii)}$$

We note that $V_B = V_A - 0.7$. Combining the two equations and eliminating I_{D2}, we find

$$V_A = 7.62 \text{ V} \quad \text{and} \quad V_B = 6.92 \text{ V}$$

From equation (i) above, we obtain

$$\frac{15 - 7.62}{10} = I_{D2} + \frac{7.62}{5} \Rightarrow I_{D2} = -0.786 \text{ mA}$$

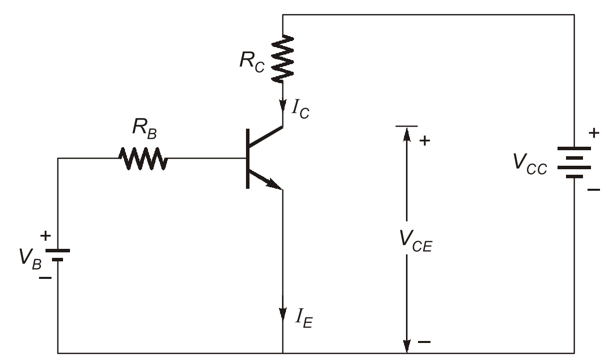
2 CHAPTER BJT-Characteristics and Biasing

Q.1 The bipolar transistor in figure is specified to have β_F in the range of 8 to 40. The load resistance is $R_C = 11\ \Omega$. The d.c. supply voltage is $V_{CC} = 200$ V and the input voltage to the base circuit is $V_B = 10$ V. If $V_{CE(sat)} = 1.0$ V and $V_{BE(sat)} = 1.5$ V, find

(a) the value of R_B that results in saturation with an ODF of 5,

(b) the β_{forced}, and

(c) the power loss P_T in the transistor.



Solution:

When the transistor is in saturation, the collector current will be

$$V_c = V_{CE}(\text{sat}) = 1\text{ V}$$

$$\therefore \quad \text{Collector current} = \frac{200-1}{11} \cong 18.1\text{ A}$$

To saturate the transistor with lowest 'β' we need to provide a base of at least

$$I_B = \frac{I_c(sat)}{\beta_{min}} = \frac{18.1}{8} = 2.26\text{ A}$$

With overdrive factor 5, $\quad I_B = 5 \times 2.26 = 11.3$ A

(a) Thus required value of R_B $\quad \dfrac{10-1.5}{R_B} = 11.3 \Rightarrow R_B = \dfrac{8.5}{11.3} = 0.752\,\Omega$

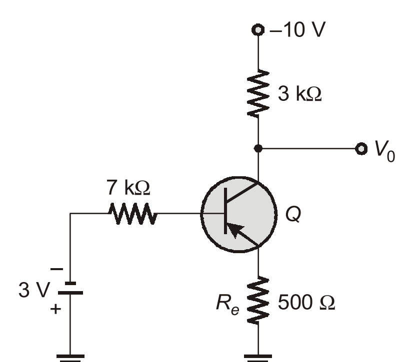
(b) $\quad \beta_{forced} = \dfrac{I_{c\,sat}}{I_B} = \dfrac{18.1}{11.3} = 1.60$

(c) Power loss in transistor, $\quad P_T = V_{CE} \times I_{CE} = (V_{CE\,sat}) \times (I_{CE\,sat}) \Rightarrow P_T = 1 \times 18.1 = 18.1$ Watt

Q.2 For the circuit shown in the figure, assume $\beta = h_{FE} = 100$.

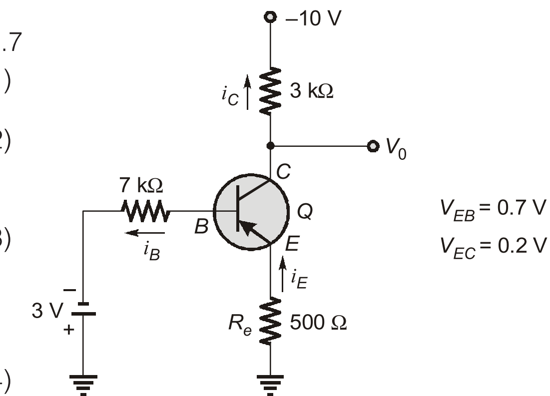
(a) Find if the silicon transistor is in cut-off, saturation or in the active region.

(b) Find v_0



Solution:

Let us assume that the circuit is in saturation.



$$V_E = 0 - 3 + 7000\, i_B + 0.7$$

$$V_E = 7000\, i_B - 2.3 \quad ...(1)$$

Now, $$i_E = \frac{0 - V_E}{R_e} = \frac{2.3 - 7000 i_B}{500} \quad ...(2)$$

Now, $$V_C = V_0 = V_E - 0.2$$

$$V_C = 7000\, i_B - 2.5 \quad ...(3)$$

Now, $$i_C = \frac{V_C - (-10)}{3000} = \frac{7000 i_B + 7.5}{3000}$$

$\Rightarrow$ $$i_C = \frac{7}{3} i_B + \frac{7.5}{3000} \quad ...(4)$$

Now, $$i_E = i_B + i_C$$

$\Rightarrow$ $$\frac{2.3 - 7000 i_B}{500} = \frac{7}{3} i_B + \frac{7.5}{3000} + i_B$$

$\Rightarrow$ $$\frac{2.3}{500} - \frac{70}{5} i_B = \frac{7}{3} i_B + \frac{7.5}{3000} + i_B$$

$\Rightarrow$ $$\frac{2.3}{500} - \frac{7.5}{3000} = \frac{7}{3} i_B + i_B + \frac{70}{5} i_B \Rightarrow \frac{21}{10000} = \frac{52}{3} i_B$$

$\Rightarrow$ $$i_B = 0.1212 \text{ mA}$$

$\Rightarrow$ $$i_C = 2.783 \text{ mA}$$

Now, $$\beta = \frac{i_C}{i_B} = 22.96 \approx 23$$

This is much less than the given β of 100. Hence, the BJT is in saturation.

Now, $$V_0 = 7000\, i_B - 2.5 = 7 \times 0.1212 - 2.5$$

$\therefore$ $$V_0 = -1.65 \text{ V}$$

Q.3 **A p-n-p transistor has V_{EB} = 0.8 V at a collector current of 1 A. What do you expect V_{EB} to become at I_C = 10 mA and at I_C = 5 A respectively. (Assume V_T = 25 mV)**

Solution:

Given that: A pnp transistor with V_{EB} = 0.8 V

for I_C = 1 A and assuming V_T = 25 mV

To find: V_{EB} at I_c = 10 mA and 5 A

Now, we know that

$$I_C = I_{CO} \exp\left(\frac{V_{EB}}{V_T}\right) \quad ...(i)$$

where, I_{CO} is the reverse saturation current

V_T is the thermal voltage

from the above equation (i), we can say

$$V_{EB} = V_T \, ln\left(\frac{I_C}{I_{CO}}\right) \quad ...(ii)$$

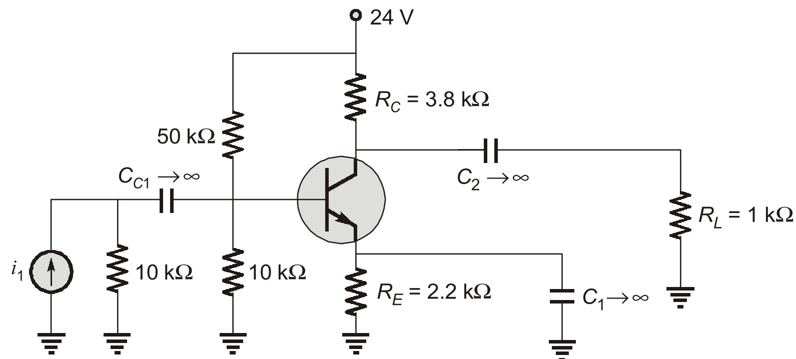
Now, substituting the value of I_C = 1 A and V_{EB} = 0.8 V, we get

$$I_{CO} = \frac{1}{\exp\left(\frac{0.8}{0.025}\right)}$$

3 CHAPTER

BJT as an Amplifier

Q.1 In an *R-C* coupled amplifier, shown below, the BJT has $h_{fe} = 50$. All bypass and coupling capacitors are assumed to have zero reactances at the signal frequency. Find quiescent conditions and draw the small signal equivalent circuit, neglecting h_{oe} and h_{re}.

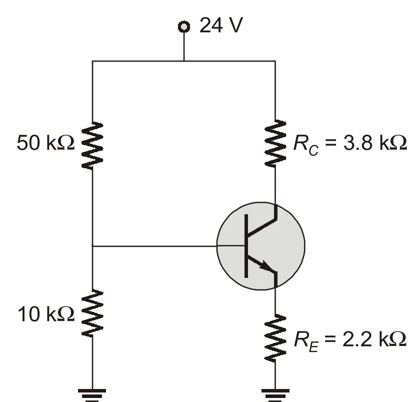


Solution:

For quiescent condition i.e. dc analysis the equivalent circuit is drawn by making all capacitors open at dc condition i.e. at $f = 0$.

Given $h_{fe} = 50$, since $\beta = h_{fe} = 50$

Find Thevenin equivalent wrt base emitter circuit



$$V_{th} = \frac{10}{10+50} \times 24 = 4\text{ V}$$

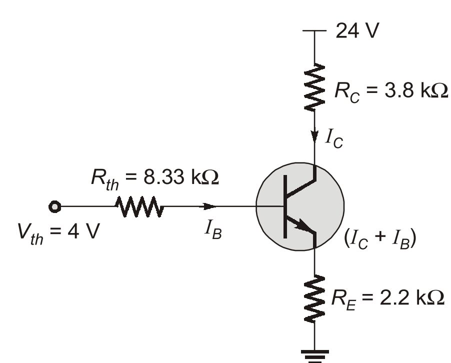
$$R_{th} = 10 \parallel 50 \text{ k}\Omega$$

$$= \frac{10 \times 50}{10+50} \text{k}\Omega = \frac{50}{6} \text{k}\Omega$$

$$R_{th} = 8.33 \text{ k}\Omega$$

Now Thevenin equivalent circuit will be as below:

Assuming it to be in active region, writing KVL in base-emitter loop, we have



$$4 - 8.33 \times 10^3 I_B - V_{BE} - (I_B + I_C)\, 2.2 \times 10^3 = 0 \qquad \text{...(i)}$$

Here $\quad V_{BE} = 0.7\text{ V}$

and $\quad I_C = \beta I_B = 50\, I_B$

∴ from equation (i)

$$4 - 8.33 \times 10^3 I_B - 0.7 - 51 \times 2.2 \times 10^3 I_B = 0$$

$$3.3 = (8.33 + 51 \times 2.2) \times 10^3 I_B$$

$$I_B = 0.027379 \text{ mA}$$

∴ $$I_C = \beta I_B = 50 \times 0.027379 \times 10^{-3} = 1.36895 \text{ mA}$$

$$I_E = (I_C + I_B) = (\beta + 1) I_B = 51 \times 0.027379 \times 10^{-3} = 1.396329 \text{ mA}$$

∴ $$V_{CE} = 24 - I_C R_C - I_E R_E$$