1.2 1. What is p-n junction ?

2. Explain the formation of depletion region in a p-n junction.

1.3 1. What is ohmic contact ? State its properties.

1.4 1. Explain the operation of forward biased diode.

1.5 1. Explain the operation of reverse biased diode.

2. Explain the breakdown mechanisms in reverse biased diode.

1.6 1. Explain the current components in a diode.

1.7 1. Draw and explain the forward characteristics of a diode.

2. Draw and explain the reverse characteristics of a diode.

3. Explain the static and dynamic forward resistance of a diode.

4. Compare the V-I characteristics of Ge and Si diodes.

1.8 1. State V-I characteristics equation of a diode. Explain each term from it.

2. Derive the nature of V-I characteristics from the equation of diode.

1.9 1. What is drift current ?

2. What is diffusion current ?

1.10 1. What is transition capacitance ?

2. State the expression for transition capacitance and explain each term from it.

Review Questions (Sectionwise)

2.1

1. State the advantages of transistor over vaccum tube.
2. What is transistor ? Give its circuit symbol.
3. Transistor means transfer-resistor, explain this.
4. Explain the construction of npn and pnp transistors.
5. Mention the different types of transistor configurations. Draw the circuit diagram of each type using NPN transistors. Explain the salient features of each type.
6. Distinguish between the different types of transistor configurations with necessary circuit diagrams, using PNP transistor.
7. Define : α_{dc} and β_{dc}.
8. Give the relationship between α_{dc} and β_{dc}
9. Compare CB, CE and CC transistor configurations. Which is the widely used configuration ? Why ?
10. Define α_{dc} and β_{dc} of a transistor. For a transistor the base current is 100 μA and collector current is 2.9 mA. Find α_{dc} and β_{dc}. **(Ans. : α_{dc} = 0.9666, β_{dc} = 29)**
11. A transistor has α = 0.99, what will be the base current if the emitter current is 8 mA ? **(Ans. : I_B = 80 μA)**
12. If the base current in a transistor is 30 μA when the emitter current is 7.2 mA, what are the values of α and β ? Also calculate the collector current. **(Ans. : α = 0.9958, β = 239, I_C = 7.17 mA)**
13. In a certain transistor, the emitter current is 1.04 times as large as the collector current. If the emitter current is 10 mA, find the base current. **(Ans. : 384 μA)**
14. In a certain transistor, 99.5% of the carriers injected into the base cross the collector-base junction. If the leakage current is 6 μA and the collector current is 10 mA, calculate (i) the value of α, (ii) the emitter current. **(Ans. : α = 0.995, I_E = 10.04 mA)**
15. The reverse leakage current of the transistor, when connected in common-base configuration is 0.2 μA, while it is 18μA when the same transistor is connected in common-emitter configuration. Calculate the α and β of the transistor. **(Ans. : α = 0.988, β = 82.33**

2.2

1. Why biasing is necessary in BJT amplifiers ?
2. The reverse saturation current of the germanium transistor shown in Fig. 2.115 is 1.2 μA at a temperature of 25°C and it doubles for every 10°C rise in temperature. The bias voltage V_{BB} = 6 V. Find the maximum allowable value of the resistance R_B if the transistor is to remain cutoff at a temperature of 75° C. Assume $V_{(BE\ cut\ off)}$ = 0.1 V in reverse direction. **(Ans. : R_B = 153.65 kΩ)**

2. *Give the comparison between half wave rectifier and full-wave (centre-tap) rectifier with help of following points.*
   a) Number of diodes
   b) Transformer necessity
   c) PIV rating of diode used
   d) Average d.c. current
   e) Average d.c. voltage
   f) RMS current
   g) Ripple factor
   h) Rectifier efficiency
   i) Ripple frequency
   j) Transformer Utilization Factor
3. *Show that the ripple factor of a full-wave rectifier is 0.482.*
4. *Prove that the maximum rectification efficiency of a full-wave rectifier is 81.2 %*
5. *A full-wave rectifier circuit is fed from a transformer having a center-tapped secondary winding. The rms voltage from either end of secondary to center tap is 20 V. If the diode forward resistance is 3Ω and that of the half secondary is 5 Ω, for a load of 1kΩ, calculate*
   a) Power delivered to load,
   b) % Regulation at full load,
   c) Efficiency at full load,
   d) TUF of secondary.

(Ans. : a) P_{dc} = 0.3191 W, b) % Regulation = 0.7649 %, c) Efficiency of full load = 0.8041, d) T.U.F. = 0.804)

5. *A full wave single phase rectifier makes use of two diodes, the internal forward resistance of each of which can be considered to be constant and equal to be constant and equal to 30 Ω. The load resistance is 1 Ω. The transformer secondary voltage is 200-0-200 V(rms). Calculate :*
   i) The D.C. load current
   ii) The D.C. output voltage
   iii) PIV of diode
   iv) RMS voltage across each diode.

(Ans. : (i) I_{dc} = 175 mA, (ii) V_{dc} = 175 V, (iii) PIV = 565.60 V, (iv) V_{rms} = 200 V)

6. A full wave rectifier uses diodes with forward resistance of 10 ohms each. The secondary of the transformer is center tapped with output voltage 12-0-12 volts (rms), and has a resistance of 5 ohms for each half winding.

i) No load dc voltage

ii) D.C. voltage when the load current is 100 mA

iii) % regulation at 100 mA load current

iv) Peak inverse voltage &

v) Ripple factor.

(Ans. : (i) $V_{NL.dc}$ = 10.8 V, (ii) V_{dcFL} = 9.8 V, (iii) % Reg. = 10.2 %, (iv) PIV = 33.94 V, (v) R_f = 0.482)

7. A full wave single phase rectifier circuit makes use of two diodes, the internal forward resistance of each of which can be considered to be constant and equal to 20 Ω. The load resistance is 1 kΩ. The transformer secondary volt is 100-0-100V (rms).

Calculate :

i) D.C. load current

ii) D.C. output voltage

iii) PIV

iv) RMS voltage across each diode. **(Ans. : (i) I_{dc} = 88.26 mA, (ii) V_{DC} = 88.26 V, (iii) PIV = 282.84 V, (iv) V_{rms} = 200 V)**

8. A full wave p-n diode rectifier without filter uses a load resistor of 1000 Ω. Assume each diode has R_f = 6 Ω and R_r = ∞. Sine wave voltage is applied to each diode has amplitude of 15 volts and frequeney 50 Hz,

Calculate : i) Peak, d.c. and r.m.s. load current;

ii) D.C. power output.

(Ans. : (i) V_m = 21.21 V, V_{dc} = 13.5 V, I_{rms} = 14.9 mA, (ii) P_{dc} = 0.179 W)

1. Draw and explain bridge-rectifier circuit with waveforms.

2. Explain why a bridge rectifier is preferred over a centre-tap rectifier.

3. Draw the circuit diagram of a full-wave rectifier using (a) centre-tap connection, and (b) bridge connection. Explain the working of each. What is the PIV in each case ?

4. The four semiconductor diodes used in a bridge rectifier circuit, each having a forward resistance of 0.05 Ω and infinite reverse resistance, feed a mean current of 10A to a resistive load from a sinusoidally varying alternating supply of 30 V (r.m.s.). Determine the resistance of the load and the efficiency of the circuit. **(Ans. : R_L = 2 Ω, % Efficiency = 78 %)**

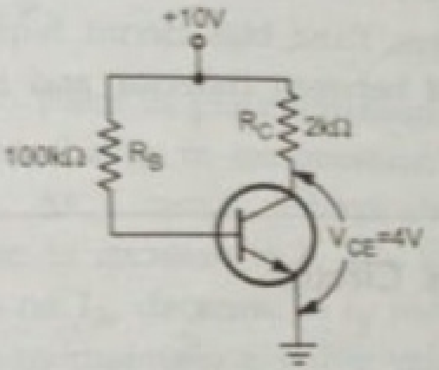
5. If the required output dc voltage is 9 volt and the voltage drop across each diode is 0.8 volt, calculate the ac rms input voltage required in the following cases :

i) Bridge rectifier

ii) Center tap full wave rectifier. **(Ans. : (i) V_{rms} = 11.7736 V, V_{rms} = 10.88 V)**

Example 2.6 : *In the circuit shown in Fig. 2.24 calculate stability factor S.*

Figure 2.24



Solution : The circuit shown in Fig. 2.24 is a fixed bias circuit. Thus the stability factor :

$$S = 1 + \beta$$

To calculate β, it is necessary to find I_C and I_B.

Applying KVL to the collector circuit we get,

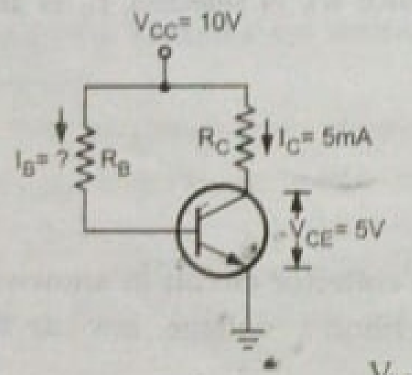
$$V_{CC} - I_C R_C - V_{CE} = 0$$

$$I_C = \frac{V_{CC} - V_{CE}}{R_C} = \frac{10 - 4}{2 \times 10^3} = 3 \text{ mA}$$

Example 2.4 : *Design a fixed biased circuit using a silicon transistor having β value of 100. V_{CC} is 10V and dc bias conditions are to be V_{CE} = 5V and I_C = 5mA.*

Solution :

Figure 2.22



Applying KVL to collector circuit we get,

$$V_{CC} - V_{CE} - I_C R_C = 0$$

$$\therefore R_C = \frac{V_{CC} - V_{CE}}{I_C} = \frac{10-5}{5mA} = 1K$$

$$I_B = \frac{I_C}{\beta} = \frac{5mA}{100} = 50\ \mu A$$

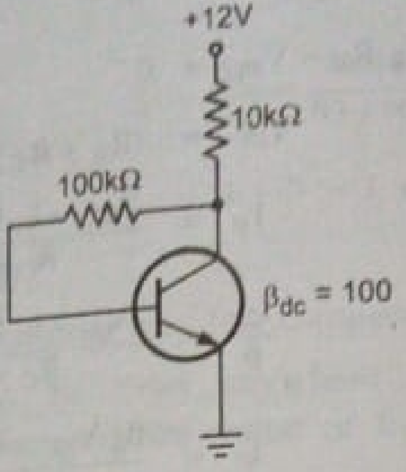
Now, applying KVL to base circuit we get,

$$V_{CC} - I_B R_B - V_{BE} = 0$$

$$R_B = \frac{V_{CC} - V_{BE}}{I_B} = \frac{10-0.7}{50\ \mu A} = 186\ k\Omega$$

Example 2.7 : *Calculate the Q-point values (I_C and V_{CE}) for the circuit in Fig. 2.26*

Figure 2.26



Solution :

Using equation (16)

$$I_C = \frac{\beta(V_{CC} - I_C R_C - V_{BE})}{R_C + R_B}$$

$$I_C (10\times10^3 + 100\times10^3) = 100(12 - 10\times10^3 I_C - 0.7)$$

$$110\times10^3 I_C = 1130 - 1000\times10^3 I_C$$

$$\therefore \quad 1110\times10^3 I_C = 1130$$

$$\therefore \quad I_C = 1.0180 \text{ mA}$$

and

$$I_B = \frac{I_C}{\beta} = \frac{1.018}{100} = 10.18\ \mu A$$

$$V_{CE} = V_{CC} - (I_B + I_C) R_C = 12 - (10.18\times10^{-6} + 1.018\times10^{-3})\times10\times10^3$$

$$= 1.7182 \text{ V}$$

Example 2.12 : *Design a voltage divider bias circuit for the specified conditions. V_{CC} = 12V, V_{CE} = 6V, I_C = 1 mA, S = 20, β = 100 and V_E = 1V*

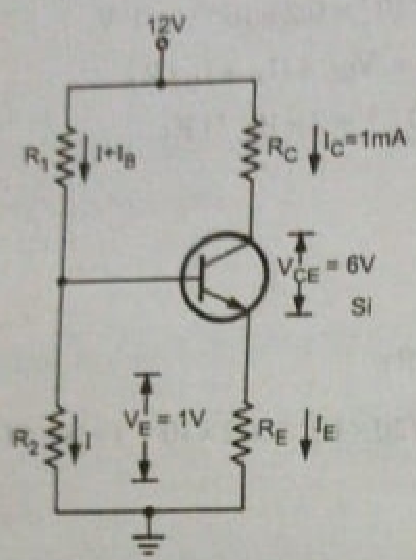
Solution :

$$I_B = \frac{I_C}{\beta} = \frac{1mA}{100} = 10\ \mu A$$

$$I_E = I_B + I_C = 10\ \mu A + 1\ mA = 1.01mA$$

$$R_E = \frac{V_E}{I_E} = \frac{1V}{1.01\ mA} = 990\ \Omega$$

Figure 2.36



We know that $$S = \frac{1+\beta}{1+\beta\frac{R_E}{R_E+R_B}}$$

$$20 = \frac{1+100}{1+100\times\frac{990}{990+R_B}}$$

$$20 = \frac{101}{1+\frac{99000}{990+R_B}}$$

$$20 = \frac{101}{\frac{990+R_B+99000}{990+R_B}}$$

$$20 = \frac{101\,(990+R_B)}{990+R_B+99000}$$

$$20(990 + R_B + 99000) = 101\,(990 + R_B)$$

$$19800 + 20R_B + 1980000 = 99990 + 101R_B$$

$$1899810 = 81\ R_B$$

$$\therefore \quad R_B = 23454.5\ \Omega$$

We know, $$V_B = V_{BE} + V_E = 0.7 + 1 = 1.7V$$

$\therefore$ Drop across R_2 = 1.7

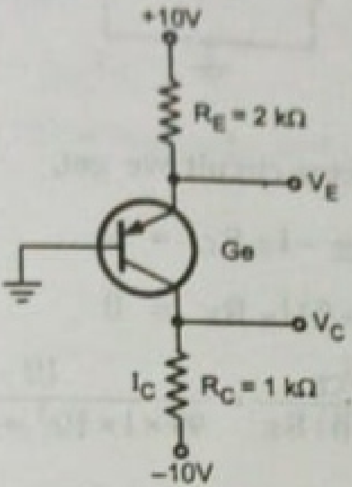
and drop across R_1 = 12 – 1.7 = 10.3

We know that, $$R_B = \frac{R_1\ R_2}{R_1 + R_2}$$

$$\therefore \quad \frac{R_1\ R_2}{R_1 + R_2} = 23454.5$$

Example 2.27: For circuit shown in Fig. 2.66, $\beta = 99$. Calculate I_E, I_B, I_C, V_E and V_C.

Figure 2.66



Solution :

$$V_E = V_B + 0.3 = 0.3\ V$$

$$I_E = \frac{\text{Voltage drop across } R_E}{R_E} = \frac{10 - V_E}{R_E} = \frac{10 - 0.3}{2 \times 10^3} = \frac{9.7}{2 \times 10^3} = 4.85\ mA$$

$$I_B = \frac{I_E}{1+\beta} = \frac{4.85mA}{1+99} = \frac{4.85 \times 10^{-3}}{100} = 48.5\ \mu A$$

$$I_C = I_E - I_B = 4.85 \times 10^{-3} - 48.5 \times 10^{-6} = 4.8015\ mA$$

Drop across $R_C = I_C \times R_C = 4.8015 \times 10^{-3} \times 1 \times 10^3 = 4.8015\ V$

$$\therefore \quad V_C = -10 + 4.8015 = -5.1985\ V$$

Review Questions (Sectionwise)

2.1

1. State the advantages of transistor over vaccum tube.
2. What is transistor ? Give its circuit symbol.
3. Transistor means transfer-resistor, explain this.
4. Explain the construction of npn and pnp transistors.
5. Mention the different types of transistor configurations. Draw the circuit diagram of each type using NPN transistors. Explain the salient features of each type.
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8. Give the relationship between α_{dc} and β_{dc}
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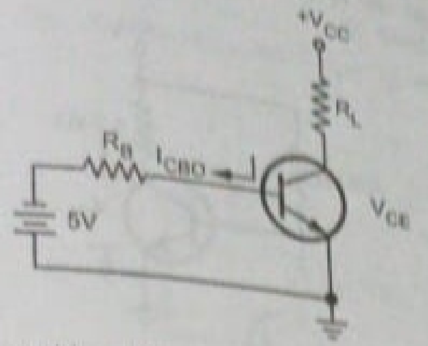
13. In a certain transistor, the emitter current is 1.04 times as large as the collector current. If the emitter current is 10 mA, find the base current. **(Ans. : 384 μA)**
14. In a certain transistor, 99.5% of the carriers injected into the base cross the collector-base junction. If the leakage current is 6 μA and the collector current is 10 mA, calculate (i) the value of α, (ii) the emitter current. **(Ans. : α = 0.995, I_E = 10.04 mA)**
15. The reverse leakage current of the transistor, when connected in common-base configuration is 0.2 μA, while it is 18μA when the same transistor is connected in common-emitter configuration. Calculate the α and β of the transistor. **(Ans. : α = 0.988, β = 82.33**

2.2

1. Why biasing is necessary in BJT amplifiers ?
2. The reverse saturation current of the germanium transistor shown in Fig. 2.115 is 1.2 μA at a temperature of 25°C and it doubles for every 10°C rise in temperature. The bias voltage V_{BB} = 6 V. Find the maximum allowable value of the resistance R_B if the transistor is to remain cutoff at a temperature of 75° C. Assume $V_{(BE\ cut\ off)}$ = 0.1 V in reverse direction. **(Ans. : R_B = 153.65 kΩ)**



3. For the circuit shown in problem 25 if $V_{BB} = 2$ V, $R_B = 100$ kΩ, upto what temperature, the transistor will remain in cut off.

(Ans. : Temp. = 64.85°C)

1. What do you understand by Q-point ? What is its significance ?

1. What are the factors against which an amplifier needs to be stabilized ?

1. Define three stability factors.

2. Explain different techniques used for biasing transistor amplifiers.

3. Which biasing method provides more stabilization amongst the three types of biasing methods ? Why ?

4. Explain any one method of biasing a single stage BJT amplifier.

5. For the improvement of stability of the operating point what suggestions you make for self bias. Discuss with the help of stability factors.

6. What are the requirements of biasing circuits ?

7. For a collector to base bias circuit, show that :

$$S = \frac{1+\beta}{1+\beta\left(\frac{R_C}{R_C + R_B}\right)}$$

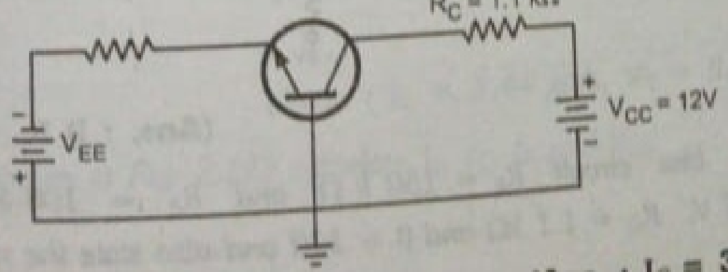
8. For a self bias circuit show that

$$S = \frac{1+\beta}{1+\beta\left(\frac{R_E}{R_E + R_B}\right)}$$

9. Draw the circuit diagram of self bias circuit using CE configuration and explain how it stabilizes operating point.

10. In the circuit shown in Fig. 2.116, find I_C when $V_{CB} = 8$ V and V_{CB} when $I_C = 2$ mA.

Figure 2.116



(Ans. : $I_C = 3.636$ mA, $V_{CB} = 9.8$ V)

1. What is diffusion capacitance ? Derive expression for it.

1.11 1. Explain the concept of a load line for a diode.

1.12 1. Explain the procedure of obtaining dynamic diode characteristics.

1.13 1. What is transfer characteristics? State its physical significance.

2. Explain the various circuit models of a diode.

1.14 1. Explain the basic parallel clipper circuit.

1.16 1. Explain the clipping above and below the reference voltage in a basic parallel clipper.

2. Explain the clippers with voltage divider circuit.

3. Explain the two way parallel clipper circuit.

4. Explain the basic series clipper circuit.

1.17 1. Explain the basic series clipper above reference voltage.

2. Explain the basic series clipper below reference voltage.

3. Explain the negative clamper circuit.

1.18 1. Explain the positive clamper circuit.

2. Write a note on comparator.

1.19 1. Define rectification.

1.20 1. Draw and explain circuit diagram of a half wave rectifier.

1.21 1. Prove that the ripple factor of a half-wave rectifier is 1.21 and that of a full-wave rectifier is 0.482.

2. Show that the maximum rectification efficiency of a half-wave rectifier is 40.6 %.

3. A half wave rectifier circuit feed a resistive load of 10 kΩ through a power transformer having a step-down turns ratio of 8 : 1 and operated from 230 V, 50 Hz A.C. mains supply. Assume the forward resistance of diode to be 40 Ω and transformer secondary winding resistance as 12 Ω. Calculate the maximum, RMS, and average values of current, DC output voltage and power, efficiency of rectification, and ripple factor.

(Ans. : I_m = 4.045 mA, I_{rms} = 2.024 mA, I_{DC} = 1.2875 mA, E_{DC} = 12.875 V, P_{DC} = 16.58 mW, P_{ac} = 41.179 mW, Rectifier efficiency = 40.26 %, Ripple factor = 1.21)

5. In a half wave rectifier, the input is 300 sin 314 t. Find its average output voltage.

(Ans. : E_{av} = 95.492 V)

1.22 1. Draw the circuit diagram of full-wave centre-tap rectifier. Explain the operation with waveforms.

Solution :

$$V_E = V_B - 0.7V = 4 - 0.7V = 3.3\ V$$

$$I_E = \frac{V_E}{R_E} = \frac{3.3\ V}{3.3\ k\Omega} = 1\ mA$$

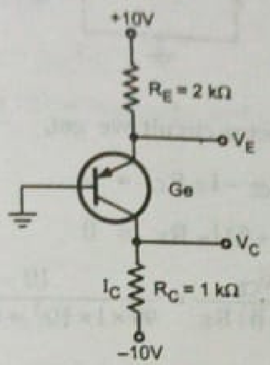
$$I_B = \frac{I_E}{1+\beta} = \frac{1\times10^{-3}}{101} = 9.90\ \mu A$$

$$I_C = I_E - I_B = 1\times10^{-3} - 9.90\times10^{-6} = 0.99\ mA$$

$$V_C = 10 - I_C R_C = 10 - 0.99\times10^{-3}\times4.7\times10^{3} = 10 - 4.653 = 5.347\ V$$

Example 2.27: *For circuit shown in Fig. 2.66, β = 99. Calculate I_E, I_B, I_C, V_E and V_C.*

Figure 2.66



Solution :

$$V_E = V_B + 0.3 = 0.3\ V$$

$$I_E = \frac{\text{Voltage drop across } R_E}{R_E} = \frac{10 - V_E}{R_E} = \frac{10 - 0.3}{2\times10^{3}} = \frac{9.7}{2\times10^{3}} = 4.85\ mA$$

$$I_B = \frac{I_E}{1+\beta} = \frac{4.85mA}{1+99} = \frac{4.85\times10^{-3}}{100} = 48.5\ \mu A$$

$$I_C = I_E - I_B = 4.85\times10^{-3} - 48.5\times10^{-6} = 4.8015\ mA$$

Drop across $R_C = I_C \times R_C = 4.8015\times10^{-3}\times1\times10^{3} = 4.8015\ V$

$$V_C = -10 + 4.8015 = -5.1985\ V$$