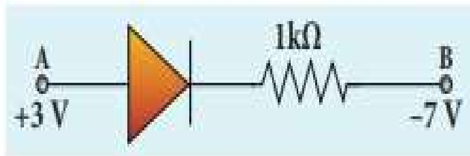
Tutorial- 4

Q1. Consider an ideal Si diode. Find the value of current flowing through AB.



Solution:

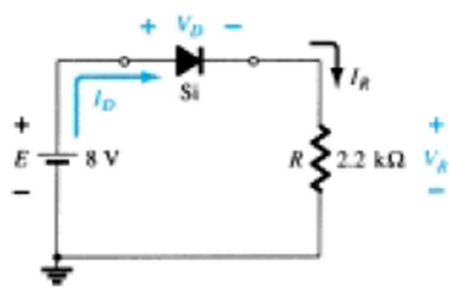
Step1: First check type of diode (Si/Ge) then check diode is forward or reverse biased.

Step-2:

The value of current flowing through AB can be obtained by using Ohm's law

$$\mathbf{I = V/R = [3-0.7 - (-7)] / [1\times 10^3] = 9.3\ mA}$$

Q2. For the series diode configuration, determine V_D, V_R, and I_D.



Solution:

Step1: First check diode is forward or reverse biased.

Step2: Since the applied voltage establishes a current in the clockwise direction to match the arrow of the symbol and the diode is in the "on" state,

$$V_D = 0.7\ \mathbf{V}$$

$$V_R = E - V_D = 8\ \mathrm{V} - 0.7\ \mathrm{V} = \mathbf{7.3\ V}$$

$$I_D = I_R = \frac{V_R}{R} = \frac{7.3\ \mathrm{V}}{2.2\ \mathrm{k\Omega}} \cong \mathbf{3.32\ mA}$$

Q3. An a.c. voltage of peak value 20 V is connected in series with a silicon diode and load resistance of 500 ohm. If the forward resistance of diode is 100 ohm, find:

(i) Peak current through diode (ii) Peak output voltage. What will be these values if the diode is assumed to be ideal?

Solution:

Peak input voltage = 20 V
Forward resistance, r_f = 10 Ω
Load resistance, R_L = 500 Ω
Potential barrier voltage, V_0 = 0.7 V
The diode will conduct during the positive half-cycles of a.c. input voltage only.
The equivalent circuit is shown in Fig.1(ii)

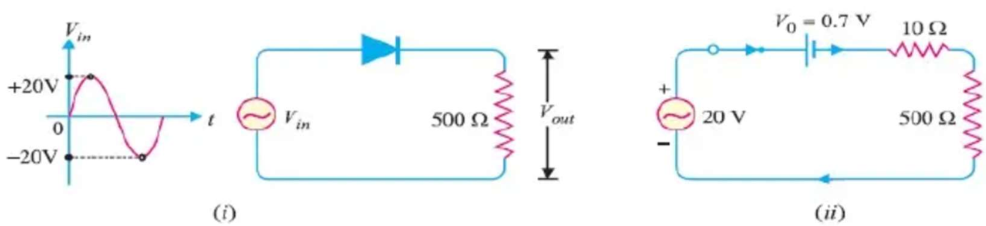


Fig. 1

(i) The peak current through the diode will occur at the instant when the input voltage reaches positive peak i.e. Vin = VF = 20 V.

$$\therefore \quad V_F = V_0 + (I_f)_{peak}\,[r_f + R_L] \quad ...(i)$$

$$\text{or} \quad (I_f)_{peak} = \frac{V_F - V_0}{r_f + R_L} = \frac{20 - 0.7}{10 + 500} = \frac{19.3}{510}\text{ A} = 37.8\text{ mA}$$

(ii) Peak output voltage :

$$\text{Peak output voltage} = (I_f)_{peak} \times R_L = 37.8\text{ mA} \times 500\ \Omega = 18.9\text{ V}$$

Ideal Diode Case:

For an ideal diode, put $V_0 = 0$ and $r_f = 0$ in equation (i).

$$V_F = (I_f)_{peak} \times R_L$$

$$\text{or} \quad (I_f)_{peak} = \frac{V_F}{R_L} = \frac{20\text{ V}}{500\ \Omega} = 40\text{ mA}$$

$$\text{Peak output voltage} = (I_f)_{peak} \times R_L = 40\text{ mA} \times 500\ \Omega = 20\text{ V}$$

Q4. Determine current through each diode in the circuit shown in Fig. 6.15 *(i)*. Use simplified model. Assume diodes to be similar.

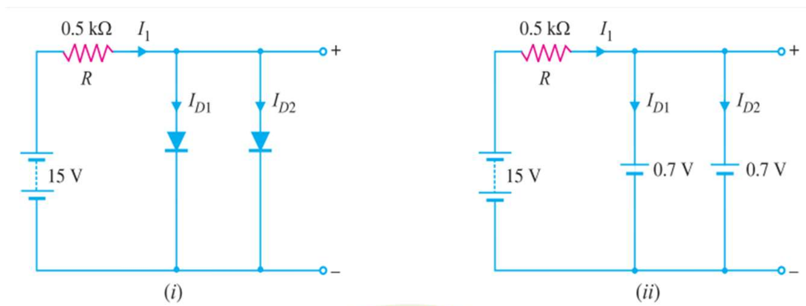


Fig. 6.15

Solution:

Step1: First find I_1 current.

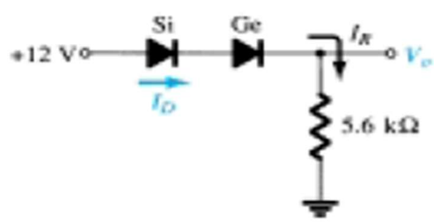
Solution. The applied voltage forward biases each diode so that they conduct current in the same direction. Fig. 6.15 (*ii*) shows the equivalent circuit using simplified model. Referring to Fig. 6.15 (*ii*),

$$I_1 = \frac{\text{Voltage across } R}{R} = \frac{15 - 0.7}{0.5\ \text{k}\Omega} = 28.6\ \text{mA}$$

Step2: First find I_{D1} and I_{D2} current.

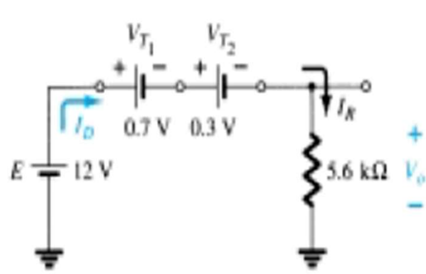
Since the diodes are similar, $I_{D1} = I_{D2} = \frac{I_1}{2} = \frac{28.6}{2} = \mathbf{14.3\ mA}$

Q5. Determine V_o and I_D for the series circuit of Fig.



Solutions:

***Step-1*:** Replace the diode by battery whose voltage is 0.7 V or 0.3 V depend upon Si or Ge diode in Forward biasesd and open in case of reverse baised.



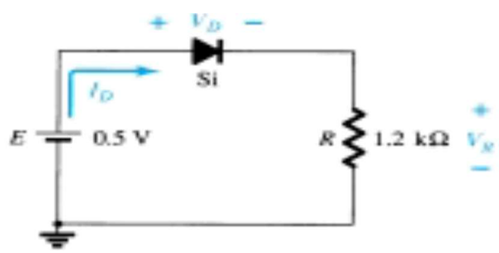
Step-2: Find output voltage and diode current using KVL and ohm's Law.

$$V_o = E - V_{T_1} - V_{T_2} = 12\text{ V} - 0.7\text{ V} - 0.3\text{ V} = \mathbf{11\ V}$$

$$I_D = I_R = \frac{V_R}{R} = \frac{V_o}{R} = \frac{11\text{ V}}{5.6\text{ k}\Omega} \cong \mathbf{1.96\ mA}$$

Home Work

Q1. For the series diode configuration, determine V_D, V_R, and I_D.



Solution:

Although the "pressure" establishes a current with the same direction as the arrow symbol, the level of applied voltage is insufficient to turn the silicon diode "on.". establishing the open circuit equivalent as the appropriate approximation. The resulting voltage and current levels are therefore the following:

$$I_D = \mathbf{0\ A}$$

$$V_R = I_R R = I_D R = (0\text{ A})1.2\text{ k}\Omega = \mathbf{0\ V}$$

V_D= 0.7 V

Q2. The current flowing in a PN-junction diode at room temperature is 200nA, when a large reverse bias is applied. Calculate the current through the diode when 0.1V forward bias is applied.

[Ans 9.165µA]

Hints:

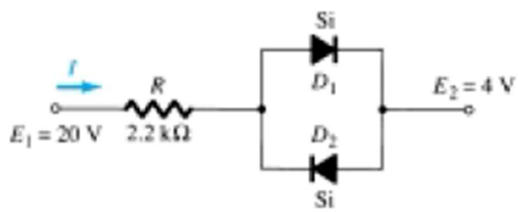
$$\boxed{I_D = I_s(e^{kV_D/T_K} - 1)} \tag{1.4}$$

where I_s = reverse saturation current

$k = 11{,}600/\eta$ with $\eta = 1$ for Ge and $\eta = 2$ for Si for relatively low levels of diode current (at or below the knee of the curve) and $\eta = 1$ for Ge and Si for higher levels of diode current (in the rapidly increasing section of the curve)

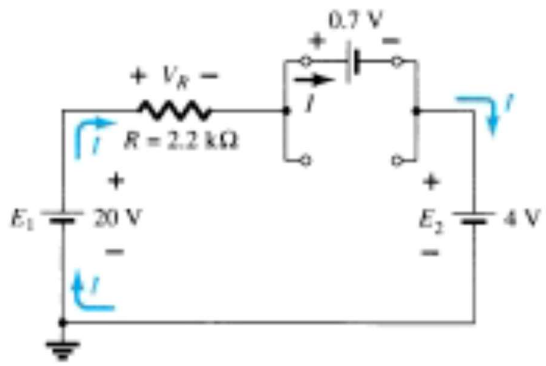
$T_K = T_C + 273°$

Q3. Determine the current ***I*** for the network.



Solutions:

Step-1: Replace the diode by battery whose voltage is 0.7 V or 0.3 V depend upon Si or Ge diode in Forward biasesd and open in case of reverse baised.



Step-2: Find current I

$$I = \frac{E_1 - E_2 - V_D}{R} = \frac{20\text{ V} - 4\text{ V} - 0.7\text{ V}}{2.2\text{ k}\Omega} \cong \mathbf{6.95\ mA}$$

Q4. Determine the currents I1, I2 and I3 for the network shown in Fig. 6.16(i). Use simplified model for the diodes.

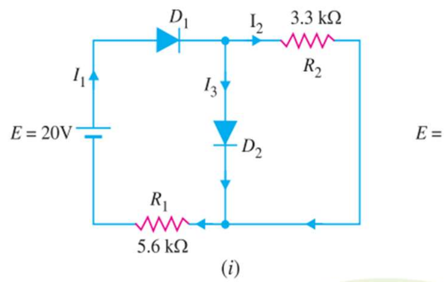
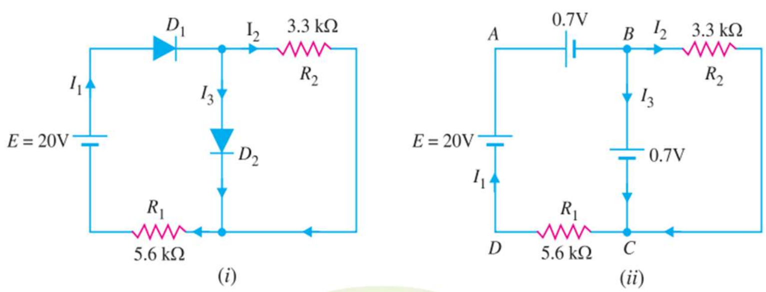


Fig. 6.16

Solutions:

Ans- I_1= 3.32 mA, I_2=0.212 mA, I_3= 3.108 mA



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<u>MCQs (Diode and its Applications)</u>

<u>1.</u> The primary function of a diode is to:

a. Amplify signals
b. Store electrical energy
c. Convert AC to DC
d. Regulate voltage
Answer: c. Convert AC to DC

2.**In a half-wave rectifier, the output frequency is:**

a. Same as the input frequency
b. Twice the input frequency
c. Half the input frequency
d. Zero
Answer: a. Same as the input frequency

3. **In a full-wave rectifier, the output frequency is:**

a. Same as the input frequency
b. Twice the input frequency
c. Half the input frequency
d. Zero
Answer: b. Twice the input frequency

4.**A Zener diode is primarily used for:**

a. Signal modulation
b. Voltage regulation
c. Rectification
d. Oscillation
Answer: b. Voltage regulation

5.**The Peak Inverse Voltage (PIV) rating of a diode in a bridge rectifier is:**

a. Equal to the peak input voltage
b. Twice the peak input voltage
c. Half the peak input voltage
d. Four times the peak input voltage
Answer: a. Equal to the peak input voltage

6.**In a bridge rectifier, how many diodes conduct during each half cycle of the input signal?** a. One
b. Two
c. Three
d. Four
Answer: b. Two

7.**The dynamic resistance of a diode in the forward bias region is:**

a. Very high
b. Very low
c. Infinity
d. Zero
Answer: b. Very low

8. **In a reverse-biased diode, the current is primarily due to:**

a. Minority carriers
b. Majority carriers
c. Both minority and majority carriers
d. No current flows
Answer: a. Minority carriers

9.**The main advantage of using a Schottky diode in power applications is:**

a. High reverse recovery time
b. Low forward voltage drop
c. High forward voltage drop

d. High breakdown voltage
Answer: b. Low forward voltage drop

10.**The operation of a Light Emitting Diode (LED) is based on:**

a. Electrostatic effect
b. Electroluminescence
c. Thermal effect
d. Photoelectric effect
Answer: b. Electroluminescence

11.**The typical forward voltage drop for a silicon diode is:**

a. 0.1V
b. 0.3V
c. 0.7V
d. 1.2V
Answer: c. 0.7V

12. **Which type of diode is used for detecting microwave signals?**

a. Zener diode
b. Schottky diode
c. PIN diode
d. Tunnel diode
Answer: c. PIN diode