$$I_{dc} = \frac{2\,I_m}{\pi}$$

$\therefore$ d.c. power output, $P_{dc} = I_{dc}^2 \times R_L = \left(\frac{2\,I_m}{\pi}\right)^2 \times R_L$ ...(*i*)

a.c. input power. The a.c. input power is given by :

$$P_{ac} = I_{rms}^2\,(r_f + R_L)$$

For a full-wave rectified wave, we have,

$$I_{rms} = I_m / \sqrt{2}$$

$\therefore$ $P_{ac} = \left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)$ ... (*ii*)

$\therefore$ Full-wave rectification efficiency is

$$\eta = \frac{P_{dc}}{P_{ac}} = \frac{(2\,I_m / \pi)^2 R_L}{\left(\frac{I_m}{\sqrt{2}}\right)^2 (r_f + R_L)}$$

$$= \frac{8}{\pi^2} \times \frac{R_L}{(r_f + R_L)} = \frac{0.812\,R_L}{r_f + R_L} = \frac{0.812}{1 + \frac{r_f}{R_L}}$$

The efficiency will be maximum if r_f is negligible as compared to R_L.

$\therefore$ Maximum efficiency = 81.2%

This is double the efficiency due to half-wave rectifier. Therefore, a full-wave rectifier is twice as effective as a half-wave rectifier.

Example 6.16. *A full-wave rectifier uses two diodes, the internal resistance of each diode may be assumed constant at 20 Ω. The transformer r.m.s. secondary voltage from centre tap to each end of secondary is 50 V and load resistance is 980 Ω. Find :*

(*i*) *the mean load current* (*ii*) *the r.m.s. value of load current*

Solution.

$$r_f = 20\ \Omega, \quad R_L = 980\ \Omega$$

Max. a.c. voltage, $V_m = 50 \times \sqrt{2} = 70.7$ V

Max. load current, $I_m = \frac{V_m}{r_f + R_L} = \frac{70.7\text{ V}}{(20 + 980)\ \Omega} = 70.7$ mA

(*i*) Mean load current, $I_{dc} = \frac{2\,I_m}{\pi} = \frac{2 \times 70.7}{\pi} =$ **45 mA**

(*ii*) R.M.S. value of load current is

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{70.7}{\sqrt{2}}\overrightarrow{AB} = \textbf{50 mA}$$

Example 6.17. *In the centre-tap circuit shown in Fig. 6.31, the diodes are assumed to be ideal i.e. having zero internal resistance. Find* :

(*i*) *d.c. output voltage* (*ii*) *peak inverse voltage* (*iii*) *rectification efficiency*.

Solution.

Primary to secondary turns, $N_1/N_2 = 5$

R.M.S. primary voltage = 230 V

∴ R.M.S. secondary voltage

$= 230 \times (1/5) = 46$ V

Maximum voltage across secondary

$= 46 \times \sqrt{2} = 65$V

Maximum voltage across half secondary winding is

$$V_m = 65/2 = 32.5 \text{ V}$$

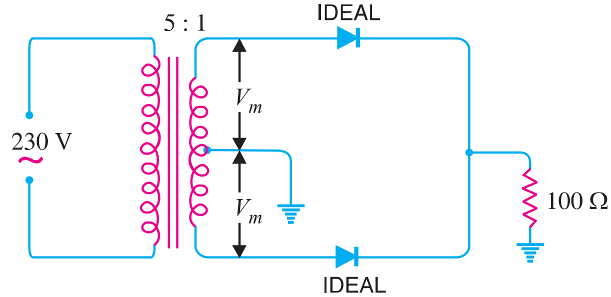

Fig. 6.31

(*i*) Average current, $I_{dc} = \dfrac{2V_m}{\pi R_L} = \dfrac{2 \times 32.5}{\pi \times 100} = 0.207$ A

∴ d.c. output voltage, $V_{dc} = I_{dc} \times R_L = 0.207 \times 100 =$ **20.7 V**

(*ii*) The peak inverse voltage is equal to the maximum secondary voltage, *i.e.*

$$PIV = \textbf{65 V}$$

(*iii*) Rectification efficiency $= \dfrac{0.812}{1 + \dfrac{r_f}{R_L}}$

Since $r_f = 0$

∴ Rectification efficiency = **81.2 %**

Example 6.18. *In the bridge type circuit shown in Fig. 6.32, the diodes are assumed to be ideal. Find : (i) d.c. output voltage (ii) peak inverse voltage (iii) output frequency. Assume primary to secondary turns to be 4.*

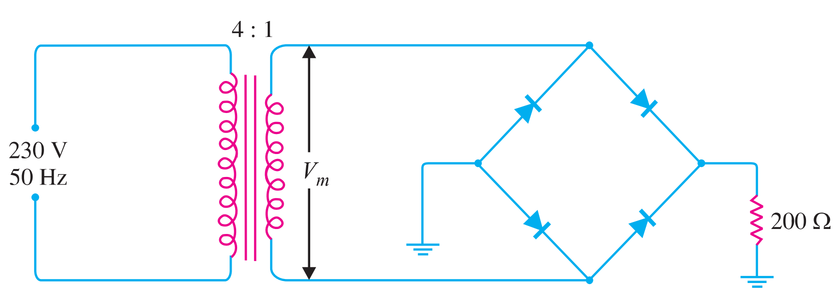

Fig. 6.32

Solution.

Primary/secondary turns, $N_1/N_2 = 4$

R.M.S. primary voltage = 230 V

∴ R.M.S. secondary voltage $= 230\,(N_2/N_1) = 230 \times (1/4) = 57.5$ V

Maximum voltage across secondary is

$$V_m = 57.5 \times \sqrt{2} = 81.3 \text{ V}$$

(*i*) Average current, $I_{dc} = \dfrac{2V_m}{\pi R_L} = \dfrac{2 \times 81.3}{\pi \times 200} = 0.26$ A

∴ d.c. output voltage, $V_{dc} = I_{dc} \times R_L = 0.26 \times 200 =$ **52 V** (*ii*) The peak inverse voltage is equal to the maximum secondary voltage *i.e.*

$$PIV = \mathbf{81.3\ V}$$

(*iii*) In full-wave rectification, there are two output pulses for each complete cycle of the input a.c. voltage. Therefore, the output frequency is twice that of the a.c. supply frequency *i.e.*

$$f_{out} = 2 \times f_{in} = 2 \times 50 = \mathbf{100\ Hz}$$

Example 6.19. *Fig. 6.33 (i) and Fig. 6.33 (ii) show the centre-tap and bridge type circuits having the same load resistance and transformer turn ratio. The primary of each is connected to 230V, 50 Hz supply.*

(*i*) *Find the d.c. voltage in each case.*

(*ii*) *PIV for each case for the same d.c. output. Assume the diodes to be ideal.*

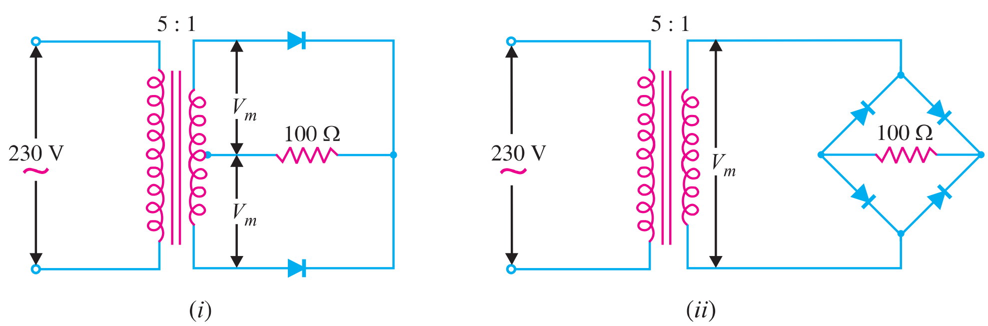

Fig. 6.33

Solution.

(*i*) **D.C. output voltage**

Centre-tap circuit

$$\text{R.M.S. secondary voltage} = 230 \times 1/5 = 46\ \text{V}$$

$$\text{Max. voltage across secondary} = 46 \times \sqrt{2} = 65\ \text{V}$$

Max. voltage appearing across half secondary winding is

$$V_m = 65/2 = 32.5\ \text{V}$$

$$\text{Average current, } I_{dc} = \frac{2V_m}{\pi R_L}$$

$$\text{D.C. output voltage, } V_{dc} = I_{dc} \times R_L = \frac{2V_m}{\pi R_L} \times R_L$$

$$= \frac{2V_m}{\pi} = \frac{2 \times 32.5}{\pi} = \mathbf{20.7\ V}$$

Bridge Circuit

$$\text{Max. voltage across secondary, } V_m = 65\ \text{V}$$

$$\text{D.C. output voltage, } V_{dc} = I_{dc} R_L = \frac{2V_m}{\pi R_L} \times R_L = \frac{2\,V_m}{\pi} = \frac{2 \times 65}{\pi} = \mathbf{41.4\ V}$$

This shows that for the same secondary voltage, the d.c. output voltage of bridge circuit is twice that of the centre-tap circuit.

(*ii*) **PIV for same d.c. output voltage**

The d.c. output voltage of the two circuits will be the same if V_m (*i.e.* max. voltage utilised by each circuit for conversion into d.c.) is the same. For this to happen, the turn ratio of the transformers should be as shown in Fig. 6.34.

Centre-tap circuit

$$\text{R.M.S. secondary voltage} = 230 \times 1/5 = 46 \text{ V}$$

$$\text{Max. voltage across secondary} = 46 \times \sqrt{2} = 65 \text{ V}$$

Max. voltage across half secondary winding is

$$V_m = 65/2 = 32.5 \text{ V}$$

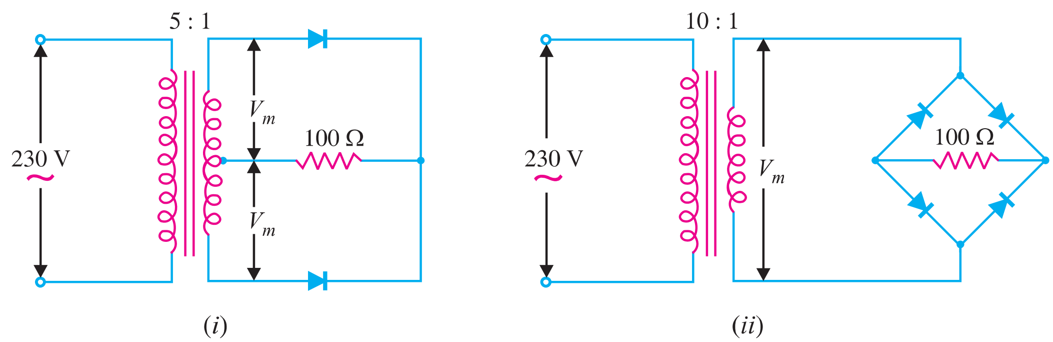

Fig. 6.34

$$\therefore \quad PIV = 2\,V_m = 2 \times 32.5 = \mathbf{65\ V}$$

Bridge type circuit

$$\text{R.M.S. secondary voltage} = 230 \times 1/10 = 23 \text{ V}$$

$$\text{Max. voltage across secondary, } V_m = 23 \times \sqrt{2} = 32.5 \text{ V}$$

$$\therefore \quad PIV = V_m = \mathbf{32.5\ V}$$

This shows that for the same d.c. output voltage, *PIV* of bridge circuit is half that of centre-tap circuit. This is a distinct advantage of bridge circuit.

Example 6.20. *The four diodes used in a bridge rectifier circuit have forward resistances which may be considered constant at 1Ω and infinite reverse resistance. The alternating supply voltage is 240 V r.m.s. and load resistance is 480 Ω. Calculate (i) mean load current and (ii) power dissipated in each diode.*

Solution.

$$\text{Max. a.c. voltage, } V_m = 240 \times \sqrt{2} \text{ V}$$

(*i*) At any instant in the bridge rectifier, two diodes in series are conducting. Therefore, total circuit resistance = $2\,r_f + R_L$.

$$\text{Max. load current, } I_m = \frac{V_m}{2\,r_f + R_L} = \frac{240 \times \sqrt{2}}{2 \times 1 + 480} = 0.7 \text{ A}$$

$$\therefore \quad \text{Mean load current, } I_{dc} = \frac{2\,I_m}{\pi} = \frac{2 \times 0.7}{\pi} = \mathbf{0.45\ A}$$

(*ii*) Since each diode conducts only half a cycle, diode r.m.s. current is :

$$I_{r.m.s.} = I_m/2 = 0.7/2 = 0.35 \text{ A}$$

$$\text{Power dissipated in each diode} = I^2_{r.m.s.} \times r_f = (0.35)^2 \times 1 = \mathbf{0.123\ W}$$

Example 6.21. *The bridge rectifier shown in Fig. 6.35 uses silicon diodes. Find (i) d.c. output* *voltage (ii) d.c. output current. Use simplified model for the diodes.*

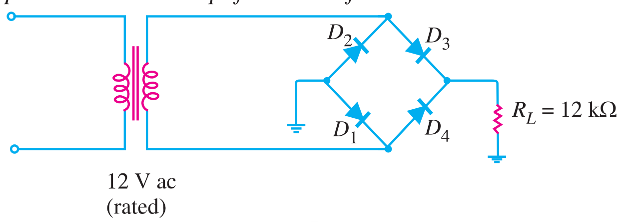

Fig. 6.35

Solution. The conditions of the problem suggest that the a.c voltage across transformer secondary is 12V r.m.s.

∴ Peak secondary voltage is

$$V_{s\,(pk)} = 12 \times \sqrt{2} = 16.97 \text{ V}$$

(*i*) At any instant in the bridge rectifier, two diodes in series are conducting.

∴ Peak output voltage is

$$V_{out\,(pk)} = 16.97 - 2\,(0.7) = 15.57 \text{ V}$$

∴ Average (or d.c.) output voltage is

$$V_{av} = V_{dc} = \frac{2\,V_{out\,(pk)}}{\pi} = \frac{2 \times 15.57}{\pi} = \mathbf{9.91V}$$

(*ii*) Average (or d.c.) output current is

$$I_{av} = \frac{V_{av}}{R_L} = \frac{9.91\text{V}}{12 \text{ k}\Omega} = \mathbf{825.8\ \mu A}$$

6.16 Faults in Centre-Tap Full-Wave Rectifier

The faults in a centre-tap full-wave rectifier may occur in the transformer or rectifier diodes. Fig. 6.36 shows the circuit of a centre-tap full-wave rectifier. A fuse is connected in the primary of the transformer for protection purposes.

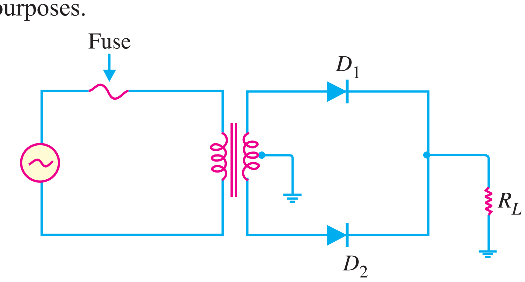

Fig. 6.36

We can divide the rectifier faults into two classes viz.

1. Faults in transformer **2.** Faults in rectifier diodes

1. Faults in Transformer. The transformer in a rectifier circuit can develop the following faults :

(*i*) A shorted primary or secondary winding.

(*ii*) An open primary or secondary winding.

(*iii*) A short between the primary or secondary winding and the transformer frame.

(*i*) In most cases, a **shorted primary** or **shorted secondary** will cause the fuse in the primary