Transformer Utilisation Factor (TUF) In the design of any power supply, the rating of the former should be determined. This can be done with a knowledge of the d.c. power delivered to the and the type of rectifying circuit used.

$$\text{TUF} = \frac{\text{d.c. power delivered to the load}}{\text{a.c. rating of the transformer secondary}}$$

$$= \frac{P_{\text{d.c.}}}{P_{\text{a.c.}}\ \text{rated}}$$

In the half-wave rectifying circuit, the rated voltage of the transformer secondary is $V_m/\sqrt{2}$, but actual rms current flowing through the winding is only $\frac{I_m}{2}$, not $I_m/\sqrt{2}$.

$$\text{TUF} = \frac{\frac{I_m^2}{\pi^2}R_L}{\frac{V_m}{\sqrt{2}} \times \frac{I_m}{2}} = \frac{\frac{V_m^2}{\pi^2}\frac{1}{R_L}}{\frac{V_m}{\sqrt{2}}\frac{V_m}{2R_L}} = \frac{2\sqrt{2}}{\pi^2} = 0.287$$

The TUF for a half-wave rectifier is 0.287.

Form Factor

$$\text{Form factor} = \frac{\text{rms value}}{\text{average value}}$$

$$= \frac{V_m/2}{V_m/\pi} = \frac{\pi}{2} = 1.57$$

Peak Factor

$$\text{Peak factor} = \frac{\text{peak value}}{\text{rms value}}$$

$$= \frac{V_m}{V_m/2} = 2$$

EXAMPLE 18.1

A half-wave rectifier, having a resistive load of 1000 Ω, rectifies an alternating voltage of 325 V peak value and the diode has a forward resistance of 100 Ω. Calculate (a) peak, average and rms value of current (b) d.c. power output (c) a.c. input power, and (d) efficiency of the rectifier.

Solution

(a) Peak value of current, $I_m = \frac{V_m}{r_f + R_L} = \frac{325}{100 + 100} = 295.45$ mA

Average current, $I_{\text{d.c.}} = \frac{I_m}{\pi} = \frac{295.45}{\pi}$ mA $= 94.046$ mA

RMS value of current, $I_{rms} = \frac{I_m}{2} = \frac{295.45}{2} = 147.725$ mA

(b) The d.c. power output, $P_{d.c.} = I_{d.c.}^2 \times R_L$

$$= (94.046 \times 10^{-3})^2 \times 1000 = 8.845 \text{ W}$$

(c) The a.c. input power, $P_{a.c.} = (I_{rms})^2 \times (r_f + R_L)$

$$= (147.725 \times 10^{-3})^2 (1100) = 24 \text{ W}$$

(d) Efficiency of rectification, $\eta = \frac{P_{d.c.}}{P_{a.c.}} = \frac{8.845}{24} = 36.85\%.$

EXAMPLE 18.2

A half-wave rectifier is used to supply 24 V d.c. to a resistive load of 500 Ω and the diode has a forward resistance of 50 Ω. Calculate the maximum value of the a.c. voltage required at the input.

Solution Average value of load current,

$$I_{d.c.} = \frac{V_{d.c.}}{R_L} = \frac{24}{500} = 48 \text{ mA}$$

Maximum value of load current, $I_m = \pi \times I_{d.c.} = \pi \times 48 \text{ mA} = 150.8$ mA

Therefore, maximum a.c. voltage required at the input,

$$V_m = I_m \times (r_f + R_L)$$

$$= 150.8 \times 10^{-3} \times 550 = 82.94 \text{ V}$$

EXAMPLE 18.3

An a.c. supply of 230 V is applied to a half-wave rectifier circuit through transformer of turns ratio 5:1. Assume the diode is an ideal one. The load resistance is 300 Ω. Find (a) d.c. output voltage (b) PIV (c) maximum, and (d) average values of power delivered to the load.

Solution

(a) The transformer secondary voltage $= \frac{230}{5} = 46$ V

Maximum value of secondary voltage, $V_m = \sqrt{2} \times 46 = 65$ V

Therefore, d.c. output voltage, $V_{d.c.} = \frac{V_m}{\pi} = \frac{65}{\pi} = 20.7$ V

(b) PIV of a diode $V_m = 65$ V

(c) Maximum value of load current, $I_m = \frac{V_m}{R_L} = \frac{65}{300} = 0.217$ A

Therefore, maximum value of power delivered to the load,

$$P_m = I_m^2 \times R_L = (0.217)^2 \times 300 = 14.1 \text{ W}$$

(d) The average value of load current, $I_{d.c.} = \dfrac{V_{d.c.}}{R_L} = \dfrac{20.7}{300} = 0.069 \text{ A}$

Therefore, average value of power delivered to the load,

$$P_{d.c.} = I_{d.c.}^2 \times R_L = (0.069)^2 \times 300 = 1.43 \text{ W}$$

EXAMPLE 18.4

A HWR has a load of 3.5 kΩ. If the diode resistance and secondary coil resistance together have a resistance of 800 Ω and the input voltage has a signal voltage of peak value 240 V. Calculate

(a) peak average and rms value of current flowing

(b) d.c. power output

(c) a.c. power input

(d) efficiency of the rectifier

Solution Load resistance in a HWR, $R_L = 3.5 \text{ k}\Omega$

Diode and secondary coil resistance, $R_f + r_s = 800\ \Omega$

Peak value of input voltage = 240 V

(a) Peak value of current, $I_m = \dfrac{V_m}{r_s + r_f + R_L} = \dfrac{240}{4300} = 55.81 \text{ mA}$

Average value of current, $I_{d.c.} = \dfrac{I_m}{\pi} = \dfrac{55.81 \times 10^{-3}}{\pi} = 17.77 \text{ mA}$

The rms value of current, $I_{rms} = \dfrac{I_m}{2} = \dfrac{55.81 \times 10^{-3}}{2} = 27.905 \text{ mA}$

(b) The d.c. power output is

$$P_{d.c.} = (I_{d.c.})^2 R_L = (17.77 \times 10^{-3})^2 \times 3500 = 1.105 \text{ W}$$

(c) The a.c. power input is

$$P_{a.c.} = (I_{rms})^2 \times (r_f + R_L) = (27.905 \times 10^{-3})^2 \times 4300 = 3.348 \text{ W}$$

(d) Efficiency of the rectifier is

$$\eta = \frac{P_{d.c.}}{P_{a.c.}} = \frac{1.105}{3.348} \times 100 = 33\%$$

EXAMPLE 18.5

A HWR circuit supplies 100 mA d.c. to a 250 Ω load. Find the d.c. output voltage. PIV rating of a diode and the rms voltage for the transformer supplying the rectifier.

Solution Given $I_{d.c.} = 100 \text{ mA}, R_L = 250\ \Omega$

(a) The d.c. output voltage, $V_{d.c.} = I_{d.c.} \times R_L = 100 \times 10^{-3} \times 250 = 25 \text{ V}$

(b) The maximum value of secondary voltage,

$$V_m = \pi \times V_{d.c.} = \pi \times 25 = 78.54 \text{ V}$$

(c) PIV rating of a diode, $V_m = 78.54$ V

(d) The rms voltage for the transformer supplying the rectifier

$$V_{rms} = \frac{V_m}{2} = \frac{78.54}{2} = 39.27 \text{ V}$$

EXAMPLE 18.6

A voltage of 200 cos ωt is applied to HWR with load resistance of 5 kΩ. Find the maximum d.c. current component, rms current, ripple facion, TUF and rectifier efficiency,

Solution Given Applied voltage = 200 cosωt, $V_m = 200$ V, $R_L = 5$ kΩ

(a) *To find d.c. current:*

$$I_m = \frac{V_m}{R_L} = \frac{200}{5 \times 10^3} = 40 \text{ mA}$$

Therfore,

$$I_{d.c.} = \frac{I_m}{\pi} = \frac{40 \times 10^{-3}}{\pi} = 12.7 \times 10^{-3} \text{ A} = 12.73 \text{ mA}$$

(b) *To find rms current:*

$$I_{rms} = \frac{I_m}{2} = \frac{40 \times 10^{-3}}{2} = 20 \text{ mA}$$

(c) *Ripple factor:*

$$\Gamma = \sqrt{\left(\frac{I_{rms}}{I_{d.c.}}\right)^2 - 1} = \sqrt{\left(\frac{20 \times 10^{-3}}{12.73 \times 10^{-3}}\right)^2 - 1} = 1.21$$

(d) *To determine TUF:*

$$TUF = \frac{P_{d.c.}}{P_{a.c.\,(rated)}}$$

$$P_{d.c.} = I_{d.c.}^2 R_L = (12.73 \times 10^{-3})^2 \times 5 \times 10^3 = 0.81 \text{ W}$$

$$P_{a.c.\,(rated)} = \frac{V_m}{\sqrt{2}} \times \frac{I_m}{2} = \frac{200}{\sqrt{2}} \times \frac{40 \times 10^{-3}}{2} = 2.828$$

Therefore,

$$\text{TUF} = \frac{P_{d.c.}}{P_{a.c.\,(rated)}} = \frac{0.81}{2.828} = 0.2863$$

(e) *Rectifier Efficiency:*

$$\eta = \frac{P_{d.c.}}{P_{a.c.}}$$

$$P_{d.c.} = 0.81 \text{ W}$$

$$P_{a.c.} = I_{rms}^2 R_L = (20 \times 10^{-3})^2 \times 5 \times 10^3 = 2 \text{ W}$$

Therefore,

$$\eta = \frac{P_{d.c.}}{P_{a.c.}} \times 100 = \frac{0.81}{2} \times 100 = 40.5\%$$

EXAMPLE 18.7

A diode has an internal resistance of 20 Ω and 1000 Ω load from a 110 V rms source of supply. Calculate (i) the efficiency of rectification (ii) the percentage regulation from no load to full load.

Solution Given $r_f = 20\ \Omega$, $R_L = 1000\ \Omega$ and V_{rms} (secondary) = 110 V

The half-wave rectifier uses a single diode.

Therefore,
$$V_m = \sqrt{2}\,V_{rms}\text{ (secondary)} = 155.56\text{ V}$$

$$I_m = \frac{V_m}{r_f + R_L} = \frac{155.56}{20 + 1000} = 0.1525\text{ A}$$

$$I_{d.c.} = \frac{I_m}{\pi} = \frac{0.1525}{\pi} = 0.04854\text{ A}$$

$$V_{d.c.} = I_{d.c.} R_L = 0.04854 \times 1000 = 48.54\text{ V}$$

$$P_{d.c.} = V_{d.c.} I_{d.c.} = 48.54 \times 0.04854 = 2.36\text{ W}$$

$$P_{a.c.} = I_{rms}^2 (r_f + R_L) = \left(\frac{I_m}{2}\right)^2 (r_f + R_L) \quad \left(\text{since } I_{rms} = \frac{I_m}{2} \text{ for half-wave}\right)$$

$$= \left(\frac{0.1525}{2}\right)^2 (1000 + 20) = 5.93\text{ W}$$

Efficiency,
$$\eta = \frac{P_{d.c.}}{P_{a.c.}} \times 100 = \frac{2.36}{5.93} \times 100 = 39.7346\%$$

$$\text{Percentage of line regulation} = \frac{V_{NL} - V_{FL}}{V_{FL}} \times 100 = \frac{\frac{V_m}{\pi} - V_{d.c.}}{V_{d.c.}} \times 100$$

$$= \frac{\frac{155.56}{\pi} - 48.54}{48.54} \times 100 = 2\%$$

EXAMPLE 18.8

Show that maximum d.c. output power $P_{d.c.} = V_{d.c.} \times I_{d.c.}$ in a half-wave single phase circuit occur when the load resistance equals diode resistance r_f.

Solution For a half wave rectifier,

$$I_m = \frac{V_m}{r_f + R_L}$$

$$I_{d.c.} = \frac{I_m}{\pi} = \frac{V_m}{\pi(r_f + R_L)}$$

$$V_{d.c.} = I_{d.c.} \times R_L$$

and

Therefore,

$$P_{d.c.} = V_{d.c.} \times I_{d.c.} = I_{d.c.}^2 R_L = \frac{V_m^2 R_L}{\pi^2(r_f + R_L)^2}$$

For this power to be maximum,

$$\frac{dP_{d.c.}}{dR_L} = 0$$

$$\frac{d}{dR_L}\left[\frac{V_m^2 R_L}{\pi^2(r_f + R_L)^2}\right] = \frac{V_m^2}{\pi^2}\left[\frac{(r_f + R_L)^2 - R_L \times 2\,(r_f + R_L)}{(r_f + R_L)^4}\right] = 0$$

$$(r_f + R_L)^2 - 2R_L(r_f + R_L) = 0$$

$$r_f^2 + 2r_f R_L + R_L^2 - 2r_f R_L - 2R_L^2 = 0$$

$$r_f^2 - R_L^2 = 0$$

$$R_L^2 = r_f^2$$

Thus the power output is maximum if $R_L = r_f$

EXAMPLE 18.9

The transformer of a half-wave rectifier has a secondary voltage of 30 V_{rms} with a winding resistance of 10 Ω. The semiconductor diode in the circuit has a forward resistance of 100 Ω. Calculate (a) No load d.c. voltage (b) d.c. output voltage at I_L = 25 mA (c) % regulation at I_L = 25 mA (d) ripple voltage across the load (e) ripple frequency (f) ripple factor (g) d.c. power output and (h) PIV of the semiconductor diode.

Solution

$$V_{rms}\text{ (secondary)} = 30\text{ V},\ r_s = 10\ \Omega,\ r_f = 100\ \Omega$$

$$V_m = \sqrt{2} \times V_{rms} = \sqrt{2} \times 30 = 42.4264\text{ V}$$

(a)
$$V_{d.c.} = \frac{V_m}{\pi} = \frac{42.4264}{\pi} = 13.5047\text{ V}$$

(b)
$$I_L = I_{d.c.} = 25\text{ mA}$$

$$V_{d.c.} = I_{d.c.} R_L = \frac{I_m}{\pi} R_L = \frac{V_m}{\pi(r_f + r_s + R_L)} \times R_L$$

Here
$$R_L = \frac{V_{d.c.}}{I_{d.c.}}$$

Therefore,

$$V_{d.c.} = \frac{V_m}{\pi\left(r_f + r_s + \frac{V_{d.c.}}{I_{d.c.}}\right)} \times \frac{V_{d.c.}}{I_{d.c.}}$$

$$V_{d.c.} = \frac{42.426\, V_{d.c.}}{\pi\left(100 + 10 + \frac{V_{d.c.}}{25 \times 10^{-3}}\right)} \times \frac{1}{25 \times 10^{-3}}$$

$$V_{d.c.}(110 + 40V_{d.c.}) = 540.1897\ V_{d.c.}$$

$$V_{d.c.} = \frac{540.1897 - 110}{40} = 10.7547\text{ V}$$

(c) Percentage of regulation

$$= \frac{V_{d.c.(NL)} - V_{d.c.(FL)}}{V_{d.c.(FL)}} \times 100$$

$$= \frac{13.5047 - 10.7547}{10.7547} \times 100 = 25.569\%$$

(d)

$$I_m = \frac{V_m}{r_f + r_s + R_L}, \text{ where } R_L = \frac{V_{d.c.}}{I_{d.c.}} = \frac{10.7547}{25 \times 10^{-3}} = 430.188\text{ V}$$

Therefore,

$$I_m = \frac{42.4264}{100 + 10 + 430.188} = 0.07854\text{ A}$$

$$I_{rms} = \frac{I_m}{2} = 0.03927\text{ A}$$

$$\Gamma = \sqrt{\left(\frac{I_{rms}}{I_{d.c.}}\right)^2 - 1} = \sqrt{\left(\frac{0.03927}{25 \times 10^{-3}}\right)^2 - 1} = 1.21$$

Ripple voltage $\Gamma \times V_{d.c.} = 1.21 \times 10.7547 = 13.02791\text{ V}$

(e) Ripple frequency, $f = 50$Hz

(f) Γ = ripple factor = 1.21

(g) $P_{d.c.} = V_{d.c.} I_{d.c.} = 10.7547 \times 25 \times 10^{-3} = 0.2688$ W

(h) PIV = V_m = 42.4264 V

Full-wave rectifier It converts an a.c. voltage into a pulsating d.c. voltage using both half cycl[illegible] the applied a.c. voltage. It uses two diodes of which one conducts during one half-cycle while the [illegible] diode conducts during the other half-cycle of the applied a.c. voltage. There are two types of full-[illegible] rectifiers viz. (i) Full-wave rectifier with center tapped transformer and (ii) Full-wave rectifier wi[illegible] transformer (Bridge rectifier).

$$I_{\text{d.c.}} = \frac{V_{\text{d.c.}}}{(r_s + r_f) + R_L} = \frac{2V_m}{\pi(r_s + r_f + R_L)}$$

RMS value of the voltage at the load resistance is

$$V_{\text{rms}} = \sqrt{\left[\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2 \omega t \, d(\omega t)\right]} = \frac{V_m}{\sqrt{2}}$$

Therefore,
$$\Gamma = \sqrt{\left(\frac{V_m/\sqrt{2}}{2V_m/\pi}\right)^2 - 1} = \sqrt{\frac{\pi^2}{8} - 1} = 0.482$$

Efficiency (η) The ratio of d.c. output power to a.c. input power is known as rectifier efficiency (

$$\eta = \frac{\text{d.c. output power}}{\text{a.c. input power}} = \frac{P_{\text{d.c.}}}{P_{\text{a.c.}}}$$

$$= \frac{(V_{\text{d.c.}})^2/R_L}{(V_{\text{rms}})^2/R_L} = \frac{\left[\frac{2V_m}{\pi}\right]^2}{\left[\frac{V_m}{\sqrt{2}}\right]^2} = \frac{8}{\pi^2} = 0.812 = 81.2\%$$

The maximum efficiency of a full-wave rectifier is 81.2%.

Transformer Utilisation Factor (TUF) The average TUF in a full-wave rectifying circuit is determined by considering the primary and secondary windings separately and it gives a value of 0.693.

(a) Form factor

$$\text{Form factor} = \frac{\text{rms value of the output voltage}}{\text{average value of the output voltage}}$$

$$= \frac{V_m/\sqrt{2}}{2V_m/\pi} = \frac{\pi}{2\sqrt{2}} = 1.11$$

(b) Peak factor

$$\text{Peak factor} = \frac{\text{peak value of the output voltage}}{\text{rms value of the output voltage}} = \frac{V_m}{V_m/\sqrt{2}} = \sqrt{2}$$

Peak inverse voltage for full-wave rectifier is $2V_m$ because the entire secondary voltage appears across the non-conducting diode.

Example 18.10

A 230 V, 60 Hz voltage is applied to the primary of a 5:1 step-down, center-tap transformer use in a full wave rectifier having a load of 900 Ω. If the diode resistance and secondary coil resistance together has a resistance of 100 Ω, determine (a) d.c. voltage across the load, (b) d.c. current flowing through the load, (c) d.c. power delivered to the load, (d) PIV across each diode, (e) ripple voltage and its frequency and (f) rectification efficiency.

Solution

The voltage across the two ends of secondary $= \frac{230}{5} = 46$ V

Voltage from center tapping to one end, $V_{rms} = \frac{46}{2} = 23$ V

(a) The d.c. voltage across the load, $V_{d.c.} = \frac{2V_m}{\pi} = \frac{2 \times 23 \times \sqrt{2}}{\pi} = 20.7$ V

(b) The d.c. current flowing through the load, $I_{d.c.} = \frac{V_{d.c.}}{(r_s + r_f + R_L)} = \frac{20.7}{1000} = 20.7$ mA

(c) The d.c. power delivered to the load,

$$P_{d.c.} = (I_{d.c.})^2 \times R_L = (20.7 \times 10^{-3})^2 \times 900 = 0.386 \text{ W}$$

(d) PIV across each diode $= 2V_m = 2 \times 23 \times \sqrt{2} = 65$ V

(e) Ripple voltage,

$$V_{r,rms} = \sqrt{(V_{rms})^2 - (V_{d.c.})^2}$$

$$= \sqrt{(23)^2 - (20.7)^2} = 10.05 \text{ V}$$

Frequency of ripple voltage $= 2 \times 60 = 120$ Hz

(f) Rectification efficiency,

$$\eta = \frac{P_{d.c.}}{P_{a.c.}} = \frac{(V_{d.c.})^2/R_L}{(V_{rms})^2/R_L} = \frac{(V_{d.c.})^2}{(V_{rms})^2}$$

$$= \frac{(20.7)^2}{(23)^2} = \frac{428.49}{529} = 0.81$$

Therefore, percentage of efficiency = 81%

EXAMPLE 18.11

A full-wave rectifier has a center-tap transformer of 100-0-100 V and each one of the diodes is rated at I_{max} = 400 mA and I_{av} = 150 mA. Neglecting the voltage drop across the diodes, determine (a) the value of load resistor that gives the largest d.c. power output, (b) d.c. load voltage and current, and (c) PIV of each diode.

Solution

(a) We know that the maximum value of current flowing through the diode for normal operation should not exceed 80% of its rated current.

Therefore, $I_{max} = 0.8 \times 400 = 320$ mA

The maximum value of the secondary voltage,

$$V_m = \sqrt{2} \times 100 = 141.4 \text{ V}$$

Therefore, the value of load resistor that gives the largest d.c. power output

$$R_L = \frac{V_m}{I_{max}} = \frac{141.4}{320 \times 10^{-3}} = 442\ \Omega$$

(b) The d.c. (load) voltage, $V_{d.c.} = \frac{2V_m}{\pi} = \frac{2 \times 141.4}{\pi} = 90\text{ V}$

The d.c. load current, $I_{d.c.} = \frac{V_{d.c.}}{R_L} = \frac{90}{442} = 0.204\text{ A}$

(c) PIV of each diode $= 2V_m = 2 \times 141.4 = 282.8\text{ V}$

EXAMPLE 18.12

A full-wave rectifier delivers 50 W to a load of 200 Ω. If the ripple factor is 1%, calculate the a.c. ripple voltage across the load.

Solution The d.c. power delivered to the load,

$$P_{d.c.} = \frac{V_{d.c.}^2}{R_L}$$

Therefore, $V_{d.c.} = \sqrt{P_{d.c.} \times R_L} = \sqrt{50 \times 200} = 100\text{ V}$

The ripple factor, $\Gamma = \frac{V_{a.c.}}{V_{d.c.}}$

i.e. $0.01 = \frac{V_{a.c.}}{100}$

Therefore, the a.c. ripple voltage across the load, $V_{a.c.} = 1\text{ V}$

EXAMPLE 18.13

In a full wave rectifier, the transformer rms secondary voltage from center tap to each end of the secondary is 50 V. The load resistance is 900 Ω. If the diode resistance and transformer secondary winding resistance together has a resistance of 100 Ω, determine the average load current and rms value of load current?

Solution Voltage from center tapping to one end, $V_{rms} = 50\text{ V}$

Maximum load current, $I_m = \frac{V_m}{r_s + r_f + R_L} = \frac{V_{rms} \times \sqrt{2}}{r_s + r_f + R_L} = \frac{70.7}{1000} = 70.7\text{ mA}$

Average load current, $I_{d.c.} = \frac{2I_m}{\pi} = \frac{2 \times 70.7 \times 10^{-3}}{\pi} = 45\text{ mA}$

RMS value of load current, $I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{70.7 \times 10^{-3}}{\sqrt{2}} = 50\text{ mA}$

EXAMPLE 18.14

A full-wave rectifier has a center-tap transformer of 100–0–100 V and each one of the diodes is rated at $I_{max} = 400$ mA and $I_{av} = 150$ mA. Neglecting the voltage drop across the diodes, determine (a) the value of load resistor that gives the largest d.c. power output, (b) d.c. load voltage and current, and (c) PIV of each diode.

Solution

(a) We know that the maximum value of current flowing through the diode for normal operation should not exceed 80% of its rated current.

Therefore, $I_{max} = 0.8 \times 400 = 320 \text{ mA}$

The maximum value of the secondary voltage,

$$V_m = \sqrt{2} \times 100 = 141.4 \text{ V}$$

Therefore, the value of load resistor that gives the largest d.c. power output

$$R_L = \frac{V_m}{I_{max}} = \frac{141.4}{320 \times 10^{-3}} = 442\ \Omega$$

(b) The d.c. load voltage, $V_{d.c.} = \frac{2V_m}{\pi} = \frac{2 \times 141.4}{\pi} = 90 \text{ V}$

The d.c. load current, $I_{d.c.} = \frac{V_{d.c.}}{R_L} = \frac{90}{442} = 0.204 \text{ A}$

(c) PIV of each diode $= 2\ V_m = 2 \times 141.4 = 282.8 \text{ V}$

EXAMPLE 18.15

A full-wave rectifier circuit uses two silicon diodes with a forward resistance of 20 Ω each. A d.c. voltmeter connected across the load of 1 kΩ reads 55.4 Volts. Calculate

(a) I_{rms}

(b) average voltage across each diode

(c) ripple factor and

(d) transformer secondary voltage rating.

Solution Given $V_{d.c.} = 55.4 \text{ V}$ and $R_L = 1 \text{ k}\Omega$

(a)

$$I_{d.c.} = \frac{V_{d.c.}}{(r_f + R_L)} = \frac{55.4}{20 + 1000} = 54.31 \times 10^{-3} \text{ A}$$

we know that $I_{d.c.} = \frac{2I_m}{\pi}$ and $I_{rms} = \frac{I_m}{\sqrt{2}}$

$$I_m = I_{d.c.} \times \frac{\pi}{2} = 54.31 \times 10^{-3} \times \frac{\pi}{2} = 85.31 \text{ mA}$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{85.31 \times 10^{-3}}{\sqrt{2}} = 60.32 \text{ mA}$$

(b) The average voltage across each silicon diode will be 0.72 V.

(c) To find ripple factor Γ

$$\Gamma = \sqrt{\left(\frac{I_{rms}}{I_{d.c.}}\right)^2 - 1}$$

$$= \sqrt{\left(\frac{60.32 \times 10^{-3}}{54.31 \times 10^{-3}}\right)^2 - 1} = 0.4833$$

To find transformer secondary voltage rating

We know that, $$V_{d.c.} = \frac{2V_m}{\pi} - I_{d.c.}(r_s + r_f)$$

where r_f is the diode forward resistance and r_s is the transformer secondary winding resistance.

$$55.4 = \frac{2V_m}{\pi} - 54.31 \times 10^{-3} \times 20 = \frac{2V_m}{\pi} - 1.086$$

$$56.49 = \frac{2V_m}{\pi}$$

Therefore, $$V_m = 56.49 \times \frac{\pi}{2} = 88.73 \text{ V}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{88.73}{\sqrt{2}} = 62.74 \text{ V}$$

Hence, transformer secondary voltage rating is 65 V – 0 = 65 V

Bridge rectifier

The need for a center tapped transformer in a full-wave rectifier is eliminated in the bridge rectifier. As shown in Fig. 18.5, the bridge rectifier has four diodes connected to form a bridge. The a.c. input voltage is applied to the diagonally opposite ends of the bridge. The load resistance is connected between the other two ends of the bridge.

For the positive half-cycle of the input a.c. voltage, diodes D_1 and D_3 conduct, whereas diodes D_2 and D_4 do not conduct. The conducting diodes will be in series through the load resistance R_L. So the load current flows through R_L.