Exercise no.4

Question 1:

A controlled half wave rectifier has an AC source of 340 V (peak) at 60 Hz. The load resistance is R = 60 Ω. Determine,

a) Delay angle such that the average load current is 1 A.

b) Find power absorbed by load.

c) Power factor.

Solution:

a) We have,

$$V_{o,avg} = \frac{V_m}{2\pi}(1 + \cos\alpha)$$

$$\Rightarrow \cos\alpha = \frac{V_{o,avg} \times 2\pi}{V_m} - 1$$

and,

$$V_{o,avg} = I_{o,avg} \times R$$

$$= 1 \times 60$$

$$= 60V$$

So,

$$\cos\alpha = \frac{60 \times 2\pi}{340} - 1$$

$$\alpha = \cos^{-1}\left(\frac{60 \times 2\pi}{340} - 1\right)$$

$$\alpha = 1.46 \text{ rad}$$

b) **Power Absorbed by load.**

We have, $P = \frac{V_{o,rms}^2}{R}$

and,

$$V_{o,rms} = \frac{V_m}{2}\sqrt{1 - \frac{\alpha}{\pi} + \frac{\sin 2\alpha}{2\pi}}$$

$$V_{o,rms} = \frac{340}{2}\sqrt{1 - \frac{1.46}{\pi} + \frac{\sin(2 \times 1.46)}{2\pi}}$$

$$V_{o,rms} = 128.3\ V$$

So,

$$P = \frac{(128.3)^2}{60} = 274.30\ W.$$

c) **Power factor**

$$PF = \frac{P}{S} = \frac{P}{V_{in,rms} \times I_{in,rms}}$$

$$PF = \frac{P}{\frac{V_m}{\sqrt{2}} \times \frac{V_{o,rms}}{R}}$$

$$PF = \frac{274.30}{\frac{340}{\sqrt{2}} \times \frac{128.30}{60}}$$

$$PF = 0.536$$

Question 2:

A single-phase full wave rectifier with resistive load of 20 Ω and AC source of 230 V-RMS. Find the following,

a) Average, peak and RMS currents in load and each diode.

b) Peak reverse voltage across each diode.

Solution:

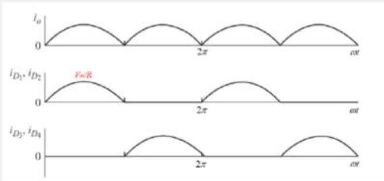
a) <u>Average, Peak and RMS Currents:</u>

Average Current (Load):

We know that,

$$i_{o\,(avg)} = \frac{V_{o\,(avg)}}{R} = \frac{2V_m}{\pi R}$$

$$i_{o\,(avg)} = \frac{2\ x\ 230\ x\ \sqrt{2}}{3.14\ x\ 20} = 10.35\ A$$



Average Current (Diode):

We have,

$$i_{D\,(avg)} = \frac{i_{o\,(avg)}}{2}$$

$$i_{D\,(avg)} = \frac{10.35}{2} = 5.17\ A$$

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Peak Current (Load and Diode):

The peak current in load and diode is same for full wave rectifier, we have

$$i_{0\,(peak)} = i_{D\,(peak)} = \frac{V_m}{R}$$

$$i_{0\,(peak)} = i_{D\,(peak)} = \frac{230\ x\ \sqrt{2}}{20} = 16.26\ A$$

RMS Current (Load):

For RMS load current we have,

$$i_{0\,(RMS)} = \frac{V_{0\,(RMS)}}{R} = \frac{V_m}{\sqrt{2}R} = \frac{230\ x\ \sqrt{2}}{\sqrt{2}\ x\ 20} = 11.50\ A$$

RMS Current (Diode):

For RMS diode current we have,

$$i_{D\,(RMS)} = \frac{i_{0\,(RMS)}}{\sqrt{2}} = \frac{V_m}{2R} = \frac{230\ x\ \sqrt{2}}{2\ x\ 20} = 8.13\ A$$

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b) Peak Reverse Voltage:

When the diode is reverse biased the voltage across it is equal to the supply voltage, so we can say that,

$$V_D = V_M = V_{RMS}\,x\sqrt{2}$$
$$V_D = 230\,x\,\sqrt{2}$$
$$V_D = 325.26\,V$$

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Question 3:

A single-phase full wave rectifier with an AC source of 200 Sin (377t) and resistive load of 20 Ω. Find,

a) Average current in load and each diode.

b) Peak reverse voltage across each diode.

c) Power factor.

Solution:

a) Average Current in Load and Diode:

Average Current (Load):

We have,

$$i_{0\,(avg)} = \frac{V_{0\,(avg)}}{R}$$
$$i_{0\,(avg)} = \frac{2V_m}{\pi R} = \frac{2\,x\,200}{3.14\,x\,20} = 6.36\,A$$

Average Current (Diode):

We have,

$$i_{0\,(avg)} = \frac{i_{0\,(avg)}}{2}$$
$$i_{0\,(avg)} = \frac{6.36}{2} = 3.18\,A$$

b) Peak Reverse Voltage across Diode:

We know that it is equal to the supply voltage,

$$V_{d\,(peak)} = V_m = 200\ V$$

c) Power Factor:

We have the power factor formula,

$$PF = \frac{P}{S} = \frac{i_{o(rms)}^2\ x\ R}{V_{in\,(rms)}\ x\ i_{in\,(rms)}}$$

Where,

$$i_{o\,(rms)} = \frac{V_{o\,(rms)}}{R} = \frac{V_m}{\sqrt{2}\ x\ R} = \frac{200}{\sqrt{2}\ x\ 20} = 7.07\ A$$

So,

$$PF = \frac{(7.07)^2\ x\ 20}{\frac{200}{\sqrt{2}}\ x\ 7.07} = 0.99$$

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Question 4:

A single-phase full wave rectifier has a 60 Hz AC source with minimum voltage of 100 V. It is to supply a load that requires a DC voltage of 100 V and will draw 0.4 A current. Find the value of filter capacitance required to limit the peak-to-peak output voltage ripples to 1% of DC output.

Solution:

To find the value of capacitance we have,

$$\Delta V_o = \frac{V_m}{2fRC}$$

For R,

$$V = IR$$

$$R = \frac{V}{I} = \frac{100}{0.4} = 250\ \Omega$$

So,

$$C = \frac{V_m}{2fR\Delta V_o}$$

$$C = \frac{100}{2 \text{ x } 60 \text{ x } 250 \text{ x } (0.01)(100)}$$

$$C = 3333\ \mu F$$

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