ELEC-E8412 **Power Electronics**

Exercise No 04 02.11.2023

Solution

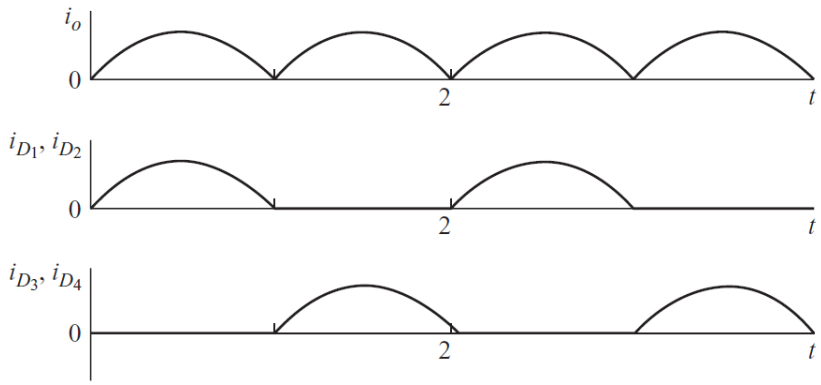
Problem 1:

A single-phase full wave rectifier with resistive load of 12 Ω and AC source of 120 V_{rms}, 60 Hz. Determine,

a) The average, peak, and rms currents in the load and in each diode.

$i_{o(avg)} = 2 * \frac{V_m}{\pi * R}$ $i_{o(avg)} = \frac{2*120*\sqrt{2}}{3.14*12} = 9A$

$i_{D(avg)} = \frac{i_{o(avg)}}{2}$ $i_{D(avg)} = \frac{9}{2} = 4.5A$



Peak load and diode current

$i_{o(peak)} = i_{D(peak)} = \frac{V_m}{R} = \frac{120*\sqrt{2}}{R}$ = 14.14 A

RMS load current

$$i_{o(rms)} = \frac{V_{rms}}{R} = \frac{120}{12} = 10\ A$$

RMS diode current

$$i_{D(rms)} = \frac{i_{o(rms)}}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07A$$

b) Determine the peak reverse voltage across each of the diodes.

When the diode is reverse biased the voltage across it is equal to the supply voltage, i.e.

$$V_D = V_m = V_{rms} * \sqrt{2} = 169.7V$$

Problem 2:
A single-phase full-wave rectifier with an ac source of 200 Sin(ω t) V has a resistive load of 20 Ω. ω=377.
Determine

a) Average current in the load and in each diode.

$$i_{o(avg)} = 2 * \frac{V_m}{\pi * R} = \frac{2 * 200}{3.14 * 20} = 6.366\ A$$

$$i_{D(avg)} = \frac{i_{o(avg)}}{2} = \frac{6.366}{2} = 3.18\ \text{A}$$

b) Peak reverse voltage across each of the diodes.

When the diode is reverse biased the voltage across it is equal to the supply voltage

c) Power factor

$$pf = \frac{P}{S} = \frac{i_{o(rms)}^2 * R}{V_{in\ (rms)} * i_{in\ (rms)}}$$

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

$$pf = \frac{i_{o(rms)}^2 * R}{V_{in\ (rms)} * i_{in\ (rms)}} = \frac{(7.07)^2 * 20}{\frac{200}{\sqrt{2}} * 7.07} = 0.999 \cong 1$$

Problem 3:

For the controlled single-phase bridge rectifier has an 18 Ω resistive load and has a 120 V_{rms} at 60 Hz source. The delay angle α is 45.

Determine

a) average load current

$$i_{o\,(avg)} = \frac{V_{o\,(avg)}}{R} = \frac{V_m * (1 + cos\alpha)}{\pi * R} = \frac{120 * \sqrt{2} * (1 + cos45)}{3.14 * 18} = 5.12\ A$$

b) rms load current

$$i_{o(rms)} = \frac{V_m}{R} * \sqrt{\frac{1}{2} - \frac{\alpha}{2\pi} + \frac{sin2\alpha}{4\pi}} = \frac{120 * \sqrt{2}}{18} * \sqrt{\frac{1}{2} - \frac{0.785}{2\pi} + \frac{sin90}{4\pi}} = 6.35\ A$$

c) rms source current

The input and output RMS currents are same.

d) power factor

$$pf = \sqrt{\frac{1}{2} - \frac{\alpha}{2\pi} + \frac{sin2\alpha}{4\pi}} = \sqrt{\frac{1}{2} - \frac{0.785}{2\pi} + \frac{sin90}{4\pi}} = 0.953$$

Or

$$pf = \frac{i_{o(rms)}^2 * R}{V_{in\,(rms)} * i_{in\,(rms)}} = \frac{(6.35)^2 * 18}{120 * 6.35} = 0.953$$

Problem 4:

A load of 50 Ω is connected to an AC source of 60 Hz, 230 V_{rms}. Full wave-controlled rectifiers has a delay angle of 45 degrees.
Determine

a) Average load current

$$i_{o\,(avg)} = \frac{V_{o\,(avg)}}{R} = \frac{V_m * (1 + cos\alpha)}{\pi * R} = \frac{230 * \sqrt{2} * (1 + cos45)}{3.14 * 50} = 3.53\ A$$

b) Power absorbed by the load

$$P = i^2_{o(rms)} * R$$

$$i_{o(rms)} = \frac{V_m}{R} * \sqrt{\frac{1}{2} - \frac{\alpha}{2\pi} + \frac{sin2\alpha}{4\pi}} = \frac{230 * \sqrt{2}}{50} * \sqrt{\frac{1}{2} - \frac{0.785}{2\pi} + \frac{sin90}{4\pi}} = 3.99\ A$$

c) Source VA.

$$\boldsymbol{S} = V_{in\,(rms)} * i_{in\,(rms)} = 230 * 3.99 = 917.7\ VA$$

Problem 5:

For an ideal full-wave rectifier with a 60-Hz ac source and maximum voltage of 100 V.

It is to supply a load that requires a dc voltage of 100 V and will draw 0.4 A.
Determine the filter capacitance required to limit the peak-to-peak output voltage ripple to 1 percent of the dc output.

$$\Delta V = \frac{V_m}{2 * f * R * C}$$

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

$$C = \frac{V_m}{2 * f * R * \Delta V} = \frac{100}{2 * 60 * 250 * 0.01 * 100} = 3333\mu\ F$$