ELEC-E8412 **Power Electronics**

Exercise No 02 05.10.2023

Problem 1:

For the half-wave rectifier, the source is a sinusoid of 300 V rms at a frequency of 50 Hz. The load resistor is 25.

Determine

a) the average load current

The voltage across the resistor in a half-wave rectified sine wave with peak value $V_m = V_{rms} * \sqrt{2} = 300\sqrt{2} = 424.4\ V$. The average voltage in a half-wave rectifier is Vm/π, and average current is:

$$\langle i_o \rangle = \frac{V_m}{\pi R} = \frac{300\left(\sqrt{2}\right)}{25\pi} = 5.4A$$

b) the power absorbed by the load

The rms voltage across the resistor for a half-wave rectified sinusoid is:

$$V_{orms} = \frac{V_m}{2} = \frac{300\left(\sqrt{2}\right)}{2} = 212.132V$$

$$I_{rms} = \frac{V_m}{2R} = \frac{300\sqrt{2}}{2*25} = 8.488\ A$$

The power absorbed by the resistor is:

$$P = R \times I_{orms}{}^2 = \frac{V_{orms}{}^2}{R} = \frac{(212.132)^2}{25} = 1800\ W$$

The rms current in the resistor is 8.488 A, and the power could also be calculated from $RI^2_{orms} = 25 \times (8.488)^2 = 1800$ w

c) the apparent power supplied by the source

Apparent Power= $V_{in-rms} * I_{in-rms}$=300*8.488= 2545

d) the power factor of the circuit

$$pf = \frac{\text{avreage power}}{\text{apparent power}} = \frac{P}{V_{in-rms} \times I_{in-rms}} = \frac{1800}{300 \times 8.488} = 0.707$$

Problem 2:

For the half-wave rectifier with R-L load, R=100Ω, L=0.1 H, ω=377 rad/s, and Vm=100V. $\boldsymbol{\beta}$=**3.5** $\boldsymbol{rad}$

Determine

a) expression for the current in this circuit,

$$i(\omega t) = \frac{V_m}{Z}\left[\sin(\omega t - \theta) + \sin(\theta) e^{-\omega t/\omega\tau}\right] \quad Z = \sqrt{R^2 + (\omega L)^2} \quad \text{and} \quad \theta = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

$$Z = \sqrt{(100)^2 + (0.1 * 377)^2} = 106.87$$

$$\theta = tan^{-1}\left(\frac{L\omega}{R}\right) = tan^{-1}\left(\frac{37.7}{100}\right) = tan^{-1}(0.377) = 0.36\,rad = 20.64^\circ$$

$$\mathrm{i}(\omega \mathrm{t}) = \frac{100}{106.87}\sin(\omega \mathrm{t} - 0.36) + \frac{100 * \sin(0.36)}{106.87}\mathrm{e}^{-\omega t/0.377}$$

$$i(\beta) = \frac{V_m}{Z}\left[\sin(\beta - \theta) + \sin(\theta) e^{-\beta/\omega\tau}\right] = 0$$

Substituting wt = β

$\beta = 3.5$ rad is given by the problem, so

$$\mathrm{i}(\omega \mathrm{t}) = 0.936\sin(\omega \mathrm{t} - 0.36) + 0.33\mathrm{e}^{-\omega t/0.377} \qquad for \quad 0 \leq \omega \mathrm{t} \leq 3.5$$

$$\mathrm{i}(\omega \mathrm{t}) = 0 \qquad for \quad 3.5 \leq \omega \mathrm{t} \leq 2\pi$$

b) the average current,

$$I_o = \frac{1}{2\pi}\int_0^{\beta} i(\omega t)\, d(\omega t) = \frac{1}{2\pi}\int_0^{3.5} [0.936\sin(\omega \mathrm{t} - 0.36) + 0.33\mathrm{e}^{-\omega t/0.377}]\, d(\omega \mathrm{t})$$

= 0.308 A

c) the rms current

$$I_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} i^2(\omega t)\, d(\omega t)} = \sqrt{\frac{1}{2\pi}\int_0^{\beta} i^2(\omega t)\, d(\omega t)}$$

$$\boldsymbol{I_{rms}} = \sqrt{\frac{1}{2\pi}\int_0^{3.5} [0.936\sin(\omega \mathrm{t} - 0.36) + 0.33\mathrm{e}^{-\omega t/0.377}]^2 d(\omega \mathrm{t})} = 0.474\, A$$

d) the power absorbed by the resistor,

$$\mathrm{P} = \mathrm{R} * \mathrm{I}_{\mathrm{rms}}^2 = 100 * (0.474)^2 = 22.47\, W$$

e) the power factor

$$Pf = \frac{P}{V_{in-rms} * I_{in-rms}} = \frac{22.47}{\frac{100}{\sqrt{2}} * 0.474} = 0.67$$

Problem 3:

For a half wave rectifier, the source voltage is 120 V-RMS at 60 Hz. The load resistance is 5 Ω.

Determine

a) **Average load current.**

$$I_{o\ (avg)} = \frac{V_{o\ (avg)}}{R}$$

$$\therefore V_{o\ (avg)} = \frac{V_m}{\pi}$$

$$I_{o\ (avg)} = \frac{V_m}{\pi R}$$

$$I_{o\ (avg)} = \frac{V_{rms}\ x\ \sqrt{2}}{\pi R} = \frac{120\ x\ \sqrt{2}}{\pi\ x\ 5} = 10.8\ A$$

b) **Average power absorbed by load**

$$P_{out} = \frac{V_{o\ (rms)}^2}{R}$$

$$V_{o\ (rms)} = \frac{V_m}{2} = \frac{120\ x\sqrt{2}}{2} = 84.9\ V$$

$$P_{out} = \frac{(84.9)^2}{5} = 1441\ W$$

c) **Power factor.**

$$PF = \frac{P}{S} = \frac{P}{V_{in\ (rms)} I_{in\ (rms)}}$$

$$P_{out} = I_{(rms)}^2\ x\ R$$

$$I_{in(rms)} = \sqrt{\frac{P_{out}}{R}} = \sqrt{\frac{1441}{5}} = 16.9\ A$$

$$PF = \frac{1441}{120\ x\ 16.97} = 0.7$$