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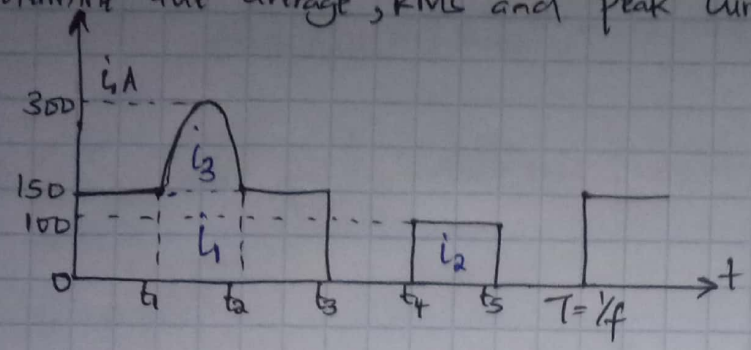
Task: CAT2 Take Away.
Course: ECE 451 by Dr. Letting.

Question ONE

The waveform of the current flowing through a diode are as shown below. Determine the average, RMS and peak current ratings of the diode.



$t_1 = 100\mu s$
$t_2 = 200\mu s$
$t_3 = 400\mu s$
$t_4 = 800\mu s$
$t_5 = 1\,ms$
$f = 200\,Hz$
$T = 1/200 = 5\times10^{-3}$

Soln:

$$i_1 = \frac{t_3 - 0}{T} \times 150 = \frac{400\times10^{-6}}{5\times10^{-3}} \times 150 = 12A$$

$$i_2 = \frac{t_5 - t_4}{T} \times 100 = \frac{10^{-3} - 800\times10^{-6}}{5\times10^{-3}} \times 100 = 4A$$

$$i_3 = \left[\frac{1}{\pi}\int_0^{\pi} 150\sin\theta\, d\theta\right] \times \frac{t_2 - t_1}{T} = 95.49 \times \frac{100\times10^{-6}}{5\times10^{-3}} = 1.90986 \simeq 1.91$$

$$i_{av} = i_1 + i_2 + i_3 = 12 + 4 + 1.91 = 17.91A$$

~~i_{rms}~~ $I_{rms} = \sqrt{i_{1rms}^2 + i_{2rms}^2 + i_{3rms}^2}$

$$i_{1rms} = 150 \times \sqrt{\frac{t_3}{T}} = 150 \times \sqrt{\frac{400}{5000}} = 42.43A$$

$$i_{3rms} = \frac{I_m}{\sqrt{2}} \times \sqrt{\frac{t_2 - t_1}{T}} = \frac{150}{\sqrt{2}} \times \sqrt{\frac{100}{5000}} = 15A$$

$$i_{2rms} = 100 \times \sqrt{\frac{t_5 - t_4}{T}} = 100 \times \sqrt{\frac{200}{5000}} = 20A$$

$$I_{rms} = \sqrt{42.43^2 + 15^2 + 20^2} = 49.25A$$

$I_p = 300A$

Question Two

i) Determine the total RMS Current Magnitude I(A)

$T = 1/50 = 0.02$

Total $I_{rms} = \sqrt{I_{1rms}^2 + I_{2rms}^2}$

$$I_{1rms} = 10 \times \sqrt{\frac{T/2 - T/4}{T}} = 5A$$

$$I_{2rms} = -10 \times \sqrt{\frac{T - 3/4\,T}{T}}$$

$$\text{Total } I_{rms} = \sqrt{5^2 + 5^2}$$

$$= 7.071A$$

ii) Determine the fundamental RMS current Magnitude I_1 A.

$$I_1 = \frac{C_1}{\sqrt{2}} \qquad C_1 = \sqrt{a_1^2 + b_1^2}$$

$$a_1 = 1/\pi \int_0^{2\pi} i(t)\cos(\omega t)\, d\omega t \qquad b_1 = 1/\pi \int_0^{2\pi} i(t)\sin(\omega t)\, d\omega t$$

$T = 2\pi$; $T/4 = 1/2\pi$; $T/2 = \pi$; $3/4\,T = 3/2\pi$

$$\therefore a_1 = \frac{I}{\pi}\left[\int_{1/2\pi}^{\pi} \cos\omega t\, d\omega t + \int_{3/2\pi}^{2\pi} -\cos\omega t\, d\omega t\right]$$

$$= \frac{-2I}{\pi} = \frac{-20}{\pi} = -6.366$$

$$b_1 = \frac{I}{\pi}\left[\int_{1/2\pi}^{\pi} \sin\omega t\, d\omega t + \int_{3/2\pi}^{2\pi} -\sin\omega t\, d\omega t\right]$$

$$= \frac{2I}{\pi} = \frac{2 \times 10}{\pi} = 6.366$$

$$C_1 = \sqrt{6.366^2 + 6.366^2}$$

$$C_1 = 9$$

$$I_1 = \frac{9}{\sqrt{2}} = 6.366\,A$$

iii) Compute the total Harmonic distortion (THD) of the current

$$THD = \left[\left(\frac{I_S}{I_{S_1}}\right)^2 - 1\right]^{1/2}$$

$I_{S_1} = I_1 = 6.366A$

$$I_S = \left[\frac{1}{\pi}\int_{1/2\pi}^{\pi} I_t^2\, d(\omega t)\right]^{1/2} = 7.071$$

~~$I_t = 10A$~~

$$THD = \left[\left(\frac{7.071}{6.366}\right)^2 - 1\right]^{1/2}$$

~~$$THD = \left[\left(\frac{10}{6.366}\right)^2 - 1\right]^{1/2}$$~~

$= 0.4835$

~~$= 1.211$~~

iv) Compute the Supply Power factor P.F

$$P.F = \frac{I_{s1}}{I_s} \cos\phi_1$$

$$\phi = \tan^{-1}\left(\frac{a_1}{b_1}\right) = \tan^{-1}\left(\frac{-6.366}{6.366}\right)$$

$$\phi = -45$$

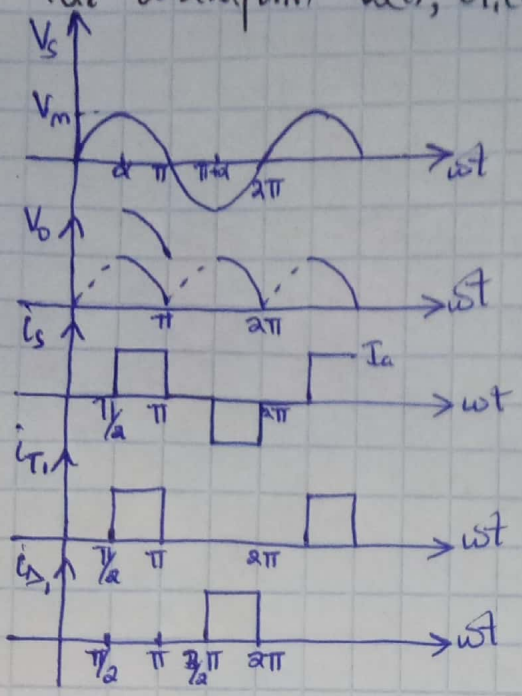
$$\cos(-45) = 0.7071$$

$$P.F = \frac{6.366}{7.071} \times 0.7071$$

$$= 0.64$$

Question THREE

a) Sketch the waveform $V_s(t)$, $i_{T_1}(t)$, $i_{D_1}(t)$ and $i_s(t)$



b) Determine the average and rms current rating of Diode D_1 and Thyristor T_1

Diode D_1:

$$I_{av} = \frac{2\pi - \frac{3}{2}\pi}{2\pi} \times 10 = 2.5A$$

$$I_{rms} = \left[\frac{1}{2\pi}\int_{3/2\pi}^{2\pi} 10^2 dt\right]^{1/2} = 5A$$

Thyristor T_1:

$$I_{av} = \frac{\pi - \pi/2}{2\pi} \times 10 = 2.5A$$

$$I_{rms} = \left[\frac{1}{2\pi}\int_{\pi/2}^{\pi} 10^2\right]^{1/2} = 5A$$