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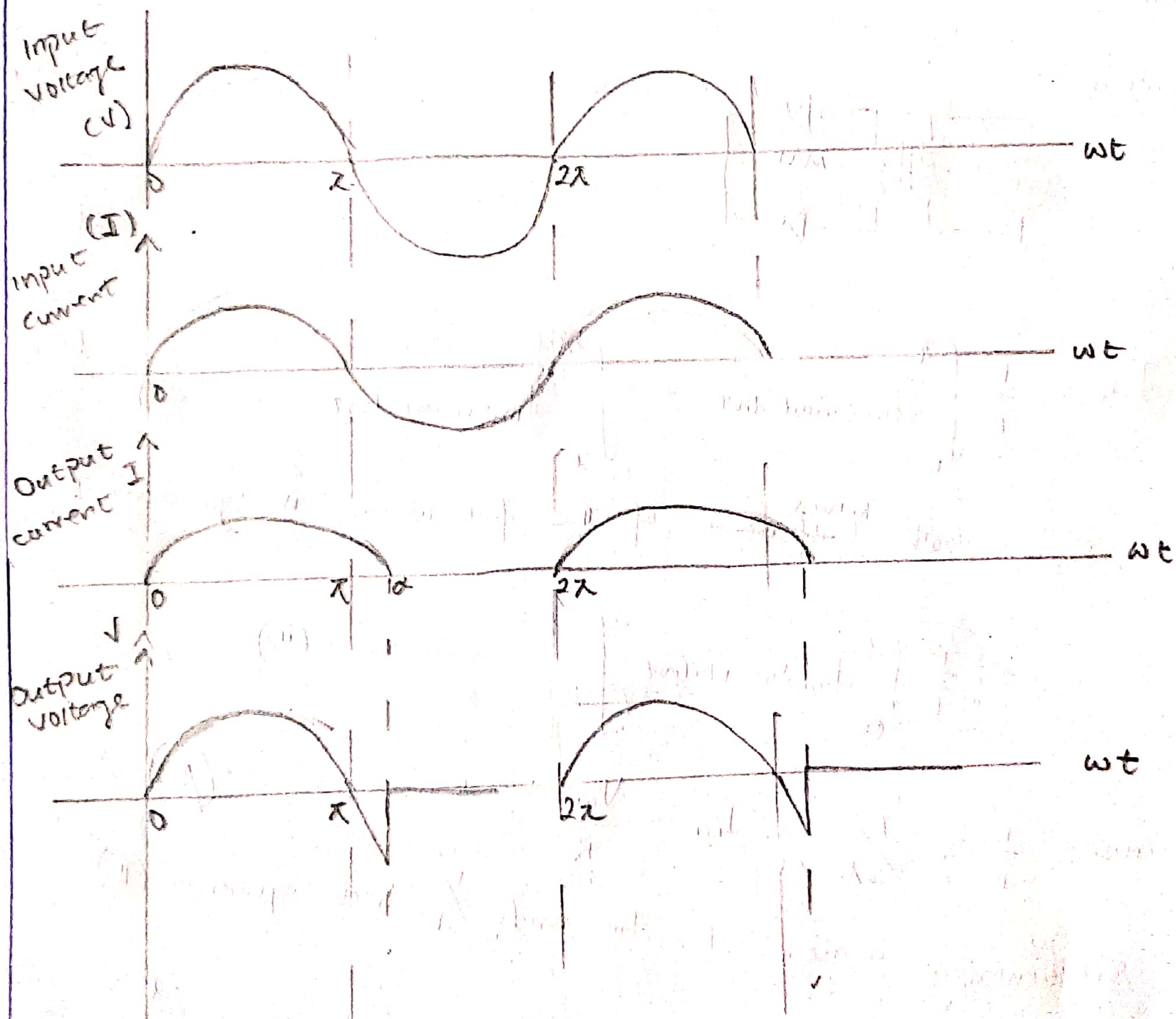
DEPARTMENT: MECHATRONICS ENGINEERING

COURSE: MCT 510

ASSIGNMENT 5

QUESTION 1: (Example 3)

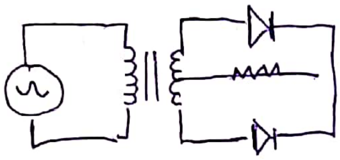
A single phase half wave diode rectifier is feeding an R-L load. Draw the wave shape of the output voltage and current.



QUESTION 2:

A full wave diode rectifier with centre tapped transformer is feeding a resistive load of R. Assume the diode has a zero forward resistance and infinite reverse resistance. find the expression for Vdc, Idc, Irms, Pdc, Pac, Efficiency (η), form factor (FF), Ripple factor (RF), TUF, PIV and crest factor (CF). Draw the wave shapes of input voltage & current output voltage & current. Take $V_m = 100v$, $R = 5\Omega$

Solution:



(i) $I_{dc} = \frac{1}{T}\left[\int_0^{\pi} I_m \sin\omega t\, d\omega t + \int_{\pi}^{2\pi} I_m \sin\omega t\, d\omega t\right]$ ——— (I)

Since both ~~half wave~~ halves of the full wave is symmetrical

$$2\left[\frac{1}{T}\int_0^{\pi} I_m \sin\omega t\, d\omega t\right] \text{ ——— (II)}$$

where $\frac{1}{T} = \frac{1}{2\pi}$, $I_m = \frac{V_m}{R}$ ——— (B)

Substituting values of I_m and $1/T$ into equation (II)

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

$$\Rightarrow \left(\frac{2}{2\pi}\right)\left(\frac{100}{5}\right)\int_0^{\pi} \sin\omega t\, d\omega t \text{ ——— (III)}$$

Integrating equation (III)

$$\frac{1}{\pi}(20)\left[-\cos\omega t\right]_0^{\pi}$$

$$\Rightarrow \frac{20}{\pi}\left[(-\cos(180))-(-\cos(0))\right]$$

$$\frac{20}{\pi}\left[1+1\right] = \frac{40}{\pi} = 12.7323 \simeq 12.73\ A$$

(ii) $V_{dc} = I_{dc} \times R = 12.73 \times 5 = 63.65\ V$

(iii) $$I_{rms}^2 = \frac{1}{T}\int_0^{\pi} I_m^2 \sin^2\omega t\, d\omega t + \int_{\pi}^{2\pi} I_m^2 \sin^2\omega t\, d\omega t \quad \text{—— (i)}$$

Since both halves of the full wave are symmetrical

$$2\left[\frac{1}{T}\int_0^{\pi} I_m^2 \sin^2\omega t\, d\omega t\right] \quad \text{—— (ii)}$$

Substituting values of I_m and $1/T$ from equation (β) into equation (ii)

$$\Rightarrow \frac{2}{2\pi}\int_0^{\pi}\left(\frac{V_m}{R}\right)^2 \sin^2\omega t\, d\omega t$$

$$\frac{2}{2\pi}\left(\frac{100}{5}\right)^2\int_0^{\pi} \sin^2\omega t\, d\omega t \quad \text{—— (iii)}$$

but from trigonometry

$$\sin^2\theta = \frac{1-\cos 2\theta}{2}$$

Similarly

$$\sin^2\omega t = \frac{1-\cos 2\omega t}{2} \quad \text{—— (}\gamma\text{)}$$

Substituting equation (8) into equation (iii)

$$\left(\frac{2}{2\pi}\right)\left(\frac{100}{5}\right)^2 \int_0^{\pi} \frac{1-\cos 2\omega t}{2}\, d\omega t \quad \text{—— (iv)}$$

Simplifying equation (iv)

$$\left(\frac{2}{2\pi}\right)\left(\frac{100}{5}\right)^2 \left(\frac{1}{2}\right) \int_0^{\pi} 1-\cos 2\omega t \, d\omega t$$

$$\left(\frac{2}{4\pi}\right)\left(\frac{100}{5}\right)^2 \left[\int_0^{\pi} \omega t\, d\omega t - \int_0^{\pi} \cos 2\omega t\, d\omega t\right]$$

$$\left(\frac{2}{4\pi}\right)\left(\frac{100}{5}\right)^2 \left[\left[\omega t\right]_0^{\pi} - \left[\frac{\sin 2\omega t}{2}\right]_0^{\pi}\right]$$

$$\left(\frac{2}{4\pi}\right)\left(\frac{100}{5}\right)^2 \left[\pi - \left[\frac{\sin 2\times 180}{2} - \frac{\sin 2(0)}{2}\right]\right]$$

$$\left(\frac{2}{4\pi}\right)\left(\frac{100}{5}\right)^2 \left[\pi\right] = \left(\frac{1}{2\pi}\right)(400)(\pi) = 200\ A$$

$$I_{rms}^2 = 200$$

$$I_{rms} = \sqrt{200} = 14.142\ A$$

(iv) $V_{rms} = I_{rms} \times R = 14.142 \times 5 = 70.71\ v$

(v) $P_{dc} = I_{dc}^2 \times R = (12.73)^2 \times 5 = 810.2645\ \Omega$

$810.26\ w$

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(vi) $P_{ac} = I_{rms}^2 \times R = (14.142)^2 \times 5 = 999.9808$

$\simeq 999.98\ W$

(vii) Efficiency $= \dfrac{P_{dc}}{P_{ac}} = \dfrac{810.52}{999.98} = 0.8105 \simeq 81.05\%$

(viii) PIV $= V_m = 100\ V$

(ix) TUF $= \dfrac{\dfrac{V_m}{\pi} \times \dfrac{V_m}{\pi R}}{\dfrac{V_m}{2\sqrt{2}} \times \dfrac{V_m}{2\cancel{\sqrt{2}}R}} = \dfrac{\dfrac{V_m^2}{\pi^2 R}}{\dfrac{V_m^2}{2\sqrt{2}R}}$

$\Rightarrow \dfrac{V_m^2}{\pi^2 R} \times \dfrac{2\sqrt{2}R}{V_m^2} = \dfrac{2\sqrt{2}}{\pi^2} = 0.2865$

(x) Crest factor $= \dfrac{I_{speak}}{I_s} = \dfrac{\cancel{I_m}}{\cancel{I_{rms}}} = \dfrac{\cancel{20}}{\cancel{14.142}} = 1.41412$

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

(3) Advantages and disadvantages of
(i) full wave rectifier using centre tap transformer
(ii) full wave rectifier using bridge circuit.

Full wave rectifier using centre tap transformer

Advantages.

(i) The output and efficiency of centre tap full wave rectifier are high because the ac supply delivers power during both halves

(ii) For the same secondary voltage bridge rectifier has double output

Disadvantages

(i) where a small voltage is required to be rectified, the full wave rectifier circuit is not suitable

(ii) In centre tap transformer, the middle of the secondary winding for tapping is difficult

Full wave rectifier using bridge circuit

Advantages:

(i.) It eliminates the use of centre tap transformer.

(ii) The output is double to that of the centre tapped full wave rectifier for the same secondary voltage

(iii) The peak inverse voltage across each diode is one-half of the centre tap circuit of the diode

Disadvantages:

(i.) It needs four diodes

(ii) The circuit is not suitable when a small voltage is required to be rectified. It is because in this case, the two ~~diods~~ diodes are ~~conne~~ connected in series and offer double voltage drop due to their internal resistance.