1. Nov/2022/Paper_41/No.7

(a) A sinusoidal alternating voltage has a root-mean-square (r.m.s.) potential difference (p.d.) of 4.2 V and a frequency of 50 kHz.

(i) The alternating voltage is applied across a resistor of resistance 760 Ω.

By considering the peak voltage, show that the maximum power dissipated by the resistor is 46 mW.

$V_{rms} = \frac{V_0}{\sqrt{2}}$

$V_0 = V_{r.m.s} \times \sqrt{2}$

$= 4.2 \times \sqrt{2}$

$= 5.9\,V$

$P = \frac{V^2}{R}$

$= \frac{5.9^2}{760}$

$= 0.046\,W$

$\simeq 4.6 \times 10^{-2}\,W$

$= 46 \times 10^{-3}\,W$

$= 46\,mW$

[2]

(ii) On Fig. 7.1, draw a smooth curve to show how the power P dissipated in the resistor varies with time t between $t = 0$ and $t = 40\,\mu s$. Assume that $P = 0$ when $t = 0$.

$T = \frac{1}{f}$

$= \frac{1}{50 \times 10^3}$

$= 0.00002\,s.$

$= 20\,\mu s$

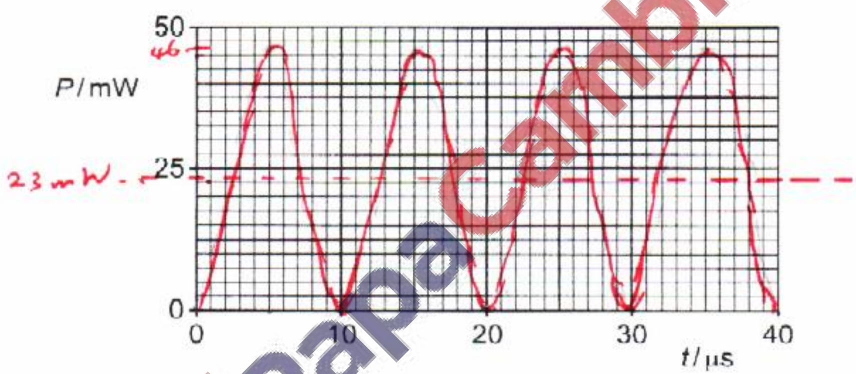


Fig. 7.1

[3]

(iii) Use your line in **(a)(ii)** to explain why the mean power dissipated in the resistor is 23 mW.

– The graph is Symmetrical at around $P = 23\,mW$ line.

[1]

(b) The alternating voltage in **(a)** is now applied to a piezoelectric crystal in air.

(i) Explain what happens to the air surrounding the crystal.

- the alternating p-d makes the crystal to vibrate.
- The vibration of crystals cause air to vibrate in the frequency of ultrasound $f > 20{,}000$ Hz

[3]

(ii) A second piezoelectric crystal is placed in the air near to the first crystal.

Explain the effect of the surrounding air in **(b)(i)** on the second crystal.

air makes the 2^{nd} crystal to vibrate and this causes an emf to be generated across the 2^{nd} crystal.

[1]

[Total: 10]

2. Nov/2022/Paper_42/No.8

(a) State Lenz's law of electromagnetic induction.

- Direction of the induced e.m.f is such that it tends to oppose the flux change causing it. [2]

(b) Two coils of insulated wire are wound on an iron bar, as shown in Fig. 8.1.

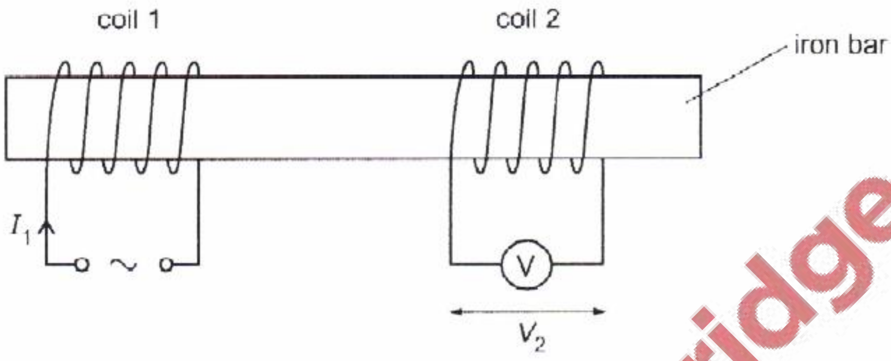


Fig. 8.1

There is a current I_1 in coil 1 that varies with time t as shown in Fig. 8.2.

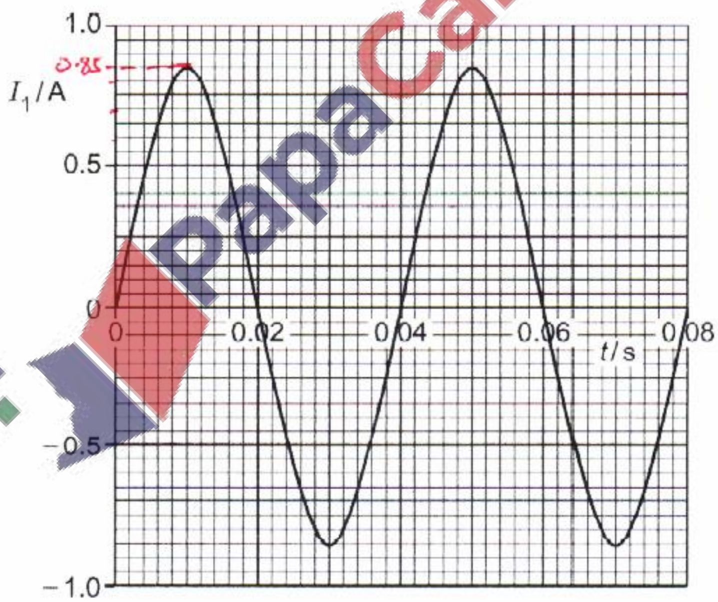


Fig. 8.2

(i) The variation with t of I_1 can be represented by the equation

$$I_1 = X \sin Yt$$

$I = I_0 \sin \omega t$ ($I_0 \to X$, $\omega \to Y$)

where X and Y are constants.

Use Fig. 8.2 to determine the values of X and Y. Give units with your answers.

I_0 = peak value = 0.35 A

X = 0.85 unit A

$\omega = \frac{2\pi}{T} = \frac{2\pi}{0.04} = 160$ rad s^{-1}

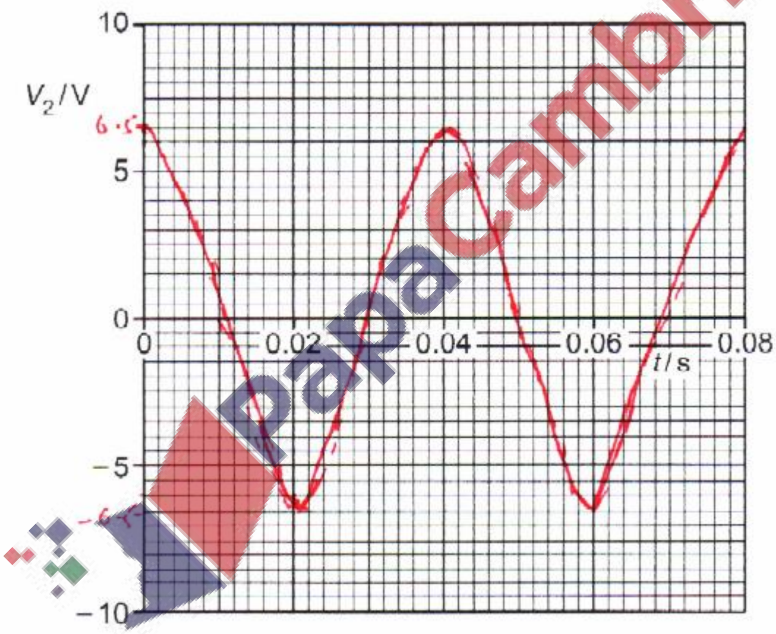
Y = 160 unit rad s^{-1}

[3]

(ii) The current in coil 1 gives rise to a magnetic field in the iron bar.
Assume that the flux density of this magnetic field is proportional to I_1.

An alternating electromotive force (e.m.f.) is induced across coil 2. The p.d. across coil 2 is measured using the voltmeter and has a root-mean-square (r.m.s.) value of 4.6 V.

On Fig. 8.3, sketch a line to show the variation with t of V_2 between $t = 0$ and $t = 0.08$ s.



$V_{rms} = \frac{V_0}{\sqrt{2}}$

$V_0 = V_{rms}\sqrt{2} = 4.6 \times \sqrt{2} = 6.5$ V.

V_2 max/min when $I = 0$, 0.02, 0.04, 0.06, 0.08.

Fig. 8.3

[3]

(iii) Use the laws of electromagnetic induction to explain the shape of your line in **(b)(ii)**.

- Magnitude of induced e.m.f (V_2) is proportional to rate of change of magnetic flux.
- V_2 is proportional to gradient in $I_1 - t$ graph.
- V_2 is zero at maximum/minimum current in $I_1 - t$ curve.

[3]

[Total: 11]

3. June/2022/Paper_41/No.5

Fig. 5.1 shows four diodes and a load resistor of resistance 1.2 kΩ, connected in a circuit that is used to produce rectification of an alternating voltage.

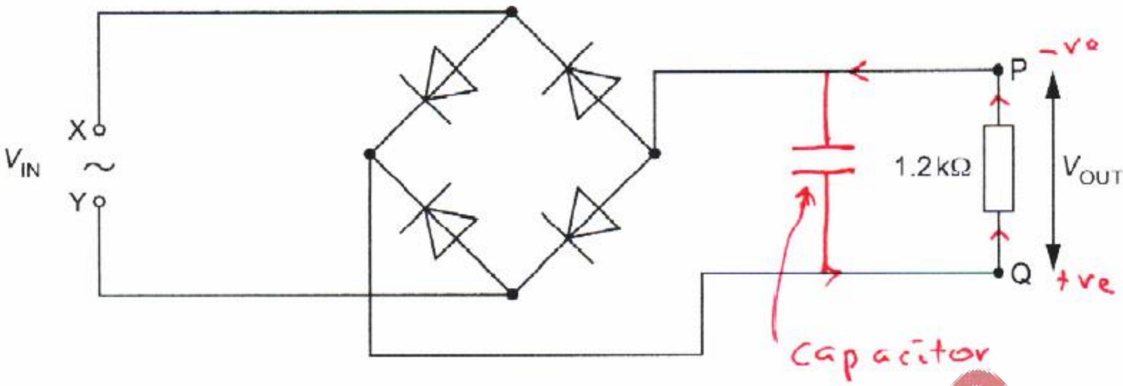


Fig. 5.1

(a) **(i)** State what is meant by rectification.

Is the conversion of a-c to d-c .

.... [1]

(ii) State the type of rectification produced by the circuit in Fig. 5.1.

full wave rectification. [1]

(b) A sinusoidal alternating voltage V_{IN} is applied across the input terminals X and Y. The variation with time t of V_{IN} is given by the equation

$$V_{IN} = 6.0 \sin 25\pi t$$

$V = V_0 \sin \omega t$

where V_{IN} is in volts and t is in seconds.

(i) On Fig. 5.1, label the output terminals P and Q with the appropriate symbols to indicate the polarity of the output voltage V_{OUT}. [1]

Current flows from Q to P.

So Q is +ve while P is -ve.

(ii) The magnitude of the output voltage V_{OUT} varies with t as shown in Fig. 5.2.

Fig. 5.2

On Fig. 5.2, label both of the axes with the correct scales. Use the space below for any working that you need.

$V_0 = 6\,V$

$\omega = 25\pi$

$\omega = \frac{2\pi}{T}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{25\pi} = 0.08\,s$

[3]

(c) The output voltage in **(b)** is smoothed by adding a capacitor to the circuit in Fig. 5.1.
The difference between the maximum and minimum values of the smoothed output voltage is 10% of the peak voltage.

100% — 6 V
90% — ?
$\frac{90 \times 6}{100} = 5.4\,V$

(i) On Fig. 5.1, draw the circuit symbol for a capacitor showing the capacitor correctly connected into the circuit. [1]

(ii) On Fig. 5.2, sketch the variation with t of the smoothed output voltage. [2]

(iii) Calculate the capacitance C of the capacitor.

$V_0 = 6.0\,V$

$V = 0.9 \times 6.0 = 5.4\,V$

discharge time $= 0.054 - 0.02 = 0.034\,s$

$V = V_0 e^{-\frac{t}{RC}}$

$5.4 = 6 e^{-\frac{0.034}{1.2 \times 10^3 \times C}}$

$\ln\left(\frac{5.4}{6}\right) = -\left(\frac{0.034}{1.2 \times 10^3 \times C}\right)$

$-0.11 = -\frac{0.034}{1.2 \times 10^3 \times C}$

$C = \frac{0.034}{1.2 \times 10^3 \times 0.11}$

$C = 0.0002575 \approx 2.6 \times 10^{-4}\,F$

C = ...2.6×10^{-4}...... F [3]

[Total: 12]

4. March/2022/Paper_42/No.7

(a) Alternating current (a.c.) is converted into direct current (d.c.) using a full-wave rectification circuit. Part of the diagram of this circuit is shown in Fig. 7.1.

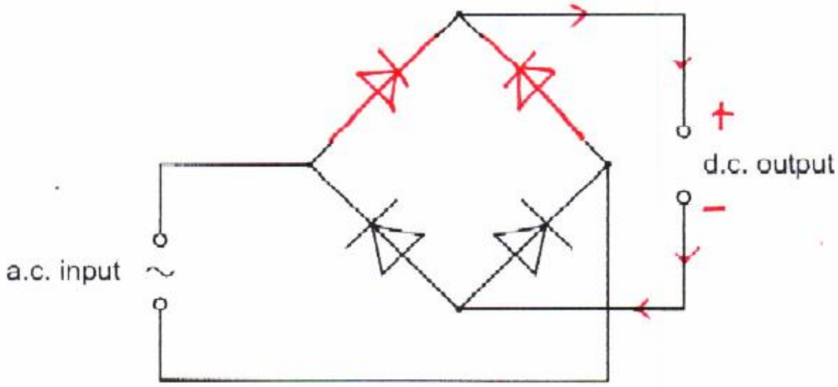


Fig. 7.1

(i) Complete the circuit in Fig. 7.1 by adding the necessary components in the gaps. [1]

(ii) On Fig. 7.1 mark with a + the positive output terminal of the rectifier. [1]

(b) The output voltage V of an a.c. power supply varies sinusoidally with time t as shown in Fig. 7.2.

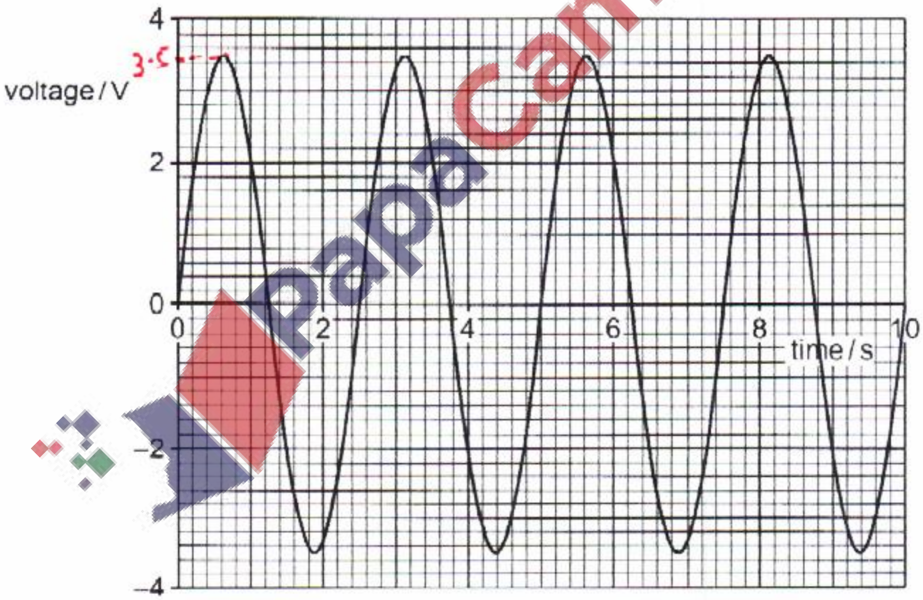


Fig. 7.2

(i) Determine the equation for V in terms of t, where V is in volts and t is in seconds.

$V = V_0 \sin \omega t$

$\omega = \frac{2\pi}{T}$

$T = \frac{10}{4} = 2.5\,s$

$\therefore \omega = \frac{2\pi}{2.5} = 2.5\ rad\,s^{-1}$

$V_0 = 3.5\,V$

$\therefore V = 3.5 \sin 2.5t$

V = ... $3.5 \sin 2.5t$ .... [2]