Alternating current - 2021 A2 Physics

1. Nov/2021/Paper_41/No.9

(a) State, by reference to the power dissipated in a resistor, what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating voltage.

Is the value of constant voltage (or current) that produces the same power in a resistor as the mean power of the alternating voltage (or current). [2]

(b) A coil is rotating freely, on frictionless bearings, at constant speed in a uniform magnetic field. This rotation causes an induced alternating electromotive force (e.m.f.) across the open terminals of the coil. The induced e.m.f. has r.m.s. value 12 V and frequency 50 Hz.

The speed of rotation of the coil is now doubled.

(i) State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced e.m.f.

– At high speed, the rate of cutting of flux will double. This doubles the r.m.s and thus doubles the induced e.m.f. [2]

(ii) On Fig. 9.1, sketch the variation with time t of the induced e.m.f. E across the terminals of the coil at the **increased** speed of rotation. Your line should extend from time $t = 0$ to time $t = 20\,\text{ms}$. Assume that $E = 0$ when $t = 0$.

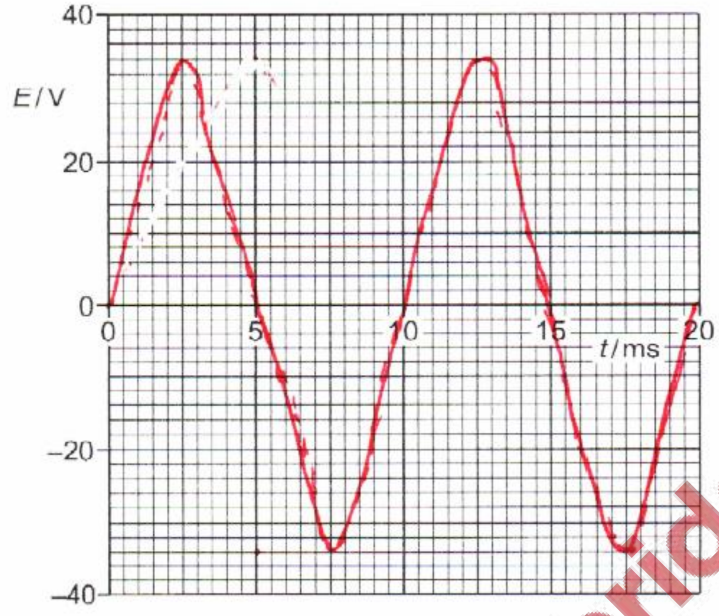


Fig. 9.1

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

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

$= 24 \times \sqrt{2}$

$= 33.9\,V$

$\simeq 34\,V$

$T = \frac{1}{50}$

$= 0.02\,s$

$= 20\,ms$

Double speed will half the period

$\frac{20}{2} = 10\,ms$

[3]

$\therefore T = 10\,ms$

(c) State and explain the effect on the motion of the coil in **(b)** of connecting a load resistor across its terminals.

– Current flowing in the resistor dissipates the energy of rotation so the coil will stop to rotate.

.... [2]

[Total: 9]

2. Nov/2021/Paper_42/No.10

Fig. 10.1 shows a simple laminated iron-cored transformer consisting of a primary coil of 25000 turns and a secondary coil of 625 turns.

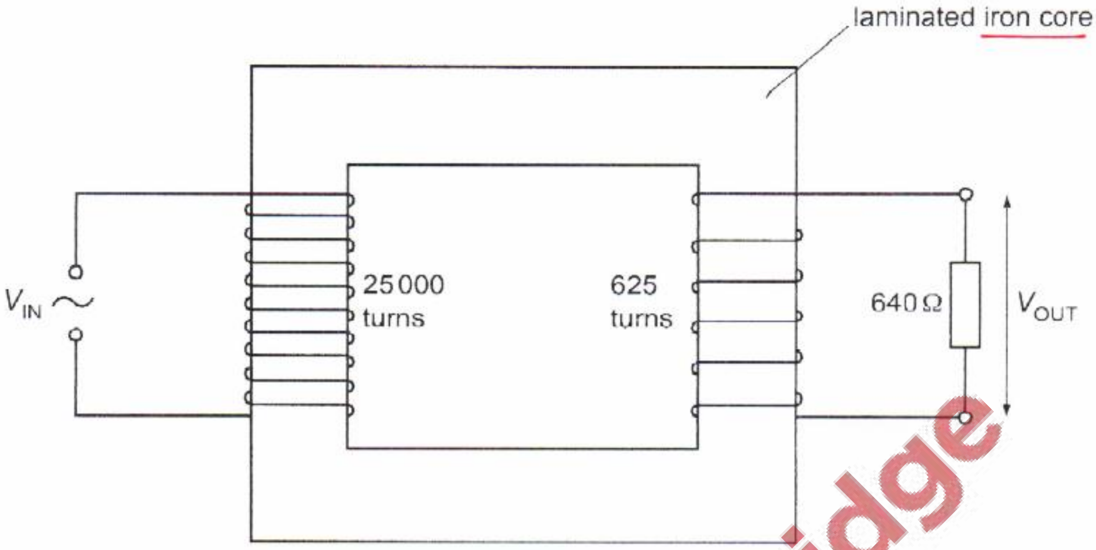


Fig. 10.1

The output potential difference (p.d.) V_{OUT} is applied to a load resistor of resistance 640 Ω.

(a) **(i)** State the function of the iron core.

to increase the magnetic flux linkage between the coils. [1]

(ii) Explain why the iron core is laminated.

- To reduce eddy currents (induced currents) and hence minimise energy losses. [2]

(b) The input p.d. V_{IN} is a sinusoidal alternating voltage of peak value 12 kV and period 40 ms.

12000 V

(i) Calculate the maximum value of V_{OUT}.

$\frac{V_{out}}{V_{in}} = \frac{N_s}{N_p}$

$V_{out} = V_{in} \times \frac{N_s}{N_p}$

$V_{out} = \frac{12000 \times 625}{25000}$

$= 300\ V$

maximum V_{OUT} = 300 V [1]

(ii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

$I = \frac{V}{R}$

$I_{rms} = \frac{I_0}{\sqrt{2}}$

$I_{rms} = \frac{300V}{640\Omega} \div \sqrt{2}$

$= \frac{300}{640 \times \sqrt{2}}$

$I_{r.m.s} = 0.33$ A

r.m.s. current = ...0.33...... A [1]

(iii) On Fig. 10.2, sketch the variation with time t of the power P dissipated in the load resistor for time t = 0 to t = 40 ms. Assume that P = 0 when t = 0.

$I_{r.m.s} = \frac{I_0}{\sqrt{2}}$

$I_0 = I_{r.m.s} \times \sqrt{2}$

$= 0.33 \times \sqrt{2}$

$= 0.466$ A

$P = I \times V$

$= 0.47 \times 300$

$= 140$ W

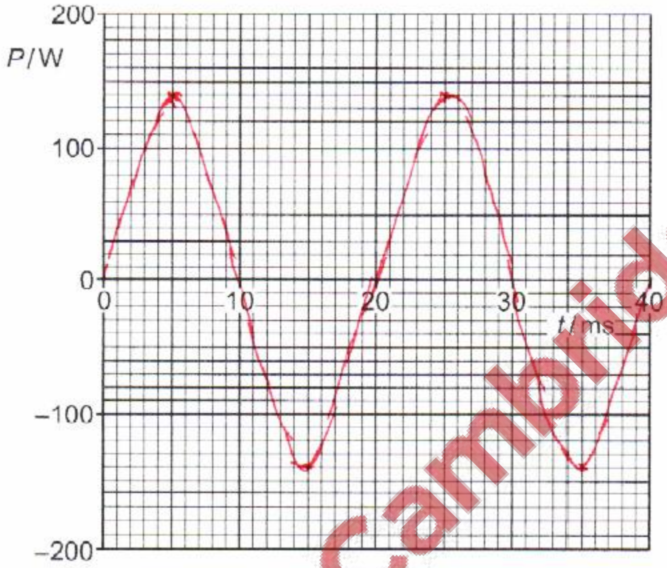


Fig. 10.2

[3]

(c) Explain, with reference to Fig. 10.2, why the mean power in the load resistor is 70 W.

– The power curve is symmetrical about the midpoint on the power axis

– So the mean power is half the peak power.

[2]

[Total: 10]

3. June/2021/Paper_42/No.10

(a) By reference to heating effect, explain what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating current.

- this is the value of direct current that produces the same heating effect as the alternating current [2]

(b) The variations with time t of two currents I_1 and I_2 are shown in Fig. 10.1 and Fig. 10.2.

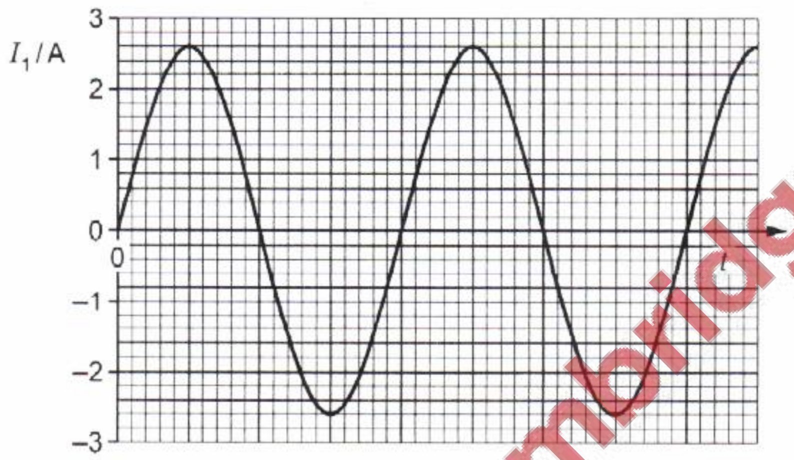


Fig. 10.1

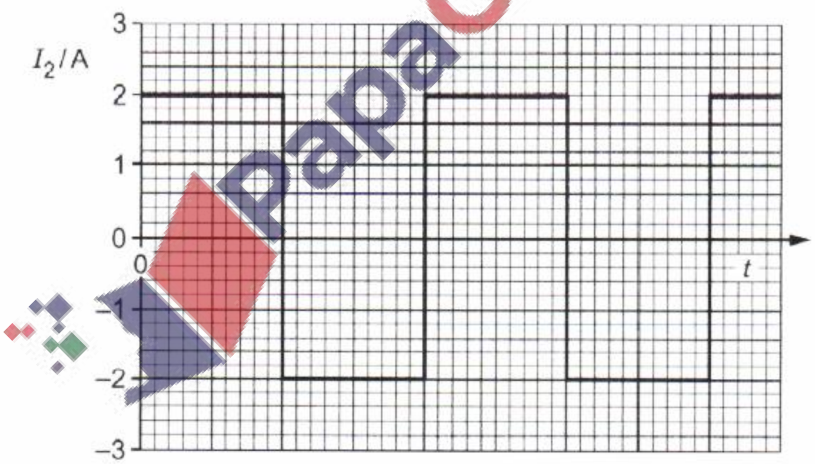


Fig. 10.2

(i) Use Fig. 10.1 to determine the peak value and the r.m.s. value of the current I_1.

$I_{rms} = \frac{I_0}{\sqrt{2}}$

$= \frac{2.6}{\sqrt{2}} = 1.838 \approx 1.8$

peak value = ...2.6...... A

r.m.s. value = ...1.8...... A [1]

(ii) Use Fig. 10.2 to determine the peak value and the r.m.s. value of the current I_2.

peak value = ...2.0...... A

r.m.s. value = ...2.0...... A [1]

The current I_2 is not fluctuating only changes direction at constant time.

(c) The variation with time t of the supply voltage V to a house is given by the expression

$$V = 240 \sin kt$$

where V is in volts, t is in seconds and k is a constant with unit rad s^{-1}. ↑ angular velocity

(i) The frequency of the supply voltage is 50 Hz.

Determine k to two significant figures.

$\omega = 2\pi f$

$\therefore k = 2\pi f$

$= 2\pi \times 50$

$= 310$ rad s^{-1}

k = ...310...... rad s^{-1} [2]

(ii) The supply voltage is applied to a heater. The mean power of the heater is 3.2 kW.

Calculate the resistance of the heater.

$P = \frac{V_{r.m.s}^2}{R}$

$R = \frac{V_{rms}^2}{P}$

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

$= \frac{240}{\sqrt{2}}$

$V_{rms} = 169.7$ V

$\therefore R = \frac{169.7^2}{3.2 \times 10^3}$

$= 8.999\ \Omega$

≈ 9.0

resistance = ...9.0...... Ω [2]

[Total: 8]

4. March/2021/Paper_42/No.10

The output potential difference (p.d.) of an alternating power supply is represented by

$$V = 320\sin(100\pi t)$$

$V = V_0 \sin \omega t$

where V is the p.d. in volts and t is the time in seconds.

(a) Determine the root-mean-square (r.m.s.) p.d. of the power supply.

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

$= \frac{320}{\sqrt{2}} = 226$

r.m.s. p.d. = ...230V........ V [1]

(b) Determine the period T of the output.

$\omega = 100\pi$

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

$= \frac{2\pi}{100\pi} = \frac{2}{100} = 0.02$

T = ...0.02........ s [2]

(c) The power supply is connected to resistor R and a diode in the circuit shown in Fig. 10.1.

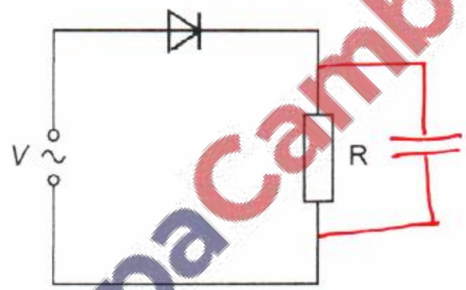
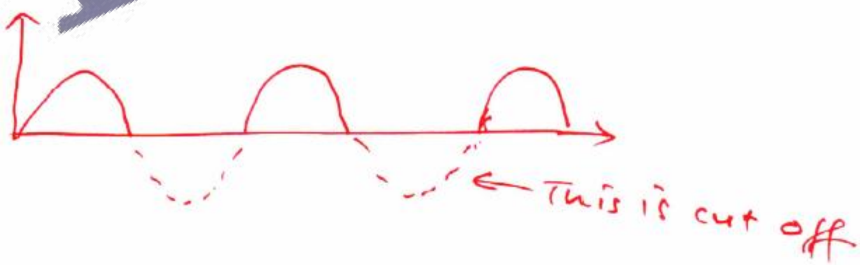


Fig. 10.1

(i) State the name of the type of rectification produced by the diode in Fig. 10.1.

........half-wave rectification........ [1]



(ii) On Fig. 10.2 sketch the variation with time t of the p.d. V_R across R from time t = 0 to time t = 40 ms.

$V_0 = 320V$

$T = 0.02$

$= 20ms.$

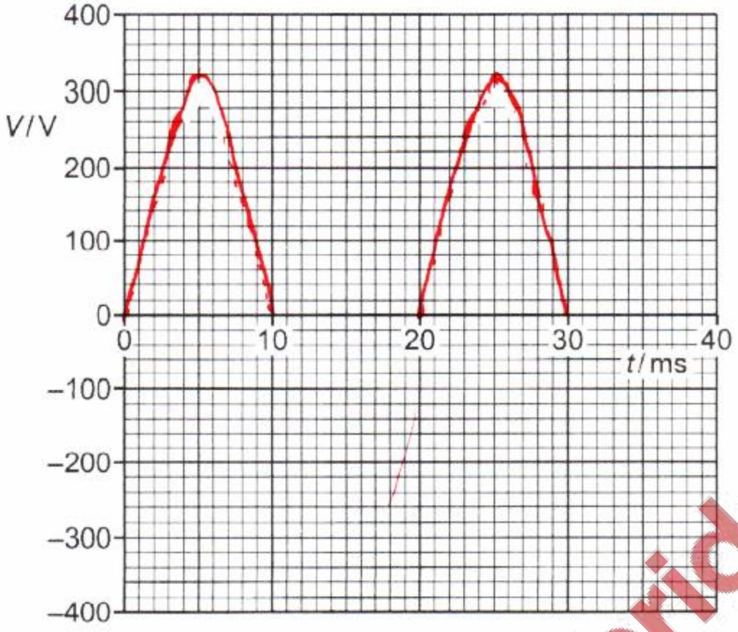


Fig. 10.2

[3]

(iii) On Fig. 10.1, draw the symbol for a component that may be connected to produce smoothing of V_R.

[1]

done by a capacitor.

[Total: 8]