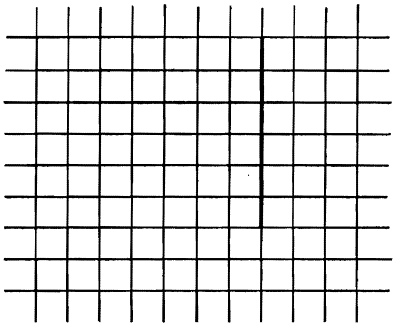
TOPIC 23 Alternating Currents

1 The diagram shows the display on a cathode-ray oscilloscope when a sinusoidal potential difference is applied to the Y-input. The Y-sensitivity is set at 2.00 V per division and the timebase is switched off.



What is the root-mean-square value of the applied p.d.?

A 4.24 V **B** 6.00 V **C** 8.49 V **D** 12.00 V

J76/II/21; J99/I/21

2 Half-wave rectification of an alternating sinusoidal voltage of amplitude 200 V gives the waveform shown in Fig. 1. The r.m.s. value of the rectified voltage is

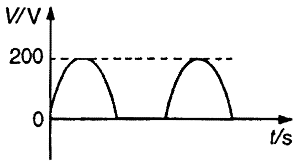


Fig. 1

A 0 V
B 70.7 V
C 100 V
D 141.4 V
E 200 V

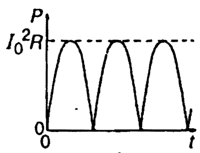
J77/II/23

3 In an ideal transformer, the most important function of the soft-iron core is

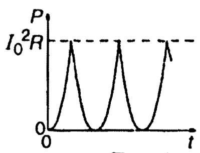
A to reduce eddy currents.
B to improve the flux-linkage between the primary and secondary coils.
C to dissipate the heat generated by the two coils.
D to eliminate the back e.m.f. produced in the secondary.
E to produce a uniform radial field in the two coils.

N78/II/22; J84/II/24

4 An alternating current, $I = I_0 \sin \omega t$, passes through a resistor of resistance R. Which one of the following best represents the variation with time t of the power P dissipated in the resistor?



A



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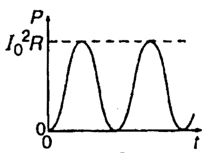

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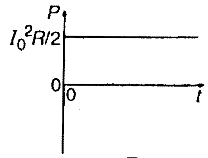

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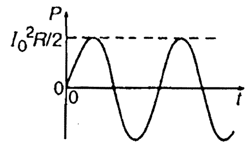


E

J80/II/25

5 An alternating current of r.m.s. magnitude 2A and a steady direct current I flowing through identical resistors dissipate heat at equal rates. What is the value of current I?

A 1A **B** $\sqrt{2A}$ **C** 2A
D $2\sqrt{2A}$ **E** 4A

J81/II/19

6 An ammeter uses the heating effect of a current to produce the deflection of the pointer. The reading, which is proportional to the heating, is X when a direct current I flows through the meter. When inserted in a circuit, in which an alternating current of r.m.s. value I flows, the reading is

A $X / 2$, because the constantly changing current produces a constantly changing heating effect which averages to one half that of the direct current.
B $X / \sqrt{2}$, because it measures r.m.s. current which is obtained by recalibrating the scale for a.c. use by dividing all scale readings by $\sqrt{2}$.
C X, because it measures the r.m.s. current which gives the same deflection on the scale as the direct current.
D $\sqrt{2X}$, because it measures the peak current which is $\sqrt{2}$ times the direct current.
E zero, because the needle cannot follow the fast oscillations of the alternating current and hence registers zero on the scale.

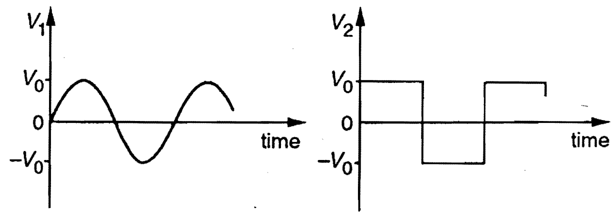
N81/II/17

7 An alternating potential difference is connected across a pure resistor and the frequency of the supply is varied, keeping the r.m.s. voltage constant. The mean rate of production of heat in the resistor is

A proportional to $(\text{frequency})^2$.
B proportional to frequency.
C proportional to $(\text{frequency})^{1/2}$.
D inversely proportional to frequency.
E independent of frequency.

N81/II/24

8 The sinusoidal potential difference V_1 shown in Fig. 2*(a)* applied across a resistor R produces heat at a mean rate W.



(a) **Fig. 2** *(b)*

What is the mean rate of production of heat when the square-ware potential difference V_2 shown in Fig. 2*(b)* is applied across the resistor?

A $W/2$
B W
C $\sqrt{2W}$
D $2W$
E $4W$

J82/II/18

9 An ammeter that uses the heating effect of a current to produce a deflection of the pointer records 10 A when used to measure a direct current. What will the ammeter record when used to measure an alternating current of 10 A r.m.s.?

A 0 A
B 5 A
C 7.1 A
D 10 A
E 14.1 A

N82/II/24; N84/II/23

10 The current balance at a certain national standards laboratory has a force F between a pair of parallel coils (whose separation is constant) when a direct current of one ampere flows in each coil. The direct current is replaced by a sinusoidal alternating current which is adjusted to give a mean force equal to F. What is the r.m.s. current?

A 0.5 A
B $\frac{1}{\sqrt{2}}$ A
C 1 A
D $\sqrt{2}$ A
E 2 A

J84/II/23

11 An ammeter that produces a pointer deflection proportional to the heating effect of a current is correctly calibrated for direct current. What will it read when used to measure an alternating current of 10 A r.m.s.?

A 0 A
B 5 A
C 7.1 A
D 10 A
E 14.1 A

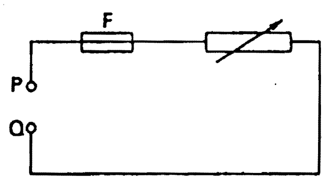
N85/I/20

12 A generator provides an output voltage $V = V_0 \sin 2\pi ft$; the amplitude V_0 is **directly proportional to** f. When the output terminals are connected to a resistor and the frequency is varied, the amplitude of the current is

A inversely proportional to f^2.
B inversely proportional to f.
C independent of f.
D proportional to f.
E proportional to f^2.

J87/I/21

13 When an a.c. supply of 240 V r.m.s. is connected to the terminals PQ in the circuit shown below, the fuse F breaks the circuit if the current just exceeds 13 A r.m.s.



When the a.c. supply is replaced with a 120 V d.c. source, an identical fuse breaks the circuit if the current just exceeds

A $\frac{13}{2}$ A
B $\frac{13}{\sqrt{2}}$ A
C 13 A
D $13\sqrt{2}$ A
E 26 A

J88/I/23

14 The power dissipated in a resistor is the same for a constant potential difference V as for a sinusoidal potential difference with peak value V_0. Which of the following is the correct relationship between V and V_0?

A $V_0 = V/2$
B $V_0 = V/\sqrt{2}$
C $V_0 = V$
D $V_0 = \sqrt{2}\,V$
E $V_0 = 2\,V$

J89/I/21

15 A steady current I dissipates a certain power in a variable resistor. The resistance has to be halved to obtain the same power when a sinusoidal alternating current is used.

What is the r.m.s. value of the alternating current?

A $\frac{1}{2} I$
B $\sqrt{\frac{1}{2}}\, I$
C I
D $\sqrt{2}\, I$
E $2I$

N90/I/20

16 A sinusoidal current is represented by the equation

$$I = I_0 \sin(\theta t)$$

Which equation represents the sinusoidal current with both its frequency and amplitude doubled?

A $2I = I_0 \sin(2\theta t)$
B $I = I_0 \sin(2\theta t)$
C $I = 2I_0 \sin(2\theta t)$
D $I = I_0 \sin(\frac{1}{2}\theta t)$
E $I = 2I_0 \sin(\frac{1}{2}\theta t)$

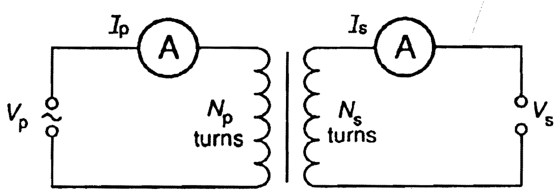
J91/I/19

17 The function of a mains transformer is to convert

A one direct voltage to another direct voltage of different magnitude.
B one alternating voltage to another alternating voltage of different magnitude.
C a high value alternating voltage to a low value direct voltage.
D a low value alternating voltage to a high value direct voltage.

J92/I/21; N95/I/19

18 In a laboratory experiment to test a transformer, a student used the circuit shown in the diagram to take measurements.



Two of the original entries in the student's results table are missing as shown;

V_P / V	I_P/mA	N_P turns	V_S / V	I_S/mA	N_S turns
240	2.0	?	?	50	50

Assuming the transformer was 100% efficient, what are the missing results?

	N_P *turns*	V_S / V
A	2	6000
B	50	9.6
C	480	1.0
D	1250	9.6
E	1250	240

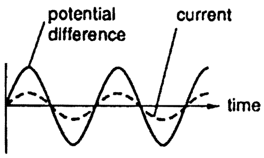
J93/I/20

19 A sinusoidal alternating current of peak value I_0 passes through a heater of resistance R. What is the mean power output of the heater?

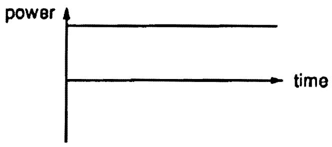
A $\frac{I_0^2R}{2}$ **B** $\frac{I_0^2R}{\sqrt{2}}$ **C** I_0^2R **D** $\sqrt{2}\,I_0^2R$ **E** $2I_0^2R$

N93/I/18

20 The variation with time of the current through, and of the potential difference across, a resistor are shown below.



Which graph best represents the variation with time of the power dissipated in the resistor?

A


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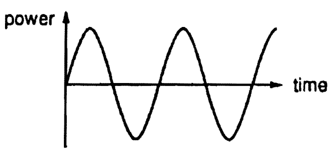

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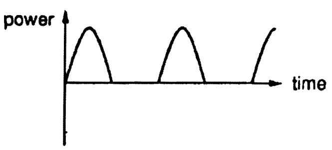

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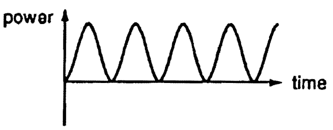


N94/I/20

21 An alternating current I/A varies with time t/s according to the equation

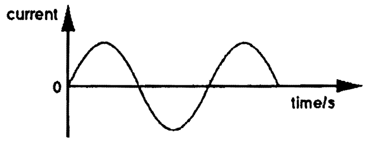
$$I = 5 \sin (100\pi t).$$

What is the **mean** power developed by the current in a resistive load of resistance 10 Ω?

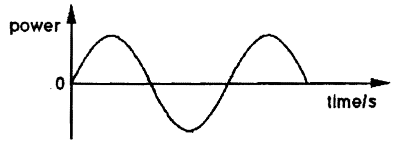
A 125 W **B** 160 W **C** 250 W **D** 500 W

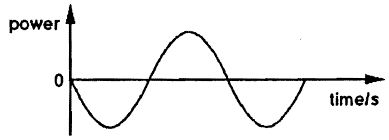
N95/I/20

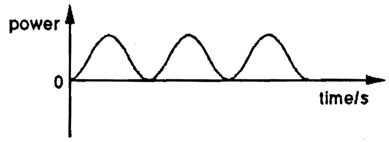
22 An alternating current flows through a resistor. The variation with time of this current is shown.

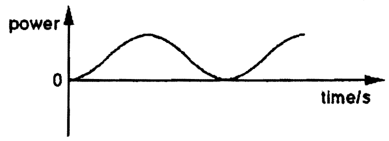


Which graph shows the variation with time of the power dissipated in the resistor?

A


B


C


D


N96/I/21

23 An a.c. supply is connected to a resistor. When the peak value of the e.m.f. of the supply is V_0 and the frequency is f, the mean power dissipated in the resistor is P. The supply frequency is then changed to $2f$, the peak value of the e.m.f. remaining as V_0.

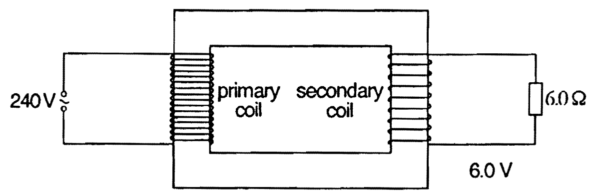
What is now the mean power in the resistor?

A P **C** $2P$

B $\sqrt{2}P$ **D** $4P$

J97/I/20

24 The diagram shows an iron-cored transformer assumed to be 100% efficient. The ratio of the secondary turns to the primary turns is 1:20.



A 240 V, a.c. supply is connected to the primary coil and a 6.0 Ω resistor is connected to the secondary coil.

What is the current in the primary coil?

A 0.10 A C 2.0 A
B 0.14 A D 40 AJ 97/I/21

25 An ideal transformer has N_P turns in its primary coil and N_S turns in its secondary coil. The alternating voltage and current in the primary coil are V_P and I_P respectively: the corresponding voltage and current in the secondary are V_S and I_S.

Which of the following relations is correct?

A $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_S}{I_P}$ C $\frac{N_S}{N_P} = \frac{V_P}{V_S} = \frac{I_S}{I_P}$

B $\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_P}{I_S}$ D $\frac{N_S}{N_P} = \frac{V_P}{V_S} = \frac{I_P}{I_S}$

N98/I/20

26 There is a sinusoidal alternating current in a resistor.

What is the mean power dissipated in the resistor?

A $\frac{1}{\sqrt{2}}$ (maximum current)^2

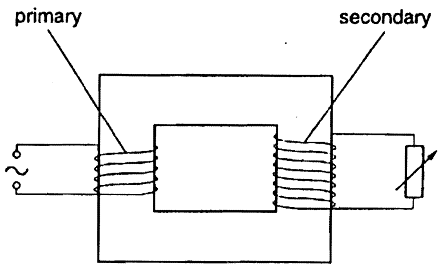
B $\frac{1}{\sqrt{2}}$ (maximum power)

C $\frac{1}{2}$ (maximum current)^2

D $\frac{1}{2}$ (maximum power) N99/I/19

27 The primary coil of a transformer is connected to an alternating voltage supply. The secondary coil is connected across a variable resistor.

Which change will cause a decrease in the p.d. across the secondary coil?



A increasing the cross-sectional area of the secondary coil
B increasing the current in the primary coil
C increasing the number of turns of the primary coil
D increasing the resistance of the variable resistor

N99/I/20

28 A mains electricity supply has a root-mean-square voltage of 240 V and a peak voltage of 340 V. When connected to this supply, a heater dissipates energy at a rate of 1000 W.

The heater is then connected to a 340 V d.c. supply and its resistance remains the same.

At what rate does the heater now dissipate energy?

A 1000 W C 2000 W
B 1400 W D 2800 W N2000/I/21

29 A coil is rotated at a constant rate in a uniform magnetic field. The peak value of the e.m.f. induced in the coil is 10 V. Find *(a)* the r.m.s. value of the e.m.f., *(b) the instantaneous* value of the e.m.f. one-quarter of a period after the e.m.f. is a maximum. N77/I/6

30 A certain type of ammeter uses the heating effect of the current to produce the deflection of the pointer. Discuss whether the same calibration can be used for measuring direct currents and alternating currents. J78/I/7

31

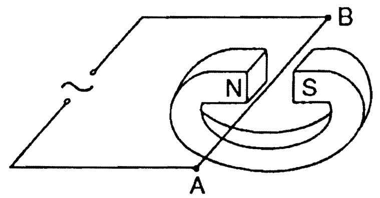


Fig. 3

A copper wire is stretched between two fixed points A and B and carries an alternating current of frequency *f*.

Describe and explain what will happen if a magnet is arranged to apply a strong magnetic field perpendicular to the central portion of the wire, as shown in Fig. 3. N79/I/7

32

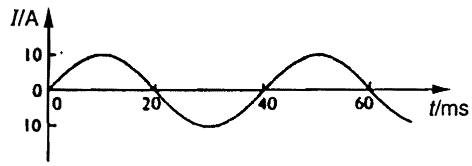


Fig. 4

Fig. 4 shows the way in which a sinusoidally-alternating current varies with time. Find *(a)* the amplitude of the current, *(b)* its r.m.s. value, *(c)* the frequency of the supply, *(d)* the phase change that occurs in a time interval of 15 ms.

N82/I/8

33

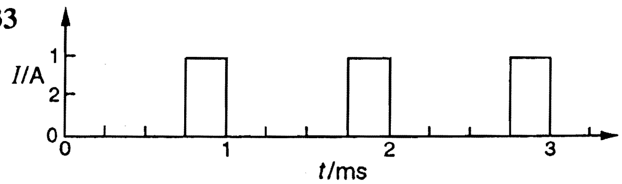


Fig. 5

Fig. 5 shows (in part) the variation with time of a periodic current.

(a) What is the average value of the current?

(b) Find the root-mean-square current.

The periodic current passes through a resistor, producing heat at a certain rate.

(c) What steady current, passing through the same resistor, would have an identical heating effect? J83/I/10

34 An alternating current is described by the equation $I = I_0 \sin \omega t$. On the same axes of time *t*, sketch graphs of *(a)* I, *(b)* I^2. Label your graphs clearly. What are the average values, over a complete cycle, of I and I^2? N84/I/7

35 The circuit shown in Fig. 6 contains a pure resistor in series with an a.c. supply.

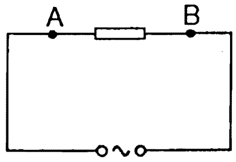


Fig. 6

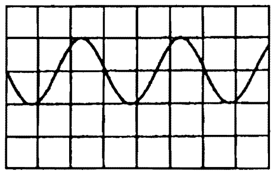


Fig. 7

A cathode ray oscilloscope is connected between the points A and B. When the Y-amplifier is set to "2 V/cm" and the timebase control to "0.5 ms/cm" the trace shown in Fig. 7 is obtained on the screen, which is ruled with a graticule of 1 cm squares. Deduce

(a) the r.m.s. potential difference across the resistor,

(b) the frequency of the a.c. supply. J86/II/5

36 A signal generator produces either *(a)* a sinusoidal or *(b)* a square wave with the same peak value of e.m.f., as illustrated in Fig. 8.

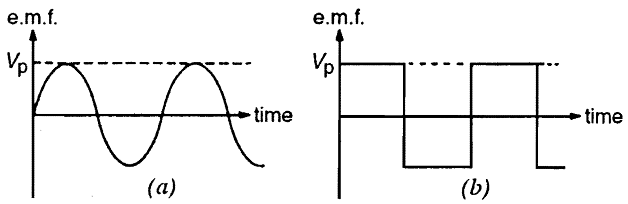


Fig. 8

Showing your working, determine, for a pure resistive load, the ratio

$$\frac{\text{mean power in case } (a)}{\text{mean power in case } (b)}$$ J86/III/7

37 When a domestic electric heater is operated from a 240 V a.c. supply, an r.m.s. current of 8.0 A flows.

Assuming that the heater is purely resistive, calculate

(a) its resistance,

(b) the mean power,

(c) the maximum instantaneous power. [6]
J89/III/6

38 *(a)* An electric kettle, designed for travellers, can be used with different supply voltages. It is rated at 700 W for a 240 V r.m.s. alternating supply. What will be its power output if used on

(i) a 120 V r.m.s. alternating supply,

(ii) a 120 V direct supply? [5]

(b) Draw a labelled diagram of a transformer which could be used to step up a 120 V alternating supply to 240 V. [4]
N90/II/5

39 *(a)* Explain why it is necessary to use *high* voltages for the efficient transmission of electrical energy. [3]

(b) Explain why it is advantageous to use *alternating* current when transmitting electrical energy. [2]
N95/II/6 (part)

40 *(a)* Describe the structure and principle of operation of an iron-cored transformer.

(b) A graph of the power input to a transformer is shown in Fig.9.

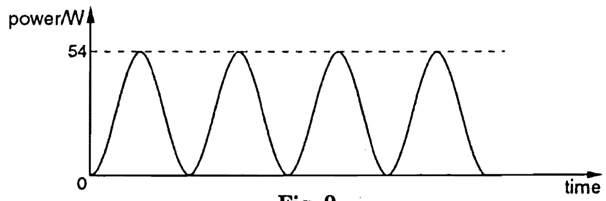


Fig. 9

The transformer has a turns ratio of N_S / N_P = 30 and the sinusoidal input voltage has a value of 6 V r.m.s. For the transformer, assumed to be ideal, calculate

(i) the r.m.s. value of the output voltage,

(ii) the mean power input (= the mean power output),

(iii) the r.m.s. value of the input current,

(iv) the r.m.s. value of the output current. [5]
J96/II/4

41 *(c)* In a transformer, the core on which the primary and secondary coils are wound is laminated, i.e. the core is made up of a large number of strips, rather than being solid. This reduces energy losses due to currents induced in the core. Explain

(i) how these currents arise in the core,

(ii) why laminating the core reduces energy losses due to the currents. [5]
J97/II/3 (part)

42 *(a)* An alternating current varies with time in the way shown in Fig. 10.

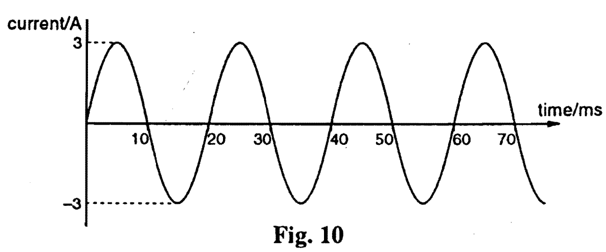


Fig. 10

Use the graph to determine, for this alternating current,

(i) the frequency,

frequency =.......................... Hz

(ii) the peak value,

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

(iii) the root-mean-square value.

root-mean-square value =...................... A [3]

(b) On Fig. 10 sketch a graph which shows how the power supplied by this current to a resistor of resistance 5Ω varies with time. Label the vertical axis as power and mark on this axis the maximum value of the power. [3]

(c) The current shown in Fig. 10 is in the 300 turn primary of an ideal transformer. The secondary of the transformer has 6000 turns. Calculate the transformer's peak output current.

peak output current =...................... A [2]

N97/II/6

43 Electrical power of 4400 kW is supplied to an industrial consumer at a considerable distance from a generating station. This is represented in Fig. 11.

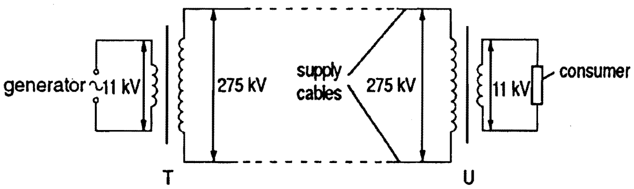


Fig. 11

In order to do this, the electricity supply company makes use of a circuit containing two transformers, T and U. The transformers can be considered to be ideal and the supply cables to have negligible resistance.

(a) The power is generated at 11 kV r.m.s. and is supplied to the consumer at 11 kV r.m.s. Calculate the r.m.s. current supplied to the consumer.

current = ... A [2]

(b) There is a potential difference of 275 kV r.m.s. between the supply cables.
Calculate

(i) the ratio N_S / N_P required for each transformer,

N_S / N_P for transformer T = ...
N_S / N_P for transformer U = ...

(ii) the current in the supply cables.

current = ... A r.m.s. [3]

(c) Explain why, when the resistance of the supply cables cannot be neglected, this arrangement is preferable to a system which generates and transmits the power at the same voltage of 11 kV r.m.s. [2]

(d) (i) Explain the distinction between the r.m.s. value and the peak value of an alternating current.

(ii) Find the peak value of the current in *(a)*.

current = ... A [3]

J98/II/5

Long Questions

44 An electric lamp, enclosed in a box with a photocell, first has a direct current passed through it and then an alternating current of r.m.s. value equal to that of the direct current. Discuss whether you would expect the photo-electric current to be the same in the two cases. J77/III/5(part)

45

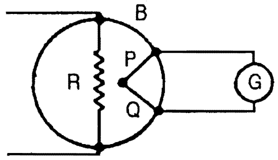


Fig. 12

In Fig. 12, B is an evacuated bulb containing a resistor R which is insulated electrically from, but in good thermal contact with, a circuit of two dissimilar metals P and Q and a galvanometer G. Explain how such a device may be used to calibrate an a.c. ammeter, if a calibrated d.c. meter is available. Sketch and label a suitable circuit diagram.

J79/III/2 (part)

46 An electrical appliance is operated from a 240 V, 50 Hz supply. Sketch a graph, with suitable values marked on the axes, to illustrate how the potential difference across the appliance varies with time. J85/III/3 (part)

47 A cathode-ray oscilloscope (c.r.o.) is connected across the input of a transformer and the appearance of the screen is as shown in Fig. 13. The squares in the diagram are all of side one centimetre.

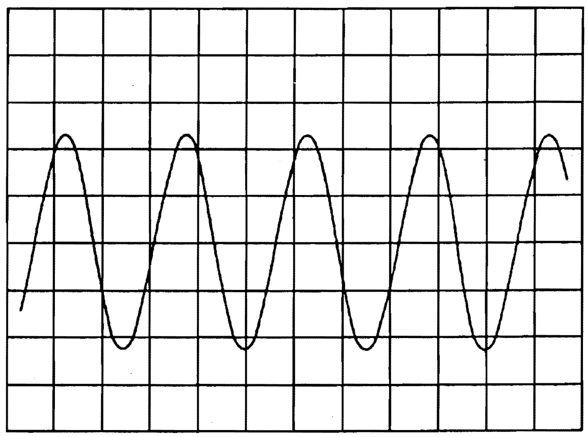


Fig. 13

The Y-plate sensitivity is set at 5 Vcm^{-1} and the timebase is set so that the horizontal deflection is 2 ms cm^{-1} (milliseconds per centimetre).

(a) For the alternating potential difference applied to the Y-plates, deduce values of the following quantities:

(i) period,

(ii) frequency,

(iii) peak value of potential difference,

(iv) root-mean-square value of potential difference. [6]

(b) Draw a circuit diagram showing the input to the transformer, the output from the transformer, and connections to the c.r.o. [3]

(c) The transformer, assumed ideal, has 120 turns on its primary winding and 840 turns on its secondary winding. State how these two values are related to the input and output r.m.s. potential differences. Use your statement to calculate the output r.m.s. potential difference. [2]

*(d) (i) Draw a circuit diagram showing how four diodes can be used to give full wave rectification of the transformer output. [2]

(ii) Briefly explain how rectification is achieved. [2]

(iii) Add to your circuit a component which would smooth the rectified output. [1]

(iv) Suggest, with reasons, a suitable value for the component introduced in (iii) if the output potential difference is not to vary by more than 1% when a current of 200 mA is drawn from the rectified output. [4] N92/III/4

48 (c) An output of 20 V r.m.s. from a coil consisting of many loops similar to the one described in *(b)* is connected to the primary of an ideal transformer. The transformer has 60 turns on its primary winding and 1800 turns on its secondary. The output current from the transformer is 0.042 A r.m .s. Calculate, for the transformer,

(i) the r.m.s. output voltage,

(ii) the mean output power,

(iii) the maximum output power,

(iv) the r.m.s. input current. [8]

(d) Explain why the transmission of electrical energy in national distribution systems is carried out with alternating current and with a high voltage. [4]

N94/III/4 (part)

Rectification

49

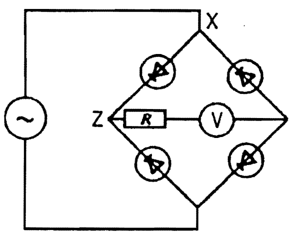


Fig. 14

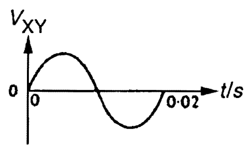
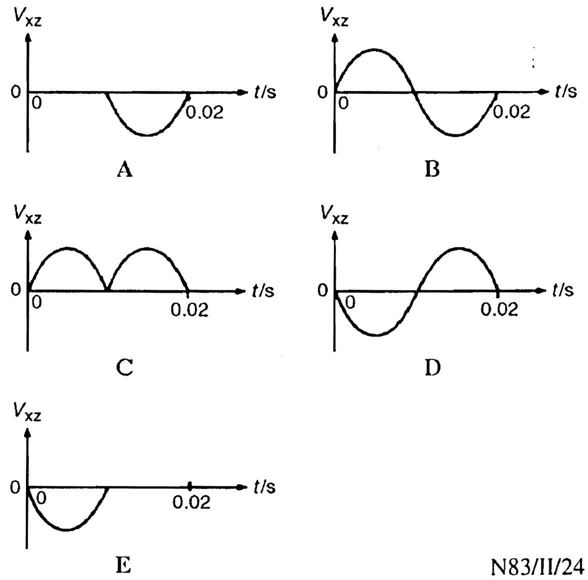


Fig. 15

The circuit (Fig. 14) represents a bridge rectifier arrangement for a voltmeter to measure alternating voltages. The graph in Fig. 15 shows the variation over one cycle of the potential of X with respect to Y.

Which one of the following graphs best represents the corresponding variation of the potential of X with respect to Z?



N83/II/24

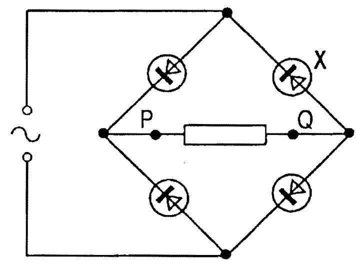
50 A sinusoidal alternating supply is connected across the terminals of a resistor causing energy to be dissipated at a mean rate *P*. A diode having zero resistance in the forward direction and infinite resistance in the reverse direction is inserted in the circuit in series with the resistor.

What is the new rate of energy dissipation?

A zero B $\frac{P}{4}$ C $\frac{P}{2\sqrt{2}}$

D $\frac{P}{2}$ E $\frac{P}{\sqrt{2}}$ N88/I/22

51 The circuit shows a bridge rectifier with a sinusoidal alternating voltage applied to it, the output terminals P and Q being joined together by a load resistor.



If the diode **X** were removed leaving a break in the circuit, which trace would be seen on a cathode-ray oscilloscope connected across PQ?

A 

B 

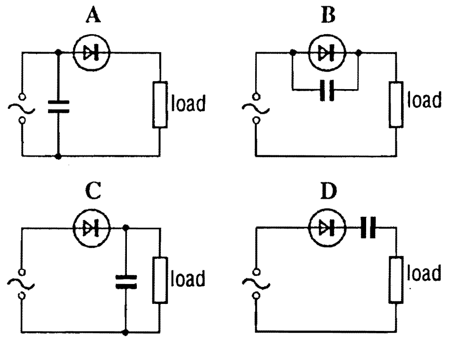
C 

D

J89/I/22; J96/I/21

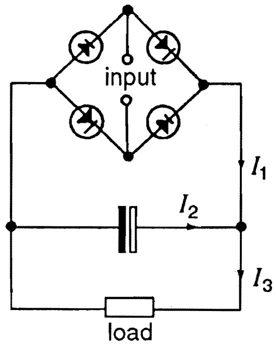
52 A capacitor is to be used to provide smoothing for a half-wave rectifier.

In which circuit is the capacitor correctly connected?

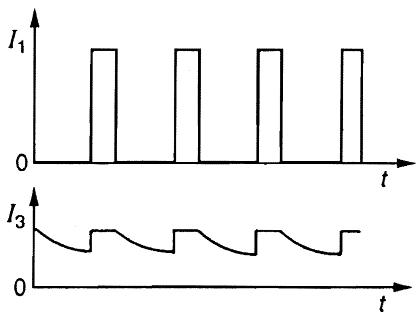


N89/I/22; J2000/I/21

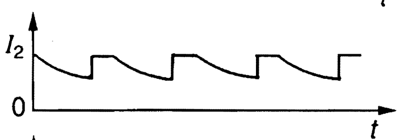
53 The circuit diagram shows a full-wave rectifier with a smoothing capacitor.



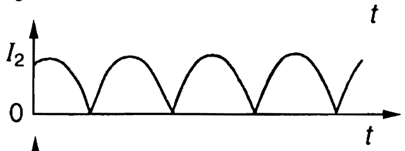
The currents I_1 and I_3 vary with time as shown below. Which of the graphs **A–E** best represents the variation with time of the current I_2?



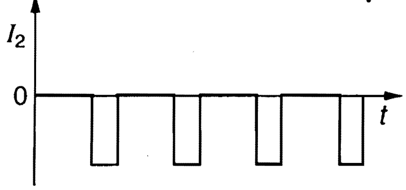
A



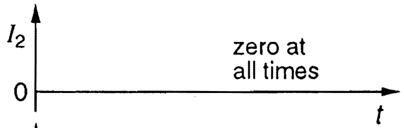
B



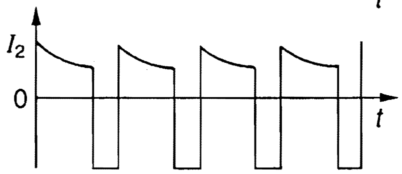
C



D

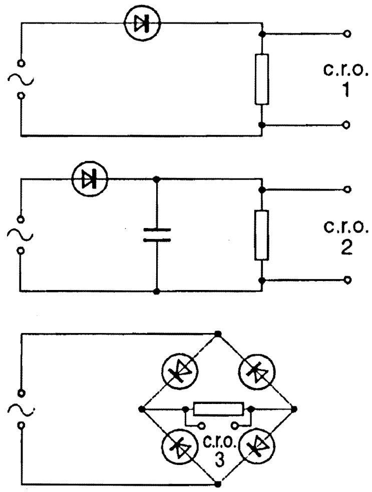


E



J90/I/21

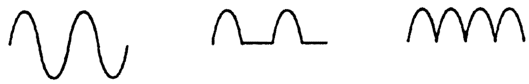
54 The diagram shows three circuits used to rectify an alternating current. A cathode-ray oscilloscope (c.r.o.) with fixed settings of time-base and Y-gain is connected in turn as shown and produces a different trace in each case.



Which set of diagrams shows these traces most accurately?

c.r.o. 1 c.r.o. 2 c.r.o. 3

A



B

C

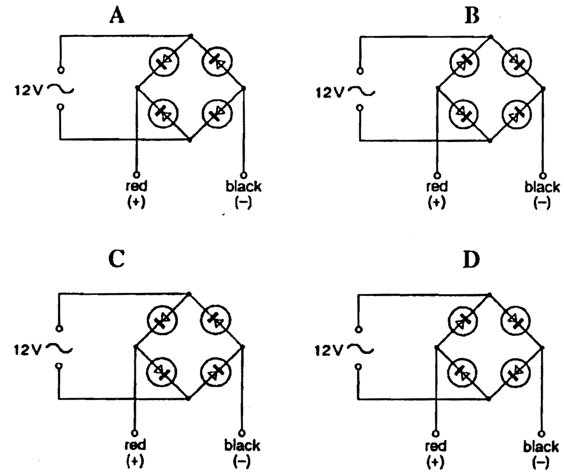
D

N91/I/21; J95/I/20

55 Some students were given the following instructions.

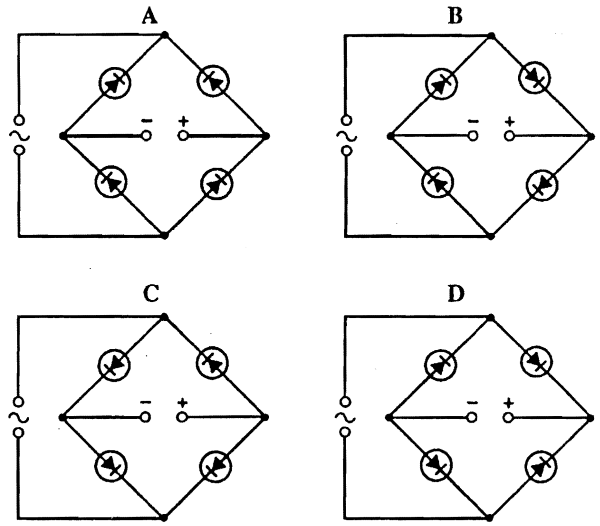
'Design a circuit to give a full-wave rectified output from a low-voltage alternating supply. The positive output must be connected to a red terminal and the negative output to a black terminal.'

Which circuit satisfies these design instructions?



J94/I/19; J98/I/20

56 Which circuit correctly shows the connection of the diodes in a bridge rectifier?



N97/I/20

57 The output from a 50 Hz full-wave rectifier is fed into a resistive load of 5 kΩ. Sketch a graph to show how the current through the load varies with time when a capacitor of capacitance 1 μF is connected in parallel with the load.
N85/III/6

58 Connected across the output terminals of a 50 Hz full-wave rectifier is a capacitor C of capacitance 200 μF and a load resistor R (see Fig. 16)

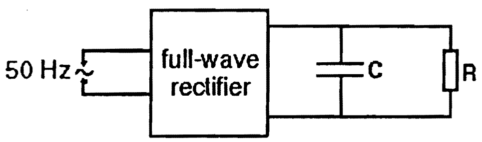


Fig. 16

Sketch graphs, one in each case, to indicate the variation of potential difference across the load with time when the load is approximately

(a) 1000 Ω, *(b)* 50 Ω. J87/III/4

59 A full-wave rectifier provides an output potential difference of 6.0 V (r.m.s.) when on open circuit.

A capacitor of capacitance 25 μF is connected between the output terminals of the rectifier. What is the maximum energy stored in the capacitor? [5]
N88/III/4

60 In the circuit of Fig. 17, the output of the generator is a 200 Hz, 2.5 V r.m.s. sinusoidal signal. The diode may be assumed to be ideal. The Y-plate sensitivity and time-base of the cathode-ray oscilloscope (c.r.o.) are set at 2.0 V cm^{-1} and 1.0 ms cm^{-1} respectively.

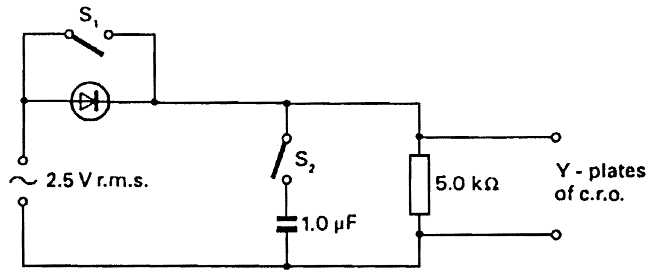


Fig. 17

Sketch full-scale diagrams to show the waveform observed when

(a) S_1 is closed and S_2 is open, [4]

(b) S_1 and S_2 are both open, [2]

(c) S_1 is open and S_2 is closed. [3] J91/II/4

61 *(c)* Using a diagram, describe and explain the use of four diodes in a bridge rectifier for the full-wave rectification of an alternating current. [3]
N95/II/6 (part)

62 In the circuit of Fig. 18, the four diodes A, B, C and D are connected to form a bridge rectifier. The diodes may be assumed to be ideal.

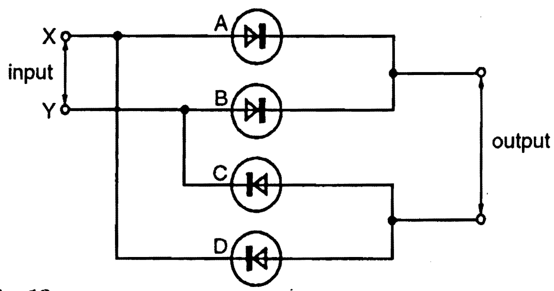


Fig. 18

(a) (i) On Fig. 18, mark with a + the positive output terminal.

(ii) State which diodes do not conduct when input terminal X is positive with respect to input terminal Y. [2]

(b) The input terminals X and Y are connected to the secondary coil of an ideal transformer. The primary coil is connected to a 240 V r.m.s. alternating supply. The input to the bridge rectifier is to be 12 V r.m.s.

(i) What is the value of the ratio

$$\frac{\text{number of turns on secondary coil}}{\text{number of turns on primary coil}}?$$

(ii) An ideal diode does not conduct when a potential difference is connected in one direction across the diode. The maximum potential difference which can be applied in this direction across a real diode before it conducts is known as the breakdown voltage of the diode. Calculate the minimum breakdown voltage of the diodes in Fig. 18 if the circuit is to function correctly. [5]

N96/II/4

63 Fig. 19 is the circuit diagram for a half-wave rectifier. The supply to the rectifier is rated as 50 Hz, 6.0 V r.m.s.

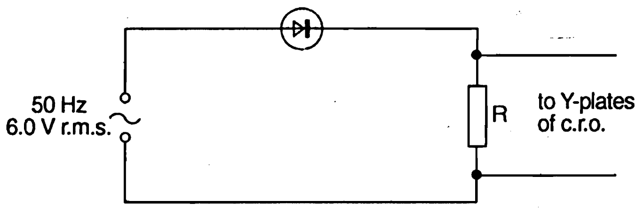


Fig. 19

A cathode-ray oscilloscope (c.r.o.) has its Y-plates connected across the load resistor R and the trace of Fig. 20 is seen.

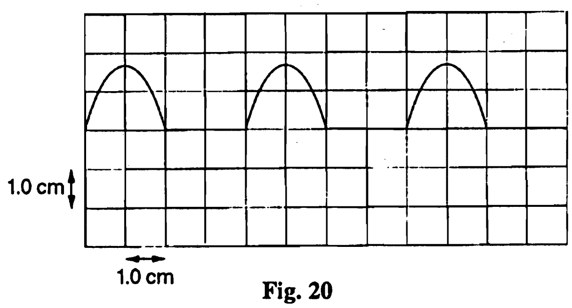


Fig. 20

(a) Calculate the Y-plate sensitivity of the c.r.o.

sensitivity = ... V cm^{-1} [3]

(b) On Fig. 20, draw a line to represent the trace seen when the connections to the diode in Fig. 19 are reversed. [3]

N98/II/4

64 The primary coil of a transformer has 1000 turns and is connected to a 230 V r.m.s. supply. The secondary coil has 40 turns and may be connected, through a switch and a diode, to a 9.0 V rechargeable battery, as illustrated in Fig. 21.

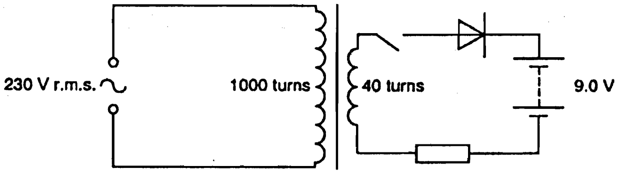


Fig. 21

(a) Initially the switch is open. Considering both the transformer and the diode to be ideal, calculate

(i) the r.m.s. potential difference across the secondary,

(ii) the peak potential difference across the secondary. [4]

(b) The switch is now closed so that the battery is being recharged.

(i) Suggest why the diode is necessary in the secondary circuit.

(ii) Suggest why the resistor is necessary in the circuit. [4]

J2000/II/5

Long Questions

65 A sinusoidal alternating p.d. is applied to a uniform metre wire AB as shown in Fig. 22.

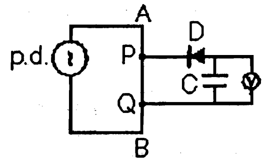


Fig. 22

In this circuit, C is a capacitor of capacitance *C*, D is an ideal diode and V is a d.c. voltmeter. The distance PQ is 30 cm. The voltmeter reads 2 V. Assuming that the capacitance *C* and the resistance R of the voltmeter are large,

(a) discuss whether the voltmeter reads the r.m.s., the peak, or the mean value of the p.d. across PQ,

(b) calculate the r.m.s. value of the p.d. applied to the metre wire AB,

(c) explain why the product *RC* must be large.

J78/III/4 (part)

66 In the circuit shown in Fig. 23, E is a sinusoidal a.c. generator of frequency *f* connected to four ideal diodes and a resistor R. P and Q are connected to the *Y*-plates of a cathode-ray oscilloscope.

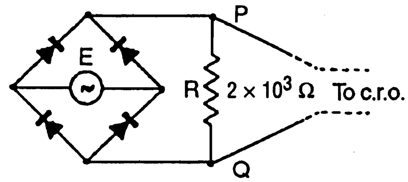


Fig. 23

Discuss the polarities of P and Q. Draw diagrams showing the appearance of the trace on the c.r.o.

(a) with no timebase,

(b) with timebase of frequency f,

(c) with timebase of frequency $2f$,

(d) with timebase of frequency $f/3$.

If the Y-sensitivity of the c.r.o. is 20 V cm^{-1} and the maximum height of the trace in *(a)* is 3.0 cm, calculate the power dissipated in the resistor R if its resistance is $2 \times 10^3\ \Omega$. Explain your calculation carefully.

N78/III/4(part)

67 *(b)* (i) Draw a diagram to show how four diodes may be used to produce a bridge rectifier for full-wave rectification of an alternating current. Indicate clearly the input and output terminals of the bridge and the direction of the current in each of the diodes during one half cycle of the alternating input. [4]

(ii) The output of a simple battery charger is a full-wave rectified sinusoidal voltage of r.m.s. value 2.0 V. The battery to be charged has e.m.f. 1.5 V and is connected as shown in Fig. 24. The battery receives charge only when the output voltage of the rectifier is greater than 1.5 V.

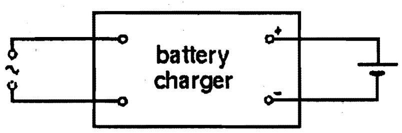


Fig. 24

For what fraction of the total time is the battery being charged? [6]

J90/III/4 (part)