

Easy Questions

1 (a) State the meaning of rectification.

Answer

Rectification is defined as:

- The process of converting alternating current (a.c) into direct current (d.c); [1 mark]

[Total: 1 mark]

(1 mark)

(b) The graph in Fig. 1.1 shows the voltage output from an alternating current supply.

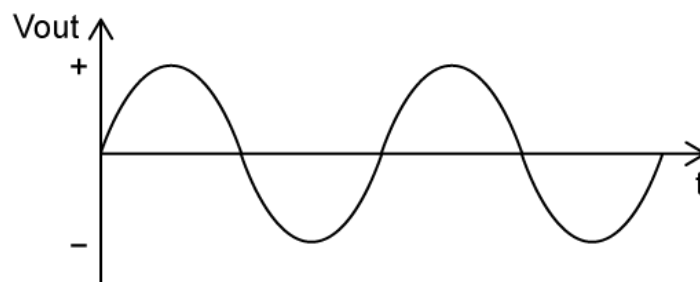


Fig. 1.1

Sketch the variation with time t of the output voltage when the following are applied:

(i) Half-wave rectification



[2]

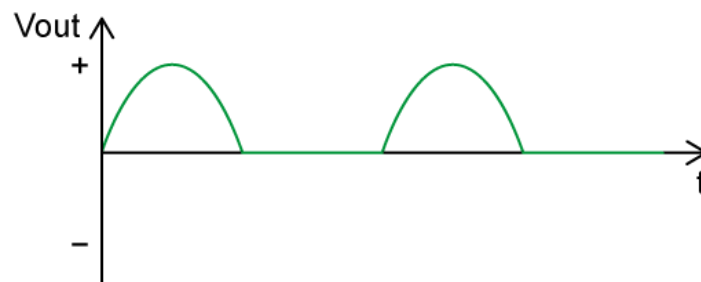
(ii) Full-wave rectification



[2]

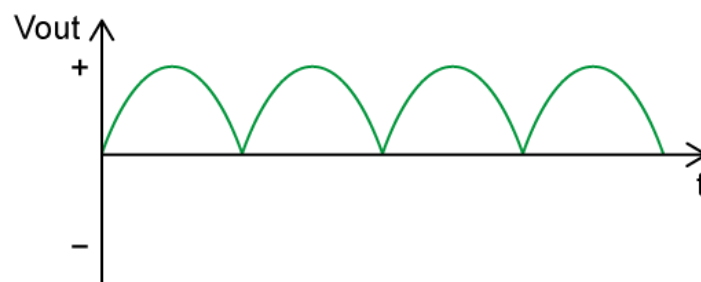
Answer

(i) The output of half-wave rectification is as follows:



- Peaks at the same height; [1 mark]
- Output alternates between peaks in the positive direction and zero output; [1 mark]

(ii) The output of full-wave rectification is as follows:



- Peaks at the same height; [1 mark]
 - All peaks in the positive direction; [1 mark]
-

[Total: 4 marks]

(4 marks)

- (c) In rectification, a smoothing capacitor is often necessary. The resulting graph of the output current against time gives a 'ripple' shape, as shown in Fig. 1.2.



Fig. 1.2

State how the 'ripples' in the graph can be reduced.

Answer

The 'ripples' in the graph can be reduced by using:

- A capacitor with greater capacitance; [1 mark]
- A (load) resistor with a larger resistance; [1 mark]

[Total: 2 marks]

This mark scheme requires **two** answers for full marks. Although this is not necessarily stated in the question, it is indicated by the number of marks. A good exam technique is to check the number of marks in the question and make sure you have that many separate points in your answer to gain them!

(2 marks)

- (d) The circuit in Fig. 1.3 shows a diode bridge rectifier connected to an alternating power

supply.

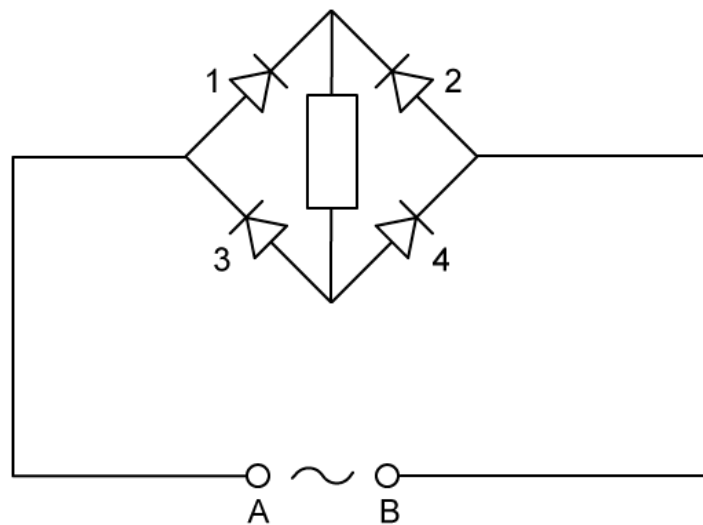


Fig. 1.3

State the diodes that will conduct when

(i) A is positive

[1]

(ii) B is positive.

[1]

Answer

(i) When A is positive:

- Diodes 1 and 4 conduct; [1 mark]

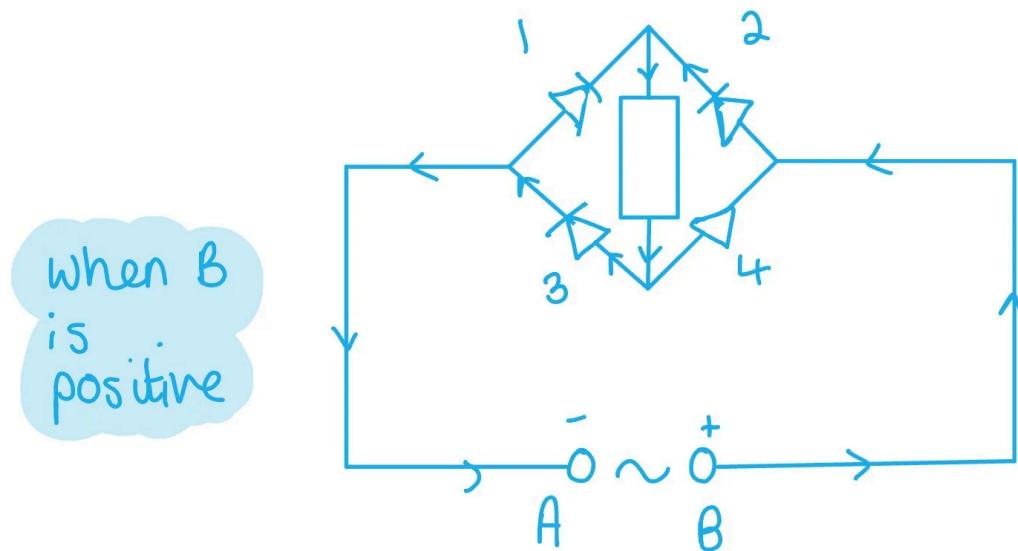
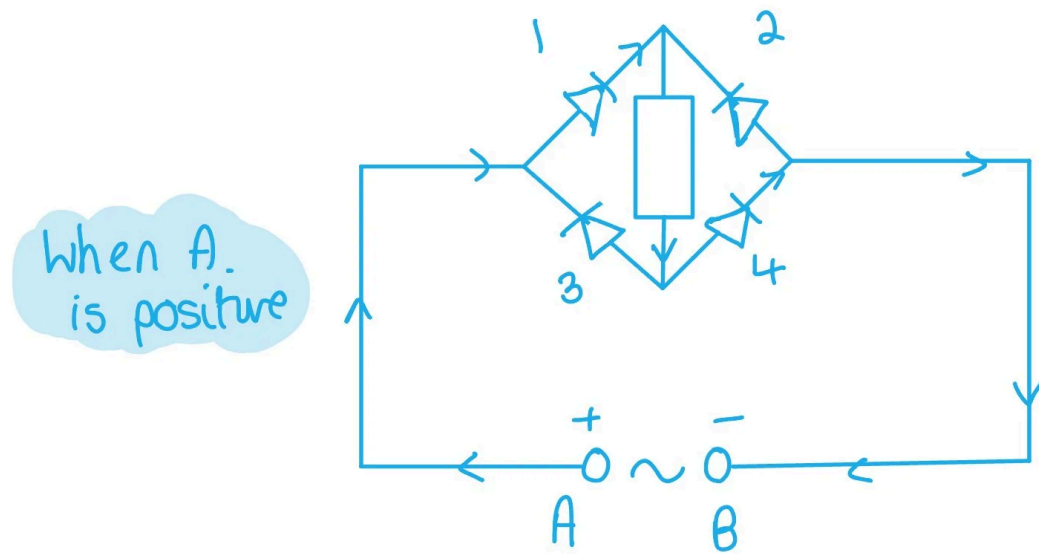
(ii) When B is positive

- Diodes 2 and 3 conduct; [1 mark]

[Total: 2 marks]

This can be a little tricky to work out but it is not using any more knowledge than you're aware of already. The important thing to remember is that a diode only allows

current to flow in **one** direction. Therefore, the current takes a different path through different diodes depending on whether A or B is positive.



(2 marks)

- 2 (a)** Alternating current (a.c.) is converted into direct current (d.c.) using a full-wave rectification circuit. Fig. 1.1. shows part of this circuit.

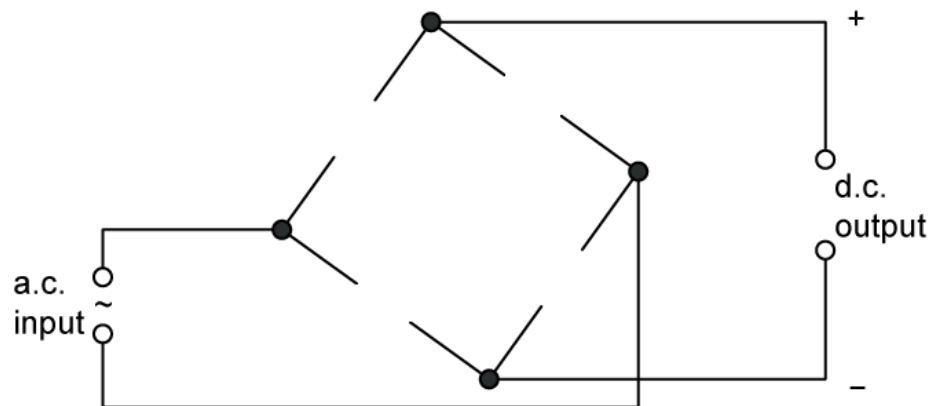
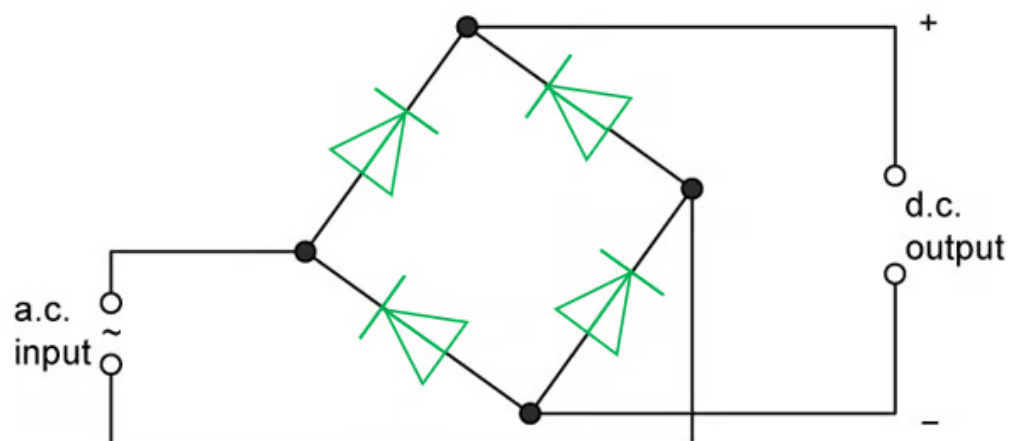


Fig. 1.1

On Fig. 1.1, draw the missing diode symbols that would produce the polarity across the d.c. output as shown on the diagram.

Answer

The correct circuit diagram is as follows:



- All four diodes are added correctly to give an output; [1 mark]
- All diodes pointing in the correct direction to give the correct polarity; [1 mark]

[Total: 2 marks]

(2 marks)

(b) The polarity of the d.c. output is reversed, as shown in Fig. 1.2.

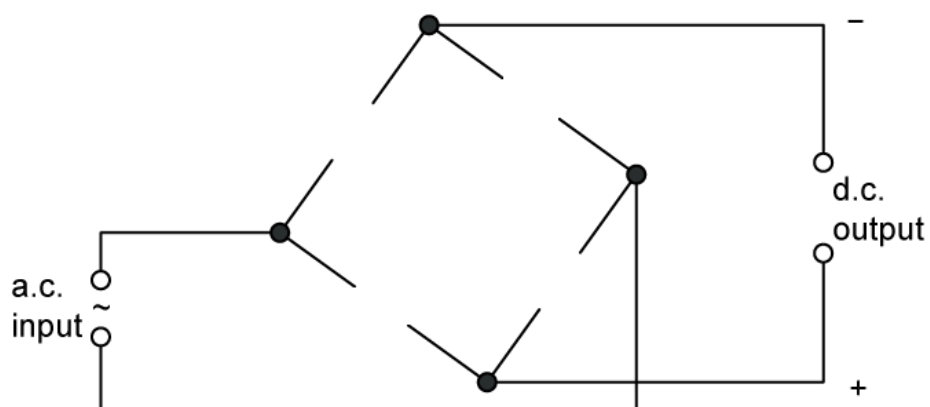
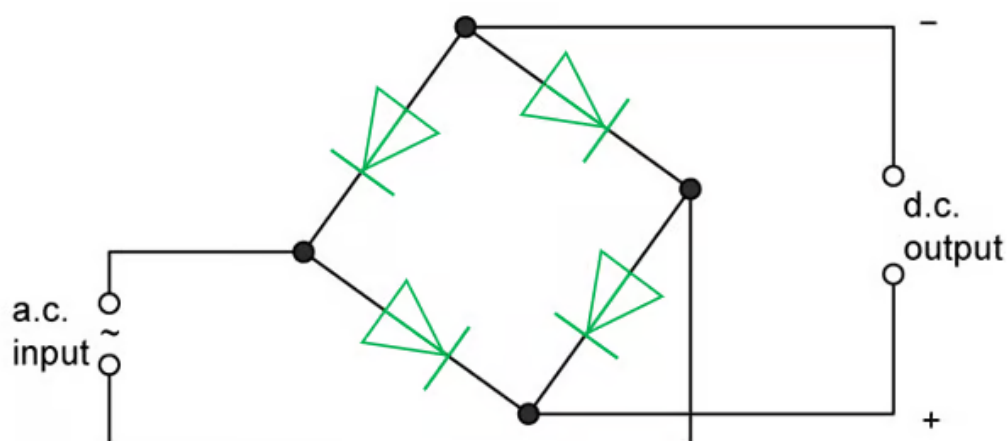


Fig. 1.2

On Fig. 1.2, draw the missing diode symbols that would produce the polarity across the d.c. output as shown on the diagram.

Answer

The correct circuit diagram is as follows:



- All four diodes are added correctly to give an output; [1 mark]
- All diodes pointing in the correct direction to give the correct polarity; [1 mark]

[Total: 2 marks]

(2 marks)

(c) (i) State what is meant by smoothing.

[1]

(ii) On Fig. 1.2, draw the symbol for a capacitor connected to provide smoothing of the potential difference across the d.c. output.

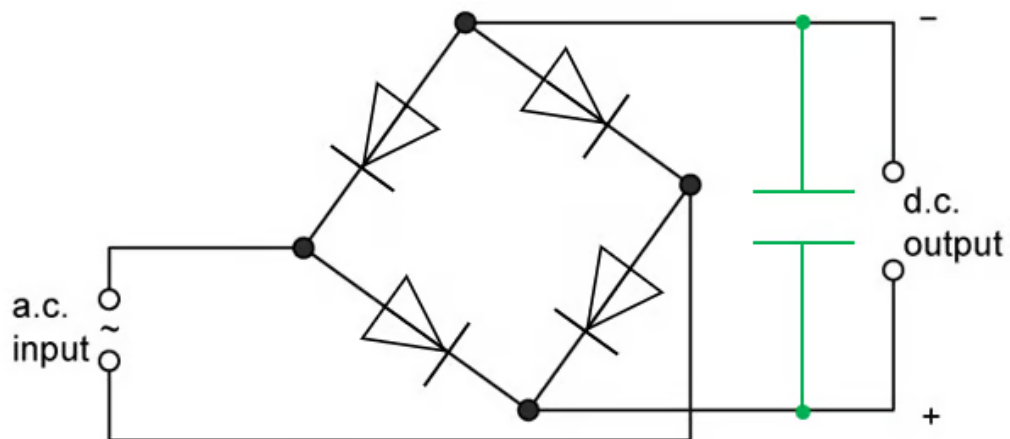
[1]

Answer

(i) Smoothing is defined as:

- The reduction in the variation of the output voltage / current; [1 mark]

(ii) The capacitor is connected as follows:



- Correct symbol, connected in parallel with d.c. output; [1 mark]

[Total: 2 marks]

(2 marks)

(d) Fig. 1.3 shows the variation with time t of the smoothed potential difference V across the

d.c. output.

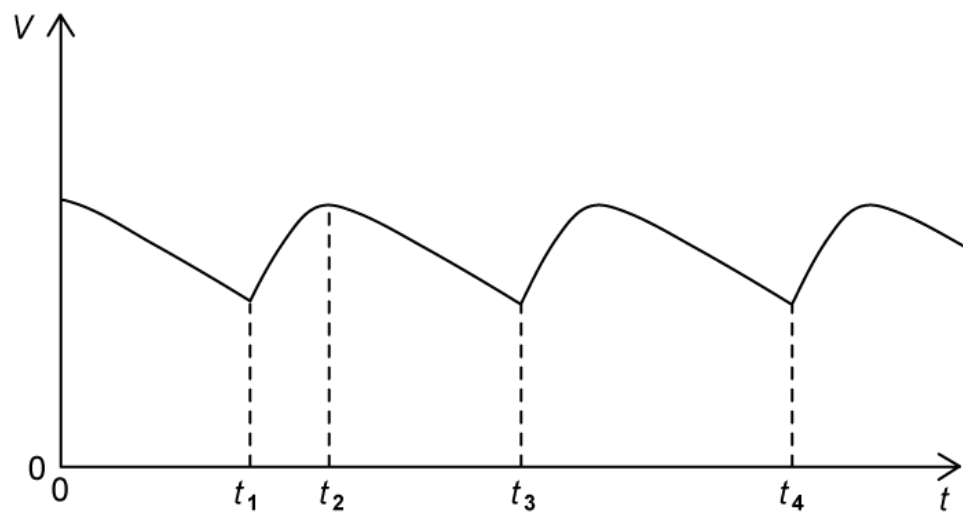


Fig. 1.3

Using Fig. 1.3, state the interval of time during which the capacitor is being charged.

Answer

The capacitor is charged from:

- Time t_1 to time t_2 ; [1 mark]

[Total: 1 mark]

(1 mark)

Medium Questions

- 1 (a)** Fig. 1.1 shows four diodes and a load resistor of resistance, $2.4\text{ k}\Omega$, connected in a circuit that is used to produce rectification of an alternating voltage.

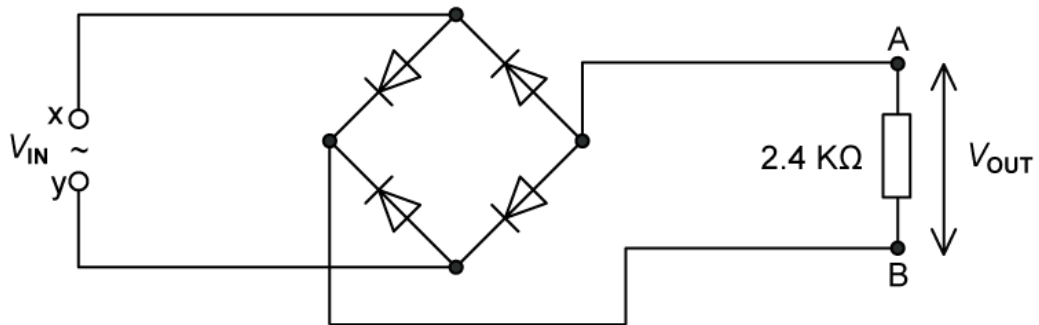


Fig. 1.1

- (i) State what is meant by rectification.

[1]

- (ii) State the type of rectification produced by the circuit in Fig. 1.1

[1]

Answer

- (i) Rectification is the:

- Conversion from a.c. to d.c.; [1 mark]

- (ii) The circuit in Fig. 1.1 produces:

- Full-wave rectification; [1 mark]

[Total: 2 marks]

(2 marks)

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

$$V_{IN} = 3.0 \sin (20 \pi t)$$

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

- (i) Label the output terminals A and B, on Fig. 1.1, with the appropriate symbols to indicate the polarity of the output voltage V_{OUT} .

[1]

- (ii) The magnitude of the output voltage V_{OUT} varies with t as shown in Fig. 1.2

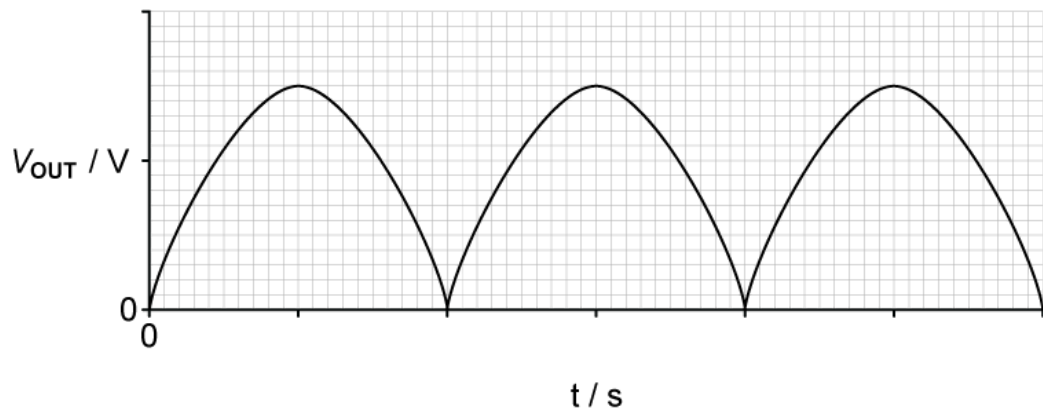


Fig. 1.2

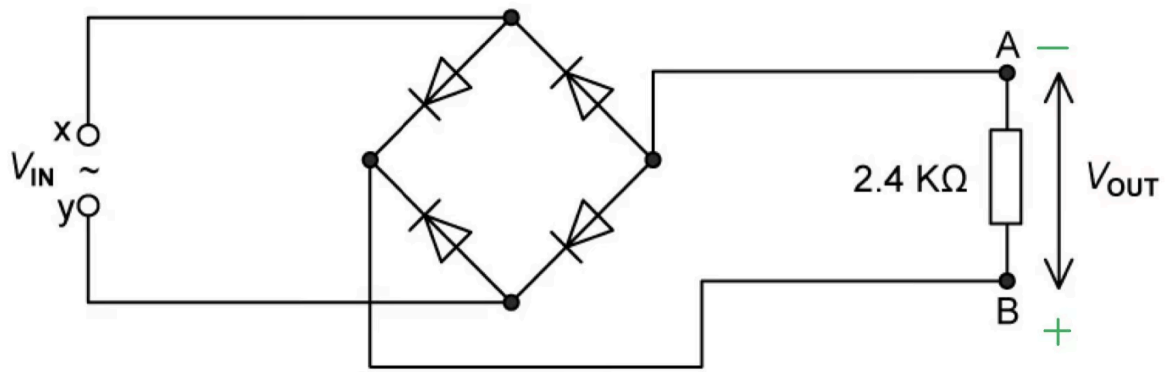
Label both the axis with the correct scales on Fig. 1.2. Use the space below for any working that you need.

[3]

Answer

- (i) A correctly labelled diagram showing the polarity of the output terminals A and B that

should earn 1 mark would look like this:



- A labelled – **and** B labelled +; [1 mark]

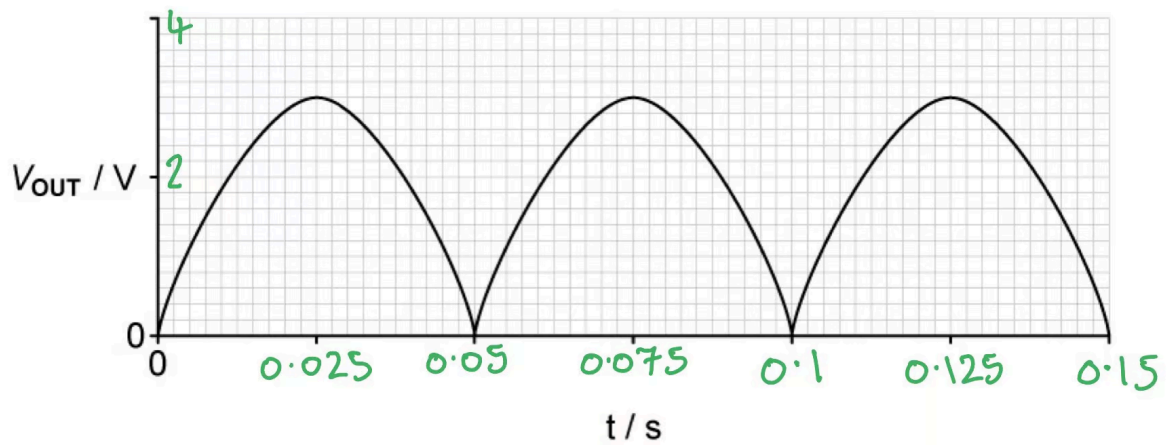
(ii) A correctly labelled axis on Fig. 1.2 that would score 3 marks should look like this:

List the known quantities from the equation:

- Max $V_{OUT} = 3.0\text{ V}$
- Angular frequency, $\omega = 20\pi$

Use the angular frequency equation to calculate the time period of the a.c.:

- $T = \frac{2\pi}{\omega}$
- $T = \frac{2\pi}{20\pi} = \frac{1}{10}$
- $T = 0.1\text{ s}$ [1 mark]

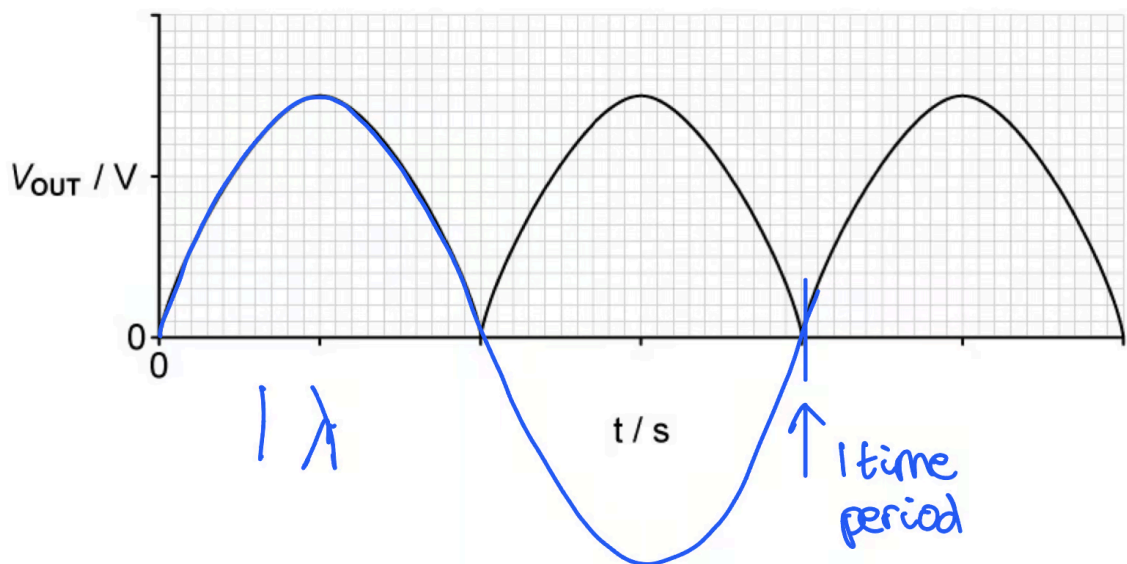


- V_{OUT} scale labelled 2 and 4 on the tick marks; [1 mark]
- t scale labelled 0.025, 0.05, 0.075, 0.1, 0.125 and 0.15 on the tick marks; [1 mark]

[Total: 4 marks]

The graph shows the **rectified wavelength**. To work out one wavelength **trace** it with your **hand** as if it hasn't been rectified,

the wave will go up, down and then back to where it came from



(4 marks)

(c) The output voltage in (b) is smoothed by adding a capacitor to the circuit in Fig. 1.1.

The difference between the maximum and minimum values of the smoothed output voltage is 15% of the peak voltage.

(i) On Fig. 1.1, draw the circuit symbol for a capacitor showing the capacitor correctly connected into the circuit.

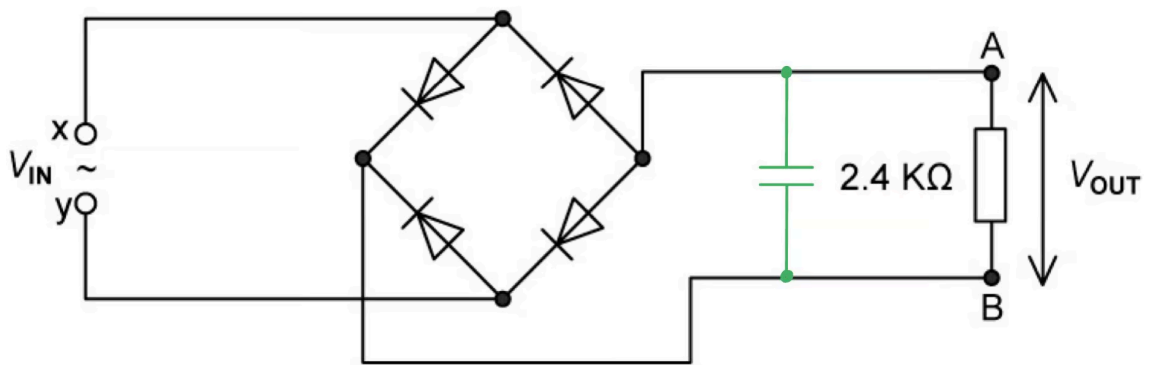
[1]

(ii) On Fig. 1.2, sketch the variation with t of the smoothed output voltage.

[2]

Answer

(i) A capacitor correctly drawn onto the circuit is as follows:

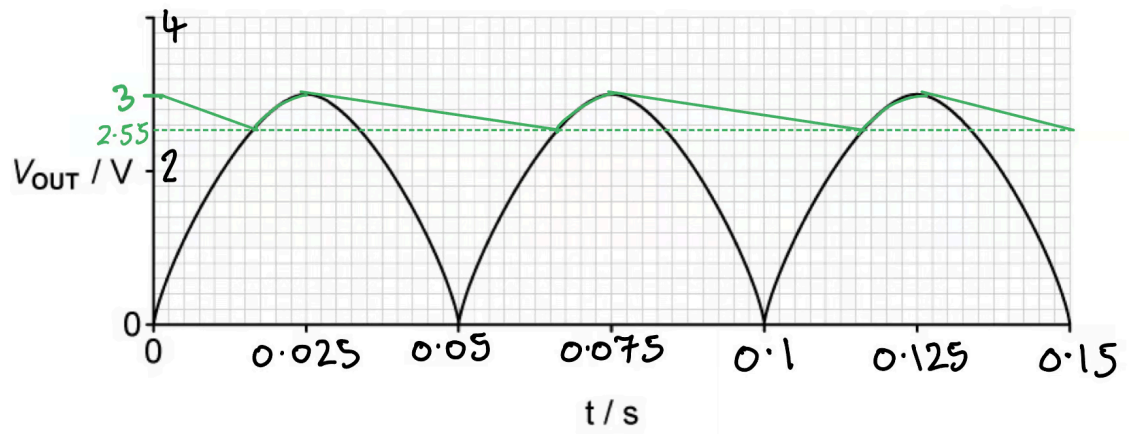


- Correct symbol used for capacitor, and the capacitor is connected in parallel with the $2.4\text{ k}\Omega$ resistor; [1 mark]

(ii) The graph of the smooth output voltage that should score 2 marks would look like this:

Calculate 15% of the peak voltage:

- $3 \times 0.15 = 0.45$
- So, the peak voltage falls by 0.45 V to 2.55 V



- Straight line sections (between the peak voltage and reduced voltage) have a negative gradient **AND** are drawn as shown; [1 mark]
- The lines between adjacent curves show a drop in p.d. of 45 V / just over 2 small squares; [1 mark]

[Total: 3 marks]

(3 marks)

- 2 (a)** A sinusoidal alternating potential difference (p.d.) from a supply is rectified using a single diode. The variation with time t of the rectified potential difference V is shown in Fig. 5.1.

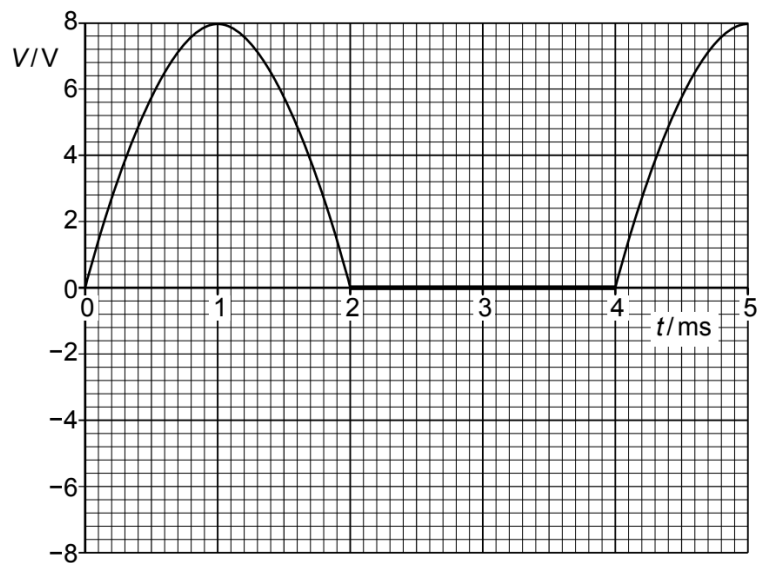


Fig. 5.1

- (i) Determine the root-mean-square (r.m.s.) value of the supply potential difference before rectification.

r.m.s. potential difference = V [2]

- (ii) State the type of rectification shown in Fig. 5.1.

[1]

Answer

- (i) Determine the root-mean-square (r.m.s.) value of the supply potential difference before rectification:

Draw lines on the graph to obtain a value for the peak voltage, V_0 :

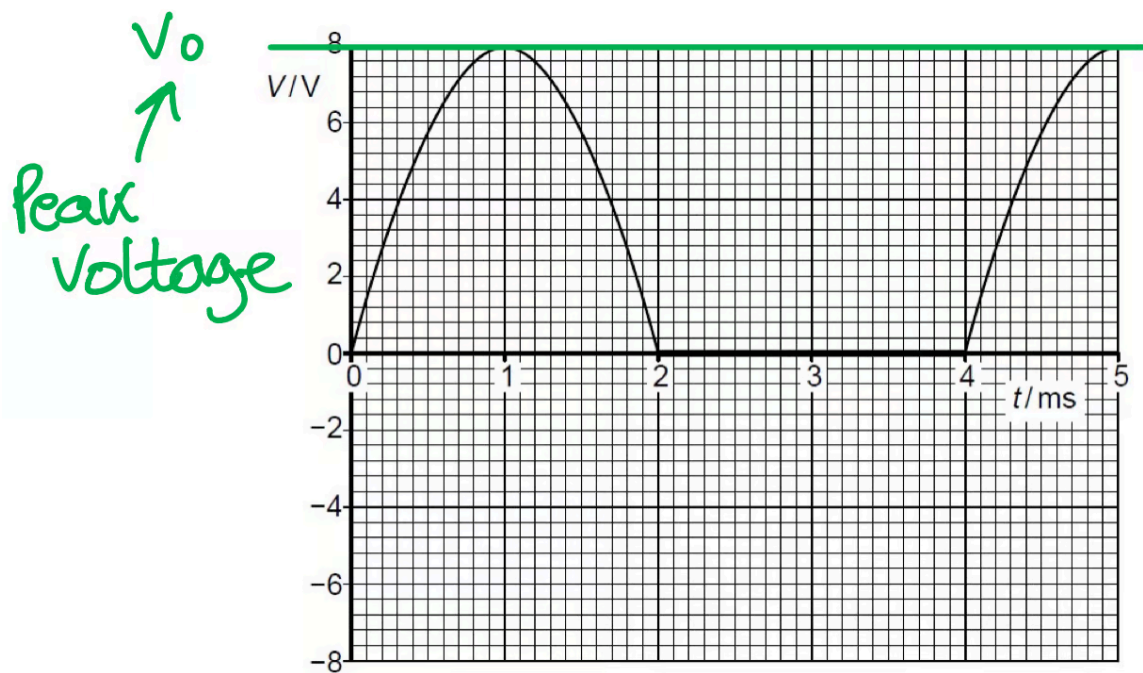


Fig. 5.1

- Peak voltage, $V_0 = 8.0 \text{ V}$

Recall the expression for $V_{r.m.s}$ and V_0 :

- $V_{r.m.s} = \frac{V_0}{\sqrt{2}}$ [1 mark]

Substitute the peak voltage into the equation and calculate $V_{r.m.s}$:

- $V_{r.m.s} = \frac{8}{\sqrt{2}}$
- $V_{r.m.s} = 5.66 \text{ V} = 5.7 \text{ V (2s.f.)}$ [1 mark]

(ii) State the type of rectification shown in Fig. 5.1:

- This is half-wave rectification; [1 mark]

[Total: 3 marks]

(3 marks)

- (b) The alternating potential difference is rectified and smoothed using the circuit in Fig. 5.2.

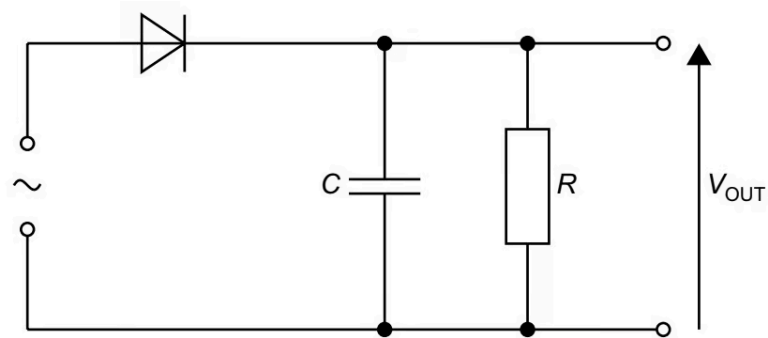


Fig. 5.2

The capacitor has capacitance C of $85\ \mu\text{F}$ and the resistor has resistance R .

The effect of the capacitor and the resistor is to produce a smoothed output potential difference V_{OUT} . The difference between maximum and minimum values of V_{OUT} is $2.0\ \text{V}$.

- (i) On Fig. 5.1, draw a line to show V_{OUT} between times $t = 1.0\ \text{ms}$ and $t = 5.0\ \text{ms}$.

[3]

- (ii) Determine the time, in s, for which the capacitor is discharging between times $t = 1.0\ \text{ms}$ and $t = 5.0\ \text{ms}$.

time = s [1]

- (iii) Use your answers in (b)(i) and (b)(ii) to calculate the resistance R .

$R = \dots\dots\dots\ \Omega$ [2]

Answer

(i) A graph that would score 3 marks:

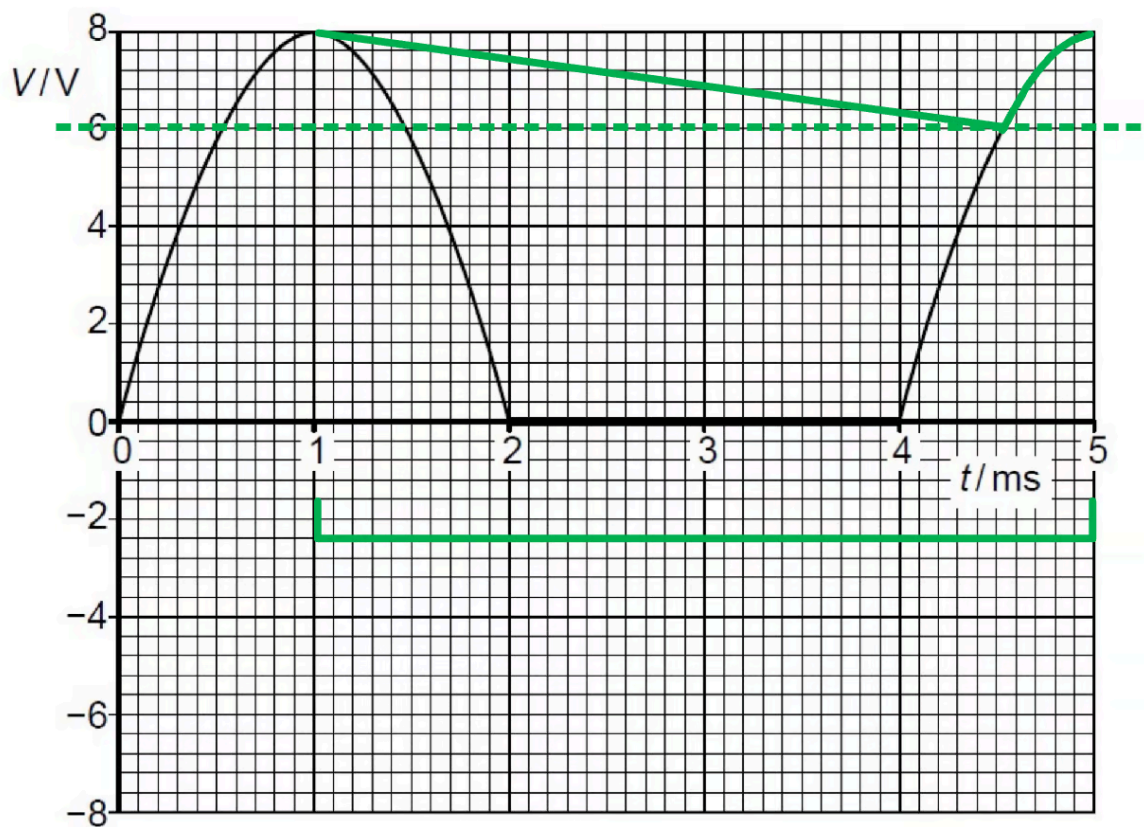


Fig. 5.1

- The minimum potential difference is $8.0 - 2.0 = 6.0$ V; [1 mark]
- Straight line drawn from peak V_0 at $t = 1.0$ ms to minimum (non-zero) value where it meets the printed line after 4.0 ms; [1 mark]
- The printed curve is followed to its peak at 5.0 ms; [1 mark]

(ii) Determine the time, in s, for which the capacitor is discharging between times $t = 1.0$ ms and $t = 5.0$ ms:

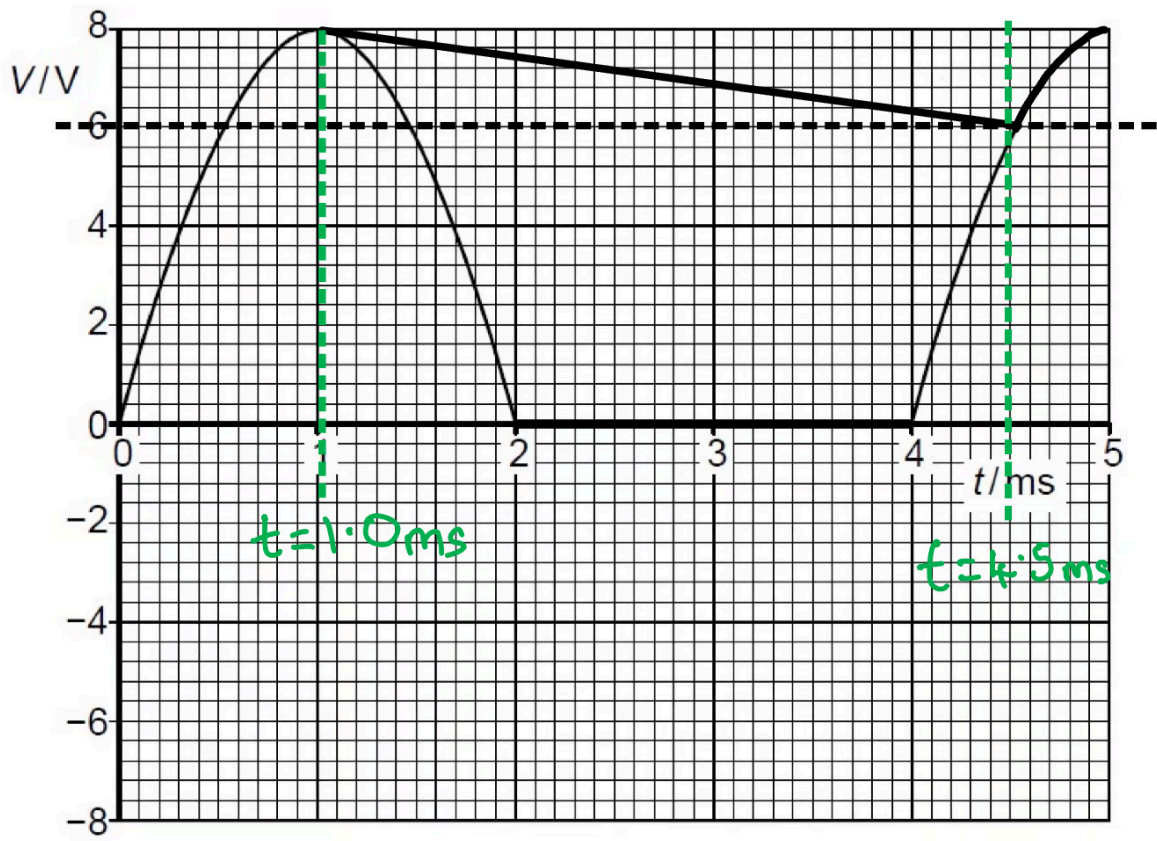


Fig. 5.1

- From the graph:
 - The capacitor begins discharging at $t = 1.0$ ms
 - The capacitor stops discharging at $t = 4.5$ ms
- $\Delta t = 4.5 - 1.0 = 3.5$ ms $= 3.5 \times 10^{-3}$ s [1 mark]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to calculate the resistance R :

List the known quantities:

- Output voltage, $V = 6.0$ V

- Peak voltage, $V_0 = 8.0 \text{ V}$
- Time to discharge = time constant, $\tau = 3.5 \times 10^{-3} \text{ s}$
- Capacitance of the capacitor, $C = 85 \text{ }\mu\text{F} = 85 \times 10^{-6} \text{ F}$

Use the capacitor discharge equation in terms of voltage:

- $V = V_0 e^{-\frac{\tau}{RC}}$ [1 mark]

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

- $\ln\left(\frac{V}{V_0}\right) = -\frac{\tau}{RC}$

- $R = \frac{-\tau}{C \ln\left(\frac{V}{V_0}\right)}$

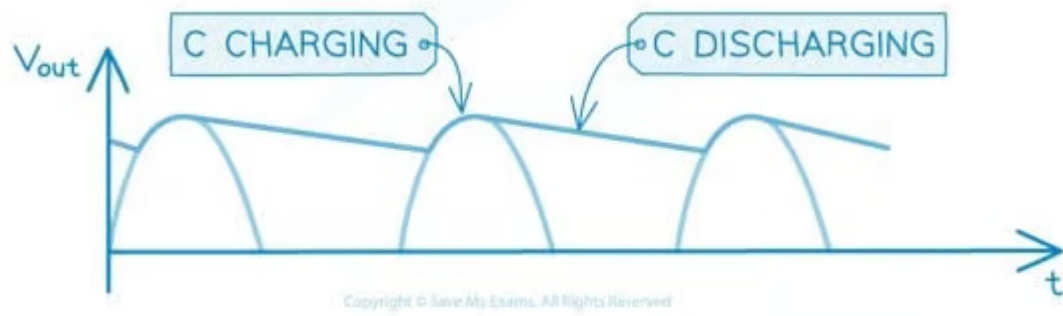
Substitute the known quantities into the equation:

- $R = \frac{-(3.5 \times 10^{-3})}{(85 \times 10^{-6}) \ln\left(\frac{6}{8}\right)}$ [1 mark]

- $R = 143 \text{ }\Omega = 140 \text{ }\Omega \text{ (2 s.f.)}$ [1 mark]

[Total: 6 marks]

- A **smoothing capacitor** connected in **parallel** with the load resistor creates a **smooth output voltage** V_{out} against time
 - The graph looks like this:
-



(6 marks)

3 (a) An investigation into rectification used the circuit shown in Fig. 1.1.

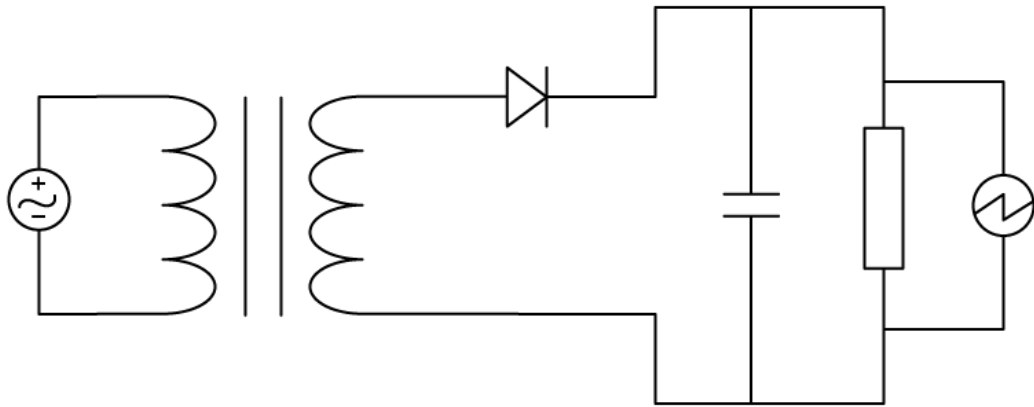
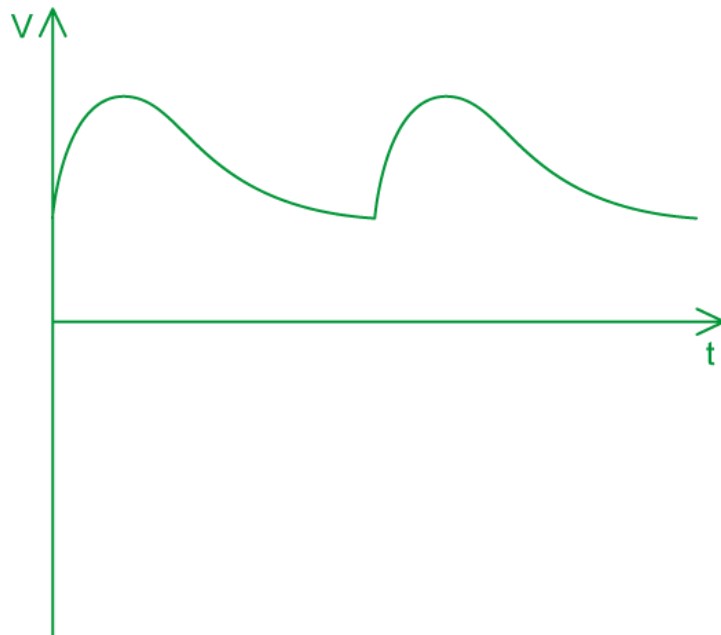


Fig. 1.1

Sketch the expected variation of the output voltage with time for the circuit in Fig. 1.1.

Answer

The expected voltage output with time is as follows:



- Graph shows half-wave rectification (power supplied every half cycle, same positive peak values); [1 mark]
- Graph shows smoothing (same peak value at start of discharge, same shape in each curve); [1 mark]

[Total: 2 marks]

You should be able to identify parts of the circuit to determine the level of rectification and if the output will undergo smoothing

- The circuit only includes **one diode** so this will produce **half-wave rectification**
- The circuit contains a **capacitor**, so the output will show **smoothing** of the peaks

This graph and the reasoning behind it are key in this topic. Make sure you understand both!

(2 marks)

(b) A modification is made to the circuit to include a bridge rectifier, as shown in Fig. 1.2.

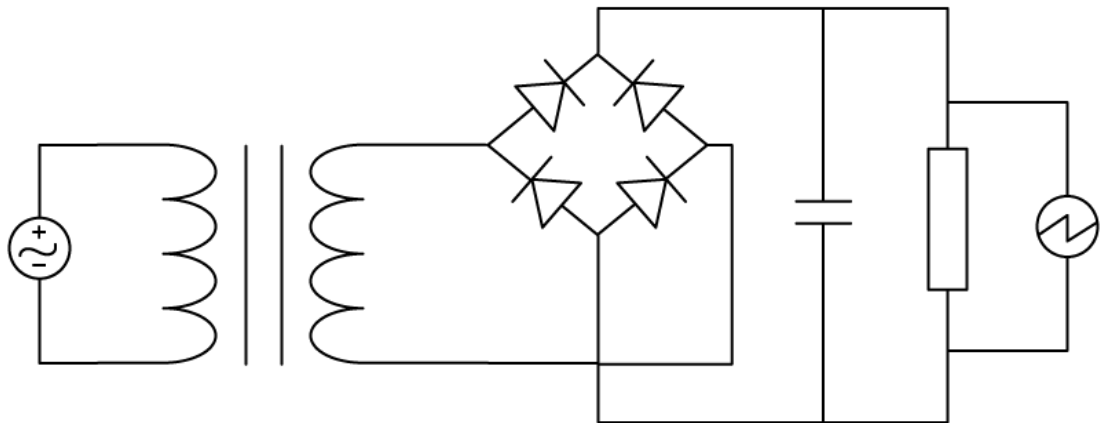
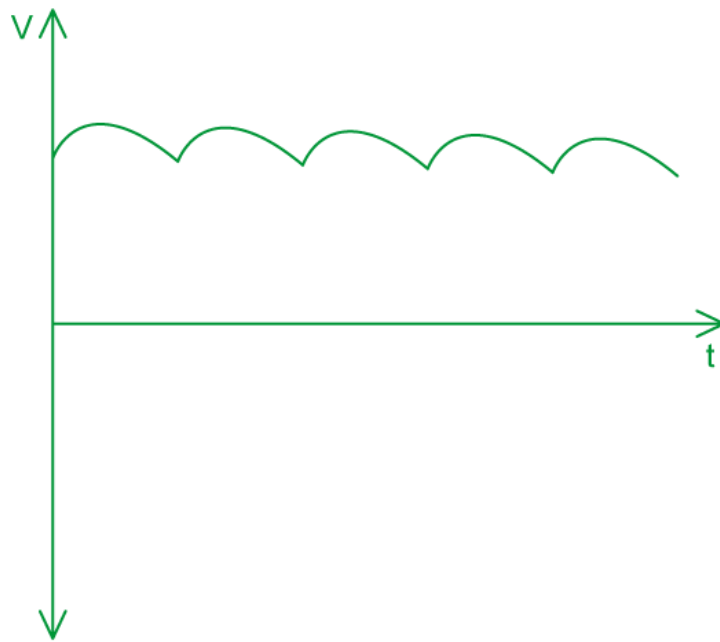


Fig. 1.2

Sketch the expected variation of the output voltage with time for the circuit in Fig. 1.2.

Answer

The expected voltage output with time is as follows:



- Graph shows full-wave rectification (more peaks, same positive peak values);
[1 mark]
- Graph shows smoothing (same peak value at start of discharge, same shape in each curve); [1 mark]
- Curve shows a greater degree of smoothing (slightly more flattened) than in (a);
[1 mark]

[Total: 3 marks]

Recall that a fully rectified and smoothed wave looks similar to the flat slope of a d.c. current graph

In this circuit, you should be able to determine:

- The circuit contains a **bridge rectifier**, so the output will produce **full-wave rectification**
- The circuit contains a **capacitor**, so the output will show **smoothing** of the peaks

(3 marks)

- (c) A bridge rectifier consists of four ideal diodes, A, B, C and D, connected to an ac generator between the terminals X and Y, as shown in Fig. 1.3.

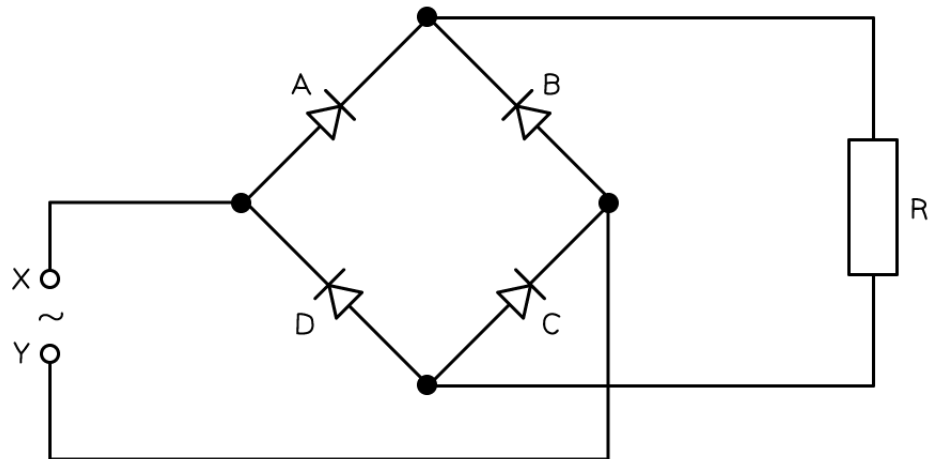


Fig. 1.3

On Fig. 1.3

- (i) label the positive (+) and negative (–) connections to the load resistor R

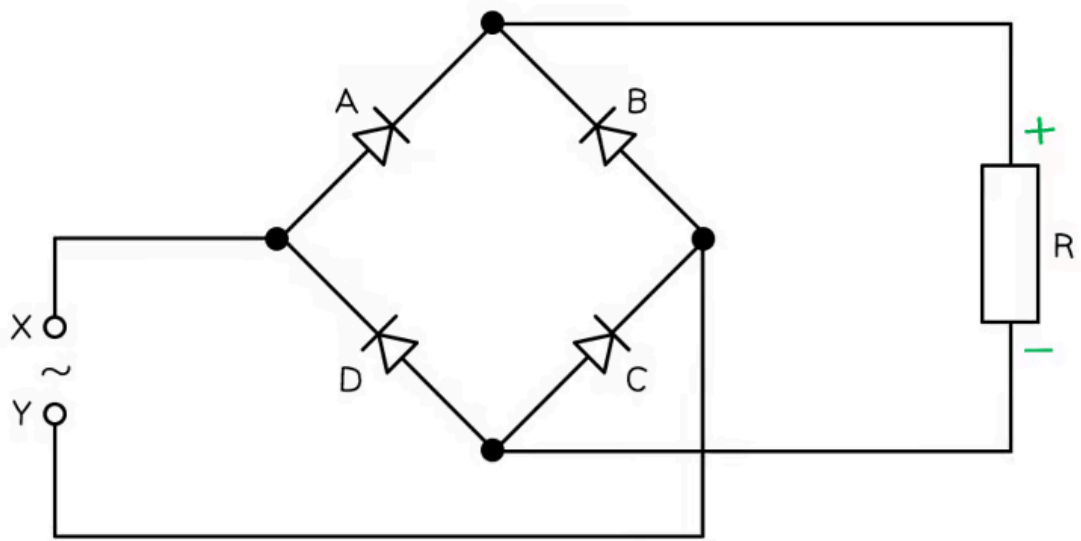
[1]

- (ii) circle the diodes which are conducting when the polarity of terminal X is negative.

[1]

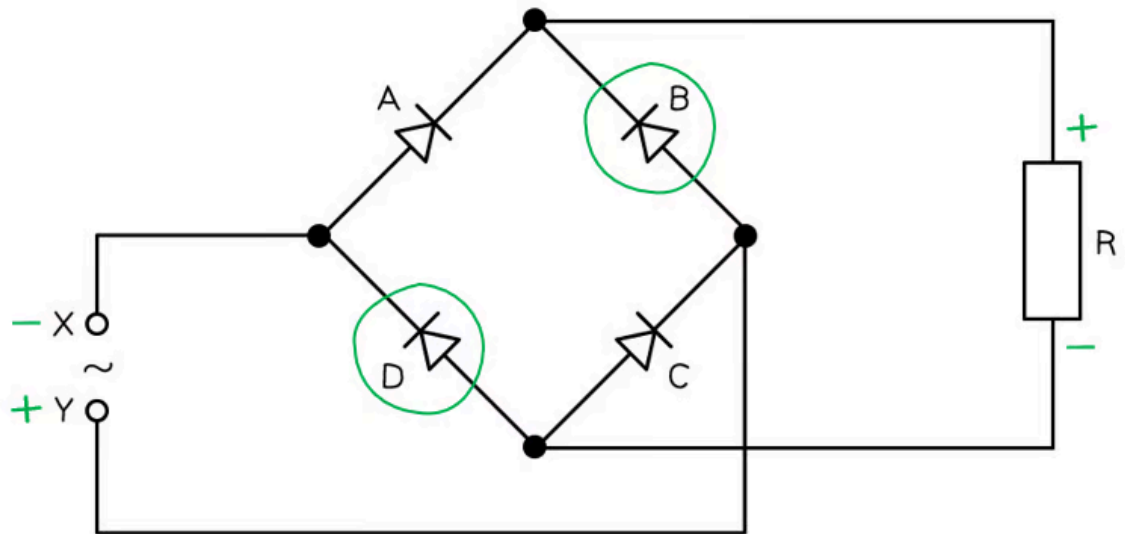
Answer

(i) The connections to the load resistor are:



- Positive (+) on top **AND** negative (-) on bottom; [1 mark]

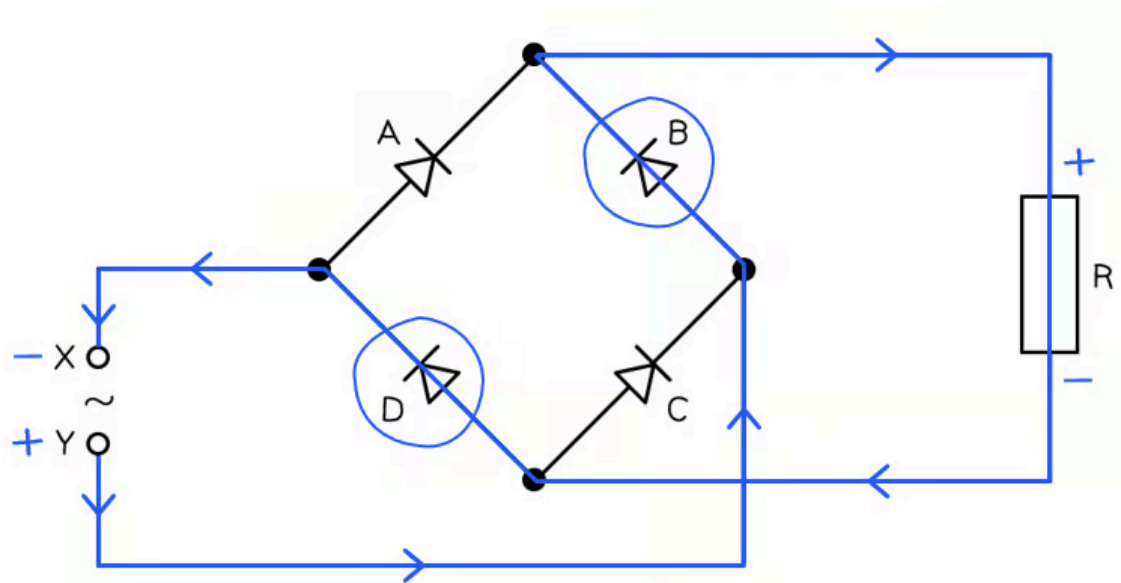
(ii) The diodes which are conducting when terminal X is negative are:



- Diodes B and D; [1 mark]

[Total: 2 marks]

Bridge rectifier problems are most easily solved by tracing the path with your finger



The key points to remember are:

- Current only goes through diodes according to the arrow – they show forward bias
- Conventional current is always depicted as moving from positive to negative
- Alternating current (AC) constantly changes direction

(2 marks)

(d) The graph in Fig. 1.4 shows the output of an ac generator after undergoing half-wave rectification.

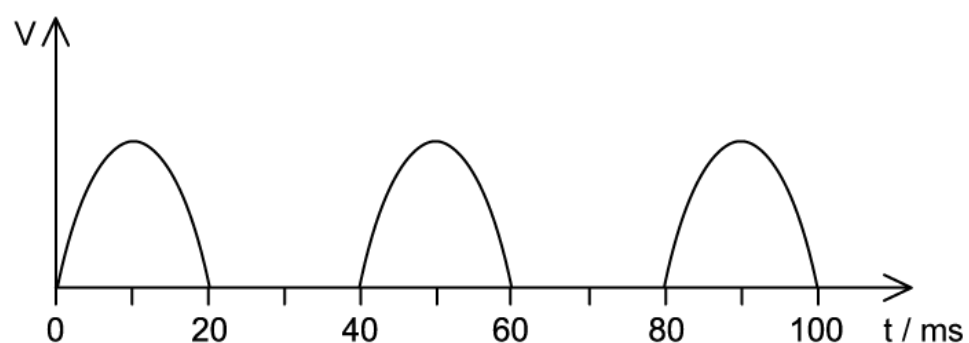


Fig. 1.4.

The load resistor has a resistance of $3.6\text{ k}\Omega$. Capacitors of capacitance 360 nF and $60\text{ }\mu\text{F}$ are available.

Determine which of the capacitors would be the most appropriate to smooth the output in Fig. 1.4.

Answer

Determine the correct capacitor to use for smoothing the output:

List the known quantities:

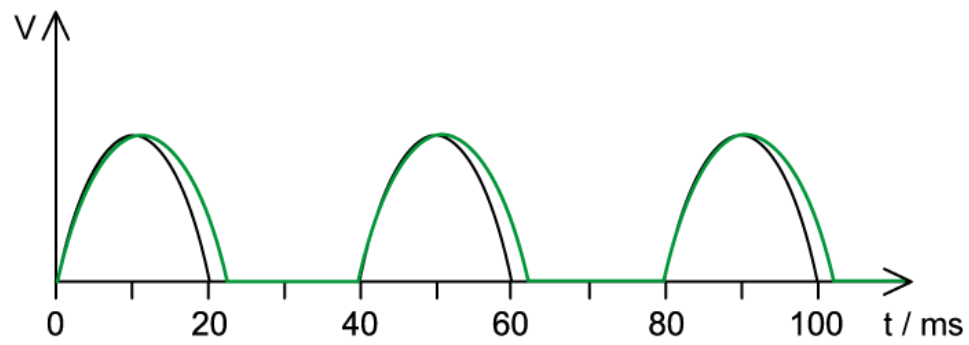
- Resistance, $R = 3.6\text{ k}\Omega = 3600\text{ }\Omega$
- Time interval between adjacent peaks, $t = 40\text{ ms} = 40 \times 10^{-3}\text{ s}$ (from the graph)
- Capacitor 1, $C_1 = 360\text{ nF} = 360 \times 10^{-9}\text{ F}$
- Capacitor 2, $C_2 = 60\text{ }\mu\text{F} = 60 \times 10^{-6}\text{ F}$

Calculate the time constants for both capacitors:

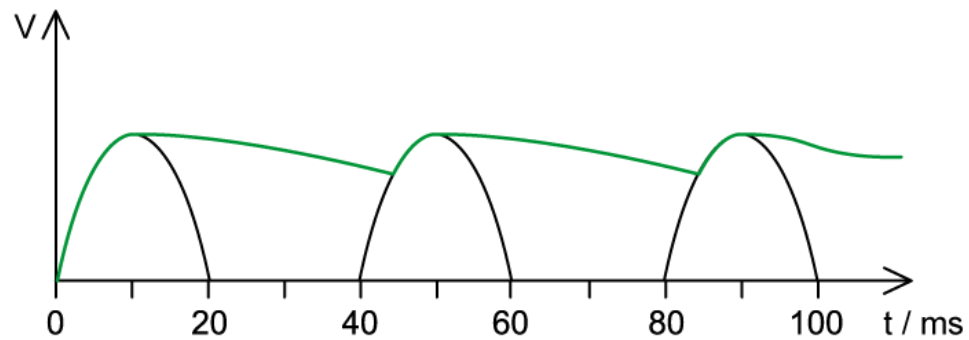
- Time constant: $T = RC$
- Capacitor 1: $T_1 = 3600 \times (360 \times 10^{-9}) = 1.3 \times 10^{-3}\text{ s}$
- Capacitor 2: $T_2 = 3600 \times (60 \times 10^{-6}) = 0.216\text{ s}$

Compare the time constants of the capacitors with the time between peaks:

- The time constant of capacitor 1, $T_1 = 1.3 \times 10^{-3}\text{ s}$, is less than the time interval, $t = 40 \times 10^{-3}\text{ s}$; [1 mark]
 - So, the output will not be smoothed significantly:
-



- The time constant of capacitor 2, $T_2 = 0.216 \text{ s}$, is much greater than the time interval, $t = 40 \times 10^{-3} \text{ s}$; [1 mark]
- So, the output will be smoothed significantly:



State the most appropriate capacitor to smooth the output correctly:

- The 60 μF capacitor; [1 mark]

[Total: 3 marks]

(3 marks)

Hard Questions

- 1 (a) Complete the circuit diagram in Fig. 1.1 such that it shows a full-wave rectifier where the bottom of the load resistor is positive and the top is negative.

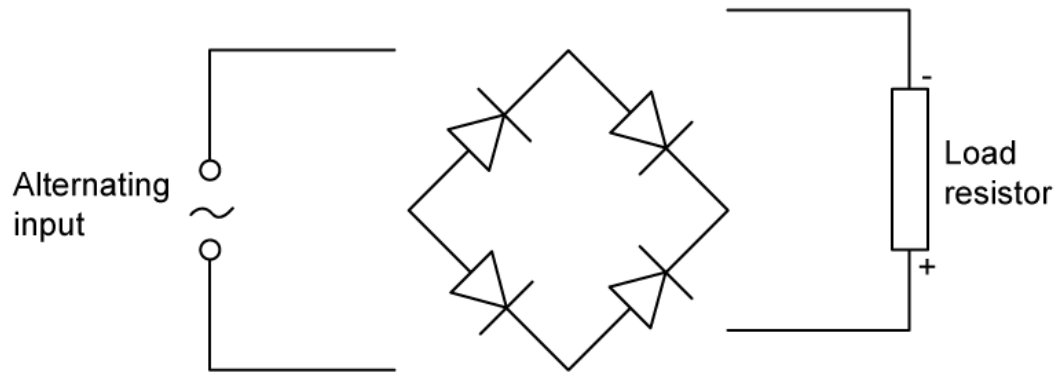
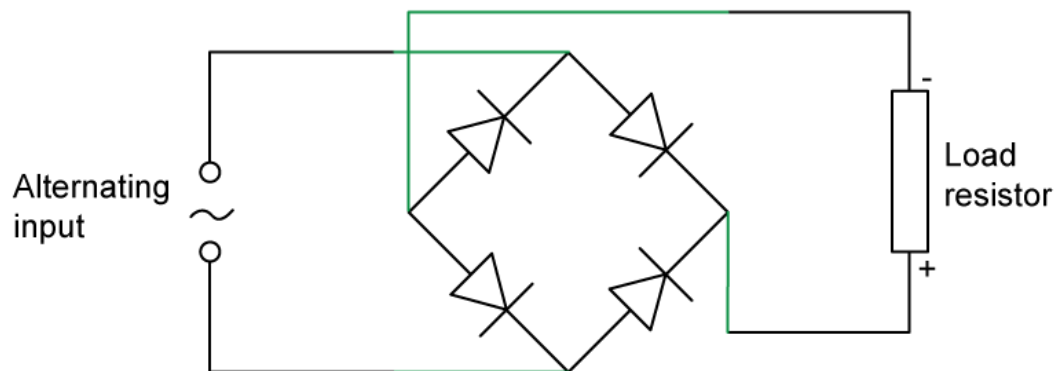


Fig. 1.1

Answer

An example of a diagram gaining two marks:



- The top of the input connects from the top corner of the diode bridge **AND** the right corner of the diode bridge connects to the bottom of the resistor; [1 mark]
- The bottom of the input connects to the bottom corner of the diode bridge **AND** the left corner of the diode bridge connects to the top of the resistor; [1 mark]

[Total: 2 marks]

(2 marks)

(b) The root-mean-square input potential difference to the full-wave rectifier is 14.1 V.

The frequency of the input potential difference is 40 Hz.

On Fig. 1.2, draw a graph of the potential difference across the load resistor for 2.5 periods, choosing a sensible scale for the y axis.



Fig. 1.2

Answer

To draw 2.5 periods of the rectified wave:

List the known quantities:

- Root-mean-square voltage, $V_{rms} = 14.1 \text{ V}$
- Frequency, $f = 40 \text{ Hz}$

Determine the period:

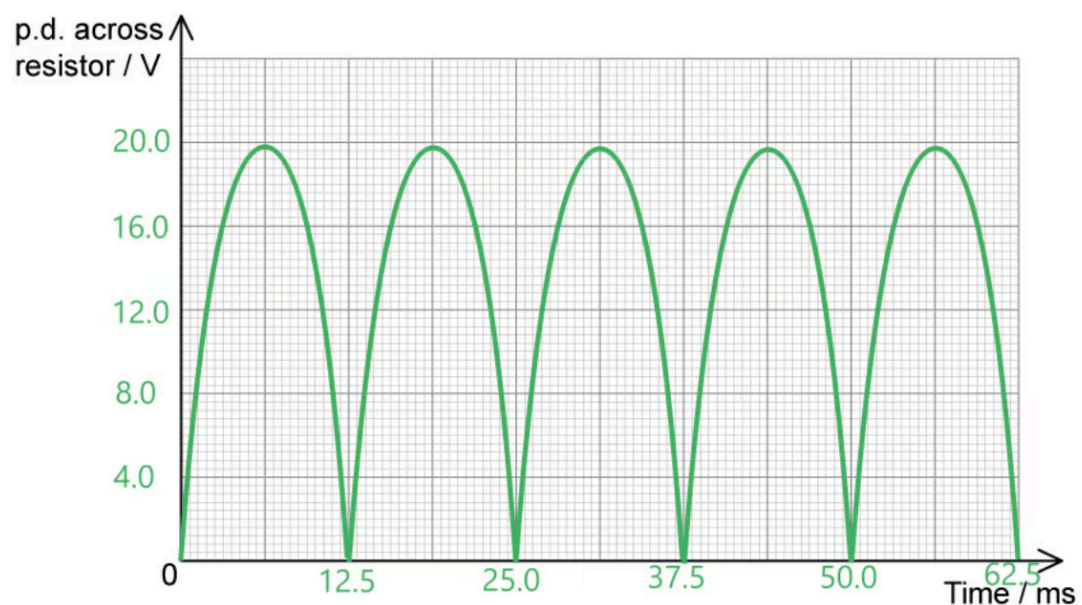
- $T = \frac{1}{f} = \frac{1}{40} = 25 \text{ ms}$

Determine the peak voltage, V_0 :

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

- $V_0 = 14.1 \times \sqrt{2} = 19.9 \text{ V}$

A graph gaining 3 marks looks like:



- Peaks reach 19.9 V ($\pm$ one small square) **AND** are more than half the height of the graph paper; [1 mark]
- Correct shape for a full-wave rectified alternating potential difference; [1 mark]
- Five peaks filling the x axis **AND** labelled as being 12.5 ms across each; [1 mark]

[Total: 3 marks]

For 2.5 periods to fill the graph paper, there are 10 squares so each period must take up 4 squares horizontally, with the last 0.5 of a period taking 2 squares.

(3 marks)

- (c) The circuit in Fig. 1.1 is then modified by two students. One student adds a single capacitor, as shown in Fig. 1.3. The other adds two capacitors in series, as shown in Fig. 1.4.

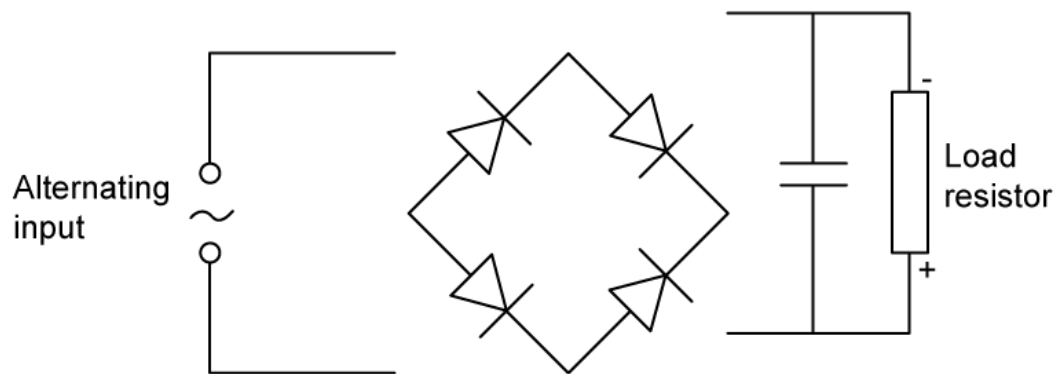


Fig. 1.3

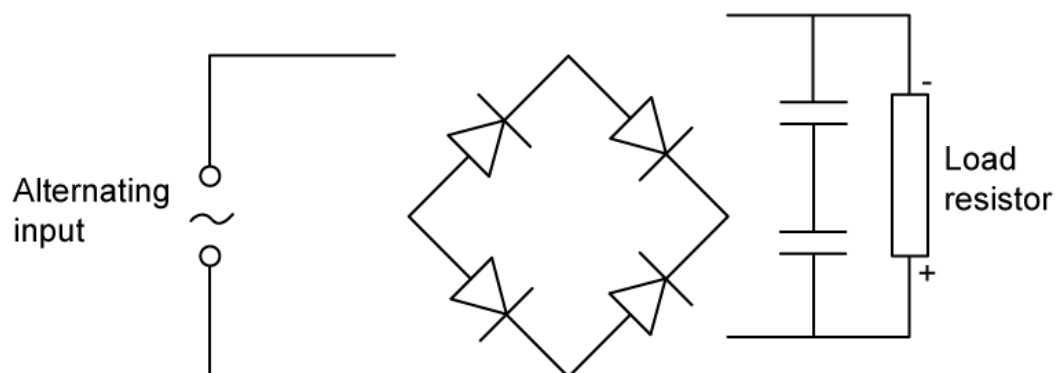


Fig. 1.4

Compare the effects of each modification on the graph you drew on Fig. 1.2, when both circuits are completed to form full-wave rectifiers. Explain any differences.

Answer

Comparing the effects of each capacitor configuration on the output signal:

- The single capacitor smooths the peaks in the output voltage; [1 mark]
- The two capacitors smooth the peaks less than the single capacitor; [1 mark]

- (Therefore) there are larger fluctuations / ripples in the output voltage with the two capacitors; [1 mark]

Explain the difference:

- Because capacitors in series have a lower capacitance; [1 mark]
- (Therefore) the time constant is smaller; [1 mark]

[Total: 5 marks]

Recall that capacitors in series have a combined capacitance according to the following equation:

$$\frac{1}{C_{tot}} = \frac{1}{C_1} + \frac{1}{C_2}$$

This means total capacitance is less than the individual capacitance of either capacitor, i.e. adding capacitors in series reduces total capacitance. This means the time constant is smaller, so the capacitor system discharges faster and the output voltage dips more in between input peaks.

(5 marks)

2 (a) A technician is testing different bulbs using the half-wave rectifier in Fig. 1.1.

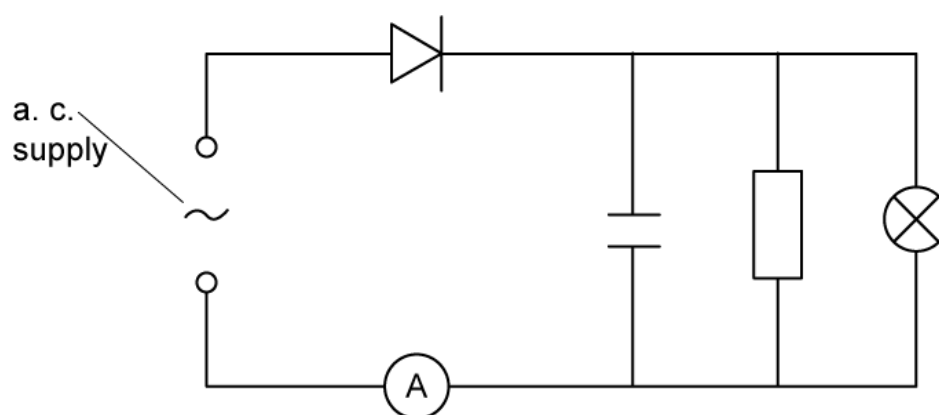


Fig. 1.1

The current I passing through the ammeter in Fig. 1.1 varies with time t according to the following equation:

$$I = 6.0\sin(6250\pi t)$$

The technician has the choice of three combinations (A, B, or C) of capacitors and resistors, as shown in Table 1.1:

Table 1.1

Combination	A	B	C
Resistance / Ω	120	20	10
Capacitance / μF	1.2	8.0	4.0

After using one particular combination, she notices the bulb being used is flickering. She recognises that this is a result of a highly fluctuating input current.

State which combination she used and explain your answer.

Answer

To determine the combination used:

List the known quantities:

- Angular frequency, $\omega = 6250\pi \text{ rad s}^{-1}$
- Table 1.1 repeated for reference:

Combination	A	B	C
Resistance / Ω	120	20	10
Capacitance / μF	1.4	8.0	4.0

Determine the period of the alternating current:

- Recall the equation $\omega = \frac{2\pi}{T}$
- $T = \frac{2\pi}{6250\pi} = 0.32 \text{ ms}$ [1 mark]

Calculate the time constant, τ , of each combination:

- $\tau_A = R_A C_A = 120 \times (1.4 \times 10^{-6}) = 0.17 \text{ ms}$

AND

- $\tau_B = R_B C_B = 20 \times (8.0 \times 10^{-6}) = 0.16 \text{ ms}$

AND

- $\tau_C = R_C C_C = 10 \times (4.0 \times 10^{-6}) = 0.040 \text{ ms}$ [1 mark]

State the combination used:

- The technician used combination C; [1 mark]
-

Explain why:

- The time between peaks is (half the time period of the a.c. which is) 0.16 ms; [1 mark]
- The time constant of combination C is too short to smooth the output signal between peaks (so the bulb experiences gaps in current); [1 mark]

[Total: 5 marks]

This question required that you can recall that, for sufficient smoothing, the time constant of the capacitor and load resistor must be at least equal to the gaps between peaks in a half-wave rectified alternating current. Remember that the gap between peaks is half the period of a full cycle of the a.c.

(5 marks)

- (b)** The technician attaches an older lightbulb to the same combination as she used in part (a).

This older lightbulb operates by heating a tungsten filament, which then emits light as a result of its high temperature.

She notices this lightbulb flickers less than the previous, more modern lightbulb.

Suggest why the old lightbulb flickers less.

Answer

The old lightbulb flickers less because:

- The lightbulb does not cool down in between peaks; [1 mark]
- As the gap is short / only 0.16 ms; [1 mark]

[Total: 2 marks]

Heated objects do not lose their high temperature instantaneously (think back to specific heat capacity), so even when current is not passing through the tungsten, it is still hot enough to emit light.

(2 marks)

(c) The mean power supplied by the source of a.c. is 36 W.

Calculate the peak voltage across the bulb.

Answer

To find the peak voltage across the bulb:

List the known quantities:

- Mean power, $P_{mean} = 36 \text{ W}$
- Peak current, $I_0 = 6.0 \text{ A}$ (from the equation in part (a))

Recall the equation relating mean power, peak current and peak voltage, V_0 :

$$\bullet \quad P_{mean} = \frac{I_0 V_0}{2}$$

Rearrange to calculate peak voltage:

$$\bullet \quad V_0 = \frac{2P_{mean}}{I_0} = \frac{2 \times 36}{6.0} = 12 \text{ V [1 mark]}$$

[Total: 1 mark]

If you are unsure where the peak current of 6.0 A came from, recall the equation in part (a):

$$I = 6.0\sin(6250\pi t)$$

This follow the format:

$$x = x_0\sin(\omega t)$$

which is given in your formula page at the start of the exam paper.

(1 mark)

(d) The next day, the technician sets up the equipment in Fig. 1.1 using resistor and capacitor combination B.

Calculate the potential difference across the plates of the capacitor, 0.20 ms after the potential difference across the bulb reaches its maximum value.

Answer

To find the potential difference across the capacitor:

List the known quantities:

- Time after being fully charged, $t = 0.20$ ms
- Peak voltage, $V_0 = 12$ V (from part (c))
- Time constant of combination B, $\tau_B = 0.16$ ms (from part (a))

Use the capacitor discharge equation from the formula page:

- $x = x_0 e^{-\frac{t}{RC}}$
 - For alternating potential difference, this becomes
 - $V = V_0 e^{-\frac{t}{RC}}$

Use this relation for voltage across the capacitor, V :

- $\tau = RC$
 - Substitute this, for combination B, into the alternating p.d. equation

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

Substitute the known quantities:

- $V = 12 \times e^{-\frac{0.20}{0.16}}$ [1 mark]
- $V = 3.4$ V [1 mark]

[Total: 2 marks]

If you got this question correct, you recognised that the capacitor discharge equation was needed. More challenging exam questions will often combine multiple areas in new contexts. The more you practice these questions, the easier they feel.

(2 marks)

