OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

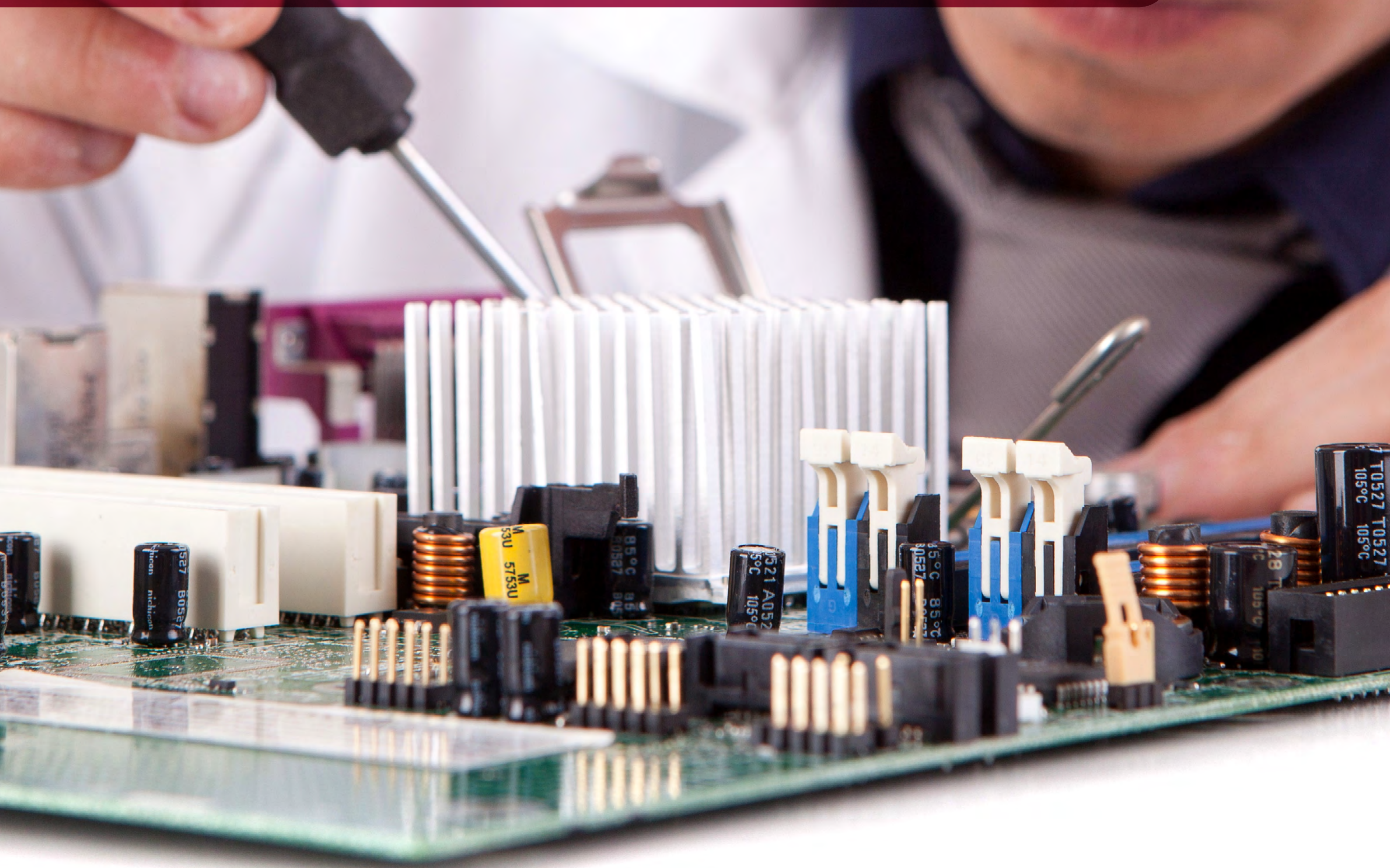
Cambridge TECHNICALS 2016

ENGINEERING

Feedback on the June 2018 exam paper (including selected exemplar candidate answers and commentary)

Unit 4 – Principles of electrical and electronic engineering

Version 1



ocr.org.uk/engineering

CONTENTS

INTRODUCTION

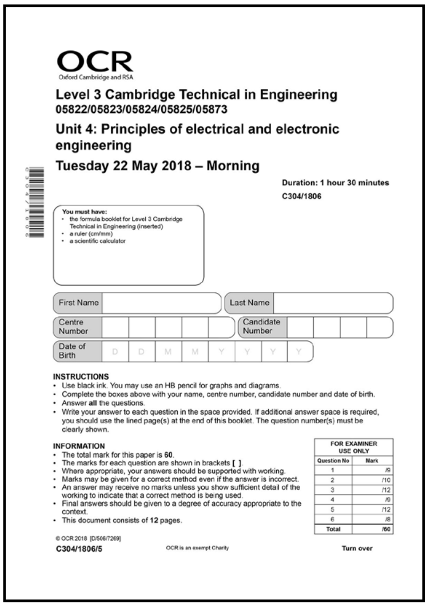
TThis resource brings together the questions from the June 2018 examined unit (Unit 4), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

We have also included exemplar candidate answers with commentary for questions 2(a)(i), 2(a)(ii), 4(a), 6(a) and 6(b).

The marking guidance and the examiner's comments are taken from the Report to Centre for this question paper.

The Question Paper, Mark Scheme and the Report to Centre are available from:

https://interchange.ocr.org.uk/Modules/PastPapers/Pages/PastPapers.aspx?menuindex=97&menuid=250



OCR
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Level 3 Cambridge Technical in Engineering
05822/05823/05824/05825/05873

Unit 4: Principles of electrical and electronic engineering

Tuesday 22 May 2018 – Morning

Duration: 1 hour 30 minutes
C304/1806

You must have:
- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

First Name | Last Name
Centre Number | Candidate Number
Date of Birth D D M M Y Y Y Y

INSTRUCTIONS
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer all the questions.
- Write your answer to each question in the space provided. If additional answer space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.

INFORMATION
- The total mark for this paper is 60.
- The marks for each question are shown in brackets [ ].
- Where appropriate, your answers should be supported with working.
- Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of 12 pages.

FOR EXAMINER USE ONLY	
Question No	Mark
1	/6
2	/10
3	/12
4	/6
5	/12
6	/8
Total	/60

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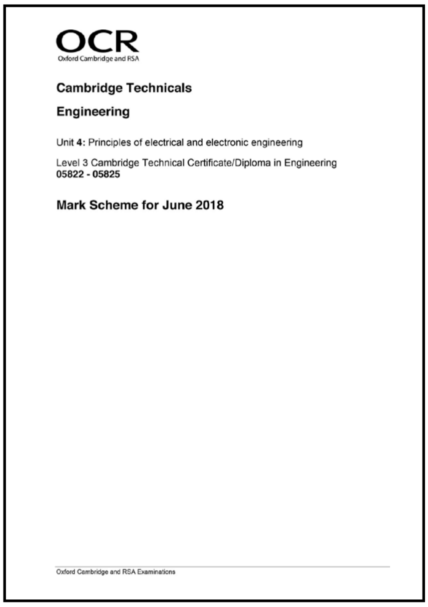

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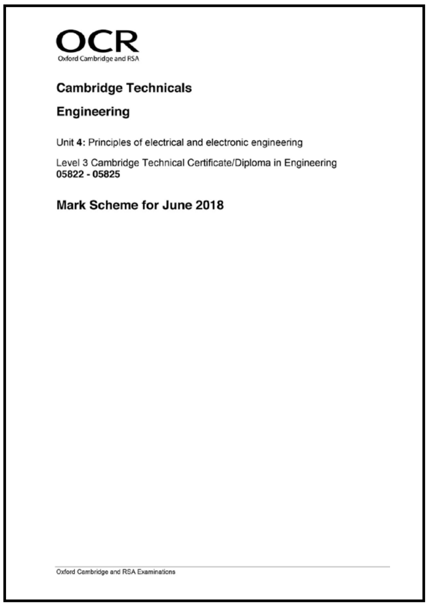
Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for June 2018

Oxford Cambridge and RSA Examinations



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Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825

Mark Scheme for June 2018

Oxford Cambridge and RSA Examinations

GENERAL EXAMINER COMMENTS ON THE PAPER

Overall performance in this examination continues to improve. There is increasing evidence of understanding of the principles of electrical engineering, evidenced, not least, by confidence in the use of the correct equations and formulae to deduce the right answers to calculations.

Questions on the fundamentals of electricity and electronics (1, 2, 3, and 5) were generally answered well. Questions on systems (4, 6), with a greater reliance on explanation and recall, were not answered so well. Question 6, for instance, was answered well only in a small minority of cases, despite the assistance of a detailed diagram of the system.

Many responses showed a lack of familiarity with common circuit symbols, leading to a lack of clarity in drawing diagrams. It would seem that more time spent early on to embed these ideas would avoid ambiguity and lost marks.

Candidates demonstrated a greater confidence with scientific units than hitherto. Question 3 was answered particularly well in this regard.

There was a notable increase in "No Response" without evidence that this was due to a lack of time. Candidates should, of course, be encouraged to attempt all questions where time permits. The best results were only possible by a combination of careful calculation and a sound grounding in the principles involved.

Resources which might help address the examiner comments:

From the link below, you'll find 'The OCR guide to examinations' (along with many other skills guides)
http://www.ocr.org.uk/i-want-to/skills-guides/

Command verbs definitions
http://www.ocr.org.uk/Images/273311-command-verbs-definitions.pdf

Question 1

Answer **all** the questions.

1 **(a)** An inverting operational amplifier is required for a preamplifier circuit. The amplifier must have a closed loop voltage gain of -20.

(i) For an inverting operational amplifier circuit

$$Voltage\ gain = A_v = -\frac{R_{feedback}}{R_{input}}$$

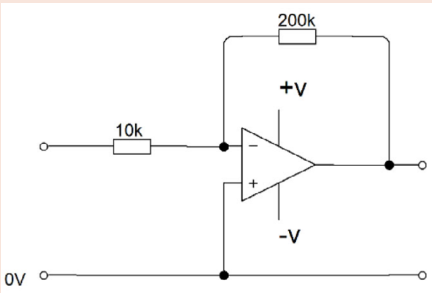
Give suitable values for $R_{feedback}$ and R_{input} in the inverting amplifier circuit.

Select R_{input} – Any suitable value between 1KΩ and 100KΩ.
For example: If R_{input} = 10 (KΩ)
$R_{feedback} = -A_v R_{input}$
= - (-20 × 10KΩ)
$R_{feedback}$ = 200 (KΩ)

$R_{feedback}$ = ... KΩ

R_{input} = ... KΩ
[4]

(ii) Draw the circuit diagram for the inverting operational amplifier circuit. Add the resistor values to the circuit diagram.



- Correct op amp symbol
- Correct position of R_{input}
- Correct position of $R_{feedback}$
- Connection of non-inverting input to 0V
- Values correctly added.

[5]

Mark scheme guidance

Question 1(a)(i):

Note: $R_{feedback}$ could be selected and R_{input} calculated.

Rearrangement

Substitution

Do not accept negative values of R.

Question 1(a)(ii):

Condone omission of power supply.

Allow ECF from 1(a)(i).

Examiner comments

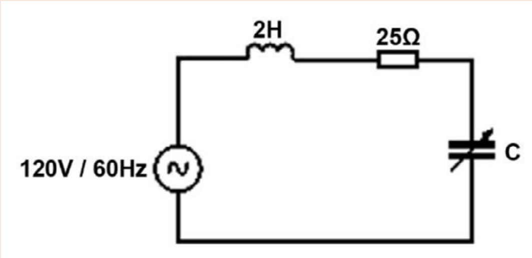
Question 1(a)(i) – was answered correctly by most candidates, but there was a number who gave a negative value for one or both resistors which was not condoned.

Question 1(a)(ii) – candidates were generally able to provide most of the required details. 0v to non- inverting input was the most common oversight.

Question 2

2 (a) An AC circuit has an inductor of 2 H connected in series with a resistor of 25 Ω and a variable capacitor. The supply voltage is 120 V, 60 Hz.

(i) Draw the circuit diagram. Include all component values.



- Variable capacitor
- Resistor with value
- Inductor with value
- Supply with value
- All components connected in series

[5]

(ii) Calculate the value of capacitance in the circuit when $X_L = X_C$. Indicate the units used in your answer.

$$2\pi fL = \frac{1}{2\pi fC}$$

$$2.\pi.60.2 = \frac{1}{2.\pi.60.C}$$

$$(2.\pi.60.2)^2\ 2 = \frac{1}{C}$$

C = 3.5 **<u>µF</u> or** 0.00000035 **<u>F</u>** or 3.5×10^{-6} **<u>F</u>**

Capacitance = ... **[5]**

Mark scheme guidance

Question 2(a)(i):

Allow any sensible and unambiguous symbol for C_{var}.

Unit not required for the marks.

Question 2(a)(ii):

Correct formulae selection.

Substitution.

$$2\pi fL = \frac{1}{2\pi fC}$$

Rearrangement.

$$2.\pi.60.2 = \frac{1}{2.\pi.60.C}$$

Correct answer.

$$(2.\pi.60.2)^2\ 2 = \frac{1}{C}$$

Correct unit.
C = 3.5 **µF** **or** 0.00000035 **F** or 3.5×10^{-6} **F**

Examiner comments

For 2(a)(i) most candidates were able to provide the power supply, inductor, and resistor correctly. There were many omissions of the capacitor, or ambiguous symbols were used.

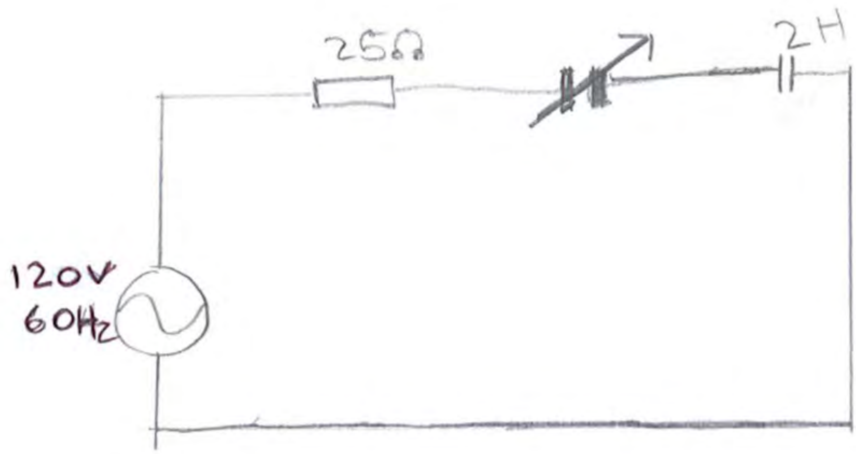
In 2(a)(ii) the most common mistake amongst those who attempted the question was with re-arrangement of the formula resulting in the candidates cancelling out 2π60.

Exemplar Candidate Work

Question 2(a)(i) – High level answer

2 **(a)** An AC circuit has an inductor of 2 H connected in series with a resistor of 25 Ω and a variable capacitor. The supply voltage is 120 V, 60 Hz.

(i) Draw the circuit diagram. Include all component values.



Commentary

We should not be overly meticulous about the quality of circuit symbols, given that they are hand-drawn and there is no universally accepted convention. However we can insist that they be sensible and unambiguous, as indicated in the mark scheme. Even a simple rectangle accompanied by unambiguous labelling will suffice. However the symbol shown here for an inductor is clearly wrong and therefore misleading.

Exemplar Candidate Work

Question 2(a)(ii) – High level answer

2 **(a)** An AC circuit has an inductor of 2 H connected in series with a resistor of 25 Ω and a variable capacitor. The supply voltage is 120 V, 60 Hz.

(ii) Calculate the value of capacitance in the circuit when $X_L = X_C$. Indicate the units used in your answer.

$X_L = 2\pi f L$ $\quad X_C = \frac{1}{2\pi f C}$

$X_L = 2 \times \pi \times 60 \times 2 = 753\ \Omega$

$X_C = \frac{1}{2\pi f C}$ $\quad X_C = \frac{1}{2 \times \pi \times f \times C}$

$X_C = \frac{1}{2 \times \pi \times 60 \times 753}$

Capacitance = 3.52 **[5]**

Commentary

The correct answer here is 3.5 μF.

The practice now adopted in this assessment, in relation to the indication of scientific units, is that units will normally be provided, right justified on the answer line. But a knowledge and use of the correct units is important, and will be tested. Where this is intended it will be indicated in the question text, as is here the case.

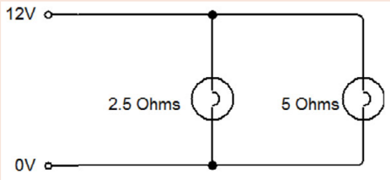
Powers of 10 can be indicated by *x10*^{n} and/or the correct prefix.

It should also be taught that answers should be given to the appropriate number of significant figures, but answers that *round* to the correct answer will be accepted unless otherwise indicated in the question text.

Question 3

3 **(a)** In a low voltage lighting system, **two** filament lamps are connected in parallel to a 12 V DC supply. The resistance of one lamp is 5Ω and the resistance of the other 2.5Ω.

(i) Draw the circuit diagram. Indicate all values on the diagram.



- 2 lamps in parallel
- Supply in parallel
- Correct values

[3]

(ii) Calculate the total resistance of the circuit.

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{Total}} = \frac{1}{2.5} + \frac{1}{5} = \frac{3}{5}$$

$R_{Total} = 1.67(\Omega)$

Total resistance = ... Ω **[3]**

(iii) Calculate the power dissipated in the 5Ω filament lamp. Indicate the units used in your answer.

$P = V^2/R$
$= 12^2/5$
= 28.8**W**
Or

P = VI
I = 12/5=2.4A
P = 12 × 2.4A = 28.8**W**

Power dissipated = ... **[3]**

(iv) Calculate the energy used by the 5Ω filament lamp if the circuit is operational for 1.5 hours. Indicate the units used in your answer.

W = PT
W = 28.8 × 1.5
W = 43.2 **Wh**

Energy used = ... **[3]**

Mark scheme guidance

Question 3(a)(i):

Max 2 marks awarded if lamps are in series.

Award marks if units not stated.

Question 3(a)(ii):

$$\frac{1}{R_{Total}} = \frac{1}{R_1} + \frac{1}{R_2}$$

For applying knowledge from Unit 2 LO3.

$$\frac{1}{R_{Total}} = \frac{1}{2.5} + \frac{1}{5} = \frac{3}{5}$$

For applying knowledge from Unit 2 LO3.

Substitution. $R_{Total} = 1.67(\Omega)$

1.7/1.67.

Question 3(a)(iii):

$P = V^2/R$
For applying knowledge from Unit 2 LO3.

$= 12^2/5$
For applying knowledge from Unit 2 LO3.

= 28.8**<u>W</u>**
Allow ECF 29/28.8.

P = VI
For applying knowledge from Unit 2 LO3.

I = 12/5=2.4A
For applying knowledge from Unit 2 LO3.

P = 12 × 2.4A = 28.8**<u>W</u>**
Allow ECF 29/28.8.

Question 3(a)(iv):

W = PT
For applying knowledge from Unit 2 LO3.

W = 28.8 × 1.5
For applying knowledge from Unit 2 LO3.

W = 43.2 **<u>Wh</u>**
Allow ECF.

Allow correct numerical answers in 0.043/0.0432 kWh/160000 J/155520 J/160/156/155.5 KJ.

<u>Not (k)Ws</u>

Examiner comments

Most candidates were able to answer 3(a) this correctly. Few errors were seen across the four parts.

Question 4(a)

4 **(a)** Fig. 1 shows an incomplete bridge rectifier circuit.

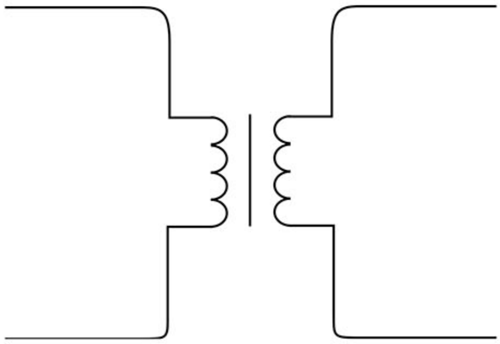
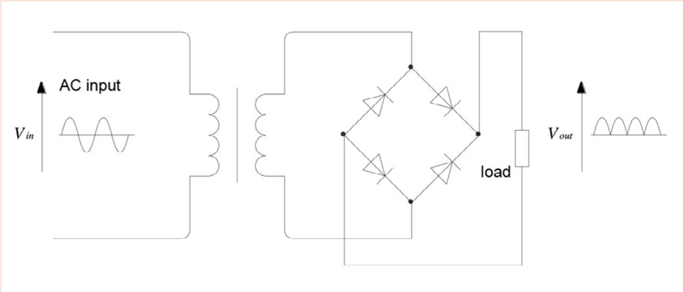


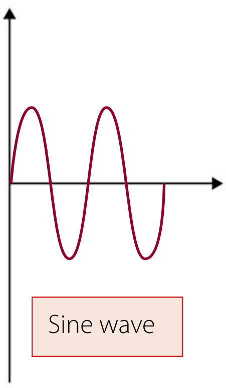
Fig. 1

(i) Complete the circuit diagram in Fig.1 to show the bridge rectifier. Indicate the input voltage (V_{in}) and the output voltage (V_{out}) on the diagram.

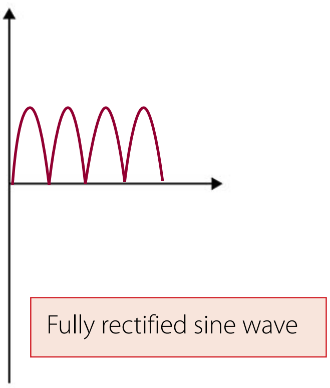
[5]



(ii) Sketch the waveforms for V_{in} and V_{out} on the axes below.



V_{in}

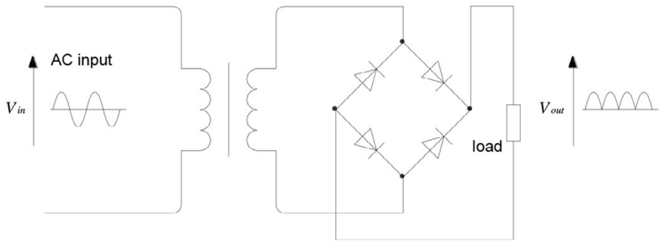


V_{out}

[2]

Mark scheme guidance

Question 4(a)(i):



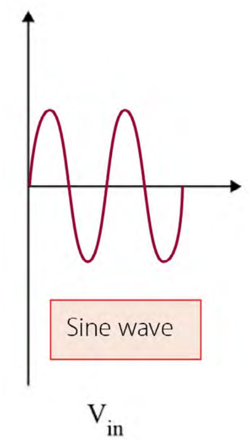
Output voltage indicated correctly Input voltage indicated correctly.

2 diodes in bridge.

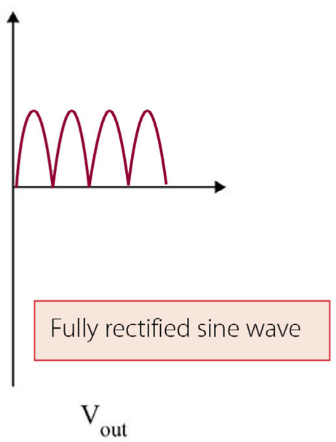
2 diodes connected correctly.

4 Diodes connected correctly.

Question 4(a)ii):



At least one complete cycle must be seen.



At least one complete cycle must be seen.

Examiner comments

Most attempted 4(a)(i), but often there was either an incorrect arrangement of diodes or a response that was worth little credit.

Those who understood full wave rectification were successful in 4(a)(ii).

Exemplar Candidate Work

Question 4(a) – High level answer

4 **(a)** Fig. 1 shows an incomplete bridge rectifier circuit.

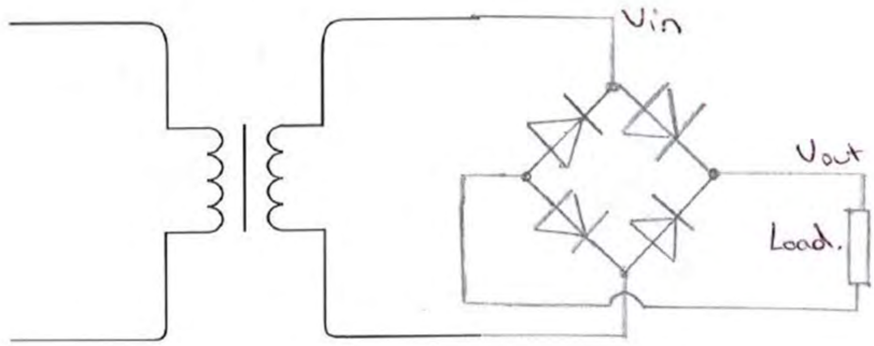


Fig. 1

Commentary

Paragraph 4.2 of the Teaching Content for Unit 4 refers.

For full marks the candidate was required to show the correct arrangement and connection of the rectifier bridge, V_{in} and V_{out}. The rectifier is very well drawn. The inclusion of a load resistor was not necessary in itself but made it clear where the output voltage could be measured. According to the mark scheme, however, the input voltage must be seen across the primary windings of the transformer, which was not the case here.

Question 4(b)

(b) The instantaneous value of the input voltage to the bridge rectifier is *v* volts where v=100sin126t. Calculate the frequency of the voltage signal.

$2\pi f = 126$
f = 126/2 π = 20.1 (Hz)

Frequency = ...Hz **[2]**

Examiner comments

In 4(b), though those who were comfortable with a sinusoidal representation of AC did well here.

Questions 5(a) and (b)

5 **(a)** The circuit symbol for a two input logic gate is shown in Fig. 2.

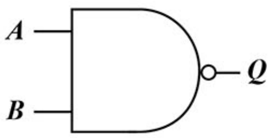


Fig. 2

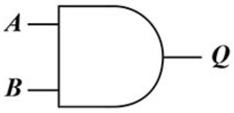
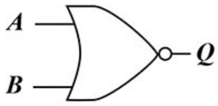
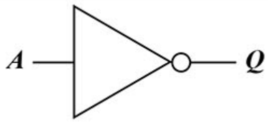
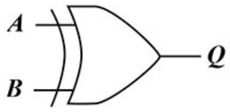
Complete the truth table below for the logic gate shown.

A	*B*	*Q*
0	0	1
0	1	1
1	0	1
1	1	0

[2]

(b) Complete the table below.

The first one has been done for you.

Logic Gate	Boolean Expression
	$Q = A.B$
	$Q = \overline{A + B}$
	$Q = \overline{A}$
	$Q = A \oplus B$ **or** $\overline{A}.B + A.\overline{B}$

[3]

Mark scheme guidance

Question 5(a):

1 mark for every 2 correct rows.

Question 5(b):

The first logic gate expression has been completed in the question.

Examiner comments

There was a good level of success across all parts of the question, with an improving standard of response to questions linking Boolean algebra and truth tables.

Question 5(c)

(c) A combinational logic circuit is shown in Fig. 3.

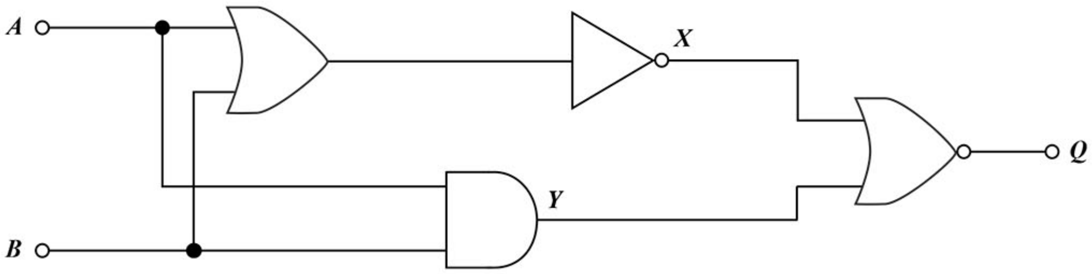


Fig. 3

(i) Complete the truth table for the circuit shown in Fig. 3.

A	*B*	*X*	*Y*	*Q*
0	0	1	0	0
0	1	0	0	1
1	0	0	0	1
1	1	0	1	0

[6]

(ii) State the name of the logic gate equivalent to the combinational logic circuit shown in Fig. 3.

Exclusive Or or XOR .. **[1]**

Mark scheme guidance

Question 5(c)(i):

1 mark for every 2 correct entries in the X column.

1 mark for every 2 correct entries in the Y column.

1 mark for every 2 correct entries in the Q column.

Question 5(c)(ii):

Allow ECF (if relevant).

Question 6(a)

6 (a) Give **four** reasons why starters are used in DC motors.

1 ....

2 ....

3 ....

4 ....

[4]

Purpose of a motor starter:

- To protect from overload or faults
- A Motor Starter is used for the smooth starting of a motor. It consists mainly of a variable resistance placed in series with the armature.

The purpose of this resistance is:

- To increase the resistance incrementally
- Thus restricting the armature current to a safe value
- To disconnect the motor in case of an overload
- To disconnect the motor when the field current is reduced beyond limit.

Any four valid points (1 mark/point) stated.

Examiner comments

6(a) was the least successful question on the paper, with the greatest occurrence of "No Response" or responses that failed to gain any credit. Only one candidate was awarded full marks for both parts, while one mark overall was the norm. This was not a question that could be answered well simply from first principles, even from a position of strength in electromagnetism. In 6(a) there needed to be evidence of an understanding that a DC motor starts up generating no back emf, and so requires to have a cascade of resistors in series with the armature, which can be backed off as motor speed builds up in order to limit the current and avoid damage.

Exemplar Candidate Work

Question 6(a) – High level answer

6 (a) Give **four** reasons why starters are used in DC motors.

1 To increase the resistance gradually

2 To add a back current to keep the current down.

3 allows it to bring it back in a surge preventing the motor from getting damaged

4 to hold the handle in place when it is fully on.

[4]

Commentary

Paragraph 3.6 of the Teaching Content for Unit 4 refers.

Point 2 of this response is no more than a poorly expressed repetition of point 1. On the other hand it is nowhere clear that the main mode for the field current to exceed safe limits occurs at start up, before rotation of the armature has developed a significant back emf. This is the principal purpose of the resistor array and should be included for full marks.

Question 6(b)

(b) Fig. 4 shows the diagram of a two point starter, used in a series wound DC motor.

[4]

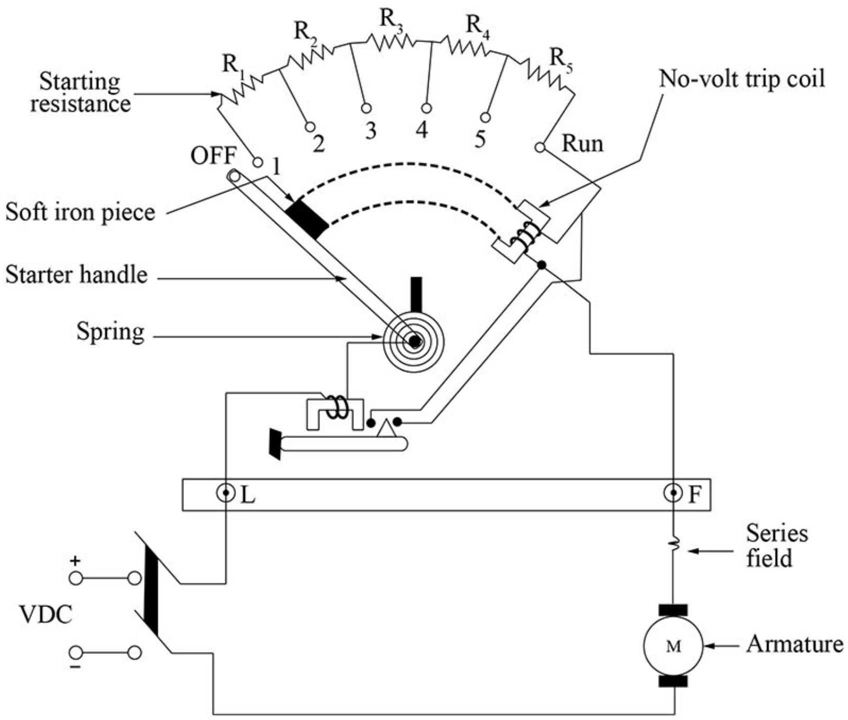


Fig. 4

Explain the purpose and operation of the no-volt trip coil in the motor starter shown in Fig. 4.

Purpose and operation of a no volt coil:

- To disconnect the motor if the supply voltage fails
- Provide automatic tripping when when there is a major voltage dip
- Prevents the motor restarting when the power supply is switched on
- When the power supply is cut the coil demagnetises and the starter handle spring returns to the 'off' position.

Any four valid points (1 mark/point) used to explain purpose and operation of the no volt coil.

Examiner comments

In 6(b), similarly to 6(a) there was little success in responses. Any marks that were gained seemed to be by germs of a theory built around the words 'no-volt trip coil', with the exception of a small number of candidates. What was needed was a clear exposition of the dangers to the motor of a dip or loss of supply voltage, requiring a means to detect such dip or loss and rapidly disconnect the supply voltage. By the same token the device had to reset the starting condition in the event that the supply was reinstated.

Exemplar Candidate Work

Question 6(b) – High level answer

(b) Fig. 4 shows the diagram of a two point starter, used in a series wound DC motor. **[4]**

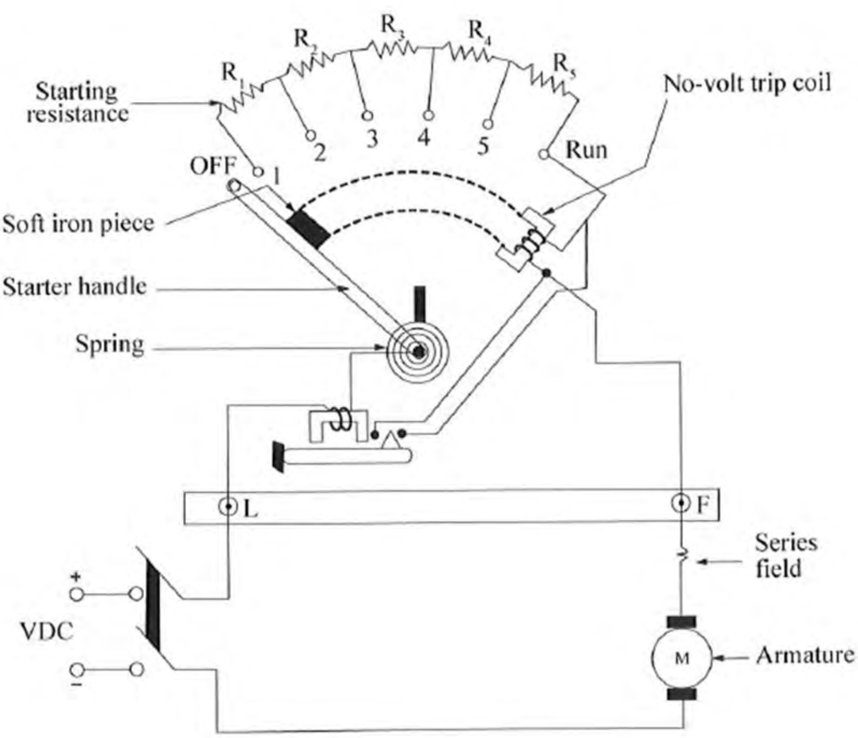


Fig. 4

Explain the purpose and operation of the no-volt trip coil in the motor starter shown in Fig. 4.

when the starter handle is in the 5 position it makes the No volt trip coil magnetise this holds the handle in places using the soft iron piece in any other position the starter handle will snap back to 'off position, allowing the DC motor to be used again

Commentary

To achieve full marks here it was necessary to make four clear and distinct points from the following list which combines the key elements of purpose and operation:

- To disconnect the motor if the supply voltage fails.
- Provide automatic tripping when there is a major voltage dip.
- Prevents the motor restarting when the power supply is switched on.
- When a current is passing through the coil it attracts the soft iron piece and latches the handle in place.
- When the power supply is cut the coil demagnetises and the starter handle spring returns to the 'off' position.

The above response could have been more clearly written but was judged to have shown understanding of three distinct elements. The important omission was any reference to stopping the motor safely in the event of a voltage drop.

The small print

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