OCR
Oxford Cambridge and RSA

Cambridge **TECHNICALS LEVEL 3**

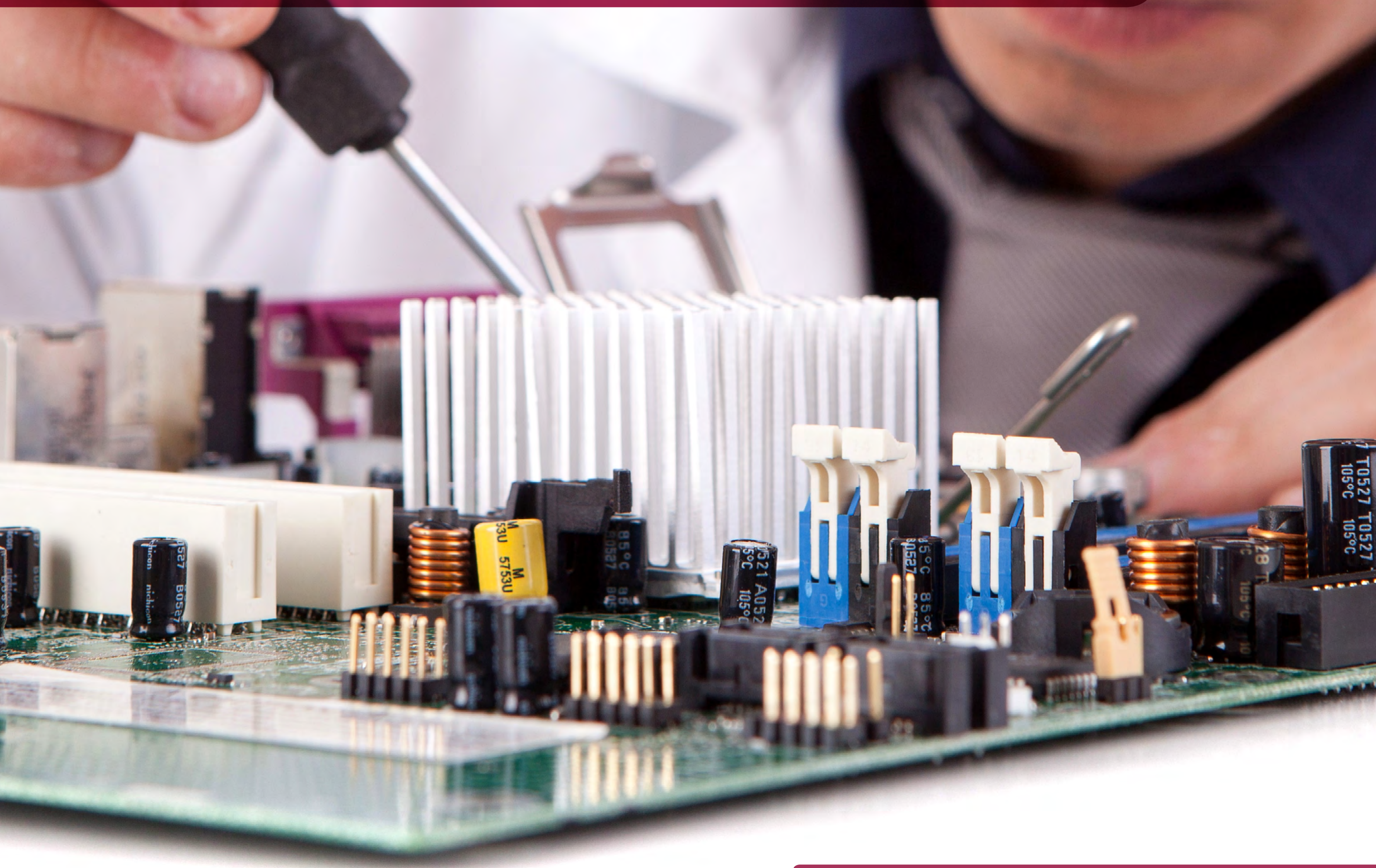
Cambridge TECHNICALS 2016

ENGINEERING

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

Unit 4 – Principles of electrical and electronic engineering

Version 1



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INTRODUCTION

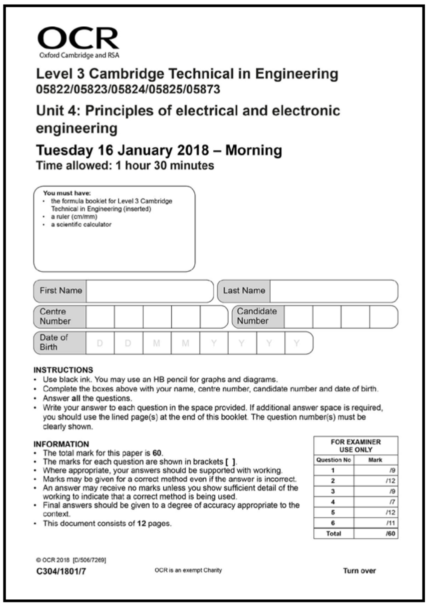
TThis resource brings together the questions from the January 2018 examined unit (Unit 4), the marking guidance, the examiners comments and the exemplar answers into one place for easy reference.

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

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



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

Unit 4: Principles of electrical and electronic engineering

Tuesday 16 January 2018 – Morning
Time allowed: 1 hour 30 minutes

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	/9
2	/12
3	/9
4	/7
5	/12
6	/11
Total	/60

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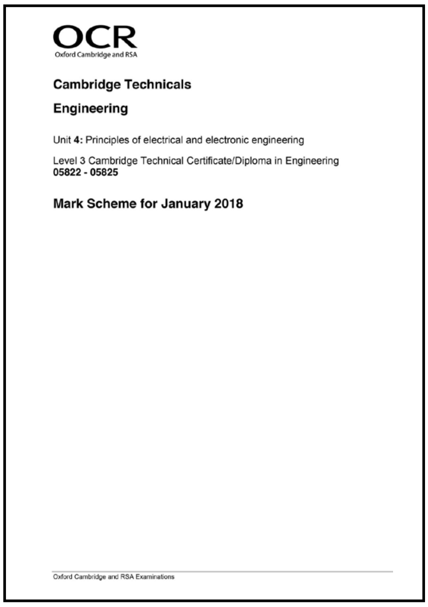

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Cambridge Technicals

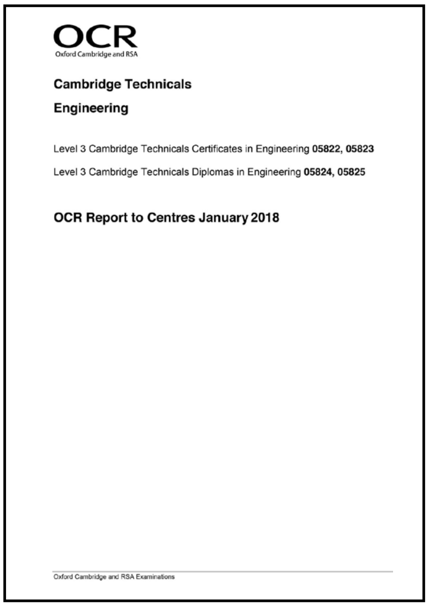
Engineering

Unit **4:** Principles of electrical and electronic engineering

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

Mark Scheme for January 2018

Oxford Cambridge and RSA Examinations



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Cambridge Technicals

Engineering

Level 3 Cambridge Technicals Certificates in Engineering **05822, 05823**

Level 3 Cambridge Technicals Diplomas in Engineering **05824, 05825**

OCR Report to Centres January 2018

Oxford Cambridge and RSA Examinations

GENERAL EXAMINER COMMENTS ON THE PAPER

Questions on the fundamentals of electricity and electronics (1, 2 and 5) were generally answered well. Questions on systems (3, 4 and 6), with a greater reliance on understanding, explanation and recall were not answered so well.

There was widespread misuse of the key words *current*, *charge*, *voltage*, *power*, *phase*, indicating a less than certain grip on the nature of electricity. It would seem that more time spent early on to embed these ideas would lead to more successful outcomes.

There were a number of missing or incorrect units being used for numerical answers.

A large number of pupils were able to correctly substitute values into the appropriate formulas but then calculated the incorrect answer. Usually these candidates were not applying the BODMAS rules when using their calculators.

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(a)

Answer **all** the questions.

1 Fig. 1 shows the circuit symbol for an operational amplifier.

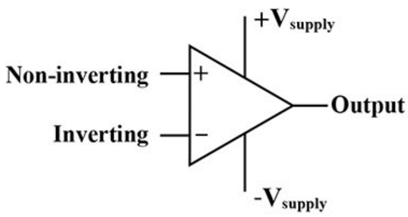


Fig. 1

(a) State, with the aid of the labelled diagram in Fig. 1, **three** key characteristics of an operational amplifier.

1 ...

2 ...

3 ...

- High/infinite gain voltage amplifier
- Differential input
- Amplifies the difference between the non-inverting and inverting inputs.
- Produces an output voltage many times larger than the voltage difference between its inputs.
- Has a single ended output.
- Has a dual supply which allows the output voltage to swing above and below 0V.
- Can be used to amplify both A.C. and D.C.
- DC-coupled voltage amplifer
- High/infinite input impedance
- Low/zero output impedance

[3]

Mark scheme guidance

Any 3 points.

Do not award a simple description of the diagram, e.g. "has two inputs and one output".

Examiner comments

The question called for identification of key characteristics of the operational amplifier. The majority of candidates contented themselves with identifying/repeating the names of aspects of the diagram and consequently scored low marks.

Question 1(b)

(b) The circuit diagram for an audio amplifier is shown in Fig. 2.

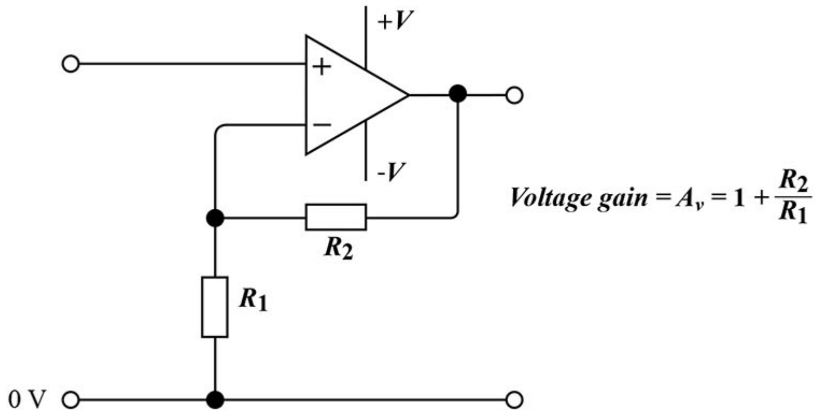


Fig. 2

(i) The voltage gain (A_v) of the amplifier is 20 and the value of R_1 is10 kΩ.
Calculate a suitable value for resistor R_2.

Voltage Gain (A_v) = $1 + \frac{R2}{R1}$

$20 = 1 + \frac{R_2}{10K\Omega}$

(20-1) × 10000 = R2
R2 = 190 kΩ

R_2 = ... kΩ **[3]**

(ii) A voltage of 10 mV is input into the amplifier. Calculate the output voltage (V_{Out}).
Indicate the units used in your answer.

Voltage Gain (A_v) = $\frac{V_{out}}{V_{in}}$

V_{out} = Voltage Gain × V_{in} = 20 × 10mV
= 0.2**V or** 200**mV**

V_{Out} = ... **[3]**

Mark scheme guidance

Question 1(b)(i):

1 mark for substitution.

1 mark for rearrangement – For applying knowledge from Unit 1 LO1.

Question 1(b)(ii):

Units required in answer.

Recalling formula (see or implied) and rearrangement and substitution.

Correct unit must be stated or maximum 2 marks.

Examiner comments

Question 1(b)(i) – This was handled successfully provided the rearrangement was done correctly. 190 kΩ

Question 1(b)(ii) – This was a straightforward use of the generalised voltage gain formula. 0.2V

Question 2(a)

2 A simple AC circuit is shown in Fig. 3.

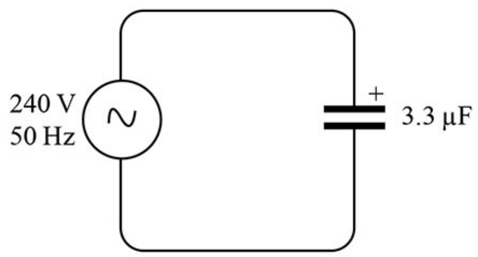


Fig. 3

(a) Calculate the reactance (X_c) of the capacitor.

$$X_c = \frac{1}{2\pi f c}$$

$$X_c = \frac{1}{2 \times \pi \times 50 \times 3.3\mu}$$

X_c = ... $X_c = 965\Omega$ ...... Ω **[2]**

Turn over

Mark scheme guidance

Allow 960 Ω (rounded to 2 sig. figs.)

Examiner comments

This was answered well provided 3.3 µ was correctly interpreted as 3.3×10^{-6}. **965Ω.**

Question 2(b)

(b) A 200 Ω resistor is added to the circuit. The updated circuit is shown in Fig. 4.

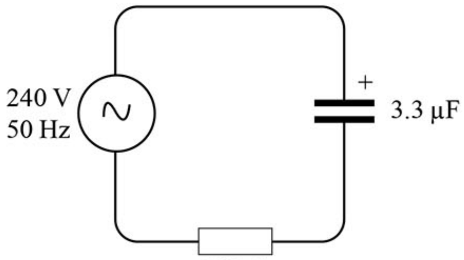


Fig. 4

(i) Calculate the total impedance (Z).
Indicate the units used in your answer.

$Z = \sqrt{R^2 + X_c^{\ 2}}$
$Z = \sqrt{964.575...^2 + 200^2}$ *
Z = 985 or 986 <u>Ω</u>
*If rounded answer from (i) 965 used = 985.51 so accept rounding to 986

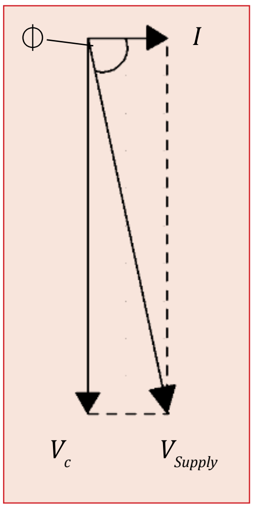
Z = ... **[3]**

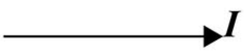
(ii) Calculate the phase angle (ϕ).
Indicate the units used in your answer.

Cos Φ = R/Z
Cos Φ = 200/985 or 200/986 or 200/980
Phase angle (Φ) = 78.3<u>°</u> /78.2<u>°</u> or 1.4 <u>**rad**</u>

Phase angle ϕ = ... **[3]**

(iii) Complete the phasor diagram below for the circuit shown in Fig. 4.
Indicate V_C, V_{Supply} and the phase angle (ϕ) on the diagram.





[4]

Mark scheme guidance

Question 2(b)(i):

Units required in answer.

Use of formula seen or implied. Allow ecf from (i) for X_c^2

1 mark for correct answer, 1 mark for unit.

Allow 980 Ω if X_C = 960 Ω in 2(a).

Question 2(b)(ii):

Units required in answer.

Allow ecf from (i) for Z.

1 mark for correct answer, 1 mark for unit.

Question 2(b)(iii):

1 mark each for the correct position of V_{Supply}, V_C and Φ.

1 mark for correct alignment (see dotted lines).

Examiner comments

Question 2(b)(i) – There was generally correct use of the formula. **985 Ω**

Question 2 (b)(ii) – As above there was generally correct use of the formula. **78.3°**

Question 2 (b)(iii) – Very few candidates were able to construct all elements of the phasor diagram and a signification number did not indicate an alignment of phasors in the correct vector formation.

Question 3

3 (a) Define Kirchhoff's first law.

At any node/junction in a circuit the sum of the currents flowing into the node are equal to the sum of the currents flowing out.

.... **[2]**

(b) A four resistor network is shown in Fig 5.

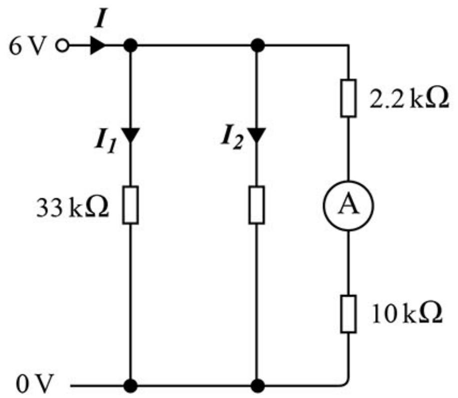


Fig. 5

(i) Calculate the value that will be displayed on the ammeter.

I = V/R
R = 10kΩ + 2.2kΩ = 12.2kΩ
I = 6/12.2kΩ
I = 0.492 mA

Current = ... mA **[3]**

(ii) Calculate the value of I if I_2 = 1 mA.
Indicate the units used in your answer.

I_1 = 6V/33 kΩ = .000182 (A) 0.182m(A) or 182μ(A)
$I = I_1 + I_2 + I_3$ (Kirchhoff's current law)
I = 0.182mA + 1mA +0.492mA
I = 1.67**mA**

Value of I = ... **[4]**

Mark scheme guidance

Question 3(a):

1 mark for recognising it is the current law. 2 marks for correct definition.

Question 3(b)(i):

For applying knowledge from Unit 2 LO3.

Question 3(b)(ii):

Units required in answer.

For applying knowledge from Unit 2 LO3

Allow ecf for 0.492mA for I_3 from (i).

Allow ecf for 0.182mA for I_1.

1 mark for correct answer. And 1 mark for correct unit.

1 mark for unit – For applying knowledge from Unit 2 LO1.

Examiner comments

Question 3(a) – This question required recall that Kirchhoff's first law is about current, for one mark, and its conservation at nodes for the second. It was rare to see both marks earned.

Question 3(b)(i) – This was a searching question on resistor combination that was usually handled competently provided time was taken to plan the three phases of the calculation. Most candidates recognised the need to use both formulae as appropriate. Combining two resistors on either side of an ammeter proved a challenge for some candidates. **0.492 mA**

Question 3(b)(ii) – The above remarks apply here too, and additionally there were many occurrences of 'sharing' the 6V potential difference as 2V to each leg. **1.67 mA**

Question 4(a)

4 **(a)** A block diagram for an **unstabilised** 12 VDC power supply is shown in Fig. 6.

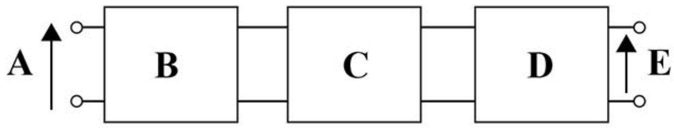


Fig. 6

(i) Identify the following elements of the power supply shown in Fig. 6.
A has been done for you.

A 240 VAC input

B Transformer

C Rectifier

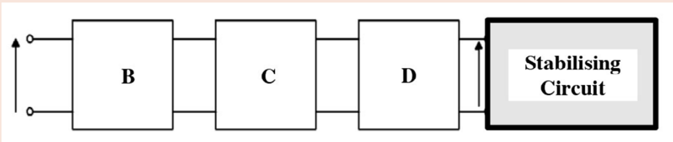
D Smoothing Circuit

E (unregulated/unstabilised) DC output

[4]

(ii) The power supply needs to be adapted so that it provides a stabilised output.
Add a block representing a stabilising circuit **to** the diagram in Fig. 6. **[1]**

Stabilising circuit connected to DC output.



Mark scheme guidance

Question 4(a)(i):

Part marks for BCD may be earned where elements are omitted provided those shown are in a logical sequence. Correct answer only.

Question 4(a)ii):

Also accept block labelled **voltage regulator.**

Examiner comments

Part (i) was straight recall of the DC power supply system and found approximately half the candidates wanting. The single mark for (ii) was rarely earned.

Exemplar Candidate Work

Question 4(a)(i) – High level answer

4 (a) A block diagram for an **unstabilised** 12 VDC power supply is shown in Fig. 6.

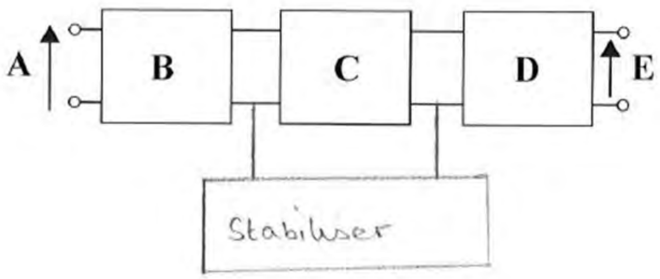


Fig. 6

(i) Identify the following elements of the power supply shown in Fig. 6.
A has been done for you.

A 240 VAC input

B Transformer

C Rectifier

D Resistor

E ~~240 VAC~~ 12 VDC output

[4]

Commentary

The correct answer for D would be 'Smoothing circuit' or equivalent. A simple resistor would not have the desired effect of reducing the AC ripple voltage. However this oversight would not render the rest of the circuit unworkable, so the damage is limited, and the answer remains high level. It was not a requirement to state that the output from E would still be unstabilised so this candidate's answer was judged to be high level.

Exemplar Candidate Work

Question 4(a)(ii) – Low level answer

4 (a) A block diagram for an **unstabilised** 12 VDC power supply is shown in Fig. 6.

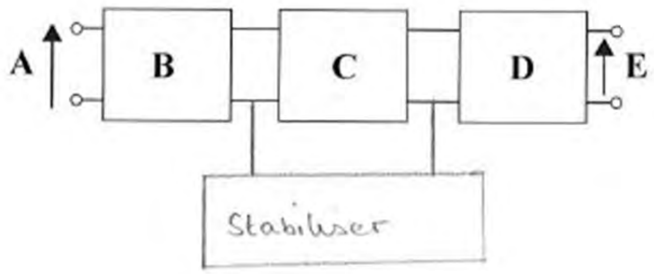


Fig. 6

(ii) The power supply needs to be adapted so that it provides a stabilised output.
Add a block representing a stabilising circuit **to** the diagram in Fig. 6. [1]

Commentary

The correct label for the added block would be either 'stabilising circuit' or 'voltage regulator', but, more importantly, the block would be in series with the output from D, rather than in parallel to C, the rectifier. This diagram would not have the required functionality, if any, and is therefore a low level answer.

Question 4(b)

(b) Explain the benefits of load regulation in a stabilised DC power supply.

- Maintains a constant voltage (or current) on the output.
- Regardless of changes in circuit load.

[2]

Mark scheme guidance

Question 4(b):

Up to two marks for an explanation.

Examiner comments

Few candidates showed appreciation of the purpose of load regulation.

Exemplar Candidate Work

Question 4(b) – Medium level answer

(b) Explain the benefits of load regulation in a stabilised DC power supply.

As it only flows in one direction and has no frequency it benefits to be stabilised as it will improve how smooth and efficient the DC is.

[2]

Commentary

A high level answer would not only recognise that load regulation leads to a more constant output voltage, but also that this benefit is maintained in the particular circumstances of variable load on the output. The latter was rarely mentioned and so high level answers were very rare. Amongst the medium level responses that did not refer to the impact of varying loads it was necessary to see some evidence that the candidate appreciated the difference between the reduction of AC ripple, which is the function of the smoothing circuit, and maintenance of a constant DC output, which is the purpose of voltage regulation. This answer is borderline low level due to some imprecise language and irrelevant elaboration. A simple phrase like 'keeps the DC output steady' would have served better.

Questions 5(a) and (b)(i)

5 **(a)** The circuit symbol for a two input logic gate is shown in Fig. 7.

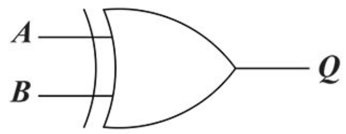


Fig. 7

(i) Complete the truth table for this logic gate.

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

[2]

(ii) State the Boolean expression for this logic gate.

$A \oplus B$

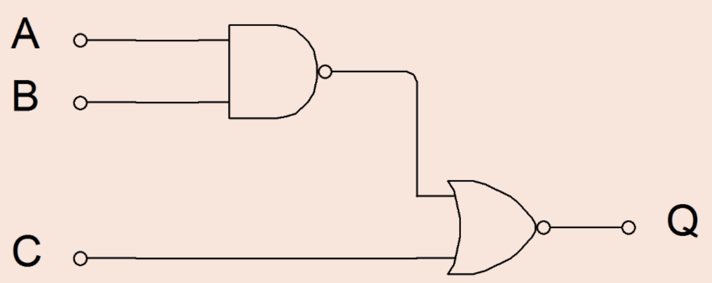
or $\overline{A}.B + \overline{A}.B$ .. **[1]**

(b) A combinational logic circuit is represented by the Boolean expression:

$$Q = \overline{(A.B) + C}$$

This forms part of a decoding circuit that opens a door lock mechanism when the correct code is entered into inputs ***A***, ***B*** and ***C***.
The door lock mechanism opens when there is a logic 1 on the output ***Q***.

(i) Draw the combinational logic circuit represented by the Boolean expression.



[4]

Mark scheme guidance

Question 5(a)(i):

1 mark for 2/3 rows correct.

Question 5(a)(ii):

One mark for either expression given.

Question 5(b)(i):

1 mark for NAND gate.

1 mark for NOR gate.

1 mark for correct connection of 2 gates.

1 mark for correct labelling of A,B,C and Q.

Examiner comments

Question 5(a) –This was generally well answered but the Boolean expression presented some difficulty.

Question 5(b)(i) – This was well answered although labels for inputs and output were often overlooked.

Question 5(b)(ii)

(ii) Complete the truth table below to determine the code required to open the door lock mechanism.

A	*B*	*C*	*A.B*	*Q*

A	B	C	A.B	$\bar{A}.\bar{B}$*	Q
0	0	0	0	1	0
0	0	1	0	1	0
0	1	0	0	1	0
0	1	1	0	1	0
1	0	0	0	1	0
1	0	1	0	1	0
1	1	0	1	0	1
1	1	1	1	0	0

Code: *A* = 1 *B* = 1 *C* = 0

[5]

Mark scheme guidance

For full marks all 8 possible combinations of ABC must be seen and all combinations bar 110 will return 0 for Q.

Award 1 mark for every 2 correct values of Q for non-repeated sequences of ABC in the truth table.

There should be no repeat combinations of ABC. If there are, and values of Q are contradictory or incorrect then do not credit. For repeated sequences where Q is correct only credit one line.

All digits must be correct.

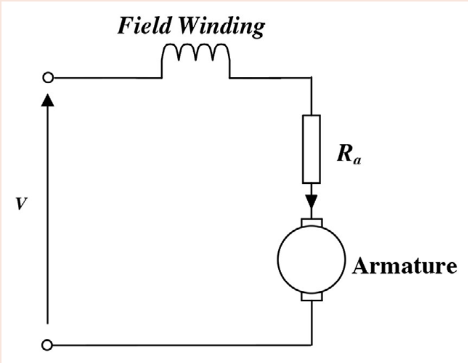
*as per post-examination correction erratum.

Examiner comments

The truth table was handled well by most although correct tabulation of the 8 input combinations would have helped some.

Question 6

6 (a) Draw a circuit diagram for a series wound self-excited DC generator.



[4]

(b) A separately excited DC generator is connected to a 68 Ω load and a current of 7 A flows. If the armature resistance is 1.5 Ω determine:

(i) The terminal voltage (V).

$V = I_a R_L$
$V = 68 \times 7$
$V = 476$ V

V = ... V **[2]**

(ii) The generated EMF (E).

$V = E - I_a R_a$
$476 = E - (1.5 \times 7)$
$E = 486.5$ V

E = ... V **[3]**

(c) Identify **one** advantage and **one** disadvantage of a separately excited DC generator over a series wound self-excited DC generator.

Advantage: Lower internal resistance.

Disadvantage: Requires additional voltage supply for field winding circuit.

[2]

Mark scheme guidance

Question 6(a):

1 mark each for correct symbols for armature, field winding, output voltage and armature resistance connected in series.

Question 6(b)(i):

For applying knowledge from Unit 2 LO3.

Unit **not** required for this mark.

Question 6(b)(ii):

For substitution.

For rearrangement – For applying knowledge from Unit 1 LO1.

Allow ecf for 476 V from (i).

Unit **not** required for this mark.

Examiner comments

Question 6(a) – Few candidates were able to recall the four essential features of the self-excited series wound DC generator, viz. armature, field winding, output voltage and armature resistance.

Question 6(b)(i) – Many candidates were applying inappropriate formulae. **476V**

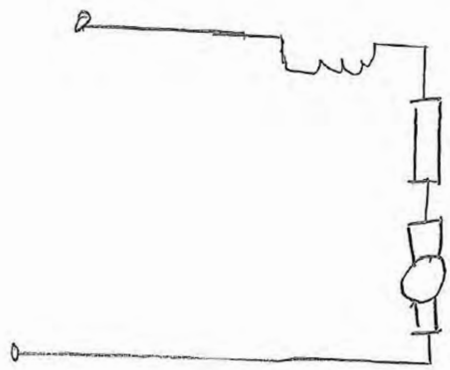
Question 6(b)(ii) – As above. **486.5V**

Question 6(c) – The advantage of lower internal resistance eluded the majority. The disadvantage of an additional voltage supply was better known.

Exemplar Candidate Work

Question 6(a) – High level answer

6 (a) Draw a circuit diagram for a series wound self-excited DC generator.



[4]

Commentary

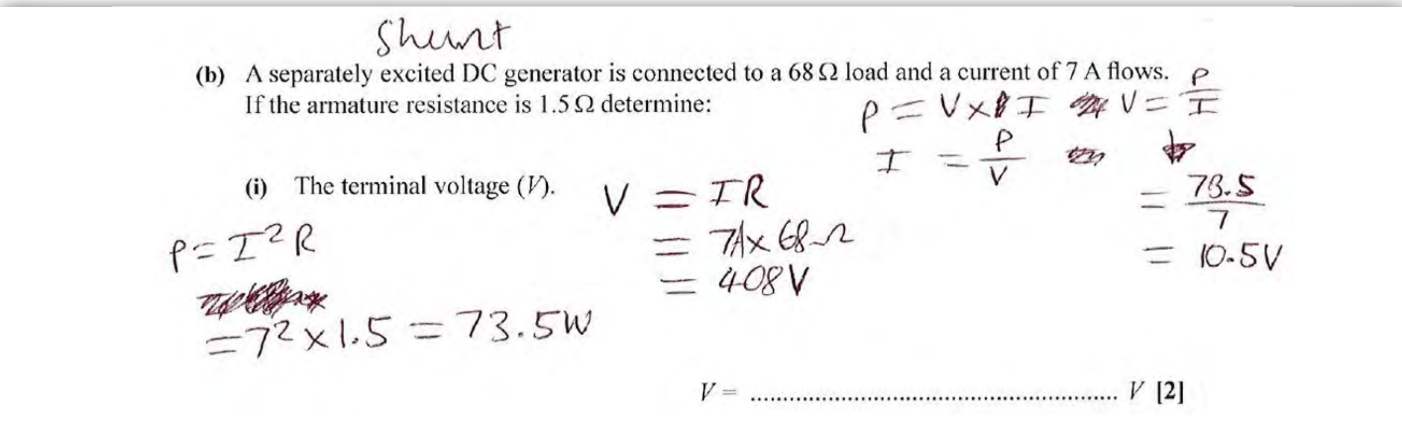
There are four essential elements to the diagram that must be illustrated unambiguously for full marks:

- Armature
- Field winding
- Armature resistance
- Output voltage

It is important for clarity that diagrams be carefully drawn and use correct symbols as well as correct labels. In the absence of these there is a risk of ambiguity and the mark for 'output voltage' in this case could not be awarded.

Exemplar Candidate Work

Question 6(b)(i) – High level answer



Shunt

(b) A separately excited DC generator is connected to a 68 Ω load and a current of 7 A flows. If the armature resistance is 1.5 Ω determine:

(i) The terminal voltage (*V*).

$P = I^2R$
$= 7^2 \times 1.5 = 73.5W$

$V = IR$
$= 7A \times 68\Omega$
$= 408V$

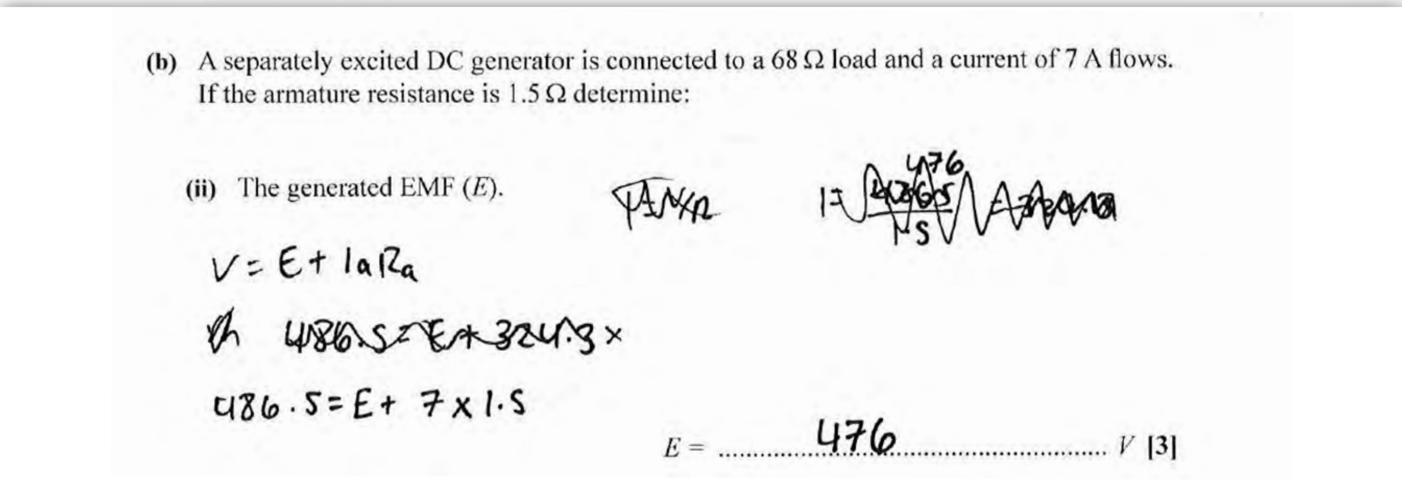
$P = V \times I$ $V = \frac{P}{I}$
$I = \frac{P}{V}$
$= \frac{73.5}{7}$
$= 10.5V$

V = ... *V* **[2]**

Commentary

The marker has ignored the incorrect workings to right and left, but candidates are advised to cross out workings that they have abandoned. The working in the middle of the page contains the correct formula and shows the correct substitutions. Unfortunately this calculation is performed incorrectly and so fails to secure full marks.

Question 6(b)(ii) – High level answer



(b) A separately excited DC generator is connected to a 68 Ω load and a current of 7 A flows. If the armature resistance is 1.5 Ω determine:

(ii) The generated EMF (*E*).

$V = E + I_aR_a$

$486.5 = E + 7 \times 1.5$

E = ...476.......................... *V* **[3]**

Commentary

The final answer here is correct but by a combination of two counteracting errors. The formula used is incorrect, it should be V = E - IaRa. However the value used for V of 486.5 is also incorrect, but carried forward from (b)(i). This leads to the correct answer of 476V, but by an incorrect route.

To gain full marks the candidate should have used V = E – IaRa. The error carried forward would still have been credited and so would the calculated answer it yielded.

A large number of candidates made the same error in 6(b)(i) of using the emf formula (E = V + IaRa) when what was asked for was the terminal voltage, V. The meaning of 'terminal voltage', as opposed to 'emf' needs to be clear in candidates' minds.

Exemplar Candidate Work

Question 6(c) – High level answer

(c) Identify **one** advantage and **one** disadvantage of a separately excited DC generator over a series wound self-excited DC generator.

Advantage: Can produce more power.

Disadvantage: Requires an external power source to start it.

[2]

Commentary

The candidate here correctly identified the disadvantageous requirement for a separate power supply (with the resulting cost and added complexity). However the expected advantage is that such motors have lower internal resistance. Very few candidates acknowledged this.

The small print

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