OCR
Oxford Cambridge and RSA

Cambridge Technicals
Engineering

Unit 4: Principles of electrical and electronic engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825 & 05873

Mark Scheme for January 2024

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1. Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Online Training*; *OCR Essential Guide to Marking*.

2. Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3. Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1. Mark strictly to the mark scheme.

2. Marks awarded must relate directly to the marking criteria.

3. The schedule of dates is very important. It is essential that you meet the RM Assessor 50% Batch 1 and 100% Batch 2 deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4. If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone or by email.

5. **Crossed Out Responses**
   Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate).
When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. (The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional lined pages if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add an annotation to confirm that the work has been seen.

7. There is a NR (No Response) option. Award NR (No Response)
   - if there is nothing written at all in the answer space
   - OR if there is a comment which does not in anyway relate to the question (e.g. 'can't do', 'don't know')
   - OR if there is a mark (e.g. a dash, a question mark) which isn't an attempt at the question

   Note: Award 0 marks - for an attempt that earns no credit (including copying out the question)

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses.
Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

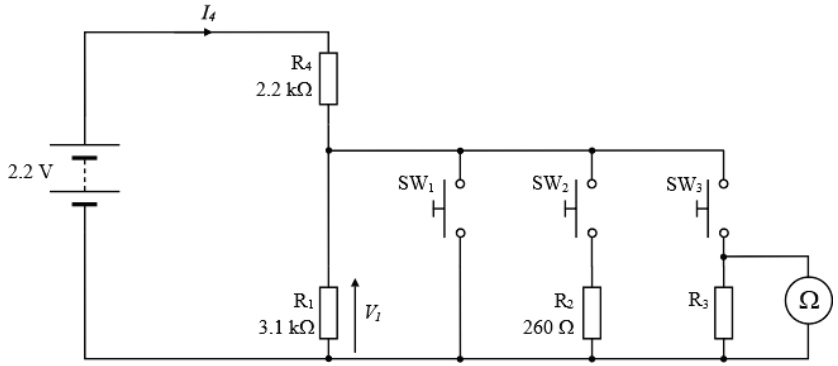
10. **Annotations**

Annotation	Meaning
	Correct response
	Incorrect response
	Incomplete response
	Error carried forward
	Benefit of doubt
	No benefit of doubt
	Rounding error

Mark scheme abbreviations:
Wtte: words to that effect
Ecf: error carried forward

11. **Subject-specific marking instructions**

- In all numerical calculation questions a correct response will gain all marks unless specified otherwise.
- Rounding of answers should be to the same number of significant figures as the data in the question, or, otherwise, an answer will be correct provided it rounds to the correct answer.
- Symbols used in circuit diagrams must identify relevant components uniquely and unambiguously.

Question			Answer	Marks	Guidance
1	(a)		 Ohmmeter across R_3	1	Circuit equivalent to Android phone headset: R_1 microphone impedance, SW_1 stop/play, SW_2 vol+, SW_3 vol−.
1	(b)		One of: • To prevent measuring the rest of the circuit in parallel with R_3 (wtte) • To prevent the current from the power supply affecting the meter (wtte) • To prevent the power supply from damaging the meter	1	
1	(c)		$V = 2.2$ V $R_T = R_4 + R_1 = 2200 + 3100 = 5300\ \Omega$ $$I_1 = \frac{V}{R_T} = \frac{2.2}{5300} = 0.000415\ A$$	1 1	Synoptic mark from unit 2: LO 1.1 Calculate total resistance in Ohms Correct voltage and calculation
1	(d)		$$I_4 = \frac{V}{R_4} = \frac{2.2}{2200} = 0.0010\ \text{A}$$	1	

Question			Answer	Marks	Guidance
1	(e)		$R_1 \parallel R_2 = R_{1\&2}$ (effective resistance of R_1 in parallel with R_2) $\frac{1}{R_{1\&2}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3100} + \frac{1}{260} = 0.00417$ $R_{1\&2} = \frac{1}{0.00417} = 240\ \Omega$		Alternative method (for R_1 in parallel with R_2) $R_{1\&2} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{3100 \times 260}{3100 + 260} = 240\ \Omega$
			$R_T = R_4 + (R_1 \parallel R_2)$ $= 2200 + 240 = 2440\ \Omega$	1	Correct calculation of resistance of network
			$I_4 = \frac{V}{R_T} = \frac{2.2}{2440}$ $= 9.02 \times 10^{-4}$ A	1	Correct calculation of current
			$V_1 = I_4 \times (R_1 \parallel R_2) = 9.02 \times 10^{-4} \times 240 = 0.216$ V OR $V_1 = V - (I_4 \times R_4) = 2.2 - (9.02 \times 10^{-4} \times 2200) = 0.216$ V	1	Correct voltage

Question			Answer	Marks	Guidance
1	(f)		$I_4 = \frac{V - V_1}{R_4} = \frac{2.2 - 0.387}{2200} = 8.241 \times 10^{-4}$ A $current\ in\ R_1$: $I_1 = \frac{V_1}{R_1} = \frac{0.387}{3100} = 1.248 \times 10^{-4}$ A current in R_3: $I_3 = I_4 - I_1$ $= 8.241 \times 10^{-4} - 1.248 \times 10^{-4}$ $= 6.993 \times 10^{-4}\ A$ $R_3 = \frac{V_1}{I_3} = \frac{0.387}{6.993 \times 10^{-4}} = 553\ \Omega\ \pm 5\ \Omega$	1 1	Calculates I_4 (or ratio of voltages equated to ratio of resistors) Calculates resistance of R_3 correctly Allow any correct alternative method. E.g. $\frac{V-V_1}{V_1} = \frac{R_4}{R_{1\&3}}$ OR $I_4 = \frac{V-V_1}{R_4} = \frac{V_1}{R_{1\&3}}$ $\therefore R_{1\&3} = \frac{R_4 V_1}{V - V_1} = \frac{2200 \times 0.387}{2.2 - 0.387} = 470\ \Omega$ $R_3 = \frac{1}{\frac{1}{R_{1\&3}} - \frac{1}{R_1}} = \frac{R_1 R_{1\&3}}{R_1 - R_{1\&3}} = \frac{3100 \times 470}{3100 - 470}$ $= 554\ \Omega$ OR $I_4 = \frac{V - V_1}{R_4} = \frac{2.2 - 0.387}{2200} = 8.241 \times 10^{-4}\ A$

Question			Answer	Marks	Guidance
					$R_{1\&3} = \frac{V_1}{I_4} = \frac{0.387}{8.241 \times 10^{-4}} = 470\ \Omega$ $\frac{1}{R_3} = \frac{1}{R_{1\&3}} - \frac{1}{R_1} = \frac{1}{470} - \frac{1}{3100} = 0.00181\ \Omega^{-1}$ $R_3 = \frac{1}{0.00181} = 554\ \Omega$
2	**(a)**		One of: • Generate an AC supply • Convert mechanical/kinetic energy into electrical energy	1	
2	**(b)**		$f = 1/T$ $f = 41.1$ kHz $= 41\,100$ Hz $T = 1/f = 1/41100 = 0.000\,024\,3$ s	 1	Synoptic mark from unit 2: LO 1.1 Accept 24.3 μs or 0.0243 ms if candidate adds prefix to units or 2.43×10^{-5} s

Question			Answer	Marks	Guidance
2	(c)		$\omega = 2\pi f$ $\omega = 2\pi \times 41\,100 = 258\,000$ rad s^{-1} or 258 000 s^{-1} Correct numerical value Correct units	 1 1	 Accept $\omega = 2\pi \times 41.1 = 258$ krad s^{-1} Accept any correct number consistent with units e.g. 258 krad s^{-1} or 0.258 Mrad s^{-1} Synoptic mark from unit 1: LO 4.1 Accept rad s^{-1} or rad/s or multiple with valid SI prefix e.g. krad s^{-1} or krad/s or Mrad s^{-1} etc. Do **not** accept Hz. Synoptic mark from unit 2: LO 1.1
2	(d)		$v = V \sin \omega t$ $v = 0.6 \times \sin(258\,000 \times 14 \times 10^{-6})$ $v = -0.27$ V $\omega\tau$	 1 1	 Numbers correctly substituted into formula [1] Correct answer including minus sign [1] ecf from 2c Beware of candidates with calculators **incorrectly** set to degrees so giving **wrong** answer of +0.038 V, only award one mark for substituting, no mark for value.

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(e)</td><td></td><td>$X_C = 1/2\pi fC = 1/(2\pi \times 41.1\times10^3 \times 15\times10^{-9}) = 258.16\ \Omega$

$X_L = 2\pi fL = 2\pi \times 41.1\times10^3 \times 1\times10^{-3} = 258.23\ \Omega$

$X_R = 0\ \Omega$ by definition

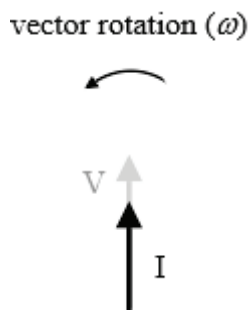
<table><tr><th>Component</th><th>Reactance / Ω</th></tr><tr><td>Capacitor</td><td>258</td></tr><tr><td>Inductor</td><td>258</td></tr><tr><td>Resistor</td><td>0</td></tr></table></td><td>1

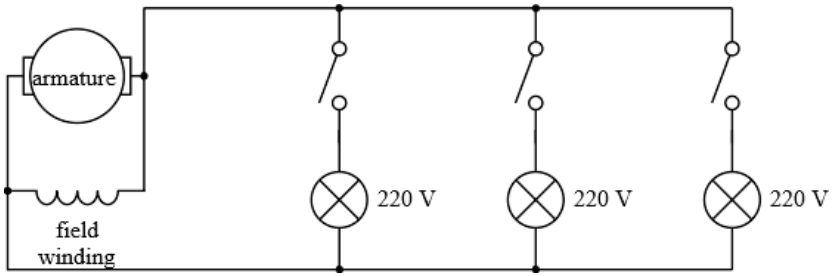
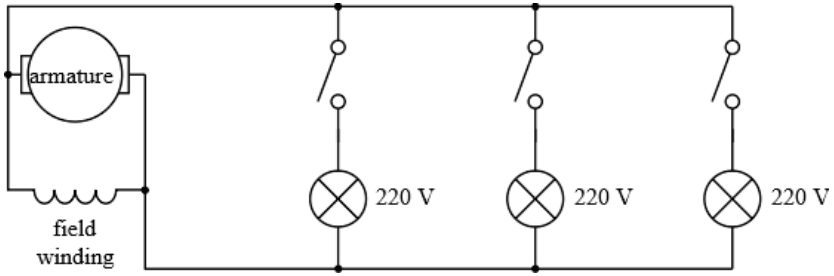
1

1</td><td>Ignore any minus signs or decimal places in answers</td></tr>
<tr><td>2</td><td>(f)</td><td></td><td>$X_L = X_C\ \therefore\ Z = R = 150\ \Omega$

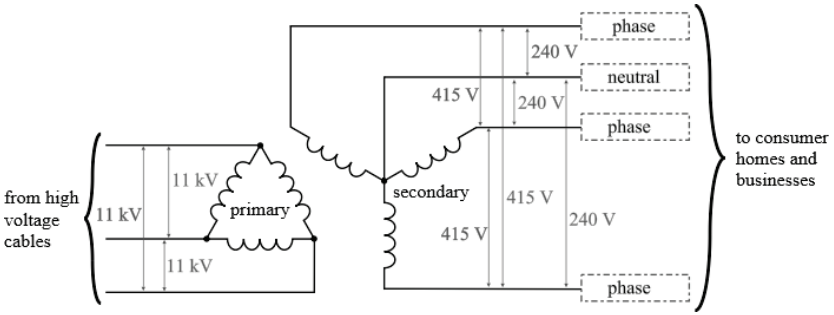
OR

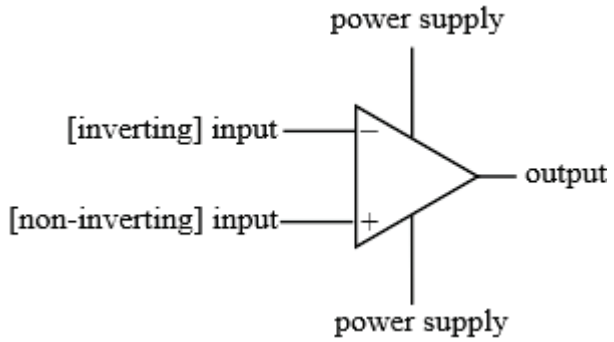
$Z = \sqrt{(R^2 + (X_L - X_C)^2)} = \sqrt{(150^2 + (258.23 - 258.16)^2)} = 150\ \Omega$</td><td>1</td><td>ecf 2e</td></tr>
<tr><td>2</td><td>(g)</td><td></td><td>$\cos\phi = R/Z$
$\phi = \cos^{-1}(R/Z) = \cos^{-1}(150/150) = 0°$</td><td>1</td><td>ecf 2f</td></tr>
</table>

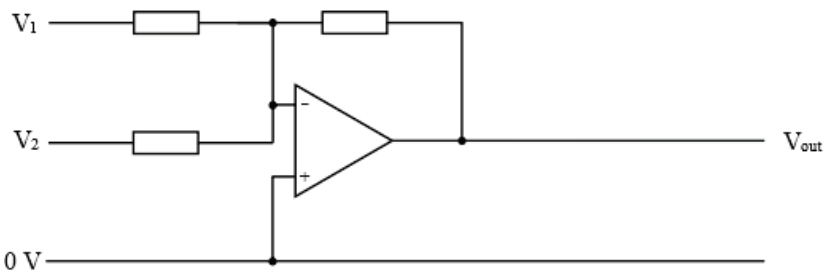
Question			Answer	Marks	Guidance
2	(h)		Vertical arrow facing up starting at same point as existing grey arrow.  	1	Length of arrow unimportant

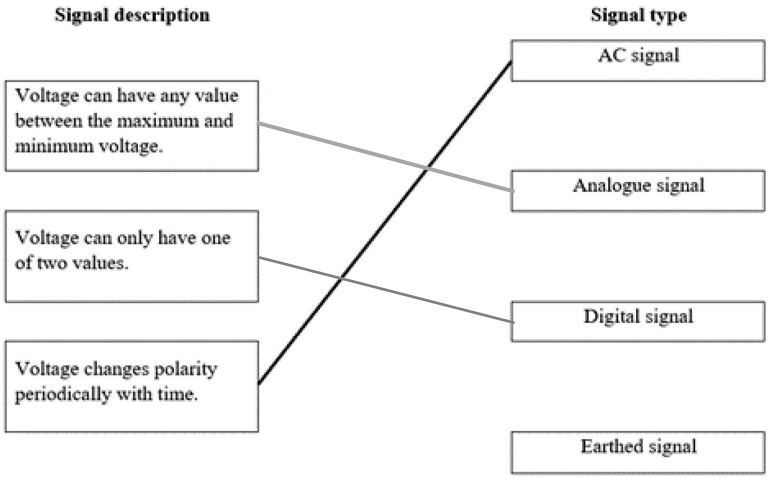
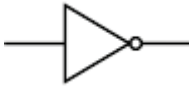
Question			Answer	Marks	Guidance
3	(a)		Armature shown provides power to lamps circuit and Armature in parallel with field winding  OR  	1 1	

Question			Answer	Marks	Guidance
3	(b)		One mark for each of (maximum 2 marks): • Generator does not require auxiliary power for field winding (wtte) • Voltage from generator remains fairly constant with changes in current/resistance/load (wtte) • Voltage does not change when more lights switched on (wtte) • Current changes when more/fewer lights switched on (wtte) • Lamps require fairly constant supply voltage (wtte)	2	Valid comment about self-excited Valid comment about shunt generators voltage-current characteristics
3	(c)		$I_f = \frac{V}{R_f} = \frac{220}{300} = 0.73\ A$	1 1	Evidence of use of correct equation Synoptic mark from unit 2: LO 3.5 Correct value
3	(d)		$I_a = I_f + I_{Lamps} = 0.73 + 1.36 = 2.09$ A	1	ecf 3c
3	(e)		$V = E - I_a R_a$ $E = V + I_a R_a$ $E = 220 + 2.1 \times 4 = 228.4$ V (ecf from 3d)	1 1 1	Evidence of correctly rearranged equation Synoptic mark from unit 1: LO 1.3 Correct answer Correct units (V

Question			Answer	Marks	Guidance
4	(a)			1	Secondary substation transformer.
4	(b)		1 mark for each correct word in the correct place. The system has a ***delta*** connected primary and a ***star*** connected secondary. The ***line*** voltage of the secondary is 415 V. The ***phase*** voltage of the secondary is 240 V.	4	
4	(c)	(i)	One mark for each of (maximum 2 marks): • Disconnects circuit from supply/stops the flow of current (wtte) • When fault/short-circuit occurs (wtte) • To protect the circuit (wtte)	2	

Question			Answer	Marks	Guidance
4	(c)	(ii)	Up to 2 from: • Circuit breaker be reset when fault is removed (wtte) • Fuse needs to be replaced after fault occurs (wtte) • Circuit breakers give a clear visual signal when they have been triggered (wtte) • Fuses need to be removed to check if they have been triggered/need careful inspection to check if they have blown (wtte)	2	
5	(a)		Output labelled to point on RHS of symbol Both inputs labelled to + and – signs on symbol Power supplies labelled to top and bottom sloping sides of symbol  	1 1 1	Not necessary to identify inverting and non-inverting

Question			Answer	Marks	Guidance
5	(b)		Circuit contains correctly drawn op-amp V_1 & V_2 each connected through resistor to inverting input of op-amp Non-inverting input of op-amp connected to 0 V Resistor connected between inverting input and output of op-amp Output connected directly to V_{out}  	1 1 1 1 1	

Question			Answer	Marks	Guidance
5	(c)		Line from '… can have any value …' to 'Analogue signal' Line from '… only have one of two…' to 'Digital signal'  	1 1	
6	(a)			1	
6	(b)		Two columns and two rows containing only 0s and 1s Correct truth table for NOT gate **Input** | **Output** 0 | 1 1 | 0	1 1	Accept T & F or High & Low or H & L

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>6</td><td>(c)</td><td></td><td>One of:
• Output is opposite of input (wtte)
• Output is high when input is low and vice versa (wtte)
• It inverts the input</td><td>1</td><td></td></tr>
<tr><td>6</td><td>(d)</td><td>(i)</td><td>One mark for each correct column

<table><tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td></tr></table></td><td>4</td><td>Allow ecf for columns D, E and Q</td></tr>
<tr><td>6</td><td>(d)</td><td>(ii)</td><td>  </td><td>1</td><td></td></tr>
</table>

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