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 June 2022

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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

TRADITIONAL

Before the Standardisation meeting you must mark at least 10 scripts from several centres. For this preliminary marking you should use **pencil** and follow the **mark scheme**. Bring these **marked scripts** to the meeting.

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 traditional 40% 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)

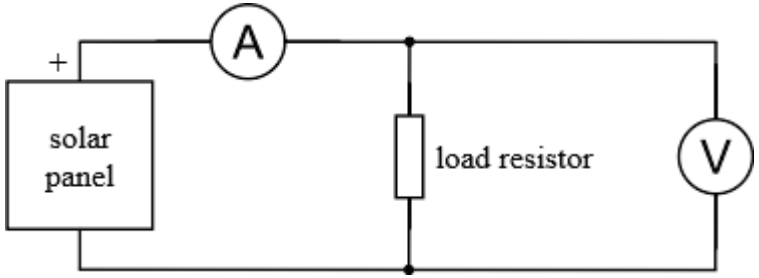
8. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking period. Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark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

9. **Annotations**

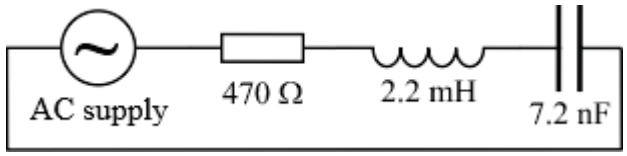
Annotation	***Meaning***
tick	Correct response
cross	Incorrect response
Omission mark (carat)	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
RE	Rounding error

10. **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)		Ammeter in series circuit with solar panel and load resistor Voltmeter in parallel with load resistor  	1 1	
1	(b)		$V = IR$ I = 150 mA = 0.15 A $V = 0.15 \times 38$ V = 5.7 V	 1 1	 Evidence of correct conversion from mA to A. Synoptic mark from unit 2: 1.1 Correct calculation (allow ecf)
1	(c)		$P = I^2R$ $P = 0.15^2 \times 38$ OR $P = IV$ $P = 0.15 \times 5.7$ P = 0.855 W	 1	 Synoptic mark from unit 2: 3.8 Allow ecf from 1b

Question			Answer	Marks	Guidance
1	(d)	(i)	$P = I^2R$ $\therefore I = \sqrt{(P/R)}$	1	Evidence of correct method. Synoptic mark from unit 1: 1.4
			From graph when 27 Ω then P = 0.91 W (±0.005 W)	1	Evidence of finding correct value from graph. Accept values in range 0.905 – 0.915 W.
			I = √(0.91/27) = 0.1835(±0.0005) A	1	Correct answer. Accept answers to 2 s.f. (i.e. 0.18 A)
1	(d)	(ii)	22 Ω	1	
1	(d)	(iii)	Graph shows <u>maximum power/peak power/graph peaks</u> at load resistance of 22 Ω (wtte)	1	
			Maximum power when <u>load resistance equals internal resistance</u> (wtte)	1	

Question			Answer	Marks	Guidance
2	(a)	(i)	$f = 20$ kHz $= 20000$ Hz $L = 2.2$ mH $= 0.0022$ H $X_L = 2\pi fL = 2\pi \times 20000 \times 0.0022$ $X_L = 276\ \Omega$	1 1	Evidence of correct conversion from kHz to Hz and mH to H Correct answer ecf conversion to Hz and/or H
2	(a)	(ii)	$Z = \sqrt{(R^2 + X_L^2)}$ $Z = \sqrt{(R^2 + X_L^2)}$ $Z = \sqrt{(470^2 + 276^2)}$ $Z = 545\ \Omega$	1 1	Evidence of correct equation used (ecf from 2ai) Correct answer (allow ecf)
2	(b)	(i)		1	Correct component symbols in series. Components can be in any order.
2	(b)	(ii)	7.2 nF $= 7.2 \times 10^{-9}$ F or 0.0000000072 F	1	Synoptic mark from unit 2: 1.1

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Marks</th><th>Guidance</th></tr>
<tr><td>2</td><td>(b)</td><td>(iii)</td><td>
<table>
<tr><th>Frequency

f / Hz</th><th>Reactance of inductor

X_L / л Ω</th><th>Reactance of capacitor

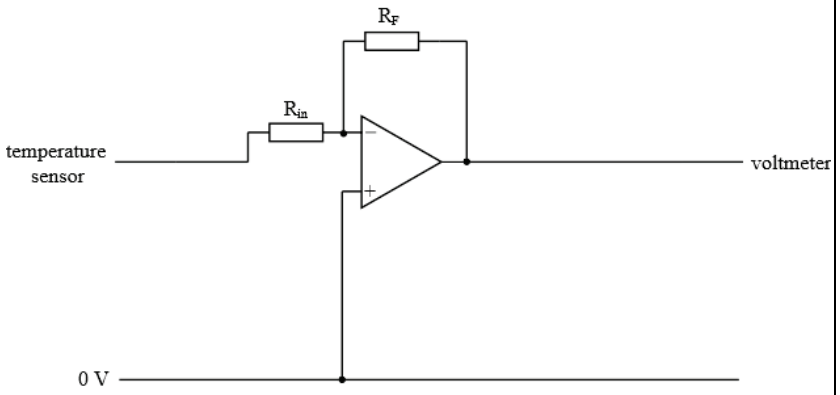
X_C / л Ω</th><th>Impedance of series RLC circuit
Z / л Ω</th></tr>
<tr><td>25000</td><td>346</td><td>884</td><td>$Z=\sqrt{(R^2 + (X_C-X_L)^2)}$
$Z==\sqrt{(470^2 + (884-346)^2)}$
714</td></tr>
<tr><td>40000</td><td>553</td><td>$Z=R$ when $X_C=X_L$
553</td><td>470</td></tr>
<tr><td>50000</td><td>$X_L=2\ л fL$
$X_L=2\ л \times 50000 \times 0.0022$
691</td><td>442</td><td>$Z=\sqrt{(R^2 + (X_L-X_C)^2)}$
$Z==\sqrt{(470^2 + (691-442)^2)}$
532</td></tr>
</table>
</td><td>4</td><td>One mark for each correct answer
Accept answers ±5 Ω</td></tr>
<tr><td>3</td><td>(a)</td><td></td><td>shunt-wound</td><td>1</td><td></td></tr>
<tr><td>3</td><td>(b)</td><td></td><td>Either:
• low starting torque needed for a fan (wtte)
• fan runs at [near] constant speed (wtte)
• speed of shunt-wound motor limited (wtte)</td><td>1</td><td></td></tr>
<tr><td>3</td><td>(c)</td><td></td><td>$V = E + I_aR_a$
$E = V – I_aR_a$
$E = 12 – 2.2 \times 0.9$
$E = 10.02 = 10$ (2 s.f.)
Units: V</td><td>1

1
1</td><td>Correct equation

Correct answer
Correct units. Synoptic mark from unit 2: 1.1</td></tr>
</table>

Question			Answer	Marks	Guidance
3	(d)		R_f = V/I R_f = 12/1.4 R_f = 8.571 = 8.6 Ω (2 s.f.)	1	
3	(e)	(i)	**One** mark for each. This order only. **reduced** **reduced** **increased**	3	e.g. When the switch SW1 is closed the current in the field winding is 1.4 A and the motor spins. When the switch SW1 is opened the resistor, R, is in series with the field winding. Therefore, the current in the field winding (I_f) is **reduced** and the magnetic flux (φ) in the motor is **reduced.** This means that the speed of the motor is **increased**.
3	(e)	(ii)	I_f = V/(R+R_f) I_f = 12/(10+8.571) ecf from d I_f = 0.6462 = 0.65 A (2 s.f.)	1 1	Correct method i.e. evidence of adding of adding resistor value to resistance of field winding. Correct answer
4	(a)		**One** mark for each correct block **transformer** → rectifier → **smoothing circuit** → **stabilising circuit**	3	
4	(b)		Converts from alternating current (wtte) to direct current (wtte)	1 1	

Question			Answer	Marks	Guidance
4	(c)		Either: • Diode only conducts/allows current to flow when the power supply is correctly connected. (wtte) OR • Diode prevents current flowing when power supply is not connected the correct way around. (wtte) OR • Idea that diode only conducts in one direction/only allows current to flow in one direction	1	Synoptic mark from unit 2: 3.3
4	(d)		**One** mark for each. This order only. **powering the wireless router** **powering the wireless router OR rectifying the supply** **being charged**	3	e.g. When the AC mains supply is not working, the battery backup power supply is **powering the wireless router**. When the AC mains supply is working, the stabilised power supply is **powering the wireless router/rectifying the supply** and battery backup power supply is **being charged**.

Question			Answer	Marks	Guidance
5	(a)		V_{in} = 30 mV = 0.03 V V_{out} = –3 V Voltage gain = V_{out}/V_{in} Voltage gain = –3/0.03 Voltage gain = –100	1 1	Evidence of correct conversion of mV to V.
5	(b)	(i)	Inverting amplifier	1	
5	(b)	(ii)	Non-inverting input on op-amp connected to 0 V Resistor from input to inverting input on op-amp Resistor from op-amp output to op-amp inverting input only Resistors in ratio 100:1 $R_F > R_{in}$  	1 1 1 1 1	ecf from (b)(i) on first 2 mark points to credit non-inverting amp ie - Non inverting input connected to temperature sensor - Resistor from 0V to inverting input

Question			Answer	Marks	Guidance
6	(a)		**One** mark for each. This order only **Clock** **changed from low to high** **D** **held high**	4	e.g. A rising edge triggered D-type flip flop is triggered when the **Clock** connection is **changed from low to high**. To make Q high, the **D** connection is **held high** whilst the D-type flip flop is triggered.
6	(b)		**One** mark for each correct line. **Statements about logic gates** The output is only high when all the inputs are low. The output is only high when only one of the inputs is high. The output is only low when all the inputs are high. **Names of logic gates** AND gate NAND gate NOR gate OR gate XOR gate	3	

<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 mark for each correct column
<table><tr><th>D</th><th>E</th><th>F</th><th>G</th></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr></table></td><td>4</td><td>ecf F from E
ecf G from D & F</td></tr>
</table>

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