Cambridge National

Engineering

R047/01: Principles of electronic and programmable systems

Level 1/2 Cambridge National Certificate/Award

Mark Scheme for January 2024

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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.

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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 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 10 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% and 100% (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 the RM Assessor messaging system, 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.

   Rubric Error Responses – Optional Questions
   Where candidates have a choice of question across a whole paper or a whole section and have provided more answers than required, then all responses are marked and the highest mark allowable within the rubric is given. Enter a mark for each question answered into RM assessor, which will select the

highest mark from those awarded. *(The underlying assumption is that the candidate has penalised themselves by attempting more questions than necessary in the time allowed.)*

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 objects 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 a tick to confirm that the work has been seen.

7. Award No Response (NR) if:
    - there is nothing written in the answer space

Award Zero '0' if:

- anything is written in the answer space and is not worthy of credit (this includes text and symbols).

Team Leaders must confirm the correct use of the NR button with their markers before live marking commences and should check this when reviewing scripts.

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 send a brief report on the performance of candidates to their Team Leader (Supervisor) via email by the end of the marking period. The report should contain notes on particular strengths displayed as well as common errors or weaknesses. Constructive criticism of the question paper/mark scheme is also appreciated.

10. For answers marked by levels of response:
    a. **To determine the level** – start at the highest level and work down until you reach the level that matches the answer
    b. **To determine the mark within the level**, consider the following

Descriptor	Award mark
On the borderline of this level and the one below	At bottom of level
Just enough achievement on balance for this level	Above bottom and either below middle or at middle of level (depending on number of marks available)
Meets the criteria but with some slight inconsistency	Above middle and either below top of level or at middle of level (depending on number of marks available)
Consistently meets the criteria for this level	At top of level

11. **Annotations**

Annotation	Meaning
BP	Blank page
SEEN	Seen
	Tick
	Cross
IRRL	Irrelevant
REP	Repetition
VG	Vague
	Unclear
BOD	Benefit of the doubt
L1	Level 1
L2	Level 2
L3	Level 3
	Highlight

Question			Answer	Mark	Guidance
1			**(b)** Flexible	1	
2			**(a)** NPN transistor	1	
3			**(a)** AND	1	
4			**(c)** Schematic	1	
5			**(c)** Oscilloscope	1	
6			**(b)** Diode	1	
7			**(a)** Kilo	1	
8			**(b)** Negative	1	
9			**(d)** Single-strand	1	
10			**(c)** Latch	1	

Question			Answer	Mark	Guidance
11	(a)	(i)	Identifying input components: Any **two** from: • Pressure sensor (plate BOD) • Infrared sensor / detector • Light Dependent Resistor/LDR **Award credit for any other appropriate response.** **One** mark for each valid reason linked to the input component e.g.: • Pressure sensor – can detect the difference in force per unit area when the car is on top of it • Infrared sensor – can detect if a car is hit by radiation emitted by the sensor • Light dependent resistor/LDR – can sense the difference in light level when a car is over it **Award credit for any other appropriate response.**	4	1 mark each for suitable input component up to a maximum of 2 marks. 1 mark for each valid reason given up to maximum of 2 marks. Marks for reasons can be awarded even if the input component identified is inappropriate. **Do not accept 'Motion Sensor', 'Distance Sensor', 'Camera', 'Heat Sensor' or 'Light Sensor'** Accept: Ultrasonic PTM QTC Proximity (use of electromagnetic field)
11	(a)	(ii)	Motor **Award credit for any other appropriate response.**	1	1 mark for suitable output device that could be used to lift the barrier.

Question			Answer	Mark	Guidance
11	**(a)**	**(iii)**	**One** from: • Lamp • Light emitting diodes/LED • LED display • Liquid crystal display/LCD **Award credit for any other appropriate response.**	1	1 mark for suitable output device that could be used to indicate to the driver that it is safe to enter the car park. **Note: Marks must only be awarded for visual indicators.**
11	**(b)**		Up to **four** marks for an evaluation e.g.: • SMT would result in small circuits (1) ○ so they could be easily placed within the barrier stands (1) ○ so less materials would be needed for the PCB (1) ○ this means more components in the same space (dense assemblies) (1) • SMT circuits can be produced using automated processes (1) ○ so they can be produced in volume / mass for the different car parks (1) ○ this would result in more accurate/reliable circuits (1) • SMT solder joints are easier to break / weaker than through-hole (mechanical stress) (1) ○ resulting in a greater chance of failure in use (1)	4	1 mark for each appropriate point of evaluation up to maximum of 4 marks. **No marks for a description of SMT** Do not accept ‘easier’

Question			Answer	Mark	Guidance
			○ resulting in additional repair/maintenance costs (1) • Initial costs are high, due to the cost of purchasing equipment such as a reflow oven (1) • Due to the use of pick and place machines, SMT boards are faster to produce (1) • Due to the use of automation, labour costs / number of staff can be reduced. (1) **Award credit for any other appropriate response.**		

Question			Answer	Mark	Guidance
12	(a)		$1/R_{tot} = 1/R_1 + 1/R_2$ $1/R_{tot} = 1/27 + 1/33$ $1/R_{tot} = 0.0673$ $R_{tot} = 14.85\ \Omega$ (2 d.p) or $14.9\ \Omega$	4	1 mark for correct formula for resistors in parallel. 1 mark for correct substitution of values into formula. 1 mark for correct value of $1/R_{tot}$ 1 mark for correct value of R_{tot}
12	(b)		P = I V P = 12 x 9 P = 108 W	4	1 mark for use of Watt's law (P = I V) 1 mark for correct substitution of values into formula. 1 mark for correct answer. 1 mark for correct unit.

Question			Answer	Mark	Guidance
13	(a)		Up to **five** marks for a description e.g.: • Design the layout in CAD (circuit) • Export to a CAM machine - convert to CAM / G code (programmed) • Secure the copper board in the machine • Fit/setup the cutting tool (settings / parameters / origin) • Ensure guards are in place/secured • Download/run the toolpath program – cutting away unwanted / excess copper • Remove the milled/routed PCB from the machine • Clean away any remaining dust/debris **Award credit for any other appropriate response.**	5	1 mark for description of each valid step. Maximum 5 marks.
13	(b)		Points of discussion might cover areas such as: • Can be used to create smaller, more complex, high density and accurate PCBs • Results in PCBs that are easier to solder to than CAM milling/routing as removes all of the excess copper • A multi-stage process so requires a range of skills from operators (more opportunity for errors) and good time planning	6	**Level 3 (high) 5-6 marks** A thorough discussion. Consisting of at least 2 advantages and 2 disadvantages being clearly identified and developed. Shows good understanding and consistently uses appropriate terminology. **Level 2 (mid) 3-4 marks** An adequate discussion which shows some understanding, with some (1-2) advantages and

Question			Answer	Mark	Guidance
			• Involves the use of very dangerous chemicals that can cause serious injury/damage if spilled • Generally, a manual process so relies on skilled labour (requires training), although some stages can be automated • Many PCBs can be etched at once, depending on the size of the tank used • Faster than using CAM milling • Quality is very high – can be used in final products (not necessarily a prototype) • Specialist equipment required, such as UV box, etch tank • Design flexibility – make various boards with little change to setup • Low setup costs when compared to CAM milling (less investment in equipment) • With etching, holes must be drilled as a second process • Labels / identifiers can be added to etched PCBs **Other relevant points should be credited.**		disadvantages (3 in total) identified and limited development. Uses some appropriate terminology. **Level 1 (low) 1-2 marks** A basic discussion which shows limited/poor understanding. 1-2 advantages **or** disadvantages identified but no development. Little or no use of appropriate terminology. **0 marks** Response is not worthy of credit. **Note: Number of 'highlights' does not equate to the number of marks awarded.**

Question			Answer	Mark	Guidance
14	**(a)**	**(i)**	Up to **two** marks for a description of the term e.g.: • PLC stands for programmable logic controller (1) • An industrial processing device (1) that can control a range of input and output devices (1) • Computer that can withstand heat, vibrations, dust, cold and adapted to control manufacturing processes (1) • Used instead of relays (1) • Interact with physical components (inputs and outputs) (1) **Other relevant points should be credited.**	2	1 mark for each appropriate point up to maximum of 2 marks.
14	**(a)**	**(ii)**	Any **three** applications e.g.: • Production line processes • Conveyor belts • Temperature control systems • Lift systems • Robotic arms • Automatic doors • Safety / warning systems • Car park barrier **Award credit for any other appropriate response.**	3	1 mark for each appropriate application up to maximum of 3 marks. **Note: most likely to be an industrial process / product** **Do not accept consumer products e.g phone / tv** No marks awarded for comments linked to engine / car management systems – micro controller

Question			Answer	Mark	Guidance
14	(b)		Advantage Up to **two** marks for one advantage explained e.g.: • Flowchart systems use a graphical user interface (1) ○ so programs are easier to write/understand/follow/fault find/learn (1) **Award credit for any other appropriate response.** Disadvantage Up to **two** marks for one disadvantage explained e.g.: • Flowchart systems have limitations to the coding that can be used (1) ○ so more complex programs to be written using text-based languages (1) • The number of commands that can run at the same time can be limited (1) • It is harder to jump between the two programming languages (1) • Due to the number of individual commands, flowcharts can take up more space / can be hard to follow them across the page compared to text line-by-line (1)	4	1 mark for any valid advantage given. 1 mark for explaining the advantage given. 1 mark for any valid disadvantage given.1 mark for explaining the disadvantage given.

Question			Answer	Mark	Guidance
			Award credit for any other appropriate response.		

Question			Answer	Mark	Guidance
15	(a)	(i)	Any **two** relevant sustainability issues e.g.: • Batteries can leak harmful chemicals into the environment • Batteries can be difficult to recycle • Batteries can add to landfill waste if not properly disposed of **Award credit for any other appropriate response.**	2	1 mark for each appropriate sustainability issue up to maximum of 2 marks. Accept comments link to use of rare metals such a lithium & cobalt where they are finite resources. **Do not accept comments linked to frequency of replacement.**

15	(a)	(ii)	Advantage
			Up to **two** marks for one advantage explained e.g.:
			• Solar energy is renewable (1)
			  ○ so is freely available (1)
			• Does not require replacing (unlike a battery) (1)
			  ○ so operating costs are lower (1)
			
			Award credit for any other appropriate response.
			
			Disadvantage
			Up to **two** marks for one disadvantage explained e.g.:
			• Solar cells do not create electricity when it is not sunny / at night / time of year (1)
			  ○ so on cloudy days the doorbell might not work properly/at all (1)
				4	1 mark for any valid advantage given.
					1 mark for explaining the advantage given.
					
					1 mark for any valid disadvantage given.
					1 mark for explaining the disadvantage given.

Question			Answer	Mark	Guidance
			• Requires additional components (rechargeable battery) in order to work **Award credit for any other appropriate response.**		
15	**(b)**	**(i)**	Up to **two** marks for each advantage explained e.g.: • A CAD model would allow the doorbell circuit to be simulated / tested (1) ○ so its functionality could be checked prior to manufacture and further developed where necessary (1) • A CAD model doesn't require the use of real components (1) ○ saving the cost of purchasing components to prototype (1) ○ avoids possibly damaging real components (1) • A CAD model could be outputted to CAM equipment (1) ○ thus aiding with the accurate production/manufacture of a PCB for the doorbell circuit (1) • Can be sent quickly across the world via email for mass production (1) ○ speeding up the time to market (1)	4	1 mark for each valid advantage given up to a maximum of 2 marks. 1 mark for explaining each advantage given up to a maximum of 2 marks. Accept comments linked to reduction in development time

Question			Answer	Mark	Guidance
			• CAD models are a safe method of testing the doorbell (1) **Award credit for any other appropriate response.**		
15	**(b)**	**(ii)**	• Modular systems kits (circuit blocks) • Breadboard • Stripboard	3	1 mark each for suitable methods up to a maximum of 3 marks.

Question			Answer	Mark	Guidance
16	**(a)**		<table><tr><th>Term</th><th>Definition</th><th>SI unit</th></tr><tr><td>Capacitance</td><td>**The ability of a component/circuit to store charge (1)**</td><td>**Farad (1)**</td></tr><tr><td>Frequency</td><td>**The number of waves that pass a fixed point (per unit time) (1)**</td><td>**Hertz (1)**</td></tr><tr><td>Potential difference</td><td>The difference in the amount of energy that charge carriers have between two points in a circuit.</td><td>**Volt (1)**</td></tr></table>	5	1 mark for each correctly filled in table cell. Accept alternative wording for definitions as long as technically correct. Also award marks for abbreviated SI units. **(F, Hz, V)** Accept correct SI without correct definition.

Question			Answer	Mark	Guidance
16	(b)		Any **two** from: • Transmit data as a series of discrete values/1s and 0s • Represented as square waves • Can only be 1 or 0 / on or off / high or low **Award credit for any other appropriate response.**	2	1 mark for each characteristic up to maximum of 2 marks.
16	(c)		Up to **two** marks for a description e.g.: • Alternating current changes direction periodically (1) • Direct current flows in one direction only (1) • AC has a frequency depending on country, where as DC does not have a frequency. • When viewed on an oscilloscope, DC is displayed as a straight line (1) whereas AC displays as a wave (1) **Award credit for any other appropriate response.**	2	1 mark for each appropriate point up to a maximum of 2 marks. Answer must cover both AC and DC to be awarded full marks. Responses may refer to electron direction or direction of current.

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