Cambridge National

Engineering Programmable Systems

R047/01: Principles of electronic and programmable systems

Level 1/2 Cambridge National Certificate/Award/Diploma

Mark Scheme for January 2025

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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 available in RM Assessor

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

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, email or via the RM Assessor messaging system.

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 the annotation 'SEEN' to confirm that the work has been seen and mark any responses using the annotations in section 11.

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 any way 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 is not 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.**

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:
To determine the level – start at the highest level and work down until you reach the level that matches the answer
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

Applying the annotations

Every page must have a stamp on it to indicate you have checked all the pages that are available. If a page is blank, use the 'seen' stamp.

Levels of response questions

- Do **not** use ticks, use the highlighter tool to indicate relevant sections. The number of highlighted sections does **not** equal the number of marks awarded.
- Always stamp the level number at the end of the question, e.g. L2

Do **not** use crosses.

Question			Answer	Mark	Guidance
1			**(b)** Current	1	
2			**(a)** CAM milling/routing	1	
3			**(b)** The output signal becoming an input signal to the same system	1	
4			**(c)** Photodiode	1	
5			**(d)** A circuit board where there are conducting tracks on just one side of the board	1	
6			**(d)** volts	1	
7			**(a)** Analogue	1	
8			**(d)** Touch sensitive switch	1	
9			**(c)** 230 V	1	
10			**(a)** Capacitor and resistor	1	

Question			Answer	Mark	Guidance
11	(a)	(i)	Identifying input sensor: Any **one** from: • NTC thermistor • Infrared sensor **Award credit for any other appropriate response.** **One** mark stating the function e.g.: • NTC thermistor – has a resistance that changes as the temperature changes (as the temperature increases, the resistance decreases) • Infrared sensor – produces a voltage output that is proportional to the infrared radiation detected (detects the amount of infrared radiation being emitted) **Award credit for any other appropriate response.**	2	1 mark for any suitable input sensor. Thermistor is an acceptable response without reference to NTC/PTC. Accept 'PTC thermistor' - has a resistance that changes as the temperature changes (as the temperature increases, the resistance increases) **Do not accept 'temperature sensor', 'heat sensor' or 'thermometer'** 1 mark for stating how the input sensor functions to achieve the required outcome. Mark for the function **only** to be awarded if the input sensor identified is appropriate. Note: If 'thermistor' is given as the input sensor (not including NTC or PTC), accept comments linked to resistance increasing or decreasing as the temperature increases.
11	(a)	(ii)	Identifying output device: Any **one** from: • Buzzer • Piezo sounder (transducer) • Loudspeaker (speaker)	2	1 mark for any suitable output device. **Do not accept 'piezo' or 'piezo buzzer'**

Question			Answer	Mark	Guidance
			Award credit for any other appropriate response. **One** mark for a valid function, e.g.: • Buzzer – (uses an internal oscillator to) produce a (buzzing) sound when current flows through it • Piezo sounder – produces sound (using the piezoelectric effect) when current flows through it • Loudspeaker – produces sound when current flows through it **Award credit for any other appropriate response.**		1 mark for stating how the output device functions to achieve the required outcome. Mark for function **only** to be awarded if the output component identified is appropriate. Allow comments for 'function' linked to signals being received.
11	**(a)**	**(iii)**	Identifying output device: Any **one** from: • LED display • Liquid crystal display / LCD **Award credit for any other appropriate response.** **One** mark for a valid function, e.g.: • LED display – uses an LED backlight to form characters/words on the screen when current is applied	2	1 mark for any suitable output device. **Do not accept 'lamp' or 'screen'** **Do not accept 'LED' without reference to a display** Accept: LED Screen LCD Screen Dot matrix display

Question			Answer	Mark	Guidance
			• LCD – Uses a liquid crystal backlight to form characters/words on the screen when current is applied **Award credit for any other appropriate response.**		1 mark for stating how the output device functions to achieve the required outcome. Marks for function **only** to be awarded if the output component identified is appropriate.
11	**(b)**		Up to **four** marks for an evaluation e.g.: • PLCs are very rugged/reliable/can operate continuously for extended periods without failure (1) so ideally suited for a machining/workshop environment (1) • PLCs are programmed to perform their required functions (1) which results in less circuitry/hardware being required (1) • PLCs can be used to control multiple different types of output devices (1) so are ideal for a system which uses both audio and visual outputs (1) • PLCs have analogue input ports (1) which can be used to receive the continuous temperature sensor readings (1) • PLCs allow for quick modification and updates (easily altered) (1) without the need for expensive hardware changes or rewiring (1) • Additional input and output modules can easily be added (1) expanding the capability	4	1 mark for each advantage up to a maximum of 2 marks. 1 mark for evaluative point relating to each advantage, up to maximum of 2 marks. **Do not accept 'easy to program'**

Question			Answer	Mark	Guidance
			of the system without significant disruption (1) • Fast response times (1) so will provide a fast indication of a temperature change (1) • PLCs can be simulated to verify the programs behaviour before installation (1) reducing the risk of errors in use (1) • PLCs can be reprogrammed to change their function (1) without the need for replacement (1) • PLCs can be compact (compact PLCs) (1) so the heating system can fit in a small space (1) • PLCs can use different programming languages (such as ladder logic) (1) so allows for some flexibility for the user in the language being used (1) • PLCs allow operators to monitor the system (diagnostics) (1) reducing downtime / simplifying maintenance / troubleshoot quickly (1) **Award credit for any other appropriate response.**		

Question			Answer	Mark	Guidance
12	(a)		Advantages Any **two** from: • Does not require automated machinery/only requires hand tools • Less cost of equipment compared to automated processes • Greater human control over the assembly process/ability to react to problems • Portability/accessibility of the assembly process for a range of settings Disadvantage Any **one** from: • Increased potential for human error (e.g. tracks / pads / component legs) • Less accuracy/precision than automated processes • Risk of accidentally overheating tracks/pads/joints/components (damage) • Potential human exposure to fumes • Slower process (time consuming) **Award credit for any other appropriate response.**	3	1 mark for each relevant advantage up to maximum of 2 marks. **Do not accept 'cheaper' without a supporting comment .e.g 'cheaper than using…..'** **Do not accept 'precise'** Accept comments linked to not having to spend time programming machines 1 mark for any relevant disadvantage.

Question			Answer	Mark	Guidance
12	(b)		Up to **four** marks for a description from: • Solder paste is applied over the top of the screen, allowing solder paste to be applied to all pads. (1) • The PCB is populated (with components) using a pick and place machine (1) • The PCB is fitted into the machine / onto the conveyor (1) • The temperature is slowly increased as the PCB moves through the reflow oven (1) • Circuits are removed from the oven/allowed to cool (1) **Award credit for any other appropriate response.**	4	1 mark for description of each valid step in the process. Maximum 4 marks. Stages must be in the correct order. Response must be describing steps of a commercial SMT assembly process to be awarded marks. Where responses contain a combination of **different** circuit assembly methods, the whole response must be read to identify any **valid points** that are in the **correct order.**
12	(c)		Up to **three** marks for a description from: • De-energise/isolate/remove power from the circuit (1) • Touch one test lead/probe at the first point (1) • Touch the other test lead/probe to the second point (1) • The tester will indicate if there is continuity between the points or not (1) **Award credit for any other appropriate response.**	3	1 mark for description of each valid step in the process. Maximum 3 marks. 1 mark can be awarded for a relevant health and safety point. Note: The question is linked to the use of a 'continuity tester' **NOT** a multimeter to test continuity. **Do not accept comments linked to the attachment of probes to the device or turning dials.**

Question			Answer	Mark	Guidance
13	(a)	(i)	18 (kHz)	1	1 mark for correct answer.
13	(a)	(ii)	2.2 (nF)	1	1 mark for correct answer.
13	(b)		P = I V P = 0.03 x 12 P = 0.36 (W)	3	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.
13	(c)	(i)	Any **one** from: A circuit where: • Components are arranged in branches/loops • There is more than one path for current to flow through • The potential difference across each component is the same **Award credit for any other appropriate response.**	1	1 mark for any correct response. **Do not accept comments linked to splitting current equally**
13	(c)	(ii)	$1/R_{tot} = 1/R_1 + 1/R_2$ $1/R_{tot} = 1/10 + 1/15$ $1/R_{tot} = 0.1667$ (accept 0.1ṁ recurring) $R_{tot} = 6\ \Omega$	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}

Question			Answer	Mark	Guidance
14	**(a)**	**(i)**	Up to **two** from: • Requires detailed knowledge of coding • Less visual than other options • Less accessible to learners/beginners (due to complexity) • Can be difficult to find/fix errors in the code • Less intuitive • Time consuming as it takes longer to write each line / word • Memory requirements are often higher • More opportunity for errors to occur (such as spelling errors) **Award credit for any other appropriate response.**	2	1 mark for each disadvantage up to maximum of 2 marks. **Do not accept 'requires training'**

14	**(a)**	**(ii)**	Up to **two** marks for **each** advantage explained.
			E.g.:
			• Uses standard flowchart symbols (1)
			• Beginner friendly (1)
			  ○ so anyone can understand how the program works (easy to read / follow/create) (1)
			• Clearly shows program flow (1)
			  ○ Through the use of arrows (1)
			• Ease of editing (1)
				4	1 mark for each advantage up to maximum of 2 marks.
					
					1 mark for explaining each advantage up to maximum of 2 marks.
					
					Do not accept 'no training required'
					
					Accept comments linked to being faster to create, less complex and a simple method, if it is justified

Question			Answer	Mark	Guidance
			○ as new commands are simply dragged on screen/into the flowchart (1) **Award credit for any other appropriate response.**		with words such as 'than' or 'in comparison to'. e.g. less complex than……
14	**(b)**		Up to **two** marks for **each** reason explained e.g.: • To check that system designs work correctly (test) prior to manufacture (1) ○ as their function can be simulated (1) • To reduce resource costs (1) ○ as physical system hardware/components are not required (1) • To allow for ease of modification to system designs (1) ○ as the hardware/programming used can be quickly changed on screen (1) • It allows designs / models to be shared and collaboration (1) ○ Resulting in products being right first time / faster to market (1) • Gives an accurate representation of what the model / circuit will look like (1) **Award credit for any other appropriate response.**	4	1 mark for each valid reason given up to a maximum of 2 marks. 1 mark for explaining each reason given, up to maximum of 2 marks.

Question			Answer	Mark	Guidance
15	(a)		Up to **two** marks for a description e.g.: • The output is 1/high when at least one of the inputs is 1/high (1) • The output is 0/low if both inputs are 0/low (1)	2	1 mark for each point up to a maximum of 2 marks.
15	(b)		Up to **two** marks for **each** reason explained e.g.: • Batteries are portable (1) ○ So the smoke alarm can be placed anywhere in the home (1) • No mains electrical wiring required (1) ○ So the smoke alarm will be easier to install / replace the alarm itself (1) ○ Does not require installation by a qualified electrician (1) • Safe power supply (1) ○ As low voltage (1) • Will function even if there is a power cut (1) ○ As batteries work independently of mains supply (1) **Award credit for any other appropriate response.**	4	1 mark for each valid reason given up to a maximum of 2 marks. 1 mark for explaining each reason given, up to maximum of 2 marks. **Do not accept comments linked to 'power', 'AC/DC', 'cheaper', 'easier to replace batteries' or 'smaller or more compact'**

Question			Answer	Mark	Guidance
15	**(c)**		Up to **two** marks for **each** benefit explained e.g.: • Accurate checking of circuit function (1) ○ As displays the current logic state (1) • Easy to use (1) ○ As only requires connecting to power and the test point (1) • Can use the alarms battery (1) ○ so only one power source is needed (1) • Low cost (1) ○ As does not contain much internal circuitry (1) • Portability (1) ○ As is small/light to carry (1) **Award credit for any other appropriate response.**	4	1 mark for each benefit given up to a maximum of 2 marks. 1 mark for explaining each benefit given, up to maximum of 2 marks. Note: Only accept ‘benefits’ **Do not accept comments linked to its function – what it does**

Question			Answer	Mark	Guidance
16	(a)		Up to **four** marks for two characteristics described e.g.: • Uses blocks of components (1) that are connected together to form a circuit / variety of different circuits (1) • Uses pre-built units (1) for a variety of input / process / output devices (1) • Non-permanent prototyping method (reusable / ease of editing) (1) that does not require soldering (1) • Physical prototyping method (1) that produces accurate testing results (1) • Due to the size of each module, they become larger (1) as the circuit increases in complexity (1) **Award credit for any other appropriate response.**	4	1 mark for each characteristic given up to a maximum of 2 marks. 1 mark for describing each characteristic given up to a maximum of 2 marks. Note: answers must link to features or qualities serving to identify them (characteristics)
16	(b)		Points of evaluation might cover areas such as: Advantages • Results in a rugged, strong and permanent circuit as components are soldered to the circuit board, less chance of components coming loose or falling off • High accuracy of testing as it uses real components instead of virtual simulations,	6	**Level 3 (high) 5-6 marks** A thorough evaluation. A good understanding with a range of advantages and disadvantages is clearly identified and developed. Consistently uses appropriate terminology. **Answers might typically contain at least 2 advantages and 2 disadvantages being clearly identified and developed.**

Question			Answer	Mark	Guidance
			which sometimes do not behave like their physical equivalents • Flexible method as the PCB layout can be changed/modified/improved as required to the meet the needs of the prototype • Use of an efficient PCB layout can result in a small circuit (shape & size) that does not take up much storage space, compared to the equivalent breadboard or stripboard prototype • Could be used in the final prototype / product Disadvantages • Requires access to/purchasing of PCB design and production equipment/software/hardware, which can increase initial costs • Because components are soldered to the PCB they cannot be easily re-used, and therefore new components will need to be purchased for further iterations/updated versions of the prototype (expensive) • Because components are not re-usable this significantly reduces the sustainability of the prototyping method		**Level 2 (mid) 3-4 marks** An adequate evaluation which shows some understanding, with some advantages and disadvantages identified and limited development. Uses some appropriate terminology. **Answers might typically contain some (1-2) advantages and disadvantages (3 in total) identified and limited development.** **Level 1 (low) 1-2 marks** A basic evaluation which shows limited/poor understanding. Some advantages or disadvantages identified but no development. Little or no use of appropriate terminology. **Answers might typically contain 1-2 advantages or disadvantages identified but no development.** **0 marks** Response is not worthy of credit. **Do not accept comments linked to mass production. The question focusses on using PCBs to prototype circuits**

Question			Answer	Mark	Guidance
			• Use of etching to produce a PCB and soldering to assemble can present potential health and safety issues • Takes time to make the PCB and then populate and solder it • It can be difficult to make changes to the PCB / components once the board has been made / populated • Solder can join pads or tracks easily leading to functionality issues • Requires an element of training / skill to allow PCBs to be made successfully **Other relevant points should be credited.**		

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