Cambridge National

Engineering Programmable Systems

R047/01: Principles of electronic and programmable systems

Level 1/2 Cambridge National Certificate/Award/Diploma

Mark Scheme for June 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 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

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.

12. **Subject Specific Marking Instructions**

Question			Answer	Mark	Guidance
1			**(c)** Photovoltaic cell	1	
2			**(d)** Pico	1	
3			**(b)** Darlington driver	1	
4			**(d)** watts	1	
5			**(c)** using characters and words	1	
6			**(b)** from negative to positive	1	
7			**(d)** Signal generator	1	
8			**(a)** Arrows	1	
9			**(c)** Pick and place assembly	1	
10			**(a)** Multi-strand wire	1	

Question			Answer	Mark	Guidance
11	(a)	(i)	**One** from: • Push-to-make (switch) • Push-to-break (switch) • Pressure sensor • Quantum Tunnelling Composite (QTC) (switch)	1	1 mark for suitable input device that could be used as a button for when the user is ready to cross the road. **Do not accept 'switch', 'SPST' or 'Light Sensor (LDR)** Accept abbreviations 'PTM' and 'PTB'
11	(a)	(ii)	**One** from: • Lamp • Light emitting diode/LED	1	1 mark for suitable output device that could be used as the green light to visually indicate when it is safe to cross the road. **Do not accept 'LED Display', 'LCD' or 'Bulb'**
11	(a)	(iii)	Identifying output components: • Buzzer • Piezo sounder (transducer) • Loudspeaker (speaker) **One** mark for each valid function linked to the output component 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	4	1 mark each for suitable output component up to a maximum of 2 marks. 1 mark for each valid function given up to maximum of 2 marks. Marks for function **only** to be awarded if the output component identified is appropriate. **Do not accept 'Piezo Buzzer', Bell or Siren** Accept comments linked to receiving 'digital signals'

Question			Answer	Mark	Guidance
			• Loudspeaker – produces sound when current flows through it		
11	**(b)**		I = V / R I = 12 / 60 I = 0.2 A	4	1 mark for correct use of Ohm's law (I = V / R) Accept (V=IR) or Ohm's law triangle. 1 mark for correct substitution of values into formula. 1 mark for correct answer. 1 mark for correct unit.

Question			Answer	Mark	Guidance
12	(a)	(i)	Any **two** from: • Storing charge/electrical energy • As a power supply to a circuit • Signal filtering – AC-DC converter • Coupling/decoupling • Capacitors used in audio, intermediate frequency (IF) or radio frequency (RF) filters • Smoothing electronic signals • Police taser • Alarm backup siren for security systems • Backup power supply when mains supply is down **Award credit for any other appropriate response.**	2	1 mark for each application up to a maximum of 2 marks. **Do not accept comments linked to 'time periods' or 'time delay'**
12	(a)	(ii)	0.000047 F	1	1 mark for correct answer. Award the mark where candidates have correctly used negative powers, e.g. $47x10^{-6}$ F, $47.x10^{-5}$ F
12	(b)		$R_{tot} = R_1 + R_2 + R_3$ $R_{tot} = 180 + 390 + 1500$ $R_{tot} = 2070\ \Omega$	3	1 mark for correct formula for resistors in series. 1 mark for correct substitution of values into formula. 1 mark for correct value of R_{tot} in ohms. **Do not accept R_{tot} in KΩ (final answer)**

Question			Answer	Mark	Guidance
12	(c)		Up to **four** marks for an evaluation e.g.: • A double sided PCB would allow components/tracks to be placed on both sides of the board instead of just one (1) ○ which would reduce the overall size of the circuitry / PCB (1) ○ Allow for more components in the same sized PCB (density) / increased functionality (1) ○ which would reduce material costs (1) • Would be more difficult to manufacture/assemble than a single-sided PCB (1) ○ due to increased complexity of the layout (1) ○ as it may require the use of surface mount technology/SMT (1) • With components being placed on both sides, the overall thickness of the circuit would increase (1) ○ so the case would need to be taller / wouldn't be as thin (1) • It is more difficult to etch / populate a double sided board (1) ○ so may cost more to produce (1) ○ so may lead to system functionality issues (1)	4	1 mark for each appropriate point of evaluation up to maximum of 4 marks. **Do not accept 'quicker', 'stronger' or 'more durable'**

Question			Answer	Mark	Guidance
			• Double sided PCB is more expensive than single sided (1) ○ but may result in savings through using less area (1) • Could be harder to problem solve / repair (1) ○ as components and tracks are on both sides (1)		

Question			Answer	Mark	Guidance
13	(a)		Up to **two** marks for each characteristic described e.g.: • Components are mounted on the plastic side (top side) of the PCB (1) and soldered on the copper side (bottom side) (1) • Has holes in the copper pads (1) for the components to be fitted through/soldered onto (1) • Has low component density (1) with larger circuitry/components (1) • Good at resisting mechanical stress (1) with strong solder joints (1) • Often used for larger components such as capacitors (1) • In most cases requires manual fitting of components (1) • Uses larger components than SMT (1) • Can be Wave Soldered (1) • Legs often require cutting as an extra step (1)	4	1 mark for naming each characteristic, up to a maximum of 2 marks. 1 mark for describing each characteristic or expansion of the initial description, up to a maximum of 2 marks. **Do not accept 'requires soldering'**
13	(b)		Up to **five** marks for a description e.g.: • The solder bath is preheated (1) • The PCB is fitted into the machine / onto the conveyor (1) • The PCB is passed over the bath of molten solder/a solder wave (1)	5	1 mark for each appropriate point up to a maximum of 5 marks. Stages must be in the correct order. Due to the wording in the specification, accept responses explaining the 'reflow' process used for surface mount components (SMT).

Question			Answer	Mark	Guidance
			• The PCB makes contact with the wave creating the joints (1) • The solder joints cool/become solid joints (1) • The soldered PCB is then visually inspected (1)		• A screen (template) is placed on top of the PCB. (1) • Solder paste is applied over the top of the screen, allowing solder paste to be applied to all pads. (1) • The PCB is populated 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 oven (1) • The rise in oven temperature causes the solder paste to become a liquid (1) • The PCB is slowly cooled to avoid dry joints (1) Stages must be in the correct order. **Do not accept the hand (manual) soldering method** **Do not accept a mixture of processes e.g SMT and wave soldering**

Question			Answer	Mark	Guidance
14	(a)		Any **three** from: • Follow the instructions given in the oscilloscope manual • Ensure appropriate grounding is in place • Use shielded probes/do not touch the metal tips of the probes when measuring • Do not exceed the maximum input voltage rating for the oscilloscope • Make sure the case/shield is closed • Ensure the correct type of oscilloscope is used for the circuit to be tested • Ensure the oscilloscope is correctly fused • Don't operate the oscilloscope if water is in close proximity • Ensure adequate air flow around the oscilloscope • Do not touch exposed wires while in use • Turn off after use to prevent overheating **Award credit for any other appropriate response.**	3	1 mark for each relevant safety precaution up to a maximum of 3 marks.

Question			Answer	Mark	Guidance
14	(b)		Points of discussion might cover areas such as: • Can be used to measure several different test parameters in a single instrument e.g. voltage, current, resistance, continuity • Results in the need for less test equipment • High accuracy of test measurements taken • Ease of reading test measurements from a digital screen • Small, light and compact, does not take up much space in toolbox • Readings can fluctuate until they stabilise, taking up time and potentially causing incorrect values to be recorded by the user • Can be susceptible to external noise and signal interference • Low cost in comparison to other test equipment - such as Oscilloscopes • Test points could be further apart than the probes will reach (length of probes) • Portable • Voltage of internal battery can drop, causing inaccuracy in readings • Multicore cabling used for probes can become damaged / break, leading to inaccurate readings • Can measure both AC and DC voltage	6	**Level 3 (high) 5-6 marks** A thorough discussion. A good understanding with a range of benefits and limitations being clearly identified and developed. Consistently uses appropriate terminology. **Answers might typically contain at least 2 benefits and 2 limitations being clearly identified and developed.** **Level 2 (mid) 3-4 marks** An adequate discussion which shows some understanding, with some benefits and limitations identified and limited development. Uses some appropriate terminology. **Answers might typically contain some (1-2) benefits and limitations (3 in total) identified and limited development.** **Level 1 (low) 1-2 marks** A basic discussion which shows limited/poor understanding. Some benefits or limitations identified but no development. Little or no use of appropriate terminology. **Answers might typically contain 1-2 benefits or limitations identified but no development.** **0 marks**

Question			Answer	Mark	Guidance
			• Unable to generate its own signal to input into a circuit (pulse) • Unable to show the frequency of a waveform – wavelength / amplitude • Unable to store readings to allow for comparison against prior data • Must know how to use it or will get incorrect readings – not for beginners / must put it on the correct settings **Other relevant points should be credited.**		Response is not worthy of credit. **Do not accept 'not very accurate'**

Question			Answer	Mark	Guidance
15	(a)	(i)	**One** from: • Photo etching • CAM milling/routing	1	1 mark for any relevant response. Accept comments linked to CAD/CAM Milling **Do not accept 'milling' or 'etching'**

15	(a)	(ii)	Up to **two** marks for each reason explained, e.g. for photo etching:
			• High level of accuracy/precision (1)
			  ○ due to the use of a mask (1)
			• The whole PCB surface is etched at the same time (1)
			  ○ reducing the time taken to complete the process (1)
			• No tool wear (1)
			  ○ As chemicals remove the unwanted copper from the board (1)
			• Low initial setup costs (1)
			  ○ As it does not necessarily require expensive equipment (1)
			• Soldering is much easier (1)
			  ○ As all unnecessary copper is removed (1)
			• Allows smaller and more complex circuits to be produced (1)
			  ○ As not restricted by milling cutter diameter (1)
				4	1 mark for each valid reason given up to a maximum of 2 marks.
					
					1 mark for explaining each reason given up to a maximum of 2 marks.
					
					Marks for reasons can **only** be awarded if the PCB production method identified is **correct**.
					
					CAM Milling – Do not accept 'quicker than photo etching'

Question			Answer	Mark	Guidance

			E.g. for CAM milling/routing:
			• High level of accuracy/precision (1)
			  ○ due to use of CAM/CNC equipment / automation (1)
			  ○ due to being less labour intensive (1)
			• Does not require the use of any harmful chemicals (1)
			  ○ so is a very safe / cleaner process (1)
			• Fewer production stages (steps) (1)
			  ○ so reduced opportunity for errors (1)
			• It be programmed to mill the tracks and drill the holes (1)
			
			Award credit for any other appropriate response.		

15	**(b)**	**(i)**	Any **two** from: • Breadboard (Breadboarding) • Stripboard (Stripboarding) • CAD / virtual modelling / circuit simulation • Use of modular systems kits	2	1 mark for each correct answer up to maximum of 2 marks. **Do not accept CAD software brands or 'software'**

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>15</td><td>(b)</td><td>(ii)</td><td>
<table>
<tr><th>Input A</th><th>Input B</th><th>Output</th></tr>
<tr><td>0</td><td>0</td><td>0 (1)</td></tr>
<tr><td>0</td><td>1 (1)</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1 (1)</td><td>1</td><td>1</td></tr>
</table>
</td><td>3</td><td>1 mark for each correctly filled in cell in the truth table.</td></tr>
</table>

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td>16</td><td>(a)</td><td></td><td>
<table>
<tr><th>Process components and devices</th><th>Function</th><th>Application</th></tr>
<tr><td>Timer</td><td>Produces an output pulse for a set time period, before returning to low (1)</td><td>Toothbrush timer
Egg timer
Alarm clock
Electronic doorbell
Automated lights
Sports timers
Alarms and security systems
Toaster
Stopwatch
Automatic gate
Kitchen timer
Traffic light system
Microwave</td></tr>
</table>
</td><td>8</td><td>1 mark for a correct function of each process device and 1 mark for a correct application of each.

Alternative wording may be accepted if technically accurate.

Allow any relevant applications.

For applications, do not accept the name of the process ending with ‘circuit’
e.g ‘Timer Circuit’, ‘Amplifier Circuit’

Do not accept ‘Alarm Circuit’ or ‘Alarm’

<u>Amplifier</u>
Function - Accept comments linked to increasing the voltage / current / power
Applications - Do not accept ‘speaker’

<u>Analogue to digital converter</u>
Function – Must include ‘wave’ or ‘signal’
Applications - Do not accept ‘watch’</td></tr>
</table>

Question			Answer			Mark	Guidance
			Pulse generator	Produces a **continuous** series of high and low signals (1)	Flashing light circuits Circuit test equipment Vehicle Indicator Metronome Input to counting / digital clock Pulsing alarms Security alarm Pacemaker Sonar Pedestrian crossing Christmas lights		
			Amplifier	**Increases** the size of the input signal **(increased output signal)** (1)	Comparator circuits Audio systems Communication systems		

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>Guidance</th></tr>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td></td><td></td><td>Temperature Control (Op Amp)

Musical Instrument Amp</td></tr>
<tr><td>Analogue to digital converter</td><td>Changes a continuous signal into a discrete signal (1)

Changes an analogue (sine wave) to a digital signal of 1’s or 0’s (1)</td><td>Light/temperature sensing circuits

Signal processing for a microcontroller / microprocessor (when using analogue input devices)

Sensor for alarm systems (PIR)</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>16</td><td>(b)</td><td></td><td>Up to two marks for any advantage explained e.g.:
• Microcontrollers are very flexible (1)
○ as they can be reprogrammed many times (1)
○ as the hardware can be re-purposed / change its function (1)
• Microcontrollers reduce the amount of circuitry (components) required (1)
○ as programming replaces physical hardware (1)</td><td>4</td><td>1 mark for any valid advantage given and 1 mark for explaining the advantage given.

1 mark for any valid disadvantage given and 1 mark for explaining the disadvantage given.</td></tr>
</table>

Question			Answer	Mark	Guidance

			• Easy to use (1)
			  ○ so can troubleshoot or maintain the system easily (1)
			• Small in size (1)
			  ○ so can allow for a smaller PCB (1)
			• Has built-in ROM/RAM (1)
			  ○ so reduced external parts (1)
			• Low power consumption (1)
			  ○ so can extend battery life of devices (1)
			• Increased functionality (1)
			  ○ so allows the product to do more (1)
			
			Up to **two** marks for any disadvantage explained e.g.:
			• Often requires additional interface devices/driver circuitry (1)
			  ○ as only provides a small current output (1)
			• Additional time/costs of programming (1)
			  ○ as it adds an extra stage to design/manufacture of the system (1)
			• Have limited memory (1)
			  ○ so can limit the size and complexity of programs (1)
			• Require additional software (1)		

Question			Answer	Mark	Guidance
			○ which may require training / knowledge (1) ○ which will require initial investment to be made (1) • Limited processing speed (1) ○ so may struggle with complex tasks (1) • Often requires a method of downloading the program e.g USB (1) ○ so may lead to computer compatibility issues (1) • May have a limited number of inputs / outputs (1) ○ so may restrict the function / complexity of the product (1) • May use a different programming language (1) ○ so may be difficult to move from one language to another (1) • Cost of purchasing the microcontroller may be higher in comparison to discrete components (1) • Not as robust as discrete components (1)		

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