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A-LEVEL

# Electronics

ELEC4 – Programmable Control Systems  
Mark scheme

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2430  
June 2016

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Version: 1.0 Final

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from [aqa.org.uk](http://aqa.org.uk)

## Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

### Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

### Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
1			<p style="text-align: center;">Description Name</p> <p>This keeps all subsystems within a microcontroller system synchronised. clock</p> <p>All arithmetic and logic operations are carried out in this subsystem. ALU</p> <p>A bidirectional bus within a microprocessor. data bus</p> <p>A temporary store for data after being sent to an output port. data latch</p> <p>Interfaces an analogue input signal to a microprocessor. ADC</p> <p>Isolates an input port from a microprocessor when it is not being read. Tri-state buffer</p> <p>A process which monitors the state of an input port.</p>	<b>10</b>	

			<p>polling</p> <p>An area of memory used by a microprocessor as temporary storage for its internal processes. stack</p> <p>A process by which an external system can request assistance from a microcontroller. interrupt</p> <p>The location of the control program in a microcontroller. ROM</p>		
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Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
2	(a)	(i)	Digital inputs only respond to two signal levels, while an analogue sensor provides many different levels. ✓	1	
2	(a)	(ii)	Schmitt provides two distinct switching levels, while comparator only one ✓, Schmitt stops the system 'hunting' ✓	2	
2	(b)	(i)	E.g. Limits the output voltage to the microcontroller ✓, to 0 and 5.1V ✓	2	

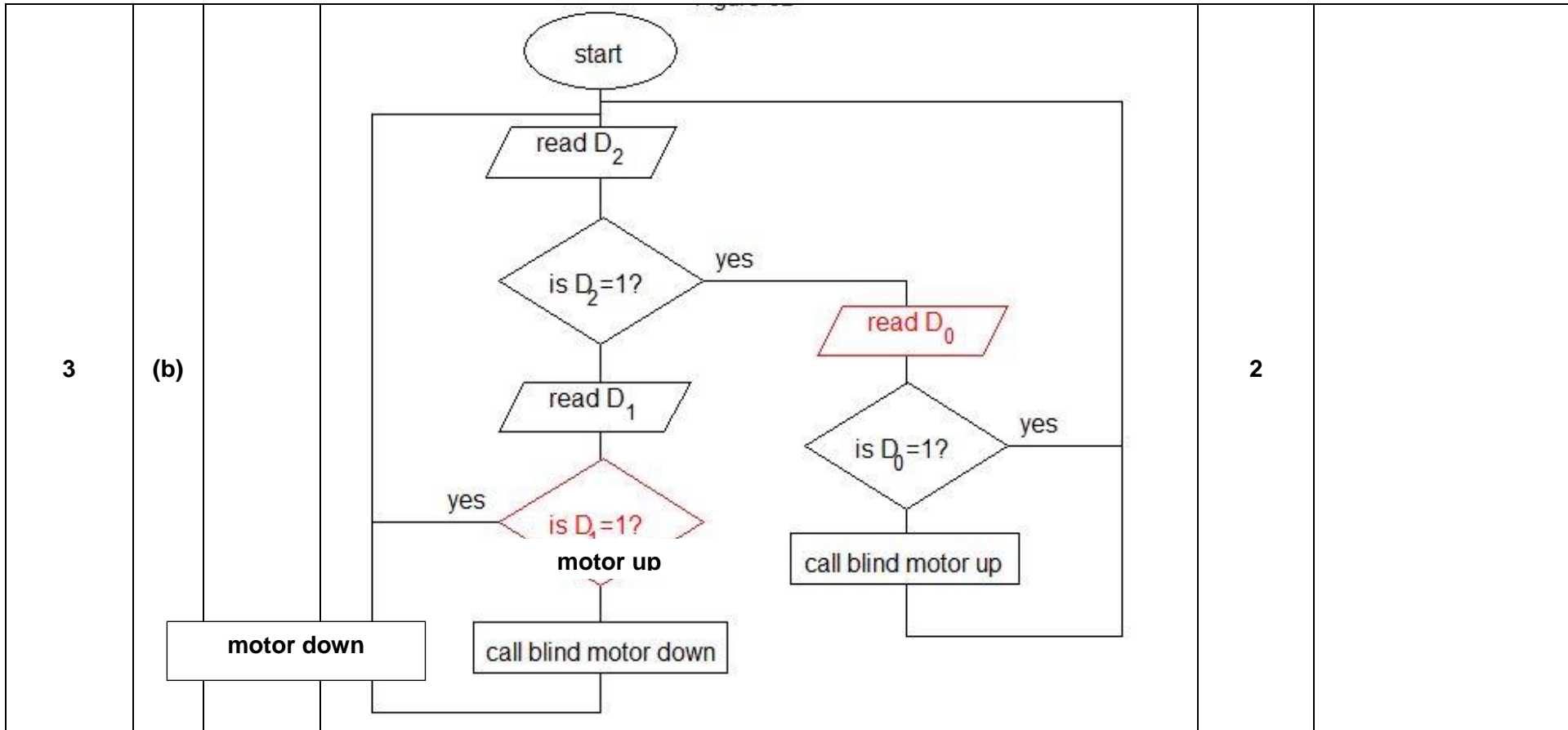
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<b>2</b>	<b>(b)</b>	<b>(ii)</b>	10k and 7.5k in parallel=4.29k ✓, use of voltage divider formula ✓, calculation yielding the answer ✓	<b>3</b>	
<b>2</b>	<b>(b)</b>	<b>(iii)</b>	Use of voltage divider formula ✓, calculation yielding the answer of 3.6V✓	<b>2</b>	

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Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
3	(a)		Inclusion of the byte 0x0F ✓, <b>MOVW</b> 0x0F ✓, <b>MOVWR TRISB</b> ✓	3	

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Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
3	(c)	(i)	0x40 ✓	1	

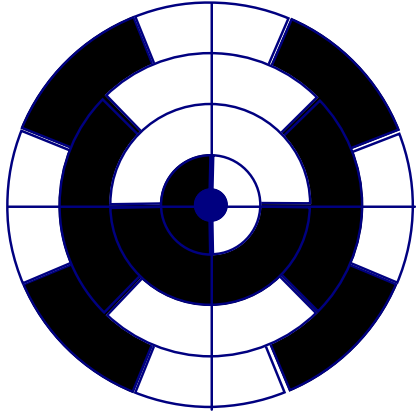


3	(c)	(ii)	0x80 ✓	1	
3	(d)		e.g. label:, <b>MOVRW PORTB</b> ✓, <b>AND 0x02</b> ✓, <b>JPZ label</b> ✓	3	

Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
4	(a)		18k $\Omega$	1	
4	(b)		Use of $t_i=0.7R_2C$ ✓, substitution and calculation to give answer ✓	2	
4	(c)		- to output and + to +12V ✓	1	
4	(d)	(i)	Sets the value in the memory location 0xA0 to 0 ✓	1	
4	(d)	(ii)	Polls PORTA until there is a pulse ✓	1	
4	(d)	(iii)	Increments 0xA0 and checks that there is still a pulse ✓, repeats this until the pulse ends and then returns ✓	2	
4	(e)		Only the section from label3 to label4 contribute to the timing $\Rightarrow 7\mu\text{s}$ ✓, so $280/7 = 40$ ✓	2	$\pm 1$

Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
5	(a)		To suppress the large induced voltages created by the motors as the coils are switched off ✓	1	
5	(b)		Voltage across R = $9 - 3.2 = 5.8\text{V}$ , so $R = 5.8/0.03 = 193\Omega$ ✓, so $R = 200 - 270\Omega$ ✓	2	
5	(c)		$24.6\text{k}\Omega$ ✓, appropriate calculation - either voltage divider or ratio ✓	2	
5	(d)		$100 \pm 50$ lux	1	
5	(e)		Illumination of left LDR becomes less so right motor slows ✓, illumination of right LDR increases so left hand motor speeds up, so robot moves to the right ✓	2	
5	(f)		The armature of conventional motors rotate continuously when current is applied ✓, whereas the armature of a stepper motor just rotates through a set angle when current is applied ✓	2	

Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
6	(a)	(i)	Very large differential voltage gain ✓	1	
6	(a)	(ii)	0.5V	1	
6	(b)		D to Q' ✓, Q' to following CK ✓, all resets connected to 0V ✓, first clock labelled as input ✓	4	
6	(c)		A.B'.C ✓	1	
6	(d)		E.g. horizontal line across the display ✓, line at the 4th row because 2.1V sets the 4th comparator ✓, continuous line seen because columns flash faster than the persistence of vision ✓	3	

Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
7	(a)		Only one bit changes at a time, so sensor alignment is not so critical as with binary encoders ✓	1	
7	(b)		<p data-bbox="517 655 1245 687">Either ✓ for each correct circle or minus ✓ for each error</p> 	3	
7	(c)		To include, LED shining outwards ✓, photo-receiver pointing outwards in same direction as LED ✓	2	
7	(d)	(i)	Correct formula ✓, substitution ✓, -4.6875V ✓	3	

7	(d)	(ii)	E.g. to invert the output from op-amp X ✓	1	
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Question	Part	Sub-part	Marking Guidance	Mark	Comments/ Guidance
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8	(a)	(i)	Both the same ✓, p-channel symbol ✓	2	
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8	(a)	(ii)	Prevents the large induced voltage when the motor switches off from damaging the MOSFETs ✓	1	
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8	(b)		First two, motor heavily damped ✓, third case, motor can rotate freely ✓	2	
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8	(c)		<p style="text-align: center;">X Y P Q A B Motor state</p> <p style="text-align: center;">0 0 1 0 NC NC OFF  0</p>	5	one ✓ for each column
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				1	
				1	
				0	
				NC	
				NC	
				OFF	
				1	
				0	
				0	
				0	
				1	
				0	
				clockwise	
				1	
				1	
				1	
				1	
				0	
				1	
				anticlockwise	