GCE A LEVEL MARKING SCHEME

AUTUMN 2021

A LEVEL
ELECTRONICS – COMPONENT 1
A490U10-1

INTRODUCTION

This marking scheme was used by WJEC for the 2021 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

EDUQAS A LEVEL ELECTRONICS - COMPONENT 1

AUTUMN 2021 MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (except for the extended response question).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct and relevant alternative responses which are not recorded in the mark scheme.

Extended response question

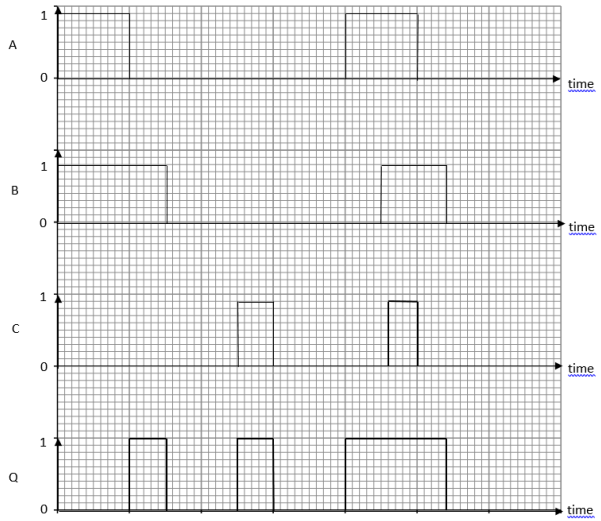
A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement.

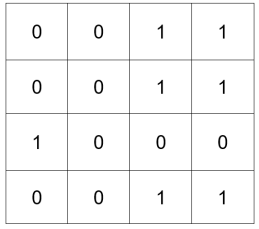
Marking abbreviations

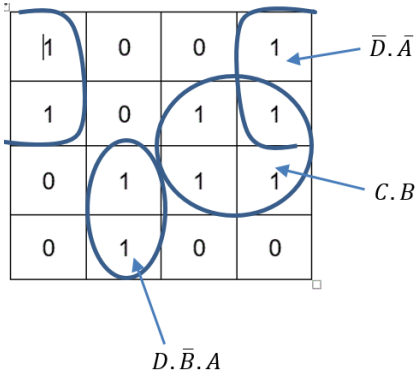
The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

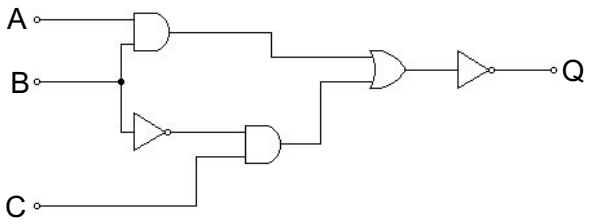
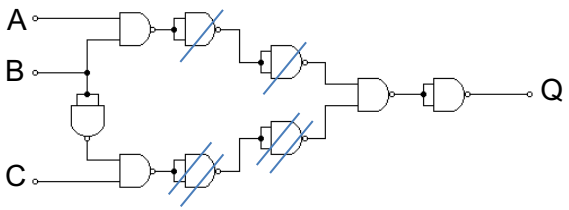
cao = correct answer only
ecf = error carried forward

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
1.	(a)		NAND	1			1	
	(b)		<table><tr><th>C</th><th>B</th><th>A</th><th>Q</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</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>1</td><td>1</td><td>1</td><td>1</td></tr></table> All correct (1)		1		1	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(c)		 First two pulses (1) Third pulse (1)		2		2	
			Question 1 total	**1**	**3**		**4**	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
2.	(a)	(i)	A (1)		1		1	
		(ii)	B (1)		1		1	
	(b)	(i)	$\bar{C}.\bar{B}.\bar{A} + \bar{C}.\bar{B}.A + C.\bar{B}.A + C.B.A$ All terms correct (2) Two terms correct (1)	2			2	
		(ii)	$\bar{C}.\bar{B}.(\bar{A} + A) + C.A.(\bar{B} + B)$ $= \bar{C}.\bar{B} + C.A$ Factorisation (1) Correct simplification (1)		2		2	2
	(c)		 Each term correctly inserted into map (1) x 3		3		3	3

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(d)		 $Q = C.B + \overline{D}.\overline{A} + D.\overline{B}.A$ Minimum number of groups identified (1) One term correctly identified (1) Whole expression correct (1)		3		3	3
			Question 2 total	**2**	**10**	**0**	**12**	**8**

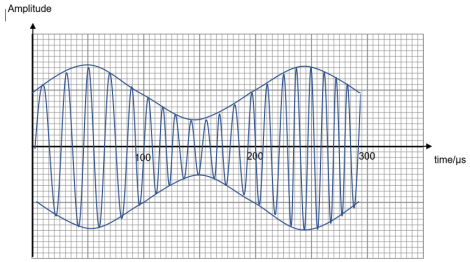
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
3.	(a)		 A and B to AND gate and the output to next gate (1) B to a NOT gate. The output of the NOT gate to the input of an AND gate. The other input of the AND gate from C (1) Both outputs from the AND gates to the inputs of an OR gate followed by a NOT gate (1)		3		3	
	(b)		 Correct replacement for NOT gates (1) Correct replacement for OR gate (1) Correct replacement for AND gate (1) 2 redundant pairs identified (1)	4			4	
			Question 3 total	**4**	**3**		**7**	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
4.	(a)	(i)	Dummy strain gauge to overcome any changes in other parameters e.g. Temperature. (1) Variable resistor to balance bridge circuit (1)	2			2	
		(ii)	V_{RHS} = 12 x 119/(120.5 + 119) = 5.962 V (1) V_{LHS} = 12 x 120/(120 + 120) = 6.000 V or by inspection (1) $V_1 = V_{RHS} – V_{LHS} = – 0.038$ V (1)		3		3	3
	(b)	(i)	Substituting into V_{out} = Gain x (V_1) (1) to obtain V_{OUT} = 0.76 V (1)		2		2	2
		(ii)	Using Gain = R_F/R_1 correctly (1) M = 5 kΩ (1) N = 5 kΩ and L = 100 kΩ (1)	1	2		3	2
	(c)	(i)	V_P = 1.25 V, V_Q = 2.50 V, VR = 3.75 V All three correct (2) Two correct (1)	1	1		2	2
		(ii)	Overflow when $V_{IN} > V_{REF}$ (1)	1			1	
		(iii)	Correctly using Resolution = Voltage range/2^n [1] Correct answer = 1.25 V (1)	1	1		2	

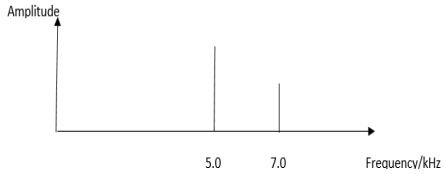
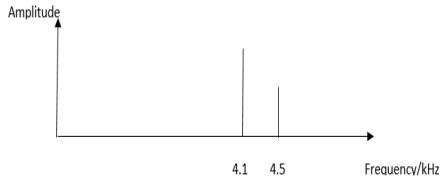
<table>
<tr><th colspan="3" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="5">Marks available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th></tr>
<tr><td></td><td></td><td>(iv)</td><td>
<table>
<tr><th rowspan="2">Value of V_{IN}/V</th><th rowspan="2">Voltage at W/V</th><th rowspan="2">Voltage at X/V</th><th rowspan="2">Voltage at Y/V</th><th rowspan="2">Voltage at Z/V</th><th colspan="2">Binary output</th></tr>
<tr><th>B</th><th>A</th></tr>
<tr><td>1.40</td><td>+10</td><td>0</td><td>0</td><td>0</td><td>0</td><td>1</td></tr>
<tr><td>3.80</td><td>+10</td><td>+10</td><td>+10</td><td>0</td><td>1</td><td>1</td></tr>
</table>
V_W, V_X, V_Y, V_Z all correct (2). (-1 for each error, max -2)
B and A correct (1)
</td><td>3</td><td></td><td></td><td>3</td><td>2</td></tr>
</table>

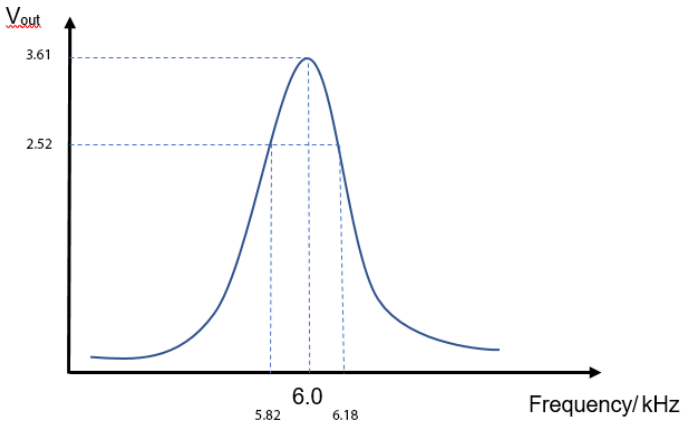
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(d)		**Indicative content:** **AO3 allocation –** Sampling rate suitable for application. Flash converter can cope with the sampling rate. Digital ramp also suitable for sampling rate. Resolution of flash converter is poor. Improving the resolution of the flash converter is complex/expensive. For the flash ADC a calculation of the number of op amps: Number of steps = 4.5/0.1 = 45 Number of op amps 2^n = 45 so n = 5.49 need 6 op amps Digital ramp more suitable for this application. **5-6 marks** Considers both types of ADC in relation to the application giving a thorough analysis of the advantages and disadvantages of both. For the flash ADC a calculation of the number of op amps required should be shown. Draws appropriate conclusion. *There is a sustained line of reasoning which is coherent, sustained and logically structured. The information included in the response is relevant to the argument.*			6	6	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
			3-4 marks Considers both types of ADC in relation to the application giving some advantages and/or disadvantages though not complete. Or/ Considers one type of ADC in relation to the application giving a thorough analysis of the advantages and disadvantages of that type. For the flash ADC a calculation of the number of op amps required should be shown for the higher mark in the band. *There is a line of reasoning which is partially coherent, supported by some evidence and with some structure. Mainly relevant information is included in the response but there may be some minor errors or the inclusion of some information that is not relevant to the argument.* **1-2 marks** One type of ADC is related to the application with at least one advantage or disadvantage considered. *There is a basic line of reasoning which is not coherent, supported by limited evidence and with very little structure. There may be significant errors or the inclusion of information not relevant to the argument.*					
			Question 4 total	**9**	**9**	**6**	**24**	**11**

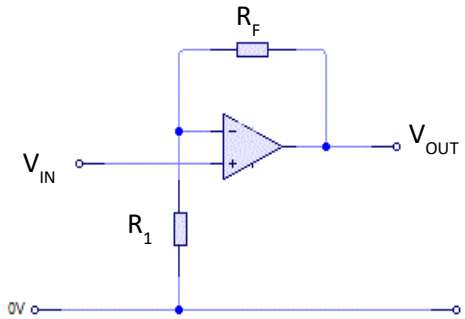
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
5.	(a)	(i)	f = 3 x 10^8/318 (1) Correct answer 943 kHz (1)		2		2	2
		(ii)	 Correct shape (1) High frequency carrier wave (1) Time period of 200 μs calculated or indicated on graph (1)	1 1	1		3	1
		(iii)	Depth of modulation = ((V_{max} – V_{min}) / (V_{max} + V_{min})) x 100 = (300 – 100) x 100% / (300 + 100) (1) = 50% (1)		1 1		2	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(b)	(i)	Constant amplitude (1) Modulation correct (1)	2			2	
		(ii)	Calculation of Δf_C (1) Substitution into $\beta = \Delta f_C / f_i$ (1) Correct answer 4.17 (1)	1	1 1		3	3
		(iii)	Correct use of Bandwidth = 2 ($\Delta f_C + f_i$) (1) Answer 124 kHz (1)	1	1		2	1
			Question 5 total	**6**	**8**		**14**	**9**

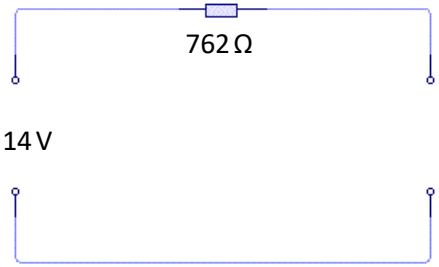
Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
6.	(a)							
			 Correct graphs (1) x 2	2			2	
	(b)	(i)	Correct substitution and rearrangement into $C = 1/4\pi^2 f_0^2 L$ (1) Correct value 319.8 nF (1)	1	1		2	2
		(ii)	Correct substitution into $R_D = L/r_L C$ (1) Answer 1.376 kΩ (1) [1.375 kΩ if 320 nF used]	1	1		2	1
		(iii)	Use of peak value of $V_{IN} = 12 \times \sqrt{2} = 17$ V (1) Substituted into voltage divider equation (1) Answer 3.61 V (1)	1 1	1		3	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iv)	Correct substitution into $Q = 2\pi f_0 L / r_L$ (1) Answer Q = 16.6 (1) Calculation of bandwidth = f_0/Q = 6000/16.6 = 361 Hz (1)	1 1	1		3	2
		(v)	 Shape (1) Resonant frequency labelled (1) Peak voltage value marked and labelled (1) Correct bandwidth frequencies shown (1)	1	3		4	

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(vi)	The filter has a resonant frequency of 6 kHz which meets the specification (1) The bandwidth of the circuit is only 361 Hz which doesn't meet the specification of 4 kHz (1) The shape is a narrow and high bell curve which doesn't meet the specification of the shape required Or/ The Q factor of 16.6 is too high compared with 1.5 of the specification (1)			3	3	
			Question 6 total	**9**	**7**	**3**	**19**	**7**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
7.	(a)	(i)	Any two from: Infinite input impedance, infinite open loop gain, zero output impedance, infinite slew rate.	2			2	
	(b)	(i)	From graph Gain = +15 (1) Non-inverting amplifier identified (1) Use of Gain = $1 + R_F/R_1$ to calculate resistors in the ratio for $R_F : R_1$ of 14:1 (1) Circuit:  R_F between V_{OUT} and the inverting input (1) R_1 between the inverting input and 0V (1) V_{IN} to the non-inverting input (1)			6	6	2
		(ii)	Range of frequencies over which gain > 0.7 max. gain (1) Correct use of Bandwidth = GBP/Gain (1) Answer 100 kHz (1)	1 1	 1		3	1

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iii)	Clipping distortion is due to the output voltage exceeding the saturation voltage for V_{OUT} (1) (accept: due to too large an input signal) One of: increasing supply voltage, decreasing gain, decreasing input voltage (1)	1	1		2	
			Question 7 total	**5**	**2**	**6**	**13**	**3**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
8.	(a)		V_{OC} = 2.14 V (1) I_{SC} = 2.81 mA (1) R_{EQ} = 762 Ω (1) Equivalent circuit (1)  	1	1 1 1		4	3

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
	(b)	(i)	Substitution into $I_b = I_c/h_{FE}$ = 68mA/400 (1) Answer 0.17 mA (1)		1 1		2	2
		(ii)	V across 762Ω resistor = 0.17 mA x 0.762 kΩ (1) V = 0.13 V (1) V_1 = 2.14 – 0.13 = 2.01 V (1)		1 1 1		3	3
		(iii)	V_{Rb} = 2.01 – 0.7 = 1.31 V (1) Substitution into $R_b = V_{Rb}/I_b$ = 1.31/0.17 x 10^{-3} (1) = 7.7 kΩ (1)		3		3	3
		(iv)	Protect the <u>transistor</u> from back emf from the motor (1) E.g. Rectification (1)	2			2	
			Question 8 total	**3**	**11**	**0**	**14**	**11**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
9.	(a)	(i)	B 001 D 011 G 110 B and G correct (1) D correct (1)	2			2	
		(ii)	Erroneous position signal when crossing a boundary (1) E.g. Moving from 000 to 111 could produce 011 then 111 (1)	1	1		2	
	(b)	(i)	 Three segments correct (1) All segments correct (2) Explanation (1) Example (1)	2 2			4	
		(ii)	Resolution = $360/2^3$ (1) Answer 45^O (1)		2		2	2

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
		(iii)	Resolution = $3^o = 360/2^n$ (1) Rearrange to get correct answer 6.91(1) 7 bits needed (1) Or/ Trial and error method (fully explained) to reach correct answer (3)	1	1 1		3	3
			Question 9 total	**8**	**5**		**13**	**5**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
10.	(a)	(i)	Time division multiplexing (1) Frequency division multiplexing (1)	1 1			2	
		(ii)	Signal can be regenerated (1)	1			1	
		(iii)	Correct substitution into $f = c/\lambda$ (1) Answers: $f_u = 2.50 \times 10^{14}$ Hz or 250 THz (1) $f_l = 2.34 \times 10^{14}$ Hz (1) Bandwidth = $(2.50 – 2.34) \times 10^{14} = 0.16 \times 10^{14}$ Hz (1) No. Channels = $0.16 \times 10^{14}/110 \times 10^{9} = 145.5$ (1) So 145 channels (1)	1	 1 1 1 1 1		6	6
	(b)	(i)	Correct use of $G_{dB} = 10\log_{10}(P_{OUT}/P_{IN})$ (1) Correct answer (-) 11.76 dB (1) Loss per km = (-) 0.78 $dBkm^{-1}$ (1)	1	 1 1		3	3
			Question 10 total	**5**	**7**		**12**	**9**

Question			Marking details	Marks available				
				AO1	AO2	AO3	Total	Maths
11.			Diagram for summing amplifier: 2 inputs with resistors both connected to the inverting input of an op amp. (1) R_F connected between the output of the op amp and then inverting input AND the non-inverting input connected to 0V (1) Addition of second op amp to invert output (1) Component values: Correct resistor values such that V_{out} = +5 V E.g. Gain of -20 for V_B and a gain of -10 for V_A with a gain of -1 for the second op amp. So for the first op amp R_F = 20 kΩ, R_A = 2 kΩ and R_B = 1 kΩ (3) [Accept any ratio of $R_F = 20R_B$ and $R_A = 2R_B$] For the second op amp $R_F = R_{in}$ (1) (All resistors ≥ 1kΩ)		3 1 1	3	8	3 1
			Question 11 total		**5**	**3**	**8**	**4**

COMPONENT 1

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

QUESTION	AO1	AO2	AO3	TOTAL MARK	MATHS
1	1	3	0	4	0
2	2	10	0	12	8
3	4	3	0	7	0
4	9	9	6	24	11
5	6	8	0	14	9
6	9	7	3	19	7
7	5	2	6	13	3
8	3	11	0	14	11
9	8	5	0	13	5
10	5	7	0	12	9
11	0	5	3	8	4
TOTAL	52	70	18	140	67